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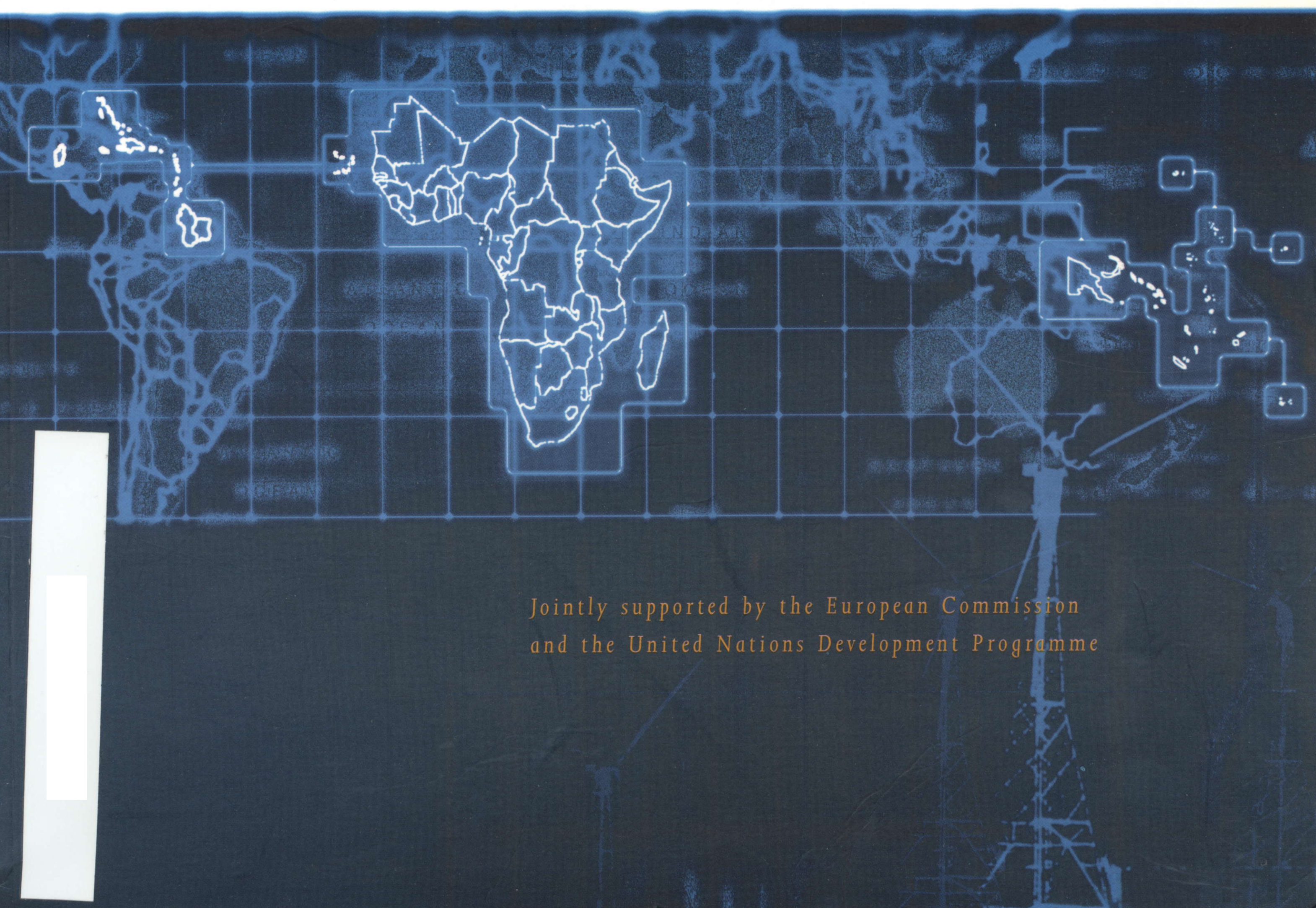
Energy as a Tool for Sustainable Development

for African, Caribbean and Pacific countries



Jointly supported by the European Commission
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Editor Ugo Farinelli

Authors

Salifou Bengaly
Lara Bertarelli
John Boyce
Abeeku Brew Hammond
Deborah Cornland
Anthony Derrick
James Graham
Michael Lazarus
Gerald Leach
Maurice Ruggeiro
Anjali Shanker
Youba Sokona

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UNDP
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USA

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NOTES ON AUTHORS

Salifou Bengaly is Director, Société d'Ingénierie de l'Energie (SINERGIE SA), based in Bamako, Mali.

Lara Bertarelli is an Energy Research Scientist for IT Power Limited, Hampshire, United Kingdom.

John Boyce is a Director of Ecoenergy Caribbean and a Parliamentary Senator in Barbados.

Abeeku Brew Hammond is Acting Director of Kumasi Institute of Technology and Environment (KITE), Kumasi, Ghana.

Deborah Cornland is Director of the Energy and Global Change Programme at the Stockholm Environment Institute in Sweden.

Anthony Derrick is a Founder Director of IT Power Limited, Hampshire, United Kingdom.

Ugo Farinelli is the former Director of the Energy Department of the Italian National Agency for New Technologies Energy and Environment (ENEA).

James Graham is an Energy and Environment Researcher for the Energy and Atmosphere Programme of the United Nations Development Programme based in Brussels, Belgium.

Michael Lazarus is Manager of the International Energy and Environment Programme at the Stockholm Environment Institute, based in Boston, USA.

Gerald Leach is the Senior Research Fellow of the Stockholm Environment Institute, based in London, United Kingdom.

Maurice Ruggeiro is President of the Fiji Institution of Engineers and a consultant at Tritech Consulting Engineers, based in Suva, Fiji.

Anjali Shanker is Director of Innovation Energie Développement (IED), based in Paris, France.

Youba Sokona is Head-Coordinator of the Energy Programme of Environnement et Développement (ENDA) - Energie, based in Dakar, Senegal.

FOREWORD

Energy plays a critical role in sustainable human development. It impacts on poverty, population, health, the environment, investment in industrial and agricultural development, foreign exchange and even security; it also has a strong gender implication. Policies aimed at providing energy services in a sustainable manner open doors to the achievement of a wide array of other development goals.

However, the manner in which the world currently produces and consumes energy is unsustainable. Furthermore, in the light of rapidly expanding world populations, the need for countries to follow sustainable development paths is becoming more and more urgent. Improving sustainability means improving the efficiency of energy production and end-use, identifying new and renewable sources of energy, and using existing sources of energy in a cleaner way. A key challenge is to incorporate strategies to limit the potential negative impact of human activity on the global climate.

Recognising these issues, national governments, bilateral cooperation agencies, and international development institutions have made efforts to promote the provision of energy services in ways which contribute to sustainable development. However, a number of barriers continue to limit the adoption of existing options. Building on the 1997 UNDP publication, *Energy after Rio: Prospects and Challenges*, the present report analyses the energy situation of two particular country groupings of global interest, Sub-Saharan Africa and ACP Small Island Developing States. It goes on to identify the actions required by different role-players to increase the adoption of sustainable energy options in these two groups.

This publication is the result of a joint EC/UNDP initiative which aims to intensify the global dialogue on sustainable energy issues and to provide a basis for future concrete cooperation activities. It is the intention of the report to support developing countries in implementing more effectively the objectives of Agenda 21, and to contribute to the follow up to the Rio Earth Summit and the work of the Commission on Sustainable Development in preparation for its 9th Session in 2001. Coming at a critical time in the work of the European Commission, with the ongoing negotiation of a new framework development agreement to replace Lomé IV, the report is an important contribution to the global debate on sustainable development strategies.

Philip Lowe
Director-General
DG VIII Development
European Commission

Eimi Watanabe
Assistant Administrator
Bureau for Development Policy
UNDP

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ABBREVIATIONS

Organisations and official bodies

ADB	Asian Development Bank
ADEME	Agence de L'Environnement et de la Maîtrise de L'Energie
AfDB	African Development Bank
AOSIS	Alliance of Small Island States
ASEAN	Association of South East Asian Nations
CDB	Caribbean Development Bank
DGVIII	Directorate General VIII: Development of the European Commission
EAP	Energy and Atmosphere Programme of UNDP, New York
EC	European Commission
EIB	European Investment Bank
ESMAP	Energy Sector Management Assistance Programme of the World Bank and UNDP
EU	European Union
FINESSE	Financing Energy Services for Small-Scale Energy Users
GEF	Global Environment Facility
IBRD	International Bank for Reconstruction and Development
IDB	Inter-American Development Bank
IDA	International Development Association
IEA	International Energy Agency
IFC	International Finance Corporation
IMF	International Monetary Fund
IT Power	Intermediate Technology Power
JICA	Japan International Cooperation Agency
JPSCo	Jamaica Public Service Company Limited
OECD	Organisation for Economic Cooperation and Development
OLADE	Latin American Energy Organisation
OPEC	Organisation of Petroleum Exporting Countries
PNG	Papua New Guinea
SADC	Southern Africa Development Community
SEI	Stockholm Environment Institute
SIDSPOA	Small Island Developing States Programme of Action for Agenda 21
SOPAC	South Pacific Applied Geoscience Commission
SPFS	South Pacific Forum Secretariat
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Education, Scientific and Cultural Organisation
UNFCCC	United Nations Framework Convention on Climate Change
UNGASS	United Nations General Assembly Special Session
UNICEF	United Nations Children's Fund
UNIDO	United Nations Industrial Development Organisation

Technical terms

Ah	Ampère-hours
BOE	Barrel of oil equivalent
Btu	British thermal unit
CFL	Compact fluorescent lamp

CHP	Combined heat and power
DRE	Decentralised rural electrification
DSM	Demand-side management
ECU	European currency unit
ESCO	Energy service company
GDP	Gross domestic product
GHG	Greenhouse gas
GNP	Gross national product
GW	Gigawatt of electricity
Ha	Hectare
Kgoe	Kilogram of oil equivalent
kVA	Kilovolt-ampère
kW	Kilowatt of electricity
kWh	Kilowatt-hour
LPG	Liquid petroleum gas
LRMC	Long-range marginal cost
MECU	Million ECU
Mtoe	Million tonnes of oil equivalent
MW	Megawatt of electricity
MWp	MegaWatt peak
OTEC	Ocean thermal energy conversion
SWH	Solar water heater
SHS	Solar home system
TOE	Tonnes of oil equivalent
USD	US dollars
W	Watt
Wp	Watt peak

Other terms

ACP	Africa, Caribbean, and Pacific
EDF	European Development Fund
FSU	Former Soviet Union
ICT	Information and Communication Technologies
IFREE	International Fund for Renewable Energy Engineering
IPP	Independent Power Producer
NGO	Non-governmental organisation
ODA	Official Development Assistance
PPA	Public Power Association
PV	Photovoltaic
R&D	Research and Development
RD&D	Research, Development, and Demonstration
RE	Renewable energy
REEF	Renewable energy and energy efficiency
RET	Renewable energy technology
SIDS	Small Island Developing States
SSA	Sub-Saharan Africa

EXECUTIVE SUMMARY

DRIVING DEVELOPMENT THROUGH THE SUSTAINABLE PROVISION OF ENERGY SERVICES

Development is a complex process, with many of its components intricately interwoven. Economic development, for example, can either complement or distort the rate and direction of social development. Countries in the process of transition from agrarian to more diverse economies often find that in many areas they are constrained by an ingredient on which all economies depend: energy services.

As an evolving economy industrialises, its need for energy per unit of GDP increases steeply, before flattening out or even dropping during post-industrialisation, when a more service-based economy begins to emerge. Nevertheless it is critical to recognise that what societies want are the services that energy provides, not fuel or electricity. Small-scale producers, whether farmers, blacksmiths, or master builders, are limited by their access to energy services, as are shopkeepers, truck drivers, teachers, and newspaper publishers. These types of businesses are the engines of development. Scaling up these activities and increasing the development options and opportunities to enable people to work efficiently and effectively is one of the key challenges that developing countries face today.

To complicate this challenge, the energy service requirements of a developing society are extremely diverse. The answers given by participants in a recent workshop held in Uganda when asked to identify their energy service requirements offers a good illustration of this diversity. In order of frequency of mention, the participants highlighted the following:

1. Food processing (including fish smoking, crop drying, timber drying, tobacco and tea processing, and bread baking)
2. Rural industry (including metal workshops, beer brewing, ice making, grain milling, lime production, and brick production)
3. Household lighting
4. Household cooking, baking, and water heating
5. Water pumping for both irrigation and domestic use
6. Entertainment (including radio, television, and music)
7. Refrigeration for hospitals and clinics
8. Transport

Admittedly, this list is specific to one country in Sub-Saharan Africa, but it does indicate the role which energy services play in a wide range of development activities.

ENERGY SERVICES AND SOCIAL DEVELOPMENT

For people living in poverty, the priority is to satisfy basic social development needs such as an adequate supply of food, shelter, availability of potable water, sanitation, and access to health services and education. Addressing these problems means addressing the many inadequacies that characterise poverty. In many cases, addressing these issues involves increasing the level of energy services available to poor people.

Hunger is generally agreed to be the worst manifestation of poverty. Increasing the productivity of agriculture in ACP countries will almost certainly involve increasing the availability of additional energy inputs, both direct (pre- and post-harvest) and indirect (fertilisers and pesticides). There is an important opportunity to raise awareness among farmers about the technologies available, and to ensure that the policy environment encourages and facilitates access to the best of these technologies.

Shelter is another area in which energy has a key role. The way in which buildings are designed, the services that are included in their design, and the building materials used, will all dramatically affect both the amount and type of energy inputs, as well as the long-term energy service needs of the residents.

Together with food and adequate shelter, water supply and sanitation are an immediate priority, and vital not only for an improved standard of living, but also for disease prevention. Solving people's water supply and sanitation needs using the most appropriate and efficient of a range of technologies will ensure that these vital services are supplied as widely as possible.

Once these very basic necessities are provided for, communities will look for the services that will improve their standard of living, including health, education, and better transport. In each of these areas the potential for maximising benefits to communities by choosing energy services wisely is enormous.

One of the main trends that is contributing to poverty in the South is urbanisation, and a key way to slow down that trend is to ensure that people in rural areas can improve their standard of living without moving to the cities. Therefore it is essential to facilitate the adoption of sustainable energy strategies that permeate every level of the economy and can provide rural dwellers with the services that they want and need. At the same time, the planning of land-use zones and transport corridors in urban areas of the developing world will have significant implications for long-term energy use patterns in the South.

ENERGY SERVICES AND ECONOMIC DEVELOPMENT

The provision of energy services has long had a central role in economic development. Economic development, both rural and urban, large and small-scale, can also be promoted and encouraged by making production processes more efficient, thereby making both the production and the end-products more affordable. Research into new technologies and techniques as well as into making existing equipment more efficient are an important factor here, but in many cases merely auditing the energy efficiency of the production process will bring results. *Energy After Rio* "seeks to identify practices and policies that will steer the economic system in sustainable directions" and to "understand better the opportunities for increasing the efficiency of materials use and for reducing practices that involve major dissipative (non-recoverable) uses of materials." It goes on to elaborate the strategies that can be used to improve material efficiency, which include:

- "good housekeeping (e.g. reduction in material losses in existing production processes);
- material-efficient production design (e.g. redesign to reduce the amount of material needed to manufacture a functional unit of the product, to increase its lifetime, or to improve its reparability);
- material substitution (e.g. use of a material with a higher material efficiency);
- product reuse (i.e. via redesign of a product to permit renewed use without changing the physical appearance of the product);
- material recycling (i.e. material reuse through the production of secondary materials by mechanical, chemical or other means); and
- quality cascading (i.e. the use of secondary materials for functions that have lower quality demands)."

There are very simple ways in which some of these savings could be made.

In addition, diversifying energy supply systems will direct countries down a more sustainable economic development path. Locally, diversification will further economic activity in both rural and urban areas, as others will soon make the most of energy services in different income-generating activities. The electrification of remote areas has to be planned carefully though. Limited services are soon overwhelmed as communities discover innumerable ways to put any available energy to use and demand grows dramatically and quickly. In the broader economic picture, diversifying energy supply sources improves economic security by lowering dependence on one or two finite primary forms of energy and by reducing the heavy economic burden of energy imports—remote islands, often heavily dependent on energy imports, must pay two or three times the world market price for oil. Furthermore, competition, resulting from the introduction of new role-players into traditional state monopolies, will help to improve the economic performance and efficiency of the sector.

ENERGY AND THE ENVIRONMENT

It is a tragic irony that the poor in developing countries often bear the brunt of the consequences of environmental degradation, while their contribution to the causes at both local and global level is often negligible. Clean fuels and efficient public transportation systems can transform the pollution in many homes and in urban areas, improving health dramatically. As industrial and human activity increases, there will be a need to provide or upgrade water treatment facilities, both to ensure a supply of potable water and to avoid poisoning of water bodies and, as a result, of the food chain.

An issue of great relevance to energy services is the effects of global climate change, largely as a result of the amount and method of energy use in developed countries. The resulting sea-level rise will particularly affect small islands and coastal communities, a disproportionate number of which are poor. In addition the unpredictable and intense weather patterns that have been occurring with increasing frequency hit poor and vulnerable communities hardest, as their homes and crops are often destroyed and they rarely have the capital to start over without help. Traditional agricultural practices may no longer be appropriate or viable, as patterns of rainfall and drought change due to altering regional climatic conditions. While until today the South has contributed little to the build-up of greenhouse gases in the atmosphere, its contribution will grow as the pursuit of progress demands increasing use of energy services. As parts of the South become more prosperous, people will use more energy to improve their standard of living, with global environmental consequences. Developing and promoting the most efficient energy supplies and appliances will help to minimise global greenhouse gas emissions by reducing the amount of energy input required to provide a given service.

ENERGY AS A TOOL FOR SUSTAINABLE DEVELOPMENT

Sustainable development consists of progress in social development, complemented by economic development, and combined with an awareness of the environmental implications of natural resource use and industrial and economic development. A sustainable energy strategy would supply the kind of energy services that people want, when and where they want them, while advancing social development and minimising the environmental impacts of energy use. Indeed, given the role of energy services across such a wide range of development activities, a sustainable energy strategy can be used as a tool to address integrated development goals. Such a strategy would include the creation of an environment more favourable to the uptake of sustainable energy practices and technologies under prevailing conditions, and target the introduction of specific technologies in ways which would increase energy services for the entire community. To be effective, it is clear that a sustainable energy strategy has to address policies across a range of conventional sectors. However, it is recognised that the energy sector should take the lead in sharing knowledge and experiences.

This report looks at energy policies and practices and suggests how their potential as a driving force for sustainable development could be harnessed in two important regions, Sub-Saharan Africa (SSA) and the African, Caribbean, and Pacific Small Island Developing States (ACP SIDS). The report identifies both the challenges that must be met before sustainable energy strategies can be effectively implemented in each region, and the many opportunities that exist for governments, the private sector, development cooperation agencies, and other role-players to accelerate their adoption. SSA and ACP SIDS have huge renewable energy resources, from traditional biomass to marine resources, but these resources are vastly underexploited and conventional solutions continue to dominate. Illustrations of innovative projects show that there are proven alternatives, and the sections in Chapters 2 and 3 from Ghana, Zimbabwe, Mali, Barbados, and Fiji describe the contribution that sustainable energy strategies would make to the development of those countries. The wide array of proven renewable energy and energy efficiency mechanisms already available and appropriate for use in these regions is described, demonstrating that the technologies are ready, if only the policy environment nurtured them, instead of discouraging them.

THE PROVISION OF ENERGY IN DEVELOPING COUNTRIES TODAY

The energy sector is still driven primarily by issues of supply instead of demand. The conditions that exist in the South today should define the strategies used to supply people with the energy services that they need to achieve sustainable development. The reality is that it is the energy supply models that evolved in the North—based on two centuries of industrialisation and urbanisation—that continue to drive the energy sector.

If countries in the North were to work together, and to work with policy-makers in the South, that model could be turned around to focus on the *demands* of energy users. If that were to happen, then there is every chance that sustainable energy strategies could be devised that will support and promote sustainable development. There is a desperate need for development cooperation agencies to look carefully at the energy interventions that they are funding and to ask if those interventions are helping to provide sustainable solutions. There is an enormous amount of research to be done in assessing the potential of and developing end-use efficiencies, cleaner technologies, renewable resources, and the market for these renewable energy and energy efficiency technologies. Many of the technologies in question are already commercialised, but others need further development or need to be adapted to suit conditions in the South, particularly to make them affordable. Ministries of Energy in the South are chronically under-resourced, and do not have the capacity to plan how to meet their Agenda 21 commitments, or how to restructure their domestic energy sector to provide an enabling environment for the dissemination and exploitation of renewable and energy efficient technologies. Development cooperation agencies can provide capacity for Southern governments to find and access the information that they need, and fund regional research and development and cooperation, in order to get the best value for money.

Since projects addressing development cooperation priorities (centering on poverty alleviation, job creation, and the improvement of basic services such as education, health, and water supply) often depend on sources of energy that are secure, affordable, and appropriate to the end-use, projects which address these priorities have been a principal means of disseminating energy technologies. Where energy has not been included or thought out in such projects until a late stage, however, users have often been saddled with inappropriate or costly technologies.

BUILDING ENERGY SYSTEMS WHICH PROMOTE SUSTAINABLE DEVELOPMENT

The key to providing energy services that promote sustainable development is reform of the policy environment in which energy decisions are made. Until an enabling policy framework is created in which a variety of enterprises are encouraged to provide sustainable energy services to communities, top-down conventional energy supply will continue to dominate. Even with the best will, this environment cannot be created overnight, however.

There are many challenges to the creation of this environment. These challenges fall into seven basic categories:

- Regional cooperation and coordination
- Institutional, legislative, and regulatory environments
- Capacity building
- Energy pricing, taxes, and subsidies
- Finance mechanisms
- Information
- Technology choice and development

Research into the best ways to overcome these challenges and information detailing best practice will be an investment in the development of sustainable societies.

REGIONAL COOPERATION AND COORDINATION

Many of the countries considered in this study have no national energy plan, while some have progressive and sustainable energy strategies that their neighbours could learn from. Neighbouring countries can share climatic and geographic conditions, but have attained very different levels of development. There is no time to waste, and every effort must be made to ensure that the lessons that have already been learned are shared with those who could benefit most.

In the case of the small island states, economies of scale may only be achieved if states work in a coordinated way to develop regional strategic plans. Ensuring consistency in regulations and standards among Caribbean islands, for example, will give energy service providers or manufacturers of adapted renewable energy technologies access to viable markets. Identifying the common problems and sharing research activities among countries will begin to build capacity in all countries, instead of just the favoured few. There are already some active regional development and energy organisations among island states. Their success should be encouraged and copied in other parts of the world.

The regional trade of energy is also extremely important. Large energy projects may be viable only if their potential markets include several countries in a region. Regional energy fora will encourage neighbouring countries to consider whether cooperation on energy production is feasible—it can prove less expensive than isolated or national options. A study in Burkina Faso showed that a grid interconnection with either Ghana or the Ivory Coast would be a better solution than the diesel- and oil-fired plants which are being installed.

Development cooperation agencies can coordinate their own work too, to avoid the duplication and overlap that exists now. Cooperation agencies can also encourage regional development banks to increase their technical and financial assistance to sustainable energy projects. There is room for better coordination and planning within cooperation agencies, and better education for staff working in all sectors, not just energy.

INSTITUTIONAL, LEGISLATIVE, AND REGULATORY ENVIRONMENTS

It is important that all countries prepare an integrated sustainable energy strategy to use energy as an instrument, planning the ways in which they can use energy more efficiently and appropriately to meet the needs of their citizens. The use of renewable and energy efficient technologies should form an essential part of these strategies. Jamaica, for example, has an energy policy which seeks to diversify its energy base, encourage the development of indigenous energy resources where economically viable and technically feasible, and ensure the security of energy supplies.

The main role of policy-makers in the energy sector is to create a framework of laws and standards in which the market is encouraged to thrive but the social development and environmental goals of nations are not neglected. Private enterprises are unlikely to share the same development goals as the state, so regulatory bodies can ensure that access to energy services is extended to the whole population.

Most developing countries have signed up to international agreements, from Agenda 21 to the UN Framework Convention on Climate Change, that have implications for energy and the environment. Regulatory bodies can work with the government to ensure that obligations are being met and are integrated into energy planning. The SIDS Programme of Action translates Agenda 21 into specific policies, actions, and measures, for example.

Regulatory bodies—which could be national or regional—could be set up to prepare guidelines to which all stakeholders could work. This would ensure that communities and countries will be installing more efficient and up-to-date technologies and systems, and that the off-loading of second-rate equipment is avoided. In West Africa, for example, there is no standard LPG tank, and this lack of coordination has reduced the potential market for energy providers considerably.

To inform regulatory bodies, institutions with the capacity and resources to carry out sound scientific and technical research could be created or, where they exist already, supported. These bodies could play an extremely important role in educating all stakeholders. One example is the South Pacific Applied Geoscience Commission, which applies geoscience to the management and sustainable development of the non-living resources of the region. The commission is also working with interested Pacific SIDS in the formulation of long-term national energy policy statements. Supporting organisations like this, which support local technical research and development, will build long-term skills and knowledge.

Regulations are necessary to guide the private sector and to protect the consumer, and should not be limited to the technical aspects of energy systems. Regulations are limited only by a lack of vision; where appropriate, for example, they could ensure that energy service providers have consulted widely and participatively with end-users before any system is installed. The US National Rural Electric Cooperative Association has found that informed participation is the most important single success factor in all the developing country solar PV projects that it has analysed.

It is not only energy generating systems that could be subject to minimum standards. Research into other sectors of the economy, such as transport, construction, and industrial production, will reveal a myriad of other energy-saving measures. Transport systems could be designed to use energy more efficiently, and can be gradually adapted to use biofuels. Locally produced building materials can often be produced with much less energy than imported cement, for example, and buildings constructed to suit local climatic conditions—saving energy used for heating and cooling. The production of basic industrial materials, such as steel, can be carried out with much less energy than currently if the most up-to-date technology is installed.

It is more efficient if products are marketable in the widest geographic area possible. Ensuring that quality standards and specifications are common to natural regional grouping will encourage economies of scale. The World Health Organisation, working with the United Nation Fund for Children (UNICEF), set international performance standards for PV refrigerators and now insists that these be met by all projects that it funds. The PV Global Accreditation Programme is supporting an industry-led effort to approve standards for PV components and systems in developing countries.

CAPACITY BUILDING

Strong institutions will be the backbone of an efficient and effective energy sector, and there is no point in creating institutions if their staff will not have the training and resources to work effectively. It is difficult to start new, good, locally based institutions from scratch without depriving all the existing organisations of their best staff. Building on existing institutional capacities will often be the most effective approach. In Ghana an alternative model was used—a loose network of local expertise that was a formal channel for advising and interacting with government.

Ongoing professional training in public administration and management at all levels of government and in all parastatal organisations could improve the situation greatly. Joint projects are effective ways to develop capacity. Policy-makers, teamed with local policy analysts/trainers, could jointly develop policy and implement programmes, thereby building both local capacity and confidence.

A scientific research and development body needs to have not only the scientific training, but also the resources to collaborate with other organisations, and the training to communicate and disseminate their work effectively.

Training in all aspects of business is important for would-be entrepreneurs, particularly where the existing small business sector is small or non-existent. It is not just the traditional skills of accounting and sales that are important. Some businesses will be importing equipment, and trying to market a product, that has no history with potential customers. They will also need to provide after-sales service and in some cases train communities to operate and maintain the equipment themselves. In the Dominican Republic, an NGO spent several years running training programmes with local technicians and entrepreneurs to create a pool of people who had sufficient knowledge to install and maintain PV systems to a standard which enabled propagation of a good reputation. The private PV market is now beginning to thrive on the island.

Lessons learned in social development about participatory technology development should be integrated into all capacity building. Involving communities from the beginning in decisions about energy supply will reap rewards. The community must define the end-uses that are most important for them, decide what they are willing to pay for different levels of service, and, based on a wide range of choices, plan for future needs. Offering communities choices and educating them about the implications of those choices will lead to informed decision-making and energy use. The Jamaica Public Service Company runs a demand-side management project designed to influence residential and commercial customers' use of electricity in ways that will produce changes in the utility's load profile, reduce customers' bills, and reduce the company's generation costs. Activities include the provision of compact fluorescent lamps and other energy efficient devices at no cost to 100 participants to establish the technical criteria regarding equipment performance, customer response, and installation problems in this small pilot group. In the second phase proven energy efficiency measures will be offered to 30,000 randomly selected customers island-wide at a discounted price.

ENERGY PRICING, TAXES, AND SUBSIDIES

Governments have long recognised the importance of energy to the development of their economy and society, and so they have sought to make it available to as many people as possible, as cheaply as possible, by subsidising its cost. These policies were well-intentioned, but based on a number of unproven assumptions. Research carried out during the last decade has shown that it is in fact the poorest people who pay the most for their energy services. In fact, poor people's willingness and capacity to pay for services is higher than policy-makers have assumed, partly because the amount that people are paying for batteries, battery-charging, small quantities of kerosene, and in some cases fuelwood, is more than policy-makers had realised. A recent survey in Uganda discovered that there are more rural and peri-urban households with private access to electricity from car batteries than there are public sector grid-connected households in the whole country. They pay on average 20 times the urban tariff, and spend over US$10 a month on candles, lighting, kerosene, dry cell batteries, and recharging car batteries—or US$320 million nationally every year.

Energy technology and equipment that has to be imported is often taxed at very high rates, making the initial capital costs of even very energy efficient technologies higher than they need be, and preventing their dissemination. Renewable energy products such as solar PV and water-heating systems, and the materials used to manufacture them locally, are often subject to government import duties and taxes that can increase their market price relative to conventional fuels—by 40 to 50% such as in Zimbabwe, for example.

The result of well-intentioned subsidy policies is that most state energy providers lose money by providing cheap energy to customers that are easy to reach and in many cases are most able to pay for it, while poor and/or remote customers continue to pay much more. The energy suppliers cannot afford to extend their supply to the remote customers, and new, private energy service providers cannot possibly compete with the low, subsidised prices charged by the state providers.

If the private sector is to begin to provide energy services, then pricing, taxes, and subsidies will need to be reformed. Energy pricing should ideally reflect, or be moving towards reflecting, the true costs, so that customers can make informed decisions. Sustainable energy strategies will identify the energy systems that represent, in the long term, the most sustainable forms of supply. If some of these technologies need to be subsidised to enable them to gain a footing, then such subsidies must be open, universal, and time-bound. It is important that these decisions are made in cooperation with the private sector and regulated so that customers know they are getting value for money. Since the mid-1980s the Government of Ghana has financed sustainable energy projects using small levies on petroleum products. With a current petroleum product consumption of about one million tonnes, over US$400,000 is raised annually. This sum is paid into an "Energy Fund" and used to promote renewable energy and energy efficiency projects.

It is not just energy supply systems that are affected by subsidies and taxes. The import or use of energy efficient equipment or materials in other sectors can also be influenced by subsidies and taxes. Equipment to enable producers to make building materials from local materials could be encouraged, while industrial equipment that does not use the efficient technology available could be discouraged—if not rejected. Setting minimum standards of efficiency will enable newly industrialising countries to avoid wasteful appliances, for example, by permitting only the import or manufacture of appliances that meet these standards.

FINANCE MECHANISMS

Countries wishing to install large hydroelectric dams to supply electricity grids or to extend grids have several financing options open to them. Countries wishing to install hundreds of micro-hydro systems or PV systems, or to enable entrepreneurs or communities to do so, have more difficulties.

The banking system is simply not set up to administer profitably long-term loans to scattered customers with no credit history or collateral. There are a number of ways that this problem is being overcome, and some are described in this report, but more research into innovative ways of financing is needed. In some countries small loans are amalgamated into one large loan through an intermediary, with the risk guaranteed by the government (See Box 4). In other cases the independent energy producers themselves build credit arrangements into the purchase of their products as in the case of a Global Environment Fund (GEF) PV project in Zimbabwe. Loans made to communities have in some cases been paid off by income-generating activities which were built in from the beginning, such as battery charging.

In Morocco, for example, several initiatives are helping villagers to form cooperative associations to own, manage, and finance their diesel-based mini-grids. The NGO bulk-buys the equipment, and raises some 40% of the capital costs, and a further 10-20% as costs in kind for labour and local materials.

In several other countries, Energy Service Companies (ESCOs) are providing financing packages as well as technical expertise. They can be paid relative to performance—a commission on savings achieved, for example. Few, if any, rural ESCOs are recovering their costs—they have to depend on some form of operational subsidy or grant. This position could change, however, as technology costs fall and markets and experience lower operating costs.

In the Dominican Republic, it was calculated that only 10% of the population could afford to pay cash for a PV system, but another 50% could afford monthly payments spread over two or three years, provided credit was available. As a result, a company there has instigated both credit and leasing systems, increasing substantially their customer base and, in the case of leasing, allowing customers to try before they buy.

Development cooperation agencies can help states which aim to maximise the share of renewable and energy efficient technologies that make up their national energy system by investigating innovative ways of financing these solutions and disseminating examples of best practice.

INFORMATION

The importance of information in overcoming all the challenges here cannot be overemphasised.

This report gives a rough sketch of the energy picture in Sub-Saharan Africa and ACP SIDS, but there is still a great lack of information in most countries that could form the basis of baseline studies. Research is needed not only to consolidate or establish basic information, but to record and explore the innovative ways in which people are fulfilling their energy service needs. Policy-makers and energy providers need to know not only how much energy people are using and in what form, but why they have chosen those methods, and who in the family and in the community prioritises and decides on how limited supplies of energy are used. Basic market assessments are vital.

In the North, the average citizen is often overwhelmed by the amount of information available, and new technologies such as the Internet are making ever more information available at ever greater speeds. The picture could not be more different in most areas of the South.

Technologies are available to improve efficiency for all energy users. Women who spend hours gathering fuelwood for all their cooking, heating, and crop drying needs could cut that time—and improve their health—by using improved efficiency and/or smokeless cooking stoves, or low-cost crop dryers, or in some cases by using more appropriate methods of transportation than headloading to collect their fuel. These technologies exist and have been extensively tested, but unless information about how to make or buy them is disseminated to those who want them, much research and development has been wasted. All technology development projects should have information dissemination through appropriate methods of communication and commercialisation built in from the beginning, and successful technologies should be adapted for similar markets. One of the most successful improved stoves is the Kenya ceramic jiko. It was actually adapted from the Thai Bucket Stove, and has gone on to be adapted itself, into the *diambar* stove of Senegal. The key to success was not just the design, but also a persistent and sound approach, including careful market assessment, production testing, market trials, and commercialisation.

Urban customers—and their numbers are growing rapidly—should be able to choose from a number of energy options, and will probably find a hybrid solution most appropriate. Solar water heating; PV panels for electricity; efficient and smokeless biofuel cooking stoves; clean bottled gas for cooking and water heating; electricity from the grid where it exists; and better home design to maximise energy efficiency are some of the typical options. Without reliable accessible information in their own language, these consumers will not be able to make informed choices about the technologies that they use.

At the other end of the scale, the acceptable ways of planning and constructing massive energy infrastructure projects have also changed dramatically. A public consultation process, in which everyone who will be affected is given full information about the project, is necessary before any construction can be scheduled. These participatory techniques are already in use and should be applied systematically.

Independent power producers and energy service providers (where they exist) need to be fully informed about the goals of the government and the needs of end-users, as well as about all the technology options available and all the ways that these might be financed. If they are to offer customers the best value for money, a comprehensive and *ongoing* programme of information must be available that ties in with the actions of policy-makers.

Information needs will extend beyond the technologies. Consumers will need to have the information to make an informed choice about the services being offered by different providers once the markets are genuinely competitive. Few people have used credit, but leasing, group loans, and other potential financing mechanisms must all be explained, along with the advantages and disadvantages of each method. If service providers are to be profitable, they will have to stimulate the market by encouraging consumers to think about innovative ways of getting the services they want. People may be able to afford a solar water heater or PV panel that serves a block of houses, for example, even if none of the houses could afford one individually. Communities may find that the electricity produced by a stand-alone energy system to provide lighting is too expensive, but if that electricity was put to use charging batteries during the day, possibly as an income-generating project, the system may well be viable. A PV panel could be used to charge up a satellite mobile telephone, which can be used as a payphone, reducing the travel and transport needs of remote communities.

Objective comparisons of the advantages and disadvantages of all the different renewable energy and energy efficient technologies—and their merits relative to conventional systems—need to be made and disseminated widely. This should not be limited to input and output costs. PV systems or a diesel generator may provide the electricity that people want, but how many local jobs do they provide compared to an efficient wood-fired power plant with a managed woodlot?

Professionals and policy-makers who do not think of themselves as working in the 'energy sector' need to understand the role of energy in their work. Collaborative projects in many sectors will be needed to demonstrate the link between energy efficiency and increased productivity throughout the economy.

This information famine can be corrected through research but also through ensuring wider access to new information and communication technologies. Traditional methods of communication such as theatre should not be ignored, and there is widespread evidence that behaviour messages—such as hygiene practices, water use, or energy efficiency—can be communicated effectively this way.

TECHNOLOGY CHOICE AND DEVELOPMENT

The developing world has two advantages on its side when it comes to energy technologies. Most countries have abundant energy resources, particularly renewable energy resources. And in many countries the lack of developed infrastructure outside of the main cities means that they can start with a "clean slate", and have an opportunity to "leapfrog" the less efficient energy systems that most industrialised countries are committed to.

In all cases the greatest short and medium-term gains will be in saving energy and improving energy efficiency. From simple, efficient cooking stoves to improved transmission and distribution of electricity, efficiency should be promoted and supported by legislative and financial incentives. An improved Mirte biomass stove in Ethiopia is designed for baking the cereal-based staple injera, an activity which accounts for 50% of Ethiopia's primary energy consumption and over 75% of all household energy use. A typical twice-weekly injera baking session consumes 10kg of woody biomass. The Mirte uses only 50-60% as much fuel, saving about half a tonne of fuel per stove annually.

Some renewable energy technologies are tried and tested but could still be improved, while others are still in development. Renewable energy and energy efficient technologies are often modular, and so are both suitable for use in remote areas and appropriate for small investors. One factor holding back all these technologies is the lack of investment in research and development. The amount of money spent on energy research is heavily weighted in favour of conventional and high-tech solutions. The opportunity to develop renewable and energy efficient technologies and to disseminate them before the South chooses the conventional route may be lost unless funding of sustainable solutions is stepped up immediately. The implications of these two options for climate change mitigation are immense.

Sustainable energy technologies include some high-tech solutions, such as thin-film PV technology, fuel cells, high-efficiency biomass gasifiers and gas turbines, solar-hydrogen systems, etc., which are unlikely to be developed in the South in the near future. There is a great need for collaborative research into adapting high-tech solutions, however, to make them more appropriate for conditions in the South, for example by making them more robust, reliable, low cost, and portable.

There are other technologies, such as improved stoves, that are already appropriately designed for some Southern countries, but could be adapted to suit more countries. Variations in production processes to take account of local materials, house designs, food preparation and consumption habits, marketing, and commercialisation will all have to be considered for technology transfer to be successful.

Small village-based gasifiers and biogas plants are popular and widespread in India. Where supported by local communities, this technology could be adapted and tested for Sub-Saharan Africa and ACP SIDS.

Medium-scale energy options which could supply the national electricity grid or isolated grids, such as wind farms, power from biomass and refuse incinerators, or micro-hydro, have been investigated and tested in developing countries. The first of 19 recommendations adopted by the participants in a seminar organised in Morocco in 1996 on decentralised rural electrification (DRE) was that "a major and immediate change of scale and pace is recommended in the implementation of DRE and increased attention should now be given to the implementation of these technological options."

Biofuels produced from biomass crops have great potential, and policy-makers should look to Latin America and Asia for examples. They will not be appropriate for every situation as crops need to be reliable and labour needs are high, but in some situations they will provide much-needed jobs as well as clean fuel. It may be appropriate to subsidise biofuel until demand grows and it becomes the obvious choice instead of the alternative. Ethanol production from local biomass to reduce oil imports was developed in the Kenya, Malawi, and Zimbabwe sugarcane industries in the 1970s. Today, Malawi still blends ethanol in petrol at rates of up to 20%, but persistent low oil prices and periodic droughts have weakened the region's ethanol industries.

Biofuels could play an important role in relieving ACP SIDS' dependency on petroleum—one-third of Jamaica's foreign exchange earnings are used to pay for imported fuel. In addition, transporting fuel to remote stations in outer islands is expensive, irregular, and loading can be hazardous—many outer islands have no wharf or jetty and the fuel must be floated ashore in drums. During the 1980s there was considerable interest shown by a number of Pacific SIDS in using copra oil as a fuel in diesel engines. In Samoa a large, slow-speed 250 kW diesel generator was run on pure crude copra oil, as were a number of the electricity corporation's heavy-duty trucks.

Hybrid systems should be evaluated under various conditions to determine appropriate combinations for diverse use. Intermittent renewables, such as wind and solar, could be combined with conventional supplies, such as diesel and biomass. This solution will not always be appropriate, particularly for remote islands or communities, as the capital costs will be higher and skilled technicians—often in short supply—will be needed for two or more technologies.

The costs of electricity transmission, distribution, wiring, and metering can be reduced through improved efficiencies. Combined with energy efficiency measures, this could make grid extensions more viable. Development cooperation agencies could play an important role here, funding secondments and placements between large grid-based power companies in the North and their Southern counterparts. Southern electricity distributors need on-site advice and demonstrations from skilled professionals, but they also need to see the diversity of solutions employed across a range of other distributors.

The most common electricity end-uses should be as efficient as possible, and these technologies or appliances (such as compact fluorescent light bulbs) have to be promoted with the same vigour as energy efficient supply technologies. As countries develop, the demand for labour-saving appliances will grow, so this must be addressed as a matter of urgency. Countries can plan for this by agreeing regional minimum standards for efficiency, thereby creating a market large enough for retail prices to be reasonable.

Finally, some ocean technologies, such as marine current turbines, are at advanced stages of development in the North. ACP SIDS should be involved in assessing their own potentials for using these technologies, which are heavily site-dependent, and cooperation in the development and adaptation of this technology should be encouraged.

THE WAY FORWARD

Experience has taught us that an energy sector dominated by government agencies has neither the flexibility nor the reach to provide the diversity of choice that consumers need to fulfil their energy service needs. However, the role of government is an important one, as only they can create the right policy environment—one in which competition among providers is encouraged where possible, but within an effective regulatory framework—that will enable independent energy service providers of many types to thrive. Northern governments have been making this transition during the last decade, and they have some experience to share. Analysing and disseminating this experience in ways that are appropriate to the developing world—particularly by keeping the social and environmental goals of poverty eradication and sustainability in focus—is vital. The development of national and regional sustainable energy strategies will put into place a framework in which each country has planned to build a policy environment that will encourage and enable the provision of energy services in a way which is most appropriate to that country.

In Sub-Saharan Africa, for example, the reform of energy sector regulations will enable and encourage energy providers to offer a wide variety of energy services on different scales to both households and businesses. Capacity building to inform consumers and potential providers about the technologies available, as well as research to both adapt existing technologies and devise new ones, will be a cornerstone of sustainable energy systems. Large conventional power installations should only proceed where they are the best option after considering many, and where the needs of the region have been taken into account during planning, costing and building. A rapidly increasing population will be demanding more energy services, and plans to satisfy this demand will have to be scaled up dramatically if they are to be adequate. If energy initiatives are linked and planned across sectors, then goals of social and economic development can be addressed together.

Capacity building will be equally important to the development of sustainable energy services in ACP SIDS. Useful information and successful practical applications often exist but, partly as a result of geography, remain isolated. Information sharing among islands which have similar social and physical conditions will promote good practice, particularly where participation is high and projects are evaluated properly and the results disseminated. Training in the role of the private sector in providing energy services will be needed where the government has been the sole provider, from technical training through to business planning, marketing, maintenance, and credit options. SIDS also have an important opportunity to be at the forefront of tidal and marine technology development, and partnerships and collaboration with Northern engineering should be encouraged.

The implications of profligate energy use have never been more clear than they are at the end of the twentieth century. We have hard evidence that the amount and type of energy that the North uses to maintain a lifestyle that most of the rest of the world aspires to is having grave consequences on our climate and our environment. Although it is too early to define precisely the relationship between global climate change and human activity, evidence of the effects of climate change are already starting to appear, so it is important to act swiftly. We are already too late to prevent some of the scientists' predictions from happening, but through considered action we can minimise the damage, and at the same time the citizens of the South can get access to the energy services they need to develop their societies in a sustainable way. The challenge is to promote sustainable development while limiting the negative impact of human activities on the climate.

The resources that will be needed to affect this change are tremendous, both in terms of funding and the amount of work to be done. The greatest change can be affected, however, by structuring the policy environment to provide incentives for people to use energy efficiently, and by making the information and skills available to translate will into action.

Annex I of this report lists the work that the cooperation agencies of the North are currently involved in and/or funding. There is clearly some overlap, and there is a need for coordination and cooperation to document and disseminate best practice, whether it be in technology development or in innovative financing schemes. It will also be crucial to extend an invitation to professionals in other sectors, such as health, education, agriculture, manufacturing, construction, transport, telecommunications, community development, etc., and to include them in energy planning, especially to focus on energy efficiency. Nevertheless, the energy sector has to make the first move and document the way in which renewable and energy efficient technologies and systems can help those professionals to reach their own development goals.

Finally, there is still much technology research and development to be done, and more of this will have to take place in the South. Cooperation agencies can help to set up or support scientific research bodies who will be capable of innovating, adapting, and standardising technology that is appropriate for each region. Pilot projects should only take place where they contribute to policy as well as technology goals, and they should advance knowledge, not simply repeat work carried out by other agencies. All new work should to be monitored and evaluated to ensure that lessons are learned, and that those lessons are disseminated widely.

CHAPTER 1 - ENERGY AND SUSTAINABLE DEVELOPMENT

CHAPTER 1 ENERGY AND SUSTAINABLE DEVELOPMENT

INTRODUCTION

"People want the services that energy provides, not fuel or electricity."

That statement is self-evident, but the energy sector is still driven by issues of supply instead of demand. The conditions that exist in the South today should define the strategies used to supply people with the energy services that they need to achieve sustainable development. The reality is that it is the energy supply models that evolved in the North—based on two centuries of industrialisation and urbanisation—that continue to drive the energy sector. If policy-makers in the South, supported by cooperation agencies, were to turn that model around, and to focus more on the *demands* of energy users, then there is every chance that sustainable energy strategies could be devised that will support and promote sustainable development.

ENERGY AFTER RIO

Energy was not a separate theme at the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro, and the conference concluded that "while energy problems could hamper attainment of key development objectives, if handled wisely, solutions to energy problems could contribute to meeting these objectives." Chapter Nine of Agenda 21 goes on to make a key statement on energy:

> "Much of the world's energy is currently produced and consumed in ways that could not be sustained if technology were to remain constant and if overall quantities were to increase substantially. The need to control atmospheric emissions and other gases and substances will increasingly need to be based on efficiency in energy production, transmission, distribution, and consumption, and on growing reliance on environmentally sound energy systems, particularly new and renewable sources of energy" (UNCED, 1993).

It is a call for the development of sustainable energy strategies to support sustainable development. The 1997 UNDP Report *Energy After Rio: Prospects and Challenges* (Reddy et al., 1997) takes up that challenge, and identifies the policy issues that make up the elements of any such strategy, and which provide the enabling environment for all stakeholders to play their part:

- Emphasise energy services
- Promote efficient markets
- Promote universal access to modern energy services
- Include external social costs in energy market decisions
- Accelerate the development and market penetration of sustainable energy technologies
- Promote indigenous capacity building
- Encourage broad participation of stakeholders in energy decision-making

With those policy goals in mind, the present report looks in detail at energy use and development in two important regions (both signatories to the Lomé Convention), Sub-Saharan Africa and Small Island Developing States, and identifies the challenges which must be addressed before effective sustainable energy strategies can be created and implemented. Illustrations of innovative projects show that there are proven alternatives, and the sections covering Ghana, Zimbabwe, Mali, Barbados, and Fiji describe in more detail the contribution that sustainable energy strategies could make to the development of those countries. Finally the wide array of proven renewable energy and energy efficiency mechanisms already available and appropriate for use in these regions is detailed, demonstrating that the technologies are ready, if only the policy environment nurtured them, instead of neglecting them or even providing disincentives.

THE NEED FOR ENERGY SYSTEMS WHICH CONTRIBUTE TO SUSTAINABLE DEVELOPMENT

The traditional methods of addressing energy problems in developing countries provide inadequate solutions. The unsustainable use of biomass is endangering the future availability of this energy source in many countries. The use of fossil fuels, which will necessarily continue to constitute an important part of energy supply for most developing countries, cannot simply be transferred from industrialised countries, where the conditions are completely different and adequate infrastructures have been in place for a long time, to countries that still have to emerge from underdevelopment. Fortunately, new technological solutions are available today, which, together with new insight into the essential requirements of development, may help to find the appropriate solutions.

"The traditional methods of addressing energy problems in developing countries provide inadequate solutions. Fortunately, new technological solutions are available today, which, together with new insight into the essential requirements of development, may help to find the appropriate solutions."

It is now clear that development, in order to be sustained over a long period of time, must not destroy the resources on which it depends. The objective of sustainable development is therefore not only economic growth: it is also social development, the eradication of poverty, improvement of health, conservation of natural resources, environmental protection, and a better quality of life.

In the field of energy, sustainability, rather than physical scarcity of resources, has become the main driver for change. Although it is possible in principle to give a precise definition of "sustainable energy" (Daly, 1991), this is of limited interest in the present context, because a transition to a fully sustainable system cannot be achieved in the short or medium term; moreover the conditions of sustainability should be respected globally, and not necessarily by each individual country. This is especially true for the poorest developing countries; many of the ACP countries contribute very little to global pollution and climate change but desperately need energy services for survival and sustainable development.

Sustainable development is made up of three equally important factors: *economic* development, *social* development, and protection of the *environment*.

THE ECONOMIC DIMENSION

Development does not need energy *per se*, but rather the services that energy can supply. Providing the same services with less energy, or more services with the same energy, is better for the environment and sustainability, and saves money. Only rarely can energy services and development be "decoupled", but the ratio between growth and energy consumption can be; it often costs less to invest in energy efficiency than to produce more energy.

"Development does not need energy per se, but rather the services that energy can supply."

This focus on energy *use* highlights the folly of planning energy in isolation. While energy is vital to industrial development, agriculture, social development, and health, for example, its role is not always acknowledged, and consequently the way in which the necessary energy is produced, distributed, and used is inadequately and unimaginatively planned. It is essential to identify all the energy components in projects which are not earmarked as energy projects, and to plan them according to the criteria of sustainability, including least cost over the *entire* life cycle.

THE SOCIAL DIMENSION

The *social* implications of the way in which energy is produced, delivered, and used (UNDP, 1995; Reddy et al., 1997) include links between energy and:

- demography and population growth;
- gender roles and the promotion of women;
- undernutrition and food;
- education;
- poverty and distribution of wealth;
- job creation and employment;
- investment and foreign exchange;
- urbanisation;
- water availability;
- land degradation, deforestation, and desertification; and
- national security and peace.

"The greater availability of commercial energy in cities is one of the driving forces behind urban migration. Supplying energy at reasonable prices to rural areas could contribute, along with other factors, to a decline in rates of urbanisation."

The availability of energy to provide water supply and sanitation or refrigerators for vaccines, for example, will have a great impact on health. Freeing rural people (usually women and children) from the daily routine of collecting fuelwood or carrying drinking water over long distances makes them available for more productive work or for education, both of which lead to future income opportunities and reduced population growth. Energy is just one aspect of development, and all other factors have to evolve concurrently. Some correlations between social improvement and energy availability tend to imply a cause-effect relationship which is often not a direct one.

Urbanisation is a key social trend in developing countries, and one in which energy is an important component. The greater availability of commercial energy in cities is one of the driving forces behind urban migration. Supplying energy at reasonable prices to rural areas could contribute, along with other factors, to a decline in rates of urbanisation.

Each of these connections deserves deeper analysis. However, the link between energy systems and social impacts depends very much on the particular context. Some specific examples will be given in Chapters 2 and 3.

THE ENVIRONMENTAL DIMENSION

The *environmental* effects of energy use are a heavy burden for developing countries, even when very little useful energy is actually produced or consumed. Acute environmental problems are widespread in developing countries; they cause severe health and economic problems, and degrade people's quality of life. Indoor air pollution from cooking with fuelwood or agricultural residues on primitive stoves in poorly ventilated dwellings is a major cause of respiratory, illnesses, eye problems, and burns, especially for women and children.

Despite the relatively small number of private vehicles, air quality in many of the large urban centres in developing countries is generally worse than in the metropolitan areas of industrialised countries because of the use of older cars and leaded fuel, and because of the burning of wood and charcoal using only basic technologies both for domestic needs (principally cooking and space-heating) and for energy generation in small businesses. Energy systems can pollute the soil and also the water through mining, burning, accidental oil-spills, and acid precipitation, for example. The serious indirect environmental effects of traditional energy systems include the depletion of wood resources, which contribute in some cases to deforestation and desertification, and which may endanger biodiversity.

Burning fossil fuels without adequate environmental controls is the main cause of acid precipitation, with regional (and transnational) consequences on agricultural productivity, the preservation of ecosystems and the quality of inland water bodies, and the conservation of buildings and structures. Although the ACP countries included in this report are less affected by acid precipitation than some developing countries in Asia and Latin America, some Central African countries and Pacific island states already have acidic soil and so are very sensitive.

Energy systems account for the largest share of anthropogenic emissions of greenhouse gases (GHG) which threaten the stability of the global climate. The potential effects of climate change on health have recently been analysed by the World Health Organization (Michael et al., 1996). Energy systems have been the focus of recent attention from the Intergovernmental Panel on Climate Change (IPCC), and the implementation of the Kyoto Protocol, which assigns legally binding emission reduction targets, will greatly influence the energy policies of its signatories who will have different responsibilities but a common goal. Furthermore, the Clean Development Mechanism, under the Kyoto Protocol, through which parties can meet part of their emission reduction targets by financing initiatives to reduce greenhouse gas emissions in developing countries, will help to lever financial support for sustainable energy development by providing additional benefits to investors.

It is particularly unfair that the ACP countries in this report, which contribute an almost negligible share of greenhouse gas emissions, are among the countries most likely to be affected by climate change: global warming could further reduce the agricultural productivity of the arid countries in Africa, while the ensuing sea-level rise, as well as the possible increasing number and intensity of typhoons during climate transition periods, will threaten small island states.

ERADICATION OF POVERTY

The eradication of poverty depends on the resolution of social, economic, and environmental problems. Development is happening in diverse ways and at very different speeds from country to country. Within each country, improvements in living standards are far from equal or homogeneous. And while some developing countries have achieved significant economic growth rates and impressive reductions in poverty, the process of development and globalisation has left other countries increasingly marginalised, with their already low living standards deteriorating further.

The countries specifically considered in this report, Sub-Saharan Africa and Small Island Developing States of Africa, the Caribbean, and the Pacific, include some of the poorest countries in the world. In Sub-Saharan African countries the per-capita GNP dropped by 18% between 1980 and 1995 (the GNP having increased 26%, but the population grew by 54% in the same period).

Moreover, most people in these countries live in rural areas and work in the agricultural sector, which adds to their difficulties. **Energy has very much to do with it.** "... two billion people live below the poverty line. For the poor, a better life first means... access to jobs, food, health services, education, housing, running water, sewage etc. In providing for these needs, energy is an important element... energy becomes an instrument for the eradication of poverty only when it is directed deliberately and specifically toward the needs of the poor." (Goldemberg and Johansson, 1995). The poor pay a disproportionate price for the energy services they use, and not just in monetary terms: "Poverty and scarcity of energy services go hand in hand, and exist in a synergistic relationship... The poor pay a much higher price for their energy services than any other group in society. The price can be measured in terms of time and labour, economics, health, and social inequity, particularly for women" (Batlivala, 1997).

"The poor pay a disproportionate price for the energy services they use, and not just in monetary terms."

Providing energy to the rural areas is a major challenge. "There are nearly two billion people without access to modern forms of energy, such as electricity and oil... Practical and affordable prescriptions are available. Biofuels [as used today, inefficiently] help trap the user in poverty. They can also damage people's health... In many countries, the number of people without electricity has risen more than the number of people connected to the grid" (World Bank, 1996).

CHALLENGES AND OPPORTUNITIES FOR THE DIFFUSION OF SUSTAINABLE ENERGY

In principle, the guidelines to creating sustainable energy systems are quite clear:

- improve efficiency of energy use;
- make more effective use and transformation of conventional fuels; and
- use renewable sources of energy more widely.

These goals are interconnected; it would be pointless, for instance, to produce expensive PV electricity and waste it on an incandescent lamp and, while improving the efficiency of electric appliances one would be well advised to look also at the efficiency of the power plant generating the electricity. These guidelines, while widely endorsed, have not yet been effectively used to transform the energy sector into an integrated, cross-cutting, demand-led tool for development because a large number of barriers have stood in the way. To stimulate this transformation, all stakeholders, but particularly policy-makers, must work together to overcome these barriers.

ENERGY PRICING, TAXES, AND SUBSIDIES

One of the most significant hindrances to change is the *subsidy* given by many governments to conventional forms of energy. Having recognised the importance of energy for development, many governments subsidise electricity or fuels so that their price to all or some of the final consumers is lower than the real cost of production and delivery. In many developing countries, energy prices and tariffs are already much lower than in industrialised countries, while the cost of producing and delivering the energy is by no means lower. This has the effect of both discouraging energy conservation by making interventions to increase efficiency artificially more expensive than the energy which is saved, and creating a barrier to the introduction of new forms of energy, renewables in particular, which are not equally subsidised. It has also been shown that this kind of incentive, originally meant to alleviate poverty, actually favours wealthier customers, who consume much more energy because they can afford to.

As in most industrialised countries, *externalities* are not reflected in the price of energy. Although there is no clear consensus on the way in which this "internalisation" should occur, and it is agreed that it would not be fair to expect developing countries to precede the North in this respect, it is clear that a gradual introduction of externalities would greatly improve the prospects of increased energy efficiency and of renewable energy sources.

INNOVATIVE FINANCING

Another difficulty inhibiting sustainable energy development, which to some extent is common to industrialised countries, is the *dispersion of interventions* in energy efficiency and decentralised energy generation, particularly where renewable sources are used. Very large supply-side projects (a gigawatt-sized hydroelectric or coal-fired plant) can find investment capital at much lower interest rates and longer return times than can hundreds of thousands of micro-hydro projects or wind installations of a few kW each, or diverse efficiency improvements. Banks and financing agencies are generally ill-equipped to manage a myriad of microprojects, so aggregation of demand is necessary if a "level playing field" is to be established among the different kinds of interventions.

Several ways of aggregating demand to overcome the dispersion barrier have been proposed and are being tested, some in ACP countries. One way is to create Energy Service Companies (ESCOs), examples of which are discussed in Box 2 of Chapter 2 for the Ivory Coast. Other approaches used in Africa are considered in Box 4. In the case of Jamaica (Box 21), the public electric utility has started a demand-side management (DSM) project, sharing the cost—and benefits—of energy efficiency measures with the customer.

"Banks and financing agencies are generally ill-equipped to manage a myriad of microprojects, so aggregation of demand is necessary."

