UNITED
NATIONS

Framework Convention
on Climate Change

Distr.
RESTRICTED

FCCC/TP/1998/1
6 October 1998

ENGLISH ONLY

TECHNICAL PAPER ON TERMS OF TRANSFER OF TECHNOLOGY AND KNOW-HOW

Barriers and opportunities related to the transfer of technology

GE.98-

CONTENTS

I. TERMS OF TRANSFER

A. Mandate

1. By its decision 13/CP.1, the Conference of the Parties (COP) requested the secretariat, *inter alia*, to elaborate "the terms under which transfers of such technologies and know-how could take place" (FCCC/CP/1995/7/Add.1). It also requested itemized progress reports (according to the types of activities specified in paragraphs 34.15 to 34.28, inclusive, of chapter 34 of Agenda 21) on concrete measures taken by the Parties listed in Annex II to the Convention, with respect to their commitments related to the transfer of environmentally sound technologies and the know-how necessary to mitigate and facilitate adequate adaptation to climate change.

2. At its fifth session, the Subsidiary Body for Scientific and Technological Advice (SBSTA) took note of a list of topics that could be addressed by the secretariat in a series of papers. These included financial flows between countries, activities undertaken by governments to facilitate the introduction and use of environmentally sound technologies, small and medium enterprises and transnational corporations, and success stories from different countries (FCCC/SB/1997/1).

3. By its decision 9/CP.3, the third session of the COP requested the secretariat "to consider specific case studies, as part of its work on terms of transfer of technologies, drawing on the experience of Parties, including demonstration projects, with the aim of evaluating barriers to the introduction and implementation of environmentally sound technologies and know-how, and of promoting their practical application" (paragraph 2 (c)).

B. Scope of the paper

4. This paper responds to the aspects of decision 9/CP.3 identified above. To prepare this paper, the secretariat collected information from literature, meetings and workshops. Information from the survey of technology and technology information needs of non-Annex II Parties, prepared in cooperation with the University of Amsterdam, was also synthesized. In addition, several contributors from developing countries assisted the secretariat in preparing information on case studies.[1] The paper was sent for review to nominees listed on the UNFCCC roster of experts and to the lead authors of the pending Intergovernmental Panel on Climate Change (IPCC) report on methodological and technological issues related to technology transfer. Comments received as of 3 September 1998 are reflected in the paper.

---

[1] O. R. Davidson, Transfer of environmentally sound technologies (ESTs) to Africa: barriers and opportunities; E. Lebre La Rovere, Barriers and opportunities related to the transfer of carbon friendly technologies to Latin America; Y. Jung, Transfer of environmentally sound technologies and know-how in some Asian countries. Copies of these papers, which include bibliographic references, could be made available by the secretariat, upon request.

5. The paper provides information about the barriers to the transfer of technology in all countries, although those faced by developing countries are given special emphasis. The focus is on the legal and institutional measures affecting admission and establishment, ownership, control and operation of technologies, services and firms.[2] It provides examples of activities, regulations and operating instruments that have been implemented in some developing countries to enhance and promote the transfer of environmentally sound technologies and to remove barriers to their introduction.[3]

6. As a technical paper, the objective is to provide background information and not possible options for further work. Parties, however, may wish to read the paper in conjunction with the progress report on development and transfer of technology, which contains elements of a future work plan (FCCC/CP/1998/6), and with the compilation and synthesis of activities of Annex II Parties in financing and transfer of technology in documents FCCC/SBSTA/1997/13 and FCCC/CP/1998/11/Add.1.

7. The paper would have been easier to construct if there had been a common view as to what is meant by technology transfer and how it should occur. This paper is based on the assumption that the transfer of technology (both hard and soft) is a process of many day-to-day activities involving several stakeholders, who are influenced by the social, economic, legal, technological and political circumstances in each country. It is assumed that technology can be transferred between private partners, between private partners and governments and between governments, but that, having ratified the Convention, governments have a unique role.

8. The paper is one of a series planned on this subject. For example, the IPCC is preparing a special report on methodological and technological issues related to technology transfer that will be available in late 1999. It will provide more detailed information on basic concepts, generic barriers and specific sectors, including case studies. Also, the subject of barriers to the transfer of technology will be covered in the Third Assessment Report (TAR) of the IPCC.

9. The information concerning case studies in this paper should be considered illustrative and viewed with caution, as perceptions about the success or failure of projects often differ among stakeholders, and vary over time and with the scope of the activity. For example, projects may be viewed as a success at the national level, but as a failure at the local level. Similarly, projects may initially be successful, but may fail after a period of time, for example, if macroeconomic conditions change. Some stakeholders may view success only after a project has

---

[2] Information on trends in financial flows and terms and conditions employed by multilateral lending institutions affecting the transfer of technology was provided in technical paper FCCC/1997/TP/1.

[3] There has been no attempt to develop a standard format for describing activities as the information available to the secretariat varied significantly in content. The IPCC is attempting to do this for its Special Report on methodological and technological issues relating to technology transfer. Examples of preliminary information on IPCC case studies may be found at the following Web site: www.usgcrp.gov/ipcc/html/cslist.html

been replicated on a large scale within the same country or in other countries. Nevertheless, there are broad lessons that can be learned from such examples.

II. GENERAL DISCUSSION

A. Introduction

10. Environmentally sound technologies (ESTs) and know-how,[4] in the climate change context can be divided into two categories: mitigation technologies to reduce emissions by sources or to enhance removals by sinks of greenhouse gases and adaptation technologies to reduce the adverse impacts of climate change.[5]

11. The international transfer of ESTs and know-how can be considered as a process originating from the countries and the companies that developed and produced them to the countries and subjects that will receive and facilitate their effective implementation and dissemination. This process follows different pathways and in each case there are different entities that can intervene and influence the process.

12. A typical technology transfer process can be divided into the steps summarized in table 1 below, according to the different participants in the process. This is not a strict division of roles, and action may be taken by both sides.[6]

Table 1. Steps in the technology transfer process

Supplier side	***Recipient side***
a) research and development	a) create awareness of the need for ESTs
b) project preparation	b) develop capacity for the adoption of ESTs
c) demonstrations	c) assess technological options
d) project implementation or technology commercialization	d) implement and operate technology
e) feedback analysis	e) feedback analysis

---

[4] Environmentally sound and economically viable technologies and know-how conducive to mitigating and adapting to climate change. The term encompasses "soft technologies" and "hard technologies". Examples of soft technologies include capacity building, information networks, training and research, while examples of hard technologies include equipment and products to control, reduce or prevent anthropogenic emissions of GHG in the energy, transportation, forestry, agriculture, industry and waste management sectors, to enhance removals by sinks, and to facilitate adaptation (FCCC/SBSTA/1996/4).

[5] In the context of this paper, to the extent possible, we will refer to all categories giving specific mention when only one group is concerned.

[6] Steps in table 1 are not directly linked between the supplier and recipient sides.

13. The implementation of the above processes calls for the involvement and commitment of different actors. There are six main actors who may enter the process at different stages: Governments, private sector businesses, multilateral financial institutions, international organizations, non-governmental organizations (NGOs) and consumers/households. These actors often perform multiple functions; for example, the private sector develops, manufactures, markets, finances, and operates technologies. However, the boundaries between actors are not rigid and may differ for different types of technologies.[7]

14. All the above actors participate in the process. Nevertheless, the process itself depends upon the varying conditions, in both developed and developing countries. To be able to facilitate the adoption and implementation of ESTs it is essential to consider specific regional, national and sectoral barriers and incentives. Encouraging key actors to value the medium- and long-term economic and competitive benefits of sustainable development over the short-term costs of shifting production and consumption patterns remains one of the most important objectives to be achieved.

B. Barriers

15. Barriers may generally be defined as factors that inhibit the technology transfer process. Examples of barriers are abundant in the literature.[8] However, the following is a short list of barriers relevant to the transfer of ESTs:

(a) Institutional: lack of legal and regulatory frameworks, limited institutional capacity, and excessive bureaucratic procedures;

(b) Political: instability, interventions in domestic markets (for example, subsidies), corruption and lack of civil society;

(c) Technological: lack of infrastructure, lack of technical standards and institutions for supporting the standards, low technical capabilities of firms and lack of a technology knowledge base;

(d) Economic: instability, inflation, poor macroeconomic conditions and disturbed and/or non-transparent markets;

(e) Information: lack of technical and financial information and of a demonstrated track record for many ESTs;

---

[7] In some of the groups it is possible to find suppliers and users. The actors will behave differently depending on whether they represent the supplier's or receiver's side.

[8] See for example: World Investment Report 1996, UNCTAD, and Technology and Finance: new opportunities and innovative strategies for sustainable development, UNDP (1994.)

(f) Financial: lack of investment capital and financing instruments;

(g) Cultural: consumer preferences and social biases;

(h) General: intellectual property protection, and unclear arbitration procedures.

16. A first step in the process of overcoming barriers is to identify and assess them according to the technologies chosen and the targeted categories of users. An example of such a process is the technology and technology information needs survey conducted by the secretariat with the cooperation of the University of Amsterdam (FCCC/SBSTA/1998/INF.5).[9]

17. In that survey Parties were requested to provide information on past experiences and projects, and to list the perceived barriers encountered in formulating and implementing them. The results are presented in table 2 .

