Economics of Renewable Energy Technologies in Sub-Saharan African Countries

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List of Abbreviations

ADB	African Development Bank
ADF	African Development Fund
AEP	African Energy Programme
AF	adjustment financing
BMZ	Bundesministerium für wirtschaftliche Zusammenarbeit
D	diesel
DC	development cooperation
E	economic analysis
ECA	Economic Commission for Africa
ECBA	economic cost-benefit analysis
ESAP	energy sector adjustment programme
ESMAP	Energy Sector Management Assistance Programme
F	financial analysis
F/ECBA	Financial Economic Cost-Benefit analysis
F/ECEA	Financial Economic Cost-Effectiveness Analysis
GTZ	Gesellschaft für Technische Zusammenarbeit
IBRD	International Bank for Reconstruction and Development
KENGO	Kenya Energy and Environmental Organization
MCA	Multicriteria Analysis
OIC	oil-importing countries
PIP	public investment programme
PVB	present value of benefits
PVC	present value of costs
R&D	Research & Development
RE	renewable energy
RET	Renewable Energy Technologies
S	solar
SAP	structural adjustment policy
SCBA	Social Cost-Benefit analysis
SSA	Sub-Saharan Africa
UNDP	United Nations Development Programme

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1 Introductory Remarks

It is a great honour to participate at this important seminar on 'Recent Experiences in Research, Development And Dissemination of Renewable Energy Technologies', hosted by KENGO and organized effectively by Mister M.J. Kimani from the International Outreach Department of KENGO. Such a Follow Up Seminar is a good opportunity to learn a lot from the current field of experience of former scholar at the Renewable Energy Courses at Oldenburg University, but is also a chance to transfer some research results and experiences gained in our German universities (Bremen and Oldenburg).

During the recent two years we have worked at the University of Bremen, in the Department of Economics, on issues most relevant for the dissemination of renewable energy technologies (RET) in Sub Saharan African (SSA) countries. In a research project headed by myself we have, firstly, identified relevant factors with regard to market prospects and dissemination chances of RETs, by focussing on the development of costs (investment and recurrent costs) and the market potential of various technologies and by highlighting the relevance of projections for assessing the future prospects of RETs, especially in SSA. Secondly, we have analysed the political economy of renewable energy promotion in SSA so as to assess the institutional and political aspects of implementing small and decentralized renewable energy projects. Thirdly, we have worked on new methods to identify, plan and evaluate RETs in their respective environment. In this context we have examined concepts and issues of new planning and evaluation tools (Multicriteria Analysis-MCA) and we have also discussed issues of economic policy adaptation so as to allow for a successful dissemination of RETs. We discussed how to adjust the economic policy framework so as to bridge the gaps between financial and economic analysis of RET projects, by making financial decisions consistent with economic evaluation results.

In this lecture I would like to report on some of the results of our research work in Bremen. The main research results can be found in various publications (Wohlmuth/Oesterdiekhoff 1993; Wohlmuth/Köllmann/Oesterdiekhoff 1993; Wohlmuth et al 1993). These reports - partly in English Language - give a detailed account of prospects and possibilities of RETs in Sub Saharan African countries, by considering not only the technologies and economic choices but also the institutional environment and the consistency of economic and financial asessments of RETs.

2. Economic Issues of Renewable Energy Technologies in African Countries

On the whole, we know that SSA has an increasing demand for initiatives to disseminate RETs. This is the more important since the 1970s as the sharp oil price increases in 1973 and 1979 led to a situation where energy was demanding a high share of the import bill of non-oil developing countries. But not only commercial energy imports caused balance of payments problems; also increasing food imports have to be mentioned in this context as they were related to some extent to resources degradation in the context of increasing reliance on fuelwood. The 'energy transition' from fuelwood and other biomass sources to commercial fuels like coal and gas proves to be extremely difficult in the SSA context. Many efficiency-related factors impede the effective use of modern als well as of traditonal energy in SSA. RETs therefore have become more and more an important option to supply rural and urban areas in African countries with alternative energy on a continual basis.

The problem for Africa is however that a two-step energy transition process has to be followed. African countries have to replace oil in the modern sector since oil is expensive and is a depletable resource, and in rural and urban areas they have to move away from traditional fuels so as to reduce pressures on the environment and to improve health conditions (see ADF 1991, p. 6). Up to now progress is very limited.

The one-step energy transition in industrialized countries from oil (and nuclear energy?) to new and renewable sources of energy is as well a very complex task but seems to be in good progress when we look at the potentials of various RETs (see Tables 1-4). Many RETs are already developed, often they are already economic and some are widely deployed. But we also recognize that there are considerable differences with regard to 'technology development', 'economic viability' and 'intensity of deployment'. With regard to some RE technologies we know that only components are developed as yet, not whole systems, that economics is variable, that deployment results are mixed, that some technologies are unproven but promising, that projections may differ considerable by source, and that economics may depend on financing and other crucial assumptions.

More recent analysis by the World Bank argues however that solar energy systems - solar-thermal and photovoltaic system - are not only less land-intensive than often assumed but that costs are declining very fast so that the two most relevant commercial drawbacks (costs and use of land for solar insolation) are of declining importance (see World Bank, 1992, pp. 122-123). Land intensities of solar schemes average only one-twentieth of hydroelectrical schemes or even less. Besides of this advantage, negative external effects are often relevant for hydroelectric projects but do not matter in the case of solar systems no comparable problems as inundation of arable land, displacement of people and serious ecological side effects occur. The decline of costs is remarkable (see Table 1). According to the World Bank data the costs of electric power from solar energy in high-solar insolation areas may become competitive with those of nuclear energy within the next ten years and over the long term also with fossil fuels (World Bank, 1992, p. 123).

Financial incentives and environmental taxes can support an even quicker deployment and market development. A joint strategy of developed and developing countries of spending more than 6 per cent of energy R&D budgets in developed countries on RETs and of focussing on more international cooperation and technology transfers in RETs towards developing countries could do a lot in promoting deployment and market development. International and national R&D programmes and development aid programmes could be refocussed towards RETs (see World Bank 1992, p. 124, on this important agenda).

We see that the prospects for RETs are favourable and that even under SSA conditions the advantages of supporting RETs are obvious. With regard to Africa the problem is however to provide for reliable information on renewable energy potentials (such informations being largely non-existent with the exception of hydro-power). Energy policies in Africa have focussed on fossil fuels and (to a minor extent) on fuelwood but have missed to indentify renewable energy potentials (see ABD/IBRD/UNDP/ECA 1990). Specific country data are either not available or they are difficult to reach by potential investors (ABD/IBRD/UNDP/ECA 1990, p. 4). Lack of comprehensive reviews of potentials, information dissemination and communication problems are crucial bottlenecks. Another problem in Africa is the uneven distribution of renewable energy sources;

this is not only the case with hydropower, but also with solar and wind energy. However, politics and policies are the most obvious constraints. This is the case with hydroelectricity projects but as well refers to solar and wind energy projects. Although micro-power stations and micro-dams have an important complementary and potential role in SSA, the prestigious marco-installations have overshadowed the whole picture in Africa. Also in the case of solar and wind energy the political factors are a hindrance to dissemination (see below, Part 4).

A most serious problem is R&D in the case of RETs in Africa. With regard to solar energy, many African countries have developed some R&D competence, but a coordination with the production of components and systems and with marketing and servicing does not take place. State supported R&D was not or too late synchronized with private business interest in dissemination of solar energy technologies. Institutional and policy issues in Egypt, Kenya and other African countries seem to retard the dissemination of solar energy by private business. Evidence on Mali, Niger, Egypt and Algeria reveals that policy failures, specific characteristics of development aid, lack of privatization (of the production of components) and lack of coordination (between state institutions and private businesses) matter more than the lack of knowhow with regard to RETs (see ABD/IBRD/UNDP/ECA 1990, pp. 18-20).