INSTITUTIONAL, LEGISLATIVE, AND REGULATORY ENVIRONMENTS

Many more conditions important for introducing more sustainable energy systems have been identified. *Norms, regulations, and the institutional environment* itself are rarely adapted to innovations in the energy field. The process of generating electricity in a dispersed or decentralised way (often by renewable energy) is frequently discouraged by the difficulties of obtaining the required permits, for example, which may follow the same procedures as permits for plants that are a thousand times larger. Sometimes this also applies to energy generated to be consumed on-site, while selling electricity to other customers is often illegal, and provisions for selling it to the grid are technically difficult, bureaucratically cumbersome, and economically unrewarding.

Agricultural, land use, and forestry policies also present institutional difficulties. The state ownership of forests in many countries (as opposed to village ownership or private concessions) does not encourage sustainable forestry practices and rational exploitation.

INFORMATION

There is a *lack of information* available to the public and to existing and potential entrepreneurs about alternative energy sources and more efficient appliances and end-uses. Many solutions are unavailable because equipment is not being distributed by retailers due to the small size of the perceived market, through lack of awareness, or because of inertia (in the case of compact fluorescent lights, for example).

CAPACITY

Another challenge to be overcome is the *lack of skills*, not only for installation and maintenance, but also for marketing. There are many well known cases of projects financed by cooperation agencies which were technically and economically sound, but which were unsuccessful or even counter-productive because they were soon abandoned for lack of appropriate maintenance, unavailability of spare parts, or even ignorance about operational procedures. Where projects are successful, there needs to be the capacity to replicate and mainstream these successes.

STAKEHOLDERS AND THEIR ROLES IN SUSTAINABLE ENERGY DEVELOPMENT

THE ROLE OF THE GOVERNMENT

In the past, the role of the public sector in energy development was exercised in the form of direct action by the government or by agencies owned and controlled by the government. Today, the role of the public sector, both in industrialised and developing countries, is more to enable and direct market forces to become the driving force for change.

Levelling the Playing-Field

Removing the barriers that impede and slow the diffusion of effective sustainable energy initiatives is one of the main roles of governments, both central and local. It is the responsibility of the government to remove subsidies; to help set up schemes to finance mini and micro projects; to adapt norms and regulations to take account of emerging sustainable energy technologies; to adopt a more balanced and productive fiscal system in the energy field; to stimulate competition; and perhaps most importantly, to contribute to capacity building.

> **"Removing the barriers that impede and slow the diffusion of effective sustainable energy initiatives is one of the main roles of governments, both central and local."**

The barriers to sustainable energy development have been identified in the past, yet they are still in place. The reasons why may be different in the various contexts, but these should be identified and studied in each case. Development cooperation agencies can support governments working towards a policy environment which is more favourable for the diffusion of sustainable energy options under market forces by adapting general guidelines to suit specific circumstances (see p.8, The Role of Development Cooperation).

Introducing Sustainability into the Market

Effective as market forces are in optimising the allocation of resources for short and medium-term objectives, the market is known to be in most cases short-sighted, and it can fail to recognise long-term trends. As the World Bank (1996) puts it, "liberalising energy markets, however important, may not be the complete answer—private companies have shown little interest in extending electricity supplies to rural areas". Industrial and urban customers are more lucrative.

Governments may correct the myopia of the market by introducing signals, related to sustainability, that adjust the perspectives of market forces, and allow them to be used in the best way to obtain strategic objectives as well as tactical ones. Removing subsidies for conventional energy services is the first step. Accounting for externalities is another. Removing the normative, legislative, institutional, and information barriers is necessary to cure market imperfections.

Transition measures to help the penetration of sustainable energy technologies are generally necessary. Examples from industrialised countries include the Non-Fossil Fuel Obligation in the UK, the Renewables Portfolio Standard in the United States, a number of methods of dispatching and incentives in uptake prices for electricity generated by renewable sources in various European countries, and various types of incentives for energy-saving interventions. Experience has shown that these interventions are most effective when they make use of market mechanisms (such as through competitive bidding) and when they actually promote technology improvement (through planned decreases of subsidies with time).

Innovative approaches are possible. One receiving attention at the moment is the "concession approach" to renewable energy resources (starting with wind resources), which applies, with the necessary changes, the same criteria used for oil or gas concessions, through the exploration phases, the setting up of joint ventures, and the exploitation phase.

THE ROLE OF THE MARKET

The world-wide move toward increased reliance on market mechanisms has progressed during the last years. In the field of energy, it was not only in the so-called Centrally Planned Economies that governments played a direct and dominant role. Energy has always been seen as a strategic sector, crucial to international competitiveness, economic and social development, and national security, and one in which the most important decisions were taken by the government. State utilities for electricity, gas, and sometimes also coal and oil were instruments for implementing energy policy in many Western countries, such as France, Italy, and the United Kingdom.

This concept was gradually abandoned in many countries, as it was recognised that market mechanisms could perform the same tasks with greater efficiency. The introduction of elements of competition even in those sectors that were previously considered natural monopolies, such as electricity and gas, is required by the directives of the European Union, and is being gradually implemented by EU countries. The prices of oil products have been deregulated in most industrialised countries, the exploration and exploitation of oil and gas deposits are open to competition, and the process of liberalisation in this field has made great progress everywhere, including countries with economies in transition and China.

Progress is slower in many of the developing countries, however. Reservations about foreign interference through investments; preoccupations about the fragility of their economic systems; reluctance to abandon instruments of control; and the lack of local capital to start energy enterprises have contributed to the delay of the transition to free market mechanisms in most developing countries.

Financing institutions feel that the development of sustainable energy would greatly benefit from market and competitive forces. The World Bank states that "one of the most powerful ways to improve energy supply is to ensure that the energy market is determined by consumers' choices... that means both that the price of energy should reflect its cost and that regulation of energy industries should encourage competition and choice" (World Bank, 1996).

The European Union also encourages the introduction of market elements in all fields in its programme of aid to ACP countries, both in terms of support for structural adjustment (including structural reforms and sectoral policies), and in taking into account the "performance" for countries, including the creation of an environment more favourable to the success of the project, in prioritising the allocation of funds (European Commission, 1996).

THE ROLE OF THE NON-COMMERCIAL ENERGY SECTOR

In rural areas of less developed countries, the economy is often mainly informal, there is little access to the commercial resources available in urban environments and, for the most part, people rely on non-commercial energy.

In the short term, improving sustainability means improving methods of using traditional energy sources, such as fuelwood and animal traction, through sustainable forest management, improved cooking stoves, better ox harnesses, etc. Experience has shown that the successful introduction of new methods of using traditional fuels can be an extremely complicated and painstaking task, and requires full community participation. Often communities have themselves already introduced more sustainable fuel use practices in response to their changing environment.

Nevertheless, possibilities already exist for the early introduction of more effective forms of commercial energy. Some poor families spend a significant portion of their disposable income on wood or charcoal (Kammen, 1995). (See also the case of Uganda in Box 5 of Chapter 2). In the long run, buying candles, or kerosene to operate inefficient lamps, or travelling regularly to a nearby city to have batteries charged, is more expensive, even in monetary terms, than paying instalments for a small PV system to perform the same services. Transforming upfront costs into dispersed paybacks requires innovative financing schemes which are discussed further in other parts of this report and which constitute one possible target area for development cooperation.

It is certainly advisable to start the introduction of new energy alternatives where there is at least a primitive monetary market for them. It should be kept in mind that this introduction is most effective where it can generate a "virtuous circle", especially by facilitating income-generating activities directly, such as small business enterprises, and by improving social conditions, notably education and health. In the longer term, the less direct effects of energy availability will become apparent, such as those on demography, wealth distribution, gender roles, and helping to create a possible escape route from the downward spiral of extreme poverty.

"The introduction of new energy alternatives is most effective where it can generate a 'virtuous circle' by facilitating income-generating activities and by improving social conditions."

THE ROLE OF DEVELOPMENT COOPERATION

Institutions providing development finance, and particularly international development banks, already allocate a significant proportion of their funds to energy programmes—some data on Official Development Assistance (ODA) financing of sustainable energy is presented in Annex I. The challenge is to mainstream lending for more sustainable energy solutions, rather than the existing conventional supply-oriented projects, and to use grant financing effectively to help create the conditions which will encourage the uptake of sustainable energy options through market forces. Critically, there remains a role for development cooperation in the non-commercial energy sector, where the poorest people serve their energy needs through practices which only compound an already disadvantaged position—threatening their own health and sometimes that of their surrounding environment.

To date, most renewable energy or energy efficiency projects have been implemented in isolation. They are useful where they demonstrate that a particular technology works, but they do not provide the full picture by any means. In most cases, such projects are technically replicable but do not find the necessary conditions for diffusion and dissemination; are not followed up by specific dissemination projects; and are not located in appropriate environments or institutions to enable diffusion.

Given the limited impact of these sorts of projects and the scale of the challenge ahead (especially in Sub-Saharan Africa) it is therefore important to devote more attention to projects that aim to create an enabling environment that favours the diffusion of sustainable energy solutions by market forces and by private initiative. Among other things, such projects may identify and remove institutional barriers; create local structures to supply energy services or to market improved equipment in both urban and rural areas; and build capacity at all levels.

Development cooperation agencies can effectively support governments working to improve this enabling environment by adapting general guidelines to fit specific circumstances. Experimenting with innovative organisational, institutional, financial, or regulatory solutions is at least as important as testing new technologies, and possibly more useful; and projects in this field should be encouraged. More precise suggestions are contained in the regional and country studies.

"It is important to devote more attention to projects that aim to create an enabling environment that favours the diffusion of sustainable energy solutions by market forces and by private initiative."

In the non-commercial energy sector, the most effective results can be achieved in the short-term by improving methods of using traditional energy sources, through for example improved cookstoves and sustainable forest management practices. These sorts of initiatives must respect the essential condition of full community participation from the first stages of project conception, otherwise they will only add to the long list of past well-intentioned failures.

As a guiding principle, aid-to-development projects should originate in a decision by a recipient institution and a cooperation institution to work together. Donor-driven initiatives are rarely successful. Development assistance will only work where there is a commitment shared by all of the partners (OECD-DAC, 1996).

Although the agreement, participation, and commitment of the authorities of the developing country concerned are necessary for the success of any project, central governments are by no means the only partners in development projects. Local authorities, private sector owners and entrepreneurs, and non-governmental organisations play a growing role in energy projects and often provide the key to their diffusion. Seeking partnerships between public and private organisations in developing countries can be an appropriate solution.

Greater coordination and synergy between the programmes promoted by different agencies (North–North cooperation) is important to ensure that sustainable energy projects are not conceived and carried out in isolation, but are rather parts of a common strategy. Consultation mechanisms among these agencies should be encouraged, but the role of the developing countries in this process should still be paramount.

The influence of industrialised countries on the rate and quality of development in Third World countries goes far beyond aid-to-development policies. Decisions about trade barriers, about environmental, sanitary, and other restrictions on imports, or on policies designed to encourage trade and investment flows and technology transfers can contribute to development objectives in the energy field as well.

South–South cooperation is essential, especially at a regional level. Some particular opportunities have been identified, such as large-scale hydro projects serving more than one country, or natural gas deposits that could be distributed regionally. The coordination of national energy policies at the regional level would also have significant benefits.

A particularly important special case of sub-regional cooperation in Africa is the potential role of the Republic of South Africa, which, in its new political situation, could be a hub for the development of the sub-region, in particular on sustainable energy matters.

EMERGING VISIONS OF ENERGY AND SUSTAINABLE DEVELOPMENT

AN HISTORICAL OVERVIEW

Throughout the history of humankind, energy has shaped development. Each major economic and social change has been accompanied by the discovery, the availability, or the exploitation of new energy sources. Although it would be reductive to write the history of development in terms of energy, the importance of energy in changing society cannot be overestimated. The first use of fire enabled humans to cook and conserve food, and provided heat and light. This change extended the human habitat, encouraged organised, cooperative hunting, and induced a more complex and stable social organisation. Some ten thousand years ago, the exploitation of animal power was an essential component of the advent of agriculture and of the ensuing stable settlements, with all their social and cultural consequences. During the Renaissance, the use of wind for navigation greatly expanded the scope of economic and cultural exchanges.

The European industrial revolution at the beginning of the 19th Century was made possible by the use of hydropower and coal as an energy source. This revolution was limited to countries with large coal reserves (such as the United Kingdom and Germany) and, due to the difficulty and cost of transporting coal, large cities were born in the vicinity of the major coal deposits. The rebirth of the economy in the industrialised countries after the second World War was made possible, and at the same time deeply conditioned by, the availability of oil: an abundant, flexible, easy to transport, and most of the time cheap, energy source.

Today, industrialised countries are on the verge of another deep change: the environmental and climatic effects of using fossil fuels at current or increased rates are unacceptable, and are adversely affecting the environment at the local, regional, and global level. The commitments enshrined in the Kyoto Protocol in December 1997, which were agreed by the industrialised countries (who are the main energy consumers and pollution producers), are a first step in the direction of a radical change which will involve not only energy systems, but also the whole approach to production processes, minimising energy and material inputs, and maximising the recycle and life-cycle analysis of products.

THE SITUATION IN DEVELOPING COUNTRIES

The situation is quite different for developing countries. A few are now undergoing a process of industrialisation, and others have achieved rapid economic growth by supplying low-cost labour to labour-intense segments of the industries (often high-tech based) of industrialised countries. Many countries, however, are pre-industrial, and their main energy source is the traditional use of biomass, mostly wood and agricultural and livestock residues. Very little of this energy is supplied commercially.

With one billion people living on less than US$1 per day, two billion people without access to modern fuels or electricity, and hundreds of millions of women and children spending hours every day to collect fuelwood carry water, there is no doubt that development, and particularly the alleviation of poverty, are the main aims in the South.

None of the existing energy solutions can entirely solve these problems. Existing traditional systems do not provide the energy services that are needed, and they can create severe environmental problems such as indoor and urban pollution; contribute in some areas to deforestation and land degradation; and endanger water resources. The fossil fuel based systems of industrialised countries are often too expensive and resource-consuming to suit most developing countries, and they depend on costly infrastructure that has been built over time in the North.

The UNDP report *Energy as an Instrument of Socio-Economic Development* (UNDP, 1995) makes it clear that energy policies are an instrument which can be used both to promote sustainable development and to achieve integrated development goals. By making the right choices and creating favourable conditions for sustainable energy in these countries, powerful support is created for the development process.

"Energy policies are an instrument which can be used both to promote sustainable development and to achieve integrated development goals."

Although the process of globalisation and the growth of the international media has made everyone aware of the contribution of modern energy systems to affluent societies, only scraps of these systems (or the energy that they generate) are actually available in the poorest countries or among the poorer strata of population in all developing countries.

One relevant example is the so-called Green Revolution, which has made several countries in Asia and South America self-sufficient for food, or even net exporters, despite rapid increases in population. The methods used, however, needed much more energy than traditional methods (for irrigation, mechanisation, post-harvest technologies, and especially for nitrogen fertilisers), and in some cases have been accused of having negative impacts on land conservation, biological diversity, and the environment in general. Moreover, the Green Revolution has barely touched Africa, which has the greatest food deficits.

Making affordable and dependable energy services available to the poorest countries and to those on low incomes is one way to help them to develop in a sustainable way.

The Global Transition

The size and difficulty of the problem would be grossly underestimated if one did not take into account that we are also in a period of extremely rapid transition. The most striking aspect of this transition is demographic growth, which originated in a sharp decline in mortality rates, and will likely be followed only after a great delay by a corresponding decrease in birth rates. The same thing happened in 19th Century Europe, but not on such a large scale, involving most of the world, nor so rapidly. For the first time, the doubling time of the global population has become shorter than the average human lifespan, and has even come close to generation time (i.e. the average age difference between parents and their children). Although population growth has begun to ease in most developing countries, indicating that stabilisation could be reached in the second half of the next century, this has not yet happened in Sub-Saharan African countries, where growth rates are the highest in the world (see p.24, The Regional Context).

Other global indicators have changed at similar or even greater speed than population growth, among them the consumption of finite resources and the emission of pollutants into the environment, driven not only by the increase in population but also by its increasing affluence, particularly in the industrialised countries. Again, for the first time in history, the effects of human activities on the global environment are no longer negligible with respect to the effects of natural phenomena.

It is only by compounding the difficulties intrinsic in energy provision with the depth and speed of the transition which is taking place that one can fully appreciate the magnitude of the challenge in front of us. We shall see in Chapter 2 (p. 19), for example, how even a supreme effort may not be enough to avoid a situation where in the next twenty or thirty years even more urban dwellers in Sub-Saharan Africa will be without access to modern energy services.

The changes taking place in the cultural domain are just as intense. The number of "cultural objects" (which in anthropological terms constitutes a measurement of cultural wealth, in lieu of considerations of value) increases with a doubling time comparable with, or shorter than, generation time: for the first time, on the global scale, acquired new knowledge has become prevalent over accumulated knowledge transmitted from one generation to the next.

Sustainable Energy on the International Scene

Being a horizontal factor, energy was not singled out as a separate subject in the discussions of the United Nations Conference on Environment and Development in Rio de Janeiro in 1992, but it was reflected in the ensuing Agenda 21, where references to energy were made in several different chapters (most notably in Chapter 9 on atmospheric pollution). Energy has acquired an increasing focus in the work of the UN Commission on Sustainable Development and a key position within the work of the Framework Convention on Climate Change. Also, in the consideration of energy issues at the United Nations General Assembly Special Session on sustainable development, held in June 1997 (UNGASS, 1997), it was agreed to devote the 2001 session of the Commission on Sustainable Development (CSD 9) to energy and transport problems.

Energy has been considered either explicitly or among other economic and social activities in all the major UN Conferences since Rio: the UN Conference on Population and Development (Cairo—1994), the Global Conference on Sustainable Development in Small Island Developing States (Barbados—1994), the Social Summit Programme of Action (Copenhagen—1995), the Fourth World Conference on Women and Development (Beijing—1995), and the UN Conference on Human Settlement HABITAT II (Istanbul—1996). These conferences, each from its own particular angle, have shared a common vision of sustainable development and have dealt with energy and its impacts on sustainability. They have consistently called for increased energy efficiency, the dissemination of renewable energy technologies, technology transfer, and legislative and institutional change to create an "enabling environment" for sustainable energy. The positions which emerged through these important events concerning the role of energy for sustainable development are analysed in some detail in the UNDP report *Energy After Rio: Prospects and Challenges* (Reddy et al., 1997).

In the past, institutions providing development finance have allocated a significant proportion of their funds to energy programmes, both through loans and, to a lesser extent, grant finance. While bilateral and multilateral grant financing has increasingly targeted sustainable energy initiatives, soft loan assistance remains supply-side dominated (see Annex I). Between 1993 and 1997, The World Bank, Asian Development Bank, African Development Bank, Interamerican Development Bank, and European Investment Bank together provided around US$6 billion annually in finance to the energy sector, of which around 3% was in support of sustainable energy projects. The picture is much the same for the energy sector lending of bilateral soft loan institutions. However, the improving viability of sustainable energy technologies and an increased awareness of environmental concerns has prompted development finance institutions to launch a number of in-house initiatives and to intensify technical support in order to increase lending for sustainable energy projects.

Although grant funded activities benefit from lower levels of financial support—in 1996 the 15 EU Member States and Canada, Japan, and the United States provided US$810 million in grant financing for all energy sector assistance—these are increasingly used to support sustainable energy initiatives. The retrofitting and rehabilitation of conventional power plants, energy efficiency, promotion of renewable energy and capacity building have become common features of bilateral cooperation programmes. Where previously energy initiatives were usually funded through a sectoral approach, energy activities now increasingly aim to address over-reaching development goals, such as the eradication of poverty, sustainable development, and protection of the environment. Indeed much experience with renewable technologies has been gained where these have formed component parts of projects in "non-energy" areas, e.g. in providing energy services for rural health clinics. Another significant source of financing for sustainable energy is the Global Environment Facility, which, since its inception in 1991, has provided US$280 million in support of renewable energy projects and US$190 million in support of energy efficiency projects.

"The retrofitting and rehabilitation of conventional power plants, energy efficiency, promotion of renewable energy, and capacity building have become common features of bilateral cooperation programmes."

Unfortunately the lack of a coordinated and coherent approach among the international development community has limited the effectiveness of assistance in the past, and has sometimes hindered the emergence of fragile new markets.

SUSTAINABLE ENERGY TECHNOLOGIES

There are three main components of a sustainable energy system:

- Improved efficiency of energy end-uses
- More efficient use and transformation of fossil fuels
- Development and diffusion of renewable energy technologies

Many sustainable energy technologies are already in use. Some of them are used in industrialised countries, but not in developing countries. Others have been adopted in some developing countries, but not in others. These technologies could be used much more widely in developing countries, but are being held back by a number of barriers and by the need to adapt them to the particular conditions of each country or region.

ENERGY RESEARCH AND DEVELOPMENT

Ongoing research and development (R&D) on sustainable energy technologies is needed to find new solutions, develop better ways to apply them, and improve their economics and performance in order to facilitate their diffusion. Most of the current R&D in this field is carried out in industrialised countries. *Public spending in energy R&D* has decreased almost everywhere during the last decade, as a consequence of both tighter budgets and the gradual privatisation of the energy sector. This decrease has not been compensated for by an increase in *private spending* (except in a few cases). Tariff regulation of the electricity and gas industry, intended to enhance competition, has discouraged investments in R&D. The overall result is not only a decrease in energy R&D, but also a concentration on short-term objectives of immediate interest to industry.

Developing countries should devise plans to conduct research in this field, especially research of direct interest to the

South, such as adapting energy technologies to developing country conditions. In the early 1990s the United Nations Secretariat together with the UN University and a number of national institutions had prepared a plan to set up a number of *energy R&D centres of excellence* in developing countries. In addition to straightforward R&D, these centres would support the harmonisation of standards, survey demonstration projects, and provide training and capacity building. The plan was studied by the UN Secretariat and considered by the World Bank; it has never come to fruition, but should perhaps be revived in light of the present circumstances.

The development and improvement of sustainable energy technologies has been ongoing, and although there have been no major breakthroughs, the accumulated incremental progress in some areas has changed the situation significantly in several sectors.

SUPPLY-SIDE TECHNOLOGIES

The progress in power generation has been outstanding, not only in increasing efficiency, but also in improving the economics and flexibility, and in reducing the unit size of plants.

To single out a few notable results, gas-fuelled *dual cycle* power stations have reached efficiencies of 60% at an overall cost of about 350 ECU/kW, a result which was unheard of ten years ago. The introduction of aeroderivative gas turbines for stationary applications, as well as development of heat resistant materials and improved cooling of blades, have helped in reaching this target. *Combined heat and power generation* (CHP) is progressing, bolstered by the liberalisation of the energy market and the diffusion of independent power producers. High efficiency small-scale CHP systems are now available.

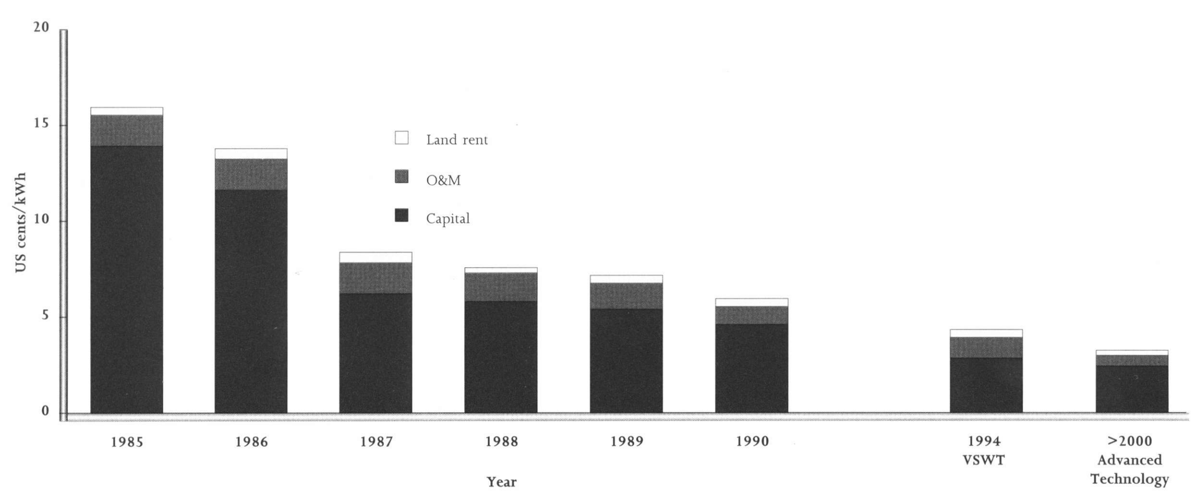
The end of the Cold War has made some previously classified military technologies available for civilian applications. Among those of interest for energy applications are simple, inexpensive, and efficient small gas turbines, which could, for example, be coupled with biomass gasifiers to provide *microgeneration* units. These innovations are particularly significant for developing countries and in particular for rural electrification.

The next step toward microgeneration will probably be the introduction of the *fuel cell* for power generation. The substantial cost reduction expected from technological improvements as well as from mass production (especially if use penetrates the transport sector) could make the fuel cell the preferred solution for small-scale power generation and CHP. The modular nature of the fuel cell makes its cost per unit of power almost independent of the size of the plant.

Progress has been made in techniques to explore and exploit *oil and gas fields*, both inland and off-shore, including advanced prospecting methods, horizontal drilling, the transport of two-phase mixtures and field stimulation technologies. Progress also occurred in refinery technology (including the gasification of tars); in the transportation of gas and oil (such as underwater pipelines); and in techniques to deal with oil spills.

Progress has been slower in the *gasification of coal*, an important technology for the cleaner and more effective use of coal through dual cycle power production. The technology exists and is tested, but its appeal is limited in this market because of its high cost compared with conventional methods. Nonetheless, the gasification of coal does have great potential: oxygen-blown

Figure 1. Recent Trends in the Cost of Electricity from Wind



Wind power costs for the period 1985-1990 are based on the actual experience with wind farms in California.
The cost shown for 1994 is for a new variable-speed wind turbine (VSWT) that went into commercial service in 1994; this cost is about the same as for electricity from a new cool steam-electric plant. For the period beyond 2000, the cost reflects expectations about improvements that could be realized over the next decade.
Source: (Johansson et al., 1993)

gasification yields a stream of pure CO_2 which can be used in chemical production and it can be used to enhance or maximise the recovery from gas and oil fields and the production of coal-bed methane, or simply sequestered in aquifers. The "syngas" produced from oxygen-blown gasification can be transformed into liquid fuels for transport, or converted to hydrogen, an ideal fuel for use in scattered locations because it yields only water on combustion, and also the best fuel for high-efficiency fuel cells.

Renewable energy technologies are improving, but more slowly than expected. The cost of manufacturing PV cells is decreasing and their efficiency is increasing; a new, cheaper PV device may be forthcoming with the adoption of thin film technologies. Larger units (2-3MW) as well as off-shore plants are under experimentation. Wind generators have grown in size and are now very reliable, and the large and growing number of units deployed in industrialised countries has significantly reduced the cost of electricity generation from wind (See Figure 1), and helps to build a sound basis for applications in developing countries as well. The use of biomass in both direct combustion and gasification is also being developed, but less work has gone into the production of liquid fuels from biomass, in particular through hydrolysis. The availability of cheap and abundant oil has probably discouraged this line of investigation, as well as that of coal liquefaction. Techniques based on the co-combustion of coal and wastes of various origins are gaining ground.

The gasification of coal and/or biomass on a whole range of different scales—and in particular at the village level—may act as a transition to a more modern energy sector by supplying fuel for cooking, for ambient and process heating, and for local power generation. Demonstration projects are under way in several countries, including China and Brazil.

END-USE TECHNOLOGIES

Technologies leading to *improved energy efficiency* are also progressing. The innovations are often driven by goals other than energy saving, such as cost or flexibility of industrial production, but the result often includes energy and environmental improvements. Very often the rate of efficiency achieved is still far from the theoretical limits.

To name just a few fields in which substantial progress has been made, as concerns industry, emerging technologies include separation by means of semi-permeable membranes, extraction by means of supercritical CO_2, drying by means of heat pumps, and selective heating by microwaves. Digitally controlled electric motors deliver higher efficiency in variable speed operations.

In the field of agriculture, direct energy consumption has been reduced not only in the field (including greenhouses) and in post-harvest operations, but also, and perhaps more importantly, indirect energy consumption through fertilisers and pesticides has been reduced through plant breeding or better information for the farmer, and this has had positive knock-on effects on the environment.

New building materials and components are now on the market in the construction sector, including transparent insulators, glasses with variable transparency, and materials that store heat. Improved designs reduce the energy required for heating, cooling, ventilation, and lighting by using the properties inherent in natural materials. Household appliances are also benefiting from continuous improvements and some basic innovations.

In the transport sector, vehicles of all types could run more efficiently. New types of vehicles, such as electric and hybrid vehicles (including electric bicycles and scooters), are already being used for special applications, and may become more widely diffused in the future. Great progress has been made in the last few years in increasing the specific power and reducing the cost of the polymer membrane in fuel cells, which may soon power vehicles of all kinds, as they have twice the efficiency of existing engines and virtually no emissions. They may be expensive now, but with mass production there is no reason why the cost of a fuel cell vehicle should not come down in a few years to the level of conventional vehicles. R&D will continue to improve traffic systems, especially through the use of information and communication technologies. A modal shift (from private road transport to public and rail) must happen to reduce fuel consumption and pollution, but there are many obstacles in the way. Energy consumption in the transport sector in developing countries is still a tiny fraction of overall consumption (especially as compared to industrialised countries), but it could expand very rapidly in countries with high economic growth rates, as happened in Europe in the 1950s and 1960s. Traffic pollution is already very significant in many cities of developing countries, and the problem is receiving increased attention.

Research on the links between energy use, environmental degradation, and climate change, as well as on the effects of pollution on health, are other important components of energy-related R&D. Social research into both the connections between energy systems and social structures, and customer attitudes to new energy systems, has only recently begun to get the attention it deserves.

THE RIGHT TECHNOLOGIES FOR DEVELOPING COUNTRIES

THE CONCEPT OF "APPROPRIATE TECHNOLOGIES"

Much debate has occurred about the choice of "appropriate technologies" for developing countries. Originally, the concept of "appropriate" applied only to simple technologies that had been developed locally, but the concept has moved on considerably since then.

Developing countries have sometimes criticised cooperation projects that they felt were mainly designed to test advanced technologies which had not found applications in their countries of origin and which, in some cases, proved to be too complicated, unsuitable or uneconomic. This criticism contains an element of truth in those cases where insufficient attention was paid to the adaptation of technologies to the actual conditions of the country, site or context of application.

However, although some energy technologies can be based on local knowledge, many energy technologies which can contribute to sustainable development are advanced and sophisticated, or at least contain some high-tech components which are not available universally. Even mature technologies, such as large-scale hydroelectricity, need "accessory knowledge", ranging from organisational methods for large works to the maintenance of construction equipment, and from the training of personnel to quality control and commissioning procedures.

Technology choice will be successful when it is carried out in a broad context, taking into account the general energy policy of the country; the priorities and forms of economic development; the social, natural, environmental, and cultural characteristics of the country or region for which it is meant; and the geographic and climatic conditions of the site. These factors are now being included in the selection criteria of many grant-giving and lending cooperation agencies, including UNDP, the World Bank, and the European Commission.

TECHNOLOGY TRANSFER AND ADAPTATION

Most advanced energy technologies have been developed and are available only in industrialised countries, and fit the requirements and specifications of these countries. While *adaptation* of the technology to the particular needs and conditions of the receiving country is necessary, it is not always enough to ensure adoption. Adaptation must be carried out largely by the receiving country itself, and the technology must fulfil an identified need: it must be the result of a "market pull", not a "technology push." Developing countries should build the capability to assess technology comprehensively.

"Adaptation of technology must be carried out largely by the receiving country itself, and must be the result of a 'market pull', not a 'technology push'."

One negative aspect of some energy technology transfers has been the limitation of the transfer to some intermediate phase of the process, generally manufacturing. This transfer will have little scope to evolve if it is not accompanied by system design, system assembly, operation, maintenance, servicing, and infrastructure arrangements. Marketing and financing are other key factors affecting the successful diffusion of a technology. It has generally proved to be more effective to start at the downstream, application end, of the technology and proceed upstream rather than vice-versa.

Giving due attention to locally developed traditional technologies is usually rewarding. These technologies have often passed through a long process of adaptation to local conditions, and they may respond to specific needs that are not easy to identify. In some cases they may be inefficient and uncompetitive, but they may also have the potential to be greatly improved.

"Giving due attention to locally developed traditional technologies is usually rewarding."

"Blending" new advanced technologies into traditional systems may provide solutions which, while respecting local conditions and adapting to actual needs, are effective, economical, and will spread the way some large earth dams and improved stoves have. A further penetration of new technologies may involve the use of advanced materials in traditional ways of producing or using energy. Genetically engineered (and environmentally sound) bacteria can be introduced into a traditional biochemical process, such as the production of alcohol or biogas by fermentation. Electronic control could improve performance and ease the operation and maintenance of a traditional process, perhaps by controlling the temperature and humidity in a solar- or biomass-fuelled drier. It is not necessary for the operator to be familiar with the internal mechanism of this type of "black box" technology, provided its functions are well understood. Modern computer-aided design methods have improved the performance of traditional hearths. Gas turbines cannot be designed or manufactured everywhere, but many developing countries maintain jet or turbo-propelled planes, and can do the same for power plants employing aeroderivative gas turbines.

"LEAPFROGGING"

Technology choice for developing countries can sometimes benefit from *"leapfrogging"*, that is the adoption of an advanced technology, sometimes not yet widely adopted in industrialised countries, without going through the intermediate steps of its development. The concept of leapfrogging has aroused some controversy and should be carefully screened on a case-by-case basis. Although it is quite obvious that one should consider the availability of satisfactory locally developed solutions to a given problem before looking for very advanced technology-based solutions, it is equally obvious that it would make no sense for a developing country to repeat the development process of a technology that has already taken place in industrialised countries: no business starting to manufacture computers today would consider passing through the development of tube computers, transistors, and integrated circuits before adopting microchips.

However, leapfrogging involves looking for solutions that are not yet fully adopted by industrialised countries, but which may prove to be more appropriate for developing countries. There are many possible reasons for such an approach. The first is the absence, in many developing countries, of infrastructure that is universal in industrialised countries. A new telephone system for a sparsely inhabited country would use cellular phones (or even satellite phones) and radio links rather than a wired network, which is the backbone of all telephone systems in industrialised countries. Similarly, in the absence of an electricity grid, local generation may well be the most appropriate and economical way forward for electrification.

A related element that also favours leapfrogging is the absence of previous investments, in terms of both money and accumulated experience. Some technologies are used today in industrialised countries instead of more effective ones because of the great amount of money that went into building plants and purchasing equipment, and because of accumulated knowledge. A country starting from scratch might choose alternative technologies that are more effective and perhaps less capital-intensive than those commonly used in industrialised countries, where existing technologies are simply too expensive to abandon.

Finally, relatively new technologies may be used where the market for particular goods is expanding rapidly in developing countries, while it is stationary or shrinking in industrialised countries. One obvious example is steel-making; virtually no new steel-making plant has been commissioned in industrialised countries in the last decade, as steel consumption is slowly decreasing, while several new plants are set up every year in developing countries. New steel-making technologies have been developed up to the pilot scale that consume less energy and need less investment, but have not yet been applied on a full-scale plant; this may be an important opportunity for developing countries (and is actually being considered by China).

THE PRESENT SITUATION

ENERGY PRODUCTION AND CONSUMPTION

Until less than a decade ago the main preoccupation concerning energy was its availability. The physical exhaustion of the reserves of fossil fuels, especially oil, was thought to be looming in the near future, if not imminent. Today, the estimated resources of all fossil fuels are actually larger than they were twenty years ago—and much larger in the case of natural gas.

Energy is part of the globalisation of economies, and an increasing amount of energy resources are being traded across national borders. Temporary disruptions of the market are still thought possible, and there is some perceived scarcity of investments in exploitation of known oil fields and in infrastructures for transporting methane. The main emphasis in the energy problematique, however, is on how to make the required amount and type of energy necessary for development available within the financial constraints and without endangering the environment and the stability of global climate.

Between 1980 and 1995, global *commercial energy consumption* (all following data from European Commission, 1997) increased from 7021 million tonnes of oil equivalent (Mtoe)[1] to 8852 Mtoe—a rise of 26%. This growth was very uneven, however: an increase of 18.3% in Organisation for Economic Cooperation and Development (OECD) countries; a decrease of 21.7% in the countries of central and Eastern Europe and in the former Soviet Union (due to the economic crisis); an increase of 108% in non-OECD Asia (including Middle Eastern countries); and increases of 43% and 61% in Latin America and Africa respectively. It is perhaps even more instructive to look at per capita energy consumption: between 1980 and 1995 this remained constant in Africa at a level of 0.50 tonnes of oil equivalent (toe)/person/ per year against a world average of 1.56. In Sub-Saharan Africa the figure dropped from 0.465 to 0.456 because of massive population growth, while in China and India consumption leapt from 0.54 to 0.83 and 0.21 to 0.33 toe/person/per year respectively. Differences in rates of development are thus reflected in per capita energy use. More detailed data for the ACP regions of interest to the present study are given in Chapters 2 and 3.

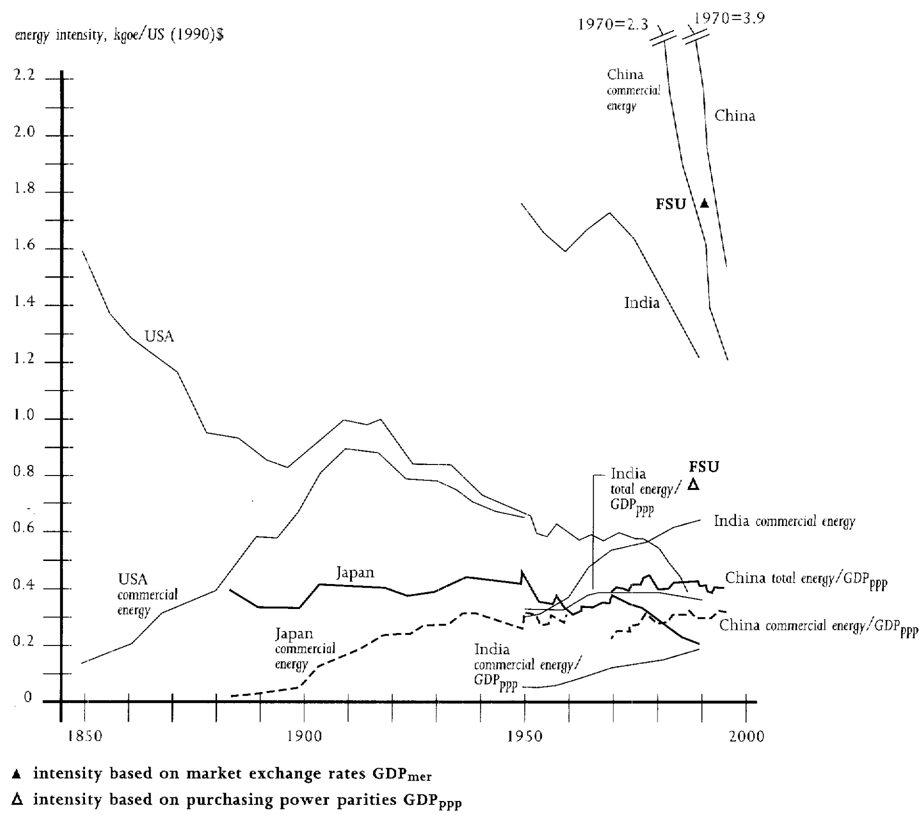
ENERGY INTENSITY

National energy intensity, defined as the ratio between commercial energy consumption and the gross national product in a given country, is a measure of the efficiency of energy use as well as of economic structure. But it can only be used as a meaningful indicator (after correcting for climatic and other differences) to compare two countries if they are at similar stages of development. The reason is that in the first phases of development, and during the industrialisation process in particular, energy intensity tends to be significantly higher than in fully industrialised countries, since production is concentrated on infrastructures and on instrumental goods, which have a high energy content, and on providing durable goods to the population for the first time. At global level, increases in manufacturing output have outpaced increases in energy consumption: correspondingly, energy intensity has decreased from 539 toe/ MECU (million ECU) (1985 rates) in 1980 to 477 in 1995 (-11.5%). Data are very different from one region to another, however. The energy intensity in the same period has decreased by 17.1% from 291 to 241 toe/MECU (1985 rates) in the European Union and from 550 to 446 in North America (-18.9%), but it has increased from 1923 to 2349 toe/MECU (1985 rates) in the former Soviet Union, where the breakdown of the economy has been greater than the growth in energy consumption (and where the extremely high values point to chronic inefficiency). In developing countries, energy intensity has dropped from 1469 to 1066 toe/MECU(1985) in Asia, but it has increased from 770 to 997 in Africa, and from 463 to 511 in Latin America.

Although this data should be taken with many reservations (both because it does not take into account non-commercial energy and because the evaluation of GNP is not easy in countries where the currency is not convertible), a related indicator should be considered carefully. As described earlier, the com-

1. One tonne of oil equivalent (toe) corresponds to 107 kilocalories, or 41.86x109 joules

Figure 2: Primary Energy Intensity for Selected Countries including Former Soviet Union (FSU), total (solid lines) and commercial energy (dashed lines), in kgoe, per GDP, in US (1990)$.



Sources: (Nakicenovic, 1987); (Martin, 1988); (TERI, 1994)

mercial energy intensity of a country generally increases during the development and industrialisation process; it then reaches a peak and decreases as demand shifts toward less energy- and material-intensive goods, toward quality rather than quantity, and toward services and software rather than hardware. The later in time a country undergoes the industrialisation process, the lower is its peak value of energy intensity, because more advanced and efficient technologies are available to them than were available to countries that industrialised earlier.

The historical curves of energy intensity for the present OECD countries all confirm this law, with Japan and Italy, which were the last to overcome peaks, having the lowest values (Bosseboeuf, 1998). Worryingly, however, many developing countries that have not yet reached their peak of energy intensity already have values that are higher than those ever reached by Italy, Japan, or France (See Figure 2). The reason is that in many cases the modern, efficient technologies that would lead to reduced energy intensity are simply not made available to these countries.

Several different scenarios have been proposed for the evolution of the energy situation at global level. Trends for the next five to seven years, taking into account the expected government interventions to comply with the Kyoto Protocol, are predictable with a modest uncertainty (European Commission, 1997). Longer term predictions are subject to much greater uncertainties, as they involve energy policy decisions that will be taken in the future. It is more appropriate to speak of "scenarios", that is self-consistent pictures of a possible future that are expected to materialise if certain conditions (both natural and political) are met.

FROM GENERICS TO SPECIFIC SITUATIONS

The content of this Chapter is of a general nature, and although it applies broadly to the situations in many different developing countries, its considerations will take up different aspects in different situations. The rest of this report deals with how such considerations are manifested in the more particular contexts of two specific regions: Sub-Saharan Africa in Chapter 2 and ACP Small Island Developing States in Chapter 3. The context under discussion will be further refined to the specific situations of the Country Studies: Ghana, Mali and Zimbabwe in Chapter 2; and Barbados and Fiji in Chapter 3.

CHAPTER 2 - THE SUB-SAHARAN AFRICA REGION

Figure 3. The Sub-Saharan Africa Region

CHAPTER 2 THE SUB-SAHARAN AFRICA REGION

INTRODUCTION

Promoting sustainable development in Sub-Saharan Africa is a challenge for which there are no easy solutions. The region still strives to satisfy many of its fundamental needs, and the task of extending even the most basic services to all members of society is daunting in the face of the highest population growth rates in the world. Energy services might, at first sight, appear to be of limited concern among so many other pressing priorities. However, Chapter 1 has illustrated how a well-conceived and effectively implemented energy policy can both help to direct development down a sustainable path and, at the same time, provide an integrated tool capable of addressing a broad range of development goals. For these reasons, the development of sustainable energy systems in Sub-Saharan Africa could be of crucial value to the region as a whole, to national interests, and to individual inhabitants.

Sub-Saharan Africa (SSA) is well endowed with diverse non-renewable and renewable energy resources (see p.23, Energy in Africa Today). These resources remain under-exploited, primarily because most countries lack both the capital resources and the favourable political and economic environment sought by private investors. SSA's energy resources are also distributed unevenly across 48 nations, and so the exploitation of these resources will rely increasingly on regional cooperation and cross-border trade. This situation is most evident for hydroelectricity, where many borders and thousands of kilometres separate regions with large untapped potential (e.g. the Congo basin) from major demand centres. It is also true for natural gas—the Kudu field in Namibia and Pande in Mozambique are both a long way from the potential markets in South Africa—and to some extent for biomass and wind resources (which are most abundant in some remote coastal and island locations). While there is significant electricity trade in Southern Africa, and growing trade in natural gas in West/Central Africa, the economic potential of further international cooperation and infrastructure investment is enormous (see p.37, Regional Trade and Cooperation).

> **"The region's abundant resources remain under-exploited primarily because most countries lack both the capital resources and the favourable political and economic environment sought by private investors."**

MOVING FORWARD

In some ways the Sub-Saharan Africa region is in a good position to make a transition to sustainable energy. Its renewable resources are vast and its accumulated wisdom from a multitude of energy sector efforts is substantial. And on the time-scale needed for such a transition, it is not weighed down by its past: much of its future infrastructure is not yet designed or built; there are few established energy systems to absorb into new strategies; and there are few entrenched interests and industries to protect.

Along with this sense of opportunity many positive ideas are emerging about the shape which African energy systems could take. The vision is of an energy sector with a human face, serving African people affordably and efficiently, and helping to propel development through its links with other sectors: industry, agriculture, transport, finance, education, and health.

This vision calls for radical change in the conception of the energy sector and its objectives—especially from traditional top-down central planning towards more diverse structures and innovative approaches. It also calls for a massive acceleration of implementation and investment rates, without which the benefits of sustainable energy development may never be realised.

> **"This vision calls for radical change in the conception of the energy sector and its objectives—especially from traditional top-down central planning towards more diverse structures and innovative approaches."**

SCALING UP TO MEET THE CHALLENGE

The need to move fast and think big is most evident in the context of electrification, and can be illustrated through a simple calculation. In 1990 only 8% of rural people and 38% of urban dwellers in SSA had electricity connections. An ambitious growth target might be to increase access to 50% of rural and 75% of urban populations by 2025. Achieving this goal would require a five-fold increase in rates of new connections per year in urban areas, and a seven-fold increase for rural areas, relative to the rates achieved in the 1980s. Nearly 720 million people would need to be connected, 60% of them (430 million) in urban areas. Yet despite this huge acceleration of effort and investment, in 2025 the absolute number of Africans without electricity would be higher than today: 470 vs. 420 million. Furthermore, if conventional approaches to grid electrification were relied upon to meet this target, with costly borrowing and inadequate cost recovery, indebtedness and aid dependence could worsen considerably.

This calculation underscores the fundamental importance of diversification and enabling policy frameworks. First, in order to meet the electrification challenge, a diverse array of technical and institutional approaches will be needed, including large-scale, grid-connected hydropower developments, lower-cost methods of grid extension and connection, large-scale and small-scale distributed renewable energy sources—both on and off—grid applications, and greater use of energy efficiency mechanisms. A similar diverse set of options will be needed to meet rapidly growing demands for transport and other liquid fuels.

Second, policies that foster productive diversification must be the priority. Policies that create the right enabling environment for rapid investment and business-led market growth must in particular replace the traditional small-project model (unless this adds real value to policy formulation).

LINKING ENERGY WITH OTHER DEVELOPMENT ACTIVITIES

For most governments, development cooperation agencies, and individual people, development priorities centre on poverty alleviation, job creation, and the improvement of basic services such as education, health, and water supply. These priorities often depend for their development on a source of energy that is secure, affordable, and appropriate to the end-use. Indeed, projects which address these priorities have been a principal means of disseminating energy technologies. In South Africa, for example, the new government undertook in 1994 to electrify all schools and health clinics in the country, and for many of them the most appropriate energy technology was PV. Where energy has not been included or thought out in such projects until a late stage, however, users have often been saddled with inappropriate or costly technologies.

In many cases, sectoral development priorities can be provided most cost-effectively and appropriately using renewable energy technologies (RETs) combined with energy efficiency measures. Leading examples include the most basic and popular development activities, such as community lighting; lighting and water pumping for schools and hospitals; and refrigeration for vaccines in remote health centres. Using RETs in sectoral projects can also provide valuable new opportunities to generate income, as was demonstrated in the Democratic Republic of Congo (see Box 1).

Renewable energy and energy efficiency (REEF) solutions are often ignored in development projects because people do not understand their capabilities, benefits, and costs as well as they understand the better-known and well-tried technologies

BOX 1

Box 1 PV Systems for Health Care and Income Generation

During 1984-1990 the European Development Fund financed, in the Democratic Republic of Congo, the world's largest rural health care project using PV. The project installed 750 lighting systems and 100 refrigeration systems for vaccine storage in rural health centres, and carried out equipment testing, maintenance, and user training.

The high PV capital costs and the expensive operating costs of the vaccination programme were major constraints on further expansion. To enable expansion, the PV systems were enlarged to generate surplus solar electricity, which was sold to the local community, and the revenue used to help pay the programme costs. The extra cost of larger PV generators was low compared to that of the solar refrigerators, while the transport, installation, and maintenance costs remained the same. The electricity was not sold directly, but used to generate a substantial income from the following businesses:

- *Recharging car batteries*, which are used locally to power TV and radio. Two simple and reliable chargers gave a 50% profit margin on the costs of running the recharging service.
- *Community TV and video service*, which generated income and had the additional benefits of popular health education, staff training videos, and entertainment.
- *Rechargeable dry cell batteries (Ni-Cad)*, a scheme which should have generated substantial income in principle but failed because of management problems and the initial high cost of the batteries.

An evaluation in 1991 showed that the first two schemes added only 13% to the total costs of the project, but generated more than 50% of the operational costs of primary health care in the whole district.

such as the diesel engine and generator. To counteract this problem there is a need for good quality information about alternative energy options for health, education, agriculture, water, small business promotion, and other development sectors. This information must be developed and distributed widely to sectoral ministries, public utilities, the private energy sector, development-oriented NGOs and, so far as possible, local communities within each project area. Establishing electronic or physical data centres where project managers can access current information is one possible approach; another is to require comparisons of conventional and alternative options in all development assistance supported projects with energy components.

The information should provide balanced comparisons of technology performance; capital and operating costs (including first costs and lifetime costs); maintenance requirements; and key aspects of project implementation. Information on the way that RETs can contribute to sector objectives should also help to ensure that they are properly considered and adopted whenever they are the least-cost or most appropriate option.

Most importantly, renewable (and other) energy systems must be fully integrated into sectoral programme activities and not – as is so often the case – treated as a low priority add-on. The RET components of projects must be managed with an enterprising and long-term perspective and should follow the requirements of good RET projects outlined in the next section and in Box 3, including especially investments for training systems' users and technicians, and for developing technology support systems.

"Renewable (and other) energy systems must be fully integrated into sectoral programme activities and not – as is so often the case – treated as a low priority add-on."

MAXIMISING THE EFFECTIVENESS OF DEVELOPMENT ASSISTANCE

Several cooperation agencies are presently revisiting their assistance strategies, with potentially significant implications for energy-sector assistance in Africa. The Energy Sector Management Assistance Programme of the World Bank and UNDP (ESMAP), which has maintained an historic focus on Sub-Saharan Africa, is currently developing a new strategy. The core Energy Unit of the World Bank is preparing a new Africa initiative, on the heels of recent energy and environment and rural energy policy reviews (the Bank has established an Africa Energy Team). And two major changes are afoot within the EC that could present a unique opportunity to make sustainable energy a central theme for cooperation with Sub-Saharan countries. First, the Lomé Convention that governs community aid to ACP countries and establishes the principal source of EC grant funding for energy in Africa (the European Development Fund) is currently being renegotiated. And second, the restructuring of DGVIII may enable sustainable energy to be built in as a cooperation theme, particularly in recognition of its linkages with other development priorities.

"The principal challenge is to design the criteria of these funding instruments so that they support investments in long-term sustainable energy development, and not merely those projects with cheap or easy-to-quantify near-term carbon reductions."

There are two principal forms of international assistance: loans and grants. Grants are widely used to support technical assistance and studies, capacity building (training and institution building), policy dialogues and stakeholder participation processes, demonstration projects, concessionary loan terms, and guarantees. Such grants—the main form of cooperation administered by the European Commission, UNDP, and ESMAP—are often a forerunner of loan investments in energy infrastructure (power plants, transmission systems) or other enterprises which are expected to yield financial returns sufficient for loan repayment. The principal actors in the African energy sector include the African Development Bank, the World Bank, and the European Investment Bank.

In order to mobilise loans, lenders must be reassured as to the creditworthiness of the borrower and the loan operation must be large enough in size to justify the bank's appraisal costs. This becomes a particularly delicate issue in the case of sustainable energy for Sub-Saharan Africa, where loan applications tend to be small and perceived as high risk. This is one of several reasons why renewable energy and energy efficiency projects have made few inroads with lenders, who, with a few notable exceptions, still invest almost exclusively in conventional energy projects in Africa. Cooperation agencies have an important role to play in various aspects of risk mitigation, such as the clustering of operations. The World Bank Group has expressed clear interest in developing innovative sustainable large-scale rural energy projects, focusing either on large countries or clusters of smaller projects, such as the Photovoltaic Market Transformation Initiative, which is focusing initially on India, Kenya, and Morocco; the Renewable Energy and Energy Efficiency (REEF) Fund; and the Solar Development Corporation of the International Finance Corporation (the private banking arm of the World Bank Group).

Global environmental problems are an increasingly important motivator for international funding agencies. Incipient environmentally motivated funding instruments, such as the Global Environment Facility, have largely bypassed Sub-Saharan Africa, in part because the region's greenhouse gas emissions are amongst the lowest in the world. As existing instruments evolve and new ones—such as the Clean Development Mechanism—emerge, they could become an increasingly important source of funding for sustainable energy activities in Sub-Saharan Africa. The principal challenge is to design the criteria of these funding instruments so that they support investments in long-term sustainable energy development, and not merely those projects with cheap or easy-to-quantify near-term carbon reductions.

Lessons Learned and Principles for More Effective Interventions

Since the 1980s there have been hundreds of small demonstration and pilot projects on REEF technologies throughout Africa. Many of these have been valuable, others have been merely repetitive. Most have also been extremely expensive in terms of capacity installed and lessons learned, helping to account for the slow progress these technologies have made in the region.

It is time to halt this process and put more effort into ensuring that projects add real value by informing sound policy and institutional development. The aim of project support should be to help create an enabling environment for sustainable energy take-off, not for additional externally funded projects. Pilot or demonstration projects should be used only where they will inform better policy-making, and should fit within a sound policy framework. In particular there is a need for:

- Better project coordination and information sharing amongst the international development community. It is not unusual to find two or more cooperation agencies proposing essentially the same project in a country, or different agencies conducting very similar projects. New studies are often funded before thorough research is made of previous studies on the same issue. Project coordination also requires close cooperation with local institutions, where proper incentives can stimulate new activities rather than duplicate past or parallel ones.
- Greater coherence is needed between projects and policies. Projects sometimes attempt to resolve problems that are much better tackled by policy changes. For example, studies on the economics and scope for renewable energy production have been proposed in countries where independent power producers and electricity sales to the grid are not (yet) allowed.
- Better coordination is needed between cooperation agencies and governments. Client ownership of projects and policy proposals is crucial to successful development assistance. Governments must truly support project objectives and be committed to learning policy lessons from them—and to putting those lessons into practice. The dust-collecting shelved project report has become an icon of misconceived development assistance.
- Greater attention must be paid to the policy lessons arising from demonstration and pilot projects, and those lessons used in consequent policy development.

As the EC, UNDP and other development cooperation institutions have voiced growing recognition of many of these key points, it is now critical to translate these lessons into common practice. There is huge scope for targeted and coordinated grant-based development assistance to build up appropriate frameworks and more directly promote and support the development of REEF systems. This assistance covers many areas and activities and calls for substantial and well-designed grant support.

"Pilot or demonstration projects should only be used where they will inform better policy-making, and should fit within a sound policy framework."

CHALLENGES AND OPPORTUNITIES

A successful sustainable energy strategy must build and massively scale up renewable energy and energy efficiency markets while addressing broader social and development objectives. Although this may take several decades, immediate actions are needed to set the ball rolling.

Success depends on developing the right mix of:

- regulatory, legal, and institutional frameworks;
- energy and related policies;
- public and private sector involvement; and
- financing mechanisms.

Many models are possible and there is no one package that can be universally applied. Certainly no obvious best practices have yet emerged. Indeed, as most of the relevant issues tend to be specific to country and local circumstances, a variety of instruments and supporting activities will be needed.

Despite all the advantages of alternative energy systems, they are still not exploited to the extent they could be, and suffer from a lack of genuine and sustained attention. To increase significantly their use in Sub-Saharan Africa, it is essential to re-think fundamentally the role of energy in the development context in most of the countries. At present, there are few operating frameworks for developing alternative energy systems that are appropriate to African social, economic, and political contexts. In addition, the multiplicity of decision-making centres results in dispersed projects that militate against the formulation of a coherent and focused policy on alternative energy development. In many poor regions, alternative energy sources are still regarded as mere experiments. And in the implementation of most projects only the technical aspects are considered truly important.

Sustainable energy involves a fundamental shift towards greater diversity, from conventional systems with relatively few actors and large supply-side structures, to systems with a multitude of small, scattered installations which are manufactured, distributed, marketed, and operated by a myriad of individuals or small firms. Getting from here to there is a big challenge, particularly for Africa, with its generally weak institutional and financial capacities. Meeting this challenge will require action to overcome several barriers:

- Fundamental restructuring of the institutional building blocks of energy markets, which were designed to promote and sustain energy systems that are based on conventional fuels. The priority is to construct new regulatory and legal frameworks that define the rules of the game in energy markets, rules which must help to advance social priorities such as poverty alleviation and rural development as well as the growth of sustainable energy enterprises and markets.
- Transitional support to help build sustainable alternative energy enterprises by tackling market failures and barriers, especially those associated with a lack of relevant information, financing, and incorrect energy pricing and taxation.
- Further development, adaptation, and standardisation of alternative energy technologies to improve applications to meet the varied demands of a wide range of African contexts.
- Facilitation of the growth of sustainable energy through programmes which promote linkages with broad development needs, including sectoral development projects, regional trade and cooperation, and capacity building at many levels.

Following an appreciation of the present energy situation in the region, the basic elements of these four required types of action (and the challenges and opportunities that they imply for development assistance efforts) are explored individually in the remainder of this chapter.

