A GENERIC SOUTHERN PERSPECTIVE ON RENEWABLE ENERGY[a]

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Abstract

The increase in the use of fossil fuels from about the mid-nineteenth century and their growing unsustainability led to a growing demand for renewable energy. Since this demand has even assumed a fundamentalist trend, the question arises: should the goal be sustainable development or renewable energy? Here, the position is taken that the goal should be sustainable development with renewable energy being an instrument. But, renewable sources must not be considered synonymous with sustainability. Renewable sources can be used non-renewably, and non-renewable sources can be used quasi-renewably for a specific end-use. Whereas a renewable energy fundamentalist would forbid the utilisation of a non-renewable resource irrespective of its equity and other advantages, a sustainable development-oriented view may support the use of a non-renewable resource if it dramatically improves the quality of life during a transition period and that it buys time before a solely renewables solution is implemented.

After indicating the inter-relationships between biomass energy, renewable energy and sustainable (urban and rural) development, the generic energy strategies to advance the goal of sustainable development are listed. Then, the specific strategies for renewable energy in general and biomass energy in particular are mentioned. A brief description of the barriers to Renewable Energy is supplemented with a Strengths-Weaknesses-Opportunities-Threats (SWOT) analysis. Following a discussion of some guidelines for the dissemination of renewable energy technologies (RETs), the characteristics of a Renewable Energy Policy Package (REPP) for sustainable development are outlined. Finally, an indication is given of the RETs for the near-, medium- and long-term.

The Rise of Fossil Fuels and their Unsustainability

Starting from about the mid-nineteenth century, human societies acquired in rapid succession control over coal, steam, oil, electricity and gas. Along with the rise of fossil fuels, there was a decline in the use of renewable sources. With these shifts in primary sources of energy (as found in nature), enormous leaps in power output were achieved. Dramatic new possibilities emerged.

But along with these opportunities, arose new threats. Environmental impacts grew in intensity. At first, there was severe local environmental degradation, then national and trans-boundary/regional degradation and finally global impacts. Human activities began

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to have impacts on a planetary scale. There was growing evidence that greenhouse gases (GHGs) were accumulating in the atmosphere and that there was a real possibility of global warming and significant climate change.

There were also alarms that fossil fuel resources particularly oil (which was concentrated in specific areas) would be exhausted. It turned out, however, that, by and large, as consumption increased, new discoveries were made. The reserves appeared to keep increasing along with postponement of the anticipated dates of exhaustion.

Even then, the non-uniform distribution of fossil fuel resources generated geopolitical and security concerns that urged reduced dependence on these sources. The oil price hikes of the 1970s aggravated the situation and led to the questioning of continued dependence on fossil fuels.

The Fundamentalist View of Renewable Energy

It was against this background that the demand for renewable energy – particularly wind, small hydro, solar (thermal and PV) and modern biomass energy[c] -- gathered in intensity in the 1980s. There was even a United Nations Conference on New and Renewable Sources of Energy in Nairobi in August 1981.

Though developing countries have contributed much less to the present high levels of greenhouse gases in the atmosphere, the current growth rates of their emissions extrapolate to dangerous levels in the atmosphere in the future and threaten the industrialised countries. An expert said:

> "... a general consensus exists that, during 1988, almost three-quarters of the CO_2 from fossil-fuel combustion was released in industrialised countries. But when non-industrial sources are included (e.g., burning of forests and other land-use changes) the contribution of industrialised countries was about 56%. ... Analysis of the available data suggests that the historical fossil-fuel related emissions from developing countries represent only about 14% of the global total, as compared to 28% of current fossil-derived CO_2 emissions..."[1]

The developing countries, with three times more population, have been far less responsible for the cumulative pollution of the global atmosphere with greenhouse gases, and are even now polluting less than the industrial countries. But, the contribution of these countries to the concentration of greenhouse gases in the atmosphere is rising!

It is no surprise, therefore, that recent and current discussions of energy systems have been invariably dominated by the goal of greenhouse gas abatement and prevention/minimisation of climate change. This is a reflection of the preoccupation of the industrialised countries.

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[c] Insofar as traditional biomass used in traditional end-use devices are very much responsible for the low levels of energy services, particularly in the rural areas of developing countries, the new demand was for modernised biomass sources and/or modern end-use devices.

Accordingly, there is an overwhelming emphasis on renewable energy. Maximisation of renewable energy has become the objective function. Renewable energy has become an end in itself. The proponents have become renewable energy fundamentalists. Some even demand that the playing field has to be distorted in favour of renewable energy. Thus, environmental soundness has become the dominant and almost exclusive concern.