Table 2. Barriers to the transfer of technology as identified by Parties

Reporting Countries	***Key barriers***	***Category***
Belize, Guinea, Latvia, Mali Poland, Republic of Korea	Lack of finance, terms of funding	Financial
Mali	Inability to obtain international finances for dissemination of indigenous technologies	Financial
Mali, Kiribati	High investment cost	Economic
Mali, Poland	High cost of service and maintenance	Economic
Zimbabwe	Affordability for technology end-users	Economic
Albania, Panama	Lack of/access to technical information	Technological
Mali	Lack of supply of spare parts	Technological
Egypt	Lack of technical capacity	Technological
Egypt, Guinea, Indonesia	Lack of local management skills, training of personnel	Institutional
Barbados, Costa Rica	Lack of public acceptance: low level of public awareness	Institutional
Mali	Cultural, including perceived comfort.	Cultural

Source: see footnote 9.

[9] See also R. van Berkel, E. Arkesteijn, Transfer of Environmentally Sound Technologies and Practices under the Climate Convention: survey of experiences, needs and opportunities among non-Annex II countries. IVAM Environmental Research, 1998.

18. The conclusions from the data provided in the survey are limited by the number of projects reported. Therefore it is not possible to give a general assessment of the comparative importance of various types of barriers. However, the key barriers, in order of decreasing importance, appear to be: financial, economic, technological, institutional and cultural. In particular, access to national and international sources of financing is seen as a major obstacle.

C. Opportunities

19. Agenda 21 provides a list of activities that can create opportunities to promote the transfer of technology, these include: a) government policies creating favourable conditions for both public-sector and private-sector transfers; b) institutional support and training for assessing, developing, and managing new technologies; c) information networks and clearinghouses that disseminate information and provide advice and training; d) collaborative networks of technology research and demonstration centers; e) international programmes for cooperation and assistance in research and development and capacity building; f) technology-assessment capabilities among international organizations; and g) long-term collaborative arrangements between private businesses for foreign direct investment and joint ventures.[10]

20. Many governments are undertaking such actions by developing legal instruments, tax regimes that reward technology upgrading, targeted lending programmes from public and private banks, public/private partnerships to support the import/export of ESTs, tax refunds or subsidies for the import and implementation of ESTs, subsidized infrastructure, tariff protection, and providing clear information about government programmes and actions. Some governments are also using economic instruments together with traditional command and control regulations (for example, emission standards) to achieve environmental goals and to encourage the transfer of technologies. Case studies suggest that no single policy instrument is likely to be sufficient to address environmental problems, and that, therefore, a combination of instruments is likely to be needed. To be effective, economic instruments also need strong institutions, the active support of economic, financial and industrial authorities, and few bureaucratic restrictions.

21. Further examples of recent activities undertaken by non-Annex II Parties can be drawn from the results of the technology and technology information needs survey, where Parties were requested to provide details on enabling measures adopted by their governments to facilitate the transfer and implementation of ESTs in different sectors relevant to climate change in their countries. The responses of Parties are summarized in table 3. Examples of programmes and projects in Annex II Parties can be found in documents FCCC/SBSTA/1997/13 and FCCC/CP/1998/11/Add.1.

---

[10] There is general recognition that the private sector plays an important role in introducing and implementing environmentally sound technologies and know-how, and that the relationship between the public and private sectors is particularly important and needs to be further explored. In this context, the secretariat is preparing a technical paper that will be available in 1999, on the role of the private sector in developing and promoting clean technologies, including problems and prospects.

Table 3. Enabling measures initiated by non-Annex II Parties

Creating awareness	Disseminating information	Providing technical assistance	Creating a fiscal environment	Removing trade barriers
Albania	Albania	Bangladesh	Barbados	Bulgaria
Barbados	Bolivia	Barbados	Bulgaria	Mali
Belize	Costa Rica	Bolivia	Lithuania	Poland
Benin	Ecuador	Botswana	Mali	Senegal
Bhutan	Egypt	Bulgaria	Poland	Uruguay
Bolivia	Georgia	Guinea	Republic of Korea	
Botswana	Guinea	Indonesia	Uruguay	
Bulgaria	Indonesia	Mali		
Costa Rica	Lithuania	Poland		
Ecuador	Mali	Uruguay		
Egypt	Philippines			
Georgia	Poland			
Guinea	Republic of Korea			
Guyana	Senegal			
Jamaica	Singapore			
Latvia	Trinidad & Tobago			
Lesotho	Uruguay			
Lithuania	Venezuela			
Mali	Zimbabwe			
Nigeria				
Philippines				
Poland				
Republic of Korea				
Senegal				
Singapore				
South Africa				
Syria				
Trinidad & Tobago				
Uruguay				
Venezuela				
Zimbabwe				

Source: see footnote 9 (Responses from national focal points or other national climate change coordinators have been considered for this table).

D. Some lessons learned from case studies

22. Section III of this document includes case studies of technology transfer processes in a few developing countries. From these case studies it is possible to draw only some preliminary lessons, since only a limited number of cases and countries have been considered.

23. The African case studies provide some useful lessons for future technology development and transfer in Africa. For example, there is a need for the developers of technology who enter the market at an early stage to provide for awareness building, demonstrations, initial training, and financial support. This was crucial when introducing solar photovoltaic (PV) systems in Kenya, where donor agencies, working with local companies, provided for such activities.

24. Rapid technology learning, substantial cost savings, materials substitution, and enhancing local capability can be achieved by the involvement of local staff during the development cycle, and for process and product improvements, as in the case of the Zimbabwe ethanol programme. Also, technical "after-sales" support and maintenance facilities can help the performance and dissemination of the technology as the case of Senegal demonstrates; and low-interest loans and other subsidies to early users encourage the penetration of new technologies. The revolving fund in Zimbabwe helped to disseminate PV technology in the country.

25. The importance of tax reductions and subsidies needs further study. At present, the final price of ESTs in Africa is very high due to a number of factors, including the lack of competition. The cost of a PV system in Kenya is almost three times that in Indonesia. Taxes (15 per cent import duty and 20 per cent VAT) contribute to this cost, but the base cost is also high. It is not clear whether a reduction of taxes alone would reduce the market cost.

26. The Latin America case studies provide other lessons. For example, it is important to incorporate environmental criteria into the management and concession of official credits and fiscal incentives. The Green Protocol established in Brazil is an example of these activities. The Protocol, composed of federal financial institutions, requires that the participating banks promote the protection and recovery of the environment through specific credit lines.

27. Small-scale pilot demonstration programmes that aim to disseminate information and reduce high initial costs through rebates and promotions can encourage electrical energy conservation.

28. Information clearing houses can play a role in promoting renewable energy by disseminating information on solar, wind, biomass and small hydro technologies. The Brazilian renewable programme case study draws attention to the successful use of reference centres.

29. The South-East Asia cases provide yet other lessons. For example, a phased long-term government strategy to tackle barriers that are closely related to the development stages of each country is important. Such a strategy needs to address institutional, financial, education and training issues. It also needs to closely link government, institutions and the private sector. The

removal of energy price subsidies appears to be an effective way to facilitate the transfer of ESTs.

30. Governments can play a key role by funding the “startup” of R & D institutions, as shown in the example of the Republic of Korea. Such institutions have been established, along with education and training programmes in formal and vocational schools, in an effort to enhance the development of human capital development.

31. Well coordinated partnerships among government, private sector and foreign companies are important to the success of technology transfer.

III. CASE STUDIES

A. Africa

1. Introduction

32. Africa, with a population estimated at 743 million, is made up of 53 countries with diverse socio-economic and political conditions, and very different resource endowments among countries. The continent accounts for about 7 per cent of global greenhouse gas emissions, and only about 4 per cent of total $C0_2$ emissions.

33. According to the African Development Bank, Africa’s annual GDP growth in 1996 was 4.8 per cent compared to 2.8 per cent in 1995, with some countries’ GDP growth exceeding 7 per cent. This is a change from the past when the GDP growth rate lagged behind the population growth rate that is now just under 3 per cent. Another positive feature is the increase in foreign direct investments (FDI) to the continent, from US$ 0.9 billion in 1990 to US$ 3.4 billion in 1994 and US$ 5.0 billion in 1996. However, Africa’s percentage share of total financial flows to developing countries has decreased from 11 per cent in 1990 to 3.8 per cent in 1996 and these flows are skewed to only a few countries.

34. African countries, as other developing countries, are utilizing ESTs in various economic sectors, such as energy, industry, forestry, transportation, and waste management, though climate change concerns have not been the main driving force behind this. In the energy supply area, these technologies are used mostly by the power sector, while for energy demand they are used in the household, industrial and transport sectors. Improved agricultural practices are being tried in a few countries as a means of improving production and minimizing the use of organic fertilizers. Improved forestry practices are being used in several countries with the aim of increasing the forest cover.

35. The technologies used in the energy sector, which is by far the most dominant, can be summarized as follows:

(a) Improved technologies are being adopted for production and waste management in the exploitation of natural gas. New gas pipelines are being constructed for supply within and outside the continent. Nigeria and Algeria are examples of countries undertaking these exercises.

(b) South Africa and Zimbabwe are examples of countries using improved methods for extracting coal and cleaner coal processing methods;

(c) Tunisia and Ghana are among countries using modern and efficient power production technologies, such as combined cycles, and cogenerating plants are under construction;

(d) Different economic sectors are adopting energy efficient technologies, using both software and hardware options. Senegal and Kenya are good examples where this is happening in the industrial sector, while Côte d'Ivoire is an example for the household and transport sectors;

(e) Utilization of biomass as a high energy source in the power sector through the use of agricultural waste is widespread in countries with wood, palm crops and sugar industries. In Mauritius, excess power produced is sold to the national grid, and represents as much as 14 per cent of the total.