ENERGY IN AFRICA TODAY

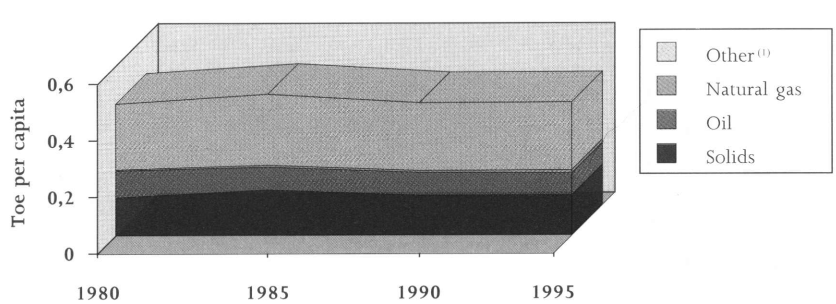
The severe problems that afflict the energy sector in most SSA countries are holding back rapid economic growth and its benefits. Throughout the region, power and fuel cut-offs are frequent, access to modern fuels and electricity is poor and unreliable, energy utilities are bankrupt, and infrastructure suffers from a chronic lack of investment. Per capita commercial energy use is less than 10% of European levels (less than 3% if South Africa is excluded) and has not grown since 1980 (see Figure 4).

> **"Sustainable energy involves a fundamental shift towards greater diversity, from conventional systems with relatively few actors and large supply-side structures, to new systems with a multitude of small, scattered installations which are manufactured, distributed, marketed, and operated by a myriad of individuals or small firms."**

Yet the region is well endowed with diverse, under-exploited non-renewable and renewable energy resources. In 1997, proven oil reserves amounted to 9.3 billion tonnes and natural gas reserves to 9.9 trillion cubic metres, representing 6.7% and 6.8% of global reserves respectively (British Petroleum, 1998). Recent exploration along the west coast suggests an additional 2-3 billion tonnes of oil reserves. Proven coal deposits stand at 61.7 billion tonnes, almost 6% of the world's reserves (British Petroleum, 1998). The region possesses 17% of the world's untapped hydropower potential, a quantity sufficient to increase its electricity capacity fourfold. There are also significant uranium deposits, many promising wind and geothermal sites, and an abundant solar resource. While traditional biomass is an increasingly scarce resource in many parts of the region, agricultural and forestry residues as well as dedicated crops offer a significant untapped renewable biomass resource.

Traditional biomass, mainly fuelwood and charcoal, is by far the most significant fuel in Sub-Saharan Africa. With the exception of South Africa, biomass accounts for over 70% of total primary energy consumption. These fuels are used mainly for cooking (with conversion rates of only 15-20%) and mostly by the poor, which explains their importance on the energy scene. The problems associated with fuelwood are often greatly exaggerated and based on extremely weak descriptive data. Never-

Figure 4. Sub-Saharan Africa Per Capita Gross Inland Energy Consumption



(1) Includes nuclear, hydro and wind, net imports of electricity and other energy sources
Source: (European Commission, 1997)

The Regional Context

The 48 ACP countries of Sub-Saharan Africa differ greatly. National population varies from under 500,000 (Equatorial Guinea) to 119 million (Nigeria). Land area ranges from 450 km^2 (Seychelles) to 2.5 million km^2 (Sudan). Forest cover is less than 2% in some arid countries and over 50% in the humid zones. Per capita GNP was only US$80 in Mozambique in 1995, but over US$3,000 in Botswana, Gabon, Mauritius, and South Africa. While a few countries have seen their economies shrink by over 4% a year, a handful have been growing at over 6% (Lesotho, Mozambique, Sudan, and Uganda). Some countries are significant energy exporters, others import all their commercial fuels.

Despite this enormous diversity, some broad generalisations are nevertheless valid. Sustainable energy strategies must be tailored precisely to the very different situations of each country, but some common demographic and economic features are central to their development:

- Sub-Saharan Africa includes 30 of the 49 countries classified by the World Bank as low-income. Not surprisingly, the alleviation of poverty is a top policy priority for many governments and donor agencies. Sustainable energy applications that can stimulate economic activity and generate incomes, while improving access to health care, education, safe water, and sanitation, are urgently needed.
- Africa is the most aid-dependent region in the world. In 1994 external aid equalled 16.3% of GNP, almost 10 times more than the second most aid-dependent region (Latin America and Caribbean, with 1.7%). External debt in 1995 averaged US$463 per person, 81% of regional GNP and 240% of export revenues. These high levels of aid dependence and indebtedness call for wise donor strategies, national investment choices and fiscal policies.
- Population growth rates are the highest in the world: 2.8% annually in 1980–1995 and 2.6% projected for 1995–2010. The population of the continent is expected to more than double by 2025 to reach 1,270 million. Living standards can be improved only if energy services increase at a much faster rate than population growth. This presents a formidable challenge for the region, as well as an important opportunity for greater penetration of renewable energy and energy-efficient technologies.
- Urban population growth rates are very high—well over 5% per year for the whole region. By 2025 half of all Sub-Saharan Africans may be city-dwellers, increasing the urban population from about 200 million today to around 630 million. Cities, towns, and peri-urban areas must be a principal focus of long-term economic development and the establishment of efficient infrastructure.
- Today two-thirds of Africans live in rural areas, often in dispersed settlement patterns. Many countries are placing an increasing priority on promoting rural economic growth in order to improve living standards and stem migration to cities. In rural areas, there are huge unmet demands for modern fuels and electricity to meet basic needs and generate income. Fed up with waiting for the arrival of the electricity grid, millions of rural Africans are turning increasingly towards stand-alone alternatives such as diesel generators and PV systems. Mounting evidence from within the region suggests that there is an unexpectedly high capacity and willingness to pay for these alternatives, as noted in the section on Building Sustainable Energy Enterprises (p.27) and Box 5 (p.31).

Democratisation, decentralisation, and market reform efforts initiated in the past decade have begun to yield more robust private sector activity in many countries. Africa's annual GDP growth, which averaged 1.6% between 1980 and 1994, climbed to 2.8% in 1995 and 4.8% in 1996. Foreign direct investment is increasing rapidly, rising from US$1 billion in 1990 to US$5 billion in 1995. Active equity markets have emerged in many countries. The total value of these markets doubled between 1989 and 1996 and, outside of South Africa, increased nearly nine-fold, from US$5 billion to US$43 billion. At the same time, the World Bank has recently launched schemes to tackle the debt burden of the poorest countries in the region. These trends, together with encouraging national political and economic transformations, have inspired optimism and renewed hope that the problems outlined above can be tackled. The new, upbeat mood in the region, though far from universal, is very different from the conditions created by stagnating economies in the 1980s and early 1990s.

theless, there is no question that biomass energy supply and use in SSA is responsible for much eye and respiratory disease from cooking fires/stoves and, in some places, for deforestation or forest degradation, and for heavy time burdens for collecting the wood or heavy cash expenditures for buying it.

Efficiency improvements and/or smoke reduction, plus substitution by modern liquid fuels, are the main demand-side remedies to these problems. They are most appropriate and easily realised amongst urban and peri-urban populations and rural-based industries, where biomass fuels such as fuelwood and charcoal are usually purchased; saving energy therefore saves money, and alternative fuels are widely available. In rural areas these remedies, as well as supply-side strategies such as planting energy woodlots, are much more problematic because "energy" must be approached indirectly as just one aspect of complex land management and resource-use strategies. Successful interventions are therefore typically slow to diffuse and dependent upon strong grassroots institutions. Two of the main opportunities, control and management of forest resources by local communities, and improved cookstoves, are discussed further in the sections on Reforming Forest Ownership (p.27) and Technology Development and Standards (p.36).

"Traditional biomass, mainly fuelwood and charcoal, is by far the most significant fuel in Sub-Saharan Africa. With the exception of South Africa, biomass accounts for over 70% of total primary energy consumption."

Table 2.1 gives a breakdown of final energy consumption in the region and shows clearly how biomass, followed by oil (much of it for transport) and electrcity, dominates energy consumption. The table also shows South Africa's major impact on the region's energy statistics.

Efficiency improvements and/or smoke reduction, plus substitution by modern liquid fuels, are the main demand-side remedies to these problems.

REGIONAL EXPERIENCE WITH SUSTAINABLE ENERGY

As this chapter is mainly concerned with increasing the role of renewable energy and energy efficiency in the region, it is worth briefly summarising the status of markets for these resources in SSA today.

The largest potential source of renewable energy in SSA is hydropower, which has already been widely developed as a large-scale grid-connected resource, but less than 10 GW of the estimated 200 GW potential has been exploited. Nearly all of the region's major hydro facilities were built before 1980, and only 2.4% of the new hydro-capacity under construction in the developing world in 1998 was taking place in Africa (Vansant, 1988). Any further development of large dams in the region must address social and environmental impacts, and, in particular, the significant financial risks associated with geological uncertainties, long lead times, and uncertain regional politics.

Medium- to large-scale grid-connected power generation from other renewable resources, most notably wind and biomass, can be economically competitive under many conditions. There has been remarkably little development of such resources in SSA. Agricultural processing industries in several African countries have for many years used residues to generate steam and electricity for their own use, but low tariffs for grid supply

Table 2.1: Final Energy Consumption in Sub-Saharan Africa

	Coal	Oil	Gas	Electricity	Total 'Modern'	Biomass	Total Overall
Mtoe							
SS Africa	19.2	42.0	1.5	17.3	80.0	184.8	264.8
SS Africa less RSA	2.3	25.5	0.9	5.0	33.7	175.2	208.9
Percent							
SS Africa	7.3	15.9	0.6	6.5	30.2	69.8	100
SS Africa less RSA	1.1	12.2	0.4	2.4	16.1	83.9	100

RSA: Republic of South Africa

Note: Transport accounts for >50% of final oil consumption. Biomass includes small amounts of modern conversion and use.

Source: (IEA, 1997)

(often below long-run marginal cost) have forced many to cease electricity production. The GEF-supported bagasse cogeneration project in Mauritius marks the first major attempt in the region (outside South Africa) to introduce modern cogeneration equipment and to sell significant amounts of biomass electricity back to the grid. Mini- and micro-hydro systems can also be economically feasible and have been installed in several countries, although many of the older facilities are currently in need of repair. In most of SSA, the laws that apply to the electricity sector have been a major obstacle to the wider use of these distributed resources for grid power. These laws need to be reformed to accommodate firm power-purchasing agreements that would enable cost-recovery and profit-making for independent power producers (IPPs) and other potential developers.

Smaller-scale, off-grid applications of renewably generated electricity have been widely demonstrated in SSA. In some areas private markets are well developed. Solar PV systems for homes and small commercial applications have become commonplace in many countries, and local entrepreneurs are involved in all stages of system design, installation, and maintenance.

Approximately 100,000 small-scale solar PV systems have been installed in Kenya, South Africa, and Zimbabwe alone, the result of a variety of private sector and government-led initiatives. These include a recently completed GEF-sponsored programme in Zimbabwe and private-sector driven activities in Kenya, where PV solar home sales were well over 8,000 in 1997 and the PV market has grown 25% annually for the past six years (Hankins, 1998). A recent estimate places the potential market for solar PV systems in SSA at 400-1500 MWp, over one hundred times current levels (Karekezi and Otiti, 1995).

Experience with small-scale, off-grid wind turbines and biomass-based generators (such as gasifiers) has been limited to a few pilot-scale activities, but these technologies may offer greater economic potential than PV for larger and more power-intensive applications than home systems.

"Approximately 100,000 small-scale solar PV systems have been installed in Kenya, South Africa, and Zimbabwe alone – the result of a variety of private sector and government-led initiatives."

Ethanol production from local biomass to reduce oil imports was developed in the Kenya, Malawi, and Zimbabwe sugarcane industries in the 1970s. Today, Malawi still blends ethanol in petrol at rates of up to 20%, but persistent low oil prices and periodic droughts have weakened the region's ethanol industries. Mali, Zimbabwe, and other countries are currently exploring the use of multi-purpose, lower-input biomass feedstocks such as jatropha for the production of diesel substitutes.

Several other, smaller scale, non-electric renewable energy options are available in many African countries. The dissemination of biogas digesters for cooking and heating fuel has been fairly widespread in Burundi, Kenya, Tanzania, and Uganda (Karekezi and Otiti, 1995). These activities have been most successful with large farmers, farm cooperatives, and rural institutions such as schools and hospitals, where the host is likely to have access to a dedicated feedstock supply, in-house maintenance capability, and state financial resources. Viable solar water heating industries have developed small commercial niches in a number of countries, including Botswana, Kenya, and Zimbabwe (Karekezi and Otiti, 1995). Locally manufactured mechanical windpumps have been widespread for over half a century in many Southern and East African countries, where they are used primarily by large commercial farmers.

Efforts to improve the efficiency of modern energy use have generally received far less funding and attention in SSA than in other developing regions. The few development assistance- and government-supported activities have included demand-side management (DSM) studies, some information campaigns, and a handful of capacity-building and implementation activities. The most significant of the latter, including the long-standing SADC Energy Management Programme, have tended to target low-cost and housekeeping industrial measures through audit and training programmes for industry managers and technicians. This is perhaps not surprising, given the relatively small and dispersed markets for promoting investment in new, higher efficiency equipment. Some examples of national efforts to implement efficiency standards do exist. Energy standards for commercial buildings have been adopted in The Ivory Coast. In South Africa, where about 70% of the region's modern fuels are consumed, studies have established the benefits of policies and programmes for appliance labelling and standards and for improving the thermal efficiency of new housing projects. Such efforts have yet to be implemented on a large scale. The relative absence of systematic policies that support investment in energy-efficient infrastructure commits the region to a more costly and less sustainable development path than is necessary.

REGULATORY AND LEGAL FRAMEWORKS

Most African countries have begun to reform their energy sectors into a wide range of market-based structures. This process is centred mainly on the conventional fossil-fuel and public power supply sectors but could, with huge long-term advantages, be steered towards supporting REEF markets. Sustainable energy and privatisation involve similar radical shifts towards involving a greater diversity of actors, institutions, technologies, and system scales, which in many ways are well matched to the African context. REEF technologies are typically modular, small-scale, and decentralised, features that make them well suited to the generally small-scale African businesses and investors. Indeed, renewable energy systems are so well matched to emerging energy markets in Africa that they can even serve as a base from which to implement energy sector reform. In Cape Verde, for example, a World Bank solar electrification and wind power loan is helping to lead the reform process by introducing the private provision of energy services in rural areas.

By using REEF systems to drive a paradigm shift away from large-scale centralised energy supply, one of the major potential social catastrophes of the privatisation process—the halting of both rural electrification and modern energy provisions for the poor—can be avoided.

The opportunities that REEF systems represent in this context cannot be seized, however, unless specific and adequate attention is given to the development of appropriate legal and regulatory structures, with enforcement mechanisms, that:

- provide clear rules of the game for all players in emerging energy markets;
- define clearly the responsibilities and obligations of the new private energy businesses; and
- protect business and investor interests while safeguarding the public and consumers; for example by ensuring an adequate level of equality of access to modern energy, particularly between rural and urban areas, the rich and the poor.

"REEF technologies are typically modular, small-scale, and decentralised, features that make them well suited to the generally small-scale African businesses and investors."

Governments (with or without development assistance) can favour REEF in the reform process by:

- developing clear social and environmental goals for the energy sector, including implementation targets for renewables. This tells the business and financial communities that sustainable energy is to be taken seriously;
- adopting regulatory and legal measures designed to promote sustainable-energy developments, based on emerging good practice world-wide;
- specifying clear rules and procedures for awarding contracts or concessions to private actors; for example, for decentralised rural electrification or independent grid-connected power producers. Getting the right balance between monopoly and competition, and between business interests and public/social goals, is not easy. For a limited period, development assistance may need to underwrite (by credit guarantees, etc.) obligations in the public interest (for example for rural electrification) that are imposed on newly privatised companies where these lose money;
- removing outdated and constraining legislation. For example, in several countries, owners of small-scale stand-alone energy systems break the law if they connect and sell electricity to neighbours, to everyone's benefit; and
- promoting a broad national dialogue on energy sector reform and REEF market development through seminars, conferences, study tours, etc., not least to increase exposure to the growing body of international experience on these matters.

REFORMING FOREST OWNERSHIP

Most African forests and woodlands are owned by the state, but forest departments typically lack the resources to manage them, or even to guard them against public exploitation as a free good. Returning this land to ownership and management by local communities, a form of privatisation, can be an effective way of turning this depredation into sound forest management that also provides income for the community (and the state) from the sale of forest products. The process is not simple. Tenure laws, forestry codes, management plans, rural wood markets, and price regulation must be developed and implemented. The World Bank with UNDP and its ESMAP and the Regional Programme for the Traditional Energy Sector (RPTES) programmes are conducting pioneering efforts along these lines in over 12 countries of the region, including Benin, Burkina Faso, Ethiopia, Gambia, Guinea, Guinea-Bissau, Mali, Mauritania, Mozambique, Niger, Senegal, and Togo.

BUILDING SUSTAINABLE ENERGY ENTERPRISES

Sound regulatory frameworks are only a first step towards a sustainable energy strategy. The huge expansion in the numbers and diversity of actors and skills that such strategies involve is a key challenge for their realisation in most African countries. Governments must nurture a capable, motivated, and vigorous sustainable energy sector until it becomes self-sustaining. Actors in this emerging sector include REEF equipment manufacturers, assemblers, importers, distributors, and retailers; equipment installers and operators such as renewables-based independent power producers and energy service companies; energy managers and consultants for the industrial and commercial sectors; technical support service providers for small users of RETs and energy efficiency devices; and NGOs.

"Governments must nurture a capable, motivated, and vigorous sustainable energy sector until it becomes self-sustaining."

This diversity of actors implies a great variety of possible business/market models and supporting activities. Most of these are relatively new and untested, especially in Africa, where the infrastructure for delivering REEF services hardly exists in most rural areas. Consequently, there are presently few African best practice models to copy or adapt.

NEW DELIVERY STRUCTURES

A number of business structures and operating models have been fairly successful in some African contexts. Four approaches deserve special mention.

- *Public/private sector joint ventures*: Public energy utilities cannot easily shift from their traditional large-scale and centralised supply business to small-scale and dispersed REEF activities. They can, however, supply technical and managerial know-how to independent operators, or share financing, risk, and management functions in some form of joint venture. In Tanzania, for example, the public utility Tanesco has worked with the town of Urambo to establish and operate a diesel-based electricity cooperative.
- *Energy Service Companies*: ESCOs were originally intended to improve energy efficiency by giving small energy users access to the technical expertise and financial muscle of the professional energy manager. In this context, ESCOs provide complete packages of technical and financial analysis, implementation, maintenance, and financing, and are paid relative to performance: they get a commission for savings achieved, for example. This useful model is also being applied increasingly to the delivery and maintenance of decentralised renewable energy systems, especially PV solar homes. ESCO-based PV delivery has been implemented in the Dominican Republic, Morocco, Indonesia, and Bolivia and is currently being tested in Zambia. In all these cases the ESCO owns the equipment and is paid a monthly service fee by the users. In the case of Bolivia the fee is about US$8 for a relatively large 50W system, excluding replacement lamps; that is about as much as a family without a PV system spends just on candles, lighting kerosene, and torch batteries.

However, few, if any, rural energy ESCOs are presently able to recover their costs. Most of them must depend on some form of operational subsidy or grant. This support could probably be eased off as technology costs fall and as ESCOs gain experience and market size and reduce their operating costs. In the meantime, these potentially valuable organisations require substantial and careful nurturing (see Box 2 for an illustration from the Ivory Coast).

- *Project-led capacity building*: Implementation projects often pay insufficient attention to building institutional and market capacity. Good project design can be extremely effective in forcing private sector developers to build up comprehensive energy delivery services. A good example is provided by the European Commission's Regional Solar Pumping Programme in nine countries of the Sahel (see Box 3).
- Community associations and cooperatives: Community cooperatives were the backbone of rural electrification

BOX 2

Box 2 Developing Energy Service Companies in the Ivory Coast

Recent electricity price rises have greatly increased the cost-effectiveness of energy efficiency in the Ivory Coast, especially for air conditioning (where savings of 50% can be economic) and for improvements to building structures. Despite these price rises and substantial development assistance for energy audits, training, demonstration, and information dissemination, energy efficiency markets still have not emerged. One main reason is that there is a conflict of interest between equipment providers and users. Firms that install and maintain electrical equipment are unwilling to form ESCOs because of the complications and risks which arise from payment by performance (i.e. according to the energy and monetary savings achieved). But energy users are unwilling to pay for more efficient equipment without guarantees of improved performance and savings.

A Small Grant GEF/World Bank project is now attempting to nurture the ESCO market. Model performance-based contracts borrowed from American and European practice are being adapted to local conditions and law. Training is being provided to potential stakeholders (beneficiaries, service providers, and bankers); to three candidate ESCOs, especially on the preparation of project feasibility studies and business plans; and to a manager who will appraise conservation projects and related contracts and oversee a grant fund designed to buy down some of the financial risk of the project.

The two-year project is expected to establish at least 20 performance-based contracts and at least two ESCOs. Based on these pioneering examples, it is hoped that more companies will be established in the Ivory Coast, and that these will form a nucleus for similar developments in neighbouring countries.

in the USA and some other industrialised countries and, increasingly, in the developing world, for example in Bangladesh. They and other forms of micro-scale collectives deserve careful consideration and appropriate support in Africa. They can contribute greatly to social empowerment by aggregating political voice, technical and managerial know-how, and financial creditworthiness. By scaling up energy demand, they can reduce unit supply costs and open the door to larger-scale options than are possible for individuals, including diesel or RET-based mini-grids, and medium- to large-scale biomass production (see Box 4 for examples from Morocco, the Philippines, Brazil, and the Sahel).

Some countries in SSA lack a culture of small-scale entrepreneurial businesses. In such cases, help may be needed to provide education and training in business management, project identification, and the preparation of bankable project proposals. These issues are being addressed by the Financing Energy Services for Small-Scale Energy Users (FINESSE) programme, which was initiated jointly in 1989 by the World Bank, the Netherlands Ministry of Development Cooperation, the US Department of Energy, and UNDP.

OPERATION AND MAINTENANCE SUPPORT SERVICES

The introduction of any new technology must include good quality operation and maintenance (O&M) support services if markets for the technology are to prosper and grow. The key issue in this context is access to technicians and spare parts. Although this seems obvious, many RET projects in Africa have failed because they ignored this cardinal rule or assumed that the private sector would take care of it. Providing these services is a particular challenge in SSA, because market infrastructure in general is at an early stage of development and because many installations will be scattered in low-density rural settings.

"The introduction of any new technology must include good quality operation and maintenance (O&M) support services if markets for the technology are to prosper and grow."

These challenges can be eased through careful planning based on a bundling approach. Large installation projects have lower unit O&M costs, as well as larger revenues to meet them, and have been found to be more sustainable than small projects. Rural installations can be grouped into geographic clusters and rural initiatives can be mixed with lower cost peri-urban installations. Nevertheless, credit financing or other forms of help are usually needed for the early establishment phase of these services, and training programmes are needed in most countries to develop and sustain a critical mass of expertise.

INFORMATION, PROMOTION AND DEMONSTRATION

REEF business development needs several types of strong backing, which the private sector can rarely provide for itself. First and foremost, clear signals from government that demonstrate a commitment to sustainable energy—perhaps backed by implementation targets—are crucial for building market confidence. Governments might consider establishing independent high-profile agencies to promote, support, or oversee REEF business development. Government promotional campaigns backed by good information are also needed to raise the profile and explain the benefits of energy efficiency and renewables to both

Box 3 Building PV Business Capacity through Project Design

The Regional Solar Pumping Programme was launched in 1986 by the European Commission. It installed nearly 700 solar PV drinking water pumps and 1000 PV community systems (totalling some 1,300 kWp) in remote rural areas of nine countries in the North African Sahel. The total project cost was about 70 MECU. A recent survey showed that more than two-thirds of the systems are still functioning.

One key feature of the project was the inclusion of challenging performance guarantees in the call for tenders. Candidate suppliers were asked to provide five-year guarantees for the equipment and to respond to requests for repairs within a maximum 36 to 72 hours (depending on the country). As a result, the European supply companies were forced to hand responsibility for installation and the maintenance contracts to a local company in each country. Each company was given training and a stock of spares. Many of these companies are still in business, with a steady rise in turnover as they expand their activities as suppliers of PV systems. The financing mechanism developed for the project, based on paying for the water produced by the PV systems, also helped build sustainable business capacity for delivering and servicing the PV systems.

BOX 4

Box 4 RET Financing Schemes in Practice

NGO-managed operators plus cooperatives

In Morocco the NGO Migrations et Dévéloppement (M&D) has helped electrify nearly 100 villages in a remote, mountainous area through diesel-based mini-grids, using a model in which local operators provide electricity to a village cooperative on a fee-for-service basis. The NGO helps the villagers form an association to own, manage, and finance the electrical system. The association raises some 40% of the capital cost and a further 10-20% as costs-in-kind (for labour, poles, etc.), the balance coming from a European Commission grant which M&D distributes. To minimise costs and maximise benefits, M&D bulk purchases equipment, insists that all households are connected, and supports the association in working out least-cost and sustainable service standards and tariffs. The government is recognising the benefits of such informal initiatives and of their integration into the public-sector national electrification programme.

Loan aggregation via cooperatives

In a Dutch-funded project in the Philippines, the Development Bank of the Philippines (DBP) agreed to finance PV solar homes but only to village cooperatives, mainly to avoid the high costs of servicing many individual small loans. The DBP leases out the systems, so that it owns the panels as collateral. But if a cooperative has to return a PV panel because of payment defaults, the DBP would have little use for it, so the dealer who supplies the PV systems has to agree to buy back such panels from the DBP. Another financial safety net is provided by the cooperatives' own funds, which can usually carry for a time the payments of individuals who run into financial difficulties.

Concession funding for public sector objectives

In the poor, rural Minas Gerais district of Brazil (population 1.4 million) most people lack electricity and there is little prospect of grid extension. The government is giving paid concession contracts to a local company to equip schools with PV lighting. This provides entry capital for the company to widen its services' provision on reasonable repayment terms to households, health clinics, community centres, and so forth. PV owners lease hardware for a monthly fee which is not greater than their payments for low-quality lighting such as candles and torch batteries.

Payments for RET energy services

These have been used successfully to fund the recurrent operational and maintenance costs of renewable energy systems—costs which are often overlooked in project design. A good example is the European Commission's Regional Solar Pumping Programme in the Sahel (see Box 3), in which village associations pay for the main project output—water. Payments cover the salary of the villager who manages the system plus day-to-day upkeep, the annual maintenance contract, and a deposit fund towards the eventual replacement of the system. In most cases, payments have been regular and sufficient to ensure financial sustainability.

the formal business and finance sectors and also to households and the small-scale service sectors.

> **"Recent ESMAP surveys in Uganda, for example, have revealed astonishingly high rates of diesel-based rural electrification and willingness-to-pay very high amounts for quality energy services."**

Experience has shown that many other kinds of information are also needed but scarcely exist in most African countries, including:

- data describing renewable energy resources (e.g. wind speeds, solar insolation, small-scale hydro resources, forestry and other biomass residues, and sustainable production from on-farm tree-growing as well as formal plantations and natural forest management); and
- market assessments of the potentials and economics of both energy efficiency (e.g. energy audits in industry, offices, hotels, etc.) and alternative forms of on- and off-grid decentralised energy supply. This will include population density, income and its distribution, distance from the grid, costs of grid extension, etc.

The importance of greatly improving information about rural energy markets can hardly be overestimated. Recent ESMAP surveys in Uganda, for example, have revealed astonishingly high rates of diesel-based rural electrification and willingness-to-pay very high amounts for quality energy services. This information has profound implications for energy planning and market development (see Box 5).

"In fact the US National Rural Electric Cooperative Association has found that informed participation is the most important single success factor in all the solar PV projects that it has analysed."

- Demonstrations of best practice in technologies, delivery systems, and institutional arrangements can be particularly effective in catalysing further activities. These need not be costly. In Ghana, for example, PV-based Solar Service Centres, established by the Kumasi University of Science and Technology to charge and provide distilled water for batteries on a commercial basis, have played a critical role in demonstrating the technology and opening up new markets for PV.

UNDERSTANDING THE DEMAND SIDE OF THE MARKET

A better understanding of the needs and aspirations of the potential beneficiaries of RETs is badly needed. Many efforts to promote RETs in SSA still retain elements of top-down, we-know-what-they-need thinking.

At the project level, informed choice is particularly important with respect to setting priorities. Informed participation approaches should be used in project design to offer target communities choices between productive services (e.g. irrigation pumps, other motor power) and consumption (e.g. radio and television), and the choice of whether to invest in energy at all or in other income-generating infrastructure such as roads, trucks, or a better water supply. Choices should also be offered when attempting to strike the right balance between performance and cost, and when making trade-offs between capital and running cost, reliability, maintenance, and dependability. Experience shows that informed participation is one of the principal success factors in decentralised energy projects. In fact the US National Rural Electric Cooperative Association has found that informed participation is the most important single success factor in all the solar PV projects that it has analysed. Conversely, if communities do not agree on project design and goals, projects will sooner or later fail.

"Consumers must be offered a range of technologies that provide choice with respect to which energy services they want, the level of service they want, and the types of technologies they use."

Understanding the demand side of the market will be crucial as the transition from project to market dissemination of RETs is made. Consumers must be offered a range of technologies that provide choice with respect to which energy services they want, the level of service they want, and the types of tech-

Box 5 Informal Rural Electrification and Willingness-to-pay in Uganda

As in some other African countries, rural electrification is occurring rapidly in Uganda without the help of government or the public utility. A recent ESMAP survey (Tuntivate, 1997) discovered that there are more rural and peri-urban households with private access to electricity (from car batteries) than there are public sector grid-connected households in the whole country. They pay a kWh price of US$2.5 or more, over 20 times the state utility's US$0.10 urban tariff. The survey also found that the average rural household spends over US$10 per month on candles, lighting kerosene, dry cell batteries, and recharging car batteries. This amounts to a national total of US$320 million annually, mostly for imported goods. With credit financing on reasonable terms, a similar sum would buy each household a substantial (40-50W) PV solar home system. The survey uncovered at least 50 MW of privately installed diesel generation in rural and peri-urban areas, mostly used very inefficiently, with load factors of around 5%, as a standby against power cuts on the grid. This capacity is growing by some 10 MW annually and has reached one-third of the public utility's grid-connected capacity of 155 MW (in 1995). Legislation which would allow equipment owners to connect and sell power to neighbours is under discussion. If implemented, the resulting micro-grids should bring about dramatic improvements in service benefits, energy efficiency, and lower kWh prices. There is a huge potential across SSA for accelerating these processes, which could form a basis for a major transition to economic renewables-based operation as RET costs fall.

nologies they use. This concept has been followed with great success in the development of the PV market in Kenya, as outlined in Box 6.

FINANCING

Sustainable energy development requires affordable credit financing. Most REEF systems have relatively large up-front costs which few operators, dealers, or purchasers in the region can afford outright. In addition, traditional banks are averse to lending small amounts for unfamiliar purposes, while most African borrowers in REEF markets are too small to pass traditional tests of creditworthiness. While many methods for resolving these problems have been tried, and experiments continue, it is too early to be sure which approaches will work best in any specific situation.

Financing methods depend to a large extent on the type of borrower and what security is provided to the lender. Different models and instruments (grants, soft loans, tax concessions, commercial loans, etc.) must be adapted to different needs and scales, as outlined below.

MEDIUM-SCALE GRID-CONNECTED SYSTEMS

Grid-connected RET systems (other than large hydro) generally lie in the 1-20 MW range and are operated by substantial commercial companies, or independent power producers (IPPs). The financing issues are much the same as for non-renewable IPP projects, but with important exceptions which are particularly relevant to Sub-Saharan Africa, where investment risk is generally perceived as high. Most banks regard RETs as technically unproven and risky. Projects are relatively small, which pushes up overheads and other lending costs. And candidate developers often have much less experience than developers of

BOX 6

Box 6 PV Developments in Kenya

The Kenyan PV market is now worth about US$2-4 million per year and has been growing by 25% annually. At least half of this market is for home lighting systems, mostly in the 12-40 Wp range. There is a strong rural demand for these systems, with many more installations in rural Kenya (well over 50,000, or over 2% of rural households) than there are connections under the Kenya Power and Lighting Company's (subsidised) Rural Electrification Programme. There are several reasons for this buoyant commercial market. There is a strong cash economy with enough rural people able to invest in solar power: a recent survey found that 60% of sales were to middle-class teachers and other professionals, coffee and tea growers, and small business owners (van der Plas and Hankins, 1998). Market nurturing has built up a well-distributed network of installers, retailers, equipment, and spare parts that helps to ensure good after-sales service and reliability. The market was driven by a high demand for televisions and radios. Cheap 12V battery-powered Chinese televisions were readily available: attaching a PV module to power the battery was seen as a very attractive alternative to carrying batteries back and forth, possibly over several kilometres, for recharging.

Until recently, there have been few efforts to finance PV home systems, largely because of high commercial interest rates. Most purchasers have preferred to buy cheaper and lower performance systems outright. As lower income groups begin to enter the market, however, dealers have begun to develop financing packages which overcome the high capital cost barrier. At present these are relatively short term and limited: one Meru-based dealer, for example, offers financing only to trusted customers with regular incomes. Typically, the customer makes a 50% down payment plus 25% after installation. There is then a three-month period after which they must pay the remaining 25%. If repayment takes longer, interest is charged at 15%, and after six months, the dealer repossesses the equipment. The customer can reclaim the system on payment of the balance, interest, and a reconnection fee. This has proved to be a successful marketing tool: 25% of customers use this loan service and none have defaulted.

As the PV market expands and lower income groups buy smaller and cheaper systems, there have been problems with quality and reliability, specifically the under-sizing of systems; poor quality lamps, batteries, and modules; and poor installation practice. A pilot project by Energy Alternatives Africa (EAA) and the Kenya Rural Enterprise Programme (K-REP), supported by the UNDP/World Bank ESMAP programme, may help to address some of these problems. Several hundred families will be helped to finance solar home systems, each designed to a suitable system size and ability to pay. Purchasers' groups guarantee each other's loans through the K-REP credit programme, while EAA ensures that all systems are suitably designed and properly installed and maintained by the local businesses.

conventional power projects. Largely for these reasons, RET schemes on this scale are still rare in Sub-Saharan Africa, even though their technical potential in many countries is tremendous.

Evidence from around the world shows that favourable tax incentives and power purchase agreements must be available to make financing medium-scale renewable investments of interest to lenders. These agreements are often based on avoided generation costs, which means higher power prices than for large conventional units. Additional incentives must often be offered to the developer, such as accelerated depreciation allowances, tax exemptions, lower import duties, government-guaranteed special lines of credit, or even direct subsidies.

Bundling individual projects together is another way of overcoming the problems of small loan size and weak developers/borrowers. If robust ways of clustering RET schemes into larger bankable projects can be developed, this idea could become a principal route towards "thinking big" and scaling up RETs into self-sustaining market take-off. Cooperation agencies could have a major role to play in developing and applying these ideas to particular country and project situations.

SMALL- TO MEDIUM-SCALE SYSTEMS

For local operators developing and managing isolated RET mini-grids or clusters of individual RET systems (e.g. PV, wind, mini- and micro-hydro), the financial issue centres on the operator's creditworthiness. Large companies who typically score well on the balance sheet (on their overall financial position) are not interested in such small and remote schemes. Smaller local companies typically have weak balance sheets and must therefore be judged on project cash flow. They can rarely bear the high cost of developing a bankable project, however, and often lack the skills to do so.

Successful approaches to these problems include the concepts of bundling consumer demand (to capture economies of scale) and financial capacities through community associations, payment according to energy services provided, and delegation of public sector responsibility to private sector concessionaires.

INDIVIDUAL SMALL SYSTEMS

At the smallest scale, many REEF technologies (including small-scale wind and hydro supplies and PV solar homes) cost a few hundred US dollars. While very few potential customers in Africa can buy RE technologies outright, an important minority of households and small businesses can afford them on a credit basis. The main financing issue is how to serve this crucial market by overcoming the reluctance of banks to manage numerous small loans and to lend without collateral or other guarantees against loan defaults. A variety of innovative approaches are being tried out (see Box 4 earlier for specific illustrations).

- *Financing via dealers*: Banks transfer the collateral problem from the end-user to the dealer, by lending to dealers who in turn lend to purchasers using payment schemes compatible with their income. The dealers must bear the financial risk on top of the technical risks. This system is best suited to large, relatively high-income rural markets.
- *Financing via Energy Service Companies*: ESCOs can replace dealers as the financing intermediary. ESCOs typically require greater efforts to establish and larger funding levels, because they provide a more comprehensive installation and back-up service to clients.
- *Revolving funds (with grant support)*: A bank takes on the risk of operating a revolving loan fund, usually with start-up capital provided by a grant.
- *Loan aggregation via cooperatives*: To avoid the high costs of servicing many small loans, intending borrowers form a community association (or enlarge the functions of an existing village or farmer cooperative). Banks lend to the cooperative or lease the RETs to it in order to retain ownership of the equipment in case of payment defaults.
- *Concession funding for public sector objectives*: The government contracts and pays a local company to provide energy services to meet development objectives, such as PV lighting for schools. This provides entry capital for the company to offer credit and expand its business to other local markets such as PV for households, health clinics, and community centres.
- *Payments for RET energy services*: Payments for RET outputs, such as irrigation and drinking water, have been used successfully to fund the recurrent operation and maintenance costs of RET development. These cost streams are usually hard to fund, or remain unfunded, when loans target the capital cost.

"While very few potential customers in Africa can buy RE technologies outright, an important minority of households and small businesses can afford them on a credit basis."

Most of these approaches demand high levels of local participation and therefore take time to mature. Participation must start from the concept development stage as it will dictate which schemes, and what parameters, are most appropriate for each community and project. No particular type of scheme is applicable for all situations in all countries.

ENERGY PRICES AND ECONOMIC INCENTIVES

Throughout much of Africa, energy-pricing policies have tilted the playing field against sustainable and equitable energy development. Conventional electricity and fuels are almost universally priced below their marginal cost. This reduces energy utility revenues, which inhibits the expansion of services to the un-served rural and peri-urban areas where the poorest live. It creates strong disincentives for investment in energy efficiency and lowers the ability of renewable energy to compete with conventional energy sources. Subsidies that allow low prices typically benefit the wealthy much more than the poor for whom they are normally intended.

Many African countries have tried to overcome these problems through a gradual phase-in of full marginal cost pricing, especially for grid electricity. This can have very positive impacts on the take up of energy efficiency as well as improving the competitiveness of renewables. This effect is usually weakened or wiped out by high inflation rates, however, combined with public objections. This has occurred in Zimbabwe, for example, and in Ghana (see Box 7).

Duties and taxes also discriminate against sustainable energy technologies in many countries. Renewable energy products such as solar-PV and water-heating systems, and the materials used to manufacture them locally, are often subject to government import duties and taxes. These taxes increase market prices relative to conventional fuels by 40 to 50% in Zimbabwe, for example. Renewable-industry representatives often cite such taxes as a major barrier to their competitiveness with conventional energy suppliers. Removing them can have very positive impacts, as in Ghana where the PV market has increased considerably since the government waived all customs duties and sales taxes on solar panels in early 1998.

The reform of discriminatory price and tax regimes is essential for building fair and sustainable markets for energy-efficient and renewable energy products. But there are also strong social and economic arguments for fiscal policies that deliberately favour these technologies. Four deserve special mention:

- Marginal cost pricing for conventional fuels and electricity has rarely been achieved and maintained in the face of inflation, in any country. Even if it were achieved, energy prices would fail to capture the negative externalities of conventional energy use, especially local and global environmental impacts, budgetary impacts of fossil fuel imports, and national security issues arising from high dependence on imported fuels. Positive fiscal incentives for REEFs can help to correct these failings.
- The desire for quick returns by private sector developers may often conflict with longer term national interests. Government or development assistance funding may be needed to buy down the costs and/or provide guaranteed returns on more sustainable, longer term investments. The need for such measures is eloquently illustrated by current attempts to meet the power crisis in Burkina Faso (see Box 8).
- Many well-known market barriers prevent the implementation of even basic cost-effective energy efficiency measures. Grants, tax breaks, and other incentives can do much to overcome these barriers.
- Most REEFs are both novel and small-scale compared to conventional energy-supply systems. Potential investors often avoid them, or demand premium interest rates, because they are seen as high-risk ventures with large transaction costs for small loans. This point is particularly relevant to Africa, where many countries are only just embarking on energy sector reform and regulatory frameworks are far from established. As a result, factors that are crucial to investment decisions and risks, such as clear power purchase agreements (PPAs) for independent producers, are often not formulated, especially for smaller scale renewable options. Grants, guarantees and other measures can be designed solely to address these problems of investment risk without undermining broader unsubsidised market development.

Many of the reforms noted above are fraught with political difficulties and inter-ministerial struggles (for example, between finance and energy ministries over equipment duty and tax concessions). They call for strong leadership and advocacy from African energy ministries, in some cases with substantial back-

BOX 7

Box 7 Economic Tariffs Encourage Energy Efficiency in Ghana

The Government of Ghana accepted the principle of long-run marginal cost (LRMC) pricing for domestic electricity in 1987, but by the end of 1995 residential and bulk supply tariffs had only risen to about 50% of LRMC. In May 1997 tariffs were increased by some 300%. This led to a more than threefold increase in the rate of capacitor installations for power factor correction in industrial establishments. The tariff increases were later suspended following a massive public outcry and the rate of capacitor installations dropped. Tariff increases have been so eroded by rising inflation that the average tariff is now only about US$0.03 per kWh. Further tariff hikes of 136% for residential consumers and 54% for bulk power supply have been proposed which, if implemented, are expected to provide strong incentives for energy efficiency improvements in the economy as a whole.

Box 8 Buying into More Sustainable Power Supply Options in Burkina Faso

Delays over power sector reform in Burkina Faso have created major uncertainties for potential private investors. This has frozen planning activities and halted capacity expansion, despite growing demand for power on the interconnected grid. During 1998 the state utility (Sonabel) has had to impose power cuts and undertake high-cost emergency investments to avoid serious shortages: 12 MW of diesel units have been installed and construction of a 30 MW oil-fired plant is scheduled to start in early 1999. These investments will meet rising peak load demand for only one year.

Meanwhile, studies show that a grid interconnection with either Ghana or the Ivory Coast, providing extra capacity based on hydro power or gas turbines, would be a better solution. Compared to these alternatives, the emergency investments have higher delivered kWh costs over the project lifetime and much higher greenhouse gas and other emissions. But in the absence of a stable post-reform framework and firm rules regarding power purchase agreements, etc., no investor is willing to consider the long-term commitments implicit in the alternatives. If the more sustainable alternatives are to be considered seriously, government or donor funding would be needed (i) to support urgent planning and engineering studies on the interconnection options; and (ii) to buy down the risk of the longer term investments by providing guarantees to potential private investors.

BOX 8

ing from development cooperation agencies. A short list of priority actions by governments, in some cases requiring development assistance, is presented here.

- Start or maintain the drive to achieve marginal-cost pricing for conventional fuels and electricity, allowing for the eroding effects of inflation. Cooperation agencies can assist here by funding supporting studies on rational pricing strategies and policies (for example, life-line tariffs for poorer consumers and small businesses) and by funding regional reviews of energy prices, taxes and subsidies and their impacts on technology adoption, and other relevant issues. These studies could be used to identify both countries where efforts need to be increased and examples of successes that could be replicated.
- Review, and apply where appropriate, fiscal incentives designed to nurture and scale up REEF markets (e.g. grants, tax concessions, soft financing, loan guarantees, etc.). These should be carefully designed and targeted to buy down initial costs, risks, and other implementation barriers. Subsidies for running costs are much harder to justify and have often been a principal cause of project failure.
- Set duties and taxes on REEF equipment which are no greater than (and possibly lower than) those paid on conventional energy equipment. Sales tax rebates may be preferable to removing import duties as they provide greater and direct benefit to locally produced energy products and services.
- Loosen controls that prevent operators of off-grid and mini-grid renewable energy systems from charging prices that recover full operating costs. As noted above, recent research has shown a willingness-to-pay that is many times higher than official electricity tariffs in many African countries.
- Provide grants, tax breaks, and other kinds of financial support for emerging renewable energy and energy efficiency technologies, particularly those that are locally manufactured. One successful model has been applied in Ghana, where a small levy on petroleum products is ear marked for financing REEF projects (see Box 9).

Development assistance agencies can help to support all such initiatives by ensuring that cooperation projects complement national policy changes. The creation of artificial markets where duties or taxes are suspended only for project-related activities is not uncommon in the region and should generally be avoided. Development agencies can also leverage their unique relationships with governments to encourage a holistic perspective on the roles and responsibilities of ministries, thus creating opportunities for identifying and rectifying conflicts between REEF and other policies, such as policies aimed at revenue generation. Development assistance would be well spent in support of efforts to find and eliminate examples of such conflicts, such as perverse subsidies and taxes.

TECHNOLOGY DEVELOPMENT AND STANDARDS

Falling costs are continuing to increase the variety of affordable sustainable energy systems. Indeed, the huge potential for technology development is a key reason why a sustainable ener-

BOX 9

BOX 9 Petroleum Taxes Help to Finance Sustainable Energy Projects in Ghana

Since the mid-1980s the Government of Ghana has financed sustainable energy projects using small levies on petroleum products. The levy, which used to be only 0.3% of the pump prices for petrol and diesel fuel and slightly less for kerosene, is now set at one Ghana Cedi per litre (about US$0.04 per 100 litres). With a current petroleum product consumption of about one million tonnes, over US$400,000 is raised annually. These sums are paid into an Energy Fund and used to promote renewable energy and energy efficiency projects.

gy future should be achievable. Research and development on advanced energy technologies (fuel cells, high-efficiency biomass gasifiers and gas turbines, solar-hydrogen systems, etc.) should, in general, be left to the industrialised countries. But there is a huge scope and need for technology adaptation to meet local conditions by making them more robust, reliable, low cost.

"There is huge scope and need for technology adaptation to meet local conditions by making them more robust, reliable, low cost, etc."

Cookstoves provide a classic example. One of the most successful of all improved charcoal stoves, the Kenyan ceramic-lined *jiko*, was adapted from the Thai Bucket Stove and was further adapted into the *diambar* stove of Senegal. Many improved stove projects have been started in the region with high hopes and substantial funding, however, only to stagnate or collapse after a few years. On the other hand, large markets have been developed in Sub-Saharan Africa for stoves that give fuel and financial savings of the order of 40%. The key to success is persistence and a sound approach, including careful market assessment, product design, production testing, market trials, and help with commercialisation. A recent outstanding example of successful cookstove development is outlined in Box 10.

Technical assistance is still needed in many locations on these design, production, marketing, and commercialisation processes, especially for more efficient and smokeless stoves, improved charcoal conversion techniques, and solar water heaters. The emphasis should be on building up know-how and capacities for local manufacture and marketing of the technologies.

Key areas where regionally specific research, development, and dissemination on REEF systems is needed include:

- Research on medium-scale renewable energy options, including wind farms, mini-hydro, and power generation from urban refuse incineration and gasification, and from biomass residues. Little has been done in the SSA region to explore these options, although they should be cost effective in some locations for supplying power to national/regional grids and isolated mini-grids. Demonstrations are required to test the technologies, their costs, and viable institutional support systems under real-life conditions.
- Research on small (village-scale) biomass-based power generation in rural areas. India has much relevant experience, especially with biogas and gasifiers feeding internal combustion engines, that needs to be adapted and evaluated under African conditions.
- Studies on biomass energy crops deserve particular priority. Tree, grass, and other crops are widely thought to have a huge world-wide potential to provide electricity or liquid fuels. Compared with Asia and Latin America, little has been done to explore their potential in Africa. A range of systems needs to be tested thoroughly, as a matter of urgency, under a range of African conditions. Some of these conditions, including rural labour shortages and highly variable rainfall patterns, may pose severe difficulties for applying these options in Africa.
- Demonstration projects applying hybrid energy systems. By combining intermittent renewable sources (solar, wind) with firm energy supplies (diesel, gas, hydro, and biomass), reliable and economic hybrid systems could greatly expand decentralised renewable energy take-up via village and town mini-grids.

"Technical assistance is still needed in many locations on these design, production, marketing, and commercialisation processes, especially for more efficient and smokeless stoves, improved charcoal conversion techniques, and solar water heaters."

- Demonstration projects to test methods of providing low-cost, multiple, modern energy services, such as motor-power, pumping, and refrigeration, as well as the usual lighting services. Examples include solar and/or diesel micro-grids, clusters of solar battery charging sta-

Box 10 Cookstove Design and Marketing in Ethiopia

The British NGO Energy for Sustainable Development (ESD) is financing and supporting a team of Ethiopian professionals working in household energy management and supply. It has achieved remarkable success in developing and commercialising two types of improved biomass cookstoves through an iterative approach of needs assessment, design, product trials, redesign, and performance monitoring. The team works with households, stove producers, installers, and merchants and pays attention to promotion, technical assistance, quality control, and to the provision of business, management, and marketing skills to producers.

The first great success was the Lakech metal and ceramic charcoal stove. Introduced commercially in early 1992, over 600,000 had been sold in Addis Ababa by mid-1998 (ESD, 1998). The second success has been the Mirte biomass stove for baking the cereal-based staple *injera*, an activity which accounts for 50% of Ethiopia's primary energy consumption and over 75% of all household energy use. A typical twice-weekly injera baking session consumes 10kg of woody biomass. The Mirte, introduced in 1994, uses only 50-60% as much fuel as traditional methods (saving about half a tonne of fuel per stove annually), reduces smoke, cuts the risk of burns, and is regarded as "modern". With these advantages, sales across the country totalled 54,000 by mid-1998 and are expected to reach 100,000 by the end of 1999 and 500,000 a year later.

tions, and the village energy centres described in the Mali country study.

- Research, development, and dissemination, followed by implementation of the many technical and societal means of reducing electricity transmission, distribution, wiring, and metering costs. When applied together with energy efficiency measures, these can reduce the costs of providing energy services by 50% or more, and can tip the balance between the economics of grid extension versus decentralised options.

REGIONAL ENERGY TRADE AND COOPERATION

Progress towards a sustainable energy future would be strengthened by greater regional cooperation in energy trade, harmonisation of technical standards, common frameworks for energy investments, better exchange of information and experience, and shared energy training and organisational capacity building.

"Progress towards a sustainable energy future would be strengthened by greater regional cooperation in energy trade, harmonisation of technical standards, common frameworks for energy investments, better exchange of information and experience, and shared energy training and organisational capacity building."

ENERGY TRADE

The largest opportunities for increasing sustainable energy supply capacity through regional trade lie in Africa's vast hydropower resources: a technical potential of nearly 300 GW and a present economic potential of 110 GW, compared to only 15 GW used in 1990 (London Economics, 1995). Because most of these resources are located far from the main demand centres, they cannot be exploited without transnational interconnections and regional power trading. But electricity interconnections can also reduce generation capacity requirements through load sharing, and cut operating costs by integrating hydro and thermal generation in wet and dry years. The resulting benefits can be enormous. One proposal to upgrade interconnections between Zambia, Malawi, Mozambique, Zimbabwe, and South Africa, with some hydropower development, has estimated that US$785 million a year will be saved (1992 prices) between 1995 and 2010 compared to equivalent independent developments.

Regional energy trade is further justified if one considers the potential economic (as opposed to purely financial) benefits. The incorporation of environmental externalities in the cost of power production (particularly in South Africa and Zimbabwe, with their heavy reliance on coal) would make regional development of hydropower even more attractive.

In light of the potential benefits, a comprehensive re-appraisal of large-scale hydropower in the region and its development in a socially and environmentally responsible manner is called for. Development constraints, including high project preparation costs, cost estimation risks due to geological uncertainties, and long construction times, need to be set against the huge potential contribution of this resource to sustainable energy development in the region. Similar reviews should be made of other forms of renewable energy that might be developed in resource-rich regions if there were suitable interconnections to link them to demand centres, including large wind farms, biomass from forestry wastes, and biomass from dedicated sources of trees, grass, or other crops.

Several transborder power connections already exist (and are described in the three specific country sections at the end of this chapter) but many more have been proposed and some have been studied further, notably for the African Regional Interconnection Study (ARPIS). But few of these projects have been implemented and others have been abandoned because of commercial and political barriers that reflect significant failures of international cooperation (see Box 11).

"Effective and reliable power pools will also require strong coordinating centres which are able to control supply-switching to meet real-time demand."

Apart from the political and capacity constraints outlined in Box 11, several technical barriers require attention. One is the fear of increased grid instability and failure as interconnection expands: investing in transmission infrastructure and maintenance is a first necessary step toward reducing this risk. Effective and reliable power pools will also require strong coordinating centres which are able to control supply-switching to meet real-time demand. Support will be needed to fund and train system operators to manage the grid effectively.

As regional energy markets develop, it is also important that countries create level playing-fields for new investments by harmonising their legal, fiscal, and tax frameworks. Failure to do this could result in stranded investments in a more open market environment.

HARMONISATION OF STANDARDS

Poor design and equipment quality, equipment incompatibility, and inefficient end-use technologies hamper energy development and trade in the region. In West Africa, for example, national LPG container designs are incompatible, preventing the rational expansion of LPG markets and trade. Common fuel specifications will greatly facilitate trade in petroleum products; and cross-border electricity networks and gas pipelines will require common technical standards. Harmonisation of these and other technical standards could result in significant benefits across the region, not least by enlarging the potential markets for energy equipment, and hence the incentive for manufacturing investment. Most continents have already moved in this direction. Africa could benefit by following suit.

For many REEF technologies, harmonised standards would also help to avoid poor design and equipment quality, which undermine consumer confidence and damage market development. Classic examples include solar water heaters that corrode and leak after a few months; and PV systems with poor quality and/or badly installed modules, charge controllers, batteries, and lamps.

Adequate technical specifications and standards, as well as monitoring systems to ensure compliance, could ensure the quality of renewable energy technologies and remove the most inefficient key energy-consuming products (e.g. some buildings,

BOX 11

Box 11 The Southern African Development Community (SADC) and Southern African Power Pool (SAPP)

Activities in the SADC Energy Sector, including the creation of the SAPP, illustrate the promise of sub-regional energy cooperation, but also highlight some of the barriers. The SADC Energy Ministers agreed in mid-1997 to develop an integrated resource planning framework for the electricity sector. This framework could promote more rational regional capacity expansion (from an economic and environmental perspective) as well as demand-side alternatives to costly new supply. The process has been stalled, however, by national concerns over energy security, insufficient capacity within regional coordinating bodies, and resistance from utilities.

Similarly, the 1995 creation of the SAPP offered a way to use complementary energy resources to meet rapidly expanding electricity demand. SAPP has also experienced growing pains, both because utilities recognise that they may be competing with each other in the future, and because many lack the capacity even to have consistent representation at SAPP meetings. For SADC and SAPP, the implicit requirement of consensus for virtually all decisions, while participants put their country's interests ahead of regional ones, has hampered their ability to develop or implement new initiatives. Investors are unlikely to finance major transnational infrastructure unless stable, transparent government and utility coordination is in place for policy-making and for implementation. If they do so without those elements in place, they could demand a significant risk premium which would raise energy prices in the region.

lights, motors, and refrigerators) from the market. This would allow for greater returns, in the form of energy services, from REEF systems. The benefits of such measures could be achieved most efficiently and with wide-reaching results if they were designed and implemented at the regional level. Regional equipment testing and evaluation, as well as certified testing centres, would be required to ensure compliance to agreed standards. Best-practice information for equipment installers and operator/users could be developed, translated into local languages, and disseminated widely. In addition, equipment producers and suppliers should be encouraged to provide guarantees.

"In West Africa, for example, national LPG container designs are incompatible, preventing the rational expansion of LPG markets and trade."

At least two initiatives along these lines already exist. The World Health Organisation, working with UNICEF, set international performance standards for PV refrigerators and now insists that these be met by all projects that it funds. This has raised the standard of available products, but international standards do not exist for all PV components/systems yet. This shortcoming is being addressed through the PV Global Accreditation Programme (PV-GAP), which is supporting an industry-led effort to approve standards for PV components and systems in developing countries. Support is needed for African countries to participate in such processes and to empower them to create their own standards, as well as the legislation to enforce them.

Many longer term opportunities for technical leapfrogging and cutting costs by accelerating progress down the learning curve could be realised if technical standards were developed and implemented soon. Energy efficiency standards for new (commercial and institutional) buildings, and selected end-use equipment (e.g. electric lights, motors, and refrigerators) are particularly important. OECD experience has shown that efficiency standards can result in huge energy savings.

While the need for harmonised standards is clear, the levels at which they should be set are not quite so obvious. Quality standards that are set too high (as is the case in many countries where legislation has been inherited from colonial times) result in unnecessarily high costs and limitations on consumer choice. With some relatively novel RETs (notably PV systems) some practitioners insist that high technical standards are essential in order to minimise failures and gain the confidence of the business and financial worlds as well as consumers. The UNDP-GEF PV project in Zimbabwe adopted this approach and achieved very low failure rates (and commensurately greater respect and trust) compared to other installations in the country. On the other hand, as with the automobile and many other consumer goods, lower standards also mean cheaper and more affordable products and, therefore, market access to a broader range of consumers. Finding the right balance between product acceptance and affordability is crucial in the market development phase that characterises REEF systems. This issue has been important in the development of PV in Kenya (see Box 6 earlier).

INSTITUTIONAL STRENGTHENING AND PROFESSIONAL DEVELOPMENT

All African countries suffer from weak energy institutions and lack of capacity or policy analysis in support of informed decision-making. They also face enormous challenges in creating appropriate policy, legal, fiscal, and administrative frameworks to mobilise and unlock the potential of their energy sectors to contribute to development. Unless this problem is tackled systematically there will be little chance of implementing sustainable energy policies and programmes in Africa.

Development agencies appreciate this issue and have done much to help build capacities in energy as in other sectors. But declining aid budgets often mean that they can now do less to help than they might wish and certainly much less than is required. Their standard response of short-term, fly-in consultancy support has not, and is not going to, resolve this problem. Neither will a model based on institutionalised dependence on northern educational and training capacity.

"Many longer term opportunities for technical leapfrogging and cutting costs by accelerating progress down the learning curve could be realised if technical standards were developed and implemented soon."

Instead, international aid agencies need to increase and sustain their commitment to strengthening energy programmes in national and regional educational and training institutions. Nevertheless, support will continue to be needed for the medium-term, to resolve acute shortages in trained, skilled, and experienced staff at three different levels, including:

- regional institutions, where pooling skills, experiences, and resources can be economically efficient and highly effective, especially for weaker countries;
- national energy institutions and other public bodies; and
- provincial, district, and local levels where energy interventions should be linked to initiatives in health care, education, agriculture, industry, and business promotion in order to maximise development benefits. Effective support for building capacity at this level is most appropriately and sustainably provided by local development-oriented institutions working closely with government, energy providers, and communities to explore, demonstrate, communicate, and replicate new delivery mechanisms.

At the national level, one of the key problems is the instability and unreliability of the policy and institutional environment. One attractive solution to this problem is to provide multi-year support in the form of independent energy analysis and capacity building/training centres that support local governments and institutions. With sustained support a reliable, long-term partnership of trust can be built between cooperation agencies, a capable local organisation committed to the same objectives, and government. The local organisation invests in building capacity internally and also in the wider energy sector; is positioned to understand the vagaries of the political environment; can build local relationships; and can provide assistance to cooperation agencies and government at appropriate moments. It can also become a sound repository of knowledge and expertise, which greatly increases the chances of sustained progress in the sector. Establishing and/or maintaining or supporting such centres is also a relatively cheap option.

"International aid agencies need to increase and sustain their commitment to strengthening energy programmes in national and regional educational and training institutions."