Some wind energy development is going on in countries as Cape Verde, Tanzania, Egypt and Algeria. Main issues seem to be - besides of the problems mentioned above - the inadequate transfer of production technologies (being mainly on a turnkey basis) and inappropriate localization (assimilation and adaptation) of RETs.

Most important besides strengthening the systems of resource identification seems to be the design of a R&D-based strategy for development of RETs in SSA. Various issues matter in this context: Presently R&D is characterized by a dispersal of effort, by wastage of human and material resources and by policies of false prestige. Supported are efforts to adapt imported equipment for RETs rather than making use of local R&D efforts for localized production. Lack of specialization and coordination in R&D is another important aspect. This lack of coordination in R&D refers to national and regional capacities and to basic and applied R&D institutions. The lack of cooperation with private businesses in R&D is also a weakness to be overcome. Suitable instruments, as research and development contracts between state agencies and private companies/individuals, are not widely used.

A coordination effort with regard to national, sub-regional and regional R&D centres may be helpful (see ABD/IBRD/UNDP/ECA 1990, p. 24). At all these levels private sector institutions have to be involved. As the relation with manufacturers in the private sector is generally weak, a new approach requires that engineering studies, market surveys, new systems of investment promotion, evaluations of investments, and analyses of impacts of RETs on economic, social and cultural development are promoted on a joint basis. It seems obvious that some progress in regional R&D cooperation and in the region-wide production of components and systems can be supported by fiscal incentives and other policy measures.

The failures in subregional and regional integration in Africa (despite of a great number of integration attempts since the 1960s) are of extreme consequences for sectors as energy and environmental protection. Neither regional R&D nor regional production specialization and regional environmental protectors can develop in such an environment. The African Energy Programme (see ADF 1991) may be an opportunity to launch a new initiative. However, there seems to be a bias in the programme towards development of fossil fuels and large-scale hydropower projects. Nonetheless it is expected that surpluses/deficits of energy can be exchanged between countries so that waste in production, transmission and distribution can hopefully be reduced.

Another aspect of regional cooperation/integration refers to afforestation/forest protection initiatives so as to protect the long-term climatic conditions and the fuelwood supply. There are, however some initiatives to coordinate programmes at the sub-regional level.

A further issue refers to energy saving as we know that the best chances for dissemination of RETs are in a context of efforts to save energy in industry, agriculture, transport and in households because in cases of effective demand reduction alternative energy supplies can make a bigger addition to overall energy supplies. However, not all over Africa we find Energy Conservation Programmes side by side with Energy Supply Management Programmes and Programmes of promotion of RETs. Because of the rather low costs of energy saving programmes in industry agriculture and transport, an initiative at regional and subregional African level is imperative in order to exploit some of these advantages by using the scientific & technological base and the pool of experiences already developed. Especially the African Regional Technology Centers/Academies and African Universities can be of use for such huge tasks. A training and research cooperation programme on these lines can supplement national and regional R&D and production initiatives related to energy. To move away from the 'consumption of imported technology' seems to be a first priority for policymakers in the African countries (ABD/IBRD/UNDP/ECA 1990, p. 37).

3. Economics of Renewable Energy Technologies: Core Issues and Implications for Africa.

Ten core issues have to be identified in the economics of renewable energy technologies and then related to Africa:

1. Inconsistent Projections: Most of the projection on costs and market prospects are inconsistent and/or contradictory. We recognize varied statements on how developed or how proven RE technologies are; we also recognize that some technologies are

considered as often or usually economic, that others show variable economics or that they are not economic at present; some RETs are considered as widely deployed, others are considered as of mixed deployment or in an early deployment stage. Vagueassess ments and wording is prevailing. We have so different sources of projections to consider and we observe that the financing, environmental or technical assumptions behind the projections are often heroic. Obviously varios actors contribute to conflicting projections and results, thereby affecting real choices and investment behaviour. The costs of information in the RE market are high.

2. Inappropriate Localization: There are mixed results with regard to the transfer of renewable energy techonologies by trade and by development cooperation; we observe a lack of assimilation and adaptation of these technologies and a lack of follow-up and assessment of technology failures. All this leads to severe localization problems; underinvestment in indigenous R&D and in local manufacturing and marketing of RETs is the result. We also observe a lack of exploitation of local traditional production experiences, especially with regard to traditional RETs like mini hydropower, wind energy and fuelwood conservation programmes.

3. Ignoring Substitution: There is a threefold substitution relation as RETs compete with modern commercial fuel, with traditional fuelwood energy and among each other. As both substitutes to RETs are largely underpriced especially in African countries, an inherent bias against RETs exists. All RETs are competing in their respective uses against modern and/or traditional substitutes. Substituion is also prevailing among RETs itself. In the case of photovoltaics village stations for electricity supply have to compete with diesel generators; solar home systems have to compete with kerosine and with mini wind generators; photovoltaics-based pumps have to compete for irrigation purposes with handpower, wind power and diesel; photovoltaics for drinking water pumping has to compete with handpower, wind power and diesel.

Such substitution relations exist for all RETs and for all relevant uses. Up to now these generalized substitution relations have neither been identified nor considered as relevant by policymakers in the energy field. However, important substitution relations exist also between RETs (as an example photovoltaic or windpower pumping). Substitution realtions of a more general nature are important at the level of household and company users as various alternatives to the use of RETs exist (for example: changing consumption attitudes, production technologies, inputs, time of energy use and changing the quality of outputs). It is important to understand the relevance of this generalized substitution calculas.

4. Payback Gap: The high investment costs relative to rather low fuel maintenance costs of RETs creates the additional problem of how to bridge the rather long payback period relative to conventional energy projects from the side of the investor. This requires that new financing modalities are designed and that neither the promotion of local supplies nor the provision of imports causes further increases of the already high investment costs per KWh. Local savings associations, sectoral credit indistutions, revolving funds, national taxes on fossil fuels (like in Ghana) and other domestic and international financing mechanisms can help to bridge the payback gap.

5. Market Imperfections: Lack of market information, inappropriate market structures and nontransparent market behaviour (especially by public utilities) create additional problems. The assessment of external effects of conventional and RETs is another major market imperfection problem as RETs look much more favourable if external effects are considered and priced (internalized). Subsidies and other government policies affect negatively the relative price of energy services supplied from RETs; these affects are too often not made transparent and thereby the dissemination of RETs is retarded. The lack of market power and of lobbying potential of users and producers of RETs in developing countries is another serious constraint. The dependence of SSA on foreign R&D sources and

biases/weaknesses in all types of Science & Technology cooperation affect a quicker dissemination of RETs. Market imperfections of all these types are therefore an extremely important issue for policymakers in the energy field.

6. Submission to Regional Planning: It is obvious from so many country experiences that RETs depend on long-term regional and sub-regional perspectives of economic and social development. If the mix of energy supplies for a whole province or region is considered (say the Gezira province with irrigated cotton production in Sudan or a coastal region in Ghana), we see that development programmes for industry, agriculture and transport can be used to implement on a long-term basis an appropriate energy policy, integrating conventional and renewable energy sources and considering growth prospects, demand changes and changes in sectoral and in employment structures. RETs are highly sensitive to this type of regional planning exercise because the relative contribution of RETs and other enerty sources to various objectives of policy can be maximized in such an environment. A main reason is that the techno-economic flexibility (regarding long-term marginal costs) of RETs can be enhanced by such planning..