(f) Zimbabwe and Kenya use ethanol made from molasses (sugar waste) to blend gasoline in the transport sector; and

(g) The use of renewable energy technologies in the form of solar electrical and thermal systems is widespread throughout the continent.

36. The following discussion will analyse the activities in three countries – Senegal in the west, Kenya in the east, and Zimbabwe in the south of the continent. They are representative of countries in the region that are embarking on several climate change-related activities as part of their development programmes.

2. Examples of government enabling activities

37. Resource flows to all three countries have been dominated by official development assistance (ODA) and long-term debts. For example in 1994, these constituted 77 per cent and 22 per cent respectively of all resource flows in Senegal, 65 per cent and 35 per cent in Kenya, and 41 per cent and 53 per cent in Zimbabwe, with hardly any difference in the total resource flows. Foreign direct investment has been minimal in all countries, nil in Senegal, 0.4 per cent

of the total resource flows in Kenya and just under 6 per cent in Zimbabwe, while equity flows from outside are nil in all countries.[11]

38. Government enabling activities are aiming to attract investors in all sectors through a variety of policies. Specific laws focusing on the transfer of ESTs or climate-relevant technologies are not priorities, however they are considered in the general context of broad economic development policies. Some measures directly related to ESTs are presented below.

39. In general, investment laws in African countries have changed since the late 1980s and early 1990s, when countries had to undertake economic reform programmes to boost their administrative and economic efficiencies. As a result, they instituted policy changes to attract foreign investors by reducing or removing legal and regulatory obstacles on the activities of foreign companies. In addition, most African countries now provide benefits to foreign companies, such as generous conditions for profit repatriation and tax-free salaries. However, countries are yet to benefit significantly from these actions as the amount of foreign investment to Africa is still comparatively small. To date there is a relatively low level of new investments by large foreign investors, especially the transnational corporations (TNCs).

40. A major change, which might attract foreign investments in African countries, is the removal of many restrictions on foreign participation in local equity markets and the easing of exchange controls. Despite the continent's economic problems, capitalization in stock markets has been growing. At the end of 1995, capitalization in the continent was just over US$265 billion, with South Africa accounting for 90 per cent, northern Africa 5.5 per cent and the other countries the remaining 4.5 per cent. However, there are signs that the emerging stock exchanges will grow at a faster pace as laws restricting foreign and regional investments are reduced or removed.

3. Barriers related to the transfer of environmentally sound technologies

41. There are still serious barriers that will affect the rate of technology acquisition in African countries, especially, for the least developed countries. They can be classified as technological, institutional, information, financial and market barriers. At the same time, there are overlaps among them because of the inter-relationships between these sectors. A significant number of African countries do not have an explicit national policy that supports technology development (acquisition of skills and knowledge from external sources and upgrading of indigenous skills). This absence creates obstacles for all the stakeholders, including government institutions, because actions by these stakeholders often requires a national policy.

---

[11] Human Development Report 1997, UNDP, and World Development Report, World Bank, 1997.

42. Another barrier is the inadequate enabling environment for non-government stakeholders. Many believe that this obstacle contributes greatly to the low flow of foreign investments to the continent. Factors contributing to the lack of an enabling environment include inadequate macro-economic policies, and lack of communications, suitable small and medium scale firms for sub-contracting, appropriate financial systems and insufficient highly skilled workers.

43. Current efforts that started in the early 1990s in most African countries are making major changes in the macro-economic environment with improved financial and administrative efficiencies. However, more attention is needed to improve productivity through streamlining of government functions and provision of support for productive activities in the economy. The absence of such a macro-economic environment is a major deterrent to foreign investments because it can increase transaction costs.

44. Another general obstacle is the absence of feasible and appropriate standards based on local conditions in many countries, though most countries have institutions that are expected to perform this function. Lack of adequate support facilities and management has eroded their performance significantly, resulting in poor technology sourcing, selection and assessment. Investments by governments in this area and establishing effective linkages with the national education system could reduce this obstacle by ensuring that standards are regularly updated.

45. The relatively low level of technological capability in African countries compared with other developing countries is the greatest technical barrier to technology transfer and development in the continent. The major reason for the low capability is inadequate highly-skilled technical manpower. A critical mass of human capital with the needed technical knowledge and skills is crucial for technology development and transfer. Developing this critical mass is urgent because at each stage of the technology transfer process such a capability is required, and it is part of the enabling environment. Appropriate policies by governments and adequate support for the national education systems can assist greatly in tackling this issue. One important obstacle that has resulted from this barrier is that normal engineering procedures for testing, commissioning, and supporting equipment purchases are often lacking. This is a common problem for renewable energy technologies and contributes to their poor performance in many applications. It also contributes to poor maintenance programmes and poorly operating equipment. As a result, many newly introduced technologies appear dysfunctional.

46. Non-transparent legal systems and relatively weak enforcement mechanisms for laws relating to investments and companies also discourage both external and local investors, especially the former. For example, very long arbitration processes, unclear property rights and high legal fees can undermine business confidence.

47. Institutional inertia, or the resistance to change, is another obstacle and is worse in a relatively uncompetitive environment as is the case in many African countries. This deters the

introduction of new methods and techniques into the productive sector and generates inefficiencies.

48. The poor technical information base in many African countries is an important barrier because it seriously affects their capacity for effective sourcing and selecting of technologies, which is the very first phase in undertaking the technology transfer process. Many technically competent personnel in these countries lack access to global information, and this results in sub-optimal choices. Also, often there is a lack of local data required for the design of good investment projects. These data, such as performance data, supporting banking information and insurance information, are crucial for helping to make investments decisions.

49. The overall poor economic situation in African countries is the most important financial barrier in addition to the lack of external investments. It creates low perceptions of the economy leading to higher discount rates, which restrict investments. The poor economic base and low incomes lead to low savings potential which reduces the chances for local investments. The continued debt problem of many countries restricts their capacity to access external finance for projects and other financial needs, and this affects technology development. It also limits the participation of local entrepreneurs wishing to collaborate with external partners. Local banks are not always supportive of new areas, such as ESTs, because they view them as being too risky.

50. In addition, the size of the market is very small in African countries for two reasons: first, the majority of African countries are small, with over 50 per cent having populations under 15 million; secondly, many economies are dependant on rural agriculture, so the market size for many goods is limited to the urban areas. A small market size poses a problem to business as it signifies lower rates of return on investments.

51. Finally, the structure of markets, often monopolistic or oligopolistic, is a barrier to establishing a fair pricing system. In many cases, the financial systems fail to give price signals, therefore energy efficiency measures may not be introduced. As a result, further development of the technological base of related industries becomes unnecessary.

4. Solar photovoltaic systems

52. The use of solar photovoltaic (PV) systems is widespread in virtually every country in Africa. Presently, Africa produces more than150,000 units with a total power output of about 5 MWp, which represents an estimated 10 per cent share of the world market. They are used mainly for lighting in remote areas not supplied by the electricity grid, for preservation of medicines in rural clinics and for telecommunication centres and back-up systems.

Kenya

53. Solar PV systems were introduced into Kenya as a response to the 1970s oil shocks and to the intense search for more reliable alternatives that followed. The cost of such systems during the early period, US$30 - US$40/peak watt, was far higher than people could afford. However, due to the decline in global prices and the interest of donor agencies, the use of PV systems for lighting, water pumping and village medical clinics has increased. International companies, such as Siemens and BP, have set up offices in Nairobi, and a few local entrepreneurs have emerged. This has led to market segmentation in which the donor agencies have concentrated on home systems while the TNCs have concentrated on large installations. Early market development, including confidence building among users through awareness campaigns, training and demonstrations, was done by the donor agencies. The combination of early donor investments, the development of local expertise trained by these companies, and an increase in solar PV globally leading to declining prices, has provided the basis for the solar PV boom that has followed.

54. The cumulative sales of solar PV systems in Kenya rose from 80 kWp in 1987 to 600 kWp in 1992. An estimated 40,0000 units have been installed today.[12] Apart from the global progress leading to efficiency improvement and price decline, the growth in the PV market can be attributed to the following:

(a) Battery production was started locally in the mid-1980s by the Associated Battery Manufacturers, a major producer of batteries in Kenya. The impact of this activity on technological capability was very positive as this led to greater use of locally-produced and assembled components. Also the cost is between 33 to 50 per cent lower than imported batteries after the initial period of learning and quality control;

(b) Electric grids have not penetrated into rural areas significantly, with access at less than 4 per cent. Prospects for more rapid penetration are due to high initial cost, low incomes of intended users, and large bureaucracies. Hence, decentralized systems with little government intervention become attractive; and

(c) Low-interest credit systems have been established to help users to pay the high initial cost over time. An example is the Solar Energy for Rural Kenyan Business programme that provides loans to business and community groups along with training and management support.

---

[12] INFORSE, 1997.

Zimbabwe

55. The use of solar PV systems in Zimbabwe started in earnest in the 1980s, mainly as a result of the search for alternatives in rural areas. Activities are many, but not as intensive as in Kenya; for example, by 1990 while Kenya had over 300 kWp of rural systems installed, Zimbabwe had less than a third.