This model is based on the experience of a few energy policy and training centres that were established in Africa during the 1990s. Several useful lessons have been learned from these local centres:

- Joint projects are effective ways to develop capacity. Policy-makers, teamed with local policy analysts/trainers, jointly developing policy and implementation programmes, can build local capacity and confidence.
- Regular interactions between policy-makers and policy analysts/trainers through training/workshop visits to the local institution, or through analysts/trainers working with policy-makers, help to maintain and enhance this capacity.
- Effective local institutions require strong political and intellectual leadership, but also, crucially, professional colleagues able to respond to the challenges and needs by providing expert assistance and training. The institutions must demonstrate that they can build internal capacity before they attempt to build capacity in government or elsewhere. Partly for this reason they need support from leading international groups through exchange visits and sabbaticals (both ways), workshops, and, importantly, through working jointly on projects.
- These institutions should demonstrate their relevance by earning a significant proportion of their income from local contracts. Some baseline support is necessary to sustain capacity building and training activities, however, and to sustain the centres as repositories of relevant knowledge, skills, and experience in periods of political and institutional uncertainty or instability.
- It is difficult to start new, good, locally based institutions from scratch. Capacity development should piggyback on the best existing institutions.

An alternative model is to support loose networks of local expertise and provide them with a formal channel for advising and interacting with government. Two successful approaches along these lines have been established in Ghana (see Box 12).

BOX 12

Box 12 Building Effective Energy Policy Institutions in Ghana

In 1983 Ghana established a National Energy Board (NEB) to attract high calibre technical staff and strengthen the institutional framework for energy planning. The NEB was responsible for giving independent energy policy advice to the government and for monitoring the public agencies which regulated and managed energy development and utilisation. By 1991, when the NEB was dissolved, it had become a dynamic national agency for energy planning and policy analysis. One of its great strengths was its independent funding (derived from a tax on petroleum products: see Box 9). This freed it from government budget uncertainties and enabled it to pay enough to attract high calibre staff. Two new institutions, the Public Utilities Regulatory Commission and the National Energy Commission, have replaced the NEB but operate on similar principles.

Ghana has also established several NGOs, often with governmental support, to facilitate closer interactions between government officials, academia, and entrepreneurs. These include the Energy Research Group and the Solar Energy Society of Ghana, established in 1987 and 1993 respectively. Membership of both organisations includes energy researchers, policy-makers, and managerial staff from industry, commerce, and the electric power utilities. Their main benefit is the successful linking of academia, government, and the private sectors in addressing key issues of energy policy as well as business development.

GHANA - SERVING INCREASING DEMANDS

CHALLENGES AND OPPORTUNITIES FOR SUSTAINABLE ENERGY

Ghana's energy sector is changing dramatically as the government tries to restructure the power sector and introduce private participation and competition. Industrial, economic, and social growth have all suffered as a result of recent power crises in Ghana, and the country has recognised that only by reforming the energy sector to address demands will the economy get back on track.

Under the World Bank/IMF Economic Recovery Programme/ Structural Adjustment Programme, the government has withdrawn all subsidies on petroleum products, but electricity tariffs still do not cover current costs. Attempts to increase electricity tariffs to reflect marginal costs have largely failed. Increases in the late 1980s and early 1990s, for instance, were quickly eroded by inflation. Recent increases generated a wave of public protests which led to a suspension of the new tariffs by the government. The recently established Public Utilities Regulatory Commission (PURC) faces the difficult task of setting tariffs free of political considerations but keeping in mind the limited income of much of the urban workforce.

Raising electricity tariffs will help to overcome the most fundamental barrier that restrains independent power producers and energy service companies from entering the Ghanaian market. Tariff structures have been a disincentive to investment in energy efficiency or grid-based renewable energy options. The key challenge facing the Regulatory Commission will be to structure tariffs that encourage energy conservation and efficiency while ensuring that tariff increases are acceptable to the population as a whole.

Ghana's energy sector has some fundamental weaknesses, which are reflected in the current power crisis threatening the national economy. The National Energy Board (NEB) was dissolved in 1991, and since then the energy planning and policy analysis of the Ministry of Mines and Energy (MOME) (which had been supporting renewables) has been limited and ad-hoc. The Volta River Authority (VRA), which is responsible for generation and high-voltage transmission throughout the country, has undertaken more systematic generation and transmission planning activities, but it has been unable to secure timely approvals from government, and hence the necessary investment. Even though the VRA formally employs an integrated resource planning approach, its plans do not appear to take renewables and energy efficiency fully into account. One of the challenges facing the country as a whole, therefore, is the need to develop energy supply strategies that give due attention to renewable energy systems and energy efficiency improvement.

POLICIES TO PROMOTE SUSTAINABLE ENERGY

Energy Sector Reform

A range of reforms has been implemented quite successfully in the petroleum sub-sector. The power sector has received much attention, but so far has produced few significant results. One effect of the current power crisis is the way in which it has spurred the government into accelerating the pace of power sector reform in Ghana. Thus prodded, the MOME is implementing long-standing proposals to restructure the power sector and introduce private participation and competition. The proposals open the door for independent power producers and the creation of several distribution companies, either as subsidiaries of the Electricity Corporation of Ghana or as separate companies. The current piecemeal and crisis-driven implementation of these proposals needs to be strengthened if the full benefits of reform are to be realised.

The mobilisation of local private capital and local entrepreneurial/organisational initiatives through cooperatives and credit unions is a good way to promote local commercial development and to respond to electrification needs in low-income areas.

Promoting Sub-Regional Cooperation: Gas Pipelines and Grid Interconnection

Investments in regional energy infrastructure could yield a host of environmental and economic benefits. Examples include the proposed natural gas pipelines from Nigeria and the Ivory Coast which would displace fuel oil use at thermal generation stations, resulting in cost savings and local and global environmental benefits. West Africa's largest natural gas reservoirs by a wide margin are in Nigeria, where 75% of all oil-associated natural gas is flared into the open skies. Several international schemes have been put forward to supply Ghana's combined cycle plant with the one million m^3 of gas/day it would require.

Extending the regional grid (Ghana, Togo, Benin, and the Ivory Coast are already connected) to Burkina Faso, Mali, and Nigeria would also help to create a more competitive market, decrease vulnerability to drought, and increase the prospects for tapping the hydro potential in Ghana and neighbouring countries.

Integrating Renewables in the National Electrification Programme

Towards the end of the 1980s Ghana launched a programme to electrify the entire country by the year 2020. Many towns and villages have since gone the traditional route of extending the grid, with little thought for mini-grid and off-grid systems, many of which could be powered by renewables. Joint public-private sector initiatives should be developed and implemented to promote innovative, lower cost, and more rapid electrification approaches, and to increase the penetration of renewables. This could be promoted through a combination of national targets (such as system-wide quotas for renewable sources or a specified number of PV lighting systems installed in primary schools), financial mechanisms, and market transformation activities. Such an initiative could yield substantial educational, environmental, and economic benefits. Projects to convert burdensome municipal wastes and agro-industrial residues into electricity should also be further explored.

Increasing energy efficiency

The ESMAP-supported initiatives have laid a strong foundation for energy efficiency activities. Many industrial energy audits and efficiency improvement measures have been implemented by trained Ghanaian engineers and the scope for energy efficiency improvements in all sectors remains large. Demand-side programmes should be expanded, perhaps by stimulating the market for Energy Service Companies through improved access to low-cost capital. A lease-finance facility for the purchase of capacitors turned out for all practical purposes to be a failure as most consumers preferred to purchase the necessary equipment either outright or under more favourable financing terms provided by independent equipment suppliers. It is also very clear that the demand for energy efficiency improvement measures will become even higher as electricity tariffs increase as part of the Government's proposed package of solutions for the current power crisis.

Energy in Transportation

As in most African countries, Ghana's road transport stock is made up predominantly of second-hand vehicles from abroad. Fuel efficiency is generally poor, and energy policy does little to address the issues of energy and transport. Recent efforts by MOME, the National Petroleum Corporation, and retailers to promote the use of household LPG were quickly "hijacked" by car owners who began switching to LPG. Ironically, this has resulted in a new and thriving market for LPG with private companies installing specialised auto-LPG dispensers in many urban centres across the country. Promoting the further use of LPG, switching from petrol to diesel engines, and developing reliable mass transit systems, are some of the ways energy use in the transport sector could be improved. Policy and technology assessments are needed to inform the decision-making process.

Institutional Strengthening and Capacity Building

There is a dearth of professionals with both the requisite experience and the commitment to promoting sustainable energy initiatives in Ghana. The country has a good number of public and private sector institutions (including universities and research institutes as well as government agencies and non-governmental organisations) with the basic human resources and facilities for energy technology development and policy research (See Box 12). "Twinning" or linking programmes between similar institutions in different countries (North–South as well as South–South) could present dynamic opportunities for catalysing the change process.

Policy Discussion Groups for Generating and Nurturing New Ideas

One of the fundamental weaknesses of the energy sector in Ghana is the absence of a continuous policy debate and consultation process. Stakeholder consultative groups could be complemented by use of the Internet, a powerful forum for generating and debating new ideas. Discussions could be synthesised on a periodic basis and fed more formally into the policy-making process through a variety of channels, such as seminars, workshops, leaflets, posters, etc.

THE ENERGY SECTOR

The Ministry of Mines and Energy has the main responsibility for energy policy formulation and coordination. The Ministry of Finance provides guarantees for loans for the utilities on behalf of the Government of Ghana and also has responsibility for reviewing and approving power sector capital investment programmes.

A competitive environment has been created in the petroleum sector, with very high private participation in downstream petroleum products' retailing activities. Work is underway to introduce some competition into the electricity sector: the first independent power producer was established by the Ghana National Petroleum Corporation (Western Power Company); the Public Utilities Regulatory Commission was established in October 1997; and the government is taking steps to introduce private participation and competition in the power sector. Until late 1997, when the Regulatory Commission was established, the MOME was involved in tariff setting and project implementation as well as energy policy formulation. In December 1997 parliament approved legislation for an Energy Commission, which will license and oversee power utilities as well as petroleum and natural gas supplies.

Electricity

Until very recently power generation was based almost entirely on hydropower. A major drought in 1982-1983 highlighted the need for thermal capacity for back-up, but the country still depends largely on the two hydropower plants completed in 1966-1972 (Akosombo, 912 MW) and 1981 (Kpong, 160 MW). The sector is also dominated by two power utilities:

- The Volta River Authority is responsible for generation and high-voltage transmission throughout the country, while its subsidiary, the Northern Electricity Department (NED), takes care of distribution in the northern regions.
- The Electricity Corporation of Ghana (ECG) was responsible for distribution throughout the country until the establishment of NED in 1987. ECG is now in charge of distribution in southern Ghana, where most people live.

The VRA was the main electricity exporter in the sub-region until 1992, but since 1993 it has been importing electricity from the Ivory Coast. VRA's 300 MW combined cycle gas turbine plant, the first of its kind in Africa, is at an advanced stage of construction with 200 MW of gas turbines already operational.

Energy demand has grown steadily since the onset of the Economic Recovery Programme (ERP), and electricity consumption annual growth rates have averaged over 10%. The high growth in demand with no increase in the supply capacity has led to the present power crisis, with frequent power rationing and load-shedding. Supplies to the largest single consumer, Volta River Aluminium Company (VALCO), have been drastically reduced, and it is estimated that power curtailment to the industrial sector alone could be responsible for a loss of around US$500 million to the Ghanaian economy by the end of 1998. (VALCO consumes a very large share of total electrical energy supplied by Ghana's main generator, the VRA. After commissioning in 1967, its share rose quickly to a peak exceeding 75% in 1968 and then dropped gradually over the years as other users came online, falling below 40% in 1995. From the late 1980s to the onset of the current power crisis, electricity supplied to VALCO had stabilised at around 2,800 GWh per year.)

Renewable Energy

Renewable energy development also suffers from a lack of commercial financing schemes and limited private sector involvement. An innovation in the energy sector which worked very well during the 1980s was the establishment of an Energy Fund, raised through levies on petroleum products and electricity bills. This fund made it possible for the Ministry of Mines and Energy—acting through the National Energy Board—to promote renewable energy research and development in Ghana. The fund also made it possible for the NEB to initiate, with the help of development cooperation agencies, a broad programme of energy conservation and efficiency improvements. Today, there are several successful renewable energy demonstration/pilot projects (e.g. solar battery-charging centres and biogas-electric systems) and the general public is well aware of the possibilities offered by solar energy technologies in particular. The

Ghana - The Economic Context

At independence in 1957, Ghana was the richest country in Sub-Saharan Africa, with a per capita income of US$490 (in 1980 US dollars). Over the next 25 years or so, political turmoil and economic mismanagement brought Ghana to its knees, and per capita incomes hit rock-bottom in the early 1980s. Since the launching of a World Bank/IMF Economic Recovery Programme (ERP)/Structural Adjustment Programme (SAP) in 1983, GDP growth rates have averaged about 5% per year and the structure of the economy has changed considerably.

Agriculture no longer dominates the economy: its share of GDP dropped from 55% to 40% between 1980 to 1995. The service sector is now the largest and fastest growing sector, accounting for 47% of GDP in 1995. Agriculture still accounts for 50% of export earnings, however, and 70% of employment. Cocoa alone occupies 25% of cultivated land, accounts for 20% of employment and, until gold took over in 1992, was the single largest source of export earnings.

In spite of its impressive growth rates, the Ghanaian economy still suffers some rather fundamental weaknesses. Inflation stood at 120% in 1983, and is still quite high (28% in 1997) and subject to alarming fluctuations (70% as recently as 1995). Interest rates are correspondingly high, hampering investment. The Bank of Ghana raised rediscount rates in 1995 from 33% to 45% in an attempt to squeeze credit expansion and encourage banks to invest in the money market. In such a high inflationary regime, any investments yielding returns lower than about 50% are generally considered unattractive.

When the first industrial census was carried out in 1962, industrial production contributed about 10% of GDP. By 1976 its share had risen to 21%, but it then declined sharply to around 8% in 1983, just before the ERP/SAP was implemented. During the first half of the ERP (1984-1988), the industrial sector recorded very high growth rates, averaging 11.2% per year and then slowed to 4.5% per year from 1989 to 1994. Industrial production stood at 14% of GDP as recently as 1994. In recent years, mining, quarrying, electricity production, and construction have outpaced growth in manufacturing, which accounts for over 60% of industrial value added.

The Ghanaian industrial sector is made up of many small- and medium-scale enterprises. The smaller enterprises are usually Ghanaian family businesses that operate informally and employ simple or traditional technologies. Large businesses are very often either wholly state-owned, wholly foreign-owned, or are joint ventures between foreign and local interests (both state and private). These include the Volta Aluminium Company, the largest primary aluminium smelter in Africa (with 200,000 tonnes annual capacity), and several large gold and diamond mining companies, which are among the most energy-intensive industries in Ghana. Since 1987 the government has pursued a policy of privatisation of state-owned enterprises.

Energy Research Group (ERG) of Ghana and the Ghana Solar Energy Society (GHASES) have also provided opportunities for policy-makers, researchers, and entrepreneurs to meet and address issues of national importance.

Energy Efficiency

Energy efficiency has been one of the cornerstones of the government's energy policies and there was an active and growing energy efficiency programme, which has been slowed down by the current power supply crisis. The latter half of the 1980s saw the implementation of a National Energy Conservation Programme (NECP) with technical assistance from the World Bank/ UNDP ESMAP programme together with the Canadian International Development Agency. More recently, in 1995, an Electricity Demand Management Project (EDMP) was initiated as an integral part of the Takoradi Thermal Power Project under a financial package with the International Development Association. The primary objective of the EDMP is to promote private sector participation in the delivery of energy management services (i.e. to perform key diagnostic and design tasks, maintenance services, etc.) to industrial and commercial enterprises. An Industrial Energy Assessment Centre (IEAC) has been established at the University of Science and Technology, Kumasi, mainly to train students in energy auditing techniques. MOME, in cooperation with the Private Enterprise Foundation (PEF), has recently established an Energy Foundation with responsibility for energy issues relating to the private sector business community as well as member organisations of the PEF.

MALI - REFORMING INSTITUTIONS AND WIDENING ACCESS

CHALLENGES AND OPPORTUNITIES FOR SUSTAINABLE ENERGY

There is enormous room for improvement in the Malian energy sector. The first and most significant issue is basic access to efficient energy services. Heavy reliance on inefficient biomass resources and the near absence of electrification are obvious obstacles to national development and reinforce a low quality of life amongst the population at large. The primary objective of any intervention in the energy sector in Mali is therefore to widen access. This is complicated by low population densities in the rural areas, and the relatively undeveloped transport systems linking them with urban centres. Dealing with this problem will require analysis and innovation. The widely dispersed population also offers an opportunity to diversify energy resources and introduce renewables such as biomass in wooded areas, micro-hydro near drainage, solar power in desert zones, etc.

Coherent and rational energy strategies and policies are essential to the goal of a sustainable energy strategy, and to ensure that it aligns with the development needs of the country. A number of spontaneous initiatives in energy use involving renewable energies and small-scale diesel generation have sprung up around the country, and they must be seized upon for the lessons they can offer.

Mali is currently in the process of establishing a national energy board within the Ministry of Energy, which will undoubtedly strengthen the coherence and rationality of national energy policy. This will only be fully effective, however, if research and analysis of the needs and possibilities are carried out. As a result, the sector is open to reform and dynamism. Options currently under consideration include: extending the national grid, exploiting the hydroelectric potential, reinforcing the capabilities of the electricity utility, interconnecting with neighbouring countries, and decentralising the sector by increasing the role of the private sector and recognising the potential of small-scale systems. The development of human resources through training programmes and technical support is another high priority area.

A number of other initiatives underpin the potential for improvement in the Malian energy sector. These include the regional initiative of the UEMOA Energy Community Programme, which aims to safeguard the security of energy provision in the member states through a systematic interconnection of electrical grids and the promotion of renewable energy. Another significant innovation will be the establishment of a "Regional Solar Energy Centre" in Bamako to elaborate and implement energy management policies for development and the environment in African countries. The new institute will also provide support in implementing the conventions on climate change and desertification.

POLICIES TO PROMOTE SUSTAINABLE ENERGY

Energy sector reform

The reform of Mali's energy sector provides an important opportunity to pursue the goals of sustainable development. The government realises that it must expand the role of the private sector in order to bring in much-needed capital and management experience. This in turn will require a robust regulatory framework to ensure that national development objectives are furthered and that access to affordable electricity for the less privileged grows as well. Institutional strengthening, capacity building, and appropriate policy mechanisms will all be required. The new minister in charge of Mali's energy portfolio is currently seeking to strengthen the country's energy institutions, which will provide an important opportunity to stimulate more effective action.

Areas in which reform is already underway include:

- Extending the national grid in two complementary ways: towards new rural and semi-urban centres close to the existing interconnected sub-region, involving the Selingué-Bamako-Fana-Ségou and the Bamako-Koulikoro axes; and by intensifying distribution in the urban centres and districts already electrified.
- Programmes under way to develop regional interconnection and cross-border energy exchange (Mali-the

Ivory Coast). New partnerships have also been formed to this effect (joint hydroelectric sites proposed with Niger and Guinea, gas network with the Bight of Benin countries, etc.)

- A number of training and human resource programmes for the electricity sector. After more than two decades of technical assistance to the electricity utility (EDM), the public authorities opted for a *Temporary Management Delegation*, with the objective of bringing the company's technical and administrative staff up to date with current practices.
- Extending the grid, adapting prices and services to the purchasing power of the population, and providing better technical support. EDM aims to increase the number of subscribers from 66,000 in 1995 to 95,000 by 2000 and 143,000 by the year 2005.
- Institutional changes, including the creation of an Energy Ministry, the transfer of responsibilities to local organisations outside Bamako, the development of a national energy plan, and opening up the sector to private investment.

These are important steps on the way to the adoption of a sustainable energy policy, but more innovative policy measures will be needed to build an energy sector that will carry the country into the next century. Further policy measures that might be recommended are described below.

Sub-Regional Cooperation and Energy Trade

With its small and isolated national market, Mali would benefit greatly from increased cooperation with its neighbours, particularly Senegal and the Ivory Coast. Regional electricity interconnections and trade, for example, are essential for developing the country's hydro potential, thereby increasing the availability of low-cost electricity supply as well as providing export earnings. The scheduled opening of the Manantali hydroelectric plant in 2001 and Mali's connection to the Ivoirian grid are important first steps in this direction.

Sub-regional cooperation in domestic energy programmes could yield similar benefits by lowering the cost of energy services, promoting technology transfer, and catalysing local economic development. Building on EC-supported projects such as the Programme to Promote the Use of LPG and the Regional Solar Programme, concerted sub-regional actions are needed to open up tight domestic markets, stimulate the regional manufacture and assembly of key equipment such as LPG cylinders, kerosene stoves, and PV system components, and bring significant economies of scale. The World Bank-funded Mali Household Energy Programme also stands to gain from this approach.

Decentralised Rural Energy Services

The government's decentralisation strategy offers an unprecedented opportunity to build on success and launch a more effective rural energy policy. In doing so, community energy needs, such as water supply, should be prioritised alongside non-productive household energy uses, such as lighting and audio-visual services. Research should be undertaken into the productive needs of rural areas in order to integrate energy strategies with rural development objectives. With its particular ability to support productive activities and thus increase rural incomes, rural motorization should be considered alongside other forms of rural electrification. Schemes to finance rural energy technologies have had mixed success. Novel and adapted strategies should be explored, avoiding the imposition of preconceived solutions.

Bioenergy Options

Efforts have been made to develop modern biofuels, but none has yet succeeded on a large scale. Most were stimulated by high oil prices and import constraints in the 1970s and 1980s, and collapsed with the subsequent steep decline in oil prices. This is what happened at the Sukala sugar plant, where two million litres per year of ethanol production capacity was installed, and now remains idle. In contrast, the production of bio-diesel oil from an indigenous plant is progressing, and the fuel is being used in motors and for electricity generation in two villages. In sum, Mali harbours many promising bioenergy applications, which with further development could offer significant opportunities for clean energy supply.

Capacity Building

The building of human and institutional capacity is imperative in every area of the energy sector. In particular, skills must be developed to improve and implement sustainable energy policy. The Bamako Regional Centre for Solar Energy is being re-launched for this purpose, to support sustainable energy management and policy conception in the region. The new institution could also help African countries implement the conventions on climate change and desertification.

THE ENERGY SECTOR

Six characteristics define the energy situation in Mali:

- *The dominance of fuelwood*. Fuelwood accounts for 90% of household consumption and is used to a considerable extent even in the urban areas, including Bamako. Rural areas depend almost entirely on fuelwood for all their energy needs. Recent estimates put consumption at about 4.7 million tonnes of fuelwood and 90,000 tonnes of charcoal annually, with demand growing at a rate of 1.6% and 4.1% per year respectively. The country's wooded area is about 17 million ha, but this has been declining by about 9,000 ha per year for the last fifteen years.
- *Considerable hydropower potential*. This is estimated at 1050 MW, of which only 50 MW is exploited at present. Hydropower provides two-thirds of the electricity supply, with the remainder from thermal production.

Mali - The National Context

A landlocked Sahelian country of 9 million people, Mali ranks among the world's lowest in both per capita GDP and energy consumption (230 kgoe/capita). Desert covers more than half of the country's territory, and population density is extremely low, varying from 1/km² in the north to almost 30/km² in the south. While the urban population is growing rapidly (4.6%/year vs. 1.3%/year in the rural areas in 1992) two-thirds of the population still live in rural areas.

The primary sector dominates the Malian economy, contributing about 50% of GDP and involving 75% of the population. This leaves the country very vulnerable to the whims of the climate. Mali's economy is usually in deficit, and financial equilibrium has been maintained by capital injections when conditions have been favourable and by humanitarian aid when they have not. After years of economic stagnation and regression, solid economic growth returned to the country in the late 1980s, coinciding with the return of favourable climatic conditions and structural reforms in the private sector.

- *A lack of proven fossil-fuel resources.* For its petroleum needs, Mali is entirely dependent on imports, traditionally from Abidjan (Ivory Coast) and Dakar (Senegal), both over 1,000 km from Bamako. Since 1987 there have been attempts to diversify with imports from the ports of Lomé (Togo) and Cotonou (Benin).
- *Only 4% of the population has access to grid electricity.* The main electricity utility (EDM) is severely constrained by a lack of coherent strategic policy, and inadequate institutional, technical, and financial resources. Together these facts have forced a retreat in service provision to only a part of the capital city, Bamako. Power stations are overworked, and along with transmission and distribution facilities, are in urgent need of rehabilitation as well as expansion.
- *Electricity supply constraints.* Electricity production has grown at an annual rate of 6.7% since 1987. Demand continues to exceed supply, however, while large new capacity expansion projects have been delayed (the Manantali dam and connection to the Ivoirian grid).
- *Large, untapped renewable energy potential.* Although solar and wind potential remains largely unknown, informed estimates consider it to be an important under-exploited resource. The country has an installed capacity of about 1 MWp of solar PV units, including about 2,000 solar home systems.

Renewable Energy

Over the past two decades, many small projects supported by a variety of external partners have introduced renewable energy technologies in Mali.

- A Malian NGO (Mali Aqua Viva) helped to double the amount of water available for domestic and productive uses through the introduction of solar PV water pumps. Their experience demonstrates that with the support of the population and well-defined rules of communal, consensual, and decentralised management, real success can be achieved.
- Other successful PV pumping projects have taken place in the regions of Tomboctou, Kolokani, Banamba, Nara, and Mandé, through the involvement of UNDP and other cooperation agencies. Positive results have also come from PV lighting systems and with the creative application of diesel motors.
- With support from UNIDO-IFAD, multi-functional 8-10 hp motor platforms have been developed to supply mechanical energy for productive purposes (shelling machines, oil presses, harvesters, etc.) as well as electricity for individual and community lighting, battery-charging, and water-pumping.
- From 1956 to the present, there have been five successful wind-pumping projects in Mali. The most recent was begun in 1993, initiated by the Canadian ODIK, and it distributed 12 systems. One project, organised by the Italian NGO LVIA, imported 15 systems from neighbouring Senegal (where wind-pumping systems are built).

ZIMBABWE - STIMULATING GROWTH THROUGH REFORM AND DIVERSIFICATION

EMERGING VISIONS FOR ENERGY AND DEVELOPMENT

Critical changes are taking place in Zimbabwe's energy sector. Foremost among these is the planned privatisation or commercialisation of parastatal bodies within the sector and the granting of access to independent power producers. It is thought that these new paradigms will bring autonomous efficiency to the management of the sector, thereby improving supply security and price stability.

The utility, the Zimbabwe Electricity Supply Authority (ZESA), has embraced demand-side management, including integrated resource planning, as demonstrated by its decision both to switch from controlled electricity pricing to a long-run marginal cost formula and to drop subsidies. ZESA is also experimenting with the use of solar PV devices to supply remote locations. The approach it will eventually adopt is not yet fully formulated, but the present experimental phase shows significant change in the strategy of the authorities, particularly with regard to rural electrification.

A strategy of diversification of technology is also inherent in the attempt to introduce solar PV generation to rural households. Through the GEF PV solar pilot project, over 9,000 units have been introduced, and thousands more have been installed outside the project. A strong supply base for PV devices is already in place. Assessments of other technologies, such as dendrothermal plants to generate power from forestry waste, have been conducted. Micro-hydro options have been studied and a few plants are already operating. Proposals for harnessing coal-bed methane for power generation are being examined by the Department of Energy.

These new options are expected to both decentralise the sub-sector and improve access, particularly for rural populations. This is critical to the government's overall policy of decentralising economic activities through rural growth points and service centres. Of the 500 or more of these centres in the country, 84% of those classified as district centres are electrified compared with only 19% of those classified as rural. Many of these present good opportunities for stand-alone electricity generating stations using small-scale hydro technology and coal-bed methane.

It is expected that wider access to electricity will mitigate local environmental problems, particularly fuelwood depletion and deforestation. In fact Zimbabwe's project on solar PV dissemination, funded by GEF through the UNDP, sought to respond to both local and global environmental demands. While global environmental benefits are not the drivers of energy sector thinking, a number of joint benefits have been identified in the various climate change mitigation studies conducted in the country.

The long-term vision for market-driven development in the energy sector is embraced in three key new initiatives: the first is the commercialisation of energy parastatals; the second is support for small business development in energy supply to small-scale energy users; and the third is a widely discussed search for market development mechanisms to enable small energy users (such as households) to purchase and use modern fuels. The market development approach, although ill-defined as yet, appears to be key to ensuring access to modern fuels by rural populations.

CHALLENGES AND OPPORTUNITIES FOR SUSTAINABLE ENERGY

There are three major challenges facing the Zimbabwean energy sector. The first and most critical is to ensure that conventional fuels are effectively diffused among rural communities to relieve pressure on declining forest resources. The second is to finance investment in the sector, with a particular emphasis on combining traditional large-scale infrastructure and small-scale alternatives. It is clear that traditional approaches alone cannot solve the problem and also that the new approaches may constitute a high risk for individual investors, where the financial base is weak to begin with.

A further challenge is the basic problem of pricing fuels, particularly electricity. This has been a dilemma right across the Southern African region where pricing has been sensitive to social needs. While it is accepted that consumers must pay the full cost of energy to send the right efficiency signals and to adopt a sustainable investment path, there are concerns about the implications that this strategy will have on fragile industries and disadvantaged social groups.

The challenge of mobilising investment depends on two activities. The first is to locate investment for traditional large-scale installations. Here, the introduction of independant power producers (IPPs) is expected to relieve investment shortfalls and to widen participation, a desired social effect. The second is to mobilise investment for small-scale installations and to ensure that an amicable relationship exists between the new operators and traditional suppliers.

Already two key challenges have been identified by the SADC/UNDP FINESSE project. The first is that IPPs and small-scale operators need market guarantees in order to survive. For electrical IPPs this means power purchase agreements and for renewable energy operators it means a social commitment to parallel activities of market development. The latter would be an uphill task without the commitment of global or international partners in Africa. The former also faces difficulties, in that parastatals undergoing commercialisation will not accept an obligation to support new competitors unless it makes financial sense for them to do so.

Two recent studies in the region have demonstrated that long-term regional electricity trade must be profitable and must guarantee security of supply in the power sector if it is to succeed. This will require quick, effective, negotiating capacity and political stability, which cannot be guaranteed at this point in time. Hence there is a considerable amount of caution, even in the SADC region, where cooperation in the power sector is significant.

There are many opportunities to improve energy efficiency in Africa, but preliminary assessments (GTZ/ADB studies in Zambia and Zimbabwe) have shown that there is a lack of energy services support. The challenge here is to finance energy services companies and build up the necessary level of competence. Two creative approaches are being tried in Zimbabwe. The first is part of the FINESSE project, administered by the SADC Energy Technical Assistance Unit (TAU) and the Public Private Partnership project, where public utilities and private industry are seeking to invest jointly in an ESCO. The second is a much larger GEF initiative which is being discussed with UNDP to introduce variations on this first approach. What these initiatives demonstrate most clearly is the urgency of completing a wide range of enabling programmes in order to mitigate the risks associated with investment in this sector.

In order to establish alternatives such as energy efficiency mechanisms and the use of renewable energy technologies, an atmosphere of energy-use optimisation must prevail. The region is better prepared now than ever before to develop this necessary condition. There is a role here for NGOs and research bodies to develop and popularise approaches such as Integrated Resource Planning which are already under discussion in the SADC.

Opportunities for "leapfrogging" need to be developed and presented for business investment. Making the transition from theory to investment is not easy, even in apparently obvious cases. The research community must take a lead role in preparing financing institutions, individual investors and, critically, policy-makers, to accept and implement these options.

POLICIES TO PROMOTE SUSTAINABLE ENERGY

Overall, strategy in the Zimbabwean energy sector is changing course, focusing more on market demand and commercialisation. It is not a straightforward task, formulating and enforcing policies to reinforce this goal. For example, it is not practical to expect the electricity parastatal to commercialise while at the same time making it responsible for the social and infrastructural development associated with rural electrification. Expanding renewable energy use, which has been embraced by the government, carries its own policy dilemmas. The first is the very controversial issue which stems from the pressure on governments to reduce import taxes on renewable energy devices. There are calls for the same amount of pressure to be applied to suppliers to push them into carrying out further technical and economic research to reduce production costs. Most governments regard these taxes as revenue to be used to redistribute wealth and finance critical development projects. Sweeping macroeconomic policies cannot address this problem. The second dilemma is that there is little capacity within government to ensure that tax concessions are passed on to the consumer. A decision has to be made regarding whether to focus on developing markets or to reduce duties and taxes to achieve affordability.

Despite these policy issues Zimbabwe has made significant progress in promoting sustainable energy. There is now a Solar Energy Industry Association, and awareness among rural households about solar energy technology is quite high. Financing mechanisms for the purchase of renewable energy technologies are in place in the form of a low-cost revolving fund. A major policy failure, however, has been the lack of support for the development of businesses which supply these devices: the newly stimulated market will collapse unless there is a sustainable supply base. Support for business has been the focus of the SADC FINESSE project. The development of markets and of the capacity of businesses to function within them are the most critical institutional capacity building gaps in the country.

Standards have been developed within the context of the GEF UNDP project, and these are available for wider application. These standards were developed in response to the high failure rate of the devices already installed and the lack of back-up support, which left consumers stranded and began to destroy the reputation, and therefore the market, of renewable energy technologies. The new standards and codes of conduct appear to be working well in Zimbabwe so far.

POTENTIAL ROLES FOR DEVELOPMENT ASSISTANCE

The traditional role of development assistance focused on carrying out studies and providing demonstration units as gifts to communities. These units usually failed because they had no service support structures. A new role for development cooperation was identified in the course of the SADC FINESSE and the Public Private Partnership projects underway in Zimbabwe: the provision of support for parallel activities to remove market barriers, bring down costs, and otherwise cushion the risks for the investor.

Much the same applies to energy efficiency mechanisms. Here risk-cushioning is essential, as is building the capacity of industries to identify exploitable options and to convert them into profitable businesses. These measures will be critical to the success of energy efficiency and conservation as a clean development option.

In conclusion, the main role for international partners in making the Zimbabwean energy sector more sustainable is to cushion the effects of the transition from central management of the sector to a more open business environment with visible participation by local investors, while maintaining social responsibility.

THE ENERGY SECTOR

The energy sector is administered by the Department of Energy, within the Ministry of Transport and Energy. Other major actors in the sector are the National Oil Company of Zimbabwe (NOCZIM), responsible for the bulk importation of refined petroleum products; the Zimbabwe Electricity Supply Authority, responsible for the generation, transmission, and distribution of electricity as well as investment decisions in the sector; and the Wankie Colliery Company, the sole supplier of coal in the country. Wankie Colliery is a private company operating a mine of 6 million tonnes per year capacity in the north-western corner of the country.

The private sector is also involved in the distribution of liquid fuels and in the electricity sector. Independent power producers are now permitted and two major power sector investments are under negotiation, one involving 200 MW of

Zimbabwe - The National Context

Zimbabwe is a relatively small country with a population of 11 million and a land area of 391,000 km^2, 29% of which is under cultivation and over 50% classified as forested. The climate is temperate: rainfall varies from 400 mm a year in the low-lying areas and 900 mm over the central watershed to 1500 mm in the country's Eastern Districts. Although Zimbabwe is a multi-party state, there is no strong opposition capable of effectively challenging the ruling party ZANU PF, which has governed the country since 1980. Elections are run at all levels of government, however, including central government and municipal authorities, and any interested party or person can stand for election. Per capita GDP in 1995 was US$580 (in 1987 US$). The national currency, the Zimbabwe Dollar, is valued at Z$17.9 to the US$, but has lost value significantly since mid-1997 when it stood at about Z$10 to the US$. Manufacturing contributes about 25% of GDP, making it the most significant economic sector. The total productive sector makes up 44% of GDP. The manufacturing sector, which comprises over 6,000 different products and employs about 17% of the workforce, is strained due to the weakening currency, increasing labour costs, and high interest rates, which range from 27% to 40% per year depending on the nature of investment.

The agricultural sector exerts considerable influence over the Zimbabwean economy but has been severely affected by droughts in recent years. It is imperative that irrigation programmes be introduced urgently, a measure which will carry important implications in the areas of energy supplies and pricing.

Infrastructure remains an area of focus for the country's development programmes. Road density is low (14,150 km of paved roads and 76,928 km of unpaved roads). Rural electrification is also low with only 20% of households connected to the national grid and over 90% of rural households dependent on fuelwood for 96% of their energy needs.

coal-based generation and the other natural gas. Smaller investments have been made in micro-hydro. Electricity capacity currently stands at 1,295 MW of thermal (coal) power and 666 MW of hydropower. Power transmission relies on 3,595 km of high voltage networks and 56,115 km of distribution lines. Total (commercial) energy consumption is 136 PJ, or 3.25 Mtoe.

Biomass resources are under pressure on two fronts: high demand in both rural and urban communities, and low biomass growth rates, depressed by drought. Between 70,000 and 100,000 hectares of forest are cleared annually for agricultural purposes, this being the major cause of deforestation. About 6 million tonnes of wood are harvested annually for household energy purposes, with significant additional consumption by small-scale rural industries such as beer-brewing, brick-making, and tobacco-curing. Although biomass use may look sustainable at the national level, there are large pockets where deforestation and shortage of timber for all applications has passed critical levels, thereby threatening fuel supplies for poor rural households.

Fuelwood is the main source of energy among rural households. In urban households fuelwood consumption varies depending on access to electricity and electrical appliances for lighting and cooking. Households without electricity consume around 5 kg of fuelwood daily, and those on a load-limited electricity supply, which cannot support electrical stoves, consume around 1 kg each day.

POLICIES TO PROMOTE SUSTAINABLE ENERGY IN SUB-SAHARAN AFRICA

ENERGY SECTOR REFORM / REGULATORY AND LEGAL FRAMEWORKS

Apart from advancing energy sector reform generally, with its main emphasis on conventional energy, policy dialogue and technical assistance are needed to:

- Develop clear social and environmental goals for the energy sector, including implementation targets for renewables.
- Include measures which help to promote sustainable energy in regulatory and legal structures for energy sector reform, and remove outdated and constraining legislation.
- Start or accelerate land reform that ensures appropriate level of ownership and responsibility of state forests and woodlands. Back-up reform with studies and projects to establish sustainable forest harvesting and rural wood markets.
- Promote REEF market interests (within the sector reform process) through seminars and study tours, etc., which help capture international experience and good practice.

ENERGY PRICES AND ECONOMIC INCENTIVES

REEF systems cannot compete in open markets as long as the playing-field is tilted to favour conventional energy resources. The playing-field must be levelled to:

- Get prices right (review and reduce perverse subsides, establish and maintain marginal cost pricing for fuels and electricity, implement measures where necessary to protect the poor).
- Remove customs duties and other taxes which discriminate against REEF equipment.
- Review and implement fiscal measures which favour REEF market development (levies on fossil fuels, grants, tax breaks, business guarantees, etc.).
- Learn, by funding/conducting regional (and worldwide) reviews of actual and good practices on energy prices, taxes, and incentive schemes and their impacts on REEF adoption.

REEF MARKET DEVELOPMENT

Given the barriers discussed above to the kind of small-scale dispersed enterprise that is inherent to REEF systems, extra transitional nudges are needed to stimulate REEF markets. Such nudges can and should come in a variety of forms to:

- Develop and extend innovative approaches to build up sustainable structures and financing methods for delivering REEF systems. Possibilities include public-private sector joint ventures, energy service companies, and community cooperatives.
- Bundle or cluster development projects to reduce costs and extend outreach. Bundling can include melding projects supported by different cooperation agencies.
- Provide technical and business management training for REEF system producers, distributors, and service technicians.
- Establish effective demonstrations of good-practice technologies and delivery systems. These can be financially self-supporting.
- Initiate or support promotional campaigns on the benefits of energy efficiency and renewables aimed at all potential markets (from the formal business and financial sectors to households and other small-scale users).
- Develop and disseminate good quality information about alternative energy options for health, education, agriculture, water, and other development sectors. Electronic or other data centres should be considered.
- Require comparisons of conventional and alternative energy options in all development projects (health, education, water supply, etc.).
- Provide good quality technical assistance on the design, production, and commercialisation of important small scale REEF technologies which have lost their appeal to some development cooperation agencies; notably improved cookstoves and charcoal conversion techniques, and solar water heaters.
- Develop energy efficiency performance standards, building codes, etc.

RESOURCE AND MARKET ASSESSMENTS

Although the following may appear obvious, assumptions are rampant and knowledge is limited regarding both the potential supply and the market demand sides of the energy equation in Sub-Saharan Africa. A range of surveys and assessments are needed to address this problem. The following are examples of categories of studies that should be given priority:

- Surveys of renewable energy resources (e.g. wind, solar, hydro, biomass residues), including regular inventories of all types of woody biomass, standing stocks, and productivity. The latter are essential for the sound planning of traditional fuel use and assessments of the potential for tree-based energy crops.
- Studies on potentials and socio-economics of biomass-energy crop production and conversion to modern fuels

(e.g. methanol, ethanol, and electricity). Studies and demonstrations under a range of African conditions are urgently needed.

- Surveys of rural and peri-urban areas to reveal patterns of energy supply and use, energy prices and ability/ willingness-to-pay, and potential demand for REEF (and other) means of increasing modern energy services.
- Market assessments of potentials and economics of all major RET systems on different scales (e.g. medium-size grid-connected, mini-grids, small-scale systems).
- Market assessments and audits, etc. amongst key energy-use sectors of potentials and economics of energy efficiency.
- Regional re-appraisal of the potential to develop large-scale hydropower in a socially and environmentally responsible manner.

TECHNOLOGY DEVELOPMENT AND DEMONSTRATION

With the repeated caveat that developing countries should not be viewed as a testing ground for new technologies, Research, Development, and Demonstration (R, D & D) is needed to test and adapt REEF technologies and systems in the African context. This work should emphasise the social, in addition to technical, aspects associated with developing REEF-based energy systems.

- Demonstration projects are urgently needed to test the economics and institutional support requirements under a range of African conditions of medium-scale RETs such as wind farms, mini-hydro, and power generation from biomass residues and urban wastes.
- R, D & D on hybrid energy systems which back-up intermittent renewables (solar, wind) with "firm" energy supplies (diesel, gas, hydro, biomass).
- R, D & D on low-cost, small-scale methods of providing a range of energy services (shaft power, pumping, battery charging, lighting, etc.) such as village energy centres.
- R, D & D on technical and institutional methods for reducing electricity delivery and billing costs.
- Energy equipment standards (quality, efficiency, and compatibility) should be harmonised in the region, and regional testing and monitoring systems should be established. Equipment producers and suppliers should be encouraged to give guarantees.

CAPACITY BUILDING

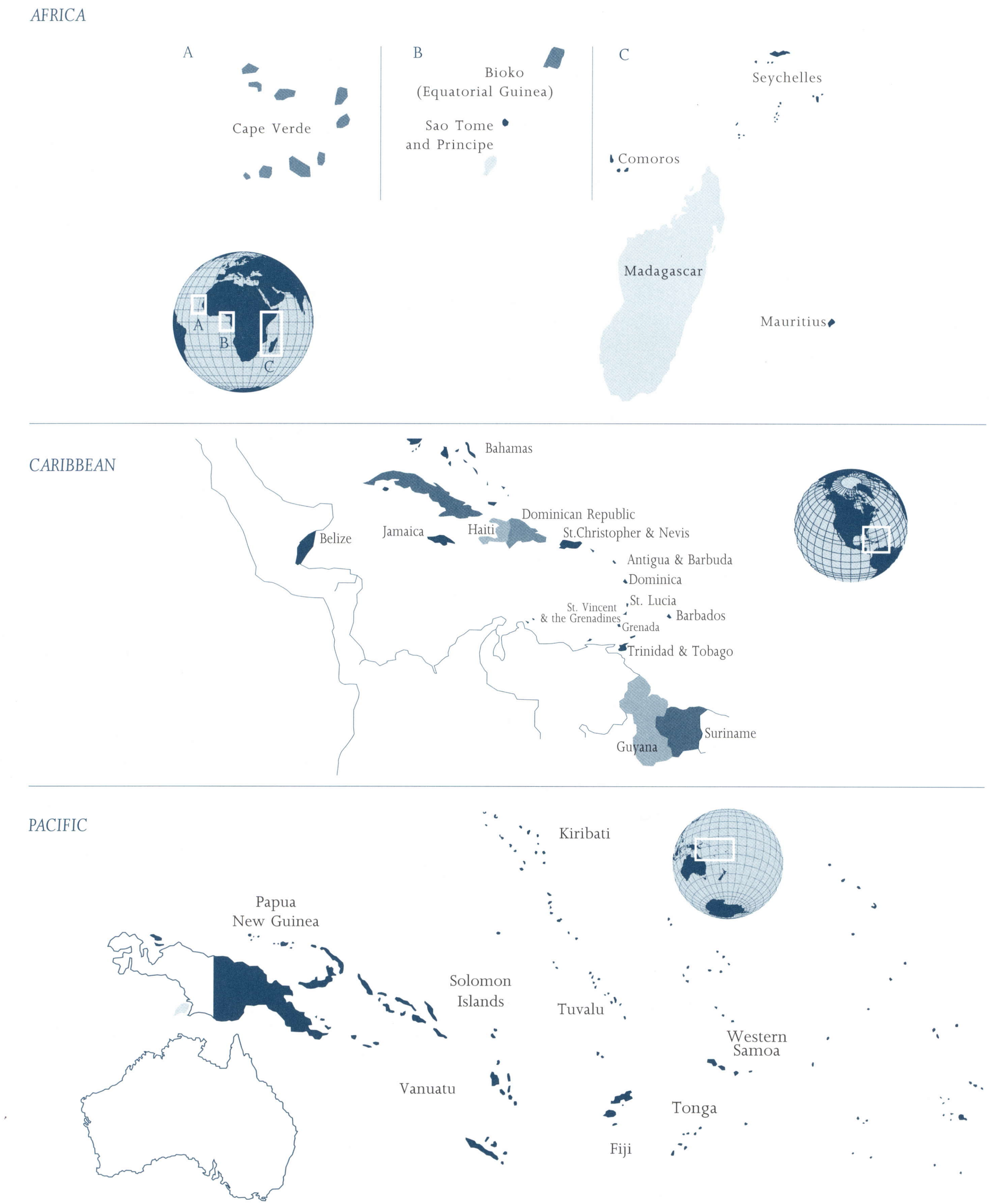
Strong institutions are the backbone of an efficient and effective energy sector. The countries of Sub-Saharan Africa face enormous challenges in creating appropriate policy, legal, fiscal, and administrative frameworks to mobilise and unlock the potential of their energy sectors to contribute to development. This is a key area where development assistance is needed to support and encourage the efforts of national governments.

- Increase and sustain commitments to build up trained and experienced staff in national energy institutions and other public bodies; regional political and energy institutions; and at provincial, district, and local levels.
- Establish and support independent energy analysis and capacity building/training centres that provide support for local governments and other institutions.
- Support national and regional networks of sustainable energy expertise.

Unless this fundamental problem is tackled systematically there will be little chance of implementing sustainable energy policies and programmes in Africa.

CHAPTER 3 - SMALL ISLAND DEVELOPING STATES

Figure 5. ACP Small Island Developing States



CHAPTER 3: SMALL ISLAND DEVELOPING STATES

INTRODUCTION

This chapter looks at the African, Caribbean, and Pacific (ACP) Small Island Developing States (SIDS) that are part of the ACP-EU cooperation under the Lomé Convention.[1] The recommendations can, however, be extended to the majority of developing island states in the world. Furthermore, although islands have some unique problems because of their geography, the institutional and policy issues that have already been identified in Chapters 1 and 2 will, for the most part, apply equally to ACP SIDS.

ACP SIDS consume very little commercial energy (about 182,510 GWh/y) and their contribution to greenhouse gas emissions is negligible, but because of their geography they are very vulnerable to the effects of gross energy consumption by the industrialised countries. Climate change and sea-level rise will have dramatic implications for coastal communities, and the increasingly intense nature of destructive weather systems will hit islands particularly hard. There is not much that ACP SIDS can do about the energy consumed elsewhere, but the one way in which these islands states can protect themselves, or at least limit the damage, is to diversify and develop their economies and countries. Improving local infrastructure and services, building durable housing, and increasing self-sufficiency will all contribute to making island states more secure.

"Most island states are blessed with abundant renewable energy resources, but they depend overwhelmingly on petroleum for their electricity production and transport and on biomass for the bulk of their energy consumption."

Most island states are blessed with abundant renewable energy resources, but they depend overwhelmingly on petroleum imports for their electricity production and for transport and on biomass for the bulk of their energy consumption. Neither of these sources is about to be depleted completely, but access to both is limited, and the use of either has severe environmental and economic consequences. Transporting oil to ACP SIDS can be environmentally risky, and it is almost always extremely expensive, diverting the scarce funds of usually poor countries away from more productive uses, such as health and education. Burning biomass rarely depletes forests, but it can severely degrade the environment near settlements, take up an inordinate amount of women's already stretched time to collect, and pollute the household, leading to respiratory and eye infections.

And what does the use of these resources add to the development of the country? Oil is usually burned in power stations or generators that were imported, and burning fuelwood on a traditional stove is very inefficient, so much of the time spent collecting it was effectively wasted. It is an exasperating picture, particularly when the alternative is so attractive.

If governments, supported by cooperation agencies, were to transform policy environments to encourage the most appropriate energy services, the knock-on effects would benefit significantly many ACP SIDS' economies. Thousands of jobs could be created providing energy services and in manufacturing energy efficient technologies, whether that means building wood-fired power stations or micro-hydro installations from locally produced building materials or the small-scale production of energy efficient cookstoves. The improved security of energy supply would enable local industry to expand and grow. The time saved from using more efficient technologies would free up millions of hours for rural people to spend more productively. And, if SIDS could decrease the amount of oil they had to import, the money saved in the long run could be spent building the country.

The variation in topography, geology, resources, land use, demography, climate, vulnerability and human resources indices, socio-cultural and economic characteristics amongst the islands and makes any generalised study on ACP SIDS a difficult one. It is therefore recommended that for the success of any programme a more specific study be carried out to assess the local needs, perceptions and resources as well as the existing economic, institutional, financial and political frameworks. This chapter provides a guideline to the main issues concerning ACP SIDS in terms of energy, environment, development, finance and policy and analyses the potential role of development assistance on the sustainable energy scene. The present energy situation in ACP SIDS is examined and the feasibility for sustainable energy systems, mainly renewable energy technologies and energy efficiency, is assessed. Site specific examples are included in the text where appropriate.

CHALLENGES AND OPPORTUNITIES

There are many and varied reasons for the disappointing results of most renewable energy technologies promoted in ACP SIDS, including:

1 The Dominican Republic, Haiti, Papua New Guinea, and Madagascar, although ACP countries, are not included in this analysis due to their land mass and/or geographical position.

- a lack of sufficient, accurate renewable energy resource data;
- a lack of detailed understanding of the economic and technical viability of these technologies in the setting of ACP SIDS;
- inappropriate institutions;
- scarcity of capital resources; and
- insufficient efforts in organising the active participation of the local community at the early planning stage.

It is important that adequate training in system operation and maintenance be provided on a long-term basis; that assistance on energy efficiency measures and renewable energy technologies be provided; and that support for local and regional organisations to plan, operate, maintain, finance, and expand the use of the technology be continued until true sustainability is achieved. Success depends on developing the right mix of regulatory, legal, and institutional frameworks; energy and related policies; private and public sector involvement; and financing mechanisms. Many models are possible and there is no one package that can be universally applied.

"Success depends on developing the right mix of regulatory, legal, and institutional frameworks; energy and related policies; private and public sector involvement; and financing mechanisms."

INSTITUTIONAL CAPACITIES

The lack of energy policy-makers, energy planners, project organisers, energy economists, energy system managers, engineers, and technicians is a continuing problem in ACP SIDS. Even for the more industrialised islands such as Barbados and Fiji, the issues of regulatory planning and control and human resource development in the energy sector have not yet been properly resolved.

With regard to renewable energy technologies, accessible after-sales service is crucial to the continued operation of any programme. Spare parts must also be readily available at reasonable prices.

The need to develop and strengthen national capacity to plan, monitor, and manage the energy sector in Pacific SIDS was recognised by the South Pacific Forum Secretariat (SPFS) and addressed through a European Development Fund supported programme, the Pacific Regional Energy Programme (PREP) (Zieroth, 1997).

PUTTING SUSTAINABLE ENERGY INTO NON-ENERGY SECTOR PROJECTS

Links should be developed between ministries and departments to inform and disseminate the use of sustainable energy in all other public sectors, such as education, health, agriculture, etc. The power industries also need to consider and develop decentralised and sustainable options. Renewable energy systems must be fully integrated into sectoral programme activities, and not treated as a low priority add-on. In most cases sectoral development priorities can be provided most cost-effectively and appropriately using RETs combined with energy efficiency measures. Popular examples are the provision of community lighting, lighting and water pumping for schools and hospitals, and the refrigeration of vaccines in remote health centres.

CREATING AND DISSEMINATING BETTER TECHNOLOGIES

In order for projects to be effective, they should not be over-engineered, which leads to high cost and increased complexity, nor should they be under-engineered, which leads to poor quality and failure to fulfil the needs of users. The early PV solar home projects in the 1980s in ACP SIDS suffered from some of these problems (Liebenthal et al., 1994). Most RETs and energy efficiency measures are now technically mature and proven. The availability of local resources and local capabilities to maintain the systems in the long term should be integral parts of all sustainable energy programmes.

Poor quality RETs (e.g. unreliable components, inappropriate design, improper installation, and poor maintenance) have hampered sustainable energy development in the past, undermining consumer confidence. Adequate technical specifications and standards, as well as monitoring systems to ensure compliance, could ensure the quality of renewable energy technologies in the market. All RET system components should be quality controlled to ensure sound and reliable operation, and best practice information for equipment installers and operator/users should be developed, translated into the local language and disseminated widely. Equipment producers and suppliers should also be encouraged to provide guarantees.

TECHNOLOGY TRANSFER AND ADAPTATION

Cooperation with neighbouring islands and other ACP SIDS to share experiences and expertise is essential for ACP SIDS. A number of networks enhancing South–South cooperation on development and environmental issues have been developed, but there is still little focus on factors relating to sustainable energy. "Piggyback" dissemination techniques using existing networks are particularly effective in rural areas.

New proven technologies cannot take off until there is a critical mass of (i) customers who know about the technology and (ii) technicians who can support it. In the Dominican Republic, Enersol Associates (an American NGO) spent several years running training programmes with local technicians and entrepreneurs to create a pool of people who had sufficient knowledge to install and maintain PV systems to a standard which propagated a good reputation. The private PV market is now beginning to thrive on the island (IT Power and Coopers & Lybrand, 1997). The private sector can be the major agent in the process of innovation/technology transfer.

"The availability of local resources and local capabilities to maintain the systems in the long term should be integral parts of all sustainable energy programmes."

It is crucial to note that no technical transfer can occur without consideration of non-technical issues that build on the knowledge and the experience of local people and their natural resources.

PROJECT IMPLEMENTATION

The dynamics of project implementation must be fully understood for effective and successful energy programmes.

Participatory appraisal methods are necessary at all stages of the programme. There is a special role for all groups, including women, youth, the elderly, indigenous people, and local communities as well as private sector and non-governmental organisations. Understanding the priorities of the community and whether the community is prepared to pay for the proposed system is crucial. The potential users and their community should be involved to determine their real energy needs and to participate in the decision-making processes of the programme.

Partnerships with local and regional organisations have been shown to be an important element in the implementation of PV solar home systems in a number of ACP SIDS (Cabraal et al., 1996).

Assessment of local resources including human resource capabilities is necessary to ensure effective understanding and implementation of all projects, and suitable human resources should be available in country. Self-investment, self-construction, and self-operation are all important elements (Cheatham, 1993).

Assessment of the most appropriate technology for local conditions is vital. Decentralised systems have proven to be more effective in dispersed communities in SIDS. Efforts need to be made to ensure, subject to national legislation and policies, that the technology, knowledge, and customary traditional practices of local and indigenous people are adequately and effectively protected and that these people benefit directly on an equitable basis.

Training/education at all levels for local installers, maintenance personnel, and users is important for the continued reliability of the systems. Training should be an integral component of any programme as the Tuvalu PV solar home systems experience illustrated (Liebenthal et al., 1994). Simple measures, such as the provision of a users' manual in the local language as well as a poster permanently fixed to a nearby wall or directly onto the system, can be used to reinforce important messages.

Establishment of sustainable infrastructures is crucial, as all of the above will rely on them. Accessible after-sales services are needed and spare parts must be available at reasonable costs and relatively quickly. If suppliers exist only in urban areas, it will lead to poor dissemination in rural areas. It follows that wide-scale dissemination usually requires strong marketing forces (which are more common in commercial operations than in development organisations).

Good quality installation, operation, and maintenance support services are necessary for all systems during and after the programme, if markets for the technology are to prosper and grow. Installation, operation, and maintenance should be undertaken by qualified local technicians.

Project assessment and follow-up should take place to ensure that the system is running successfully even after the programme has been contractually completed.

Developing an integrated project is time consuming, but the benefits in terms of the success of the project are considerable. Failure to carry out agreements to involve the community in discussions, decision-making, or evaluation would be counterproductive.

INFORMATION, PROMOTION AND DISSEMINATION

Lack of knowledge and misunderstanding have held back the wider use of RETs and energy efficiency measures. Without adequate information dissemination on sustainable energy technologies and measures, a number of misconceptions may be perpetuated. For building market confidence, it is crucial that governments include clear signals that demonstrate a commitment to sustainable energy. Government promotional campaigns backed up by sound information are also needed to raise the profile and explain the benefits of RETs and energy efficiency both to the business and finance sectors, and to households and the small-scale service sectors.

"Lack of knowledge and misunderstanding have held back the wider use of RETs and energy efficiency measures."

FINANCING

Experience has shown that to provide high quality and reliable energy supplies to ACP SIDS, capital investments in renewable energy systems are essential. Sustainable energy development, however, requires affordable credit financing, as many ACP SIDS do not have the financial resources to afford the relatively high up-front costs of renewable energy technologies. Traditional banks are rarely willing to lend small amounts for unfamiliar purposes. Innovative financing schemes are sometimes required to promote sustainable energy development successfully (see Boxes 13 and 14). Whatever financial mechanism is used, programmes must be financially sustainable if they are to expand and reach the rural population.

Mechanisms to mobilise financial resources are required and should include continued encouragement of private investment, small-scale grants, and micro-enterprise loans. Financing methods depend to a large extent on the type of borrower and

BOX 13

Box 13 Innovative Financing in Jamaica

The mandate of the Environmental Foundation of Jamaica (EFJ) is to promote and implement activities designed to conserve and manage the natural resources and environment of Jamaica, in the interest of sustainable development. The EFJ achieves this mission primarily through providing funds to NGOs and CBOs for implementing strategic environmental initiatives. The EFJ's uniqueness lies in the fact that it is an NGO-controlled mechanism. The control is built in at the level of governance (NGOs comprise the largest percentage of board membership), and at the level of membership, to whom the Foundation is accountable.

what security is provided by the lender. Different models and instruments (grants, soft loans, tax concessions, commercial loans, etc.) must be adapted to different needs and scales and should be explored to assess their suitability for the ACP SIDS situation. International aid funds must also be made available.

Not surprisingly, some of the following considerations on financing mechanisms for sustainable energy in SIDS duplicate those made for the SSA region (p.32-34), but with different emphasis due to the different conditions.