This focus on renewable energy was abetted by the industrialised countries. Despite being major contributors to the accumulation of greenhouse gases, they started pressurising developing countries to reduce their emissions of greenhouse gases primarily by focusing on renewable sources of energy. One must not fail to note the negative and counter-productive role played by the major diversion of scarce and precious Southern talent into greenhouse gas mitigation analysis for developing countries even though the problem has arisen primarily from Northern energy consumption patterns.

Should the Goal be Sustainable Development or Renewable Energy?

Against this background, the question arises as to whether renewable energy should be an end in itself or a means to an end -- whether it should be a goal or an instrument to achieve a goal. The answer depends upon whether the objective is technology dissemination or improvement of the quality of life of people with technology dissemination being a means.

It is submitted here that the goal should be sustainable development. The goal of sustainable development implies the criteria of economic efficiency, distributional equity/access (particularly for the poor, women and rural areas), self-reliance/empowerment and environmental soundness.

Thus, renewable energy should not be a goal *per se*; it should only be an instrument to achieve the goal of sustainable development. However, renewable energy is particularly appropriate for advancing sustainable development because, apart from being environmentally sound, it is invariably available locally. Also, it is decentralised and therefore facilitates the empowerment of individuals and communities, and strengthens their self-reliance. However, like all instruments, it must be appropriately designed and effectively wielded. Thus, renewable energy cannot *ipso facto* ensure sustainable development. Renewable Energy must earn its place in such a way that it is compatible and integrated with the goal of sustainable development.

This distinction between renewable energy and sustainable development is particularly important because they do not tend to enjoy the same political standing. Sustainable development is often given lip service by the country spokesmen at international conferences but, within the country, there are no political and economic instruments for its implementation. Worse still, following some industrialised country interpretations, sustainable development is often equated with environmentally sound development, ignoring its equity and empowerment (self-reliance) dimensions.

Renewability and Sustainability

Renewable sources must not be considered synonymous with non-depletability and inexhaustibility. It is well known that even renewable sources can be used non-renewably, for instance when the rate of extraction exceeds the rate of regeneration of the resource. The classic example is when forests are cleared and/or wood is extracted at a rate much greater than the rate of growth. History abounds in examples where once densely forested areas became devoid of tree cover.

What is not so well appreciated is that non-renewable sources can be used *quasi*-renewably for an end-use, in the sense that the rate of depletion due to that end-use is negligibly small compared to the magnitude of the reserves and to consumption for other tasks. In such a situation, a renewable energy fundamentalist would forbid the utilisation of a non-renewable resource irrespective of its other advantages and would insist that a renewable resource must be used notwithstanding its incompatibility with the equity and environmental disadvantages. In contrast, a sustainable development-oriented view would also look at the equity and other dimensions and may support the use of a non-renewable resource on the grounds that it dramatically improves the quality of life during a transition period and that it buys time before a solely renewables solution is implemented. It is perhaps with this understanding that in many Latin American countries, LPG is being disseminated in rural areas for cooking in preference to fuelwood[2].

Sustainable Development, Biomass Energy and Renewable Energy

The inter-relationships between renewable energy, biomass energy and sustainable development are brought out in Figure 1. The set of renewable energy technologies (RETs) at the bottom of the figure consists of both decentralised and centralised RETs. It is the decentralised RETS that are particularly appropriate for rural areas. These decentralised rural RETs can be of two types -- biomass-based and those that are not biomass-based. Together, they are the basis of energy for sustainable rural development. The centralised RETS that are appropriate for urban areas are also of two types: biomass-based and those that are not biomass-based. Together, they are the basis of energy for sustainable urban development. It is important to ensure a synergy between energy for sustainable rural development and energy for sustainable urban development and between sustainable rural development and sustainable urban development.

Specialised agencies responsible for biomass energy and for rural energy are absent in most countries. In India, for example, only renewable energy has been given political approval through the formation of a Ministry of Non-conventional Energy Sources. But, it is easy to see that, particularly when market forces are given priority, an emphasis on renewable energy can result in a preoccupation with technologies that cater to urban energy demands and/or with centralised biomass energy. Further, there is far less emphasis on biomass than on photovoltaics. This disparity is perhaps because industrialised countries can find a greater role in selling PV modules and systems than in growing and harnessing biomass.

Energy Strategies to advance Sustainable Development

While the definition of goals or objectives is crucial, it is necessary to go beyond that to the next step of formulating the strategies or broad plans for achieving the objectives.