56. A Global Environment Facility (GEF) solar project costing US$7.4 million is one of the most important projects in Zimbabwe. This is a 5-year project, which aims to demonstrate the benefits of solar energy through the provision of power for lighting, radio and television and the commercialization of solar systems. The main components of the project include easy access to foreign exchange, low interest credits for end-users, training of installers and users, and local purchasing of components. The project has installed approximately 8,500 solar home systems (SHS), and now supports 50 local companies that employ over 500 technicians. The major driving force for the project's achievement is the revolving fund managed by the Agricultural Finance Corporation, which provides low-interest loans to potential PV owners. Four thousand such loans have been disbursed so far.. The project has been using local manufacturing companies for charge controllers, batteries, lights and assembled solar panels. Also technical manuals have been produced for installers and users in addition to a price guide.

Senegal

57. The use of solar PV systems in rural areas of Senegal is significant though not as high as in Kenya and Zimbabwe. Introduced in a significant way about 8 years ago, about 1,600 SHS are currently in use in rural Senegal. However, there is a potential market for 130,000 households, which represents 30 per cent of the 420,000 rural households in the country. Two main obstacles affect the penetration of these systems: lack of finance to cover the high initial cost and poor maintenance. The lack of finance is being addressed by a financial initiative by ENDA, an international NGO, and FOPEN Solaire, a national NGO formed in 1994 by local co-operatives. FOPEN, formed mainly to provide advice and maintenance for the dissemination of SHS, now trains technicians and disseminates about 100 systems a year in a market for about 300 a year after import tax removal. In addition it provides spare parts. To improve maintenance FOPEN established a credit scheme for users to purchase major components, such as batteries, and it provides workshop facilities for its member associations.

Approaches for financing

58. The relatively high front-end cost of PV technology and the low income of the intended end-users (rural communities) is a major barrier to the penetration of this technology. Government intervention is needed because the normal banking system cannot provide credit facilities to these end-users due to their strict adherence to banking rules. They normally require

feasibility studies at the applicant's expense, land titles as collateral, and accounting management documents moreover, banks charge high interests rates as was shown in the case of Uganda.[13]

59. In some countries, such as Kenya, private companies have set up "hire-purchase" schemes with down payments of 40 per cent and the remaining 60 per cent paid in monthly instalments, but the success has been limited due to repayment problems.[14] In Botswana, government intervention has proved useful. The Government entered into an agreement with a village cooperative, Rural Industries Innovation Centre, to undertake a financial and technical feasibility study for the use of photovoltaic systems for lighting in the village of Kanye. The Government contributes 70 per cent to the revolving loan fund and the Renewable Energy for Africa contributes 30 per cent. Loans are amortized over two years with monthly payments of $8.75 for two-light systems and $31.25 for six-light systems. Only five out of 42 recipients in the programme defaulted and they have promised to pay at a later date. The success of the scheme led to its replication in four other villages. The flexibility of repayments under this scheme, which was due to the Government's intervention, contributed to its being viewed by many as a success.[15] Zimbabwe also has a revolving fund through the GEF project, but this has shown limited success.

60. The successful operation of renewable energy technologies require specialized training to ensure proper operation and after-sales service. All three countries are carrying out this type of training mainly through the NGO community. For example, Zimbabwe has a five-year training program for farmers in River Estate, which has 26 solar homes. In this programme, operated by the NGO, Development Aid for People to People (DAPP), users are trained to operate and maintain PV systems. Also, there are several specialized courses in different renewable energy technologies, and some specifically on PV installation, including one conducted by KARADEA, an NGO in Tanzania.

61. Promoters of this technology have advocated removal of import duties and taxes as a means of providing subsidies to users of PV technology. Government responses have been mixed owing to the resultant loss of revenue and because most of the current users are from the middle and higher classes, which they are unwilling to subsidize. However, the impact of duties and taxes on the final pricing of home units can be significant. In Kenya, compact fluorescent lamps (CFLs) carry a 37 per cent import duty and 18 per cent VAT, the same as other electric bulbs. Locally-produced batteries are charged 18 per cent VAT, and imported batteries 37 per cent import duty and 18 per cent VAT. PV panels have a slightly lower import duty of 31 per

---

[13] Turyareeba, 1993.

[14] Kimani, 1993.

[15] J. Geche and J. Irvine, 1996.

cent, but a VAT of 18 per cent. The import duty on D.C. generators is only 12 per cent and VAT is only 5 per cent. In Zambia, the Government in 1994 provided incentives to purchase PV by Statute 114, which removed duty and sales tax on PV, but the impact is yet to be reported. In Uganda, a 58 per cent tax on PV systems was removed in 1992/93 and re-introduced in 1993. However, since most governments in the region subsidize kerosene because it is used mainly by the poor, reducing tax for PV in a reasonably large market will lower the final price. Table 4 provides examples of financing programmes in selected African countries.

Table 4. Financing programmes for PV in selected countries

Country	Financing condition
Botswana	- 45 per cent duty on PV removed in June 1986 - VAT and duty exemption on all PVs imported by donors - Government grants for wind pumps
Kenya	- Government grants for renewable energy development.
Senegal	- Removal of import duties on PVs. Devaluation of local currency by 100 per cent affected sales.
Seychelles	- Tax exemption on solar devices
Zambia	- Removal of import tax and VAT
Zimbabwe	- Soft loans for PV users under GEF project. Reduced taxes and import duties

5. Ethanol programmes

62. Of the three countries in Africa reported to be using ethanol as an additive to gasoline for transport fuel, Kenya, Malawi and Zimbabwe, only Zimbabwe has proved successful. Hence most of the discussions in this section will focus on the use of ethanol in Zimbabwe. However, the activities in Kenya are also reported because its experiences provides some lessons for other countries in the region.

Zimbabwe

63. The ethanol production programme which was started in Zimbabwe in 1979, is one of the world's most successful programmes, second only to Brazil.[16] Ethanol production for transport fuel is an innovative programme between the Government and the private sector resulting from a conscious effort to cope with economic pressures to reduce imports. The private sector company involved is Triangle Ltd. It uses molasses from sugar cane production in Zimbabwe and Zambia

[16] Scurlock et al, 1991.

to produce enough ethanol to displace over 40 million litres of gasoline imports annually. The Triangle Ltd. plant was locally planned, controlled and operated. The plant was established during a period when Zimbabwe could afford to convert sugar to ethanol due to low export prices and a large molasses supply. Local construction benefited the country because the control systems were adapted to cope with local skills, and substantial local materials were used in place of imports, resulting in a 60 per cent local content of the plant. This led to substantial cost savings. Currently, ethanol is sold to the Government-controlled Oil Corporation, which then sells it to various oil companies for blending (up to 13 per cent in gasoline) and distribution.[17]

64. The ethanol programme in Zimbabwe provided the following benefits: it produced ethanol with an energy ratio of 1:1.9 in an ethanol/gasoline mixture (13 per cent); it is the only fuel available for use in spark ignition engines in the country; it has produced significant foreign exchange savings by reducing the need for imported gasoline; it has improved human resources capacity, increased rural employment; and stimulated the private sector.

Kenya

65. A similar ethanol programme for transport fuel production was introduced in Kenya in 1977 with the objective of reducing oil imports, but the results were different from those in Zimbabwe. Only one of the three envisaged projects got started, and that was operated by a private company, Agro-Chemical and Food Company. The ethanol produced was used to blend with gasoline of up to 10 per cent.[18] The project had several technical problems, such as frequent blender breakdowns and fluctuating molasses supplies. Other problems affecting the programme included: subsidies that undermined efficient production even though the private sector was also involved, technical and management problems resulting from the limited involvement of local personnel in the project design, construction and operation; and the lack of well-developed manufacturing and technological capabilities made the programme very expensive.

B. Latin America

1. Introduction

66. The Latin American region includes 26 countries[19] with an estimated population of 459 million (in 1993). The four largest economies within Latin America (Argentina, Brazil,

---

[17] Rosenchein, 1991.

[18] INFORSE,1997.

[19] Twenty-five of these countries have signed and ratified the Convention.

Mexico and Venezuela) accounted for 60 per cent of the region's population and 74 per cent of its GDP in 1990.

67. In the early nineties, Latin American economies were growing, faster than the world average, with the important exception of Brazil. Economic growth in the region further accelerated after 1993, including the Brazilian economy, which also started to grow by over 4 per cent per year. This performance lies between the extremes of the past two decades: rapid growth during the seventies (when the regional economy increased by 37 per cent) and the recession in the eighties resulting in an overall negative growth of 8 per cent.

68. Economic activity is known to be one of the major driving forces behind CO_2 emissions from the energy sector, the main source of GHG emissions in the region, with the important exception of Brazil. In this country, CO_2 emissions from deforestation in the Amazon are two to three times higher than current levels from the combustion of fossil fuels.[20] Accordingly, economic growth between 1990 and 1996 is associated with an average increase of 2.1 per cent per year in CO_2 emissions from the combustion of fossil fuels in Latin American.[21] This pace of growth corresponds to exactly the same average historical rate of increase in CO_2 emissions from 1970 (664 million tons) to 1990 (1 billion tons), a balanced result of two very different decades in Latin America.[22]

69. Within Latin America, the four largest economies are responsible for 80 per cent of the CO_2 emissions in the region. The case of Brazil is interesting as an example of a relatively energy efficient sector with low carbon intensity, compared with OECD levels. This is due to the supply role of renewables in the Brazilian energy balance, accounting for more than half of the total primary energy consumption: 92 per cent of electricity comes from hydropower, while ethanol and bagasse from sugar cane contribute 10 per cent to primary energy supply and charcoal from afforestation schemes feed a not negligible proportion ofn the Brazilian pig iron and steel industry. However, current trends in the Brazilian energy picture point to a decrease in the share of renewables in the fuel mix.