7. Programme Sensitiveness: It is obvious that isolated projects for dissemination of RETs will have a limited effect relative to programmes of dissemination of RETs. This advantage of programmes and packages is obvious with regard to afforestation programmes, integrated drinking water pumping projects based on photovoltaics (for example the German BMZ/GTZ programme), small industry energy saving programmes and integrated rural household energy programmes. Programmes of this type are more cost-effective, can be brought more easily into context with national planning and policy, can have synegatic effects by supporting simultaneously various objectives, and can more easily lead to follow-up/evaluation efforts. Technoeconomic flexibility of RETs is increased in programmes when considering the long term marginal costs of conven-

tional and alternative energy supplies and when assessing the maintenance and services infrastructure.

8. Economic Policy Sensitiveness: Extremely important is the fact that the dissemination of RETs is highly sensitive to an appropriate economic policy framework. Neutral incentives and other relevant economic conditions for application of conventional and renewable energy technologies in all relevant uses have to be created by economic policy makers. However in most developing countries the economic policies favour conventional rather than renewable energy technologies by granting subsidies and by maintaining distorted price systems, structures of taxes, duties, tariffs and other biased incentive measures. Therefore, corrections of all relevant price systems, trade regimes, tax systems, but also of institutions and decisionmaking processes, matter.

9. Unrealistic Renewable Energy Promotion Programmes: In the context of efforts to promote renewable energy technologies various unrealistic assumptions and myths inhibit the design of promotion programmes. There are unrealistic assumptions with regard to the degree of complexity of RETs, the acceptance pre conditions, the technology transfer problems, the need for integration of projects and programmes into national planning and policies, the transparency of the energy market, especially the market for RETs, and also with regard to the institutional and political back-up of RETs.

All these myths and assumptions matter. In this context it is necessary to redesign on a realistic basis the investment incentives, the trade and finance arrangements, the industrial and technology policies, and all other policy areas of relevance for the dissemination of RETs.

10. Inappropriate Planning, Monitoring and Evaluation: In order to promote decentralized and small energy projects in rural (and also suburban) areas in developing countries, a new approach for plan-

ning, evaluating and monitoring of such projects is required. More participatory approaches are needed based on a multiplicity of criteria and reflecting more properly the socioeconomic conditions of the region. A complementarity of (traditional) cost-benefit analysis and (alternative) multicriteria analysis emerges as an outcome of discussions about appropriate planning and evaluation approaches. Most important however is the intensive use of (conventional as well as of alternative) methods of project evaluation for providing information to policymakers so as to change the economic policy environment in such a way that a viable project (on the basis of an economic calculation) is also chosen preferred by the private investor (on the basis of his financial analysis). Inappropriate incentive systems (in cases of otherwise economically viable RETs) can lead to a rejection of these new technologies.

Use of evaluation methods for screening/reforming the economic policy environment and using new and more participatory planning tools on the basis of multicriteria analyses are important new developments of relevance for the dissemination of RETs.

What follows from these 10 core issues for policy formation in SSA? 10 core policy conclusions emerge: It is necessary

1 - to consolidate the varied projections on RETs for use in SSA, by discussing the regional and sub-regional implications;

2 - to localize RETs in SSA by focussing on all areas and levels of technology transfer, as assimilation, adaptation, local R&D and local manufacturing of RETs;

3 - to consider the manifold economic substitution relations existing between various modern/traditional/renewable energy sources, by referring to the substitution elasticities (price and nonprice sensitiveness of dissemination of RETs) and the behavioural determinants of energy choices in SSA;

4 - to promote innovative financing modalities to bridge the payback gap by involving all relevant financial intermediaries and international agencies, and by relating finance to a whole package of services for users and producers of RETs;

5 - to correct for market imperfections by a compact information, awareness and dissemination strategy, by correcting market structures in the context of privatizing and reregulating public utilities, and by supporting lobbying efforts for RETs;

6 - to underline the importance of streamlined national and regional planning for dissemination of RETs, by coordinating regional and provincial socioeconomic planning with the dissemination of RETs, a more rational use of fossil fuels and energy saving in all sectors;

7 - to consider the importance of programme sensitiveness of most RETs by incorporating the introduction of RETs into basic needs - oriented programmes, small industries energy saving programmes and integrated household energy programmes;

8 - to understand the high degree of economic policy sensitiveness of RETs, by rearranging the systems for formation of prices, taxes, duties, and by redesigning the trade, investment and technology acquisition regimes;

9 - to design more realistic promotional programmes for RETs by avoiding that myths on RETs (e.g., simplicity, easy implementation and application; high degree of policy independence) affect energy policies; and

10 - to redesign the planning, evaluation and monitoring procedures in such a way that small and decentralized projects have equal chances.

All this looks not that easy when regarding the task to promote renewable energy technologies especially in SSA.

4. Political Economy of Renewable Energy Promotion

In a research survey on energy policy formation in 4 countries of SSA (Sudan, Ghana, Zimbabwe and Ivory Coast) we identified six issues of major relevance for energy policy formation and the promotion of RETs (see Wohlmuth 1993[1]). We found out that at various levels institutional and political factors impede the dissemination of RETs.

1. Lack of integrated energy planning and energy policy

Most important is the fact that four core policy areas matter in energy policy (supply management, demand management, sector management, and the reform of the incentives framework and of the institutions), but that in the countries where the conditions have been studied only supply management is the area being of interest for policymakers. This concentration of energy policy on supply management has a lot to do with the role of Ministries of Finance and Planning in the context of overall investment planning. We have identified the instrumental role of Public Investment Programmes (PIPs) in energy planning, and so we could observe that the Ministries of Finance and Planning are the major decisionmakers with regard to energy investments and long-term energy planning. This has the effect that large-scale and new projects rather than small and decentralized energy projects are identified, selected and ultimately financed. Demand management is neglected although low cost-interventions or even no cost-interventions by energy policy institutions could reduce considerably the energy demand. The energy sector management shows extreme weaknesses in SSA as reveled by the low operational efficiency. However, huge gains and savings are possible, although a reform of the sector management is demanding in terms of regulation, privatization, changes in prices, taxes and duties, and especially in operational management at all levels.

Most important is the reform of institutions and of macroeconomy wide incentives as the energy sector was virtually considered as being isolated from the national economy, the productive sectors and the household sector. This view had negative repercussions on energy demand as structural changes were not seen as a route to optimize energy demanand supply. This interdependence of Africa is crises with regard to energy and sustainable development is brought out in Table 5. There are some attempts now to overcome this one-sidedness of energy policies in some countries (e.g. in Kenya).

2. Inappropriate structural adjustment policies during the 1980s

In our survey we found out that despite of more than ten years of experience with structural adjustment policies (SAPs) and adjustment financing (AF) the outcome with regard of energy conservation and environmental protection is poor. Two approaches to affect the energy sector were prevalent: first, an indirect approach to affect the energy sector, and secondly, a more direct route. The indirect route was based on the working of the main principles and instruments of structural adjustment policies, by focussing on price reform and deregulation, opening up of the economy towards the world market, privatization and commercialization of public enterprises, and macreconomic stabilization. The expected result of all these interventions was a more rational use of energy in all sectors of the economy, especially of imported fuels.

However, the poor result of the overall SAPs in the energy sector (lack of price reforms, of privatization, of appropriate deregulation and reregulation, failure of establishing neutrality of incentives for users and producers for all forms of energy) led to more direct forms of adjustment financing in the energy sector. Energy Sector Adjustment Programmes (ESAPs) as in Cote d'Ivoire were attacking more directly the perceived sectoral weaknesses. Despite of heavy conditionality involved from the side of international and regional multilateral donors also this route proved not to be very successful. Neither an improvement of energy policies nor a reduction of energy consumption (while maintaining or regaining growth and consolidating the balance of payments and the fiscal budget) can be observed.