If energy is to be an instrument of sustainable development, then the associated energy strategies must

- focus on energy services (rather than mere energy consumption) particularly for the satisfaction of basic needs,
- ensure access to modern energy services for all (implying an obligation to serve on the part of energy suppliers),
- involve a rationally derived mix of "cleaner" centralised sources (not only the conventional sources but also the next generation of fossil-fuel-using technologies), centralised and decentralised renewable sources, and efficiency improvements,
- not depend solely on government top-down action but also build upon entrepreneurial and community action,
- build indigenous capacity,
- have a role for other stake-holders (environmentalists, current and potential consumers, etc.), and

Specific Strategies for Renewable Energy in general and Biomass Energy in particular

Apart from the above generic strategies that are common to all energy sources, certain special features of renewable sources necessitate specific strategies for these sources.

Firstly, the emphasis on a rationally derived integrated resource mix -- of conventional sources, renewable sources (centralised and decentralised) and efficiency improvements -- means that renewable energy must win for itself a rightful place in the mix. This requires the establishment and maintenance of a level playing field and the promotion and safeguarding of competition within the mix.

Secondly, it must be recognised that, unlike conventional centralised energy sources, most renewable energy technologies are still maturing. This is particularly the case with non-traditional biomass energy technologies. Hence, there must be specific strategies for assisting renewable energy technologies to mature.

Thirdly, whereas the linkages from sources to end-uses via end-use devices – the so-called fuel-cycles – are well established in the case of conventional sources, the linkages may have to be forged and maintained in the case of renewable sources. Hence, specific strategies are necessary for the development and dissemination of efficient end-use devices to reduce the requirement of renewable sources.

Fourthly, whereas most renewable energy resources -- like conventional non-renewable sources (oil, natural, coal) -- are “given” by nature, biomass output can be increased through plantations. Hence, specific strategies for augmenting biomass availability may be necessary.

Barriers[3,4] to Renewable Energy[d]

However well crafted the strategies specific to renewable energy, they are unlikely to succeed unless the barriers that renewables face are identified and policies custom designed to overcome them.

One sub-set of barriers is associated with commercialisation. RETs may have characteristic technical problems that have to be solved through research, development and demonstration (R, D & D) before market dissemination. Unfortunately, R, D & D institutions in developing countries, suffer from a number of shortages (trained personnel, infrastructure, funding, information, etc.).

The market sub-set of barriers include:

- subsidies (open and hidden) to conventional energy, particularly to fossil fuels, giving their energy systems an unfair advantage over renewable energy systems;
- market prices that do not reflect environmental costs and damage and that mask the striking environmental advantages of the new and cleaner energy options;
- limited access to information particularly with regard to the availability of renewable energy resources[5] and the technologies available for utilising these resources;
- first-cost sensitivity (where decisions are based on initial, rather than life-cycle, costs) making the provision of consumer credit through microfinance and other mechanisms extremely important for disseminating small renewable energy systems.
- the unfamiliarity and inefficiency of financial institutions vis-à-vis the small-scale investments required for renewable energy systems resulting in inadequate financing to the end-users for the purchase and installation of biomass energy systems;
- split incentives or the common "landlord-tenant" problem (whereby the "landlord" has no incentive to invest in renewable energy because it is the "tenant" who pays the energy bills);
- indifference to energy costs (because they are often a small fraction of total costs) leading to limited attention to alternative energy options.

Another sub-set of barriers consists of non-market barriers including

- vested interests (in the private and public sector) that benefit from business-as-usual approaches and practices and, therefore, resist change;
- the lack of appropriate institutions[e];
- the absence of a government agency specifically mandated to promote renewable energy development;
- the lack of coordination among institutions involved in renewable energy development and commercialisation;

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[d] This section is based on the author's paper on barriers to energy efficiency improvements and on the analysis of barriers to renewables provided in this volume by Bhattacharya and by Rao and Ravindranath, to whom the author is grateful.

[e] The term "institution" represents a forum plus rules for interaction between relevant organisations/individuals in that forum.

- institutional obstacles such as the monopoly position of utilities, which do not have an institutional interest in encouraging competing sources of electricity
- agencies that are more comfortable with large-scale and centralised systems and have a culture alien to the modular nature of renewable energy systems.

SWOT analysis of Renewable Energy

Many of the barriers are also reflected in a Strengths-Weaknesses-Opportunities-Threats (SWOT) analysis of renewable energy presented.