Medium-Scale Grid-Connected Systems

These systems are in the 1-20 MW range and are operated by substantial commercial companies (independent power producers). Investment risk is generally perceived as high, as most banks regard RETs as technically unproven and risky. Projects are relatively small, which pushes up overheads and other lending costs. RET schemes on this scale in ACP SIDS are very rare. Favourable tax incentives and power purchase agreements must be available to make the financing of RETs more appealing to lenders. Bundling individual projects together is another way of overcoming the problems of small loan size and weak developers/borrowers.

Small- to Medium-Scale Decentralised Systems

The use of local or regional resources can be promoted by exploring possibilities for increasing the use of economic instruments, promoting private sector investment, and using innovative financial mechanisms with a view to achieving an appropriate mix between traditional regulation and market-based mechanisms. For local operators developing and managing isolated RET mini-grids or clusters of individual RET systems, financing will depend on the operators creditworthiness. Large companies are typically not interested in small and remote schemes, and smaller companies are usually in relatively weak financial positions. Successful approaches that have overcome these problems include the bundling of consumer demand (to capture economies of scale) and financing through community associations, with payment according to energy services provided, and the delegation of public-sector responsibility to private-sector concessionaires.

Individual Small Systems

At the smallest scale RETs or energy efficiency measures cost a few hundred US dollars. A small minority of individuals, households, and small businesses can afford the systems outright or by using credit schemes. The main financing issue is how to serve this crucial market by persuading banks to manage numerous small loans and to lend without collateral or other guarantees against loan defaults. A variety of financing approaches have been developed including the following:

BOX 14

Box 14 Financing PV in The Dominican Republic

Enersol Associates realised that only 10% of the population could afford to pay cash for a PV system, but another 50% could afford monthly payments spread over two or three years. They have therefore instigated both credit schemes and leasing schemes which have enabled more consumers to procure a PV system. Importantly, leasing a system has allowed customers the option of trying out the technology before developing the confidence to purchase it some months later.

Financing via dealers Banks avoid the collateral problem by lending to dealers, who lend to purchasers using payment schemes compatible to their income. Dealers must bare the financial risks as well as the technical risks. Loans are usually for short periods at high interest rates (up to 40%).

Financing via Energy Service Companies ESCOs can also act as financing intermediaries. ESCOs typically require more effort to establish and larger funding levels, as they provide a more comprehensive installation and backup service to clients. ESCOs in ACP SIDS should be promoted, perhaps along the lines of the PV solar home systems in Tuvalu (Gregory et al., 1997).

Revolving funds (with grant support) A bank takes on the risk of operating a revolving loan fund, usually with start-up capital provided by a grant.

Loan aggregation via cooperatives To avoid the high cost of servicing many small loans, borrowers form a community association or extend the functions of existing associations. The bank then lends to the cooperative or leases the RETs to it in order to retain ownership of the equipment in case of payment defaults.

Concession funding for public sector objectives The government contracts and pays a local company to provide energy services to meet development objectives.

Payments for RET energy services Payments for RET services have been used to fund the recurrent operation and maintenance costs of RET development.

REDUCING COSTS

As in most other developing countries, electricity in ACP SIDS is available mainly in cities and surrounding rural areas, and in most of these countries electricity is generated from fossil fuel-based systems, since that is the most economical option for power generation in remote areas. Prices of petroleum fuels landed in Pacific SIDS are typically 200-300% of international values. The cost of distributing the fuels within each country is added on, resulting in a very costly operation, especially as most generation systems are on a small-scale to very small-scale basis. In most Pacific SIDS, for example, the cost of electricity generation using diesel-based systems with capacities of 5 MW to 20 MW is more than US$0.20/kWh. By comparison, electricity generation costs in industrialised countries average US$0.10/kWh to US$0.15/kWh (CSD, 1996).

"Prices of petroleum fuels landed in Pacific SIDS are typically 200-300% of international values."

Despite the subsidies that exist in many cases, rural energy supplies remain expensive. While high commercial energy costs hinder the development of rural industries and facilities, they also make renewable energy sources marginally more competitive (Ramani et al., 1992).

There are prospects for substantial reductions in the capital costs of RETs as different markets develop and the policy environment is developed to facilitate their market penetration. The price of PV modules, for example, decreased from US$20/Wp to around US$5/Wp between 1980-1995, and is expected to fall by at least a further 50% by 2005 (Gregory et al., 1997). Duties and taxes discriminate against sustainable energy technologies in many of the ACP SIDS, however, as they apply only to conventional solutions. Removing these barriers will improve the viability of RETs. The cheapest schemes remain those where the equipment is manufactured locally and the majority of civil works are completed by the owner with the help of local contractors.

Privatisation in the Power Sector

A market-driven approach can play an important role in developing a more dynamic investment climate, but the market for RETs and energy efficiency measures is not yet developed enough to support substantial industries. The changes in developed country structures, however, could be translated at least in part to the most developed ACP SIDS.

The options for ownership scenarios need to be addressed at all levels, including exploring the need for IPPs, long-term concessions, and private ownership schemes. Some private initiatives in ACP SIDS are already taking place and should be supported. In Vanuatu, for example, a private utility has operated on a concession basis for more than 50 years. In Fiji the sugar industry supplies surplus electricity to the Fiji Electricity Authority (FEA); micro-hydro schemes have been installed by Missions in Papua New Guinea (Zieroth, 1997) and by Small Industries' Centres in Tonga (Asian Development Bank, 1996). Jamaica began to deregulate its energy industry in 1990 (Wright, 1996), and the Pacific Regional Energy Assessment (PREA) now recommends a similar approach for Samoa (PREA, 1992).

It is also important to establish monitoring and regulatory requirements for the privatised industry. Jamaica developed the Office of Utility Regulation (OUR) in 1996 (Wright, 1996), but no such framework yet exists in the Pacific SIDS.

Energy Trade

Greater regional cooperation in energy trade, harmonisation of technical standards, common frameworks for energy investments, better exchange of information and experience, and shared energy training and organisational capacity building is important in achieving progress toward a sustainable energy future. The development of bodies similar to the Pacific Power Association (PPA), through which utilities pool resources and expertise for a common benefit and ultimately gain improved access to international power sector programmes (Cheatham, 1993), should be considered.

ENERGY STRATEGIES IN SIDS TODAY

It is important that all programmes take into account the major development issues that will confront island states in the coming decade, including:

- rapid urbanisation;
- increased population growth;
- urban unemployment;
- deteriorating environmental conditions (waste disposal, pollution);
- impacts caused by climate change (enhanced level of natural disasters, sea-level rise, land degradation, etc.);
- increased frequency of natural hazards;
- rising energy prices for commercial fuels;
- increased energy demand;
- continuing dependence on foreign assistance; and
- vulnerability of ACP SIDS to changes in global energy prices, and external political and economic situations.

ENERGY SYSTEMS

Throughout the region, transmission and distribution losses are high and power and fuel cut-offs are frequent. The limited or scarce indigenous commercial energy resources and the difficulties of securing energy supplies, coupled with the shortage of trained human resources, are thought to exacerbate the many constraints in the economic and social development of island states. The introduction and deployment of renewable energy technologies and energy efficiency measures that harness, in a sustainable way, natural island resources, can play an increasingly important role in meeting the energy requirements of island states, and thus smoothing their path to development.

> **"The transport sector accounts for the greatest commercial energy consumption in most ACP SIDS; in the Pacific it accounts for 70% of all imported petroleum products."**

Traditional biomass fuel (fuelwood and crop residues) is the main source of energy for the majority of island states, and its principal end uses are for cooking and crop drying. Accessible supplies of fuelwood are becoming increasingly scarce in some areas, however, because of the pressures placed on land resources by agriculture, timber production, and urbanisation.

Petroleum products often account for more than 12% of imports, and are used mainly for transport and electricity generation. The transport sector accounts for the greatest commercial energy consumption in most ACP SIDS; in the Pacific it accounts for 70% of all imported petroleum products (UN, 1994). The share of imported petroleum used for electricity generation varies widely among the island states, from less than 25% to almost 100%; the average is more than a third. Total electricity losses in the region are about 995 TWh (EIA, 1996) or 7% of the total electricity generated. It is crucial that efficient and reliable electricity distribution networks are put in place or improved throughout ACP SIDS.

There has been a gradual increase in the use of renewable energy technologies such as modernised biomass technologies, micro-hydro, PVs, solar thermal, and wind, but their contribution to the total energy mix is still minimal. The section "Renewable Energy Technologies and Resources" (p.66) describes the extent to which these technologies have been used in the region.

It is predicted that ACP SIDS will continue to be heavily dependent on petroleum fuels and biomass both in the short and medium term (UN, 1994). The detrimental impacts on the environment and the financial burden placed on island states through the current inefficient use of these fuels needs to be addressed through the application of appropriate technologies, national energy policies, and management measures.

COMMERCIAL ENERGY

Petroleum will remain the single most important commercial energy source for island states in the foreseeable future, despite the continuing attempts to develop alternative sources of energy. Petroleum products in most ACP SIDS are imported at some of the highest prices in the world, usually at costs that small island economies can ill afford. Between 1978 and 1981 petroleum fuels more than tripled in cost. Up to one-third of Jamaica's foreign exchange earnings were used to pay for imported fuel. Transporting fuel to remote stations in outer islands is also expensive and shipments are irregular. The Niuas islands in Tonga are serviced by a ship every six months. In addition, many of these outer islands are without wharves or jetties and fuel must be floated ashore in drums, which often results in spills and environmental damage (JICA, 1998).

Petroleum imports in Pacific SIDS are sourced primarily from Singapore refineries, but also from Australia and the USA, while in the Caribbean SIDS, petroleum imports are from Venezuela, Trinidad and Tobago, and/or Mexico. The remoteness and size of the ACP SIDS petroleum market makes service and transport expensive, and reduces the number of potential suppliers, minimising competition.

The total annual commercial energy consumption in ACP SIDS is 182,510 GWh. The level of variation in energy consumption ranges from 264 GWh in Vanuatu to 95,196 GWh in Trinidad and Tobago. Electricity consumption also varies considerably, from a mere 7 GWh in Kiribati to 5,696 GWh in Jamaica.

Coal is used only to a small extent in the larger countries like Jamaica and Fiji. Commercial biomass is used for electricity generation only for small rural power needs and by the sugar industry. Biomass feedstocks include bagasse from the sugar factories and residues from coconut plantations.

NON-COMMERCIAL ENERGY

Fuelwood, charcoal, and bagasse are the main energy source for the largely subsistence island state communities. This traditional biomass is used mainly for household cooking and crop drying, particularly in rural households.

Surveys in the mid-1980s in Fiji showed that about 98% of rural homes and 49% of urban homes cook with fuelwood for some, if not all, of their meals. Surveys in various other Pacific SIDS have also revealed a high degree of fuelwood use in urban areas to supplement commercial cooking fuels such as kerosene and liquid petroleum gas. All fuelwood for cooking is obtained at no financial cost from surrounding vegetation cover, agricultural residues, and more recently from natural forests. Few island states have substantial vegetation cover and/or dedicated forestry plantations to sustain the growing fuelwood demands. At the current rate of population increase, the demand for fuelwood may outstrip the vegetation regeneration rate in many island states in the near future. Already, there are severe island-wide fuelwood shortages in some densely populated low-lying islands such as Funafuti in Tuvalu and Tongatapu in Tonga. In larger high islands, such as Viti Levu in Fiji or Guadalcanal in the Solomon Islands, the shortage is restricted to pockets of densely populated areas. There is an opportunity to develop dedicated sustainable forestry plantations using fast-growing indigenous plant species in most ACP SIDS to ensure a sustainable supply of fuelwood.

"Petroleum will remain the single most important commercial energy source for island states in the foreseeable future, despite the continuing attempts to develop alternative sources of energy."

The contribution of energy from renewable sources in ACP SIDS is increasing, although their share of total energy supply remains significantly below their potential. At present, around 25% of primary energy consumed in Barbados comes from renewable sources; this could increase to 50 to 75% by the year 2015, using mainly solar, biomass, and wind energy (CDB, 1997a). Most island states have abundant solar and ocean resources and considerable wind and hydropower potential. Many ACP SIDS also have potential geothermal resources. Given the remote location of many ACP SIDS, their low energy demands, and the high costs of oil imports, the development of renewable energy sources and energy efficient mechanisms is ideal. The potential for renewable energy technologies is explored in the section "Renewable Energy Technologies and Resources" (p.66).

ENERGY DEMAND

Total energy consumption across the ACP SIDS increased gradually between 1982 and 1992, from about 7 million to 8.4 million tonnes of oil equivalent, an average annual increase of less than 2%. Pacific ACP countries are experiencing a growth in energy demand of around 6% per annum. Not all ACP SIDS have increased their total energy consumption. In fact, there have been more cases of declining per capita energy consumption, as increasing demand from expanding populations has outpaced energy supply. The average per capita electricity consumption in ACP SIDS of 840kWh per annum (CIA, 1996) is barely one tenth of the corresponding figure for OECD countries (see Figure 6).

Control of electricity demand through the targeted promotion of efficient end-use, demand-side management, and improved transmission and distribution electricity networks offer the least-cost, most secure, and environmentally benign means of satisfying the rapidly growing demands for electricity. This is recognised in many sustainable energy studies (Waide, 1994).

Energy demand for the transport sector is also increasing at a considerable rate. Efficient transport mechanisms are needed and the use of alternative fuels is worth exploring.

EMERGING VISIONS OF ENERGY AND SUSTAINABLE DEVELOPMENT

The major energy concerns for ACP SIDS are:

- environmental consequences;
- level of rural accessibility to energy services;
- vulnerability to external petroleum, economic, and political shocks;
- high petroleum costs;
- increasing energy consumption levels; and
- the inefficient use, transmission, and distribution of energy.

Carefully integrated strategic energy plans should address the following:

- energy security;
- energy access;
- energy diversification;
- environmental and political targets; and
- technology leapfrogging.

"Surveys in the mid-1980s in Fiji showed that about 98% of rural homes and 49% of urban homes cook with fuelwood for some, if not all, of their meals."

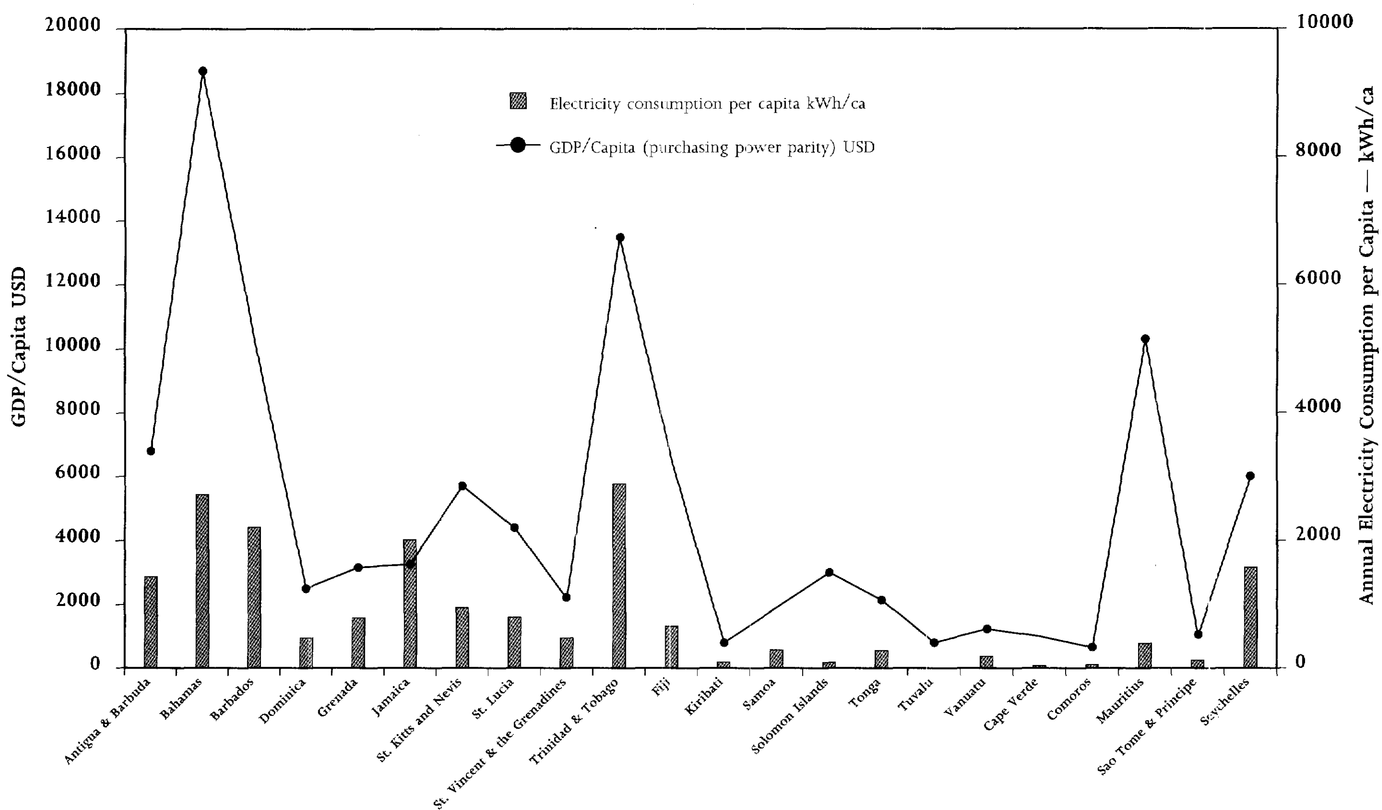
An integrated energy management programme should promote sustainable energy technologies, demand-side management, and efficient methods of energy consumption.

A number of sustainable energy programmes have already been developed in ACP SIDS. In 1985 the **Indian Ocean Commission (COI)** embarked on a programme to develop new and renewable energy sources in Madagascar, Mauritius, and the Seychelles called "Développement des Energies Nouvelles et Renouvelables dans les pays du sud-ouest de l'Océan Indien" (DENROI) (CREIO, 1998). Activities in the region should increasingly focus on developing integrated sustainable energy programmes to address the needs of ACP SIDS communities.

ACCESS TO ENERGY SERVICES

Access to energy for all is one of the most important development objectives for ACP SIDS. The electricity market in ACP

Figure 6. GDP Per Capita (PPP) and Electricity Consumption per Capita for Surveyed SIDS



Data for Antigua and Barbuda, St.Kitts & Nevis, Kiribati, Solomon Islands, Tonga, Vanuatu and Sao Tome & Principe from (UNDESA, 1994). All other data from (CIA, 1996)

SIDS tends to satisfy only the needs of existing solvent consumers, excluding a significant proportion of the population. Because of the low incomes and small markets the economics of supplying rural areas are poor, and there is no incentive to supply modern energy services to them.

In Cape Verde the existing electricity networks currently supply only 30% of the population and future growth is constrained by the fact that insufficient revenues are likely to be raised even to cover the costs of running the existing diesel-powered plants. Nevertheless, to achieve their development objectives, aid agencies and local communities have focused on extending the electricity networks out from the three main urban centres (EU DGXVII – Thermie, no date).

ENERGY SECURITY

ACP SIDS are vulnerable to interruptions in fuel supply as they rely so heavily on imported commercial fuels. The oil shocks of the 1970s which led to the interruption of supply of petroleum products to ACP SIDS illustrated the serious impact that shortages would have on regional economic activities. It is crucial, therefore, to develop an energy system that is secure and within economic reach of the island communities.

Security of energy supplies in ACP SIDS depends not only on the geopolitical factors that govern access to energy and the price of energy, but also on the safety and ecological criteria of the alternative supply options. Security of energy supplies will improve as local resources are sustainably developed. The use of renewable energy technologies and energy efficiency mechanisms can play a major role in maintaining energy security.

ENERGY DIVERSIFICATION

As ACP SIDS rely on costly, vulnerable supplies of imported petroleum and increasingly scarce fuelwood, there is a real need to diversify the energy mix and increase self-reliance in ACP SIDS. The use of renewable energy technologies combined with energy efficiency measures could provide this sustainable and diversified energy mix.

SUSTAINABLE ENERGY

Satisfying energy demand in a sustainable manner is likely to involve a fundamental shift toward a greater diversity of energy supply alternatives. In the past there have been attempts to develop renewable energy technologies in ACP SIDS. These have mainly been small-scale, stand-alone units in dispersed settings and they have had limited success, for three main reasons: (i) technologies were used that were not yet fully proved and/or too technically complex for rural applications; (ii) no training was given to local communities; and (iii) there was no consultation with local communities. So far only small-scale hydropower, fuelwood, bagasse, and charcoal contribute significantly to the overall energy needs of ACP SIDS. Recognising the potential role and benefits of RETs is important, but any new programme should first address the reasons for past project failure.

THE ROLE OF DEVELOPMENT COOPERATION

The international community tries to support the process of formulating and implementing long-term sustainable development plans and programmes. Historically, ACP SIDS have depended heavily on overseas development assistance to finance their social and economic development activities. There is still a need for external development assistance to enable ACP SIDS to address and overcome the full barriers to sustainable energy development, but there is also a growing determination throughout ACP SIDS to move towards a much greater degree of economic self-sufficiency.

"Recognising the potential role and benefits of RETs is important, but any new programme should first address the reasons for past project failure."

Development assistance to ACP SIDS amounted to US$1,046 million in 1991, down to US$734 million in 1992. Of that, 79% was assistance from bilateral donors, and 21% from multilateral sources, including UN agencies and intergovernmental organisations (UN, 1994). In terms of distribution, assistance from multilaterals has tended to be more evenly spread among ACP SIDS than bilateral flows, which have tended to favour fewer countries (UNDP, no date). The largest beneficiaries were Papua New Guinea (US$339 million) and Jamaica (US$325 million), followed by Trinidad and Tobago, Mauritius, and Cape Verde. The value of assistance allocated to energy resources was US$143.3 million, or 8.1% of total assistance to ACP SIDS; 0.4% of total assistance in all programme areas went to climate change and sea-level rise projects.

Split between 22 countries, (and not split evenly in practice), US$143.4 million does not go very far: US$6.52 million per country, or about US$16 per person. It is vital that policy-makers from across the development spectrum recognise the contribution that sustainable energy services could make to widespread sustainable development, and fund it accordingly. The nature of this funding will be just as important as the amount. Capital expenditure on hardware will need to be funded in some cases, but resources need to be allocated in such a way that lasting capacity is built in-country to research, finance, develop, and implement energy innovations in the future.

The amounts provided through grants are generally too small to run a project on an engineering scale, such as constructing a hydro plant or installing wind power stations. Grants are more widely used to support small projects, such as energy resources surveys, feasibility studies, and training courses.

In order to mobilise loans, lenders must be reassured as to the creditworthiness of the borrower and the loan operation must be large enough in size to justify the bank's appraisal costs. This becomes particularly difficult as most sustainable energy projects tend to be small and perceived as high risk. Loan applications are time consuming and, as they tend to support large-scale development projects, rarely successful on a small-scale. The World Bank's procedure for loans, for example, takes six years for a proposed project to be approved and funded.

PRIORITY AREAS IN ENERGY COOPERATION FOR SUSTAINABLE DEVELOPMENT

Each ACP SIDS would benefit from having a sustainable energy policy and a Renewable Energy/Energy Efficiency Master Plan. Support for the preparation of Master Plans through existing regional organisations is a key area for technical cooperation.

REFORMING ENERGY PRICES, TAXES, AND SUBSIDIES

- Renewable energy and energy efficiency technologies are discriminated against in the market because they are often subject to import duties and taxes. When combined with the subsidies that conventional energy sources receive, this puts REEFs at a sharp disadvantage. Because REEFs already have high up-front costs compared to grid electricity, these taxes make them seem even more expensive. As REEFs are the most efficient in the long term, the government could promote them by subsidising them as an incentive.

"It is vital that policy-makers from across the development spectrum recognise the contribution that sustainable energy services could make to widespread sustainable development, and fund it accordingly."

SUPPORTING INNOVATIVE FINANCING

- Financial institutions in some ACP SIDS have no experience in providing loans and credit for renewable energy and energy efficiency projects and consider them high risk. Sensitising the banking sector to sustainable energy projects through information seminars is another key area for technical cooperation. Links with financial organisations with existing experience would be beneficial.
- Developing appropriate financing mechanisms to provide end-users and enterprises with credit should be

considered a high priority. The possibility of bundling loans through financial intermediaries should also be considered.

- Major multilateral and bilateral funding should have a pro-active policy for lending for sustainable energy projects. Procedures and mechanisms should be clearly defined and documented.

UPDATING INSTITUTIONAL, LEGISLATIVE, AND REGULATORY ENVIRONMENTS

- It is important that activities to introduce renewable energy technologies and energy efficiency should have parallel activities supporting standards, technical specifications, guidelines, codes of practice, and guarantees. These parallel activities should be developed on a regional and international basis. Various international initiatives are underway including the PV Global Accreditation Programme (PV-GAP).

"The strengthening of indigenous capacity should be aimed at both government departments and the private sector, to build a sustainable sector to specify, supply, install, operate and maintain equipment."

PROVIDING INFORMATION

- Ensure adequate information dissemination on sustainable energy technologies and measures including promotional campaigns backed by sound information.

BUILDING CAPACITY

- Encouraging the establishment of viable businesses in sustainable energy is key to sustainable development. Experiences with the UNDP FINESSE initiative, where support is provided to identify and develop bankable business plans, has been good. Viable projects could include ESCOs, energy management companies, wind-farm developers, etc.
- Initiatives of the GEF and IFC in this area may be appropriate to encourage viable and sustainable businesses. The GEF/IFC Photovoltaic Market transformation initiative (PVMTI), for example, provides concessional finance to private sector companies to stimulate the PV sector and accelerate commercialisation of PV technology. The model may be appropriate for SIDS.
- The strengthening of indigenous capacity should be aimed at both government departments and the private sector, to build a sustainable sector to specify, supply, install, operate, and maintain equipment. Many of the electricity utilities also need to strengthen their capacity on renewable energy, energy efficiency, and demand-side management issues. Because SIDS are remote and many have very small populations, it will not always be possible to have people trained in every necessary skill. Innovative solutions, such as the use of new information communication technologies should be investigated.
- It is important to involve all sectors of the community in the decision-making processes of the programme. Understanding the priorities of the community and learning whether the community is prepared to pay for the proposed system is crucial, as is ensuring that the community is able to run their system and plan for the future.
- The training of local installers, maintenance personnel, and users is important to the continued reliability of the systems. Training should be an integral component of any programme.

COOPERATION AND COLLABORATION

- The relatively small economies of many ACP SIDS means that regional cooperation among islands with similar conditions and at similar stages of development should be encouraged and supported to avoid unnecessary duplication (See Box 15). Initiatives could include the development of regional information points, networks, bulletins, internet conferencing, etc. which can be achieved at a relatively low cost.
- It is apparent that much can also be gained from cooperation between regions (for example between CARICOM and SOPAC) so that everyone gains from learning experiences with existing projects and in the development of new projects.

TECHNOLOGY CHOICE AND DEVELOPMENT

- The wider considerations of using renewable energy in energy planning is key to implementing sustainable energy policies. PVs for individual household electrification and wind electric systems for both individual households and contributions to grid power are economically attractive in many ACP SIDS and are commercially available.
- The inefficient and unsustainable use of biomass can be greatly reduced by using efficient cooking stoves, or promoting the development of dedicated energy plantations and modern biomass energy technologies to take advantage of the agricultural residues that exist on many island states.
- Alternative biofuels can, in some cases, be produced and promoted for the growing transport sector, if incentives are provided to use them.
- Solar water heating can make an extremely important contribution to sustainable development, particularly in the growing hotel sector, but also for its potential to develop into a local manufacturing industry.
- The energy locked up in the ocean that surrounds islands

Box 15 Regional Cooperation and Coordination in SIDS

Since the United Nations Conference on Environment and Development in Rio de Janeiro in 1992 and the Declaration of Barbados in 1994 a number of national and international organisations and networks concerned with safeguarding the present and future survival of ACP SIDS have developed.

Concerted efforts and commitments by national governments as well as national and international organisations have been made in some ACP SIDS to develop effective sustainable development programmes. Their success in the past has been limited.

The **SIDS Programme of Action (SIDSPOA),** which translates Agenda 21 into specific policies, actions, and measures, aims to: (i) address the constraints to sustainable development and (ii) enhance national self-reliance capacities. The region has begun to implement over 700 projects and programmes under SIDSPOA, and a full review of the Programme of Action is scheduled for April 1999.

Alliance of Small Island States (AOSIS) is an established *ad hoc* lobby and negotiating voice for a coalition of 42 small island states which share common objectives on environmental and sustainable development matters. The objective of AOSIS is to safeguard the survival of small island states with a focus on climate change issues.

The **Indian Ocean Commission (COI)** is one of the main active organisations in the Indian Ocean. Its objectives are to (i) strengthen the bonds of friendship and solidarity among the people and (ii) improve the standard of living of the population through co-operation, especially in the diplomatic, economic, social, cultural, and technical fields.

The South Pacific Forum Secretariat (SPFS) has stressed the need to adopt a global perspective with regard to the development of economic policies, in particular:

- ensuring the achievement of maximum sustainable economic returns on the region's resources;
- enhancing development of the private sector;
- responding to changing global economic conditions;
- increasing the level of value-added production; and
- developing regional approaches to international trade.

The Forum leaders have recognised the development of a Vulnerability Index as a high priority for all organisations in the Pacific SIDS.

The objective of the **South Pacific Applied Geoscience Commission (SOPAC)** is to improve the well being of the peoples of Pacific island member countries through the application of geoscience to the management and sustainable development of their non-living resources. SOPAC's main roles are to gather new data to help member countries to assess and quantify their natural resources, and to build national capacities in the geosciences to move towards self-sufficiency in the long term. The South Pacific Forum Secretariat's Energy Division has been transferred to SOPAC.

The **Caribbean: Planning for Adaptation to Global Climate Change (CPACC) Project** has the overall objective of supporting Caribbean countries in preparing to cope with the adverse effects of global climate change, particularly sea-level rise, in coastal and marine areas through vulnerability assessment, adaptation planning, and capacity building linked to adaptation planning (CDB, 1997b).

The **Caribbean Community and Common Market (CARICOM)** was established in 1973. It comprises 15 member states, and has three key objectives: (i) economic cooperation through the Caribbean Common Market; (ii) coordination of foreign policy among the independent Member States; and (iii) common services and cooperation on matters such as health, education and culture, communications, and industrial relations.

BOX 15

The **Latin American Energy Organisation (OLADE)** is an international public cooperation, coordination, and advisory energy organisation aimed at ensuring the integration, protection, conservation, rational development, marketing, and defence of the region's energy resources.

The **Unit of Sustainable Development and Environment, Organisations of American States (OAS)** has four basic functions: (i) to provide support in the areas of expertise to the fora organs of the OAS, and to participate in pertinent technical dialogue in hemispheric and subregional conferences, workshops, and seminars; (ii) to formulate and selectively execute technical cooperation projects within its field of technical competence; (iii) to facilitate the exchange of information related to sustainable development and environment in the region; and (iv) to support efforts to promote coordination and cooperation among agencies in the pursuit of goals established by the member states of the OAS.

There is a need for increased coordination, sharing of information, and experience between these different programmes and organisations. In addition information on all sustainable development programmes should be centrally available to facilitate information flow and exchange.

states is enormous and harnessing the energy in marine currents could be particularly important for some ACP SIDS. The potential of marine current turbine technology is heavily dependent on the right site conditions and its applicability must be assessed on a case-by-case basis. Most of the technology development work has taken place in Europe, but by setting up research and development partnerships in which ACP SIDS are full participants, there is the opportunity for island states to be on the cutting edge of marine energy technology.

- Research on renewable energy use for desalination should be encouraged and cooperation with Middle Eastern organisations may be appropriate.
- ACP SIDS need to assess and quantify their potential sustainable energy resources.
- Priority should be given to saving energy rather than generating energy where possible, and to improving energy efficiency through the use of demand-side management and more efficient appliances. Specific recommendations support the identification of the potential for energy efficiencies (energy savings and cost implications) and decision-maker and public awareness campaigns. Action must be taken to reduce the energy losses from generation, transmission, and distribution networks.

RENEWABLE ENERGY TECHNOLOGIES AND RESOURCES

The renewable energy resource endowments of ACP SIDS vary greatly. All have substantial solar and ocean resources, which have still not been developed to their full potential, if at all. Wind potential varies significantly with location, both within and between countries. Hydroelectric power is a possibility only for some islands. Biomass endowment is common but distributed unequally between island states. Studies of the potential for geothermal, ocean thermal energy conversion, and wave energy are still to be undertaken.

"Priority should be given to saving energy rather than generating energy where possible, and to improving energy efficiency through the use of demand-side management and more efficient appliances."

The renewable energy technologies and resources that appear to be most promising in the short term are:

- more efficient use and production of biomass;
- more efficient end-use consumption of electricity;
- demand-side management;
- improved generation, transmission, and distribution networks to reduce losses and increase efficiency;
- biofuels (derived from the sugar industry or from copra) to substitute petroleum fuels used in the transport sector;
- efficient transport mechanisms;
- solar PVs, particularly for remote islands;
- solar water heaters, particularly for urban areas and the growing hotel industry;
- mini/micro-hydropower plants, where adequate sites are available; and
- wind turbine generators, depending on favourable wind regimes.

In the long term, tidal, ocean thermal, and wave power may prove to be substantial energy sources, but they have not yet been commercially developed.

"The amount of land being cleared for agriculture and timber production, and the increasing pressures of rapid urbanisation have in many cases led to a shortage of traditional biomass feedstocks."

BIOMASS

Of the new and renewable sources of energy, biomass energy is the greatest, but in most ACP SIDS current use of traditional biomass fuel is inefficient and unsustainable. Cooking, especially in rural households, depends on fuelwood and crop residues. Almost all fuelwood for cooking is obtained at no financial cost from surrounding vegetation cover. This makes quantifying the amount of biomass consumed difficult. The amount of land being cleared for agriculture, timber production, and the increasing pressures of rapid urbanisation have in many cases led to a shortage of traditional biomass feedstocks. The amount of time spent by women and children gathering fuelwood is increasing as the shortage becomes more evident. The amount of traditional biomass used within the household must be quantified in order to fully gauge the extent of fuelwood use and dependence and the impact on surrounding fuelwood resources. It is also important to stress the need for (i) energy efficiency measures to reduce energy consumption within the household, and (ii) integrated forest management techniques to ensure a sustainable supply of fuelwood.

There have been efforts in the Caribbean, with assistance from the German government, to improve charcoal production, improve cookstoves and bakery ovens, and to increase the use of residues from rice-milling and sawmilling. The programme is active in Dominica, Grenada, Guyana, and St Vincent and the Grenadines (CDB, 1990).

Few ACP SIDS have any sizeable commercial production of fuelwood and whatever is available in the market appears to be purchased by relatively affluent households, for convenience of supply or for special occasions. Also widely used are crop residues from coconut (shells, husks, and stemwood), coffee, cocoa, maize, cassava, peanuts, and rice plantations.

In those island countries where sugar cane is grown in large quantities, for example Barbados and Jamaica, bagasse is used as fuel for sugar mills. In Fiji, about 30% of the peak electricity demand is produced from bagasse, including the electricity used in the sugar mills themselves. Most ACP SIDS plan to expand their use of this energy source, for example, Mauritius has initiated a Bagasse Energy Development Programme.

Waste is a major problem for island states, so biogas systems could play an important role in reducing organic waste build-up while producing useful biofertiliser and gas.

Biofuels are used in small-scale agro-industry for process heat to dry copra, coffee, tea, fish, and other foodstuffs, and there is a potential role for biofuels as a substitute fuel for the growing transport industry.

Wood-fired Power Stations

An economic form of fuelwood is the waste from timber mills and crop residues. Such generation is currently taking place in Fiji, but it is not yet fully exploited. There are a significant number of sawmills in Fiji and the Department of Energy thinks there could be great potential in using sawmill wastes for power generation, and that there may also be potential for the cogeneration of power using steam from sawmills.

There have also been serious proposals to establish wood-fired steam-generating stations in Pacific SIDS. Most of these will require fuelwood plantations, and some ACP SIDS have sufficient land for these.

Waste coconut husks and shells can also provide a feedstock for gasifiers.

Biogas

Biogas from sewage, animal manure, and fish wastes can be used for cooking, lighting, or as a substitute fuel in internal combustion engines. Most ACP SIDS lack central sewage systems, established fish-processing plants, or animal-raising compounds of sufficient size, but the potential for biogas systems is still substantial in some ACP SIDS. Since 1983, numerous biogas systems of various sizes and designs using different feedstocks have been built in Barbados, Guyana, Jamaica, St Lucia, St Vincent and the Grenadines, and Trinidad and Tobago with assistance from the German government (CDB, 1990). Three of these countries have national biogas programmes.

Small biogas plants were installed in a number of Pacific SIDS during the high oil prices of the 1970s and 1980s. None of the plants in Tonga or Tuvalu were successful, however, because there was not enough feedstock (JICA, 1988). More recently, biogas has been investigated as a waste disposal option for Samoa (Rivard, 1993).

"The experience of Pacific SIDS suggests that PVs could play a substantial role in the electrification of rural areas in the near future."

Programmes should assess the local resources and the potential for biogas operation in communities or individual households in light of the past biogas programme failures.

Biofuels

During the 1980s there was considerable interest in a number of Pacific SIDS in using copra oil as a fuel in diesel engines. Trials have proved this to be technically viable, and in Fiji and Tuvalu, for example, small diesel generators have been running on crude copra oil. In Samoa a large, slow-speed 250 kW diesel generator was run on pure crude copra oil, as were a number of the Electric Power Corporation's heavy-duty trucks.

Most Pacific SIDS export either copra or copra oil, or would be capable of doing so. Technically there is little or no problem in adding 20% copra oil to diesel fuel, and a favourable pricing system would allow crude copra oil to be used extensively (JICA, 1998). Bagasse from the sugar industry can also be efficiently converted into an alternative fuel for the growing transport sector.

SOLAR

ACP SIDS have a high and relatively constant supply of solar energy (ranging from 4 to more than 6 kWh/m2/day). The principal uses of direct solar energy in most ACP SIDS are for heating water (urban houses and commercial establishments) and drying crops for consumption or processing, as well as for water purification and distillation on a limited scale.

Photovoltaics

Solar energy is also used for PV systems to provide electricity in some rural areas and remote islands. PV systems have been used on many islands, mainly in dispersed settings, for telecommunication transmission and reception, lighting, small medical refrigerators, and water pumping, and their use in ACP SIDS has been increasing.

PV systems have been distributed to some village households, village schools, and community halls, for water pumping and to power satellite earth stations. In the Pacific region, the Small Energy Projects Programme (SEPP) and the EU Lomé II PV follow-up programme have supported solar PV projects, mainly household lighting systems. Some systems installed in rural communities have been unsuccessful, but by integrating participatory appraisal methods into the programme and with improved financing mechanisms, PV systems are more than likely to be successful.

The varied experience of Pacific SIDS in using and maintaining PV systems suggests that with the implementation of a strategic energy programme the use of such systems could play a substantial role in the electrification of rural areas in the near future. Solar home systems (SHSs) can provide reliable power more cheaply than diesel systems in small, remote villages for consumers with a limited number of appliances. Market niches for PV applications include solar lanterns, water pumping, and desalination, as well as bio-climatic interventions (EC DGXVII, 1997).

BOX 16

Box 16 PV in the Republic of Kiribati

Solar energy is the most widely used renewable energy resource in Kiribati. The Energy Planning Unit (EPU) is the main institution for energy planning and renewable energy administration. The Solar Energy Company (SEC) began operations in 1984 with initial support from the Foundation of the People of the South Pacific (FPSP) and funding from USAID, with the long-term goal of raising revenue and becoming a self-financing organisation. The SEC is responsible for the marketing of solar energy products to private users on outer islands for lighting and other uses.

SEC's functions have included the installation of solar systems, provision of a maintenance service for customers, and collection of fees for service. Solar energy systems provided by SEC operate more efficiently and reliably and are more affordable than those installed before the SEC's inception. This is mainly because the solar PV systems are professionally installed, proper maintenance is provided on a full-time basis, and a monthly tariff is paid by users.

The Island of North Tarawa has 156 solar PV systems. Of these, 100 were funded by the EU, the rest funded by the Japanese Aid Agency (JICA). There are two technicians to maintain them. The SEC monthly tariff covers the replacement of all equipment (including storage batteries) and maintenance. Each month, the householder has to pay AUS$9 (which is affordable for most Kiribatians).

To date, PV systems have been installed in all the health centres on the 19 islands to provide power for vaccine refrigeration, lights, and an emergency two-way radio. Water supply for 10 rural communities in Kiribati is provided by PV water pump systems, and 10 more systems were to be installed in 1995. At present, a total of 310 solar home systems have been installed, and other PV power systems have been installed on many of the 26 inhabited islands of Kiribati for communication purposes. A solar hot water system is used at the Otintaal Hotel in Tarawa.

In 1996, the French government announced funding for an AUS$1.3 million project to install a further 300 solar home systems; in 1998 UNDP will possibly fund a further 1000 SHSs at a cost of AUS$3 million. A further SEC venture involves the establishment of a solar light manufacturing facility in Kiribati in 1997 with German government funding. At present, the solar lights used in Kiribati are made in Australia and New Zealand, and cost about AUS$30-40 per light.

Box 17 Solar Drying in the Caribbean

The University of the West Indies/Inter American Development Bank Solar Drying Project was launched in 1996. The project intends to disseminate over the entire CARICOM region the research work in solar drying carried out at the University of the West Indies for the past 20 years. Its main target groups are the medium-to-large-scale farmer and operator.

The first dryer was built in Trinidad; it has a capacity of 100 kg of fresh produce and will dry a load in two to three days. Solar dryers are intended for operators who are drying products such as herbs, fruit, fish, root crops, and timber on a small commercial scale. The project has also designed large-scale dryers, and through the project, large-scale dryers will be set up for copra in Trinidad and Tobago and cocoa in Grenada. Jamaica has also expressed interest in solar agricultural dryers.

BOX 17

The use of PV systems in ACP SIDS is increasing, largely due to the decrease of capital, installation, and operating costs. Box 16 summarises experiences with solar energy in Kiribati. Solar systems have been installed in many islands of the Cape Verde archipelago, and in Jamaica approximately 45 solar street lamps have been installed (Headley, 1998). In Tuvalu, PV-based electricity is used in 40% of households in the outer islands for lighting. Customer growth in Tuvalu is limited only by the availability of new PV units, which is constrained by a lack of capital and a reliance on development assistance (Gregory et al., 1997).

Solar Thermal

Solar thermal energy is used to heat water for urban houses and commercial establishments, dry crops, and purify and distil water on a limited scale. In recent years, the use of solar thermal has increased considerably in the ACP SIDS, particularly in upper-income homes and commercial establishments.

In the Caribbean, solar thermal technology is one of the most widely used renewable energy applications. The Solar Water Heater (SWH) industry of Barbados is the best known example of a renewable energy technology in the Caribbean. More than 23,000 SWHs were installed in Barbados between 1974 and 1992 (Headley, 1998). By the end of 1997 there were 30,200 systems installed (Headley, personal communication).

SWHs have also been installed in Mauritius and the Seychelles. Tourism is a rapidly increasing industry in most ACP SIDS so the potential market for SWHs in hotels is large.

In Trinidad & Tobago over 50 solar distillation stills have been installed and a similar number have also been installed in Jamaica (Headley, 1998).

Solar Drying

Solar drying is a simple technology but one that can be made much more efficient and could be disseminated widely in all ACP SIDS (see Box 17). The costs for dryers have usually been prohibitive, as the machines were usually imported and energy costs were high. Only the sugar industry had the capacity to justify large-scale dryers. With locally manufactured solar dryers, however, the problems experienced in the past can be overcome.

"In the Caribbean, solar thermal technology is one of the most widely used renewable energy applications."

HYDRO-ELECTRIC POWER

Generally it is only the islands with highlands that have hydroelectric power potential, not atolls that rise only a few metres above sea level. In 1982 a Mini-Hydro Resource Inventory was undertaken to assess the potential in Pacific SIDS.

Hydropower resources for primary electricity production in ACP SIDS range from zero in the low-lying islands (e.g. Tuvalu), to moderate (many island countries have mini-hydro power capacity of a few megawatts), to extensive (e.g. Fiji, Solomon Islands, Samoa, and Vanuatu, with a capacity of a few hundred megawatts altogether). Installed capacity for hydro in Jamaica is 23.8 MW, with a potential of another 90 MW (Fairbairn, 1993). Hydropower has currently been developed in 11 ACP SIDS, where it accounts for 4 to 13% of total commercial energy supply. Total annual hydroelectricity generation varies from about 10 GWh in Sao Tome and Principe to 430 GWh in Fiji. Hydropower supplies over 90% of Fiji's electricity requirements but less than 10% of the nation's total energy use. Samoa also obtains a substantial proportion of its electricity needs from hydropower. Barriers to the further development of large-scale hydropower in ACP SIDS are largely attributable to the many financial and institutional problems associated with their development and to environmental considerations. Local communities in the Solomon Islands have recognised micro-hydro facilities as an energy source which can help to diversify their economy by providing electrical energy for small-scale industry to produce market goods and augment existing incomes (see Box 18).

WIND POWER

Prospects have been improving for electricity generation by wind turbines, but much depends on site availability. Wind resources may be neither strong enough nor constant enough in ACP SIDS to be harnessed economically for power production. Wind regimes are in most cases seasonal, and there are periodic storms with wind speeds that would damage wind power systems.

Wind generation is particularly unsuited to atolls. Turbulence and reduction in wind speeds is caused by trees as much as 100 metres upwind of the generator and a shorter distance downwind and to the side. In order to provide a clear wind path (since wind direction is not constant), a large number of coconut trees would need to be cleared around the site. Since coconut trees are the primary agricultural resource of the Pacific atoll islands, this is not considered socially or economically appropriate. Furthermore, the trees are a major factor in preventing erosion and loss of available land to the sea.

In addition, wind generators require considerable maintenance in the humid and saline atmosphere of the islands. The skills needed to maintain and repair the mechanical and electronic components of the machines are usually not available on the outer islands and would have to be developed at a cost that could not be justified unless a number of wind machines were installed (JICA, 1998).

Small wind turbines have been successfully installed in two remote, rural communities in the Cape Verde archipelago, supported in part by the French government (see Box 19). Substantial opportunities to further exploit wind energy in the Cape Verde archipelago exist. A 1995 study financed by ADEME and the French Ministry of Industry estimated the wind power potential of Cape Verde to be 8 MW. The major barrier to its development is finance. The Cape Verde government has put in a request to the French government to provide financial assistance to a programme aiming to supply a further ten villages with wind energy stations (EU DGXVII - Thermie, no date).

A 225 kW wind turbine has also been installed in Munro, Jamaica, supplying power to the Jamaica Public Service Company (JPSCo). The turbine can generate up to 1 million kW hours of energy per year. The major safety feature is that in the case of over-speed on the rotor or in weather conditions such as a hurricane, a monitor independent of the controller will stop the turbine (CDB, 1996a). The suitability of wind energy for Pacific islands is discussed in Box 20. The potential for small wind energy systems (200-300 W) should be explored.

MARINE

Island states have jurisdiction over a large area of surrounding sea (usually much larger than their land area). This area will certainly contain more than enough marine energy (wave, currents, thermal gradients) to meet the energy needs of the whole island: the only question is whether it can be tapped economically.

Marine Current Turbines

Marine current systems are still at the experimental stage, but show promise where favourable site conditions prevail because of the predictability of the resource and the relative simplicity of removing energy from a flow of water. Marine currents of 4-6 knots are needed, which often occur around headlands, in shallow water, or in the straits between islands. The European Union has been active in supporting research in this area.

Wave Power

Sea wave power is an innovative technology which has yet to be proven as technically viable and cost-effective in the ACP

BOX 18

Box 18 Micro-hydro in the Solomon Islands

Micro-hydro technology is small-scale, decentralised, and, in the Solomon Islands, built using mainly local labour, materials, and technology. Imported equipment, used only where necessary, is designed to be long-lasting and needs only cheap, easily obtained spare parts. These aspects are important in remote rural areas where people are organised in relatively small groups and have few options for system maintenance.

APACE, an NGO based in Australia has been working in the region for a number of years and is responsible for most of the hydro activities in the region. A hydro-electric facility was requested by local community members who saw the advantages of the small (3 kW) facility in Iriri village, 6.5 km along the coast to the north, which has been in operation since 1983. Another facility is also nearing completion at Vavanga village, another 3 km along the coast between Iriri and Ghatere. The Vavanga hydro system has an expected output of about 2.5 kW. A fifth project has now begun at Bulelavata, Roviana Lagoon, representing a major step in local capacity building. Inspired by the success of these initial projects, more than one hundred villages have requested a micro-hydro system.

Box 19 Wind Energy for the Remote Island Communities of Cape Verde

To date, 2.5 MW of hybrid diesel-wind and stand-alone wind energy systems have been installed in Cape Verde. The implementation of the autonomous wind energy station proved to be the most economic. Compared to energy costs in the range of 0.2-0.75 ECU/kWh for traditional, diesel-powered systems, wind energy systems with small, back-up diesel generators can lower costs to 0.09-0.15 ECU/kWh. Moreover, villagers have reduced their energy expenditures from 6.8 ECU/month, spent on kerosene, candles, etc., down to 2.2 ECU/month on electricity.

BOX 19

SIDS environment. The energy resource is abundant, and the size of probable plants is suitable for most ACP SIDS.

The most promising prototype wave devices are shoreline or near-shore systems, using oscillating water columns or tapered channels, but these are yet to be exploited commercially.

"The sea area surrounding island states will certainly contain more than enough marine energy (wave, currents, thermal gradients) to meet the energy needs of the whole island: the only question is whether it can be tapped economically."

Ocean Thermal Energy Conversion (OTEC)

OTEC is an interesting renewable resource especially for the larger energy consuming ACP SIDS. Given the apparent lack of development of OTEC technology, it is probable that the cost of OTEC systems in the region would be extremely high.

OTEC plants have been proposed for several of the Caribbean islands since many of them are close to water of more than 1000 m depth. OTEC has been demonstrated but design and economic uncertainties have hindered its commercial development. Many parts of the Jamaican coastline have the steep, near-shore bathymetric conditions suitable for OTEC plants.

The South Pacific Applied Geoscience Commission (SOPAC) has carried out OTEC site exploratory investigations for a number of island countries in the Pacific region.

HYBRID SYSTEMS

A combination of PV arrays and wind generators combined with battery banks and diesel generators is often considered as a means for minimising diesel fuel consumption. The use of any form of hybrid with diesel generation will increase the capital costs considerably and increase the complexity of operation and maintenance. Technical skills are scarce in the outer islands and

Box 20 Wind Energy in Pacific SIDS

Wind energy penetration of 10-20% may technically be achieved within a 10 to 15-year period in those Pacific SIDS with sufficient wind resources.

The number of large power grids in Pacific SIDS that can absorb power generated from large wind farms is very limited, however. Only Papua New Guinea, Fiji, Solomon Islands, and Samoa have power systems with generation capacities larger than 20 MW.

There are a number of islands with potential for grid-connected wind turbines in the range of 100 kW to 1,000 kW. About 30 of these islands have 24-hour public power supply systems.

The largest potential for wind turbine installations is for the small (<100 kW) wind-diesel hybrid power systems appropriate for the numerous outer islands, and for small remote communities similar to the village power system pilot project in Vanua Levu, Fiji. Their wider application in outer Pacific SIDS depends on technological development as much as economic development.

Site visits made to Fiji and Tonga have highlighted the potential for wind energy in these regions.

BOX 20

BOX 21

Box 21 Influencing Energy Use in Jamaica

The Jamaica Public Service Company (JPSCo), the island's only electricity utility, has developed a Demand-Side Management Demonstration Pilot Project in collaboration with the Inter-American Development Bank, GEF, the Rockefeller Foundation, and the Canadian Trust Facility. The DSM project, which is estimated to cost US$12.5 million, is designed to influence customers' use of electricity in ways that will produce changes in the utility's load profile, reduce customer bills, and reduce JPSCo's generation costs.

The DSM Demonstration Pilot Project seeks to test and demonstrate the marketing, technical, financial, and economic feasibility of implementing cost-effective energy conservation measures in both the commercial and residential sectors. The project has a target of reducing peak loads by 7 MW and an energy savings target of 30,000 MWh by 1998. Developments in the residential and commercial sectors have included the provision of compact fluorescent lamps (CFL) and other energy efficient devices at no cost to 100 participants to establish the technical criteria regarding equipment performance, customer response, and installation problems in a small pilot group of participants. A second phase of the residential power saver programme seeks to increase the diffusion of high-efficiency electrical equipment, boost consumer demand for them, and test the commercial viability of the equipment in the residential market. This involves the provision of energy efficiency measures to 30,000 randomly selected customers island-wide at a discounted price. The cost of the energy efficiency measures is shared between JPSCo and the customer with the discount to the customer being 50% of the incremental cost of the measures. The implementation is being carried out over a three-year period. The commercial programmes are being marketed under the slogan "Power Plus Program" which has two components: retrofitting existing commercial buildings and implementing energy efficiency measures in new construction sites.

there is limited access to spare parts and specialised skills. The capital cost of such hybrid arrangements combined with the need for skilled maintenance and operation has thus far limited their use to a few remote islands for telecommunications systems.

DEMAND-SIDE MANAGEMENT

Demand-side management (DSM) optimises the use of electricity, thus reducing the need for fossil fuels and capital investment in generating plant. A DSM Demonstration Pilot Project implemented by the electricity utility in Jamaica has tested and demonstrated the marketing, technical, financial, and economic feasibility of implementing cost-effective energy conservation measures in both the commercial and residential sectors (see Box 21). DSM has an equally important role to play in preventing the misallocation of resources.

FEATURES OF SUSTAINABLE ENERGY STRATEGIES

ENVIRONMENTAL TARGETS

Some ACP SIDS have begun to implement Agenda 21 and Climate Change mitigation programmes and to include some aspects of sustainable development in their national policy development. Further progress is required to ensure that environmental considerations are given appropriate levels of attention, in particular at central levels of decision-making, and that environmental and development considerations are fully integrated at both micro- and macro-levels respecting domestic, environmental, and cultural values.

POLITICAL TARGETS

Energy issues in SIDS have been a major barrier to ecologically sustainable development. Few ACP SIDS have a clearly defined national energy policy, and greater action is needed in the region to draft sustainable energy policies with well-defined targets. Energy policies should focus on economic growth in a sustainable manner by reducing the level of imports and increasing the level of self-sufficiency. A sustainable energy policy should address the following: (i) replacing unsustainable energy systems with systems based on renewable energy technologies that can be locally manufactured and/or maintained; (ii) promoting energy conservation methods including energy pricing initiatives; and (iii) developing energy databases and monitoring stations.

The energy policy of Jamaica seeks to diversify the energy base, encourage the development of indigenous energy resources where economically viable and technically feasible, and ensure the security of energy supplies. The government will foster, facilitate, and encourage the development of energy-efficiency

Putting SIDS into Context

Geography and Population

ACP SIDS are geographically dispersed, isolated, and small in size. They are located over three-quarters of the world's oceans and cover a total land area of 109,000 km^2, a mere 0.08% of the total global land area. The Bahamas, Jamaica, Trinidad & Tobago, Fiji, Solomon Islands, and Vanuatu are bigger than 5,000 km^2, but many ACP SIDS are smaller than that and most are very small or tiny, some less than 100 km^2. The majority of islands are widely scattered groups of small coral atolls such as Kiribati (total land area 717 km^2 with a coastline of 1,143 km) and Tuvalu (total land area 26 km^2 with a coastline of 24 km).

Population in the region also varies greatly, but usually reflects the level of gross domestic product of the island. Population ranges from 10,000 in Tuvalu to 2.5 million in Jamaica, with most islands having fewer than 400,000 people. In fact the 9 million people who populate the ACP SIDS make up only 0.15% of the world's population (in 1995). However, these figures do not give the whole picture. ACP SIDS have high population densities, and in most cases over half of the population lives within 2 km of the coast. On some islands the population growth rate exceeds the rate of economic growth.

Economy

Most ACP SIDS have small and limited financial reserves. They have inadequate infrastructure, depend on international trade and donor aid, and are usually classified as high-risk with respect to insurance due to their small size and vulnerability to natural disasters and external shocks. For these reasons most SIDS are economically vulnerable and have low levels of economic activity. The Pacific SIDS have experienced extreme financial difficulties in recent years. Kiribati, for example, is a predominantly rural society with a subsistence economy, and it depends on fuel imports. Its trade deficits have increased over the years since 1980, and now Kiribati has been classified as a least developed country by the UN.

The total GDP (purchasing power parity) in ACP SIDS is US$55,466 million (1996), or 0.2% of total world GDP. The level of economic activity varies considerably from one island state to another. Trinidad and Tobago's main products include petroleum, chemical products, crude oil, and sugar, for example, whereas in Tuvalu the main product is copra. Not surprisingly Trinidad and Tobago's GDP is US$17,100 million (US$13,500/capita) while Tuvalu's is US$7.8 million (US$800/capita). Although Tuvalu has the lowest national GDP, it also has the highest percentage GDP growth rate. Economic development of these island states should not be judged by their GDP, however, as they are very vulnerable to external forces and to natural disasters (Ghirlando, 1998). The South Pacific Forum Secretariat has recently prioritised the development of the Vulnerability Index.

Economic development in ACP SIDS is largely dependent on coastal and marine resources and, increasingly, on tourism. Tourism is becoming the most rapidly expanding industry in the majority of ACP SIDS, providing an important source of revenue and employment. In the Caribbean it is responsible for more than 15 percent of gross national product.

Environment

ACP SIDS are usually described as environmentally vulnerable, prone to ecological hazards (in the form of pollution and resource depletion) and to extremely damaging natural disasters, primarily in the form of cyclones, tsunamis, volcanic eruptions, and earthquakes. ACP SIDS are also particularly vulnerable to the effects of global climate change (see Box 22) though they emit few greenhouse gases themselves.

On some islands, the range of natural disasters includes storm surges, landslides, extended droughts, and extensive floods. Climate change is thought to be increasing the frequency and intensity of these events. If this is so, it will cause considerable economic, social, cultural, and environmental dislocation, and consequently affect any development programme.

The impacts of sea-level rise pose the greatest threat to ACP SIDS. Even a sea-level rise of 20 cm or

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less could have devastating impacts. The intrusion of seawater will salinise natural underground reservoirs of freshwater; groundwater in several islands including Tuvalu and Kiribati are already seriously contaminated by salt-water intrusion. A rise of 50 cm or more would have even more disastrous implications, as the very existence of low-lying atolls would be threatened. As so many people live near the coast, major population displacements would occur on most islands (Slade, 1998). Island states with extensive coastal plains and little highland, such as Barbados, Antigua and Barbuda, and the Bahamas would be highly vulnerable. Many fertile coastal areas would be put out of production, significantly affecting the economies and living conditions of the population.

A case study of the likely impacts on the Marshall Islands of an accelerated one-metre rise in sea level by 2100 has shown that between 10% and 30% of the shoreline would be eroded or forced back and 60% of the arable land would be lost. There would be a significant increase in the frequency of severe floods and a reduction in the underground freshwater on which the Islands depend. The cost of protecting the coast is estimated to be four to six times the country's GDP and well beyond its means (Slade, 1998).