70. According to the International Energy Agency (IEA) World Energy Outlook, a significant growth of energy-related CO_2 emissions is expected in Latin America between 1990 and 2010: from 63 to 80 per cent under the two cases, compared to the 52 per cent increase recorded for the 1970-1990 period. As global energy-related CO_2 emissions are projected to grow by 17 to 30 per cent during the same period, the Latin American share in this world total

[20] La Rovere et al, 1993.

[21] Jefferson, 1997a.

[22] OLADE, 1996.

would increase from 5 per cent in 1996 to 6 per cent in 2010. Still, the increase in Latin American energy-related CO_2 emissions until 2010 forecast by the IEA is much more modest than in Africa (84 to 92 per cent growth), which has a much lower base, and in Asia, where emissions were expected to more than double prior to the current economic crisis.[23]

2. Examples of government enabling activities

71. In the nineties the notion that technology imports and local technology capabilities can be complementary has become widely recognized by policy makers in the region. This is partly inspired by analyses of the industrialization process in other countries (for example, in Germany in the nineteenth century, Japan in the twentieth century, and more recently, in the Republic of Korea).[24]

72. Another important factor in this transformation has been the enormous pressure to reduce protectionist controls over technology transfer stemming from the Uruguay Round agreements under the General Agreement on Tariffs and Trade (GATT) and its successor, the World Trade Organization (WTO).[25] Accordingly, laws and regulations to achieve this have recently been passed in Latin American countries to foster the flow of technology transfer from abroad, while recognizing the intellectual property rights on technology.

73. The Brazilian case illustrates how changes in policies during these periods affected transfer of technology in the region. The1950s and 1960s experienced high foreign currency expenditures on technology imports. In 1970, the National Institute of Industrial Property, was established and import controls were imposed as well as a variety of measures, in order to reduce expenditures, which dropped to between 200-300 millions dollars per year. The situation was again reversed in the 1990s, when a number of laws were passed, such as the Resolution 022 on patents in 1991, No. 9279 on the same issue in 1996, and in 1993 the INPI Normative Act. As a result foreign currency expenditures increased from US$226 million in 1993 to US$1.5 billion in 1997.[26]

74. The supply of financial resources for the implementation of GHG mitigation projects has been strengthened by several government-lending programmes targeted at promoting the diffusion of environmentally sound technologies in Latin America. An example is the Green

---

23 IEA, 1996.

24 Cassiolato, 1996.

25 Cruz, 1997.

26 Cruz, 1997.

Protocol established in 1995 by a pool of Brazilian federal financial institutions: the National Bank for Economic and Social Development (BNDES), Bank do Brazil (BB), the Federal Savings Bank (CEF), the Bank of the Northeast of Brazil (BNB) and the Bank of Amazon (BASA). A working group, comprising representatives of these banks together with representatives from several ministries and the Central Bank, was created to incorporate environmental criteria into the management and concession of official credits and fiscal incentives. The Green Protocol requires that, besides complying with legal requirements and identifying environmental costs in their project analyses, the banks should promote the recovery and protection of the environment, through specific credit lines.

75. In addition, fiscal incentives are being used to stimulate environmental projects, including carbon-friendly technologies, especially those aimed at industrial technological development. In Brazil, for example, exemptions of up to 8 per cent of total corporate income tax are granted to enterprises for their investment in technological development.

76. Tax regimes are also being transformed in many other Latin American countries, including a general cut in import taxes, thus promoting the integration of regional economies into the world market. In particular, within sub-regional blocs, such as the Andean Pact and Mercosur, reductions in import taxes have accelerated the movement toward the establishment of common markets.

77. More specifically relevant to the mitigation of energy-related CO_2 emissions, are the regulatory reforms coupled with the privatization of the energy sector that are underway throughout Latin American countries during the nineties. The transfer of ownership of power and oil companies to the private sector has resulted in changes in the fuel mix, with important consequences to the level of CO_2 emissions according to the patterns of the energy resource of each country. For example, this process is near completion in Argentina, incipient in Venezuela, and well advanced in Brazil. It has been accompanied by a general trend towards expanding the use of natural gas, including for power generation. When natural gas is used as a substitute for other fossil fuels, the intensity of CO_2 emissions per unit of output is reduced (as happened in Argentina and many other Latin American countries).

78. Another important outcome of the new institutional building of the energy sector in Latin America is the emergence of a new actor in the energy system – the independent power producer. The reduction of constraints to the grid of solar, wind, biomass and small-hydro power producers can become increasingly important for fostering the diffusion of renewables and the consequent mitigation of CO_2 emissions in the region.

3. Barriers related to the transfer of environmentally sound technologies

79. A number of common structural macroeconomic barriers to investment in cleaner technologies exist in the largest Latin American countries. Capital constraints are acute, and

there might be larger up-front investment costs for some environmentally sound technologies. Many countries have high interest rates and low levels of domestic savings. Financial markets do not always work efficiently in allocating funds to productive activities.

80. Specifically in the energy sector, price distortions are often an important barrier to the penetration of carbon-friendly technologies in Latin America. Consumer energy subsidies in the region were estimated to reach US$13 billion in 1991 – US$5 billion for electricity and US$8 billion for fossil fuels. According to the same sources, the total amount of consumer energy subsidies in developing countries were estimated to be about US$300 billion in 1991, which indicates that Latin American levels are not particularly high compared with other regions in the developing world. The situation varies widely from country to country, as illustrated by the rate of domestic to world prices for oil in 1991: only about 25 per cent for Venezuela, compared to nearly 75 per cent for Mexico and more than 80 per cent for Brazil.[27]

81. Several studies (for example, by the World Bank and OECD) have shown that eliminating energy subsidies can be done when there is an overall increase in the level of income. However, the cutting of energy subsidies to low-income consumers can lead to social unrest, as experienced on several occasions by Venezuela (increases in gasoline prices) and in Argentina (increase in the power tariffs of slums around Buenos Aires following privatization of the local utility). The overall benefits of reducing the gap between domestic and world fossil fuel prices, as well as between power tariffs and marginal electricity costs, would improve the possibilities for greater market penetration of carbon-friendly technologies.

82. Another important barrier to overcome in Latin America, as elsewhere, is the absence of accounting for the negative environmental externalities of fossil fuel consumption. The methodological and data difficulties in estimating environmental costs of different energy sources cannot be underestimated. An interesting example is in the current discussion about the adoption of a green tax on gasoline and diesel oil in Brazil to raise the funds needed to proceed with the Ethanol Programme. The Brazilian Government responded to the falling trend in international sugar prices and the increasing burden of the petroleum bill after 1973, by creating the Ethanol Programme. After the launch of the programme in 1975, ethanol production from sugar cane increased from 600 million litres to 13.74 billion litres per year in 1996-1997. Tax reductions made ethanol and ethanol-powered car prices highly attractive to consumers. Over four million cars consumed 9.47 billion litres of hydrated ethanol per year and another 4.27 billion litres of pure ethanol was used for the production of gasohol (a blend of 22 per cent of ethanol in gasoline).

83. The sharp decrease in oil prices in the international market in the mid-eighties seriously affected the cost-effectiveness of the Ethanol Programme. The Government stopped supporting

---

[27] de Moor and Calamai, 1997.

new distilleries and therefore limited the production capacity. The future existence of the Ethanol Programme is now in jeopardy as a result of persistently low oil prices. An overall evaluation of the Ethanol Programme would need to consider its contribution to curbing local air pollution in Brazilian cities and to reducing the greenhouse gas emissions (net avoided emissions of 14 million tons of carbon per year in 1996, or approximately 20 per cent of total emissions by the energy sector).[28]

4. Energy conservation programmes

84. There is a large potential to reduce electricity production by the adoption of more efficient end-use technologies in Latin America.[29] In Brazil, PROCEL – The Eletrobrás Programme of Electricity Conservation – has identified, and is currently implementing, a number of options for reducing waste and saving power through the introduction of more efficient technology, including: street lighting, public building lighting retrofits, high-efficiency motors with adjustable speed drives, popular housing, public schools, pumping needs of water and wastewater systems, efficient refrigerators and compact fluorescent lamps. The main reason for doing so is to reduce the capital needed for large new generating facilities.

85. In the case of electrical energy conservation in Brazil, barriers hampering the diffusion of efficient end-use technologies include: financial constraints, inadequate pricing policies, lack of institutional settings, absence of information, risk aversion, and insufficient managerial skills, among others.

86. In the near term, reductions of GHG emissions resulting from improved efficiency would not be very high since most electricity is supplied by hydro power plants (92 per cent).[30] However, current trends point to an acceleration in the building of new thermopower plants,

---

[28] Rosa and La Rovere, 1997.

[29] The economic and environmental long-term impact of adopting some electrical energy conservation measures were assessed in the prospective modelling exercise carried out by La Rovere et al, 1993. All the measures were able to penetrate at the maximum allowed level in the abatement scenarios; as the electricity savings were cost-effective, their incremental cost was lower than the long-term marginal cost of expanding power generation. As these options were not included in the reference scenario, which only assumed autonomous technical change, they were the so-called "no-regret" mitigation measures with negative abatement costs. There is a large controversy about "no-regret" options for mitigating climate change. Mainstream economics would find it difficult to accept the concept of negative abatement costs. Most "top-down" modelers would argue that the “hidden costs” (such as transaction costs) of these measures were not properly taken into account in the engineers’ type cost assessments. Hidden or not, the fact is that in the real world these costs arise due to a variety of market imperfections, which tend to be greater in developing countries.