STRENGTHS	WEAKNESSES
• Decentralised • Locally available • Strengthens self-reliance • Environmentally sound particularly re: global environment	• May have to mature • Replicability not yet proven • Present costs may be too high • Potential not adequate to replace fossil fuelled generation
OPPORTUNITIES	**THREATS**
• Costs are declining • Future costs may be attractive • Mega centralised projects not coming through as rapidly as possible • Rural needs not being met by conventional projects	• Power sector reform may underemphasise renewables • Declining R&D interest

Dissemination of RETs

Since there are *barriers* at all levels -- at the international, government, utility, equipment manufacturer/distributor and consumer levels, a *multi-level and multi-target approach* is required with simultaneous advocacy and action at all levels. This approach must be addressed not only to decision-makers in government but also to politicians, utilities, various categories of consumers, the media, and civil society. The top-down approach pursued by international organisations and governments is necessary, but not sufficient. One of the problems is that governments and their bureaucracies are oftener than not the custodians and propagators of obsolete paradigms. Paradigm-shifts definitely require the simultaneous *bottom-up* pressure from civil society.

Apart from technology generation and demonstration, what is essential is *technology dissemination*. This is totally different "ball-game". For, manufacturing a thousand or a million is a totally different challenge from making one-off. And the establishment and operation of a hundred or thousand units is quite different from one demonstration.

Notwithstanding the usual official enthusiasm to rush implementation with a step-function or a linear increase of penetration, it is best to start with a slow penetration incorporating learning from field trials and then to increase more rapidly before achieving saturation. In other words, it is best to follow a *logistic curve*[f] for dissemination.

Since not only technology, but also economics, financing, management, training, institutions, etc., are essential, it is important to have implementation packages (*IMPACKS*), i.e., complete hardware plus software packages, to guide the dissemination and replication of technology. Quite clearly therefore the evolution has to be *from hardware to software to systems integration*.

If the interest is, not only in analysis but also in implementation, the entire gamut of activities from Information, Training, Analysis, Advocacy and Action (*INTAAACT*) assumes importance. A crucial part of action is *commercialisation* going from prototypes to products in the economy.

With the growing experience and awareness of the defects of state-controlled technology dissemination and implementation, the privatization option with its emphasis on the market is being offered as a solution to the problem of monitoring and control of resources and facilities.

Against this background, the examples of telephone booths for subscriber trunk dialling/international subscriber dialling (STD/ISD) and connections for cable TV reception are worth considering because they have shown a dramatic proliferation of information services through entrepreneurial initiative. In both these cases, entrepreneurs could enter the market with investments well within their reach, provide services to customers at affordable prices and make attractive profits in the bargain.

Even in these cases of entrepreneurial success, the role of government in providing the enabling environment is crucial. This role includes a deliberate decision to leave the process to the private sector.

The market may be an excellent allocator of men, materials and resources, but it is not perfect. It has both *power* and *limits*. In particular, it does not have a very successful record at looking after equity, the environment and the long-term, i.e., in situations warranting a low discount rate. Whereas the market can ensure economic growth, it cannot ensure sustainable development. In this debate, it is invariably forgotten that individual initiative subject to local community control is a distinct third option that has very attractive features[6].

A Renewable Energy Policy Package (REPP) for Sustainable Development

Whereas strategies are the broad plans to achieve defined goals, policies are the detailed courses of action required to implement strategies. Obviously, discussions of policies are meaningless without specifying the strategies that the strategies are meant to implement. Unfortunately, policy discussions too often proceed without a specification of the underlying strategies.

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f The S-shaped logistic curve is appropriate for representing the dissemination of renewables as a function of time as it suggests a gradual introduction, followed by increasingly rapid acceptance and finally a tapering off as saturation is approached so that the penetration $p_t = K/[1 + \{K-N(0)/N(0)\} * e^{-rt}]$, where K is the saturation level, N(0) is the initial acceptance level and r determines the slope.

Since it is unlikely that a single renewable energy policy is sufficient to implement the associated energy strategies, what is required is a renewable energy policy package (REPP), a set of policies that follows logically from the renewable energy strategies.

In addition to all the policies to ensure that energy advances sustainable development, there must be special policies for renewable energy to overcome the barriers to renewable energy.

The necessary condition for renewable energy winning for itself a rightful place in the integrated resource mix is the establishment and maintenance of a level playing field for all sources and the promotion and safeguarding of competition within the mix. Unfortunately, many conventional sources, particularly fossil fuel sources, enjoy all sorts of explicit and/or implicit subsidies apart from excluding external costs. Ideally, therefore, policies must be implemented to eliminate permanent subsidies and to ensure that social and environmental costs are reflected in pricing. Failing this, a perhaps less satisfactory but necessary alternative is to accord to renewables compensating subsidies and/or "green" rewards.