It is crucial that all the necessary data and information concerning these aspects of climate change be collated and widely disseminated, as it may enable ACP SIDS to develop and implement appropriate response strategies.

The growing tourism industry, population, consumption levels, and imports of polluting and hazardous substances coupled with the limited land resources of island states have resulted in overall increased pressures on natural resources and natural cleansing processes. Wastes and natural resource depletion in these states tend to be highly visible.

BOX 22

Box 22 Climate Change in the South Pacific Region

Temperatures have been increasing by 0.1°C per decade in the South Pacific region and sea levels by 2 mm/yr. A doubling of atmospheric CO_2 concentration is predicted to increase sea-surface temperatures by 1°C and increase rainfall intensity in the central equatorial Pacific—which may increase the tropical cyclone intensity by 10-20% above current levels. Some regions have shown accelerated sea level rise with increases of up to 25 mm/yr, for example satellite data shows 20 mm to 30 mm per year rises in a region from Papua New Guinea to south-east of Fiji.

measures and all new and renewable energy sources, especially micro-hydro, biomass, solar, and wind energy (Wright, 1997).

The South Pacific Applied Geoscience Commission Energy Division is working with interested Pacific SIDS in the formulation of long-term national energy policy statements. The statements emphasise the need to use sustainable energy sources which are suited to the needs of the consumer and the characteristics of the site. The policy statements also emphasise the need to establish a financially sustainable and commercially oriented agency charged with the responsibility for installation, operation, maintenance, administration, and tariffs for public rural electrification systems (Wardrop, 1996).

The Pacific Western Provincial Assembly agreed in 1993 to plan and design a provincial rural community electrification programme, the Western Province Rural Electrification Programme (WPREP). The Solomon Islands Rural Community Electrification Committee (SIRCEC) has since developed guidelines for community projects and advised the government on appropriate rural electrification policy so that development assistance can be directly channelled into worthwhile projects that have already been identified by the community (Zuke News, 1997).

LEAPFROGGING

ACP SIDS can avoid some of the errors committed in the past by industrialised countries, by literally "leapfrogging" over some steps of the energy industrialisation process. The need for major investments to create new institutional structures is an opportunity to implement the most efficient technologies, appropriate energy plans, and energy-efficient end-use applications.

Breaking the dependency on imported fuel should be a key objective in a sustainable long-term energy strategy. Decentralised schemes, as opposed to national grid connection networks, can be small and simple enough for local people to be involved in buying, building, and operating the schemes, without being dependent on government or aid agency decision-making, which slows things down and is affected by many external influences.

BARBADOS – DIVERSIFYING SUPPLY AND IMPROVING EFFICIENCY

CHALLENGES, OPPORTUNITIES, AND INITIATIVES FOR SUSTAINABLE ENERGY

Barbados, like all ACP SIDS, needs to put in place a clear sustainable energy policy. In addition to reducing the amount of energy lost in generation, distribution, and transmission, the amount of energy consumed at end-use should be reduced. Policies are required that will help to reduce demand for fossil fuels and increase the number of sustainable energy applications. Utilities have a specific role to play in the integration of sustainable energy technologies and measures.

The approach used to develop the SWH market should be used on other renewable energy technologies and energy efficiency measures. The expansion of the natural gas distribution grid in Barbados had a similar uptake to the SWH industry. The installation procedure made the changeover easy and less costly for the householder, mainly by hooking the gas line directly to the cooking stove. The gas company also checks and modifies burners where required. This approach to delivering new technologies inspires confidence in the customer.

Existing legislation needs to be examined to enable utility companies to be set up to support a faster transition to a more sustainable energy future. The government of Barbados should introduce legislation that requires the utilities to purchase energy from independent power producers at realistic prices. A successful example to follow is the Public Utilities Regulatory Act (PURPA) of the USA.

The Barbados Light & Power company has promised to look into the area of demand-side management. The Jamaican model should be taken into account in the development of such a programme, particularly:

- time of day savings for medium and large power users;
- incentives for demand charge reductions for large and medium power users; and
- discounts for kWh reductions for small domestic users

This approach will result in large electricity users applying energy management measures. In the home, simple energy saving measures can be applied, such as turning lights off when not needed and fine-tuning air conditioning controls, which will also apply to the hotel sector. Turning down guest room units when they are empty, for example, can save as much as 30% of energy consumption.

In Barbados the local utility has yet to speak up publicly about these initiatives, generating the impression that they see this programme of energy conservation as a threat to their revenue.

The main challenge Barbados faces is its size, which means relatively small projects and a small market. Two approaches could help to overcome this difficulty. The first is pooling projects together to make it easier to work with established organisations in the developed world. Alternatively local lending institutions, such as energy service companies, could help finance energy efficiency projects.

Performance contracting will ensure that energy audits are carried out by the ESCO to identify where energy consumption and therefore energy expenditure can be reduced. By guaranteeing and sharing the savings from improved energy efficiencies and improved productivity, both groups will benefit and prosper. Performance contracting has great potential as the owner of the facility shares the risk with the ESCO.

Performance contracting has to be disseminated throughout the Caribbean SIDS to build consumers' confidence. Barbados has only begun to use this method, but a programme to disseminate information about ESCOs and sustainable energy technologies and measures to potential customers is crucial. Barbados should follow up on the successful programmes developed in Jamaica on energy awareness and the promotion of independent power producers.

The following considerations may be useful when drafting a new government energy policy:

- Taxation on fuel on a Btu basis seems an equitable arrangement. This case is even stronger for fuel sources such as LPG and natural gas.
- Tax concessions for all fuels used by the productive sector are desirable.
- Duty concessions for sustainable energy technologies and measures should be investigated and implemented wherever possible.
- Tax incentives for SWH should be maintained and extended to include PV.
- Incentives should be provided for any technology that significantly promotes the sustainable application of renewable energy sources.

There is need for legislation to put more pressure on the utility to reward customers for saving energy. The utility should consider implementing time of day discounts and push customers into efficient energy practices if necessary.

Existing energy institutions should be strengthened and new ones should be developed where appropriate. At government level there is the Ministry of Finance, Energy Division, the Ministry of the Environment, the Town and Country Planning Department, the Government Electrical Engineering Department, the Ministry of Health, the Ministry of Tourism, and the Attorney General's Office where legal drafting is initiated. It is not realistic to attempt to bring all these departments together, but it should be recognised that there is a high level of overlap in relation to environmental considerations within these different departments. Regular workshops to bring together all these departments and allow for the exchange of information, experiences, and ideas should be promoted.

At the level of non-governmental organisations there is a lot of work being carried out. For example, the Caribbean Action for Sustainable Tourism (CAST) programme encourages sustainable development in the tourism industry and implements energy efficiency programmes in the hotel sector. The work on renewable energy at CERMES, the Centre for Resource Management and Environmental Studies at the University of the West Indies, should be disseminated.

Community groups should be encouraged to look at projects that can help their areas. UNDP, under its Global Environmental Facility and the NGO Small Grants Programme, has been able to disburse some US$400,000 during the period 1994–1997. Projects have been about containing global warming, preserving biodiversity, teaching citizens who work at sea the value of the management of economic zones, and preventing the degradation of the ozone layer. Along with Barbados these projects have been implemented in Anguilla, British Virgin Islands, Dominica, Montserrat, St. Lucia, and St. Vincent.

CURRENT ENERGY SUPPLY AND USE

Total energy consumption for Barbados in 1996 was 5,391 GWh, about 21% of which is produced nationally. Otherwise Barbados relies heavily on petroleum fuels: crude oil alone was 60% of total energy consumption in 1992, followed by natural gas and LPG (together 17%).

The remaining 23% of total energy consumption is supplied by renewable energy technologies. Bagasse is the main source, followed by solar water heaters. There is reason to believe that renewable sources of energy could contribute 50 to 75% of the total primary energy consumed by the year 2015, using mainly solar, biomass, and wind energy.

The total electricity consumption in Barbados is 558 GWh and electricity losses due to inefficient generation, distribution, and transmission amount to 70 GWh, or 7% of the total electricity generated.

Petroleum and Natural Gas

Total annual petroleum consumption in Barbados is 10,179 TJ, of which about 30% is produced nationally. The production of crude oil, natural gas, and LPG in Barbados is carried out by the state-owned corporation Barbados National Oil Company Limited (BNOCL). On average 500,000 barrels of crude oil and 1 billion cubic feet of natural gas are produced annually. The known oil and gas reserves in the region amount to 2.5 million barrels of oil and 5.0 billion cubic feet of gas.

The recent closure of the Mobil Oil refinery in Barbados has left BNOCL with two main options: (i) to begin crude processing on a small skid-mounted refinery at its site, or (ii) to export the local crude to the refinery in Trinidad.

The closure of the refinery and the establishment of a local importing and regulating body will see Barbados purchasing all its refinery products in a finished form and taking advantage of low oil prices when they are available. (The previous agreement with Mobil Oil contained a clause which guaranteed a certain profit for Mobil. This clause was inserted in return for Mobil developing a refinery point in Barbados and therefore ensuring a level of security of supply for Barbados.) The National Petroleum Corporation (NPC) is responsible for the distribution and sale of the natural gas produced by BNOCL. At present there are some 14,000 customers, mainly domestic households, but most of the revenue actually comes from commercial customers of whom the Barbados Light and Power (BL&P) company is the major end user. There is an arrangement between BL&P and the

Table 3.1: Energy Consumption (1992) by Sector and by Petroleum Fuel Type (TJ).

	Residential (TJ)	Commercial (TJ)	Industrial (TJ)	Public & Government (TJ)	Total (TJ)
Gasoline	2411	33	27	82	2553 (25%)
Kerosene	10	10	25	2	47 (0.5%)
Auto Diesel	395	577	180	251	1403 (14%)
Industrial Diesel	-	41	120	28	189 (1.5%)
Fuel Oil	-	4913	140	10	5063 (50%)
LPG	358	6	14	42	420 (4%)
Natural Gas	84	365	55	0.03	504 (5%)
Total	**3258 (32%)**	**5945 (58%)**	**561 (6%)**	**415 (4%)**	**10 179**

NPC that allows BL&P to be taken off the distribution at short notice in deference to other customers. In practice this seldom happens and BL&P are needed to use up the otherwise excess gas.

The NPC has recently undertaken a capital expansion programme to increase their customer base and reduce dependency on BL&P, whose supply is subsidised because they are a user of last resort. The programme aims to attract both the hotel sector and heavily populated areas.

In 1992 Liquid Petroleum Gas (LPG) consumption was 420 TJ, of which 85% was used for domestic cooking and commercial cooking in hotels. There are also some industrial applications, including forklift trucks and lifting equipment. In 1996 the consumption of LPG was some 650 TJ, but it is gradually being replaced by natural gas as the latter becomes readily available through the NPC expansion programmes.

Table 3.1 illustrates energy consumption by sector and by petroleum fuel type. The major end use of petroleum-based fuels is the commercial sector, followed by the residential, industrial, and public and government sectors.

POTENTIAL ROLES FOR DEVELOPMENT ASSISTANCE

As awareness of the Energy Conservation Programme for the Caribbean has fluctuated, there have been similar fluctuations in the presence of cooperation agencies and their programmes. Recently there have been greater attempts to understand how cooperation agencies can best support the businesses and governments in ACP SIDS.

It is well established, however, that the best way forward for these kinds of cooperation programmes is to establish partnerships with local organisations and businesses, to disseminate more effectively sustainable energy programmes. The potential for performance contracting as the method by which the ESCOs can effectively develop has been mentioned. Cooperation agencies can promote local joint ventures with these objectives in mind, and should help develop local ESCOs.

There will continue to be a role for direct grants for research and development, education, and training. Projects will have to be divided between the more fundamental training and awareness building exercises and those that are installing tried and tested technologies.

EMERGING VISIONS FOR SUSTAINABLE ENERGY

The development and promotion of sustainable energy technologies and energy efficiency measures have been a priority of the Government of Barbados since the first oil crisis in 1973 made everyone aware of how vulnerable they were, being so dependent on imported petroleum fuels. Government interest in alternative sources of energy has tended to fluctuate along with oil prices and the availability of petroleum products.

The high capital costs of renewable energy technologies are the major barrier to their wider application. Better pricing systems are needed to include the benefits accrued from the implementation of sustainable energy systems and measures.

Solar Energy

Barbados has tried, through policies agreed at the highest level, to take every opportunity to promote the development of renewable energy technologies. The continued use of solar energy is increasingly encouraged and tax incentives should be provided and maintained.

The Energy Group at the University of the West Indies, has a programme that aims to develop further applications for solar energy. The group aims to lead the Caribbean SIDS to a position where the majority of the energy consumed comes from renewable energy sources. R&D topics have included crop dryers, solar ovens, and PV solar refrigeration.

As the price of PV systems drops, it may be able to compete with the widely accessible and inexpensive national electricity grid. A list of PV projects presently carried out in Barbados is given in Table 3.2.

Wind Energy

Research should be commissioned to evaluate the economic and technical performance of the two wind energy generators that were working in Barbados.

Energy Efficiency Measures

Many facilities in Barbados have taken advantage of the opportunity to study their energy consumption pattern. The resulting Energy Audit has usually pointed out exact areas where substantial energy savings can be achieved. This initiative is being spearheaded by ESCOs.

The implementation of recommendations from these studies has always been the stumbling block. More recently programmes to finance these projects are being promoted through performance contracting. This method is still to be tested in the region and in Barbados in particular.

The future of energy saving projects lays in the ability to make them attractive for the investor. The fact is that the decision-maker in any business usually uses the tested formula of Return On Investment (ROI) to decide whether to go ahead with any new project. Energy saving projects will have to compete with all other investment opportunities. Production facilities, though aware of energy saving opportunities, would have to compare any investment with the profits they might make by improving production levels.

Energy conservation projects must come with a tax incentive for them to work. A reduction in electricity consumption can allow the utility to postpone expansion, reducing the use of precious foreign reserves.

Renewable Energy

The second largest type of energy consumed in Barbados is bagasse. Bagasse is the dried, ground fibre of the sugar cane that is collected after the juice is extracted. It is burned to create elec-

Table 3.2: PV Projects in Barbados

Project	Status
10 kW PV panel for lighting at Harrison Cave, St. Thomas	BP Solar engineer has visited the project. The engineers have recommended building a separate base to mount the panels on as the roof area used now is sometimes too shaded. The cost of this base is estimated at US$5,000. Funding is being sought.
10 kW ice plant for fishing needs at Speightstown, Oistins, and Skeete's Bay	Still at planning stage.
PV glass for application to new government building at Warrens, St. Michael	Looking for source of PV film. Does not appear achievable on this occasion. This project has been abandoned.
PV electrification of chattel houses	Part of Millennium 2000 Project
Solar-powered transport	Part of Millennium 2000 Project
School PV electrification for lighting applications	To be included as part of Edutech 2000. To be looked at for trial application over the next two years.
Future Centre Trust	This project is planned as a permanent display of the Barbados "A Village of Hope vs. Horror". This theme was coined at the local exhibition during the SIDS conference of 1994. The building is to be fitted with 100 kW of PV panels. All the panels are in Barbados and the roof of the Trust's building is to be strengthened to accommodate the new loading.

tricity and displaces the need to buy electricity from BL&P. Bagasse consumption in 1992 amounted to 2,244TJ, an increase of 28% on 1988 levels, although sugar production has been decreasing since 1989.

Table 3.3: Solar Water Heaters Installed Between 1988 and 1992.

Year	Units installed/yr	Accumulative units	Growth (%)
1988	2445	2445	0
1989	2857	5302	117
1990	2579	7881	49
1991	2250	10131	29
1992	1768	11899	18

Another well-established RET in Barbados is solar water heating. That industry is now worth more than US$5 million per year. There are about 30,000 SWHs in Barbados, installed in 95% of homes. The success of SWHs in Barbados can be attributed to a tax incentive which allowed homeowners to claim the cost of installing SWHs against their tax.

Each SWH replaces an electric heater capable of using a 4,000 kWh/year. At a cost of US$0.16 per kWh and an initial cost of US$350 per heater, the cost of a SWHs is paid off in about two years. Thereafter the annual savings all accrue to the benefit of the household. On average the minimum life span of a SWH system is 10 years, so savings can be US$5120 or more. The total savings for the existing 30,000 SWH units is therefore US$19.2 million, and petroleum imports of 120 GWh have been avoided. The overall fuel savings is estimated at 32 000 tonnes, or about US$3.7 million at oil prices of US$15 per barrel.

There have also been detailed experiments on wind energy generation in Barbados. One unit was run by BL&P and a second unit was operated by the conglomerate CO Williams Electrical. Today there are no active wind energy generators, but the potential of wind energy is still under consideration.

Table 3.4 illustrates the total generated electricity from wind energy between 1986 and 1990.

Table 3.4: Wind Energy Generation, 1986 to 1990.

Year	1986	1987	1988	1989	1990
KWh	88320	55560	300520	298360	1080

Barbados – The National Context

Barbados is located in the West Indies (longitude 59° 35' W and latitude 13° 10' N), to the east of all the other Caribbean islands. The total land area amounts to 430 km², of which 77% is classified as arable land.

The total population of Barbados in 1996 was 261,000, of which 52% live in rural areas. Barbados' population density of 607/km² is one of the highest of the ACP SIDS.

Since independence from Britain in 1996, Barbados has developed into a strong service-oriented economy. Its GDP (purchasing power parity) currently amounts to US$2,650 million with a growth rate of 3.5%. With an annual GDP/capita of US$10,300, Barbados has the highest human development index rating (0.907) of all the ACP SIDS.

The Barbadian sugar industry has been shrinking for the last 25 years, and the government has tried to diversify economically to avoid economic downfall. The main manufactured products now include sugar, chemicals, electrical components, and rum. Manufacturing has not grown much, but still contributes strongly to GDP (US$89 million), and as a result continues to provide a steady source of employment.

Tourism is the main source of foreign exchange, earning US$135 million per year. The government is trying to expand the international business sector.

FIJI – BALANCING URBAN DEMAND WITH ENERGY FOR ALL

CHALLENGES, OPPORTUNITIES, AND INITIATIVES FOR SUSTAINABLE ENERGY

Fiji's biggest challenge in sustainable energy development is how to generate efficiently enough electricity to meet increasing demands. An archipelago of small islands with a small demand for energy on each of the islands, Fiji's problem is how to produce energy efficiently on the scale that it needs.

In 1998, as a result of government re-structuring, the Fiji Electricity Authority (FEA) was split into three major service component companies, each with its own area of responsibility and operation:

- Generation of electricity
- Transmission of electricity
- Distribution and sale of electricity

New proposals are being sought from independent power producers to work either jointly with the above companies or independently. It is hoped that this move will ensure long-term development in the power sector through profitable commercialisation.

Independent Power Producers

Independent power producers (IPPs) may be the long-term solution for Fiji. The nature of Fiji's electricity market, however, means that it will be extremely difficult to find an IPP plant that will match Fiji's energy and capacity requirements exactly. The country may end up paying for energy that it does not actually require or paying for diesel generation to top up the shortfalls.

Of course, the other avenue to pursue is to open up the market even further and give the IPPs some of the best customers. IPPs operating in a commercial environment would naturally set their sights on big load centres. Large industries operating in concentrated industrial areas would be ideal target markets.

It is unlikely that any IPP operating a diesel or gas turbine plant will be able to compete on price with FEA's diesel operation costs. Although the Tropik Wood Factory and Waste Plant proposal was competitive, the same cannot be said of the IPPs trying to set up diesel and gas turbine stations in Fiji. Such proposals are viewed with caution, especially as Fiji already has the expertise and knowledge of local conditions to make the best use of these fuels. So the only IPPs that appear to be viable are those using a relatively cheap form of fuel such as domestic waste and biomass residues.

The IPP that gives the highest rate of return may not be the least-cost alternative when seen from the wider perspective.

It is therefore suggested that while IPPs may provide timely and neat solutions to some of Fiji's energy problems, the country should also be developing its own natural resources to solve energy problems.

Waste-to-energy Plants

There are two proposals on the table to establish waste-to-energy plants from IPPs. The proposed plants are for Lami (3 MW) and Nadi (3 MW). This concept enjoys significant government backing.

Environmental Legislation

There is presently no environmental legislation with which power producers, including FEA, are required to conform. This may become a problem if several small IPPs started burning cheap low-grade fuels and increasing pollution levels. An Environment Act is presently being drafted, based on the guidelines of Agenda 21 of the Earth Summit at Rio de Janeiro.

POLICIES TO PROMOTE SUSTAINABLE ENERGY

Energy Conservation

There is no energy conservation policy in Fiji, although this has not deterred the government from implementing an Energy Conservation Programme. The objective of The Department of Energy (DOE) is to develop an energy conservation policy that promotes more efficient use of energy in both the public and private sector and encourages private sector involvement in energy efficiency programmes.

Fiji's Energy Conservation Programme assesses and implements energy efficiency measures, focusing on the efficient use of energy in government premises, particularly public hospitals. The majority of energy conservation projects are initiated and funded by DOE with some aid from the international community. There is very little energy conservation work done in the public sector apart from that funded by DOE. There are only about six companies in the private sector who are involved in energy management services. DOE has used private companies in both the assessment and implementation of its energy conservation projects.

Taxation and Duty Concessions on Renewable Energy Technologies

The Fijian government has yet to formulate definite plans for special concessions or taxation reforms to encourage the development and/or use of renewable energy technologies. DOE projects normally apply for, and receive, duty-free status on a project-by-project basis for materials and/or equipment bought or received through foreign aid agencies. Legislation is being drafted to adopt taxation reforms designed to facilitate the use of RETs.

Environmental Protection

Several pieces of legislation regarding oil pollution are already in place, including the Ports Authority of Fiji Regulations 1990, Public Health Act 1955, Traffic Regulation 1974, and Health and Safety Act 1997.

Not all these laws are enforced; there is no active programme to enforce emission standards for motor vehicles, for example. There are no policies or guidelines on the removal of waste oil in Fiji. A study on the use of waste oil in all Pacific Island countries has recently been completed by the Pacific Island Forum Secretariat, however, and policies are currently being formulated on the removal of waste oil in Forum Island countries.

Unleaded petrol was introduced in 1997 and the phasing out of leaded petrol by the year 2000 is being considered, although this will be subject to Cabinet approval.

A Fiji National Oil Pollution Contingency Plan is in place. The plan sets out the procedures to be followed in case of pollution from oil tankers, large bulk carriers, and container vessels carrying significant quantities of bunker fuel. Private organisations and government departments are involved when oil spills need to be contained.

KANA, a non-governmental organisation, is also involved in the promotion of environmental protection. They are playing the lead role in the construction and dissemination of institutional woodstoves and the raising and distribution of fuelwood seedlings. They promote the growing of wood lots to meet the fuelwood requirements of rural boarding schools, a requirement of the National Fuelwood Strategy.

The National Fuelwood Strategy is an attempt to make fuelwood use sustainable; it is estimated that 17% of Fiji's primary energy supply is derived from wood. While no figures are available on the rate of depletion of fuelwood, a concerted effort has been made since 1995 to plant approximately 10,000 fuelwood seedlings per annum. Net deforestation was approximately 60 000 hectares in 1998.

Although there are several Acts designed to protect the environment from the effects of energy consumption, the Department of Environment has begun to draft further legislation. The proposed legislation will incorporate and update existing environmental and resource management legislation. It will ensure an effective environmental management capability, comprehensive heritage protection, meaningful private sector and general public involvement, and sound and integrated environmental and resource use.

Renewable Energy Development Programme

This programme involves the investigation, assessment, and development of Fiji's renewable energy resources, specifically through the accumulation and analysis of raw data. A technology assessment will follow which will determine whether appropriate technology exists to capitalise on the identified resource. Once the technical viability has been established, an economic assessment of the resource will be carried out by comparing its development cost with other options including conventional energy sources.

Issues such as sustainability, income generation potential, and established loads are also considered in the assessment.

Energy Prices and Subsidies

Although arguable, it is generally accepted that the demand for electricity is sensitive to price. Tariffs also affect the financial performance of the utility and the redistribution of income within the national economy. The Fiji electricity supply industry comprises of a number of geographically different systems, so the true economic cost of supply in each of these systems is vastly different. The FEA's present tariff is structured so that all consumers in one sector (e.g. commercial) are charged one rate irrespective of geography.

The size of the Viti Levu Interconnected System (VLIS) means that the entire Authority's financial performance depends on VLIS. The other systems are simply too small to be significant in this calculation. It follows, then, that a geographically uniform tariff structure for each sector will be largely determined by VLIS' costs, resulting in the VLIS system cross-subsidising the other isolated systems. Any tariff review will have to examine the cross subsidies inherent in the geographically different systems. It may be desirable to remove these cross subsidies, and to set tariffs in each system to reflect the true cost.

In the next five years the direct marginal cost of generation is expected to come down from about US$0.12/kWh to slightly more than US$0.06/kWh. The direct marginal cost of capacity, however, is expected to rise from the present value to about US$376 per kW per annum. If the existing demand patterns from the various sectors remain unchanged then the result will be a reduction in domestic cost per unit and a slight increase in commercial and industrial cost per unit.

POTENTIAL ROLES FOR FINANCE/BUSINESS AND DEVELOPMENT ASSISTANCE

The following considerations, although inspired by the situation in Fiji, apply to most Pacific SIDS. On a per capita basis, the Pacific islands are among the highest recipients of official foreign aid and funds from private foundations in the world. This is partly a result of larger countries using the military and political strategic value of this vast area. Official aid rates vary considerably, but generally range from US$100 to US$1,000 per capita per annum.

There are serious drawbacks to such intensive aid: the beneficiaries come to depend on its continuation and then, in time, may consider that they have a right to such assistance. Such attitudes become a potential source of conflict between cooperation agencies and beneficiary countries. More relevant for present purposes is the transfer of responsibility that is implied by such intensive aid. It can engender an expectation that the results of problems and mistakes will be looked after, and paid for, by others. A sense of ownership is never achieved.

In the energy sector this can result in the non-discriminatory acceptance of equipment, followed by a lack of concern for its effective use or upkeep. Avoiding these consequences requires cooperation agencies to take care in choosing the form in which they provide aid. The temptation to "parachute" hardware into a location must be resisted in favour of careful on-site investigations of the value to the recipients of the alternatives available. When the institution providing assistance is remote from the recipient this can be difficult, expensive, and time consuming. Organisations such as the Forum Secretariat and the South Pacific Applied Geo-science Commission (SOPAC), which have technically competent staff and close links to aid recipient countries can, and do, play an effective role in overcoming this problem.

There is also a need for recipient countries not to accept aid just because it is offered. This can be difficult for a government faced with severe resource constraints and expectations of improved standards of living. It is in the best long-term interests of recipients, however, to use aid to generate commensurate benefits, otherwise the country may be perceived as incapable of benefiting from further aid. It is particularly difficult for a country to carry out the necessary assessments when it is short of specialist expertise, or to turn down an inappropriate aid offer without causing political embarrassment. Organisations such as the Forum Secretariat and SOPAC can, and do, play an "honest broker" role to overcome such problems.

Development of Sustainable Energy Strategies

A successful strategy for developing the energy systems of South Pacific countries like Fiji cannot be derived from experience in other parts of the world. It must be based on a full recognition of the specific and distinct characteristics of the Pacific islands.

In particular, the following issues must be taken into account:

- The societies are small, as are their energy requirements. This means that all supply facilities need to be small to very small and that the full range of specialist capabilities necessary to maintain installations are unlikely to exist within the society. Outside assistance, either by expatriates working under contracts, or through support from regional organisations continues to be needed.
- The narrow range of resources available, particularly in the atoll countries, severely restricts the technologies that are feasible.
- The isolation from external sources of assistance means that back-up resources cannot be easily called in at short notice and transport costs, even for small items, are high.
- The capability of systems to withstand the impact of extreme climatic events and to replace damaged components quickly.
- A lack of data even on basic parameters such as climate, the acceptability and performance of possible biomass species, or the potential for adapting a technology's organisational requirements to fit into local cultural systems. Distances are such that data obtained for one island group cannot be safely assumed valid even for its nearest neighbours. Yet the cost of collection of comprehensive data for each island would represent an impossibly large overhead on energy projects.
- The ready availability of aid finance, grants, or concessional loans to meet capital costs, but not to meet running expenses.
- The overwhelming dependence on petroleum.
- The fact that subsidies rather than "hand-outs" are a more effective means of instilling a sense of ownership and responsibility for services and equipment received.
- In rural areas, a shift from government-controlled energy projects to control by Village Co-operatives is much more desirable. Government is too busy to provide meaningful and effective management.

CURRENT ENERGY SUPPLY AND USE

Fiji's energy requirements are met by petroleum products (heavy oil, kerosene, gasoline, etc.), hydropower, LPG, coal, fuelwood, industrial residue (bagasse, wood chip), agricultural residue (coconut husk and shell), and solar power. Oil, LPG, and coal are imported, while others are produced locally.

An analysis of Fiji's 1997 energy balance shows that about 56% of the country's energy requirements are met from local resources, including hydro, wood, and bagasse.

Hydropower is the main source of electricity, but bagasse (residue from sugarcane) is also a major source of energy supply—the Fiji Sugar Corporation (FSC) burns it to produce process heat and generate electricity, both for its own use and for sale to the Fiji Electricity Authority. Wood is similarly used by the timber industry, but not on such a large scale as bagasse.

Fuelwood is used for cooking mainly in peri-urban and rural areas. Where agricultural residue exists it supplements fuelwood and is used for drying copra, but these uses are limited. Solar energy is mainly used to heat water for domestic purposes and in a few villages for lighting, but the quantity is negligible.

The commercial sector is the main user of electricity, accounting for 46% in 1997.

Fiji imported 43% of its energy, comprising petroleum products, coal, and LPG. Petroleum products are used for transportation, electricity generation, and household lighting and cooking. Coal is used only for heating and by one cement factory. LPG is used for household cooking. These fuels are imported mainly from Australia, New Zealand, and Singapore.

Government Agencies

Department of Energy (DOE) The DOE's vision is to facilitate the development of a resource-efficient, cost-effective, and environmentally sustainable energy sector in Fiji.

The department promotes both the efficient use of energy and the use of renewable energy resources. They assess continually the potential of renewable energy resources like solar, wind, micro-hydro, biogas, and geothermal. Trial projects are installed in several rural locations, and include PV lighting for villages, local solar water heater design and development, several micro-hydro schemes, biogas projects, a wind and solar hybrid power station, manufacture of institutional woodstoves, and energy distribution to rural boarding schools and other communities. The DOE's budget for 1997 was US$2.03 million.

Rural Electrification Unit (REU) is a government unit responsible for coordinating all rural electrification works. It ensures increased penetration of electrification in rural areas through the provision of solar, diesel, and grid extension schemes. The REU's budget for 1997 was US$1 million.

Public Works Department (PWD) is an implementing agency responsible for the construction and maintenance of national roads, installation of water supply schemes, construction and maintenance of hospitals and health centres, and which is also involved in rural electrification works.

Fiji Electricity Authority (FEA) Until recently a government-owned statutory body, but now undergoing privatisation under the government's public sector reform. FEA is responsible for the supply of electricity in Fiji, providing a 24-hour electricity supply to villages, settlements, and cities through their electrification network. About 66% of Fiji's population is connected to the FEA national grid. Transmission and distribution losses are about 9% of total power generated.

FEA operates five separate supply systems, of which the hydro-based Viti Levu Interconnected System is by far the largest, accounting for more than 90% of overall sales. The other four systems—at Korovou on Viti Levu; Savusavu and Labasa on Vanua Levu; and Levuka on Ovalau—are isolated and rely mainly on diesel generation. The 80 MW installed-capacity Monasavu Hydro Scheme (71.65 MW maximum output) supplies 91% of the energy consumed in the VLIS since it was commissioned in 1983, with FEA's stock of older diesel plants providing only back-up services. Growth in demand is rapidly reaching the capacity of the hydro systems, and FEA faces the prospect of having to rely increasingly on diesel generation unless new hydropower capacity is commissioned early in the new millennium. There is still some scattered diesel generation in remote areas.

EMERGING VISIONS FOR ENERGY AND DEVELOPMENT

Rural Electrification Policy

In 1993, the Cabinet endorsed a revised Rural Electrification Policy which entitles any rural dweller to ask for government assistance to provide electricity to their village or settlement. The Cabinet also directed the Department of Energy to set up the Rural Electrification Unit to coordinate all rural electrification work.

Under the previous policy, a diesel system was the only type of electrification scheme available, but consumers can now choose the scheme that best suits them. The main aim is for the villagers to install a scheme that they feel they can afford to operate and sustain. The communities can choose from:

- a diesel scheme;
- connection to the FEA grid;
- a solar lighting scheme—for a community house only (Focal Point) or for individual households;
- a small hydro scheme; or
- a centralised power system, (i.e. from government power stations).

Under the terms of the revised policy, the applicants are required to pay 10% of the total capital cost while the government subsidises the remaining 90%. Included in the subsidy for each option is the provision of two 18 W fluorescent lights and one 10 A power outlet, except for the solar option where no power outlets are included.

There is a grace period of three years during which the government will help to maintain and repair the scheme (except FEA and centralised power systems). During this period scheme-owners are required to open a savings account into which they must deposit F$20, F$30, and F$40 per month during the first, second, and third year respectively. The account is called the Rural Electrification Sustaining Account, and it is established to help villagers to meet the repair and part replacement costs at the end of the grace period. The Accountant of the REU is required to be a trustee of the account only during the grace period term. It is emphasised that the money belongs to the scheme and can be used solely on the scheme and not for any other village commitment. At the end of the grace period the scheme is fully owned by the village, and they are responsible for operating and maintaining it.

There were 14 new stand-alone diesel rural electrification schemes built between mid-1997 and early 1998. The Public Works Department is responsible for the construction of the diesel schemes, although the Department of Environment would have preferred to do this via competitive bidding as is done for grid connection schemes.

One solar scheme was built in 1998. It was a focal point solar scheme for the community hall at Tiliva village in Kadavu.

Also in 1998 the Vunisea Government Station power network was extended beyond the Namalata District School toward the airport, enabling two neighbouring villages, Namalata and Namuana, to be supplied.

Some 65 settlements and villages have already benefited from the formation of the REU in 1993, 32 in 1997 alone. Altogether 52% were connected to the national FEA grid, 44% received diesel generation plant, and 4% received solar lighting schemes.

Sustainable Energy Initiatives

The DOE has a Renewable Energy Development Programme which has been running for several years. The objective of the programme is to promote the use of economically and technically efficient renewable energy resources.

In Fiji, an estimated 1500 kW of power is generated from combined renewable energy sources such as hydro, solar, and biomass fuels.

Solar Energy Projects: The goal of the DOE solar projects is to assess and demonstrate the suitability of solar in various applications such as PV lighting, audio/visual, etc. The solar projects are classified as either trial or demonstration projects. Trial projects are those that require regular monitoring to determine the suitability of solar systems to a particular geographical area, while demonstration projects aim to make rural people aware of the applications of solar energy.

Based on a DOE assessment, focal point lighting systems have been included as one of the options under the Rural Electrification Programme. This system is for lighting community halls and churches, and comprises four elements: two 48 Wp panels, a controller, a 105 Ah battery, and two lights. The DOE has a number of demonstration projects in rural communities.

The DOE also has trial projects running in three different rural locations. These included domestic lighting systems; solar-powered video, and solar-powered television. Furthermore DOE is currently producing a solar radiation map of Fiji, using over 30 years of sunshine data collected at various centres around Fiji by the Meteorological Office. This information will be of particular interest to customers who are considering using solar power. The radiation map will be a guide for designing optimum-sized systems for a given electrical load, at both the household and commercial level.

Five trial and demonstration solar projects are currently monitored and maintained by DOE. This responsibility is expected to be carried out by the villages in the next three years.

- *Namara Village - A PV lighting success story.* Namara Village on the island of Kadavu was provided with PV lighting systems in April 1994 under the Lomé II provisions. A total of 70 houses had PV systems installed, along with a church and a community hall. The project will be monitored by the DOE for the next 10 years. Recent surveys indicate that the installations are working well, and a paid technician provides monthly reports on the condition of the installation. The village solar committee endorses these reports prior to submission to DOE.
- *Solar water pumps - A failed project.* An intensive survey and information-gathering exercise was undertaken on 20 PV water pump systems installed throughout Fiji in 1996. The survey aimed to analyse the cost of PV against diesel/petrol-powered pumps. A large number of the pumps had failed, for both technical and management reasons. Additional funds are being allocated in 1998 to train Public Works Department water supply personnel in the correct installation and maintenance of these PV water pump systems. This in turn will also lead to the formation of policy and selection criteria for solar water pump systems.

Wind Power: The aim of DOE's wind energy assessment programme is to determine the potential of Fiji's wind energy resources. This will allow an assessment to be made of the viability and role, if any, of wind resources in helping to meet future national power demands. It is envisaged that eventually all potential wind generation sites close to a grid in Fiji will be monitored. At present DOE has four wind-monitoring stations on the southern coast of Viti Levu which are recording hourly wind speed and direction data. The sites with the highest potential are being assessed for appropriate system design and development costs by potential windfarm developers.

Hybrid Power Systems: The Nabouwalu hybrid power project was initiated in 1995 and in October of that year three PICHTR engineers met with DOE and visited the Nabouwalu government station. In January 1996 DOE, through its Renewable Energy Development Programme, installed wind and solar monitoring stations at this site to collect the relevant environmental data and determine the feasibility of using wind and solar energy. In November 1996, after the feasibility of the project had been confirmed, land-lease negotiations began between DOE, the Land Department, NLTB, and the landowners to secure land for the construction of the hybrid system.

It is envisaged that this project will demonstrate the technical and financial viability of hybrid power systems in Fiji. In May 1997 two local officers from DOE and PWD visited PICHTR in Hawaii to finalise the design and plans for the hybrid project.

The Nabouwalu village hybrid power system uses wind, solar, and diesel generators. The last two of eight US-made turbines were commissioned in June 1998. It also includes a 40 kWp solar array and two 100 kVA diesel generators as a back-up electricity supply system. This hybrid system is designed to provide power to the whole Nabouwalu government station and Nabouwalu village, which are on the second largest island of Vanua Levu.

The government station includes a hospital, post office, provincial council building, Agriculture and Fisheries Department, Public Works Department depot and its staff quarters, police station and its staff quarters, three shops, and other government departments; about 100 consumers altogether.

The Nabouwalu village hybrid power system has been optimised to produce 80 % of its electricity from renewable energy sources (wind and solar) and the balance with diesel generators.

Funding of US$0.8 million for the project was provided by the Japanese Ministry of Foreign Affairs to PICHTR. The aid covered the hardware, including the wind turbines and towers, solar array, inverters, batteries, controllers, and accessories. The local costs of approximately US$180,000 for civil and road works, construction of the power house, purchase of transformers, electrical cables, and accessories were met by DOE, and the two diesel generators were provided by the PWD.

The construction and civil works on the project began in July 1997 and equipment installation began in September 1997. The PWD completed the civil and road works and will continue to operate the government power station at Nabouwalu after completion of the project. The DOE will continue to monitor the performance of the hybrid power system.

A lot of attention will now be focused on Nabouwalu; the future of such projects in Fiji depends on the success of its village hybrid power system.

Micro-hydro Power: Micro-hydro is an attractive option for rural electrification in Fiji. Preliminary investigations have identified 164 potential sites using information from maps and past surveys, and DOE is assessing potential sites for subsequent development. This will enable the sites to be ranked for a more detailed examination and development. To date 60 sites have been assessed, 30 of which are feasible. Of the 30 feasible sites, only four have had systems installed. Progress on micro-hydro assessment is limited by the availability of equipment; DOE has only four sets of hydrological monitoring equipment.

Geothermal Energy: Geophysical studies have concluded that the Savusavu and Labasa sites have the best prospects for geothermal power in Fiji. Savusavu could generate power, while Labasa has process heat potential. Deep drilling is to be conducted to confirm the geophysical studies and to obtain a firm indication of the energy potential, but it is a very costly procedure and depends on the availability of aid funds, as does further progress on geothermal resource assessment.

Wave Energy: Detailed data on wave energy has been collected. The south-eastern shores of the islands in the southern part of Fiji have suitable wave energy resources: sea waves from the Trade Winds and swells from the southern oceans could be a source of power. Data has been collected over a period of almost five years from a location in the open ocean just south of Kadavu. Analysis of open sea data shows wave energy potential of between 15 kW/m to 30 kW/m. Site specific data has also been collected for short periods—up to two months—from locations on the coasts of Kadavu and Matuku.

Because the Fijian islands are volcanic there are a number of sites with deep-sea bottoms close to the shore. Such sites are of interest for their OTEC potential, although the technology for these energy systems is still at an experimental stage.

Biomass Energy: The DOE believes that there is great potential for the use of biomass and a number of projects using various technologies have been studied, some of which have been implemented.

Woodstoves: Funds have finally been acquired from the Forum Secretariat for this programme, part of the department's ongoing work to disseminate energy efficient technologies in the region. The Regional Institutional Wood-fired Stove Promotion project will enable key individuals in Pacific Island countries to be trained to build stoves appropriate to their respective countries.

Initially the Forum Secretariat funds were restricted to the first phase of the project, which included the following activities:

- Revise and reprint the instruction manual for building the stoves.
- Ascertain the level of interest among other Pacific Island countries for the proposed project.
- From the information gathered, seek funds for the second phase of the project.

The outcome of the Phase I resulted in the upgrading of the Instruction Manual and five countries in the region—Papua New Guinea, Tonga, Tuvalu, Kiribati, and Solomon Island—showed great interest in adopting the technology.

Moreover, in late 1997 the Forum Secretariat Energy Division, which has now shifted to the SOPAC, expressed interest in funding the first stage of Phase II of the project, the staging of an Institutional Workshop for stove building in Tuvalu, Kiribati,

Fiji – The National Context

The South Pacific is vast, and the density of land and people in that area is tiny. Some small islands are coral atolls; others, like Fiji, are made up of high volcanic islands. Fiji is an archipelago covering an area of over 709 660 km^2 in the south-west Pacific. The land area in relation to total area is only 10%, an indication of the enormous distances separating the islands. The majority of its 306 islands are volcanic, of which 108 are inhabited. The total population is just over three-quarters of a million, and 94% of Fijians live on the two main islands, although 61% are nonetheless living in scattered rural villages and settlements.

The economy depends on agriculture and tourism, and although few products are manufactured, the distribution of imported products is a significant industry in itself. Industrial activity includes gold mining, timber milling, and the production of sugar, a well-developed industry. Notwithstanding this dependence on agriculture, the land resources of Fiji are very underdeveloped by Western standards.

Fiji has had an annual trade deficit since 1970. This deficit averaged 50% of total exports between 1990 and 1996. Its largest trading partner is Australia (both exports and imports), and sugar remains the main export, although in recent years the export of clothing has been increasingly important. Transport equipment and manufactured goods are Fiji's major imports.

The South Pacific is a region of occasional violent climatic extremes. Destructive cyclones and floods following intense rainfall are annual hazards. The effects of El Niño have led to drought conditions in parts of Fiji during the last two years.

and Tonga. This stage is presently underway. The second stage of Phase II will involve other interested countries including Vanuatu, Solomon Islands, PNG, and the Federated States of Micronesia. This stage of the project should take place in 1999.

Failed Project - Navakawau Steam Plant: This biomass project was set up in 1987. The plant has not been working, for several reasons: fuelwood seedlings were not planted; fuelwood was not collected on time; and there was a general lack of interest on the part of the villagers who were supposed to be running the plant. Despite this, a general overhaul of the plant was completed in 1996 and the plant has been put back into operation. A final batch of 3,000 fuelwood seedlings has been delivered by the DOE to the village to supplement fuel for the plant.

Pilot Biogas Project: A pilot biogas plant was successfully installed at Hari Ram Lakhan's dairy farm in Waidalice, Tailevu. Funds for the project were provided by the DOE while the design, construction, and supervision work was carried out by MAFFA. The DOE was mainly involved in co-ordinating the project and monitoring biogas production.

The construction of the biogas plant was completed in December 1997, having been set back by the rainy season.

The digester plant processes cow dung from the farm. The dairy farmer used to use fuelwood to boil water to sterilise the milking equipment. The biogas will replace the fuelwood, and the slurry from the plant will be used as fish feed for the three fishponds (at the dairy) which cultivate Tilapia.

POLICIES TO PROMOTE SUSTAINABLE ENERGY IN ACP SIDS

Proactive government policies and actions are vital for the successful implementation of sustainable energy sources in ACP SIDS. A list of priority actions by governments, institutional bodies, and NGOs, some of which will require development assistance, is presented here.

CAPACITY BUILDING FOR ENERGY MANAGEMENT, PLANNING, AND POLICY FORMULATION

- Develop strategic national energy policies addressing the needs for energy security, energy access, energy diversification, and environmental targets. Enhance national capacity to effectively plan, manage, and monitor the energy sector.
- Increase self-reliance by developing indigenous technologies while promoting RETs and energy efficiency measures, including the capacity to manage, assess, acquire, and disseminate local appropriate technologies.
- Integrate sustainable energy technologies into sectoral programme activities.

REGIONAL COOPERATION, TRADE, AND INFRASTRUCTURE DEVELOPMENT

- Support local and regional cooperation with neighbouring islands and other ACP SIDS in energy trade, harmonisation of technical standards, common frameworks for energy investments, better exchange of information and experience, and shared energy training and organisational capacity-building.
- Develop new and existing regional groupings to pool resources and expertise for common benefit and to gain improved access to international power sector programmes.
- Provide training to local installers, maintenance personnel, and end-users to ensure long-term sustained operation.
- Implement appropriate public education and awareness programmes, including consumer incentives, to promote energy conservation.
- Develop technical specifications, standards, and codes of practice to ensure good and reliable operation of sustainable energy technologies.
- Ensure accessible after-sales services and readily available spare parts at reasonable costs.

TECHNOLOGY DEVELOPMENT AND DISSEMINATION: ENERGY EFFICIENCY, DSM, RENEWABLES, AND SUPPORTIVE SERVICES

- Establish or strengthen research and policy capabilities in the development of sustainable energy technologies and measures.
- Ensure data gathering/mapping to establish the real potential of sustainable energy technologies and measures.
- Provide monitoring, oversight, and information dissemination on sustainable energy projects.
- Ensure information and data is made centrally available to all.

NON-TECHNICAL ISSUES

- Ensure participatory appraisal methods are included as integral parts of energy programmes. Women must also be directly involved in the decision-making processes.
- Ensure community ownership and management.
- Ensure partnerships with local and regional organisations and non-governmental organisations.

ENERGY PRICES, TAXES, AND SUBSIDIES

- Remove market distortions to achieve marginal cost pricing for conventional fuels and electricity.
- Provide fiscal incentives designed to increase the market penetration of RETs and energy efficiency measures, particularly those that are locally manufactured (for example grants, tax concessions, soft financing, loan guarantees, power purchase agreements, etc.).
- Ensure duties and taxes on RETs and energy efficiency equipment are no greater than those paid on conventional fuels.

DEVELOPMENT AND SUPPORT OF EFFECTIVE METHODS OF CREDIT FINANCING

- Encourage the commercial sector and financing agencies to support rural energy development in a sustainable way.

PRIVATE BUSINESS DEVELOPMENT AND SUPPORT

- Provide training, technical assistance, and workshops for the private sector, for example those organised through the Pacific Regional Energy Programme (PREP) on private sector involvement in the power sector.
- Remove regulatory barriers that limit competition among energy service providers.
- Promote independent/autonomous agencies to pursue rural electrification/decentralised energy systems (for example, the Central Energy Conservation and Renewable Unit, Jamaica and the TSECS Solar Power Co-operative, Tuvalu.

ANNEX I - RELEVANT ACTIVITIES OF DEVELOPMENT COOPERATION INSTITUTIONS

ANNEX I RELEVANT ACTIVITIES OF DEVELOPMENT COOPERATION INSTITUTIONS

The information contained in this Annex has been collated from a wide range of sources including existing publications (including annual reports and policy papers), questionnaires, and unpublished material. Bilateral cooperation agencies were sent a standard questionnaire concerning their present activity in the field of energy cooperation. Most of the information on the energy sector lending of international development banks was taken from the annual reports of these institutions and from official publications; in addition the banks responded to a separate questionnaire.

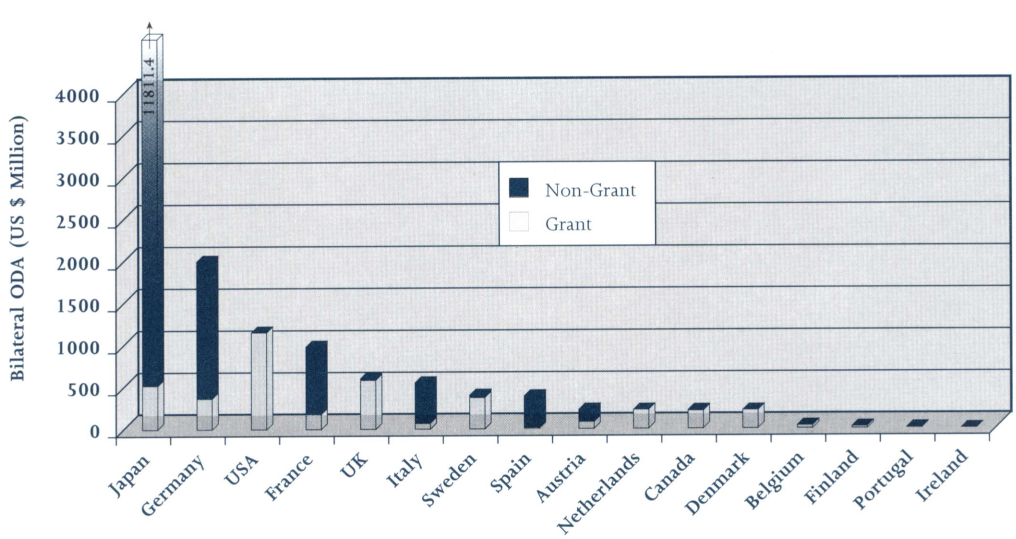
Further to the questionnaires, personal communications with representatives of development finance institutions helped significantly to construct an up-to-date summary of present cooperation priorities. Often the number of individual energy-related projects undertaken by a single agency is immense and the Annex does not purport to be a complete index of development assistance-supported initiatives, but rather an indication of present activities. Where possible, the future direction of cooperation is also outlined. Official Development Assistance provided by the institutions of the European Union and by institutions of EU Member States is given in European Currency Units (ECU). ODA provided by other institutions is given in US$ (US$1 = c. 0.88 ECU in 1997).

There are three principal sources of finance promoting sustainable energy systems in developing countries: bilateral and multilateral cooperation agencies (which administer grants, loans, and tied aid); international development banks; and national governments. The private sector represents the largest potential financier, however, and many of the grant and soft-loan-funded initiatives detailed below aim to encourage much larger investments in sustainable energy from this source.

BILATERAL DEVELOPMENT COOPERATION PROGRAMMES

The amount that donor governments commit to development assistance varies widely. They administer their aid both bilaterally and multilaterally, and in many different forms, such as grants, loans, or tied credits. Figure 1.1 shows the major sources of bilateral aid to the energy sector in recent years. Japan is the largest donor—mainly through non-grant activities—and the United States is the most significant donor in terms of grant aid. These two apart, EU Member States are the principal source of bilateral finance. Energy initiatives have usually been funded through a sectoral approach, but increasingly energy activities address overreaching general development goals, such as the reduction of poverty, sustainable development, and the environment. The figure for total resources financing sustainable energy initiatives therefore includes unquantified resources from multi-sectoral programmes or resources classified under other sectors, such as forestry and transport.

Figure 1.1 Bilateral ODA to the Energy Sector (1992-1996)



Source: OECD DAC Database

EU MEMBER STATES

Between 1992 and 1996, EU Member States committed around 1,000 MECU annually in grants and loans in support of energy initiatives in the developing world. Germany (35% of these commitments) has been the largest single European donor, followed by France (17%), United Kingdom (11%), Italy (10%), and Sweden (7%). Table 1.1 shows that energy co-operation typically makes up a small but significant part of Member States' bilateral aid budgets, and details current priority areas of bilateral cooperation programmes. Energy infrastructure (including rural electrification), energy efficiency, renewable energy, and capacity building are common target areas. Sectoral initiatives reflect the importance given to institutional, financial, and legal conditions and the need to establish an enabling environment before sustainable energy systems are adopted on a wide scale.

Table 1.2 provides an overview of bilateral cooperation in selected priority areas.

Table 1.1 Member States Bilateral Aid to the Energy Sector and Current Funding Priority Areas

	Bilateral Support 1996		Current Energy Priority Areas*						
	Aid to Energy Sector (MECU)	Energy as % Total Aid	CP	EI	HY	EE	RE	SR	CB
Austria	7,4	1,7		•			••		•
Belgium	3,0	0,8	•	••		•	•••		•••
Denmark	44,6	6,3		•••		•••	•••	•••	•••
Finland	24,1	13,9		••		••	••	•	••
France#	144,6	2,9	-	-	-	-	-	-	-
Germany	353,6	9,3	•••		•••	••	•••	•••	••
Greece	0	-	•••			•••	••		••
Ireland	0,6	0,9		••					
Italy	27,3	4,3	••	•••			••		•••
Luxembourg	0	-		••					
Netherlands	53,9	3,0		•		•••	•••	•	
Portugal	0,2	0,2						••	
Spain	62,9	9,8		•••		•••	•••		•••
Sweden	81,6	8,7		•••	•••	•••	•••	•••	•••
United Kingdom	75,5	5,6		•••	•••	•••	•	•••	•••

Priority Areas *	CP	EI	HY	EE	RE	SR	CB
	Conventional Power	Electricity Infrastructure	Hydro Power	Energy Efficiency	Renewable Energy	Sector Reform	Capacity Building

Source: (OECD, 1997)

Energy Priority Areas for France Not Available

Table 1.2 Overview of EU Member States' Commitments in Selected Priority Areas

Sub Sector	Overview of Cooperation Activities
Conventional Power	• France, construction and rehabilitation
	• Germany, retrofitting (41 MECU in 1997)
	• Italy, construction
Electricity Infrastructure	• Germany (19 MECU in 1997)
	• Denmark (14.3 MECU in 1997)
	• United Kingdom (13 MECU ongoing cooperation)
	• Spain (14 MECU in 1997)
Hydro	• France
	• Germany strategic development (23 MECU 1997)
	• Sweden studies and investments
	• United Kingdom (17MECU ongoing cooperation)
Energy Efficiency	• United Kingdom (17MECU ongoing cooperation)
	• Germany (17 MECU ongoing cooperation)
Renewables	• Austria especially **mini-hydro**, **biogas**, and **biodiesel**
	• Denmark (14 MECU in 1997) **wind** and **mini-hydro**
	• Finland (14 MECU) for **forestry** cooperation
	• France, especially **PV**
Hydro	• Germany (16 MECU in 1997) **PV**, **wind**, and **mini-hydro**
	• Netherlands (18MECU in 1997)
Sector Reform	• Denmark, Germany, Sweden
	• United Kingdom (17MECU ongoing cooperation)
Capacity Building	• Germany (35 MECU ongoing cooperation)
	• Austria, Denmark, France, Netherlands, Sweden, UK
Gender	• Denmark, Sweden

• Austria

Austrian development cooperation in the energy field is financed through the Projects and Programmes budget (80 MECU annually) and managed by the Technical Cooperation Unit of the Federal Ministry of Foreign Affairs. Cooperation in the energy field (5-6 MECU in grant aid annually) is the result of requests from host countries. There is no sector policy, but the Technical Cooperation Unit plans to develop an energy policy in the near future. Principal areas currently addressed are energy education and training (43% of commitments in 1997), renewables, and environmental impact assessment. Austria has financed mini-hydro plants in Bhutan and Nepal and mini-hydro planning and maintenance training in Ethiopia. A larger 20 MW hydro plant is under construction in Bhutan (part soft loan Finance). Biogas initiatives in the Ivory Coast, Senegal, and Nicaragua have been implemented in connection with agricultural extension programmes. A 10-year-old biomass technical cooperation programme in Nicaragua has investigated the potential for various energy crops, established a plant producing biodiesel, and offers technical assistance for the planning and construction of biogas digesters.

• Belgium

Within the Ministry of Foreign Affairs, the Belgian Administration for Development Cooperation (BADC) is in charge of planning and implementing development cooperation actions. A new policy for cooperation, approved in October 1996, concentrates on five priorities: public health; education; agriculture and food security; basic infrastructure; and society building. Furthermore, employment creation is seen as a key goal. Joint ventures between developing country small- and medium-sized enterprises (SMEs) and Belgian counterparts are therefore supported. In the future, assistance will be limited to 20 programme countries, in the main situated in Sub-Saharan Africa.

In 1996 ODA to the energy sector totalled 3 MECU (less than 1% total ODA). Table 1.3 summarises recent energy initiatives funded by Belgian ODA. Electrification programmes and capacity building have been the principal areas receiving support. Electrification programmes are normally part of integrated programmes including rural development, health, water, and agriculture. In terms of capacity building, the institutional strengthening of bodies responsible for the production and distribution of electricity (Zaïre, Rwanda, Burundi), the elaboration of 15-20 year utility development plans, and university partnerships have all been supported.

Belgium's regions are also active in development cooperation, particularly in the field of education. APEFE (representing the Walloon region) runs a number of training programmes including those for electricity pricing policy, biomass and energy, solar energy, rural electricity, energy management in public buildings, and maintenance in the renewable energy sector.

Table 1.3 Recent Energy Projects Financed by Belgian ODA

Sub Sector	Country	Project	MECU
Conventional Energy	Indonesia	Feasibility study for coordinated development of coal resources	1.23
	Indonesia	Rehabilitation of diesel generators on remote islands	2.11 (L); 0.28 (G)
Renewables	Philippines	Supply and installation of PV power station on a remote island	0.54
Energy Policy	Guatemala	Energy policy and administrative management for electrification of rural zones	0.46
Electricity Infrastructure	Cambodia	Supply of cables, transformers, and connection boxes for urban electrification	1.23
	Ecuador	Supply of cables, transformers, and connection boxes for rehabilitation of electricity grid	4.93
Capacity Building	Surinam	University cooperation on micro-hydro plants	0.40
	Vietnam	University cooperation to strengthen energy education	0.70
	SADC	Support of Technical and Administrative Unit	2.22

(L) Loan (G) Grant

• Denmark

The Danish Ministry of Foreign Affairs administers Danish International Development Assistance (Danida). Danida's bilateral aid is restricted to 20 countries and in each country support focuses on between two and four sectors. Country policies, where possible linked with national policies and strategies, identify issues to be addressed in each sector and incorporate cross-cutting themes such as women's and children's conditions, the environment, democratisation, and human rights. Danida's energy sector policy (Danida, 1993) requires that a review of the sector (including institutional performance) is completed before an assistance programme can be initiated. An Environmental Impact Assessment, economic analysis, and financial analysis are also required for each energy project. Activities must respect the principles of economic viability and long-term sustainability, so Danida will fund only proven renewable technologies in countries that have taken a political decision to support renewables. In 1997 35.3 MECU were provided in support of energy sector activities (5.1% of total bilateral aid), targeted primarily at electrification projects (41%) and new and renewable energy projects (33%). Table 1.4 details ongoing energy projects financed by Danida. Although Danida provides grant funding to governments, by agreement this can be on-lent to utilities. Currently around 75% of Danida's funding to the energy sector is on-lent.