A third route was then followed by some countries to use the services of the Energy Sector Management Assistance Programme (ESMAP). It was related to a careful use of traditional fuels and aimed at energy saving by identifying potentials for energy substitution and saving in industry agriculture, transport and the household and export sectors. Also this approach was not that sucessful. Most important, a neutrality of incentives between energy sources, progress with regard to energy institutions and energy policies and broadening the scope of dissemination of RETs did not result from following these policies.

3. Strategic energy policy decisions

All these policy and institutional weaknesses lead to more fundamental questions with regard to the causes of these policy failures and the prospects for reform. Most relevant is the result of our survey that the energy policy decisions of strategic importance are taken outside of the major energypolicy institutions and are concentrated in the Ministres of Finance and Planning.

In this context strategic decisions refer to energy sector objectives, investments and to key energy prices; these decisions are drafted and excuted by the Ministries of Finance and Planning. The strategy for energy sector investment allocation (including foreign exchange allocation) and for pricing electricity, fuels and oil products as kerosene is intentionally related to such policy objectives as growth, regional development, equity, security of energy supply, reduction of foreign economic dependence etc., but in reality the tradeoffs between these objectives are not made clear and a hierarchy of the stated objectives is not revealed. The coordination of authorities and institutions with competencies in the field of energy sector issues is difficult, but more important than the issue of coordination is the issue of the hierarchy in the decision-marking process; the hierarchical structure of decision-making is working against the competencies of the Ministries of Energy and the National Energy Boards. Some countries tried to involve all relevant institutions in a National Energy Board or a National Energy Commission. These attempts have not been successful, and where successful as in Ghana, the Board ultimately was climinated because of a perceived conflict of interest with the Ministries of Finance and Planning. The Ministry of Energy is then left with minor responsibilities and areas of decision-making, especially the (small) Renewable Energy Programme and/or the (insignificant) Energy Conservation Programme.

4. Ineffective Forms of Development Cooperation

Development cooperation (DC) in energy, especially with regard to RETs, is ineffective, and we have identified four areas of relevance for the dissemination of renewable energy technologies in the context of the effectiviness of DC.

DC is ineffective because the coordination between donor institutions and the local institutions (governments, local authorities and public utilities) does neiter work in the case of large-scale energy projects nor in the case of small, decentralized and NGO-based energy projects. The lack of coordination is obvious with regard to large-scale electricity, hydropower and refinery projects and is explained by the hierarchical process of decision-making, the supply-side orientation of energy policies and planning, and the role of large-scale energy projects in foreign exchange generation and balance of payments policy. With regard to small and decentralized projects the lack of coordination is explained by the great number of stated objectives and by ten fact that these objectives (as supplying energy services, environmental protection, basic needs provision and powerty alleviation) are not always revealed and quantified. The donors often prefer to escape national control (integration, screening, monitoring) of small projects, thereby passing by the Ministry of Energy even in small energy projects.

Development cooperation is also ineffective because of policy factors enhancing the supply-side orientation of energy planning, and because of the existence of coalitions between donor countries' institutions and (governments public utilities in African) countries; they share a common interest in favouring large-scale energy projects for financing. Balance of payments policies, international creditworthiness and financial autonomy of public utilities are issues in this context.

Most serious are however the deficiencies of DC with regard to technology transfers in RETs. It is obvious from international comparisons that even in the case of standardized energy technologies (as diesel generators in use in various developing countries, in private as well as in public sectors) huge but varying differences exist between best practice and actual performance. Main reasons are that issues of incentives, relevant operational management factors and appropriate relations between donor institutions and local energy institutions (public utilities and other energy actors) are ignored. Even more problems arise in the case of RETs because technology is largely unproven, operations require still more back-up support and a whole package of services in the process of technology transfer is required (incorporating R&D, training and extension, maintenance, upgrading technological competence, logistics, technological adaptation, and acquiring manufacturing competencies). Such packages are usually not provided by DC, and the elements of the package are not systematically transferred in an unpacked form.

5. Discriminatory Strategic Prices

Strategic prices for electricity, fuel, oil products and kerosene are discriminating against RETs on the grounds of stated developmental objectives thereby justifying often a heavy subsidization element of these key energy sources. Nonneutral incentive policies favour so-called strategic sources of energy supply. There is however evidence that in African countries no clear, unambignous and consistent policy of strategic energy pricing exists, and that clear priorities and a clear hierarchy of objectives are lacking. The continual subsidization of energy does no longer sustain growth, employment creation, equitable and sustainable development, but discriminates against the RETs. More and more these prices have became political prices, thereby contributing to increasing budget deficits, inflation and balance of payments problems while preserving the survival of inefficient public utilities.

6. Myths on Renewable Energy Promotion

We identified in our research four groups of myths. In Group 1 we find myths relating to the attitudes of those actors confronted with RETs during production and technology use. When propagating afforestation, biogas and stove programmes it is implicitly assumed that neither the labour time allocation, the time budget of the users, nor the social acceptance issues matter. So many projects and programmes fail because the available labour time - at a given level of labour productivity - does not allow, say in a biogas project, for time to care for provision of inputs, maintenance and other activities in competition with other demands on time.

A second group of myths refers to the implicit assumption that small and decentralized projects have only limited problems with regard to technological complexity and technology transfers. However, at least four levels of technological complexity have to be distinguished in this context: first, production efficiency concerning the feasibility/viability of the production of components and systems; second, the issue of operational efficiency concerning the actual working period when the RET is already installed; third, the issue of systemic efficiency when looking at the related incentives and the management environment; and fourth, the efficiency in the specific context of techno-economic flexibility of RETs, when considering the inherent flexibility of RETs to adjust energy services supply in case of increasing regional/local energy demand (as measured by the long-run marginal costs). If all or some of these four aspects of efficiency are ignored in the process of technological mastery and technology transfer, what is too often the case, frustrating experiences oocur in DC.

A third group of myths refers to the assumption that small and decentralized energy project have less demand for national political and planning integration. On the contrary, so many projects fail because the demand for macroeconomic and policy integration is considerably higher in the case of RETs than often assumed; and the demand for certain public goods (education & training, R&D, social and economic infrastructure, maintenance and standardization services and for various complementary private services is also high.

A fourth group of myths refers to the assumption that the market for RETs is relatively transparent and that the overall market structure in the energy sector does not impede the identification and execution of RE projects. However, we identified so many factors which characterize the RE market as highly politicized and influenced by nonmarket influences. Demand and supply of RETs are affected by political disincentives and impediments, subsidies, lack of information and lobbying, lack ofinformational transparency, tremendous market failures, highly erratic policy choices, but also by a lack of awareness that adequate policies on education and training, finance, trade and investment, R&D, and new forms of DC have to compensate for these characteristics of political markets.

These six areas are of concern if we look at the Political Economy of Renewable Energy Promotion; we found detailed evidence that the slow pace of dissemination of RETs is much more a political and economic issue than a 'technological' issue; it is a complex systemic issue. The whole system of incentives, institutions and political choices is affected and has to be reformed.

5. Planning, Monitoring and Evaluating Renewable Energy Projects

It is therefore obvious that for the acceleration of the dissemination of RETs not only the economic policy framework and an appropriate regime for technology transfers do matter. As well of importance is the interaction of the economic policy framework, the economic analysis (national perspective) and the financial analysis (by the prospective investor) of RE projects. Therefore we will focus on this interaction first. Then we will discuss the issue of more participatory planning and evaluation approaches.