The plea for rationally derived mixes of conventional sources, renewable sources and efficiency improvements implies that the share of renewable sources must not be stipulated in advance; rather it must be the outcome of an exercise. However, pending this exercise of arriving at the share of renewables, experience of previous exercises shows [7,8] that the share turns out to be of the order of 10%. Further, renewables (excluding traditional biomass) currently have such a small share in the total usage pattern that the bias(es) against them must be corrected.

One important step in this direction is to articulate a renewables manifesto[g]. An essential part of such a manifesto would be the definition of targets for renewables as interim measures. Setting a target sends a strong economic and political signal that can amplify the power of the market. An impressive example of such a target is the May 2002 resolution of the São Paulo Forum of Ministers of Environment from Latin American and Caribbean Countries[9] to "increase in the region the use of renewable energy to 10% as a share of total by 2010". Equally impressive is the European Union target of attaining 12% energy from renewables by 2010. One must conclude that such a target must be a crucial part of a REPP without which the package would be largely ineffective.

Since most renewable energy technologies are maturing and their costs are declining, there must be special policies in place to promote technological advances and organisational learning. Further, since the costs of renewable energy technologies are declining (Figure 2) because of technological advances and organisational learning (Appendix 1), they must not be compared on the basis of their current costs. Their place in the mix must be determined on the basis of their future costs after technological advances and organisational learning. This means that the difference between current and future costs must be compensated for through special policies. If subsidies are used as the relevant policy instrument, they must be time-bound (and not a permanent crutch) and they must be justified on the basis that they are indeed promoting technological advances and organisational learning.

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[g] Manifesto = call to action

Since the economics of a renewable energy source depends upon the sale of its output (say electricity), then it is vital that government formulates and implements policies that guarantee via long-term contracts with assured power purchases at a reasonable price. The most well known example of such a measure is the Public Utilities Regulatory Policy Act (PURPA)[10] in the USA whereby utilities were obliged to buy-back electricity from renewable sources at reasonable rates with long-term contracts. This was the single most helpful measure that led to the dramatic increase in independent non-utility power production. Even in India the wheeling and banking arrangements provided by the electricity boards were responsible for the growth of wind power to over 800 MW.

Unfortunately, the corporatisation of the electricity boards and their obligation to run on commercial lines (unencumbered by environmental responsibilities) may threaten the future of renewable energy as has happened in the USA. In this context of power sector restructuring and reform, attempts to protect renewables in the USA have involved measures such as the Renewables Portfolio Standard[11] (RPS). According to the RPS, each electricity supplier must provide a minimum percentage (specified by the government, say 0.5%) of renewable energy in its portfolio of electricity supplies. The electricity retailer is free to obtain the renewable energy from its own facilities or through purchase from other suppliers.

To summarise, a REPP must include

- a renewables manifesto,
- the definition of targets (as interim measures) for renewables,
- protection of the place of renewables with special measures with regard to supply and end-use,
- assured purchases at reasonable prices of fuels and/or electricity from renewable sources,
- the promotion of technological advances and organisational learning,
- the establishment and maintenance of a level playing field for all sources,
- the promotion and safeguarding of competition within the mix.

RETs for the Near-, Medium- and Long-term

The identification of renewable technological options for sources/ devices depends very much on the time horizon. Unfortunately, two extreme trends can be observed. Grassroots development workers are preoccupied with the immediate problems of the people with whom they work directly. As a result, they tend to choose technological options that are straightaway available off-the-shelf. They use a very high discount rate for their technological decisions being totally preoccupied with the present. In contrast, technical experts are excited by technological possibilities. They talk of futuristic solutions as if they are already valid. They use a very low discount rate for their technological decisions being totally preoccupied with the distant future. Thus, the grassroots rural development workers are moved by real human beings and restrict themselves to “Band-Aid” or Quick-Fix remedies forgetting about ultimate sustainable solutions. In contrast, technologists are sometimes enamoured with technological innovations even though these will take quite considerable time to become realities. They are little concerned with the fact that, while waiting for “the Pie in the Sky”, people are condemned to remain in their present misery.