Six Danida programme countries (Burkina Faso, Egypt, Ghana, India, Mozambique, and Nepal) have energy as a priority sector. In these countries, the Sector Programme Supports (SPS) can be used to provide a framework for long-term (a minimum of 10 years) commitment. A SPS typically contains four aspects: institutional strengthening for energy policy and planning and legislative reform; support for utilities in improving efficiency and coping with restructuring in the sector; investment activities (e.g. electrification projects); and support for traditional coal-based energy (often with GEF) and fuelwood (often with RPTES). Plans for future Danida cooperation include promotion of renewables and energy conservation in industry in Egypt, and rural access to sustainable energy and reorganisation of the power utility in Burkina Faso. In all its operations, Danida uses programme indicators to measure achievements and stresses the importance of coordination within the international donor community. Monitoring of projects is often facilitated by the appointment of Danida technical advisors, who also provide project guidance and assist local institutions and Danish embassies with aspects of project implementation.

Following UNCED, the Danish government set up an environment and natural disaster relief fund (MIKA), which will reach 0.5% of GNP by 2002. The funds are distributed evenly between disaster relief and environmental assistance. Environmental assistance (71 MECU in 1997) targets a selected number of countries in South East Asia and Southern Africa. The Danish Ministry of Environment and Energy is responsible for assistance to the more developed countries of the two regions, while Danida deals with the poorest. Under MIKA strategy for environmental assistance (Danida/Danced, 1996), sustainable use of energy (including energy management, efficient production and end-use of energy, and promotion of renewables through resource mapping and demonstration) is a thematic priority. Sustainable energy has been selected as a priority in some upcoming country programmes although energy initiatives to date (3-4 MECU in 1997) have principally been in the field of sustainable use of forest resources. MIKA funds have implemented an energy-saving programme in new buildings and supported the training of energy industry staff in Thailand (1.7 MECU), the demonstration of biogas technology in Malaysia, and capacity building in the field of sustainable energy.

Table 1.4 Ongoing Energy Projects Financed by Danida

Sub Sector	Country	Project
Conventional Energy	Mozambique	Rehabilitation of Inhambane power station
Renewables	Egypt	60 MW wind farm at Sarafana on Red Sea
	Burkina Faso	First phase of RPTES programme (biomass)
	Ghana	Sustainable management of fuelwood resources
	India	Promotion of renewables
	Nepal	Support for solar and biomass
Energy Efficiency	India	Energy conservation in industrial consumption
Electricity Infrastructure	Ghana	Electrification by grid extension in Central and Upper West regions
	Egypt	Regional transmission centre for Canal zone
	Mozambique	Construction of 100 kV transmission line
Capacity Building	Burkina Faso	Institutional support and capacity building for Ministry of Energy and state utility
	Ghana	Institutional support to power utility training centre

- Finland

The Finnish Ministry of Foreign Affairs administers development aid (176 MECU in 1997) in pursuit of three substantive goals: to reduce widespread poverty; to combat environmental threats; and to promote social equality, democracy, and human rights. There is no official energy policy or sectoral budget allocation (projects are adopted within country budget frames), but priority areas are improving access to electricity for rural populations (grid extensions and isolated systems) and reducing environmental impacts (Finnish Ministry of Foreign Affairs, 1998). Aid for investments in commercial energy is often given as concessional credits (within the limitations of OECD rules) rather than as grant aid.

Support for energy projects has declined in recent years, but totalled around 10 MECU in 1997. Finland has financed the extension of electricity transmission and distribution systems in Bangladesh, Nepal, Peru, Zambia, and Zimbabwe. In cooperation with Sweden and Norway, Finland contributed (33%) to the establishment of the 66 MW Pangani hydropower plant in Tanzania. Diesel-powered electricity generation units have been financed in Nepal (24 MW), Nicaragua (two of 6 MW), Peru (12 MW), and Tanzania (50 units, typically 640 kW). In China, Finnish concessional credit has financed several projects in the district heating field, one on desulphurisation and combustion technology with a small hydropower plant. Energy cooperation with Eastern Europe and the New Independent States (NIS), managed in partnership with the Ministry for Trade and Industry, has primarily focused on district heating activities.

Additional aid for forestry activities (about 13 MECU annually) has supported the management of traditional fuel sources. Fuelwood supply issues are addressed in Forestry Master Plans (Nepal, Thailand, Kenya, Tanzania) and in Rural Forest Management projects (Vietnam, Laos, Tanzania, Zambia, Mozambique, Central America, Malawi).

- France

French ODA is administered by the recently merged French Ministry of Foreign Affairs and Ministry of Cooperation (grant aid) and also by L'Agence française de développement (AFD). ODA to the energy sector totalled 165 MECU in 1996, 30% in grant form.

AFD administers French ODA in the form of grants (for governments, community organisations, and NGOs) and loans (for public and private sectors). In 1997 AFD provided 946 MECU, principally as project aid. Financing was also provided for structural adjustment programmes (130 MECU). Sustainable energy initiatives have been funded both in energy sector projects and through rural development projects (e.g. PV water pumps). Energy sector operations, predominantly loans, accounted for 15% of project aid in 1997 (114 MECU). The construction of new electricity power production facilities and the rehabilitation of old facilities were the principal areas of support. Co-financing (74 MECU) for the construction and distribution of 200 MW hydroelectric power for Mali, Senegal, and Mauritania was the largest single engagement. Other power projects were financed in Chad, Comores (hydro), Ethiopia, Mali, Tanzania, Tuvalu, Vanuatu, and Zambia (hydro). Electricity distribution projects were financed in Ghana and Tanzania. In terms of renewables, AFD has supported Morocco's rural electrification programme (34 MECU) (which includes a PV component), wind power generation (8 MECU) in Morocco, PV electrification in Vanuatu (0.5 MECU grant), and PV as a component of telecommunications projects. In other areas, AFD has supported the establishment of a hydropower technical and maintenance training centre in Laos (4.3 MECU) and an electrical training centre in Benin. Le Fond Français pour L'Environnement Mondial (FFEM), a bilateral fund that works in a similar way to the GEF, provides an additional source of funds for sustainable energy initiatives (67 MECU 1994–1997). To date 26 climate change projects account for 45% of approved funding, including 15 on new and renewable energy and eight on energy efficiency.

Information is not available on projects and programmes funded by the French Ministry of Foreign Affairs and Ministry of Cooperation. L'Agence de l'Environnement et de la Maitrise de l'Energie (ADEME) is a government agency which aims to promote improved energy management, renewable energy, and energy efficiency and to protect the environment. Some of ADEME's activities are international. ADEME was a co-organiser of the November 1995 Marrakech decentralised rural electrification seminar which pooled experiences of developing countries, the industrial sector, NGOs, development banks, and other international organisations, in order to increase the scale of rural electrification throughout the developing world.

• Germany

The German Federal Ministry for Economic Cooperation and Development (BMZ) is responsible for German development cooperation. Its principal policy objectives are to improve the living conditions of the poor; to ensure sustainable economic growth (economic, ecological, and social sustainability); to promote technological expertise in developing countries; to reduce dependency on imported fossil fuels; and to support developing countries to implement UNCED resolutions. Energy policy must contribute to these broad development objectives and structural and sectoral reform programmes remain central to the approach in this sector. Individual projects have targeted fields where energy has an identifiable role beyond mere supply, such as forestry (for household fuels and improved stoves), agriculture (water pumping), and industry (energy efficiency). BMZ uses a number of different partners to implement energy/development programmes and projects. Technical cooperation projects (186 MECU as grants 1987-1996 (BMZ, 1997)) are implemented principally by the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), The Federal Institute for Geosciences and Natural Resources (BGR), and The Carl Duisberg Society (CDG) while Kreditanstalt für Wiederaufbau (KfW), the German development bank, implements financial cooperation (FC) projects (2850 MECU as grants and loans 1987–1996).

Ongoing technical assistance projects target renewable energy (105 MECU), capacity building (35 MECU), and energy efficiency (35 MECU). In general, bilateral technical assistance has become increasingly geared towards energy policy adjustment and the promotion of institutional reforms to ensure greater involvement of private finance in the energy sector (policy and planning initiatives accounted for 28% of energy sector ODA commitments in 1997). The Energy Programme Zimbabwe, for example, promoted revision of the legal framework to enable private sector participation in the power sector and institutional reform in Zimbabwe. Technical assistance has been provided in Nepal to explore privatisation options for 25 mini-hydro plants that have been operated uneconomically in the past by the Nepal Electricity Authority, and in Pakistan a refinancing facility of 80 MECU—of which 35 MECU is provided on concessionary terms—for investments in renewable energy has been established. On a regional level, a programme in six Central American countries has tried to establish mechanisms to harmonise regulation, supply planning, and the pricing of petroleum, and another programme advises regional institutions (OLADE and ECLAC) and selected countries in Latin American and Caribbean countries on integrated energy and economic policy. Outside technical assistance loans provided by KfW and by The German Investment and Development Company (DEG) also aims to increase private sector participation in energy projects.

KfW distributes FC to developing countries both as federal government grants (to LDCs) and as low-interest loans. In an effort to meet expanding financing requirements, KfW also raises funds from the capital markets to supplement FC funding in *mixed* or *composite* financing schemes. With an increase in the bank's social infrastructure activities, the energy portfolio has recently shrunk but was still the second largest sector receiving FC in 1997, when KfW committed 330 MECU—23% of developing country commitments (KfW, 1998). Ongoing FC projects (841 MECU) concentrate on upgrading power generation facilities (efficiency and emissions improvements) and electricity transmission. Commitments for hydropower projects, which accounted for over 20% of energy sector commitments between 1987 and 1996, have recently declined, but those for renewables are increasing and new commitments in 1997 were for wind energy in China (12 MECU, 50% composite finance) and for PV in Morocco (5 MECU grant). Although bilateral sectoral adjustment loans have not been widely used in the energy sector, power supply projects hoping to receive FC must meet certain operational appraisal criteria (OAC). These criteria require that the project is consistent with the wider economic expansion paths and structural adjustment programmes, demonstrates efforts to achieve full cost recovery, and takes into account environmental standards.

Building technological expertise and institutional capacity within developing countries remains a priority area of German development assistance. "Twinning arrangements", in which personnel from utilities in developed countries take part in routine operations in a partner developing country, are to be stepped-up following successes in Thailand and elsewhere. BMZ has also funded the development of technical tools, such as The Environmental Manual for Power Development. The German Ministry for Technology has financed technical research into energy activities with applications in developing countries for 23 years. Although this programme is now ending, it provided around 12 MECU annually in its final years, mainly for renewable projects and for some energy efficiency projects. Beyond bilateral cooperation, sector investment programmes (SIPs) unite cooperation agencies in a common approach, optimising the use of resources. The success of policy implementation is monitored by particularly strict evaluation procedures that include an ex-post report (financial and general) produced at the end of projects to assess their sustainability.

Table 1.5 Typical Ongoing Energy Projects Funded by BMZ

Sub Sector	Country	Project	MECU
Conventional	PR China	Retrofitting coal power stations with flue-gas desulfurisation equipment and boilers	147
Hydro	Pakistan	Country-wide hydropower development programme	6.6
Renewables	Egypt	Installation of 40 MW of wind power by 1999 at the Red Sea	70
	India	Promotion of renewables through a refinancing facility	82
	Morocco	Development of a regional renewable energy supply concept	6.6
	Namibia	Promotion of the use of renewable sources of energy	2
	Senegal	Integrated approach to the supply and demand side of traditional biomass fuels, and testing and dissemination of PV systems	5
	Turkey	Construction of a biogas cogeneration plant at a sewage plant	23
Energy Efficiency	India	Improvement of industrial energy efficiency in Karnataka	3.1
Sector Reform	Zimbabwe	Revision of legal framework for private sector participation in the power sector and institutional reform	5
Capacity Building	Egypt	Training of thermal power plant personnel	10
	Indonesia	Institutional support for training in operation of electricity distribution networks	2.8
	Brazil	Energy conservation in SMES by establishing information and training network	1.8

Greece

Greek development assistance is managed by three institutional bodies, the Inter-Ministerial Committee for the Coordination of International Economic Relations (EDOS), The Directorate for Development Cooperation, Special Finances, and Programmes (DCD) in the Ministry of National Economy; and the Monitoring and Administrative Committee of the Development Cooperation Programme of Greece. In 1997 Greece began a five-year overseas assistance program of bilateral aid. The geographical priority areas are the Balkan states, but NIS, the Middle East, and Sub-Saharan African countries are also supported. In 1997 the total development aid budget was 40 MECU, which included support for two energy workshops on energy savings in Balkan countries at a cost of 0.133 MECU. To date no energy initiatives have been financed in ACP countries, but the Ministry of Energy has provided training in energy management for less developed Mediterranean countries in the past. Outside government Ministries, the Centre for Renewable Energy Sources (CRES), a publicly owned institution partly supported by EC funds, promotes renewables and the rational use of energy both nationally and internationally. Business missions to South America and China have promoted sustainable energy technologies.

Ireland

Irish bilateral aid is managed through the Department of Foreign Affairs. The energy sector has not been a major area of attention, receiving only around 1 MECU annually (0.9% ODA), but occasional projects have received support. In 1997 Irish aid, with local financing partners, co-financed a rural electrification project in Vietnam and upgraded the electricity distribution system in the copperbelt towns of Zambia. Earlier projects supported peat development in Rwanda and Burundi in addition to pilot projects, training activities, and studies in Vietnam, Zambia, Rwanda, and the Palestinian Territories.

Italy

Italian development aid is administered through the Direzione Generale Cooperazione Allo Sviluppo (DGCS) of The Ministry of Foreign Affairs. The National Agency for Electrical Power (ENEL) and the National Agency for Energy and Environment (ENEA) are involved in developing energy cooperation projects and programmes. Activities have been almost entirely bilateral in nature, determined within a triennial programme agreed with beneficiary countries. Italy has not yet defined an energy cooperation strategy, and past activities have concentrated on supply-side power production. Soft loans (120 MECU annually on average) account for most cooperation in the energy field, although these are often administered in conjunction with grants (around 25 MECU annually). Recently energy sector funding has declined significantly and in 1997 4.3 MECU of grant aid was dedicated to energy projects.

Table 1.6 Ongoing Energy Projects Financed by Italian ODA

Sub Sector	Country	Project	MECU
Conventional Energy	Argentina	Rehabilitation of thermal power plant	2.3^{G} 85^{L}
	Egypt	Construction of thermal power plant	75^{L}
	India	Construction of thermal power plant	40^{L}
Renewables	China	Biogas from agricultural waste	0.18^{G}
	Indonesia	Construction of geothermal power plant	40^{L}
	Peru	Construction of micro-hydro facilities	2.3^{G} 4^{L}
Electricity Infrastructure	Somalia	Electrification by grid extension	7.3
Capacity Building	Ethiopia	Technical assistance to energy ministry	25^{G}

(L) Loan (G) Grant

• Luxembourg

The Directorate for Cooperation within the Ministry of Foreign Affairs manages the majority of Luxembourg's bilateral ODA (39 MECU in 1996). Development cooperation priorities include poverty eradication, women and development, economic self-reliance and environmental sustainability. At the same time 14 target countries—Burkina Faso, Burundi, Cape Verde, Ecuador, El Salvador, Mauritius, Laos, Namibia, Nicaragua, Niger, Senegal, Palestinian Territories, Tunisia, and Vietnam—receive priority support. Development programmes are addressed within the above broad priorities. Specific energy initiatives include: electrification projects in Cape Verde and Vietnam (La Cooperation Luxembourgeoise, 1996), biogas production in India, and domestic waste and used oil management in Tunisia. In 1996 the electrification of medical centres in Cuba using solar power was supported through an NGO. Luxembourg collaborates with UNCTAD in the provision of financing for micro-projects in developing countries. The programme provides concessionary loans, typically of US$500 to US$1,000, which can be paid back over a period of 20 years and might provide a financing mechanism for the purchase of PV equipment. Finally, Luxembourg has supported a climate change information campaign in developing countries and hopes to strengthen its support of sound technology transfer in the future.

• The Netherlands

The Climate, Energy, and Environmental Technology Division of The Ministry of Foreign Affairs administers Dutch development assistance in the field of energy. Assistance is guided by three principles: equity, environmental sustainability, and economic growth. Based on these broad principles, an energy sector policy has been defined (NEDA, 1991). The main thrust

Table 1.7 Examples of Ongoing Energy Projects Funded by NEDA

Sub Sector	Country	Project
Renewables	Asia	Regional Wood Energy Development Programme
	Bhutan	Solar energy for public buildings and health centres; dissemination of biogas systems
	Bolivia	Installation of solar equipment in schools and health centres; PV dissemination strategy
	India	Installation of three wind farms (1 MW and 2 x 20 MW) (MILIEV)
	Nepal	Biogas support programme: promotion, subsidy, and research
	Philippines	Rural electrification by solar home systems (MILIEV)
Electricity Infrastructure	Bangladesh	Electrification of rural areas by grid extension
	Bhutan	Extension of distribution systems from existing mini-hydro facilities
Financing Mechanisms	India	Support of loans for development of new and renewable energy (10 MECU)
	Bolivia	Tailor-made loans for renewable and energy efficiency technologies (4.5 MECU)
	Peru	Trust fund for renewable energy (4.8 MECU)
	Global	Subsidy for Solar Investment Fund TRIODOS bank
Market Reform	Bolivia	Market assessment and policy reform
Appropriate Technology	Asia	Asian Regional Woodstove Programme
Capacity Building	SADC	Institutional support to SADC Technical Assistance Unit (training on rural energy)

of energy policies is the support of renewable energies, energy efficiency, and rural energy. Emphasis is placed on an end-use approach, capacity building, environmental sustainability, and market development. A wide array of policy instruments has been used to implement sustainable energy policies: bilateral programmes, regional co-operation, international initiatives, activities implemented jointly (AIJ), and a tied-aid programme (MILIEV). Bilateral programmes in Africa, Asia, and Latin America have implemented renewable (wind solar, biomass, biogas, and mini-hydro), DSM, energy efficiency, and rural development projects. Renewable energy activities (18 MECU in 1997) incorporate capacity building, institutional development, rural development, and market development aspects, including support for on-lending schemes. In the period 1995-1997 Netherlands Development Assistance (NEDA) funded 97 energy projects, 27 concerning renewables and 31 concerning energy conservation (ETC Netherlands, 1998). Table 1.7 contains examples of ongoing projects funded by NEDA.

In an attempt to be more efficient and cost effective than individual national projects, NEDA has adopted a regional approach to information dissemination, development of methodologies, and capacity building, for example through its support of the Regional Programme on the Traditional Energy Sector. A unique initiative aims to re-orientate the energy sector investments of the multilateral development banks towards sustainable energy through the establishment of regional coordination bodies which are creating inventories of the activities of the regional banks and networks within these organisations to further discussions on sustainable energy investments. Other international initiatives supported by NEDA include ESMAP's Small Project Funds, The Environmental Manual of Power Development (World Bank, no date), and ongoing support of the Asian Alternative Energy Unit (ASTAE). The Netherlands has gained valuable experience in AIJs (27.3 MECU in financing 1995-2000) through projects in Botswana and Morocco (solar systems), India (creation of Independent Rural Power Producers (IRPP)), Peru (landfill gas exploitation), Costa Rica (anaerobic treatment of coffee wastewaters), Bolivia (gas-fuelled generators), and Honduras (compact fluorescent lamps).

• Portugal

Portuguese development assistance is administered both through the Portuguese Cooperation Institute and through the Economic Cooperation Fund. Within the Ministry for Foreign Affairs, the Portuguese Cooperation Institute manages grant aid to developing countries. Five PALOP (Pays Africains à Langue Officielle Portugaise) countries (Angola, Cape Verde, Guinea Bissau, Mozambique and São Tomé e Principe) enjoy priority status, but a number of other countries or regions, notably Brazil, North Africa, and Zimbabwe, also benefit. The Economic Cooperation Fund, jointly managed by the Ministry for Foreign Affairs, Ministry of Economy, and the Ministry of Finance, supports Portuguese private sector initiatives in developing countries.

Official aid to the energy sector has varied widely over the years (8 MECU in 1995, 0.2 MECU in 1996). Recent cooperation in São Tomé e Principe has financed technical assistance in accountancy and financial management for the electricity and water utility (0.17 MECU), and also the maintenance of a hydroelectric facility (0.11 MECU). Planned activities include a feasibility study for additional hydroelectric power and support of the Forestry Authority to manage fuelwood supply. A three-year programme of support for the Energy Administration in Cape Verde (1995–1998) has focused on strengthening institutional capacities and providing technical training for the Directorate-General for Industry and Energy. Other examples of past energy initiatives exist in Mozambique (hydro) and Costa Rica (training). In addition, the Portuguese Directorate General of Energy in the Ministry of Economy has provided some training and technical support for the formulation of power and electricity legislation in PALOPs. In the spirit of partnership, The Directorate General has also contributed 25% of the cost (0.18 MECU) of the SYNERGY initiative "Energy Policy in Cape Verde".

• Spain

The bulk of Spanish cooperation in the energy sector is financed by soft loans managed by the Ministry of Commerce. Between 1993 and 1997 commitments totalling 266 MECU supported principally electrical transmission and distribution projects (110 MECU), notably in China, and the construction of hydropower plants (97 MECU), notably one in Honduras. In 1998 the first renewables loan (2.4 MECU) was made in support of solar energy in Ghana.

The Agencia Española de Cooperación Internacional (AECI) of the Ministry for Foreign Affairs, manages Spanish bilateral grant aid. Grant aid to the energy sector is around 1.6 MECU annually, with an additional 0.38 MECU for research initiatives. AECI activities are handled by two distinct bodies with regional competencies, one for Latin America (ICI) and the other for the rest of the developing world (ICMAMPD). Energy policy in Latin America is linked to the ARAUCAIA Programme for conservation of biodiversity in Iberoamerica. ARAUCAIA activities include integrated, comprehensive projects on different subject areas (including one on renewable sources of energy), along with training and parallel activities. Ongoing projects include the sustainable production of fuelwood in Peru and Ecuador, and decentralised PV electrification in Nicaragua and Bolivia. ICMAMPD projects (in non-Latin American countries) are addressed within the Eurasia Plan, a regional cooperation strategy reflecting the countries and sectors in which Spanish cooperation acts most effectively. Cooperation aims to identify the most suitable technology while considering the financial resources available for its long-term maintenance. Mediterranean countries, Middle Eastern countries, and Equatorial Guinea receive special support. The rehabilitation of basic infrastructure (including energy infrastructure) is one of seven principal areas of action. Energy projects have not been a major area of activity —receiving around 1% of ICMAMPD funds in 1997—but there has been a four-year programme to maintain and improve the electricity grid in Luanda and additional electricity sector training activities in Angola; integrated rural energy and PV management in the Philippines; and grid extensions in Tunis.

• Sweden

Under the development policies set out by the Swedish government and parliament, The Swedish International Cooperation Agency (Sida) is responsible for energy cooperation policies. The overall aim of Sida's sustainable energy policy is to develop efficient and sustainable energy systems which improve the energy situation of populations who are currently without access to reliable and effective energy supplies (Sida, 1996). Particular priorities are the development of regulatory frameworks, capacity building, energy efficiency, new sustainable energy sources, and direct assistance to target groups. The two key principles of energy sector assistance are that energy systems must be both economically and environmentally sustainable; hence subsidies and energy imports are not supported and environmental impact assessments are required for all energy projects, regardless of working and financing methods. Recognising the difficulties of reaching target groups through individual energy activities, such initiatives are carried out as part of rural or slum development programmes or as grants in support of individual organisations. Particular attention has been paid to gender perspectives in Sida's energy activities (Sida, 1998). Gender issues are to be mainstreamed prior to project design and evaluated after project completion.

The average annual budget for energy sector assistance is 70 MECU, administered in three principal forms. Long-term grant aid (approximately 50 MECU in 1997) is available to 10 of the world's poorest countries. Credit financing (approximately 20 MECU in 1997), either in support of contracts won by Swedish companies or as soft loans (with a grant content of up to 80%) is available to all developing countries. Finally, around 2 MECU is available each year to support new systems and technologies with development applications through bodies such as the Stockholm Environment Institute. Table 1.8 details recent energy projects financed by Sida.

Over 90% of assistance has financed electricity sector projects (hydropower in particular) and around 20% has been as grants for capacity building. The construction of the Song Hinh hydropower station in Vietnam has been accompanied by support to project management, capacity building, and funding for studies. Launched in 1989, Sida continues to support AFREPEN, a network of researchers and policy-makers which aims to build capacity in energy policy formulation and analysis. With a secretariat in Nairobi, the network involves around 90 experts in 12 countries, principally in East and Southern Africa, from both academia and government bodies. Recently emphasis has been placed on power sector reform, management and efficiency, the marketing of petroleum products, and environmental impacts (local impacts and climate change). A similar network in Asia is also supported.

• United Kingdom

Following the change of government in the United Kingdom in 1997, development assistance was re-launched with the creation of the Department for International Development (DFID) and the adoption of the elimination of poverty in poorer countries as the single aim of all development policies. In the context of this aim, development policy has three broad objectives: the creation of sustainable livelihoods for poor people; the provision of better education, health, and opportunities for poor people; and the protection and improved management of the environment. Therefore DFID energy policy is no longer approached sectorally, but designed in support of this poverty focus.

Energy initiatives in developing countries (84 MECU in 1997) are coordinated through a horizontal advice unit in the Infrastructure Division. This unit consists of a power engineering advisor and an energy advisor, backed up by expertise from ETSU, who act as a resource centre on call for advice. Table 1.9 details ongoing DFID energy projects that are dominated by sector reform (29%), hydro (23%), energy efficiency (20%), and electricity infrastructure (15%). Until recently large-scale energy infrastructure projects and energy efficiency programmes have been central to energy initiatives. Energy efficiency covered activities in three main areas: electricity generation and distribution; the promotion of appropriate renewable energy; and the improved of energy efficiency of end uses (particularly in the industrial and commercial sectors). Current policy is moving towards smaller scale rural and renewable interventions.

Table 1.8 Recent Energy Initiatives Financed by Sida

Sub Sector	Country	Project
Renewables	Eritrea, Zambia	Promotion of PV and mini-hydro technologies
Hydro	Multiple	Investments in Chile, India, Lesotho, Tanzania, Uganda, and Zambia Studies in Namibia and Ecuador
	Zambia	Hydro plant rehabilitation
	Vietnam	Construction of hydropower station (70 MW) co-financing from NIB and NDF
Capacity Building	Multiple	Institutional development in Vietnam, Eritrea, Zambia, and Mozambique
	Asia, Africa	Regional energy consultation networks

Table 1.9 Ongoing Energy Projects Financed by DFID

Sub Sector	Country	Project	MECU
Conventional Energy	India	Environmental issues in power sector (through ESMAP)	2
Hydro	India	Rehabilitation of power station	34^{3y}
	Uganda	Rehabilitation of power station	40
Energy Efficiency	China	Energy efficiency in two provinces, including clean coal technology	2.5
	India	Efficient electricity distribution and agricultural use	56^{4y}
Electricity Infrastructure	India	High voltage interconnector between northern and eastern regions	64^{5y}
	Montserrat	Reconstruction of electricity network following volcanic eruption	
	Bosnia	Reconstruction of electricity distribution network following war	
Sector Reform	India	Orissa State power sector reform in support of World Bank loan	120^{5y}
Capacity Building	Uganda	Institutional strengthening of state electricity utility	6.5
	SADC	Institutional support to the Southern Africa Power Pool	
Research Projects	Multiple	Renewables (5); Energy Efficiency (4); Planning (2); Building design (1)	2.4

3y = over 3 years etc.

In addition to large project initiatives, DFID funds small-scale technology development and research projects (TDR), such as studies on the design of windpumps for local manufacture and energy efficiency in small-scale clay brick-making. Other energy-related activities of DFID are the publication of a biannual newsletter entitled *Energy Efficiency*, detailing TDR projects, and coordination of United Kingdom global climate change initiatives, particularly in China and India.

The Commonwealth Development Corporation (CDC), currently in the process of changing status from a government corporation to a private/public partnership, invests around 160 MECU annually in energy projects in developing countries (James Coombs CPL Scientific Ltd., no date). Energy investments, which support the operation of viable commercial developments and sound business enterprises, are expected to increase by around 15% annually in the future. CDC has moved away from providing loans to public utilities and operations and now targets private sector investments or CDC's own investments. CDC provides commercial loans and, to an increasing extent, equity finance, principally for large-scale power generation projects. A number of country and regional private equity funds in Sub-Saharan Africa, South Asia, the Caribbean, and the Pacific, enable CDC to provide risk capital to medium-sized enterprises in chosen markets. In terms of renewable energy, CDC has provided finance for hydroelectric projects in Costa Rica, Ghana, and Indonesia, for construction of a 24 MW geothermal plant in Guatemala, and for bagasse cogeneration plants in Nicaragua and Guatemala. CDC is actively pursuing viable renewable projects and has established a manager for new business development in this area.

OTHER BILATERAL DEVELOPMENT COOPERATION

• Canada

The Canadian International Development Agency (CIDA) is a Canadian federal government agency whose mandate is to support sustainable development in developing countries and technical cooperation in countries in transition in order to reduce poverty and to contribute to a more secure, equitable, and prosperous world. CIDA's policies are developed on a thematic rather than a sectoral basis and budgeting is carried out on a country or regional basis, but annual commitments in the energy sector are typically US$35-40 million. With a shift away from equipment procurement projects, CIDA's primary goal in the energy sector is to support environmentally and economically sustainable energy development and use. Current assistance is typically given for strengthening the capacity of sector institutions, supporting the development of infrastructure where appropriate, improving efficiency in end use, and reforming regulatory systems. The oil and gas sub-sector features as an area of focus, making use of Canadian expertise in this field. Table 1.10 lists on-going projects indicative of CIDA activities. Most CIDA projects are monitored by private sector consultants and formal evaluations are completed for a smaller number of projects. Lessons learned are fed back into the policy/project cycle.

Outside CIDA, The Ministry of Natural Resources (NRCan) and The Ministry of Foreign Affairs play significant roles in Canadian international cooperation in the energy sector. NRCan promotes an "enabling framework", participating in multilateral fora such as the Hemispheric Energy Initiative (HEI)and the Asia-Pacific Economic Cooperation Energy Working Group, and engaging developing countries in energy policy dialogue. This process includes the sharing of information on market structures and approaches to regulation which will attract capital, and support of technology and knowledge exchange, for

Table 1.10 Ongoing Projects Indicative of CIDA Activities

Sub Sector	Country	Project	US$ M
Oil and Gas	China	Provision of production technology and improved sector regulation	19.3
	Russia	Gas utilities twinning	1.1
Hydro	Pakistan	Rehabilitation of hydropower plant	5.7
	Guinea	Supply of generators and transformers	20.0
Energy Efficiency	China	Development of codes and standards for energy efficiency in commercial buildings	16.7
	SADC	Technical assistance to reduce energy use, particularly in mining and mineral processing	7.4
Renewables	India	Support for NGOs disseminating biogas plants in rural areas	3.7
Strategy Planning	C.America	Modernisation and expansion of electricity sector, strategies for natural gas, loss reduction, energy efficiency, and DSM	16.7
Capacity Building	Mali	Improved operation and maintenance of high voltage transmission system	7.8
	Peru	Assistance for institutions regulating and monitoring hydrocarbon sector	7.6

example through visits to the Canadian Energy Technology Center (CETC). Finally the Ministry of Foreign Affairs is spearheading national policy development on international climate change issues, including the CDM.

* Japan

Japan is the world's largest provider of bilateral development assistance, and in 1997 administered some US$14.5 billion in ODA grants (45%) and loans (55%). Bilateral grants are distributed both as economic development assistance, by the Japanese Ministry of Foreign Affairs, and as technical assistance, by the Japan International Cooperation Agency (JICA). Most ODA loans are managed by Japan's Overseas Economic Cooperation Fund (OECF).

The Japanese Ministry of Foreign Affairs funds sustainable energy projects through its infrastructure and environment initiatives. There is no specific energy policy or budget, but economic development assistance supported five energy projects in 1997, totalling around US$19 million (see Table 1.11). Projects financed with economic development assistance are often backed up by technical support from JICA. JICA's Energy and Mining Development Study Division (EMDSD), supported by an annual budget of between US$15 and 20 million, typically finances feasibility studies concerning the implementation of environmentally sound technologies. Current activity focuses on feasibility studies for the dissemination of various renewable technologies: mini-hydro (Cameroon, Kenya (hydro), and Morocco); PV (Laos, Kiribati, Mongolia, and Zimbabwe); wind (Morocco); and geothermal (Guatemala). Other studies of note have concerned the feasibility of a combined cycle power project in Sri Lanka, the promotion of energy efficiency in Malaysia, and the assessment of environmental impacts of existing power plants in Brazil and Hungary.

The Overseas Economic Cooperation Fund (OECF) is a bilateral development finance institution providing development finance in the form of ODA loans and private sector investment finance. In 1996 OECF lending totalled almost US$11 billion, greater than that of any regional development bank. Over three-quarters of the loans were assigned to the Asia region, while smaller amounts were lent to Latin America and the Caribbean (11.4%), Africa (6.3%), and the Middle East (5.2%). Around a quarter of the loans made in 1996 were to the energy sector (US$ 2700 million) (OECF, 1997). Over the last five years thermal power plant construction (50%), hydropower (26%), and

Table 1.11 Examples of Ongoing Projects Funded by Japanese Ministry of Foreign Affairs

Sub Sector	Country	Project	US$ M
Electrification	Ghana	Construction of transmission lines in rural areas	5
	Tanzania	Design for construction of two substations and transmission line	0.3
Hydro	Indonesia	Construction of hydropower plant (250 kW)	5.3
Environment	Mongolia	Rehabilitation of diesel power plants in village centres	2.5
Capacity Building	Syria	Construction of electricity training centre, training of trainers	13.9

Table 1.12 Ongoing Projects Indicative of USAID Activities

Sub Sector	Country	Project
Renewables	Mexico	Mexican Renewable Energy Program (PV)
Energy Efficiency	CEEC/NIS	Industrial and building energy audits, financial, management, and marketing experience for 200 new ESCOs
	Mexico	Installation of advanced clean technology giving improved boiler efficiency
Legal Framework	Egypt	Establishment of legal framework for BOOT projects
Capacity Building	Asia	Training for the implementation of energy labelling programmes in India, Indonesia, and the Philippines

transmission lines and distribution systems (16%) have accounted for the bulk of lending operations (see Figure 1.2). During the same period OECF provided some US$474 million in financing for geothermal power plants and one energy-efficiency loan (US$26 million) for a DSM programme in Thailand. An additional power project has been financed through OECF's private sector investment finance facility.

• United States of America

The United States Agency for International Development (USAID) is responsible for the management of American overseas development assistance. Energy programmes are managed by the Office of Energy, Environment, and Technology (EET) within the Global Environment Centre of the Bureau for Global Programs. USAID's energy sector strategy follows two tracks: the fostering of energy sector reform (legislative, regulatory, and institutional reform) to stimulate private investment, and the promotion of the use of renewables, energy efficiency, and clean energy technologies. Activities in the energy sector have been supported by around US$180 million annually and examples of ongoing projects are given in Table 1.12. With four regional bureaus and field offices in over 100 countries, energy policies and technologies can be discussed and adapted to suit host countries.

In helping to amend legal frameworks to increase private sector investments, USAID activities have supported the legal separation of electricity generation, transmission, and distribution into different competencies in Armenia and El Salvador, and enabled the establishment of the first privately funded power production project in Nepal. Working with the Philippines Department of Energy, USAID is developing economic models that account for externalities of energy planning options and reflect these costs in revised regulations. USAID's renewables programme includes actions on policy and regulatory changes, mobilisation of business entities, increasing financial commitments, and building capacity in host country institutions which promote renewables. The joint USAID/US Department of Energy-sponsored Mexican Renewable Energy Program has promoted the use of off-grid PV and wind energy, and succeeded in getting these technologies included in a large national agricultural modernisation programme. Energy efficiency activities have been widespread and include the support of energy service companies, DSM, capacity building, the development of standards and codes, and the definition of international financial credit windows to support energy efficiency projects. In CEEC and the NIS, USAID established five energy efficiency centres and provided experts and energy efficiency equipment to produce industrial and building energy audits. This gave some 200 new energy service companies financial, management, and marketing experience. Elsewhere feasibility work in Mexico led to the ILUMEX programme which aims to procure and install two million compact fluorescent lamps. A new credit window, The Environmental Enterprises Assistance Fund (EEAF), set up by USAID, has raised US$13 million for debt or equity investments in environmental projects, including energy efficiency.

Other USAID initiatives in the energy field are:

- International partnership programmes, such as the Utility Partnership Program, which aims to ensure the sustainable impact of projects by pairing utilities in the developing world with American utilities.
- The Sustainable Cities Initiative, promoting investment in energy efficiency and clean technology by international financial institutions and increasing public and private sector involvement.
- Collaboration with developing countries to lower global greenhouse gas emissions. A demonstration program with the National Thermal Power Corporation in India has resulted in a US$2.5 million investment in energy efficiency technology.
- US-AEP, providing exporters of environmental technology with trade leads, grants, and other services.

THE EUROPEAN COMMISSION AND PARITY INSTITUTIONS

The European Community, as distinct from European bilateral donors, has become the world's fifth largest aid donor, providing around 6.5 billion ECU in grant aid in 1995 (Cox and Koning, 1997). The European Commission is responsible for the management of Community relations with developing countries, including the administration of development aid funds and funds for economic and technical cooperation programmes. The Commission is divided into Directorates General (DGs), some with regional competencies and others with sectoral competencies. Commission activities in the field of energy for development are managed by: DGI (External Relations including North America, Japan, and China); DGIB (Asia, Latin America, Southern Mediterranean, and the Middle East); DGVIII (African, Caribbean, and Pacific Countries); DGXI (Environment); DGXII (Science, Research, and Development); and DGXVII (Energy). Two parity institutions, the Centre for Development of Industry (for ACP countries) and the European Community Investment Partners Scheme (for other developing countries), promote private sector investment in developing countries. Community financing provided by the European Investment Bank (EIB; see p.112) is distinct from the grant and co-financing funds administered by the above institutions since all EIB activities must be commercially viable. As a consequence, EIB energy investments have focused on conventional energy projects, while grant funding from the Commission has been the principal source of Community support for alternative technologies in the developing world. Table 2.1 provides a brief overview of the activities of the Commission and parity institutions supporting energy initiatives for developing countries.

THE EUROPEAN COMMISSION

• Directorate General VIII (Development)

Community aid to African, Caribbean, and Pacific (ACP) countries (the 70 Signatories to the Lomé IV Convention plus South Africa) is managed by DGVIII, under the terms of the Lomé IV Convention (covering the period 1990-2000). The European Development Fund (EDF), the financial protocol of the convention, is made up of varying contributions from Member States and totalled around 13 billion ECU for the period 1995-2000. In the past there has been no overall energy sector strategy for assistance and project aid to the sector, 1357 MECU for 1986-1995 or 5.7% of total EDF grant aid, has varied widely on an annual basis. Energy projects are proposed by ACP countries through National and Regional Indicative Programmes (NIPs and RIPs), and in this way DGVIII attempts to integrate energy initiatives into broader development actions. Existing structural adjustment programmes aim to improve enabling conditions while the proposed "rolling" nature of programming provides further incentives for good governance, thereby increasing the chances of success of individual projects. However, requests for EDF assistance for energy projects by ACP countries (especially SIDS) have declined recently and as a result disbursement has slowed.

The "Green Paper on relations between the EU and the ACP countries on the eve of the 21st century" (European Commission, 1996a) recognised that project aid is "inappropriate and ineffective where there is no clear sectoral policy" (ETSU, 1997). The present renegotiation of the Lomé IV Agreement as the Development Partnership Agreement provides an opportune moment for DGVIII to implement an energy strategy which would complement the energy policies of Member States, maximise effectiveness of Member States activities, and avoid duplication (Gocht et al., 1994).

Examples of past projects financed through the EDF include the CILSS Sahel project (total budget 63 MECU) which installed 1260 kWp of PV systems in nine countries. In 1995 and 1996 the hydroelectric sub-sector received the most attention, with funding for projects in Guinee (19 MECU), Tanzania (23 MECU), and the Dominican Republic (18.9 MECU). In 1997 an extension of the electricity grid in Mauritania, Mali, and Senegal (30.2 MECU) and rural electrification using renewable energy in Cape Verde (1.9 MECU) accounted for almost the entire energy sector funding. Finally, rural development programmes and, in particular, the Microprojects Programme also includes energy components.

Outside the EDF, DGVIII administers certain specific budget lines of the General Budget of the European Communities, whose portfolios include occasional sustainable energy activities. In addition to this report, the Environment in Developing Countries line has funded studies on "charbon de biomasse" in Senegal and pico-hydro for affordable village power in Ethiopia. The Tropical Forests line has funded a regional biomass energy conservation programme for Southern Africa. The substantial NGO budget line has funded rural village electrification in Tanzania and other energy initiatives in integrated development projects. Micro-credit for business groups in Ghana and Zimbabwe has been provided through the Women and Development budget line. The South Africa and Southern Africa budget lines offer funding possibilities for energy projects in particular regions. In this way the South Africa budget line is providing 15 MECU over an 18-month period to electrify 1000 schools in rural South Africa using PV.

• Directorates General I & IB (External Relations)

The activities of DGIB can be divided into development cooperation (financial and technical) and economic cooperation. Support is administered through two separate budget lines with their legal basis in Council Regulation 443/92.

Asia (excluding the People's Republic of China) In 1996 DGIB produced a Europe–Asia Cooperation Strategy for Energy (European Commission, 1996b). This paper suggested that energy cooperation projects should be of mutual interest to Asia and Europe and therefore the emphasis was on economic cooperation. The priority areas of this strategy are modernising the electricity sector, promoting natural gas, introducing "clean coal" technologies, promoting energy efficiency, and improving the supply of energy to rural areas through increased use of renewable energies. Between 20 and 25 MECU are committed annually for energy cooperation initiatives in Asia through the economic cooperation budget line. It is proposed that the 1998 budget is split into 18 MECU for new and renewable energy projects in ASEAN countries and 7 MECU for renewable pro-

Table 2.1 Grant Supported Energy Cooperation Activities Funded by the European Community

Directorate General	Instrument	ACP	Asia	LA	Med	Energy Sector Activities	CE	RE	EE	Funding Provision
IB External Relations	Economic Cooperation		•			Modernisation of the energy sector, natural gas, energy efficiency, renewables	•	•	•	20-25 MECU annually
	COGEN		•			Implementation of proven cogeneration technologies in ASEAN countries		•		25 MECU 1998-2002
	AEEMTRC		•			Institutional support and training		•	•	1.2 MECU annually
	Development Cooperation		•			Technical support to energy sector; rural electrification, and RE dissemination strategy	•	•	•	68 MECU 1986-1995
	Economic Cooperation			•		Energy efficiency, market liberalisation, institutional support	•	•	•	1-2 MECU annually
	ALURE (II)				•	Co-financing energy sector partnerships; promotion of sectoral reform		•	•	25 MECU 1998-2002
	Development Aid			•		Technical support, e.g. improving efficiency of electricity transmission; demand driven	•	•	•	32 MECU 1986-1995
	MEDA				•	Regional cooperation framework. Policy; infrastructure; technology (MED-techno)	•	•	•	3425 MECU 1995-1999
VIII Development	EDF Grants to Energy Sector	•				Energy activities through NIPs; principally electricity infrastructure, and RE	•	•	•	1357 MECU 1986-1995
	South Africa B7-3200	•				One initiative on PV in rural schools		•		128 MECU 1997
XI Environment	LIFE Third				•	Environmental policy				22.5 MECU 1996-1999
XII Science Research & Development	JOULE (III)				•	RTD on non-nuclear energy technologies; dissemination strategies; modelling	•	•		460 MECU 1994-1998
	DC Research Collaboration	•	•	•		DC research collaboration: policies, dissemination strategies, and feasibility studies		•	•	250 MECU 1994-1998
	IRESMED				•	Large-scale integration of PV and wind energy into rural regions of the southern Mediterranean		•		1 MECU 1998-2000
XVII Energy	ALTENER (II)*					Promotion of RE; breakdown of economic, technical, and institutional barriers		•		30 MECU 1998-1999
	SAVE (II)*					Promotion of investments in EE; labelling standardisation; energy management			•	45 MECU 1996-2000
	SYNERGY	•	•	•	•	Policy evolution and cooperation through training seminars and capacity building	•	•	•	5 MECU 1998
	THERMIE#	•	•	•	•	Demonstration and dissemination of non-nuclear energy technology	•	•	•	566 MECU 1994-1998
General Budget Lines	Environ DC B7-6200	•	•	•	•	Policy/strategy; assessments and reports on, for example charcoal; pico-hydro; agroforestry		•	•	45 MECU 1997-1999
	Tropical Forests B7-6201	•	•	•		Assessing and managing biodiversity resources; projects and regional programmes		•		200 MECU 1996-1999
	NGOs B7-6000	•	•	•	•	Co-financed projects; energy in integrated development projects; rural electrification		•		200 MECU 1998
Other Institutions	CDI	•				Promotion of private sector partnerships, technical assistance, feasibility studies		•	•	73 MECU 1995-2000
	ECIP		•	•	•	Promotion of private sector partnerships, technical assistance, feasibility studies		•	•	52 MECU 1997

CE = Conventional Energy; RE = Renewable Energy; EE = Energy Efficiency / Rational Use of Energy; NIP = National Indicative Programme

*Open to members of EEA and Third countries that have signed a Science and Technology Cooperation Agreement with the EU; #40 MECU of which is available to countries outside the EU jects in India. A particular role is envisaged for off-grid mini-hydro. Under economic cooperation, the COGEN programme promotes the implementation of proven heat and power generation technologies in ASEAN countries. Phase II of the programme (1993-1997) provided the financing of 20 MECU (5 MECU from the Commission and the rest from the ASEAN private sector) which was invested in cogeneration projects using wood and agro-industrial residues. The next phase will widen activities to cogeneration applications in all industrial sectors, including the implementation of energy efficiency, gas, and advanced coal technologies. The proposed financing provision is 250 MECU (of which the Commission will contribute 25 MECU). The ASEAN-EC Energy Management Training and Research Centre (AEEMTRC) was set up in 1988 with EC funding but is now sufficiently well established that funding may be withdrawn. The centre has become a focal point for policy dialogue, training, and the dissemination of information.

In the period 1986–1995 development aid to the Asia region in the energy sector totalled 68 MECU (1.7% of all aid). Projects, driven by demands from host countries, included the electrification of 80,0000 households in 540 rural villages by extending the grid in the Punjab region of Pakistan (21 MECU) and renewable natural resources extension support in Bhutan.

People's Republic of China: Relations between the EU and China are handled by DGI. EU policy for energy cooperation with China is, in the main, consistent with that for the rest of Asia, although here energy efficiency, as well as developing clean coal technologies and alternative energy resources, notably natural gas, are explicitly mentioned as top priorities (European Commission, 1998c). Following an official visit of the European Energy Commissioner to China in October 1996, a standing working group has been set up within the framework of the EU-China joint committee to review and coordinate energy cooperation initiatives. EU energy cooperation with China has been promoted primarily through DGXVII SYNERGY and THERMIE sponsored actions. The SYNERGY programme has supported numerous initiatives in China, including training courses in energy efficiency, management, coal combustion, and the promotion of marine-current-derived renewable energy. Recently the activities of THERMIE—the Demonstration Component of the JOULE—THERMIE programme-have focused on the promotion of advanced renewable energy technologies (wind, biomass gasification, solar, and small-hydro), flue gas desulphurisation, upstream oil and gas technologies, and energy efficient technologies for the building sector. The EC-China environmental cooperation programme (EMCP), funded through the financial and technical cooperation budget, supports co-financed or partnership-in-kind projects, including activities in the development of natural gas, energy efficiency, and the implementation of clean coal technologies. Finally, the LAIONING programme is an integrated regional environmental programme that includes some energy activities.

Latin America: In 1995 DGIB produced a strategy paper outlining the basis for EU–Latin America cooperation in the energy sector (European Commission, 1995b). In addition to partnership, the strategy identified the environment as an overriding theme for cooperation and had three particular objectives: firstly, to influence national and regional policies towards creation of efficient and effective energy systems (liberalisation of markets is to be achieved through reform of legislation and fiscal measures); secondly to support institutions to adapt to these policies and encourage the definition of government and institutional roles; and finally to modernise energy businesses in terms of finance, management, and commercialisation. Energy efficiency and the optimum use of existing resources were identified as key areas here.

The ALURE (now ALURE II) programme is administered by DGIB in conjunction with DGXVII as a co-financing instrument promoting EU/Latin America public and private sector partnerships. Specific aims of the second phase are to improve the technical, economic, and financial performance of Latin American energy companies, to assist in the adaptation of political, regulatory, or institutional frameworks to improve the business environment, and to carry out sustainable energy activities. Development of natural gas is an ongoing priority area. In addition to ALURE, the economic cooperation budget line finances individual energy initiatives in Latin American countries. Currently such activities include support for the adaptation of the electricity sector to new legislation in Brazil and promotion of the rational use of energy policy and planning in Argentina.

EC aid to the energy sector in Latin America (32 MECU) accounted for 1.1% of EC aid to the region over the period 1986–1995. Projects are normally initiated as a result of country requests, such as the present technical support to the electricity utility in Nicaragua (7 MECU), incorporating studies on loss reduction measures. Other channels used to fund energy initiatives in Asian and Latin American countries are the existing SYNERGY and THERMIE actions of DGXVII (which are described later in this section) and the General Budget lines of the European Community.

Mediterranean: MEDA, the EU--Mediterranean framework cooperation agreement, aims to support the Mediterranean countries of Algeria, Egypt, Cyprus, Israel, Jordan, Lebanon, Malta, Morocco, Palestinian Authority, Syria, Tunisia, and Turkey to improve their social and economic structures and, in the long term, to create a free trade area. Bilateral initiatives (90% of funding) are demand-driven through the priorities identified by host countries. Projects are typically of the technical assistance or feasibility study nature. There is no sectoral breakdown within MEDA and energy has not been a high priority in many countries, but Lebanon (administrative reform), Syria (electricity sector support), and Morocco (renewables) have had the most significant bilateral energy activities.

Multilateral energy initiatives are a particular concern of The Euro-Med Energy Forum, which has adopted in its action plan (European Commission, 1998b) the same three main objectives as the European Energy Policy White Paper (European Commission, 1995a), namely, security of supply, competitiveness of the energy industry, and protection of the environment. Partnerships are fostered through consultation on the European Energy Charter, identification of opportunities for investment, and cooperation on Trans-European Networks (TENs). This last area, with its implications concerning the security and stability of EU energy supplies, has been noted as a critical area of EU energy cooperation in the region (European Commission, 1996a). In May 1998 the Forum produced a Mediterranean Energy Policy Paper (European Commission, 1998a) outlining the energy situation in each of the 12 Mediterranean countries and calling for a reinforcement of cooperation.

Technological partnerships are already fostered through MEDA's MED-techno programme, which has identified roles for renewables in municipal and industrial wastewater treatment and reuse. In addition, DGXII has financed feasibility studies and integration strategies and developed energy-use scenarios for renewables in the region (see section on DGXII).

• Directorate General XVII (Energy)

Directorate General XVII funds energy initiatives in developing countries using a range of instruments, although activities reflect a spirit of cooperation rather than one of development aid. THERMIE (the demonstration component of the JOULE-THERMIE programme for non-nuclear RTD activities) focuses on the targeted demonstration and promotion of: renewable energy technologies; technologies for the rational use of energy in industry, buildings, and transport; technologies for a clean and more efficient use of solid fuels; and technologies for the better exploitation of hydrocarbons. THERMIE has an overall budget of 566 MECU (1994-1998), of which 40 MECU has been allocated to the promotion of European energy technologies in markets outside the EU (European Commission, 1998d). Activities have focused on countries of Central and Eastern Europe (including the CIS), Latin America, the Mediterranean Basin, Asia (including China and India), and Africa (in particular Southern Africa). Examples of past activities include: the establishment of a Renewable Energy Network in the countries of Southern Africa; a feasibility study for the optimisation of a renewable-based power supply system for Cape Verde; joint activities with the EBRD for the identification and preparation of energy efficient bankable projects in Eastern Europe; promotion of European oil and gas technologies in the Gulf region; and the setting up of a large-scale decentralised rural electrification programme in China. THERMIE has also been supporting the World Solar Programme.

The SYNERGY programme (5 MECU in 1998) aims to support the formulation and implementation of energy policies in non-EU countries through training, seminars, and capacity building. Examples of projects financed by SYNERGY include the Black Sea Regional Energy Centre, the restructuring of the Chinese coal sector, and an evaluation of the potential for gas in the Philippines. In Africa, SYNERGY has identified possible energy cooperation projects between the European Community and countries of Southern Africa and financed the creation of a network of experts in rural electrification. (South Africa became eligible for SYNERGY funding in 1996 and this was extended to the rest of Africa in 1997.) DGXVII has recently launched an energy cooperation database, to be accessible through the internet, which will incorporate information from Community international energy cooperation programmes. Other energy programmes such as SAVE (rational use of energy) and ALTENER (promotion of renewables) are targeted at EU countries and at countries in the process of adhesion to the EU rather than at developing countries, but have important implications for the commercialisation and future transfer of technologies.

• Directorate General XI (Environment, Nuclear Safety, and Civil Protection)

The LIFE programme, DGXI's principal financial instrument, supports the development of Community environmental policy and, where appropriate, its implementation. As such, initiatives are limited to Member States and certain countries bordering the EU. International environmental issues are addressed in the context of the follow up to international initiatives (such as UNCED), and therefore climate change, biodiversity, tropical forests, stratospheric ozone, and desertification are priorities. Financing resources are limited. The Global Environment budget line (0.5 MECU) primarily supports workshops and conferences that develop EU strategies and negotiating positions. It is worth noting that DGXI is the focal point for the Commission's policy work on the CDM, and future work may address baseline project eligibility criteria and technology baselines for this flexible mechanism.

• Directorate General XII (Science, Research and Development)

EC research and technological development (RTD) activities are governed by five-year framework programmes made up of a number of subsidiary thematic programmes. Under the 4th RTD framework programme (1994–1998), the JOULE-THERMIE programme supports research, technological development, and the demonstration of non-nuclear energy technologies. Research is funded through the JOULE part of the programme with a budget of 460 MECU covering four areas: strategy, rational use of energy, renewables, and fossil fuels. JOULE II (1990-1994) had funded eight studies specifically concerning renewable energies in developing countries, including SAPHIR—Solar energy Applications in Primary Healthcare clinics for remote rural areas—and the development of strategies to integrate renewables. Although JOULE III (1994-1998) does not target technologies for developing countries as such, renewable energy, the rational use of energy, and clean technology research activities should have long-term benefits for energy systems in developing countries. Also under JOULE funding, the INTERSUDMED project performed pre-feasibility studies for one large renewable energy project in each Mediterranean country. Following this, the new IRSEMED project will study strategies for the large-scale integration of PV systems and wind farms into rural regions of the southern Mediterranean countries. Complementarily, the MEMA project will develop scenarios for the use of energy technologies in the southern Mediterranean which should help market evaluation in IRSEMED. Finally, in a post-Kyoto perspective, JOULE III has supported work on the world POLES model to evaluate environmental and energy technology policies within the new flexible mechanisms framework (emissions trading, joint implementation, and the clean development mechanism) as applied to all regions of the world including developing countries.

In the proposed 5th RTD Framework Programme (European Commission, 1998e) energy research activities will be addressed through two key actions, Cleaner Energy Systems Including Renewables, and Economic and Efficient Energy for a Competitive Europe, which together will receive around 1 billion ECU in financing. Cooperation with developing countries in these areas will be assessed on a case by case basis, but a cross-cutting theme of the framework proposal is to confirm the international role of Community research.

INCO provides funding specifically for community RTD activities in cooperation with countries outside the EU. INCO actually finances THERMIE actions outside the EU. Additional technology research and dissemination cooperation activities in developing countries are funded through the INCO-DC programme (250 MECU 1994-1998). The Sustainable Management of Renewable Natural Resources is one of three research themes and is concerned principally with policies and strategies. Under this theme, projects included an agenda for cooperation in the deployment of sustainable energy systems in India; charcoal production potential in Southern Africa; and the potential for the use of renewable energy and its cost effectiveness in air pollution abatement in Asia. In future INCO-DC will also fund energy research in terms of mechanisms and policy conditions for sustainable development (European Commission, 1998f).

COMMUNITY PARITY INSTITUTIONS PROMOTING THE PRIVATE SECTOR PARTNERSHIPS

• The Centre for Development of Industry (CDI)

The CDI is a parity institution established by the Lomé Convention supporting SMEs in the ACP region through training, technical support (including sourcing of finance and marketing assistance), and feasibility studies. CDI has its own financing instrument (73 MECU for 1995–2000), administered in grant form for up to two-thirds of the cost of activities. Programmes build EU/ACP partnerships in the form of financial, technical, or commercial partnerships, or licensing and franchising agreements. Energy activities have typically been addressed in the context of rational use of energy, for example in the manufacture of construction materials (bricks and tiles). Technical support publications include a guide to help entrepreneurs to set up biomass briquetting projects using agricultural, agro-industrial, and forestry residues (CDI, 1996).

• European Community Investment Partners Scheme (ECIP)

ECIP promotes partnerships between EU private sector firms and SMEs in Asia, Latin America, the Mediterranean, and South Africa. ECIP administers grants to fund the identification of opportunities for partnership and feasibility studies, interest-free loans for technical assistance and training, and financial advice and equity support for investors. Priority activities include the improvement or privatization of utilities and environmental services. Since its inception in 1989, ECIP has funded 53 energy initiatives, mainly feasibility studies such as studies on mini-hydro and the privatization of power production in Brazil, wind power in Morocco, and small-scale power development and biomass for electricity in the Philippines. In 1998 ECIP also supported a seminar on the natural gas sector and energy production held in Venezuela.

UNITED NATIONS AGENCIES AND OTHER FUNDS

UNITED NATIONS DEVELOPMENT PROGRAMME

UNDP provides development assistance to its programme countries and is the driving force for UN development cooperation. Through a network of 132 country offices, UNDP manages programmes in 174 countries and territories, focusing on four core development themes: poverty elimination, environmental regeneration, job creation, and the advancement of women. As far as energy is concerned, a review of UNDP energy country programming (UNDP, 1995b) showed that between 1974 and 1994 UNDP provided US$430 million for 980 energy projects, bringing in a further US$200 million in cost sharing. Around two-thirds of these projects concerned energy planning and conventional energy; while renewables and energy efficiency projects accounted for only 12%. With the creation in 1994 of the Sustainable Energy and Environment Division (SEED), UNDP has sought to mainstream sustainable energy, relating energy issues to UNDP's core development themes and working as one of the Global Environment Facility implementing agencies.