[30] La Rovere and Americano, 1998.

mainly natural gas fired, under the adjustment policy for the power sector promoted by multilateral financial agencies.[31] In the Decennial Plan of Power Generation 1998-2007 recently issued by Eletrobrás, over 26,000 MW of new hydropower installed capacity is scheduled for starting operations in the next ten years and nearly 8,000 MW for fossil fuel (of which around 6,000 MW from natural gas) fired plants.[32] Therefore, electricity savings would avoid CO_2 emissions in the medium and long term by postponing the need for building new thermopower plants.

87. PROCEL has been able to make a significant contribution towards increased energy efficiency in Brazil. Electrical energy savings accumulated during the period 1990-1996 were about 9.2 billion kWh, and it was estimated that they would reach nearly 5.8 billion kWh in 1997 alone. The corresponding avoided emissions were about 8 per cent of annual CO_2 emissions from the power sector in Brazil. An important component of PROCEL's success was the continuous cooperation provided by the American Council for an Energy Efficient Economy[33] and the European Commission, which enabled the transfer of technology in the design and management of energy conservation measures.

Residential lighting programmes in Brazil[34]

88. Lighting accounts for 17 per cent of total electricity use in Brazil one third of which is residential consumption. As incandescent lamps account for about 95 per cent of electricity used in lighting, there is a great potential for improving the energy efficiency of lighting in the residential sector through the introduction of compact fluorescent lights (CFLs). However, the high up-front cost of these energy-efficient lights is a major barrier to their adoption by low-income households.

89. Seventy per cent of Brazilian households consume less than 150 kWh/month, a very low consumption level by international standards, due to low income levels. CFLs were introduced in Brazil in the early eighties, and about 3 million lamps of this kind were sold in 1996. The

---

31 La Rovere, 1996.

32 La Rovere and Americano, 1998.

33 Geller et al, 1997.

34 Jannuzzi, 1997.

expansion of the use of CFLs by PROCEL and utilities (state-owned until 1996) has resulted in only 10 per cent of the electricity savings in 1996.[35]

Table 5. Electricity savings due to efficient lighting technologies in Brazil, 1996

Type of efficient Lighting technology	Total savings in 1996 (GWh/yr)	Annual savings due to sales in 1996 (GWh/yr)	PROCEL / Utility share: Total savings[36] in 1996 (GWh/yr)	Savings from 1996 sales (GWh/yr)
a. High Pressure Sodium	1499	405	240	65
b. CFLs	810	338	81	34
c. Circular Fluorescent	71	36	4	2
d. Thin tube fluorescent	173	57	9	3
e. Electronic ballasts	171	101	9	5
f. Specular reflectors	83	48	4	2
TOTAL	2807	985	347	111

Source: Geller et al, 1996 in Jannuzzi, 1997

90. These data illustrate that a number of efficient lighting technologies have already been introduced into the Brazilian market, many of them without any programme or manufacturer's incentive. Small-scale pilot programmes have indicated that demonstration, rebate and promotion programmes could further extend the reach of efficient lighting technologies to low- income households.

91. In 1994, a utility in the state of São Paulo conducted a lamp rebate programme in three medium-sized cities (200,000 to 300,000 inhabitants). Different rebate levels were offered in the three cities: 30 per cent in Americana, 60 per cent in Marília and 70 per cent in Franca. Rebate levels of 60 per cent were sufficient to attract customers and were cost-effective for utilities and participating households. The sole exception was the group of low consumers (51 to 100 kWh/month) in the 30 per cent rebate programme. Programme participation rates were higher and greater wattage was saved among higher-income households. Households with consumption above 200 kWh/month, which represented 30 per cent of total households in these cities, acquired about 60 per cent of the CFLs sold.

---

35 Geller et al, 1996.

36 Savings were estimated by Geller et al, assuming that efficient lighting is substituted for the following technologies: a) mercury vapour and self-ballasted lamps; b) and c) incandescent lamps; d) conventional tubular fluorescent lamps; e) electromagnetic ballasts; f) regular lamp fixtures. The average power savings per unit replaced were: a) 150 W; b) 45 W; c) 60 W; d) 10 W; e) 28 W; f) 52 W.

92. This shows that in the absence of efforts to increase adoption by low-income households, market allocation will favour higher-income households. Low-income households are, however, a good target for utility-sponsored efficient lighting programmes because they have a high lamp usage rate (that is, they use their lamps intensively, although they have fewer lamps than wealthier households) and because they pay subsidized electricity tariffs.

Residential lighting programmes in Mexico[37]

93. The ILUMEX project will replace approximately 1.7 million incandescent bulbs with fluorescent light bulbs in the domestic sectors of the cities of Guadalajara and Monterey. These are Mexico's second and third largest cities, with approximately 550,000 residential consumers each. The federally-owned electric power utility, CFE (Comisión Federal de Electricidad) is responsible for the distribution of electricity in both cities and for running the ILUMEX project. As the bulk of power generation in Mexico comes from fossil fuels, the Global Environment Facility (GEF) will contribute to the project with a grant of US$10 million. CFE counterpart provides another US$10 million and Norway has offered a grant of US$3 million to support the project. The grant funds are used partly to finance the purchase of fluorescent lamps and subsequently are transferred to the participant consumers through a rebate of 60 per cent of the total cost of fluorescent lamps.

94. The project started in April 1995 and within two years a total of 1.6 million lamps had been purchased. Participants pay for the fluorescent lamps either in cash or under a deferred payment plan of 24 months (as part of their electricity bill), paying an interest rate equivalent to the prevailing rate for Government treasury bills. Technical standards and specifications have been developed to ensure that the fluorescent lamps will operate properly and last their projected lifetime. Acceptable performance guarantees for the fluorescent lamps are provided to both the customer and the CFE.

95. A very important aspect of the project implementation is the advantage offered by the system of implementing units financed through trust accounts. The system has been shown to be efficient and low cost, and has allowed CFE to retain control of the project and to introduce timely adjustments to ensure its success. It also guarantees that the funds, including those resulting from the credit sales to the participants, are kept separate from those that enter into the CFE's own treasury and that they are only used for the purposes of the project. CFE has proposed to restrict the project to the residential sector on grounds that other users, such as the industrial and commercial sectors, do not require special incentives to make the installation of fluorescent lamps attractive. In addition, CFE does not wish to be seen by commercial distributors of fluorescent lamps in Mexico as their competitor.

---

[37] Quintanilla, 1997.

96. ILUMEX will be able to postpone CFE investments for 100 MW power generation and save about 169 GWh (311,000 barrels of fuel oil and 34,000 tons of coal) annually. The global and national environmental benefits from this project can be measured in terms of the following emissions avoided annually: 118 ,000 tons of carbon dioxide; 250 tons of methane; 205 tons of nitrogen oxides; 3000 tons of sulphur dioxide; and 200 tons of particulates.

5. Renewable energy programmes

97. Latin American has a very large potential for renewable energy from solar, wind, biomass and small hydro power. In the seventies, the first large-scale projects to tap this potential were launched because of oil price increases in the international market. The previously-mentioned Brazilian Ethanol Programme remains to date the largest commercial application of renewables in the world. However, after oil prices sharply decreased in 1986 technological research and development in this field were discontinued owing to shrinking governmental budgets and attention to other priorities. Only in the mid-nineties did interest in renewables regain momentum at the level of research, development and demonstration.

98. During the period 1994-96, hundreds of representatives from government agencies, universities, non-governmental organizations (NGOs), research centers, equipment manufacturers and utilities involved with renewable energy development in Brazil met annually with experts from abroad. These annual meetings were promoted by the Permanent Forum of Renewable Energy – Solar, Wind and Biomass, constituted by both governmental and non-governmental organizations. Its main support and sponsorship comes from Brazilian Ministries (Mines and Energy, Science and Technology, Foreign Affairs), governmental bodies, utilities, industry (manufacturers of renewable energy equipment) and universities in Rio de Janeiro (COPPE/UFRJ) and São Paulo (USP, UNICAMP).

99. These meetings have resulted in a broad consensus on strategic actions needed for the development of renewables in Brazil. A methodology, including training, research, dissemination, funding, and standards was developed in order to elaborate the National Plan of Action for the Development of Renewable Energy. It was signed by 313 participants from over 100 institutions and includes 14 programmes to reach commonly agreed targets for development of renewables by the year 2005. Some of the programmes suggested are: a) Incentives to substitute renewables for fossil fuels in remote energy systems; b) Incentives for complementary power generation from solar, wind and biomass energy by independent producers and utilities; c) Use of solar energy in the residential sector; d) Temporary exemption of taxes for renewables (equipment and energy generated); e) Priority to the use of renewables in public works and buildings; and f) Education and training in renewables.

100. The most interesting outcome of the Plan is the successful implementation of the concept of Reference Centres for solar, wind, biomass and small hydro energy. These centres serve as clearing houses, disseminating information by various means, including a newsletter periodically

published both in printed and electronic formats. Besides performing technological research work in their specific fields of excellence, they play a key catalytic role in bringing together the different actors involved in this field: international agencies (such as the World Bank and GEF), governmental bodies, utilities, industry (both equipment manufacturers and users), other research centres and universities. They are contributing to the design and implementation of large demonstration projects, such as rural electrification projects based on photovoltaic cells: for instance, CEMIG, the utility in the state of Minas Gerais, plans to install 700 small systems (one or two panels) this year and to reach 4,000 installations in 1998. There is also a growing interest in wind energy, particularly in the northeastern region where there is a large potential for installing wind power generators. For example, COELCE, the utility in the state of Ceará, did a feasibility study and obtained international funding to install two 30 MW plants that are scheduled to start operating in 1999 and 2001.