Obviously, an either-or approach must be avoided. Starting from the present technology (the initial condition), there is a necessity of three types of technologies for each energy-utilising task. A near-term technology should lead to immediate improvement compared to the present situation. A medium-term technology to achieve a dramatic advance should be available in five to ten years. And a long-term technology should prevail after say 20 to 30 years and provide an ideal sustainable solution. Ideally, the technologies for the near, medium- and long-terms should be forward compatible so that the technology at any one stage should be upgradable to the better version. And in planning efforts, it is wise to have a balanced portfolio with a combination of near-, medium- and long-term technologies. This will ensure that political decision-makers will support long-term technologies because of guarantees of near-term improvements before the next election.

The present emphasis with regard to electricity as a convenient energy carrier is on grid electricity. However, due to the problems of supplying grid electricity to small and scattered loads, the attraction of decentralised generation of electricity is increasing. Where appropriate, decentralised generation from biomass and from the intermittent sources of wind and/or small hydel, solar photovoltaics and solar-thermal devices have roles to play. New possibilities are arising because of the development of micro-turbines. Biomass-based generation of fuels to run fuel cells is an attractive long-term option particular because there are possibilities of generating surplus base-load power that can be exported from rural areas to urban metropolises.

At present, the predominant fuel in rural areas is biomass, particularly fuelwood and agricultural crop residues. Improving the efficiency of the stoves in which these biomass sources are combusted is an immediate challenge, but a switch to stoves and furnaces fuelled with natural gas and LPG is an obvious next step. But, modern LPG-like fuels derived from biomass, so-called biofuels, are the medium- and long-term answer.

In the case of cooking, the perspective should be to go from the present inefficient, unhealthy stoves using arduously gathered fuelwood through improved woodstoves to gaseous-fuelled stoves to clean, efficient and convenient stoves operating on electricity or on gaseous biomass-based biofuels.

The provision of safe water is a crucial task that yields an enormous payoff in terms of improved health. But, it invariably requires inputs of energy to go from surface water (often contaminated) to “safe” ground water lifted from tubewells to filtered or treated water to safe piped water.

With roughly 70% of rural households being without electricity connections and therefore being forced to depend on lamps burning plant oils or kerosene, the way forward is electric incandescent bulbs that are replaced as rapidly as possible with fluorescent tubelights and compact fluorescent lamps.

Radical improvements in the quality of life often depend on replacing human and animal power with motive power based on electric motors and engines driven by the combustion of fuels. Today, fossil fuels are conventional sources for engines but prime movers running on biomass-derived fuels and hydrogen are the future. In parallel, motors with much greater efficiency should be implemented.

The plight of women is very much connected to their being forced to put in enormous amounts of arduous physical labour performing various household chores. A key objective of rural energy must therefore involve the displacement of this manual labour with appliances. The advance can then be from simple electrical appliances to efficient appliances and super-efficient appliances.

Rural industries such as pottery and metalworking are currently based on process heat derived from fuelwood and/or other biomass sources such as sugarcane bagasse. Future developments have to be based on electric furnaces, cogenerated heat, and solar thermal and induction furnaces. The long-term future will perhaps belong to furnaces based biomass-derived fuels.

Rural transport particularly within villages and from house to farm and vice versa is today based overwhelmingly on animal-drawn vehicles and human-powered bicycles. Mechanisation, however, is making inroads with vehicles fuelled with petroleum products gasoline/motor spirit and diesel. Natural-gas-fuelled vehicles are bound to play a part. Over the medium-term, however, vehicles can be run on biomass-derived fuels such as producer gas and/or methanol and/or ethanol and over the long-term, fuel-cell-driven vehicles are the option.

Table 1: Sources and Devices for the Near-, Medium- and Long-term[h]

SOURCE	PRESENT	NEAR TERM	MEDIUM TERM	LONG TERM
Electricity	Grid or No electricity	*Biomass-based generation via IC Engines/ Micro-turbines*	*Biomass-based generation PV/Wind/ Small Hydel/ Solar Thermal*	*Fuel Cells for baseload power*
Fuels	*Wood/Charcoal/Animal Wastes/Crop Residues*	NG/LPG/ *Producer Gas/Biogas*	*Biofuels/ Synthetic DME*/LPG	*Biofuels*
TASK	PRESENT	NEAR TERM	MEDIUM TERM	LONG TERM
Cooking	*Woodstoves*	*Improved Woodstoves/ Producer Gas/Biogas*	LPG/*Biogas/Producer Gas*/NG/*DiMethyl Ether (DME)* Stoves	*Gaseous biofuelled Stoves/* Catalytic Burners/ Electric Stoves

h This table benefited from finishing touches from Robert Williams (Princeton University).