In order to promote small and decentralized energy projects it is necessary to consider the very close interaction of economic policy variables, economic analysis of projects and the response of private investors/public investors in their financial analysis. Table 6 reminds us that there are various principal steps to be followed in order to match the results of economic and financial investment analysis. In order to prepare for an investment decision the economic analysis (the national viewpoint) is relevant so as to see if a project is justfied by national welfare reasons. When looking at the costs of a project, a RE technology to be selected has to be least cost by the national viewpoint to be accepted for further tests. If not, it is rejected on the grounds of lacking cost-effectiveness. If accepted, another test is based on the economic cost-benefit analysis, thereby also taking into account in detail the output side of the project. If the technology is a) least cost and b) profitable (if the discounted costs are lower than the discounted benefits), the investment decision is economically justified. However, non-economic objectives are ignored at this stage, e.g. economic independence, self-sufficiency, mobilization of local energy sources, although all such objectives are very difficult to quantify. Therefore at another stage of evaluation the policymakers have to weigh the non-economic objectives in the context of their strategic objectives (see Munasingh 1990[3]).

Project evaluation is therefore a multi-step process. After identification of demand for energy services (step 1), least cost analysis with a national viewpoint (step 2) and cost-benefit analysis with a national viewpoint (step 3) have to follow. A further step 4 is then the test of the feasiblility of the project implementation. If the project is implemented by the government, the question is whether energy is demanded at the market or financial price to be charged to the consumer. In order to meet the economic efficiency objective of pricing, the price should reflect the marginal economic opportunity cost or long-run marginal cost of supply , possibly to be modified by various national strategic goals (Munasinghe 1990[3]).

More complicated is the decision if, say, a private agricultural investor has to decide if it is profitable for him to switch from reinvesting into diesel pumping for irrigation into a RET, say photovoltaic water pumping for irrigation (see the case study by Munasinghe 1990[3], pp. 212-216). If the RET is proven to be (1) least-cost and (2) profitable, the private investor is likely to decide in a distortion-free economy in conformity with the results of economic analysis. However, because of so many price distortions in developing countries especially in SSA, this will not necessarily be often the case.

In order to make a project a technology that is economically justifiable also attractive for private investors, the government has to consider and to compensate for all relevant economic policy distortions. For example, if the conventional technology (diesel pumping) has an advantage only because of a fuel subsidy, the removal of the subsidy may be the solution. However, if this is difficult to implement, even other routes can be followed by government. Prices of inputs and of outputs can be changed and regulations/deregulations can be introduced in such a way that the economically justified technology is also attractive on a private basis. Only when all economic and financial tests are met, implementation of an investment can begin and the RET can be promoted (see Munasinghe 1990[3]).

Table 6 reminds us that implementation of RET projects as of all other projects often requires considerable policy changes with regard to national pricing, but that also other policy adjustments may be necessary, so that revised policies then with induce the choice of the least-cost and profitable RE technology. This iterative process is therefore highly dependent on appropriate policy changes so as to compensate for the distortions in the economy against RETs. The case illustrated by Munasinghe (1990[3]) compares a photovoltaic and a diesel pumping system for irrigation; the case is highlighting all these relevant policy issues (see Summary Table 7). The analysis is based on the Present Value of Costs (PVC) and the Present Value of Benefits (PVB) for Solar (S) and Diesel (D) technologies on the basis of Economic Analysis (E) and Financial Analysis (F).

We see that in the case at least two rounds of policy changes are required to come to the benefical technology choice - a RET which is economically justified but also privately preferred. The policy makers have various options. Government could reduce import duty on solar PV systems first, or raise the subsidized price of diesel fuel second, or legislate that farmers could no longer buy diesel pumps third, or give low interest loans to buy solar pumps fourth, and remove the import subsidy on diesel motors as a fifth option. In column C (of Table 7) we can see that option 5 (removal of import subsidies for diesel motors) will make the solar technology attractive but that there are still no net benefits for the private investor. Another policy variable has to be changed by the government. The government can increase procurement prices for agricultural products, so that solar technology is then least cost and also profitable on a financial basis (see column D).

This type of demand management for implementing RETs has up to now no real chance in many SSA countries, because of the one-sided supply management focus and the lack of any interaction between macroeconomic and energy policies. We have argued that these tools and policies (economic and financial analysis in conjuction with policy changes) are indispensable for any promotion of renewable energy projects, but that still non-economic objectives have to be considered in a further round of planning and evaluation. Therefore, implementation of RETs has to be judged also with regard to non-economic objectives.

Non-economic objectives (other objectives than efficiency) and more participatory planning approaches can be considered and introduced on the basis of multicriteria analysis (MCA). When we look at Table 8 we see that even in cases where efficiency is the only criterion for evaluation MCA analysis matters because some efficiency attributes may not be known in monetary terms. Therefore, the results of the Financial Economic Cost-Effectiveness Analysis (F/ECEA) or of a partial Cost-Benefit Analysis (F/ECBA) are used as a criterion in MCA; another route is going directly for a MCA. Even in cases when all efficiency attributes are known, other criteria besides income distribution (as covered by the Social Cost-Benefit Analysis - SCBA) can only by incorporated on the basis of a MCA, using SCBA outcomes as a criterion. Using the results of an ECBA as a criterion is a way to combine MCA with cost-benefit analysis. This procedure looks complicated for small and decentralized RE projects but if we look at energy programmes, this approach has advantages. The case study on Kenya by Ramphall (1992) reveals how fruitful this approach can be. As we see in Table 9 eight energy strategies at the household level have to be compared and evaluated on the basis of revealed local experience. A rather complex set of evaluation criteria emerges (see Table 10). Besides of economic efficiency a variety of other criteria (technical, ecological and sozial) is included in MCA. MCA requires definite steps: first, identification of alternatives; second, assessing the set of relevant criteria; third, determining the weights for the criteria; fourth, impact assessment and standardization of effects; fifth, integrated comparison of alternatives; and sixth, risk and uncertainty analysis (sensitivity analysis).

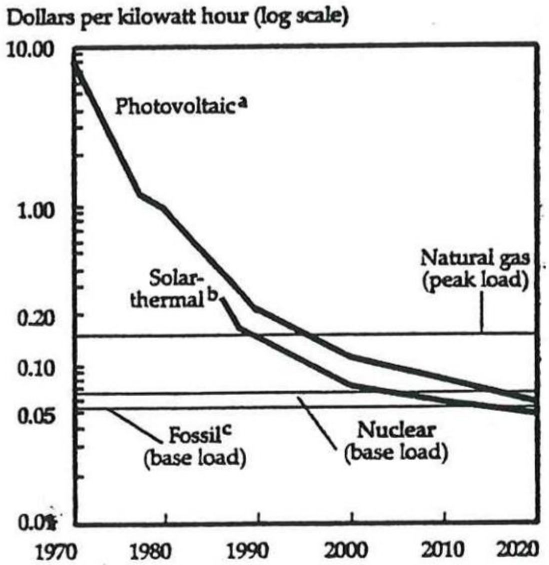
Standardization, as a concept means that cardinal criteria scores (see Table 10) - which are incommensurable units, e.g. dollars, acres, tons, ... - are standardized into dimensiones numbers between zero and one in a manner which preserves the degree of difference between alternative energy strategies (Ramphall 1992, p. 11; van Pelt 1991, p. 20). Standardization sets a minimum evaluation score at zero, a maximum evaluation score at one, in order then to space out linearly the other evaluation scores.

All this looks rather complicated relative to financial and economic analysis of projects, but allows for a more participatory assessment of alternatives, criteria, weights and impacts. Various methods can be used for MCA (see Oesterdiekhoff 1993), and number of suitable software support packages is available (see Wohlmuth/Oesterdiekhoff 1993). In our research project we have identified also a list of relevant criteria adapted to small and decentralized energy projects in developing countries, and we have also proven to complementary role of MCA methods in projectplanning and evaluation by demonstrating that MCA has inherent advantages (as allowing to work with weak data; considerable flexibility of the MCA methods; possibility to discover methodical biases by using various MCA methods; participation as a basic ingredient of the whole assement of alternatives, criteria and weights; contribution to identifying solving trade offs between project and programme objectives) Wohlmuth/Oesterdiekhoff (1993, Part B) and Ramphall (1993) highlight also the importance of this methodology for planning and evaluating alternative national, regional and local energy policies in SSA.