101. The Reference Centres for renewables are considerably benefiting from international cooperation, and particularly from the transfer of technology and exchange of experiences with similar institutions abroad.[38]

C. South-East Asia

1. Introduction

102. Many economies in Asia, including the Republic of Korea, Indonesia, and Thailand, have experienced substantial growth rates over the past decades, one of the major factors influencing GHG emissions. Before the current financial crisis, many analysts suggested that these trends would continue. The most recent statistics seem to indicate that the trend will be reversed to a significant degree at least for the short term.

103. The Asian region accounted for nearly 17 per cent of the total world GDP in 1971 and approximately 25 per cent in 1994. During this period the region was industrializing more rapidly than any other region. At the same time, the Asian share of the total world population increased from 53.9 per cent in 1994 to 55 per cent in 1997. This rapid economic development and increased population resulted in a rapid growth in energy consumption. The region’s share in the world’s total primary energy consumption was about 24.8 per cent in 1994, compared with only 13.8 per cent in 1971.

104. GHG emissions in the energy sector grew by approximately 2.4 per cent per annum in the Republic of Korea during the period 1971-1994 while those for Indonesia and Thailand grew by

---

[38] Moszkowicz, 1997.

3.4 per cent and 3.6 per cent respectively. These rates were high relative to other developed countries.[39]

105. An analysis of GHG emissions by sector shows that the industrial and residential sectors contribute the major share of GHG emissions in the Republic of Korea while in both Indonesia and Thailand it is the transport and power generation sectors that contribute the major share of such emissions. These sectors seem to have relatively larger potential for technology transfer than other sectors. The electricity generation sector appears to be important for all three countries since electricity consumption has grown and will probably continue to grow as incomes rise, since electricity is easy to use and of high quality.

106. Fossil fuels are likely to remain a major source of energy in these countries, even in the long run, and some strategies, such as adoption of clean fuel technology and conversion efficiency improvements, will be essential. Examples of such technologies include clean coal technologies (CCT) and integrated gasification combined cycles (IGCC).

107. As all three countries are now experiencing major economic problems, it is not certain how and when they will be able to resume economic progress. The current financial crisis will, therefore, be a major barrier to the transfer of ESTs for some time, especially owing to their lack of foreign exchange for the purchase of ESTs from abroad.

2. Examples of government enabling activities

108. Asian governments have played a very active role in all aspects of social and economic life. One of their most important enabling activities was to incorporate technology transfer and development as a key element in their national development plans at an early stage. In Korea, the first "Five Year Economic Development Plan" was initiated in 1963 while the first "Five Year Development Plan" (Replita) in Indonesia and the "National Economic and Social Development Plan in Thailand” (NESDP) were introduced in 1969 and 1961 respectively. These plans provided adequate government budget allocations for institutional development needed for the transfer of technology.

109. All these countries undertook policy reforms to change institutions and legal frameworks in order to facilitate the transfer of technology. In Thailand and the Republic of Korea, environmental and energy conservation laws and regulations have been established and periodically revised to reflect the environmental needs of each country. An example is the Thai National Environment Protection Law of 1995 that stipulates energy conservation measures. There are also a number of laws and regulations facilitating transfer of technology in

---

[39] ESCAP/UNDP, 1995.

Thailand including the Alien Business Law (for foreign investment) and the Investment Promotion Act (providing investment incentives).

110. The Indonesian Government also issued the Environmental Law in 1992 making environment impact assessments (EIA) mandatory for all projects prior to their approval or implementation. Under the law measures for environmental protection have been undertaken including the transfer of ESTs.[40]

111. In order to encourage the private sector to develop indigenous technologies and to participate in technology transfer, the Korean Government established and strengthened in 1990 a number of separate laws and regulations for the protection of intellectual property rights (IPRs) including patents, trademarks, industrial designs, trade secrets, copy rights, and computer programmes.[41] For the same reason, the Thai Government also established an Intellectual Property Court for protecting IPRs.[42]

112. Concerning intellectual property rights and patent laws, the Indonesian Government issued Act 6 in 1982 to replace an existing patent law dating back to its colonial era. However, it has been suggested that more work needs to be done to make it operational.[43]

113. In the case of the Republic of Korea the Government provides tax exemptions for advanced technologies, which are regarded essential for the national economy but are too advanced to be developed domestically. Also the licensing fees received by the technology licensor are exempted (100 per cent) from income and corporation tax for five years. In the future, the Korean Government has plans to set up a technology promotion fund to help develop some core technologies as well as to expand the Korea Technology Financial Corporation. Also, tax deductions for private investments in R & D will be increased and an 80 per cent tariff reduction is planned for the import of equipment and material for R & D.[44]

114. Thailand also provides financial incentives for technology transfer, such as import duty exemptions and tax incentives. The former have been reduced on all proven energy conservation machinery and equipment from about 40 per cent to 10 per cent and the latter have promoted energy conservation projects through energy conservation funds in accordance with the Energy

---

[40] Sasmojo, Soejachmoen, and Siagian, 1994

[41] Lee and Kim, 1994.

[42] Thebtaranonth, 1997.

[43] Sasmojo, Soejachmoen, and Siagian, 1994.

[44] Lee and Kim, 1994.

Conservation Act of 1992. In addition, the government-owned Industrial Financial Corporation of Thailand provides capital financing to eligible projects.[45] Also, the Energy Conservation Promotion Fund make subsidies available to projects which yield a rate of return below 9 per cent.[46]

115. Technology research and development plays a key role in all phases of technology transfer from acquisition to indigenization. The establishment of an R & D infrastructure can benefit the transfer of technology in various ways. It can increase efficiency and promote assimilation and adaptation of transferred technologies. It can also contribute information that could be helpful for the selection of technologies prior to technology transfer, and can enable countries to negotiate better technology transfer contracts. Even after transfer of technology, it remains a useful source of learning.[47]

116. The most important factor affecting R & D in the Republic of Korea was the phased establishment of R & D institutions and implementation of government policies with clear objectives. In the early stage of industrialization in the 1960s, the Ministry of Science and Technology and the Korea Institute of Science and Technology (KIST) were established in accordance with the Science and Technology Promotion Law of the 1960s. Throughout the 1980s and in the early 1990s, Korean firms began to enhance their own R & D capacity as the protective government regulations favouring domestic industries were gradually lifted. The government's science and technology policy during this period was directed towards localization of key core technologies, and the promotion of private sector R & D capabilities.[48]

117. The Indonesian Government is considering incentive measures, such as output price incentives, and input price incentives,[49] to accelerate the adoption of new technology. Most R & D initiatives are undertaken by the university system and comparable R& D activities by government research organizations such as the Indonesian Institute of Sciences, BATAN, and the National Aeronautic and Space Agency.

118. In Thailand, universities, along with R & D units of large industries, are the main organizations conducting R & D. It is also notable that R & D for technology transfer has been

---

[45] Boonyubol and Chamchoy, 1994.

[46] Geronne, 1997.

[47] Bad, 1997.

[48] Hong, 1994.

[49] CES/IPB, 1998.

carried out at the university level. For example, the Department of Energy Development and Promotion has sponsored an electronic ballast development project at Chularlongkorn University.

119. All these countries have had institutions for R & D in place for a number of years, but their scope and performance varies with government support and other factors. One way to enhance R & D capacity is through partnerships between public- and private-sector institutions based on a long-term development perspective.

120. These countries also have formal education and informal education and training institutions. For example in the Republic of Korea, a number of universities are producing qualified engineers for technology development, such as Pohang Institute of Technology. Also a number of vocational schools were established in the 1980s, and large corporations have in-house training centres. The industries' internal training programmes are supported by the Government.

3. Barriers related to the transfer of environmentally sound technologies

121. Although the Republic of Korea has a number of successful cases of technology transfer, it still faces barriers in some areas. Since technology transfer is an ongoing process in all countries in the world, regardless of their level of industrialization, new barriers constantly emerge even as old barriers are overcome.

122. Until recently, the transfer of ESTs through FDI was limited resulting in lost opportunities for the transfer of ESTs. The role of FDI has been negligible in the Republic of Korea due to the strong orientation of the Government and private entrepreneurs towards independent business operations.[50]

123. The Korean economy depends heavily on energy-intensive heavy industries, such as steel and cement. Efforts by the private sector to improve energy efficiency have been largely neglected due mainly to the low share of energy costs in total production costs. Government policy has aimed to keep energy prices down to support industries. In manufacturing industries, for example, the share of energy costs is so low (on average 4 to 5 per cent) that entrepreneurs do not bother to adopt energy efficient technologies as savings from the adoption of such technologies are negligible.[51]

---

[50] Hong, 1994.

[51] Jung, 1996.

124. In the Republic of Korea, despite the presence of a number of information centres for new and efficient technologies, small and medium enterprises(SMEs) still have difficulty accessing technology information because[52] database systems are inadequate and there are inefficiencies in transferring information. As a result, some SMEs often cannot find optimal ESTs to meet their needs.

125. Improper planning can also be a factor affecting the performance of technology once it is imported. For example, the Korean Government initiated a wind power development project in the 1990s, acquired technology from abroad and further developed it domestically. However, there was insufficient wind to make the project economically viable. A wind survey should have been conducted prior to the transfer of the technology.