Safe Water	Surface/ Tubewell Water	Filtered/UV radiated/ Treated Water	Safe piped/ Centralised/ Decentralised Treated water	Ultra Safe piped/ treated water
Lighting	Oil/Kerosene Lamps	*Electric Lights*	*Fluorescent/ Compact Fluorescent Lamps*	*Fluorescent/ Compact Fluorescent Lamps*
Motive Power	*Human/Animal powered devices*	IC Engines/ Electric motors	*Biofuelled prime movers*/ Fuel cells/ Micro-turbines/ Improved motors	*Biofuelled prime movers* Improved motors
Appliances	--	Electric Appliances	Efficient appliances	Super-efficient appliances
Process Heat	*Wood/Biomass*	Electric Furnaces/ *Producer Gas*/ Cogeneration/ NG-fueled/ *Solar Thermal*	Induction Furnaces *Biomass-fuelled Solar Thermal*	*Biofuels/ Solar*
Transport	*Animal-drawn vehicles/human-powered bicycles*	Petroleum/ NG-fuelled Vehicles	*Biomass-fuelled vehicles*	*Fuel-cell driven vehicles*

General Implications of Renewable Energy Strategies and Policies

If renewable energy strategies and policies are oriented towards the goal of sustainable development in the manner outlined above, they will have implications for other pressing social problems. Above all, they will result in a betterment of the quality of life. They will advance poverty alleviation in a direct way. In addition, they will dramatically improve the position of women. The life of children will also be improved. The environment and the health of inhabitants will take a turn for the better. In the long run, there will be a positive impact on population growth. Thus, a focus on renewable energy will have a synergistic effect on an array of major social problems.

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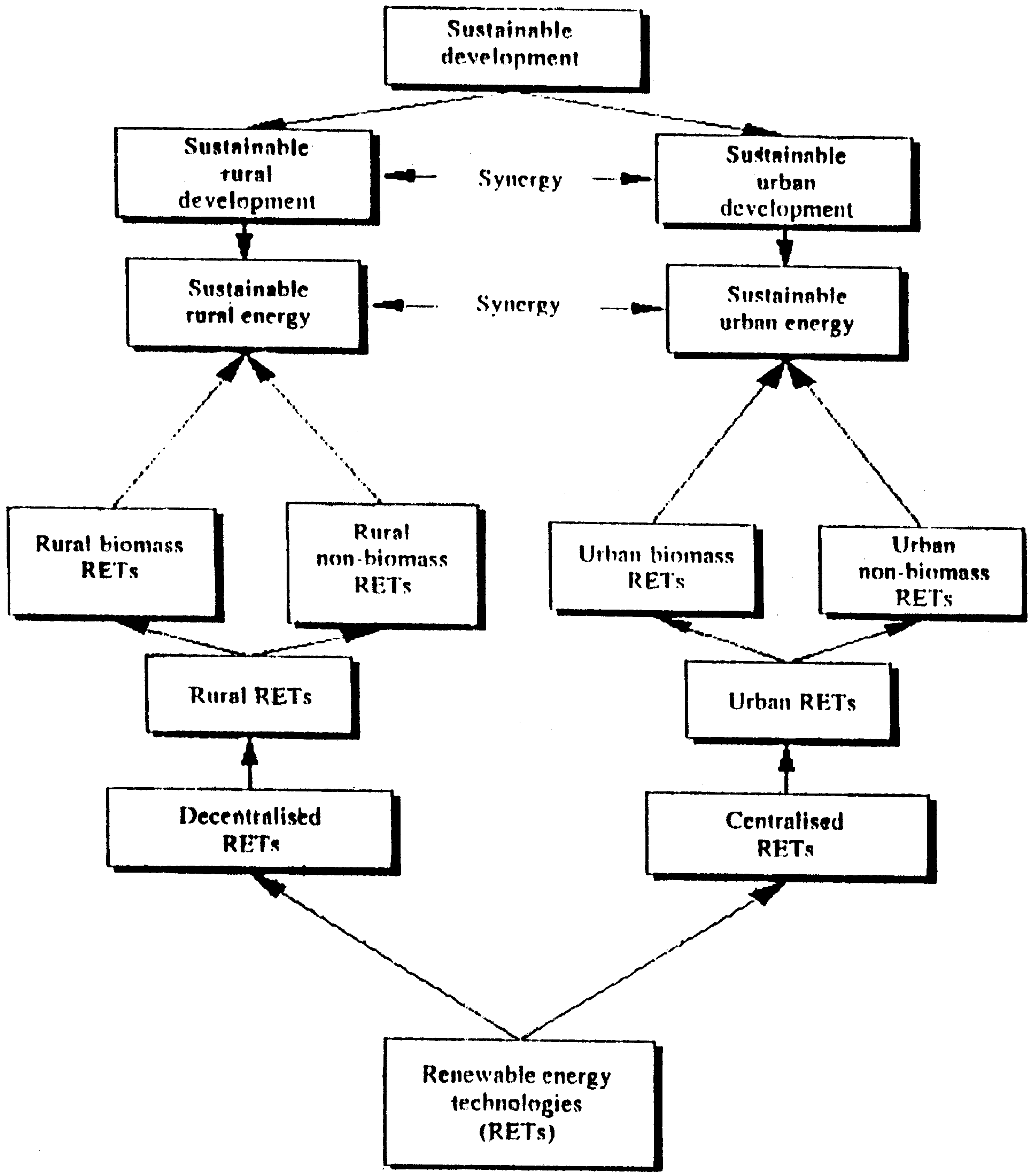