Within the Bureau for Development Policy (BDP), The Sustainable Energy and Environment Division (SEED) was created to enable UNDP to follow up UNCED more effectively. One of SEED's units, The Energy and Atmosphere Programme (EAP), promotes sustainable energy activities and provides technical assistance and support to programme countries in the design and implementation of energy-related activities that integrate protection of the environment and socio-economic development. In May 1996 SEED launched the Initiative for Sustainable Energy (UNISE) to spearhead a new approach to energy initiatives (UNDP, 1996). UNISE marked a shift from the traditional supply-side energy approach, linking energy with social and environmental issues as well as with economic development. Activities are supported through global, regional, and national programmes and through the provision of services, technical expertise, and training. UNISE activities include:

- *Nationally*: Assisting Country Offices to include sustainable energy concepts when formulating Country Cooperation Frameworks (CCFs), resulting in energy being included in around 40% of completed CCFs.
- *Regionally*: Reorientating the Programme for Asian Cooperation on Energy and the Environment to reflect UNISE's aggressive pursuit of energy efficiency and more widespread use of new renewable energy sources. The Regional Bureau for Asia and the Pacific (RBAP) has also supported a study on the commercialisation of renewable energy, and a programme on renewable energy technology in north-east Asia. The Latin American and Arab regional bureaus have also adopted UNISE principles in energy policies.
- *Globally*: Evolving sustainable energy policies and strategies (global energy policies, post Kyoto climate change policies, and the Clean Development Mechanism), disseminating technologies, piloting new approaches to sustainable energy, linking programmes with GEF, and supporting ESMAP. UNDP has participated actively in the global energy dialogue, notably through publication of the reports "Energy After Rio: Prospects and Challenges" (Reddy et al., 1997) and "Energy as an Instrument for Socio-economic Development" (UNDP, 1995a).

Energy activities are financed by core funds (total core funding was US$844 million in 1996), cost-sharing activities (specifically the "Sustainable Energy Global Programme" and "The Energy Account"), and the GEF. UNDP core funds are administered in country development programmes designed by country offices following discussion with national counterparts. Additional core funding is available for projects identified in CCFs where activities have a particular sustainable development perspective. In 1997 UNDP technical cooperation to the energy sector (including core funds) totalled US$33.7 million, more than double the amount disbursed in 1996 (UNDP, 1998). Resources of non-core programme funding energy initiatives are summarised in Table 3.1.

The Sustainable Energy Global Programme has four principal aims: to support the follow-up to global conferences and UNGASS in the energy sector; to support UNISE activities at a national level; to support newly established UNDP Sub-Regional Resource Facilities' (SURFs) decentralised information and networking centres; and to support technology leapfrogging through piloting activities. The financing of the programme is provided both by UNDP core funds (US$3.9 million) and through bilateral development assistance (US$4.8 million). Under the EAP, technical assistance projects have included support for the Philippines and decentralised PV rural electrification in Syria. Pipeline projects include Energy and Women, Capacity building for Sustainable Energy, Modernised Biomass for China, and The World Energy Assessment.

UNDP/EAP, with the support of the relevant country offices and financing from Norway, is carrying out small-scale climate change-related activities in four pilot countries, Peru, South Africa, the Philippines, and Bulgaria. This project aims to contribute to the advancement of the UNFCCC/Kyoto Protocol process, more particularly in the areas of the Clean Development Mechanism and Activities Implemented Jointly. The project builds capacity and assists in developing locally the knowledge necessary for attracting future climate change-related investments. Furthermore, a larger initiative concerning this issue is currently being developed jointly with other United Nations agencies (UNEP, UNIDO, and UNCTAD) under the leadership of the UNFCCC Secretariat.

The Energy Account receives funds from contributors earmarked for specific projects at the country level following close collaboration with country offices. Funds are normally administered on a co-financing basis with bilateral and multilateral cooperation agencies, and projects vary in size from US$20,000 to US$2 million. FINESSE (Financing Energy Services for Small-scale Energy-Users) programmes, managed by the Energy Account, have been implemented in Asia and the Southern Africa Development Community (SADC) (see Box 23). The Energy Account has also funded supply-side energy conservation and planning strategies and the installation of decentralised PV systems in Syria, and the development of a regional rural electrification strategy for the Asia-Pacific Economic Cooperation region.

In its capacity as one of the three implementing partners of the Global Environment Facility (GEF), UNDP ensures the development and management of capacity building and technical

Table 3.1 UNDP Energy Related Non-Core Programme Resources ($Million)

Programme	Years	Total Programme Funds
Sustainable Energy Global Programme (cost-sharing)	1996-2000	8.7
Energy Account	1992-1997	6.3
UNDP/GEF/Climate Change/Renewables	1992-1998	63
UNDP/GEF/Climate Change/Energy Efficiency	1992-1998	56
GEF/SGP/Climate Change	1997-1998	0.9

BOX 23

Box 23 Financing Energy Services for Small-scale Energy-users (FINESSE)

The FINESSE programme aims to accelerate the commercialisation of renewable energy technologies through pre-investment activities and the creation of the conditions and mechanisms for the credit sector to on-lend to small-scale energy users. FINESSE secures the involvement of small-scale operators, supporting franchise operations and enabling the local manufacture of key components. In Asia FINESSE started by preparing business plans and market studies for Indonesia, Malaysia, Thailand, and the Philippines. Following the presentation of these business plans, the World Bank set up the Asia Alternative Energy Unit (ASTAE) to mainstream alternative energy sector loans. As a result Bank renewable energy loans have been prepared and a pipeline of biomass cogeneration projects has been developed. The Development Bank of the Philippines (DBP) has received FINESSE-type technical assistance to strengthen its capability to evaluate and manage alternative energy projects. In Africa, a FINESSE programme in the SADC region (US$1.2 million) has produced market studies and business plans for investments in projects including biogas, PV, mini-hydro, and solar water heaters. A loan-guarantee fund has been supplied to help business plans meet loan conditions. Building on the FINESSE experiences in the SADC region, a proposed EAP activity will strengthen the African Development Bank's capacity to identify, prepare, appraise, and implement sustainable energy projects and to develop an Africa-wide sustainable energy portfolio.

assistance programmes, and also manages the GEF Small Grants Programme. At the end of September 1998 the UNDP GEF Climate Change portfolio totalled US$222 million, including US$ 63 million in support of renewables and US$56 million in support of energy efficiency initiatives. The Small Grants Programme (SGP) funds national projects of up to US$50,000 and regional projects of up to US$250,000 put forward by grassroots groups and NGOs in developing countries. In the financial year 1997–1998 the SGP approved US$5.5 million for 269 projects. Of these projects, 44 concerned climate change (US$ 0.9 million), and 14 were specifically for energy efficiency and conservation and 12 for renewable energy. Past projects supported have included the installation of biodigestors in Costa Rica, solar seawater desalination in Mauritius, a district renewable energy and environmental park in Barbados, and construction of micro-hydro power plants in the Dominican Republic, Poland, and Sri Lanka.

Outside SEED activities, the UNDP's Public Private Partnerships programme (PPPP) promotes the participation of the private sector and wider society in urban management issues, including the provision of energy services. The programme has three components, a project development facility designed to prepare for investments of US$5-30 million; the development and transfer of environmental technologies; and a capacity-building programme to harness the resources of international academic institutions.

UNITED NATIONS ENVIRONMENT PROGRAMME

UNEP has traditionally performed environmental assessments, produced policy frameworks and best practice guidelines, and provided technical support for global, regional, and national environmental actions. Energy strategies have become part of UNEP operations in recognition of their environmental impacts, including the management of global greenhouse gas emissions. In its support of the UN Framework Convention on Climate Change, UNEP also aims to increase developing country participation by helping to identify opportunities to implement future projects through the Clean Development Mechanism. One of UNEP's key roles in the field of energy for sustainable development is as an implementing partner of the GEF. The UNEP GEF Climate Change portfolio (US$16 million) has included capacity building to enhance the contribution of experts from developing countries to IPCC activities; country case studies on sources and sinks of greenhouse gases and on climate change impacts and adaptation assessments; and the establishment of a methodological framework for climate change mitigation assessment. Additionally, enabling activities have supported developing countries in making their national communications to the United Nations Framework Convention on Climate Change (UNFCCC).

In 1996 UNEP launched its own energy programme, which can be divided into three sub-programmes: the promotion of energy efficiency and use of energy resources with low environmental impacts; the incorporation of environmental principals in energy sector analysis; and the analysis of the environmental and social impacts of restructuring in the energy sector. The energy programme, jointly implemented by the UNEP

Collaborating Centre on Energy and Environment (UCCEE), is helping the CSD to prepare for the Conference on Sustainable Development (CSD) 2001. In 1997 the programme completed studies on the economics of greenhouse gas limitations and a training handbook on 'Tools and Methods for Integrated Resource Planning'. A new programme initiative will attempt to analyse how to overcome existing barriers to the more widespread dissemination of sustainable energy technologies through studies in three developing countries. The programme is also producing state of the art reviews of wind power and of economic experiences in renewables with implications for the introduction of small-scale renewable energy in Thailand.

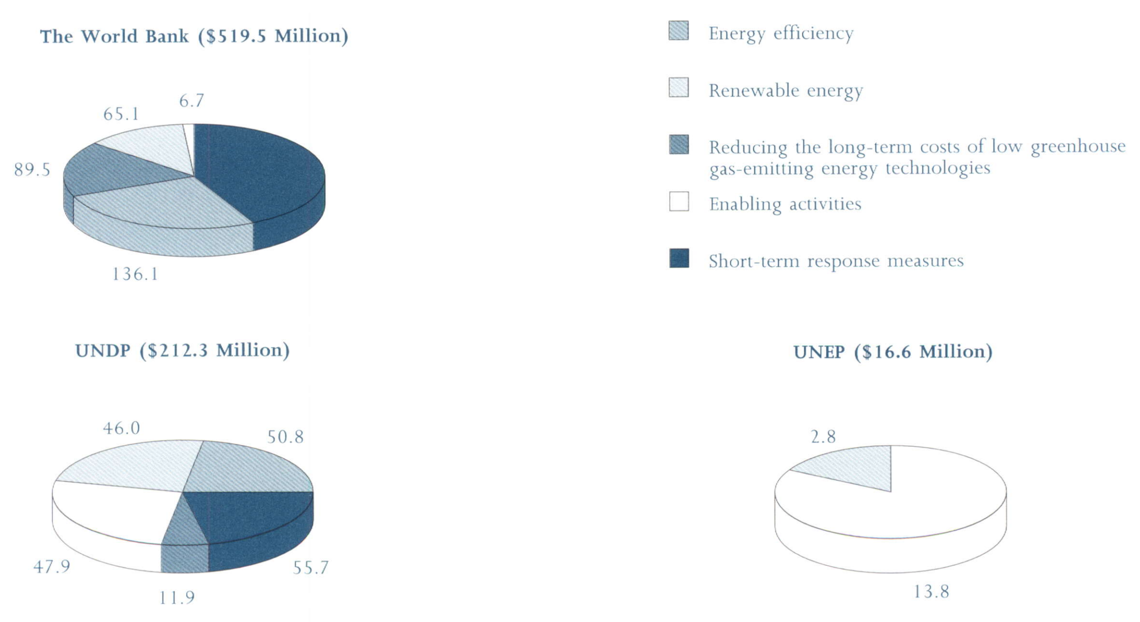
Following the appointment of a senior energy officer to the Industry Programme, energy issues will be targeted more directly in UNEP's existing work programme, and particularly in the Cleaner Production initiative. UNEP also promotes information exchange and technology transfer through initiatives such as The Climate Technology Initiative, run in collaboration with the International Energy Agency.

THE GLOBAL ENVIRONMENT FACILITY (GEF)

The GEF is an international financing mechanism providing incremental funding (grant and concessional funds) for projects with global environment benefits. At present the GEF is also the funding mechanism for the Framework Convention on Climate Change. Countries eligible for IBRD and/or IDA funding, or receiving technical assistance grants from UNDP through a country programme, are eligible for GEF funding. The GEF is jointly implemented by UNDP, UNEP, and the World Bank. UNDP provides technical support and is responsible for the development and management of capacity-building programmes. UNDP also manages the GEF Small Grants Programme, which funds projects of a limited size put forward by grassroots groups and NGOs in developing countries. UNEP is responsible for scientific and technical analysis, manages the Scientific and Technical Advisory Panel, and catalyses global, regional, and national environmental assessments and policy frameworks. The World Bank, the repository of the Trust Fund, programmes investment activities, mobilises private sector resources, and manages its own GEF project portfolio. The GEF is governed by a Council and an Assembly, reported to and served by the GEF Secretariat, which is functionally independent from the three implementing agencies.

Since its inception in 1991, the GEF has provided access to over US$2 billion in funding and has attracted additional funding for projects by helping them to overcome initial investment costs and reducing risks for investors. Funding for the original pilot phase (1991–1994) totalled US$1.2 billion. Following a detailed review of this phase, the GEF was restructured and the fund was replenished with US$2 billion for the period 1994–1997. In February 1998 a further replenishment of the GEF was initiated when 36 donor countries pledged US$2.7 billion for the period 1998-2000. In addition to full projects, the GEF funds medium-sized projects (of up to US$1 million), project development activities, and enabling activities. Enabling activities are limited to the areas of biodiversity and climate change, and include support to developing countries in their prepa-

Figure 1.2 Climate Change Portfolios of GEF Implementing Bodies (Total US$ 748.1 million)



Source: GEF (1998)

ration of initial communications to the Framework Convention on Climate Change. Around 40% of GEF funds have supported climate change activities. Figure 1.2 details the programmes funded under the GEF Climate Change portfolio (not including the Small Grants Programme).

GEF funding underpins global sustainable energy funds, such as the IFC's Photovoltaic Market Transformation Initiative, which is helping to accelerate the expansion of PV markets in India, Kenya, and Morocco, and the Renewable Energy and Energy Efficiency Fund which finances private sector activities globally (US$30 million each). Short-term response measures include landfill gas recovery and coal bed methane capture and a $25 million coal-to-gas project in Poland.

THE OPEC FUND FOR INTERNATIONAL DEVELOPMENT

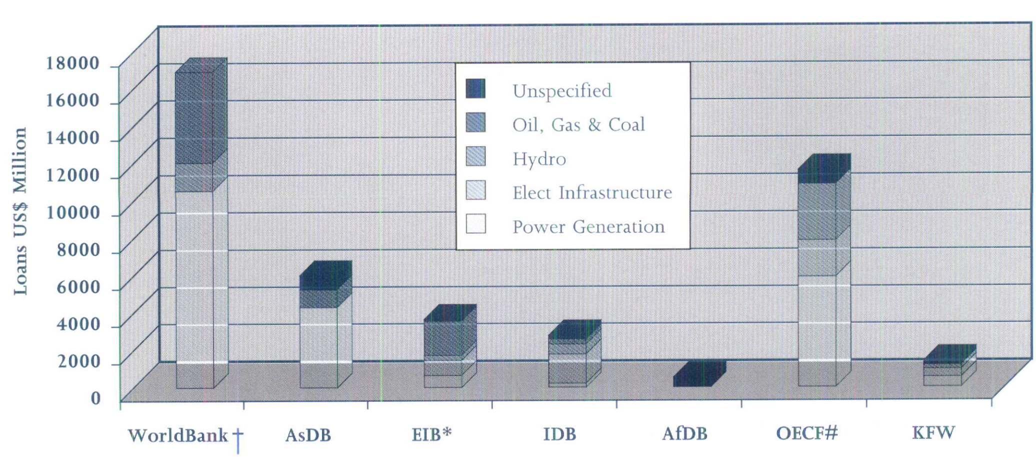
Since its creation in 1975, The OPEC Fund has committed both grants (US$ 240 million) and concessional loans (US$ 3900 million) as financial assistance to developing countries in support of their economic and social development. One-quarter of project lending operations (US$713 million) have been in the energy sector. Energy activities in recent years incorporated loans for the construction of conventional power plants in Mauritania (US$2 million) and Eritrea (US$5 million), petroleum storage in Western Samoa (US$2 million), and rural electrification in Vietnam (US$10 million). In the sustainable energy field, grant financing has been used to co-finance energy conservation and planning in Syria (US$180,000 co-financing in a US$4.75 million GEF project) and a feasibility study on rural electrification based on micro-hydro and wind energy in Honduras (US$75,000 contribution to UNDP Energy Account).

INTERNATIONAL DEVELOPMENT FINANCE INSTITUTIONS

In the last five years the World Bank, regional development banks, and European Investment Bank have provided, on average, over US$6 billion annually in financing for the energy sector. Figure 1.3 summarises the energy sector lending activities of these institutions between 1992–1997 and shows that the Japanese OECF and German KfW have also been significant sources of development finance.

In general, lending remains supply-side dominated, with power production, electricity transmission and distribution, and oil and gas development accounting for the bulk of financing. Large-scale hydropower has established itself as a principal area of operation for these institutions but other sustainable energy options have remained sidelined in terms of mainstream lending. The improving viability of sustainable energy technologies and an increasing awareness of environmental concerns, however, have prompted these institutions to launch a number of in-house initiatives and to intensify technical support in order to increase financing of sustainable energy alternatives. To date the largest financiers of renewable energy (excluding large-scale hydro) have been the World Bank (US$547 million in loans plus US$278 million in GEF financing) and the Inter-American Development Bank (US$213 million since 1993). The Asian Development Bank's first renewable energy loan (US$100 million) was implemented in 1997. Japan's OECF provided US$474 million for geothermal power between 1992

Figure 1.3 Energy Sector Lending of International Development Finance Institutions (1993-97)



† Power generation loans include Sector Reform

* Loans outside the EU

Figures for 1992-96

and 1996, while KfW has provided US$81 million for a range of renewables since 1993. Energy efficiency financing is harder to discern, often existing as a component part of power sector loans. However, in recent years exclusively energy efficiency loans exceeding US$50 million have been provided by the Inter-American Development Bank for Colombia, Costa Rica, Jamaica, and Mexico. The World Bank manages energy efficiency projects supported by US$136 million in GEF funding and in 1998 prepared energy efficiency loans for China, India, and Brazil totalling over US$100 million.

THE AFRICAN DEVELOPMENT BANK

The Africa Development Bank aims to promote economic and social development in its Regional Member Countries (RMCs). Energy activities are integrated into individual country strategies formulated by the Country Programming Departments of the Bank Group. Financing in the energy sector has fluctuated over the years. Loans of US$48.5 million were approved for this sector during 1997, compared to US$23.8 million in 1996 (AfDB, no date). During the period 1982-1991 annual energy lending operations averaged US$235 million, however, accounting for 12.2% loans and grants approved by the Africa Development Bank Group (AfDB, 1994). Most funding was provided to the electricity sub-sector and in particular for thermal power production (US$984 million) and transport and distribution networks (US$652 million). Over the same period hydropower projects received US$339 million.

The Africa Energy Programme (AEP), stemming from UNDP/AfDB cooperation in the late 1980s, has recently been concluded. Activities of the AEP included the preparation of national, sub-regional, and regional energy balances, the establishment of energy consumption and supply forecasting models, the preparation of an accounting model, and the introduction of an energy information network. The efficient use of energy and the pursuit of less expensive and less polluting energy resources were stated objectives of the programme. In the final phase, the AEP assisted RMCs in the production of feasibility studies for energy projects, focusing particularly on multinational and issue-specific projects. The data resources of the AEP are being used to develop coherent policies promoting cooperation and integration in the energy sector across the region. The Bank's only financing for renewable energy to date has been for a Solar Thermal Power study in Egypt, for which a follow-up is currently being planned. However, the Bank does aim to develop a Renewable Energy and Energy Efficiency Programme in the style of the FINESSE programme. Subject to the approval of NEDA funding, UNDP would provide technical assistance in the training of project officers to identify, prepare, and appraise renewable energy projects including solar, wind, biomass, and micro-hydro projects. The Bank itself would provide funds through local commercial banks available to individuals as micro-finance.

THE ASIAN DEVELOPMENT BANK

The Asian Development Bank promotes the economic and social progress of developing countries in the Asian and Pacific region. In 1995 the Bank published its policy for the energy sector (ADB, 1995) which focuses on defining an appropriate role for the government, increasing private sector participation in large-scale energy investments, improving energy efficiency on both supply and demand sides, and integrating environmental considerations into energy development. Despite technical assistance for sustainable energy options, however, the Bank's loan portfolio remains supply-side orientated.

Loans to the energy sector totalled US$668 million in 1997 (ADB, 1998), accounting for 7.1% of overall bank lending. Five of the seven energy sector loans were for power transmission projects and the others were for natural gas and district heating. The Bank's first renewable energy loan was implemented in 1997 to support expansion of biomethanation, bagasse cogeneration, wind energy, and solar thermal systems in India. This US$100 million loan will be on-lent for investments in small-scale power generation using these technologies. The Bank supports the development of renewable energy technologies and recommends financing where activities are economically viable. Technical assistance (US$13.3 million for the energy sector in 1997) also funds assessments of the economic viability of solar, mini-hydro, and wind power options in rural areas as well as activities to encourage the removal of institutional barriers to renewable energies. Recent technical assistance projects in PR China have studied improvements in the efficiency of coal power generation and market-based energy conservation.

THE CARIBBEAN DEVELOPMENT BANK

The Caribbean Development Bank (CDB) promotes economic development in and cooperation between Member Countries (these include Anguilla, Antigua and Barbados, The Bahamas, Barbados, Belize, British Virgin Islands, Cayman Islands, Dominica, Grenada, Guyana, Jamaica, Montserrat, St.Kitts and Nevis, St.Lucia, St.Vincent and the Grenadines, Trinidad and Tobago, and the Turks and Caicos Islands) with special regard for less developed countries. CDB provides loans to governments and the private sector, makes equity investments, and provides technical assistance for government, public, and private sector enterprises. Gross approvals for Bank operations totalled US$ 87.4 million in 1997 and grant disbursements in the same year were US$ 4.8 million (CDB, 1997). Between 1970 and 1997 US$ 57 million in finance was provided for Power and Energy (4% total financing), principally for power generating plants, electricity transmission, and distribution and oil exploitation. During this period US$3.6 million was provided (80% in grant form) for alternative energy sources.

CDB's Caribbean Technological Consultancy Services (CTCS) Network provides low-cost technical assistance to SMEs and has provided advice for the construction of solar dryers and biogas facilities. Between 1981 and 1983, CDB implemented the USAID-funded Caribbean Alternative Energy Programme (CAEP), which was continued with German support in 1983–1991. Under CAEP, feasibility studies for biogas plants were carried out and a number of facilities were constructed. Mini-hydro and biomass projects were also undertaken towards the end of the programme.

THE EUROPEAN INVESTMENT BANK

The EIB, the financing institution of the European Union, also provides financing for activities outside the Community. During 1997 EIB provided 3,244 MECU to countries outside the EU, much of which was advanced to Central and Eastern European countries (46%) and Mediterranean countries (35%). Fewer resources were invested in Asia and Latin America (12%), South Africa (6%), and ACP countries (2%) (EIB, 1997). ACP countries benefit from interest rates of between 3% and 6% as loans are subsidised by risk capital from the EDF. In all cases, however, projects must be economically viable to be eligible for financing. For this reason, research and development or pilot projects are not part of EIB activities.

In principle, energy projects are assessed within a wider policy framework that supports the development of domestic energy resources, diversification of energy supplies, and rational use of energy. Promotion of competitiveness in the energy sector and integration with EU energy markets (e.g. Trans-European Networks) are other factors that are taken into account. Energy sector commitments outside the EU were 593 MECU in 1997 (18% of financial contracts signed outside the EU) and 704 MECU in 1996 (30% in 1996). Loans have mainly been for the development of gas resources in Eastern Europe and the Mediterranean, construction or upgrading of power stations in ACP countries, and expansion of transmission and distribution capacity (e.g. Algeria, Bahamas, Barbados, Botswana, South Africa). Other projects receiving finance have included rehabilitation of the Akosombo hydroelectric power plant in Ghana, construction and commissioning of a hydropower complex on the river Indus in Pakistan, and the development of oil and gas deposits in Kenya, Zambia, the Ivory Coast, and South Africa. The strict commercial assessment of investments means that renewable projects in Europe often fail to meet EIB criteria. However, a loan of 20 MECU has been approved for financing 50.4 MW of wind power (84 x 600 kW sets) in Morocco.

"Global loans", which are distributed to small loan projects by banks within developing countries, provide EIB with an additional mechanism through which it may finance energy-related activities. Global loans can be targeted at specific types of project, defined by EIB in loan criteria. In 1997 global loans to Asian and Latin American countries totalled 40 MECU and 16 MECU to ACP countries. Energy projects account for only around 2% of the value of currently active global loans.

THE INTER-AMERICAN DEVELOPMENT BANK

The Inter-American Development Bank (IDB) aims to accelerate the economic and social development of Latin America and the Caribbean by providing finance and technical support and by mobilising other resources. In 1997 The Bank's annual lending totalled US$5.95 billion. Historically, large-scale investment in hydropower projects in the 1970s and 80s meant that the energy sector typically accounted for 25% to 35% of Bank lending. During the 1990s the energy portfolio shrank significantly and contained predominantly rural electrification and electricity infrastructure projects (except for 1993 when there were large hydropower loans to Venezuela and Colombia). In 1997 energy sector commitments rose again (US$970 million), however, with major loans incorporating power sector reform in Guatemala (US$107.5 million) and the Bolivia–Brazil gas pipeline (US$240 million). Commitments for 1998 include multi-sectoral credit support in Brazil (US$750 million).

In the 1980s loans for small and medium-scale renewable energy projects focused on grid-connected mini-hydro and geothermal facilities. More recently loans for geothermal projects have been the focus of renewable energy lending (US$213 million since 1993). Three loans for geothermal in El Salvador alone totalled over US$140 million and in 1998 a new geothermal loan was approved for Costa Rica. Costa Rica has also received two small loans for mini-hydro projects and a US$28 million loan for 20 MW of wind power. Technical support from IDB's Environment Division (US$7 million 1993–1996), has targeted feasibility studies for wind and geothermal. Apart from financing a regional private sector programme piloting renewables in 1996, there has been no additional lending for renewable energy. Most IDB activity in the field of energy efficiency has taken place since 1991. The Bank offers technical assistance in the form of studies and business plans and has supplied energy efficiency loans totalling US$55.6 million to The Bahamas, Colombia, Costa Rica, El Salvador (this was a component of a power loan), Jamaica, and Mexico. Of particular note, the Jamaica pilot energy efficiency project involved many aspects including residential programmes, incentives for cogeneration, and a large- and small-scale commercial efficiency programme.

As well as providing technical support, IDB's Sustainable Development Department develops sectoral strategies and best practice guidelines. IDB is preparing a new energy sector strategy (IDB, 1997a) which, complementary to the objectives of The Eighth Replenishment of Resources (IDB-8), recognises the importance of consolidating the structural and regulatory reforms undertaken in the 1990s and the financing of projects which incorporate clean energy and energy efficiency. This approach has already been employed by the Sustainable Markets for Sustainable Energy (SMSE) programme. Coordinated by the Environment Division, SMSE aims to develop a strategy for the Bank in catalysing markets for sustainable energy in the context of restructuring energy markets. Within the programme, Brazil is devising an action plan for rural energy services, Argentina and El Salvador for energy efficiency measures, and Peru for energy efficiency services for industrial customers (IDB, 1997b). Discussions are also being held with Jamaica and the Bahamas on the possibility of establishing a regional Energy Services Company (ESCO) to promote energy efficiency in hotels. The transport sector, the largest energy consuming sector in Latin America and the Caribbean, is of particular importance to the SMSE programme, and Argentina, Brazil, and Ecuador have all undertaken urban transport screening activities.

THE WORLD BANK

The energy sector has always been an important area of the World Bank's activities. Loan commitments in this sector totalled US$2.54 billion in FY1998 (IDA, IBRD, and IFC) and typically represent between one-fifth and one-sixth of total annual commitments of the World Bank Group (World Bank, 1997a). Sector operations are carried out through regional sector units, and in an anchor unit, the Energy, Mining, and Telecommunications Department (EMT). The EMT consists of the Energy Unit (EMTEG), the Oil and Gas Division (EMTOG), and the Industry and Mining Division (EMTIM). EMTEG is responsible for the Bank's core business areas, focusing on power sector reform and restructuring (loans in support of energy sector reform accounted for around half of energy loans in 1997), energy efficiency, rural and household energy, commercialisation of renewable energy, and environmentally sound energy development. The sector lending policies of the Bank have evolved to adopt environmentally sustainable policies in support of its economic development projects (World Bank, 1993). A recent draft paper on energy and environment (World Bank, 1997a) stresses the role of institutional interventions, capacity building, and the importance of energy conservation and renewable energy. Rural Energy and Development: Improving Energy Supplies for Two Billion People (World Bank, 1996) outlines the role of the Bank in broadening access to energy and improving the quality of life in the rural developing world. EMTEG also disseminates technical assistance and best practice guidelines through workshops and symposia, for example holding roundtables on Rural Energy and Development and on Energy Efficiency. EMTOG, responsible for the Bank's lending policy in the oil and gas sectors, committed US$136 million in 1997, principally in support of the modernisation of natural gas in Azerbaijan and oil systems in Kazakhstan. Assistance to the mining sector emphasises the establishment of sound legal and fiscal frameworks to attract the private sector. In 1997 a single loan of US$300 million was made in support of a coal sector reform programme in Ukraine and in 1998 US$1.3 billion was allocated for coal projects in Russia and India. In addition to the above Bank Group activities, MIGA provides political risk cover for energy projects (eight loans in 1997).

To date Bank loans for renewable energy (US$547 million) have principally been to Asian countries, and loans for renewables committed in 1997 (US$111 million) included those in support of 200,000 solar home systems in Indonesia and of wind and mini-hydro in Sri Lanka. Loans awaiting approval include US$175 million for 400 MW of mini-hydro in Nepal; US$46.5 million as part of a renewable energy for rural markets programme (total finance US$187 million) in Argentina; and US$115 million for the dissemination of 200,000 solar home systems in China. A previously approved loan for mini-hydro and bagasse in Indonesia (US$66 million) has been cancelled because of government difficulties with implementation.

Energy efficiency initiatives, once only component parts of power sector loans, are now addressed in their own right in lending operations. In 1998 the Bank prepared three energy efficiency loans. Following implementation of a US$4.5 million EC grant which initiated pre-programme activities in China, the Bank has approved US$61 million, backed up by a US$22 million GEF grant, for a programme to develop Energy Management Companies and disseminate information. Two additional loans currently under preparation include one to provide a financing facility for on-lending for electricity efficiency in private and public utilities in Brazil (US$43 million loan with US$20 million GEF grant) and another for on-lending to public utilities in India.

Bank renewable energy and energy efficiency loans are often supported by GEF grants. Past and planned loans for renewables in Argentina, China, Indonesia, and Sri Lanka benefit from GEF grant support. As an implementing partner of the GEF, the Bank also manages its own portfolio of GEF projects, including over US$500 million in support of climate change projects. Renewable energy projects presently under implementation (US$ 222 million) include IFC's Renewable Energy and Energy Efficiency Fund (REEF) (US$30 million GEF funding), promotion of wind and PV in India (US$26 million), and geothermal in the Philippines (US$30 million). GEF has funded most Bank renewable energy projects in Africa including projects concerning household energy in Mali, sugar bio-energy technology in Mauritius, biomass management in Senegal, and solar water heating in Tunisia. US$30 million of GEF funding has been approved in support of The PV Market Transformation Initiative, promoting adoption of SHS and water pumping equipment in Kenya, India, and Morocco. Energy efficiency initiatives (US$ 136 million in GEF funding) include the development and dissemination of efficient industrial boilers in China and the promotion of electricity efficiency in Hungary, Jamaica (DSM), Poland, and Thailand. Future GEF-supported programmes include the development of renewables in China (US$35 million) a biomass pilot project in Brazil (US$40 million) and solar thermal power in Egypt (US$50 million).

In addition to lending and GEF activities, the Bank has a number of programmes and initiatives promoting the mainstreaming of sustainable energy and providing technical assistance. ESMAP is the longest established of the Bank's specialised energy programmes. ESMAP provides global technical assistance for the energy sector, specifically in its six priority thematic areas: energy and the environment; rural and household energy; renewable energy technologies; energy sector reform; energy efficiency; and international energy trade. Resources include both a Core Fund of unrestricted contributions as well as earmarked contributions from the World Bank, UNDP, and bilateral donors. Support for ESMAP totalled US$8.4 million in 1997, of which the Bank provided US$1.6 million and bilateral donors (notably the Netherlands and the UK) provided the rest (ESMAP, 1997). Excluding Bank contributions, ESMAP managed projects with a total budget of US$36 million between 1991 and 1998 (World Bank, 1998). Past activities have included National Energy Sector Assessments for over 60 developing countries which, with other preparatory work, have helped to pave the way for subsequent investment. Country and regional gas sector development and trade have been a key focus area. The Africa Gas Initiative is reviewing undeveloped gas discoveries and flared gas in Sub-Saharan Africa and will prepare pre-feasibility studies for any gas reserves identified. Renewable projects, such as the PV concession system in Argentina and the implementation of solar electric equipment through NGOs and local credit organisations in Kenya, have explored alternative approaches for financing renewable energy.

The Bank has launched a number of initiatives to encourage private sector investment in renewable energy in the developing world:

- The Renewable Energy and Energy Efficiency Fund (REEF), a global fund (US$150-210 million) financing private sector renewable (on/off grid projects of less than 50 MW) and energy efficiency activities (Jechoutek, 1998).
- The Small and Medium Scale Enterprise Program (SME) is a US$21 million IFC initiative supported by the GEF which finances biodiversity and climate change projects carried out by SMEs in GEF-eligible countries. Contingent, concessional loans are provided to financial intermediaries (FIs). These FIs then finance the SMEs. To date two PV projects and one energy efficiency project have been approved.
- The Solar Development Corporation (SDC), a collaboration between the Bank and a number of foundations, promotes stand-alone PV systems through sustainable private sector mechanisms. SDC aims to provide up to US$50 million in capital, plus additional financing, and also business advisory, training, and market development services for solar entrepreneurs.

The following additional programmes aim to increase the Bank's own investments in renewables:

- The Asia Alternative Energy Group (formerly ASTAE) helps

BOX 24

Box 24 Review of Policies, Strategies, and Programmes in the Traditional Energy Sector (RPTES)

With support from the World Bank and the Netherlands, RPTES was established in recognition of the impact that traditional energy sector policy has on environmental sustainability, rural poverty alleviation, energy and economic efficiency, and gender equity in developing countries. The first phase of the programme reviewed traditional energy sector policies in five Sahelian countries, Burkina Faso, Mali, Niger, Senegal, and the Gambia. The programme identifies inter-sectoral linkages, which then enable the definition of an operational strategic framework in a broad context. The identification of focused implementation priorities and the preparation of investment projects helps to ensure that concrete action follows the programme recommendations. By mid-1997 the RPTES had been expanded to include policy and operational support in the original five countries and Benin, Ethiopia, Guinea, Guinea Bissau, Mauritania, Mozambique, and Togo.

A key factor in the success of RPTES has been the principle of country ownership of policy findings, which is essential to ensure their practical application. This has been achieved through the maximisation of in-house African contributions. National teams, made up of officials in charge of relevant ministries and representatives of other bodies, carry out a review of their own energy policy. The programme works with the national teams, transferring analytical methodologies and performing capacity building tasks through consultant support.

RPTES manages a portfolio of follow-up investments, currently totalling US$60 million but expected to reach US$100 million by December 1998. Phase II of the programme, re-named and launched as the "Regional Programme for the Traditional Energy Sector", is continuing the work in the existing countries and expanding work to include countries of the Southern Africa Development Community on a demand-driven basis. Technical reports on RPTES activities are published in an independent discussion paper series.

to prepare renewable energy and energy efficiency components for Bank-supported operations in Asia (Shaeffer, 1996). Donor commitments to ASTAE totalled US$ 15 million by April 1998, and have levered almost US$ 1.3 billion in World Bank/GEF funding, in turn contributing to US$2-3 billion in total project costs.

- The recently launched Africa Rural Electrification Initiative aims to identify two or three countries where the Bank will assist with mainstreaming rural electrification activities (on and off-grid) in order to increase access to energy and intensify productive use of energy in rural areas. The initiative will harness bilateral funds to build capacity in developing countries and encourage the participation of private sector entrepreneurs as upstream activities to subsequent Bank lending.
- The World Bank Solar Initiative includes an operational programme to integrate commercial and near-commercial renewable energy technologies into World Bank and GEF funding/project pipelines and a research and development (R&D) programme aimed at directing solar R&D to more consistent and reliable funding levels.
- Hydropower receives special attention through the Large Dams Commission, which identifies lessons learned and aims to continue the application of viable hydropower.

Other Bank programmes in the energy environment field are:

- The Review of Policies, Strategies and Programmes in the Traditional Energy Sector (RPTES) programme, focusing on the traditional energy markets in Africa (see Box 24), maximises host country participation in policy development.
- The Pollution Prevention and Abatement Handbook (World Bank, 1997b), containing policies and project preparation guidelines which promote the concepts of sustainable development through pollution prevention, including cleaner production and good management techniques.
- The Clean Coal Initiative encourages cutting-edge technologies and management of best practices for environmental gains through the entire coal utilisation chain.
- The Activities Implemented Jointly (AIJ) Programme pilots a scheme through which foreign investors can gain emissions credits by financing activities in other countries. The programme has used bilateral grants (US$ 5.5 million from Norway) coupled with GEF grants and other finance. To date implemented projects have concerned dissemination of CFLs in Mexico, coal-to-gas technology in Poland, and community-based forestry management and the promotion of PV in Burkina Faso. Projects under consideration (US$2-5 million AIJ funding each) include integrated agricultural DSM in India, fuel cells in Barbados, and RE/diesel hybrid isolated grids in the Philippines.
- The Bank's proposed post-Kyoto Carbon Investment Fund, which would allow investors to pool resources for carbon-reducing investments and include in the price of carbon offsets a margin representing equitable benefit-sharing between the investor and host.

ANNEX II - CONTACT DETAILS OF PERSONS INVOLVED IN THE PREPARATION OF THIS REPORT

Table II.1 Authors of the Report

Author	Position/Institution	Tel/Fax/Email	Principal Input
Bengaly, Salifou	AFRITEC Boulevard Nelson Mandela, Porte 1351 B.P. E 2502 Bamako,Mali	Tel: +223 21 00 53 Fax: +223 21 00 53	Mali Country Study
Bertarelli, Lara	Energy Research Scientist IT Power Limited, Hampshire, United Kingdom, RG27 0PR	Tel: +44 118 973 0073 Fax: +44 118 973 0820 lb@itpower.co.uk	Chapter 3
Boyce, John	Director, Ecoenergy Caribbean 194 Atlantic Shores, Christ Church Barbados	Tel: +246 228 2337 Mobile: +246 220 2494 Fax: +246 420 84 61 jdeboyce@caribsurf.com	Barbados Country Study
Brew Hammond, Abeeku	Acting Director of Kumasi Institute of Technology and Environment (KITE), Kumasi, Ghana	Tel: +233 5160231 Fax: +233 516032/26026 Kite@ghana.com	Ghana Country Study
Cornland, Deborah	Director of the Energy and Global Change Programmes, Stockholm Environment Institute, Sweden	Tel: +46 8 412 1400 Fax: +46 8 723 0348 Deborah.cornland@sei.se http://www.sei.se/	Chapter 2
Derrick, Anthony	Director, IT Power Limited, The Warren, Bramshill Road, Eversley, Hampshire, United Kingdom, RG27 0PR	Tel: +44 118 973 0073 Fax: +44 118 973 0820 aderrick@itpower.co.uk	Chapter 3
Farinelli, Ugo	Former Director of the Energy Department of the Italian National Agency for New Technologies Energy and Environment (ENEA)	Tel: +39 06 3627 2521 Fax: +39 06 3627 2280 erg@esedgt.sede.enea.it	Chapter 1
Graham. James	Research Assistant UNDP Brussels Liaison Office Rue Montoyer, 14 1000, Brussels, Belgium	Tel: +32 2 505 4627 Fax: + 32 2 503 4729 j.graham@skynet.be	Annex I
Lazarus, Michael	Manager of the International Energy and Environment Programme at the Stockholm Environment Institute, Boston, USA	Tel: +1 617 266 8090 Email: MLAZ@TELLUS.ORG	Chapter 2
Leach, Gerald	Senior Research Fellow of the Stockholm Environment Institute, based in London, United Kingdom	Tel.:+44 171 794 6228 Fax: +44 171 431 6147 Galeach@gn.apc.org	Chapter 2
Ruggeiro, Maurice	Tritech Consulting Engineers based in Suva, Fiji	Tel: +679 322 703 Fax: +679 320 301 Email: Spycom@is.com.fj	Fiji Country Study
Shanker, Anjali	Director, Innovation Energie Développement (IED), 46, rue de Provence, 75009 Paris, France	Tel: +33 1 48 74 6215 Fax: +33 1 48 74 5052 a.shanker-ied@wanadoo.fr	Chapter 2
Sokona, Youba	Director, Environnement et Développement du Tiers Monde (ENDA TM), Dakar, Senegal	Tel: +221 225983 Fax: +221 222496 energy@enda.sn	Chapter 2

Table II.2 Developing Country Experts Invited to Review Draft Report in Vienna, June 1998

Name	Nationality	Position/Institution	Tel/Fax/Email
Adegbulugbe, Anthony	Nigeria	Centre for Energy Research and Development Obafemi Awolowo University Ile-Ife, Nigeria	Tel: +234-1 49 77875 Fax: +234-1 4977845 aadegbul@cerd.oauife.edu.ng
Bengaly, Salifou	Mali	AFRITEC Boulevard Nelson Mandela, Porte 1351 B.P. E 2502 Bamako, Mali	Tel: +223 21 00 53 Fax: +223 21 00 53
Billy Sow, Aissatou	Guinée	AGUIPER B.P. 3075 Conakry Rep. Guinée	Tel: +224 221738/229121 Fax: +224 452346
Boyce, John	Barbados	Ecoenergy Caribbean Barbados 194 Atlantic Shores, Christ Church Barbados	Tel: +246 228 2337 Mobile: +246 220 2494 Fax: +246 420 84 61 jdeboyce@caribsurf.com
Brew-Hammond, Abeeku	Ghana	Acting Director KITE 48 Okodee Road UST P.O. Box 5601 Kumasi Ghana	Tel: +233 5160231 Fax: +233 516032/26026 Kite@ghana.com
Cisse, Ibrahima	Côte d'Ivoire	Ministère de l'Energie Cabinet BP V6 Abidjan Côte d'Ivoire	Tel: +225 34 79 12 Fax: +225 34 79 10
Eberhard, Anton	South Africa	Director, Energy & Development Research Centre, University of Cape Town Private Bag Rondebosch 7701, South Africa	Tel: +27 21 650 2827 Fax: +27 21 650 2830 anton@engfac.uct.ac.za
Fifita, Solomone	Fiji	Energy Advisor Energy Unit South Pacific Applied Geosciences Commission (SOPAC) Suva, Fiji	Tel: +679 381 377 Fax: +679 370 040 solomone@sopac.org.fj
Harris, Hugh	Jamaica	Manager, Demand-Side-Management Jamaica Public Services Company PCJ Building - Ground Floor 36 Trafalgar Road Kingston 10, Jamaica	Tel: +1 876 926 0057 Fax: +1 876 926 0409 hharris@jpsco.com
Maya, Shakespeare	Zimbabwe	Executive Director SCEE 31 Frank Johnson Avenue Eastlea Harare, Zimbabwe	Tel: +263 4 708 551 Fax: +263 4 738 315 scentr@harare.iafrica.com
Mintah, Isaac Kwaku	Ghana	Director of Energy Ministry of Mines and Energy P.O. Box 40 Stadium Post Office, Accra, Ghana	Tel: +233 21 667151 Fax: +233 21 667 119

Table II.2 Developing Country Experts Invited to Review Draft Report in Vienna, June 1998 (contd.)

Name	Nationality	Position/Institution	Tel/Fax/Email
Ndoutoum, Jean Pierre	Gabon	Institut de l'Energie et de l'Environnement de la Francophonie (IEPF) 56 rue Saint Pierre, 3ème etage Québec, QUE Canada G1K 4A1	Tel : +1 418 692 5727 Fax: +1 418 692 5644 jp.ndoutoum@iepf.org
Ouiminga, Seydou	Burkina Faso	Directeur de l'Energie Direction générale de l'Energie Ministère de l'Energie et des Mines 01 B.P. 3922 Ouagadougou, Burkina Faso	Tel: +226 34 04 37 and 38 Fax: +226 30 79 78
Raj, Suresh	Fiji	Pacific Regional Energy Programme G.P.O. Box 14788 Suva, Fiji	Tel: +679 220295 Fax: +679 303828/30161? Email: Suresh@sprep.org.ws
Razanajatovo, Mamy	Seychelles	Senior Research Officer Energy Affairs Bureau Seychelles Bureau of Standards P.O. Box 953 Victoria Mahé, Seychelles	Tel: +248 37 53 33 Fax: +248 37 51 51 sborg@seychelles.net
Ruas, Manuel	Mozambique	Instituto de Desenvolvimento Rural (INDER) Av. Eduardo Mondlane 2221, 2∫ Andar Maputo, Mozambique	Tel: +258 1 42 4973 / 42 46 21 / 42 46 80 Fax: +258 1 42 46 23
Ruggiero, Maurice	Fiji	President of Fiji Institution of Engineers 152 Ragg Avenue Namadi Heights Suva Fiji	Tel: +679 322 703 Fax: +679 320 301 Spycom@is.com.fj
Salifou, Djibril	Bénin	Ministère des Mines, de l'Energie et de l'Hydraulique (MEMH) 06 B.P. 2049 Cotonou, Bénin	Tel: +229 33 0514 Fax: +229 31 35 46
Sarr, Sécou	Sénégal	Réseau Africain Bioressource Energie pour le Développement & l'Environnement B.P. 3370 Dakar, Sénégal	Tel: +221 22 24 96 Fax: +221 23 51 57
Siwatibau, Suliana	Vanuatu	Island Consulting FSPI P.O. Box 1045 Port Vila Vanuatu, South Pacific	Tel: +678 22283 Fax: +678 22283 siwatsul@vanuatu.com.vu
Sokona, Youba	Sénégal	ENDA-TM B.P. 3370 Dakar, Senegal	Tel: +221 225983 Fax: +221 222496 energy@enda.sn
Sy, Bocary	Mali	Conseiller Technique Ministère des Mines et de l'Energie P.O. Box 1909 Bamako, Mali	Tel: +223 22 4184/224238 (home) +223 23 0185 Fax: +223 22 2160
Trotz, Neville	Trinidad & Tobago	Caribbean Planning for Adaptation to Global Climate Change CPACC Cermes Building University of the West Indies St.Michael, Barbados	Tel: +1 246 417 4581 Fax: +1 246 424 4204 utrotz@ndl.net

Table II.2 Developing Country Experts Invited to Review Draft Report in Vienna, June 1998 (contd.)

Name	Nationality	Position/Institution	Tel/Fax/Email
Yamba, Francis	Zambia	Director Centre for Energy-Environment Engineering Zambia Ltd. Private Bag E 721 Lusaka, Zambia	Tel: +260 1 236 942 Fax: +260 1 224170 f.d.yamba@eng.unza.zm
Yameogo, Gabriel	Burkina Faso	GERED Groupe d'étude et de Recherche Energie-Environnement pour le Développement. 01 B.P. 3709 Ouagadougou 01 ou B.P. 540 Ouagadougou Burkina Faso	Tel: +226 36 80 40 Fax: +226 36 80 40/30 29 66 gered@fasonet.bf
Zhou, Peter	Botswana	Centre for Energy-Environment, Computer and Geographical Ltd. P.O. Box 402339 Gaborone, Botswana	Tel/Fax: +267 1 307 310 pzhou@global.bw

Table II.3 Representatives of EU Member States' Government Agencies

Country	Institution	Responsible
Austria	Bundesministerium für auswärtige Angelegenheiten Ballhausplatz 2 A-1014 Wien Austria	Guenther Stachel Head, Technical Cooperation Tel: +43 1 53115 Fax: +43 1 5354530 Guenther.stachel@wien.bmaa.gv.at
Belgium	Administration Générale de la Coopération au Développement Institutions Européennes (AGCD) rue Brèderode, 6 B - 1000 Bruxelles	Patrick De Bouck Tel: +332 2 519 06 44 Fax: +332 2 519 05 70 m2.euro@badc.fgov.be
Denmark	DANIDA Royal Danish Ministry of Foreign Affairs 2 Asiatisk Plads DK-1448 Copenhagen K, Denmark	Jean Paul Laude Technical Advisor Tel: +45 33 92 0000 Fax: +45 31 54 0533 Jealau@um.dk
Finland	Department for International Development Cooperation Ministry of Foreign Affairs P.O. Box 127 FIN 00161 Helsinki Finland	Krister Lonngren Energy Advisor Tel. 358 9 1341 6438 Fax. 358 9 1341 6428 Krister.lonngren@formin.fi
France	Direction de la Coopération Scientifique et Technique Ministère des Affaires Etrangères 244, boulevard Saint Germain F-75303 Paris 07 SP, France	Janine Ferry Tel: +33 1 43 17 93 04 Fax: +33 1 43 17 8950 janine.ferry@diplomatie.fr
Germany	Bundeministerium für wirtschaftliche Zusammenarbeit und Entwicklung (BMZ) Postfach 120322 53045 Bonn Germany	Dr.Rainer Lotz Director, Unit 416 Infrastructure Tel: +49 228 535 3760 Fax: +49 228 535 3755 Lotz@bmz.bmz.bund400.de
	Sector Policy Kreditanstalt für Wiederaufbau (KfW) Palmengartenstrasse 5-9 60325 Frankfurt am Main	Rolf Siefried Tel: +49 69 7431 3755 Fax: +49 69 7431 3746 Rolf.Seifried@KfW.de
	Energy and Transport Division Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) Dag-Hammarsskjöld-Weg 1-5 Postfach 5160 65726 Eschborn, Germany	Bernhard Bösl, Tel: +49 61 96 79 1626 Fax: +49 61 96 79 7144 Bernhard.boesl@gtz.de
Greece	Hellenic Republic Ministry of National Economy Hermou & Kornarou 1 Str. 105 63 Athens Greece	Ms. Kraia Directorate for Development Assistance Cooperation Tel: +301 328 6321 Fax: +301 328 6234

Table II.3 Representatives of EU Member States' Government Agencies (contd.)

Country	Institution	Responsible
Ireland	Department of Foreign Affairs 76-78 Harcourt Street, Dublin 2 Ireland	Edward O'Louthlin Irish Aid Tel: +35 31 478 0822 Fax: +35 31 408 2844
Italy	Direzione Generale per la Cooperazione allo Sviluppo Ministero Affari Esteri Via S.Courtarini,25 00194 Roma Italy	Carlo Cibo Energy-Industry Expert Unita Tecnica Centrale Tel: +39 0 6 36 91 41 74 Fax: +39 0 6 324 05 85 Cibo@esteri.it
Luxembourg	Ministère des Affaires Etrangères, du Commerce Extérieur et de la Coopération 6, rue de la Congrégation L-1352 Luxembourg	Marc Bichler Service de la Coopération Tel: +352 478 2346 Fax: +352 22 20 48 Mark.bichler@mae.etat.lu
Netherlands	Ministerie van Buitenlandse Zaken P.O.Box 20061 2500EB The Hague The Netherlands	Paul Hassing Head Climate, Energy and Environmental Technology Tel: +31 703 48 4306 Fax: +31 703 48 4303 p.hassing@dml.minbuza.nl
Portugal	Instituto de Cooperacaõ Portuguesa Avenida de Liberdade, 192, 1/5 1250 Lisboa Portugal	Ms. Henny-Silva Tel: +351 1 317 6700 Fax: +351 1 314 7897
Spain	Agencia Española de Cooperación Internacional Ministerio de Asuntos Exteriores Av.Reyes Catolicos, 4 28040 Madrid Spain	Jesus Gracia General Manager ICI (Latin America) Tel: +34 91 583 8100 Fax: +34 91 583 8219 Jesus.garcia@aeci.es Senen Florensa General Manager ICMAPD (non-Latin America) Tel: +34 91 583 8181 Fax: +34 91 583 8219 Senen.florensa@aeci.es
Sweden	Swedish International Development Cooperation Agency (Sida) S-105 25 Stockholm Sweden	Anders Hagwall Head, Infrastructure Division Tel: +46 8 698 5000 Fax: +46 8 20 8864 Anders.hagwall@sida.se
United Kingdom	Department for International Development (DFID) 94 Victoria Street London SW1E 5JL United Kingdom	Clive Caffall Energy Advisor Infrastructure Division Tel: +44 171 917 0541 Fax: +44 171 917 0072 c-caffall@dfid.gtnet. gov.uk

Table II.4 Representatives of Other Bilateral Government Agencies

Country	Institution	Responsible
Canada	Canadian International Development Agency (CIDA) 200 Promenade du Portagu Hull Québec Canada K1A OG4	Gerry Collins Senior Advisor, Energy Policy Branch Tel: + 1 819 953 2242 Fax: +1 819 953 3248
Japan	Japanese Ministry for Foreign Affairs 2-2-1 Kasumigaseki Chiyoda-ku Tokyo 100-8919 Japan	Toshiki Kato, Grant Aid Division, Economic Cooperation Bureau Tel: +81 3 3580 3311 Fax: +81 3 3593 8025 Toshiki.kato@mofa.go.jp
	Japan International Cooperation Agency (JICA) Shinjuku Maynds Tower Building, 8th Floor 1-1, Yoyogi, 2- Chome Shibuya-ku Tokyo, Japan	Kuniaki Nagata Director, Energy & Mining Development Study Division Tel: +81 3 5352 5292 Fax: +81 3 5352 5326 nagatak@jica.go.jp
	Japanese Overseas Cooperation Fund (OECF) 4-1 Ohtemachi 1- Chome, Chiyoda-ku Japan	Kaoru Suzuki Manager Africa Region Tel. +81 3 3215 1398 Fax. +81 3 3215 1533 Kao-suzuki@oecf.go.jp
USA	US Agency for International Development (USAID) 1300 Pensalyvania Avenue N.W Washington 20523-3800, D.C. U.S.A.	Jeff Seabright Director, Energy and Environment Division. Tel: +1 202 712 1772 Fax: + 1 202 216 3230 jseabright@usaid.gov

Table II.5 Representatives of Multilateral Development Banks

Institution	Address	Responsible
African Development Bank	Environment & Sustainable Development Unit African Development Bank Abidjan Côte d'Ivoire	Dr. Yogesh Vyas Chief Environmental Officer Tel. +226 20 48 26 Fax +226 20 50 33 y.vyas@afdb.org
Asian Development Bank	Infrastructure, Energy and Financial Sectors Department (East) Asian Development Bank 6 ADB Avenue Mandaluyong City 0401 Metro Manila Philippines	Dr P.N. Fernando Manager Tel: +63 2 632 6648 Fax: +63 2 636 2422 pfernando@mail.asiandevbank.org
European Investment Bank	Energy Department European Investment Bank 100, Boulevard Konrad Adenauer L-2950 Luxembourg	Ghunter Westermann Tel: +352 4379 2446 Fax: +352 4379 2492 g.westermann@eib.org
Inter-American Development Bank	Division de Medio Ambiente Banco Interamericano de Desarrollo 11300 New York Avenue, N.W Washington, D.C. 20577 U.S.A	Jaime Millan Chief Economist Tel: +1 202 623 1949. Fax: +1 202 623 1786 Jaimem@adb.org
The World Bank	The Energy Unit Energy, Mining and Telecommunications Department The World Bank 1818 H Street, N.W. Washington, DC 29433 U.S.A.	Karl Jechoutek Division Chief Tel: +1 202 458 2872 Fax: +1 202 477 0542 Kjechoutek@worldbank.org
	Africa Rural Renewable Energy Initiative	Arun Sanghvi Tel: +1 202 458 2504 asanghvi@worldbank.org
	Regional Programme for the Review of the Traditional Energy Sector	Boris Utria butria@worldbank.org

Table II.6 Multilateral Cooperation Institutions

Institution	Responsible Department	Responsible Person
European Commission DGVIII : Development	Unit A3 Infrastructure DGVIII Development European Commission Rue de la Loi, 200 B-1049 Bruxelles, Belgium	Eric Donni Tel: +32 2 295 1259 Fax: +32 2 295 2897 eric.donni@dg8.cec.be
European Commission DGXI Environment, Nuclear Safety and Civil Protection	Climate Change Task Force DGXI, European Commission Rue de la Loi, 200 B-1049 Bruxelles, Belgium	Peter Horrocks Tel: +32 2 295 7384 Fax: +32 2 295 9557 peter.horrocks@dg11.cec.be
European Commission DGXII: Science, Research and Development	Rational Energy Use and Integration of Renewable Resources DG XII/F/1, MO 7/1 European Commission Rue de la Loi, 200 B-1049 Bruxelles, Belgium	Domenico Rossetti di Valdalbero Tel: +32 2 296 2811 Fax: +32 2 299 4991 Domenico.rossetti-di- valdalbero@dg12.cec.be
European Commission DGXVII: Energy	Energy Cooperation with Non- Member Countries DG XVII/A/4, TERV, 4/5 European Commission Rue de la Loi, 200 B-1049 Bruxelles, Belgium THERMIE DG XVII/D/1, TERV, 5/4A European Commission Rue de la Loi, 200 B-1049 Bruxelles, Belgium	Francois Casana Tel: +32 2 295 1978 Fax: +32 296 6282 francois.casana@dg17.cec.be Paula Abreu Marques Tel: +32 2 295 3805 Fax: +32 2 295 6116 paula.abreu-marques@ bxl.dg17.cec.be
UNDP	Energy and Atmosphere Programme (EAP) Sustainable Energy and Environment Division UNDP 304 East 45th St. New York 10017 New York, USA	Prof. Thomas. B. Johansson Director Tel: +1 212 906 5030 Fax: +1 212 906 5148 tjohanss@undp.org Annie Roncerel Senior Programme Adviser Tel: +1 212 906 6616 Fax: +1 212 906 5148 annie.roncerel@undp.org
UNEP	Tour Mirabeau, 39-43 quai André Citroën 75739 Paris Cedex 15 France	Mark Radka Energy Programme Coordinator Tel: +331 44 37 14 27 Fax: +331 44 37 14 74 mark.radka@unep.fr
UNEP CCEE	UNEP Collaborating Centre on Energy and Environment Risø National Laboratory P.O. Box 49 DK-4000 Roskilde Denmark	John Christiansen Director Tel: +45 46 32 2288 Fax: +45 46 31 1999 John.christiansen@risoe.dk

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ABOUT...

DG VIII OF THE EUROPEAN COMMISSION

Directorate-General VIII is responsible for development cooperation between the European Community and developing countries of the Africa, the Caribbean and the Pacific (ACP) region, a group which includes many of the poorest countries in the world. The objectives of development cooperation are:

1. to foster the sustainable economic and social development of ACP countries;
2. to promote their smooth and gradual integration into the world economy;
3. to campaign against poverty and;
4. to develop and consolidate democracy, the rule of law, and respect for human rights.

UNDP

The United Nations Development Programme is the UN's largest source of grant finance for development cooperation. Its funding is from voluntary contributions of Member States of the United Nations and affiliated agencies. Through a network of 132 country offices, UNDP manages programmes in 174 countries and territories, focusing on four core development themes: poverty elimination, environmental regeneration, job creation, and the advancement of women. Ninety per cent of UNDP's core programme is focused on 66 countries that are home to 90 per cent of the world's extremely poor.

EUROPEAN COMMISSION
Directorate General
for Development
Rue de la Loi, 200
B-1049 Brussels

UNITED NATIONS
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Bureau for Development Policy
1 United Nations Plaza
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