6. Conclusions

From our analysis we can conclude that despite of rather favourable perspectives for renewable energies in developing countries, especially of solar energy, there are serious constraints to dissemination promotion. Therefore, we have identified the most important problem areas: firstly, the economics of renewable energy technologies shows the complexities of the market characteristics with regard to the application of such technologies; secondly, the political economy of renewable energy promotion identifies various significant barriers for implementation of RETs; and thirdly, the investment analysis of RE projects and programmes is up to now ignoring the interaction of economic policy changes and the investment analysis as well as the necessity of more participatory planning and evaluation approaches.

Table 1: <u>Cost of alternative means of generating electric power in high-insolation areas, 1970-2020</u>



Notes: Data after 1990 are predicted. Future costs of fossil-fuel and nuclear generation are uncertain; they are affected by such factors as demand shifts, technological change, environmental concerns, and political conditions, which may act in opposite directions.
a. Excluding storage costs.
b. Including storage costs (on the basis of hybrid natural gas/solar schemes through 1990 and heat storage thereafter).
c. Natural gas and coal.
Sources: For solar sources, U.S. Department of Energy 1990; for others, *Scientific American* 1990.

<u>Source:</u> World Development, 1992, p. 123

Table 2: Main renewable energy categories

Resource technology	Energy product	Status
Hydro		
Large-scale	Electricity	Developed, often economic, widely deployed
Micro-hydro	E	Developed, usually economic, not widely deployed
Solar		
Passive heating	Heat	Developed, usually economic, mixed deployment
Active heating	H	Developed, variable economics & development
Thermal electric	E	Large test stations, results not favourable
Photovoltaic	E	Rapidly developing, varied projections
Solar ponds	E	Demonstrated, not economic at present
PV–hydrogen	Fuel	Components proven; economics speculative
Wind		
Pumping	Mechanical	Developed, deployed in remote areas
Onshore turbines	E	Recently developed, still improving, early deployment stage
Offshore turbines	E	Some trial stations, varied projections
Biomass		
Agricultural & Forest Residues & surpluses		
Domestic & Industrial Wastes		
Biomass crops		
Direct combustion	H	Widely used but inefficient
Decomposition/hydrogenation/ fermentation etc	F	Various demonstrated, usually not economic at present
Gasification	F, E	Unproven but promising
Geothermal		
Aquifiers	H, E	Proven, often economic
Hot dry rock	H, E	Exploratory schemes, mixed results
Tidal		
Estuary Dams	E	Proven; economics depend heavily on financing assumptions
Streams	E	Speculative
Wave		
Shore-based	E	Test stations, favourable results
Deep water	E	Wide variety of devices; pilots but no prototypes tested
Others		
OTEC; Dew point energy; Salt gradients; Solar satellites		

Source: Grubb, 1990[1], p. 529

Table 3: Status of Renewable Energy Technologies

Economic (in some locations)

Solar water heaters, replacing electricity or with seasonal storage, and for swimming pools
Solar industrial process heat with parabolic trough collectors or large flat-plate collectors
Residential passive solar heating designs and daylighting
Solar agricultural drying
Small to medium photovoltaic systems
Small to medium wind systems
Direct biomass combustion
Anaerobic digestion (of some feedstocks)
Conventional geothermal technologies (dry and flashed steam power generation, high temperature hot water and low temperature heat)
Tidal systems

Commercial (with incentives)

Solar water and space heaters replacing natural gas or oil
Electricity generation with parabolic trough collectors
Non-residential passive solar heating and daylighting
Biomass liquid fuels (ethanol) from sugar and starch feedstocks
Binary cycle hydro-geothermal systems

Under Development

Solar space cooling (active and passive)
Solar thermal power systems (other than parabolic trough collectors)
Photovoltaic power systems
Large-sized wind systems
Biomass gasification
Hot dry rock geothermal
Geothermal total flow prime movers
Wave energy systems

Future Technologies

Photochemical and thermochemical conversion
Fast pyrolysis or direct liquefaction of biomass
Biochemical biomass conversion systems
Ocean thermal energy conversion systems
Geopressured geothermal
Geothermal magma

Definition of Categories

Economic. Technologies are well developed and economically viable at least in some markets and locations, for which further market penetration will require technology refinements, mass production and/or economies of scale.

Commercial (with incentives). Technologies are available in some markets, but are competitive with the conventional technologies only with preferential treatments, so that they still need further development to be economically competitive.

Under Development. Technologies need more R&D to improve efficiency, reliability or cost to become commercial.

Future. Technologies have not yet been technically proven, even though they are scientifically feasible.

Source: IEA, Renewable Sources of Energy, Paris, 1987.

Source: Munasinghe, 1990[2], p. 225

Table 4: <u>Present state of the art and expected developments in renewable energy technologies</u>

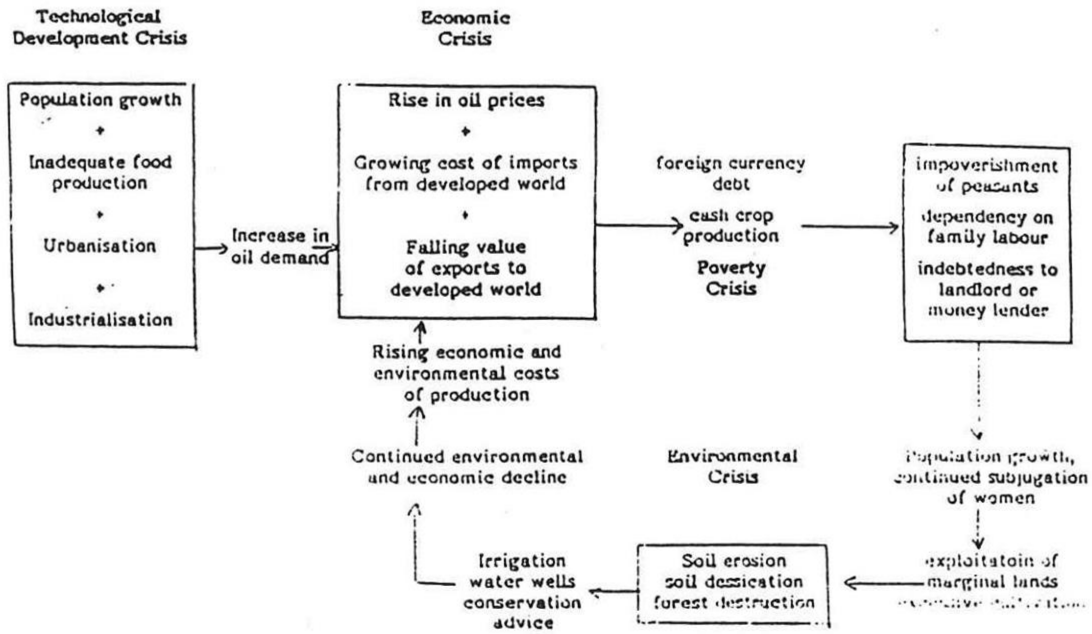
Technology	Present state of the art	Expected future developments 1990	2000	2010	2020
1. Solar water heaters	R,D,P,C,E	C,E	E		
2. Active solar space heating	R,D,P,C	C	E		
3. Passive solar space heating and cooling	R,D,P,C	C	E		
4. Solar air conditioning	R,D	R,D,P,C	C,E		
5. Solar refrigeration	R,D	R,D,P,C	C,E	E	
6. Solar stills	R,D,P,C	C,E	E		
7. Solar dryers	R,D,P,C	C	E		
8. Solar evaporation	C,E	E			
9. Solar cookers and food warmers	R,D,P,C	C	E		
10. Solar sterilizers	R,D,P,C	C	E		
11. Solar greenhouses	R,D,P,C	C	E		
12. Non-convective solar ponds	R,D,P,C	P,C	C,E	E	
13. Solar pumping and irrigation	R,D,P,C	P,C	C,E	E	
14. Solar-thermal electric conversion	R,D,P	R,D,P	D,P	D,P,C	C,E
15. Solar photovoltaics	R,D,P,C	R,D,P,C	C,E	E	
16. Sensible heat storage systems	R,D,P,C	R,D,P,C	P,C,E	C,E	E
17. Phase-change heat storage system	R,D,P	R,D,P,C	C,E	C,E	E
18. Thermochemical storage systems	R	R,D	R,D,P	R,D,P,C	C,E
19. Wind-powered mechanical systems	R,C	C,E	E		
20. Wind-powered electrical systems	R,D,P	R,D,P,C	C,E	E	
21. Wind-powered fertilizer production	R,D	R,D,P,C	C,E	E	
22. Direct combustion of biomass	R,C,E	C,E	E		
23. Biogas plants	R,D,P,C	R,C,E	E		
24. Pyrolysis	R,D	R,D,C	C,E	E	
25. Alcohol production	R,D,P,C	R,D,P,C	P,C,E	C,E	E
26. Oil plants	R,D,P	R,D,P,C	P,C,E	C,E	E
27. Hydraulic production of mechanical shaft power	R,C,E	C,E	E		
28. Hydraulic generation of electricity	R,C,E	R,C,E	R,C,E	E	
29. Geothermal energy	R,D,P,C	R,D,P,C	E		