Figure 1: Sustainable Development, Biomass Energy and Renewable Energy Technologies

Appendix 1: Organisational Learning

Organisational learning corresponds to improvements through better organisation. It is manifested through *learning curves* for near-term cost reductions achieved by improvements in the efficiency or organisation of the work force, management, or other variable inputs for a given production process. Organisational learning is also manifested through *experience curves* for long-term improvements and cost reductions from every conceivable source including technical improvements, input substitution, economies of scale, new product design, changing input prices and labour productivity improvement. The phenomenon can be described by the formula $c(x) = ax^b$ where c(x) is the cost of producing the xth unit of output, x, the cumulative production, between the 1st and xth unit, a, the cost of producing the 1st unit, and b, a measure of the rate of cost reduction as cumulative production increases. Typically, the cost declines 20% for each doubling of cumulative production, corresponding to a Progress Ratio of 80%.

Endnotes and References

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3 Reddy, A.K.N., "Barriers to Improvements in Energy Efficiency", presented at "The International Workshop on Reducing Carbon Emission from the Developing World: Assessment of Benefits,Costs and Barriers, Berkeley,CA, October 4, 1990, Report LBL-31349, 1991 and published in **Energy Policy**, Vol. 19, No.10 Special Issue: Climate change - country case studies: (1991), pp 953-961.

4 After this paper was written, the author received an independent study by Sudhakar Reddy, B., "Barriers to the Diffusion of Renewable Energy Technologies – A Case Study of the State of Maharashtra, India", UNEP Collaborating Centre on Energy and Environment, Ris Nastional Laboratory, Roskilde, Denmark. 2001

5 The availability must take into account any hourly, daily, monthly and seasonal variation in the renewable source. Also, if dispersed biomass feedstock has to be collected and taken to a processing plant, the associated transport costs may involve dis-economies that may make enlarging the scale unviable proposition. For instance, only by turning a blind eye to these transport costs can expansion from say village-scale to taluk-scale energy systems be made to look attractive (a taluk is an administrative unit of about 100 contiguous villages of about 1000 km^2 and a population of about 200,000) (cf. Rajvanshi, Anil K., "Talukas can provide critical mass for India's sustainable development", pp 632, **Current Science,** Vol. 82, No. 6, 25 March 2002

6 Reddy, A.K.N., "The Blessings of the Commons or How Pura Village dealt with the Tragedy of the Commons", **Energy for Sustainable Development**, Vol.II, No.1, May 1995 pp 48-50.

7 According to the **Vision 2030** of the Pacific Gas & Electric (PG&E), California,

the share of renewables was envisaged to rise from about 6% in 2010 to 15% in 2020 to 38% in 2030.

8 A least cost planning exercise for the state of Karnataka in India led to 25% role for renewables: Reddy, A.K.N., Sumithra, Gladys D, Balachandra, P. and D'Sa, A., A Development -Focused End-Use-Oriented Electricity Scenario for Karnataka. Part 1 Economic and Political Weekly, Vol XXVI, Nos 14 & 15, April 6 1991 pp 891-910 and Part II Economic and Political Weekly April 13 1991, pp 983-1002.

9 Goldemberg, José, "The Brazilian Energy Initiative", 2002 (private communication).

10 The Public Utilities Regulatory Act (PURPA), USA, 1978

11 The Renewables Portfolio Standard (RPS) is a policy requirement that a small but growing minimum percentage of the nation's power supply portfolio in the USA come from renewable sources like wind, solar, biomass and geothermal energy. The RPS can put the electricity industry on a path toward increasing sustainability.