Table 6. Examples of barriers per technology in the Republic of Korea

Technology	**Barriers and Constraints**
Efficient lighting	High price, unreliable product quality
Condensing gas boiler in building	Domestic technology is not yet developed; high price
CNG vehicle	Lack of infrastructure; high price
Electric vehicle	Lack of technology, lack of infrastructure, high price.
Efficient motor	Lack of technology development; unreliable product quality.
LNG combined cycle power plant	High fuel cost; lack of infrastructure

Source: ALGAS final report of Republic of Korea

126. Examples of barriers to the transfer of technology in Indonesia are listed below:

(a) Cultural: business practices in Indonesia differ greatly from those in other countries. Business contracts may not be drafted in a legally enforceable manner, and often rely on relationships and bonds of trust between stakeholders;[53]

(b) Legal system: some of the Indonesia's commercial codes are old and complicated, which creates problems in business investment;[54]

---

[52] To access the passive database one needs a certain level of expertise which is often difficult to come by.

[53] Sasmojo Soejachmoen, Siagan, 1994.

[54] Sasmojo Soejachmoen, Siagan, 1994.

(c) Subsidies: prices of energy are currently set by the Government and subsidized. As energy prices do not reflect the full cost of energy supply, end users have little incentive to invest in energy efficient technologies,[55]

(d) Lack of information: domestic investors and consumers tend to have insufficient information regarding efficient technologies, which entails increasing transactions costs associated with identification of options;

(e) Low world energy prices in the late 1980s and 1990s: Indonesia relies heavily on revenues from the sale of oil and gas. The currently low world prices for oil and gas reduces earnings on these exports and therefore the ability to pay for technology transfer. These investments are therefore less attractive as the rates of return drop.[56]

127. In Thailand, barriers to the transfer of technology can be summarized as follows:

(a) Low energy costs: since energy prices are regulated and kept low the benefits from the adoption of energy efficient technology are negligible;

(b) Lack of funding: the economic crisis in Thailand has resulted in a scarcity of financial resources for funding the transfer of ESTs. Also the recent fall in the country's credit rating will raise the financial cost of projects involving the transfer of ESTs. Lack of financial resources inhibits large-scale deployment of ESTs;

(c) Lack of awareness:[57] owing to a lack of environmental awareness the prices of products often do not reflect the environmental benefits from ESTs, so there is no compelling reason for the transfer to be viewed attractive; and

(d) Lack of human capital: there is an insufficient supply of trained manpower for the assimilation and adoption of technologies.[58]

---

55 ESCAP/UNDP, 1995.

56 Sasmojo Soejachmoen, Siagan, 1994.

57 ESCAP/UNDP, 1995.

58 Boonyubul and Chamchoy, 1994.

4. Cogeneration programmes

128. Cogeneration is one of the most attractive modes of electricity generation because it is 70 per cent efficient compared with conventional thermal power plants that are 40 per cent efficient. It is also appealing because of its high energy efficiency, low capital investment requirements and relatively short construction periods, due to modular unit construction.

The Republic of Korea[59]

129. The Ildo combined cycle cogeneration project was built in 1992 to provide both electricity and heat to the Ildo area. A private company, Korea Heavy Industry Corporation, and General Electric of the U.S. were the contractors. The total cost for two units of 940 MW cogeneration was 1.1 billion US dollars. Korea Electricity Power Company (KEPCO), the government monopoly company in the electricity generation industry, made an attempt to indigenize the cogeneration technology by identifying three different areas of activity: management techniques, technician training, and design techniques for boilers. As a result the level of indigenization reached 60 per cent, but the core technology came predominantly from foreign sources.

130. The following enabling activities were developed for the implementation of this project:

(a) Many of the participants in the project benefited from government R & D initiatives during the 1970s and 1980s. This helped to build the necessary human capacity for the project;

(b) Reinforcing environmental regulation: the Government restricts the use of coal or oil in large cities so that many commercial and residential building have no option but to use the small-scale gas engine cogeneration system developed from this project. The Government helped diffuse the technology which was indigenized from this project; and

(c) Facilitating financial support and legal reforms: the Government provided financial support as well as legal reforms to facilitate the utilization of the cogeneration power plants in the industrial sector.

131. The barriers identified in this project are:

(a) Relatively high input fuel cost: many cogeneration systems use natural gas, usually more expensive than coal or oil. Also, these systems are often used for peak loads.

---

[59] Ildo Combined Cycle Cogeneration Project, Lee and Kim, 1994.

Therefore, their utilization rates are relatively low and the potential benefits are not fully realized;

(b) Slow indigenization of core technologies: when transferred, the desired level of efficiency of the system was so high that imported support was the only available option. There was little indigenization at the outset of the project and afterwards the indigenization process became too slow; and

(c) Monopolistic environment: as KEPCO, is a government company, and a monopoly, commercialization of gas engine cogeneration technology was not been promoted aggressively.

Indonesia[60]

132. An Indonesian plywood manufacturing company, PT Siak Raya Timber located in Pekanbaru, Sumatra, produces a yearly average of 160,000 m^3 of plywood and secondary plywood products. In addition, an affiliated woodworking factory produces about 50, 000 m^3 per annum of downstream products. The raw materials used for these products comes mainly from company-owned forests in central Sumatra. In the process, a lot of residues are produced. So far, the company generates electricity using diesel gensets, but it has decided to install an energy plant, using its own wood residue as fuel, to meet its heat and power requirements.

133. The project will reduce costs and environmental impacts by replacing the existing diesel engines with a new energy plant fueled by wood residues generating 5.55 MW of electricity for captive use. In this way, expenditures on fossil fuels are also avoided. Contracts have been signed with European equipment suppliers. This is slightly more expensive than locally-manufactured equipment, but it is anticipated that reliability and efficiency will be higher, thus reducing the operating and maintenance costs.

134. For this project, the EC-ASEAN COGEN programme has carried out a pre-investment study. Operating staff are to receive special training and the plant will be monitored following implementation.

135. The total investment cost for the equipment on a turnkey basis is US$5.6 million. Based on the present diesel consumption and price, the annual savings in diesel purchase will be more than US$1.7 million. The expected pay-back period is around three years.

---

[60] A woodwaste power plant in Pekanbaru, Sumatra. Pennington, Lacrosse, and Gonzales, 1997.

136. Environmental benefits will also occur as residues from plywood manufacturing are recycled and emissions of carbon monoxide, poly cycle-aromatic-hydrocarbons (PACs), nitrous oxides (NOx) and particulates are reduced. The use of wood fuel, including the residue, is beneficial to global climate since it is carbon-neutral.

Thailand[61]

137. In October 1992, Nordic Power Invest AB (NPI),[62] and BANPU,[63] a local coal company formed a joint venture called Cogeneration Co. Ltd. (Coco). The joint venture initiated a contract with Marubeni Corp. (Japan) and Balck & Veatch (U.S.A.) to supply and install a power plant in the MapTa Phut Industrial Estate in Rayoung Province, Thailand. This plant has an electricity generating capacity of 400 MW and 350 tons of steam per hour. The plant consumes 800,000 tons of bituminous coal per day and 50-60 million cubic feet of natural gas per day. Contracts for the supply and installation of power transmission lines and cable and distribution systems were awarded to Thai Electric Development Associated and Sino Thai Engineering & Construction Plc.

138. The enabling activities of the Thai Board of Investment (BOI) that led to the implementation of this projects included: a) exemption or reduction of import duties on machinery; b) exemption from corporate income tax for 8 years, and further reductions of 50 per cent for additional years; c) income tax deduction for water, electricity and transport costs for 10 years from the date of first sales; d) deduction of the costs of installation or construction of the project's infrastructure facilities from net profits; and e) exemption of dividends to shareholders from personal income tax.

139. The joint venture also sought to attract financing for the project by demonstrating the strong commitment of the project sponsors and securing long-term electricity contracts from metal processing industries situated in the industrial estate. The Electricity Generating Authority of Thailand (EGAT) played an important role by not only purchasing surplus electricity from the project, but also providing backup electricity. In this way EGAT enhanced the reliability of the project.

140. In addition to these enabling activities on the recipient side, GEC ALSTHOM, the technology supplier, provided assistance to the developers including: a) proposing viable technological options; b) advising on fuel choice and supply, taking into account environmental

---

[61] Map Ta Phut Cogeneration Project, Geronne 1997.

[62] NPI was established by four major utilities from Sweden, Denmark, and Finland.

[63] The leading coal company in Thailand.

aspects; c) tailoring the design of the power plant to meet the developer's need and specification; d) making a firm commitment on the specified project milestone; e) providing subsidized buyer credits to help ease the financial burden; f) entering into an operation support and maintenance contact; and g) becoming a partner in the ownership.

141. The barriers this project had to overcome include:

(a) Technical and financial constraints and poor institutional frameworks;

(b) Limited human technical capacity in the design, construction, and operation of the cogeneration power plant;

(c) Scarcity of capital: in an effort to reduce the burden on developers the Government is promoting financial incentives such as subsidies and tax relief; and

(d) Lack of public awareness and concern for environmental protection. As cogeneration is a relatively new concept the benefits are still not widely known.[64] In order to cope with the lack of public awareness, the Royal Thai Government established the Energy

Conservation Act to show its strong commitment to energy conservation and environmental protection.

142. Other barriers include: a) scarcity of experienced power engineers; b) uncertainties associated with the sale of excess electricity to the utilities and direct to associated customers, which will lower the expected rate of return from the technology transfer; and c) the low share of energy cost in the total production cost. In some industries where the energy cost is only a small fraction of the total production cost, the energy efficiency (saving) does not get high priority in the capital investment programme.

- - - - -

[64] Chullabodhi and Tia, 1993.