[a]Phases of development:
- R = R&D
- D = Demonstration plants.
- P = Prototype plants.
- C = Commercial plants economically competitive under special conditions.
- E = Economically and technically feasible plants in most locations.

Source: Taşdemiroğlu, *op cit*, Ref 5. Energy technologies classified according to T.A. Lawand, *The Potential of Renewable Energies in Planning the Development of Rural Areas*, Brace Research Institute Report No I-126, Quebec, Canada, 1978.

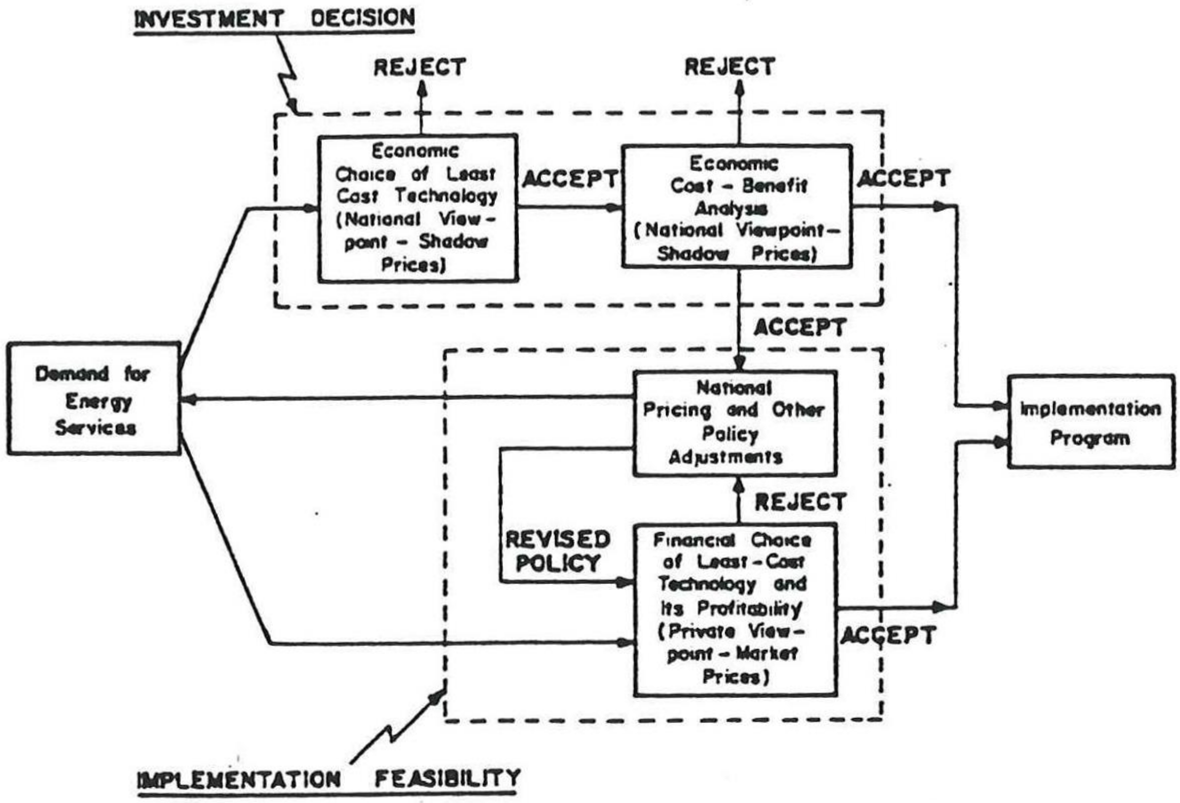
<u>Source</u>: Tasdemiroglu 1989, p. 583

Table 5: <u>Energy Crisis and Sustainable Development in Developing Countries</u>



Source: Wereko-Brobby/Hagan 1991, p. 32

Table 6: Steps in Economic and Financial Analysis and Related Economic Policy Revisions



Source: Munasinghe 1990[3], p. 211

Table 7: Investment Analysis and Economic Policy Changes - An Illustration for RETs

Economic and Financial Tests for Investment Decision
(All amounts are in present value terms)

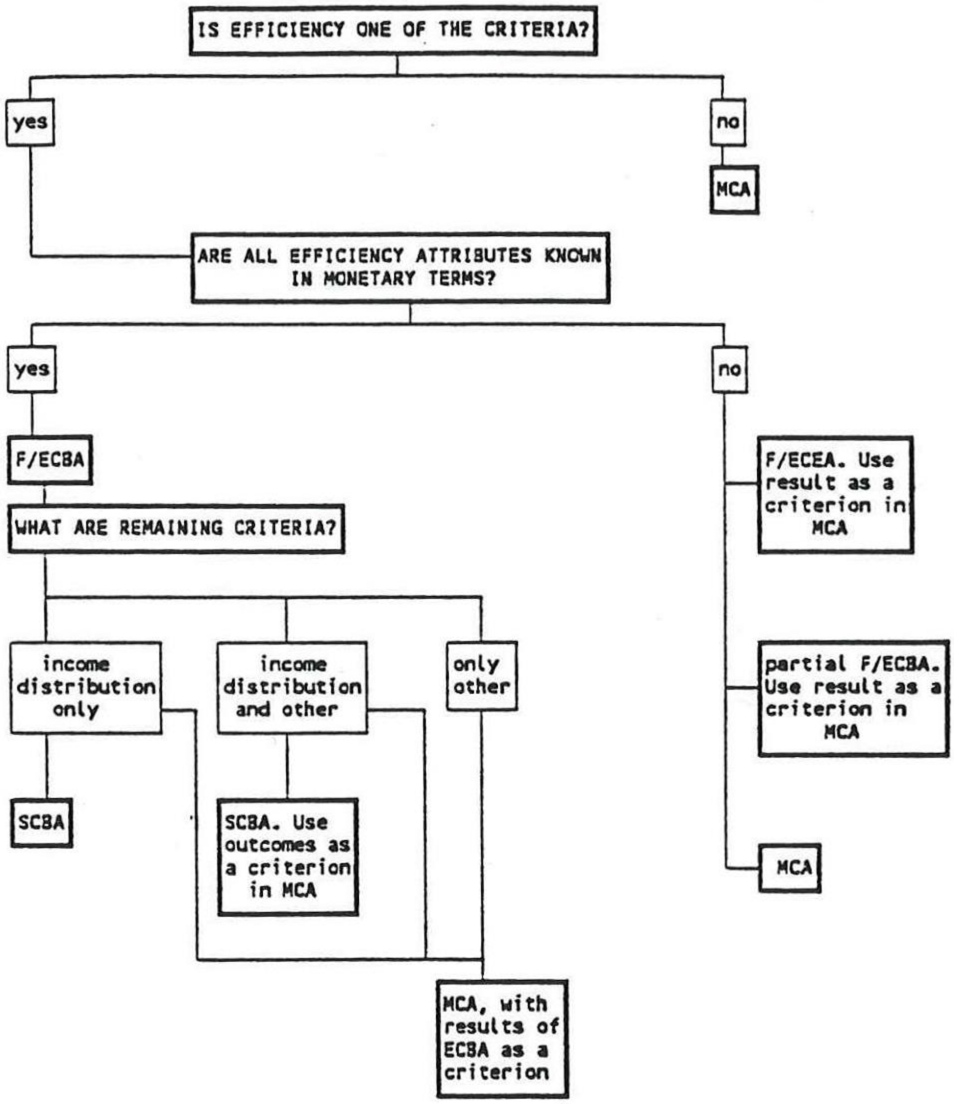
Item	A National Viewpoint: Shadow Prices (Border Rs.)	B Private Viewpoint (Initial) Market Prices before Policy Changes (Domestic Rs.)	C Private Viewpoint (Interim) Market Prices after First Policy Change (Domestic Rs.)	D Private Viewpoint (Final) Market Prices After Second Policy Change (Domestic Rs.)
Solar PV Costs	PVC_{SE} = 66,760	PVC_{SF} = 75,080	PVC_{SF} = 75,080	PVC_{SF} = 75,080
Diesel Costs	PVC_{DE} = 74,540	PVC_{DF} = 71,110	PVC_{DF} = 85,070	PVC_{DE} = 85,070
Irrigation Benefits	PVC_E = 70,970	PVB_F = 73,670	PVB_F = 73,670	PVB_F = 78,000

CONCLUSIONS

Condition		Consequence
A. Shadow Priced Values:		
$PVC_{SE} < PVC_{DE}$	-	Solar PV is the economically preferred least-cost technology.
$PVB_E > PVC_{SE}$	-	Investment in solar PV is economically justified.
B. Market Priced Values Before Policy Changes:		
$PVC_{SF} > PVC_{DF}$	-	Farmers will prefer diesel to solar PV pumps, financially.
C. Market Priced Values After First Policy Change:		
$PVC_{SF} < PVC_{DF}$	-	Farmers will prefer solar PV to diesel pumps, financially.
$PVB_F < PVC_{SF}$	-	Farmers will find solar PV pumps financially unprofitable to install.
D. Market Priced Values After Second Policy Change:		
$PVC_{SF} < PVC_{DF}$	-	Farmers will prefer solar PV to diesel pumps, financially.
$PVB_F > PVC_{SF}$	-	Farmers will find solar PV pumps financially profitable to install.

Source: Munasinghe 1990[3], p. 215

Table 8: The Choice Of Method in Investment Analysis



Source: van Pelt, 1991, p. 30

Table 9: <u>Evaluating feasible energy strategies in rural Kenya - Identification of Alternatives</u>

Energy Strategy	Description
A (The "Do Nothing" strategy)	Cooking: 5100 Kg of fuelwood gathered from common lands and 1200 Kg of maize residue. Both fuels burnt in a traditional mud/clay stove. Lighting: 60 litres of paraffin. Burnt in three hurricane type or standing lamps. Space Heating: Radiant heat from cooking and lighting activities.
B	Cooking: 6170 Kg of fuelwood from an agroforestry system. Burnt in a traditional mud/clay stove. Lighting: 109.8 litres of paraffin. Burnt in two hurricane type or standing lamps and one pressure lamp. Space Heating: Radiant heat from cooking and lighting activities.
C	Cooking: 2469 Kg of fuelwood from an agroforestry system. Burnt in a portable metal stove. Lighting: Same as for Energy Strategy B. Space Heating: Partly from radiant heat from cooking and lighting activities. Partly from 1303 Kg of fuelwood produced from an agroforestry system and burnt in a hearth.
D	Cooking: 1214 Kg of charcoal. Produced in an earth kiln from 8855 Kg of fuelwood grown under an agroforestry system. Burnt in a metal ceramic stove (jiko). Lighting: Same as for Energy Strategy B. Space Heating: Partly from radiant heat from cooking and lighting activities. Partly from 1155 Kg of fuelwood produced from an agroforestry system and burnt in a hearth.

Energy Strategy	Description
E	Cooking: 1214 Kg of charcoal. Produced in two 200-litre oil drums frum 5285 Kg of fuelwood grown under an agroforestry system. Burnt in a metal ceramic stove (jiko). Lighting: Same as for Energy Strategy B. Space Heating: Same as for Energy Strategy D.
F	Cooking: 1214 Kg of charcoal. Purchased commercially and burnt in a metal ceramic stove (jiko). Lighting: Same as for Energy Strategy B. Space Heating: Same as for Energy Strategy D.
G	Cooking: 1095 cu. m. of biogas. Burnt in a biogas stove. Lighting: 865 cu. m. of biogas. Burnt in three 3-mantle gas lamps. Space Heating: Partly from radiant heat from cooking and lighting activities. Partly from 388 Kg of fuelwood produced from an agroforestry system and burnt in a hearth.
H	Cooking: 805 litres of paraffin (Kerosene). Purchased commercially and burnt in a paraffin stove. Lighting: Same as for Energy Strategy B. Space Heating: Partly from radiant heat from cooking and lighting activities. Partly from 1255 Kg of fuelwood produced from an agroforestry system and burnt in a hearth.

Source: Ramphall, 1992

Table 10: Evaluating feasible energy strategies in rural Kenya - Set of Evaluation Criteria

Criteria	Description	Unit of Measurement
Technical		
1	First Law Energy System Efficiency	Percent
2	Second Law Energy System Efficiency	Percent
3	Fuel Conservation through Efficiency Gains	Megajoules per year
4	Technical Lifetime of Energy Strategy	Rank
5	Rapidity of Energy Development	Rank
Economic		
6	Absence of Time Recurrent Costs	Rank
7	Fuel Costs	U.S. dollars per utilized Gigajoule-year
8	Cost of Energy Conversion/End Use Devices	U.S. dollars
Ecological		
9	Local Sources of Energy Inputs	Proportion
10	Present or Near-Term Deleterious Impacts on the Local Ecosystem	Kilograms of fuelwood cut per year
11	Absence of Resource Competition (Fuel Versus Food for Humans)	Rank
12	Absence of Resource Competition (Fuel Versus Fertilizer)	Rank
13	Absence of Temporal Fluxes in Energy Availability	Rank
14	Potential for Sustained Yield	Proportion
15	Absence of Uncertainties	Rank
16	Absence of Risk	Rank
17	Absence of Vulnerability	Rank
Social		
18	Non-Monetary Benefits	Rank
19	Absence of Distributional Ill Effects	Rank
20	Employment Generated Per Unit Capital Investment	Rank
21	Absence of Social Obstacles to Acceptance	Rank

Source: Ramphall, 1992

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