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Barriers to renewable energy penetration; a framework for analysis

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Abstract

Renewable energy has the potential to play an important role in providing energy with sustainability to the vast populations in developing countries who as yet have no access to clean energy. Although economically viable for several applications, renewable energy has not been able to realise its potential due to several barriers to its penetration. A framework has been developed in this paper to identify the barriers to renewable energy penetration and to suggest measures to overcome them.

Keywords: Renewable energy; Barriers; Measures to overcome barriers; Barrier framework

1. Introduction

Renewable energy has been considered as one of the strong contenders to improve plight of two billion people, mostly in rural areas, without access to modern forms of energy [1]. At least another half billion people have such limited or unreliable access that for all intents and purposes they do not have access. It must be kept in mind that these people live in regions of the world where the population is growing most rapidly. If we are to make a difference in these people's lives, we have to provide them with a connection to the electricity grid or provide them with power sources suitable for off-grid applications — i.e. renewable electric technologies. When people have no access to electricity, even a small wind turbine or a low wattage photovoltaic panel combined with battery storage can make a very large

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difference in the quality of their lives. Many experts now argue that technologies such as solar, wind, and small-scale hydropower are not only economically viable but also ideal for rural areas. Renewable energy technologies (RETs) are cost-competitive with conventional energy sources in applications such as solar water heating, off-grid electrification with solar photovoltaics (PV), small-scale biomass power generation, biofuels, grid-connected and off-grid wind power, small hydropower, geothermal power, and methane utilisation from urban and industrial waste [2]. Despite technological developments and economic viability for several applications, renewable energy has been tapped only to a small fraction of its potential. This is due to the existence of several types of barriers to the penetration of renewable energy. Recognising this, the Global Environment Facility set up an operational programme during execution of it's second tranche to support projects for the removal of barriers to renewable energy in developing countries. Several other international donors also fund barrier removal projects. The barriers to renewable energy may vary across technologies and countries. This paper focuses on identification of these barriers and possible ways to overcome them.

2. Potential for renewable energy technologies (RETs)

Renewable energy sources currently supply somewhere between 15% and 20% of total world energy demand. It is estimated that in 1990, all renewable energy sources produced nearly 2900 TWh, accounting for about 24% of the world's total electricity supply [3]. If traditional uses of biomass were also taken into account, then renewables would supply nearly 18% of global energy demand [4]. Most of the renewables contribution to current electricity supply is provided by hydroelectric schemes, a large proportion of which has been in place for a considerable time. However, the importance of the newer technologies is increasing. From a small base in the 1970s, the 'new' renewables (i.e. biomass, geothermal, PV, small-scale hydro, solar thermal electric and wind) have grown proportionally more rapidly than any other electricity supply technology [4]. Again, most regions of the world have contributed to the exploitation of these new resources.

The International Energy Agency projects that, without new policy initiatives, fossil fuels will account for more than 90% of total primary energy demand in 2020 [5]. Looking even further into the 21st century, the World Bank has estimated that developing countries alone over the next four decades will require five million megawatts of new electrical generating capacity to meet anticipated needs. To put this number into perspective, the world's total installed capacity today is three million megawatts. Thus, even if the World Bank's estimate is too optimistic, we will essentially have to double the world's installed capacity during the next 40 years. In financial terms, this amount of new capacity will require approximately five trillion dollars of new investment. While it is true that renewables can anticipate capturing only a fraction of this market, every 1% of that market in developing countries represents approximately US$50 billion of investments. If renewables can capture several percent of that market, we're looking at a potential for several hundred billion

dollars of renewable technology sales world-wide and creation of many new jobs over the next decades.

Major international studies indicate significant growth-potential for renewables, particularly in scenarios where environmental constraints are imposed, for example on CO_2 emissions [6]:

1. International Energy Agency: 7.5–8.5% annual growth in the commercial use of energy from 'new' renewables to 2010;
2. World Energy Council:
   Business as usual scenario: growth from 18 to 21% of world needs by 2020
   Ecologically driven scenario: growth from 18 to 30% of world needs by 2020;
3. United Nations: growth to 30% of world needs met by renewables by 2025 and 45% by 2050.

By 2100 the capital stock of the global energy system will turn over at least twice, offering the opportunity to increase renewables contribution significantly. World Energy Council/IIASA scenarios for global energy consumption indicate a large contribution from renewables by 2050, equivalent to total fossil fuel and nuclear in 1990, and three times this amount by 2100. However this requires substantial expenditure on R&D and support for initial deployment, estimated to be US$15–20 billion by the World Energy Council.

The technological potential of RETs is virtually many times current world energy requirement [7], but is limited by climatic and organisational conditions (e.g. available amounts of water, wind, biomass, structure of urban development and land use). Their development is, therefore, an essential ingredient in the realisation of a sustainable energy system. Scientific studies and project experiences have identified applications such as solar PV systems for home electrification, electricity from mini-hydro, wind and solar for villages, wind powered pumps for agricultural water supply, biogas digesters for lighting and water pumping, heating, cooling, and hot water for buildings using solar technologies and so on [2]. Many of these opportunities provided by the RETs are not being realised due to barriers to their diffusion.

3. What are the barriers to RETs?

Several barriers that have prevented penetration of RETs, have been listed in the literature. These include cost-effectiveness, technical barriers, and market barriers such as inconsistent pricing structures, institutional, political and regulatory barriers, and social and environmental barriers. Some barriers may be specific to a technology, while some may be specific to a country or a region. Barriers were briefly discussed in the IPCC second assessment report [8], and the IPCC third assessment (currently underway) is scheduled to cover the barriers in details. The Global Environmental Facility has a full-fledged operational programme on barrier removal. A detailed discussion on barriers and measures to overcome the barriers can be found in a GEF paper by Martinot and McDoom [2]. They also discuss barriers studied in various

energy efficiency and RET projects financed by GEF. Solar PVs have received special attention as a potential RET; barriers and ways to overcome them can be found in a World Bank report [9] and also in Oliver and Jackson [10].

Financing issues have been considered as crucial for the development of RETs. Financial barriers and measures need to be taken by the state to overcome the barriers and have been discussed by Gutermuth [11]. Financial incentives used in various countries to promote RETs have been discussed in detail in a World Bank workshop [12]. A World Bank discussion paper by Taylor and Bogach [13] reveals a strategy to accelerate RET development in China based on international assistance. Barriers to RET penetration with special discussions on financial barriers and initiatives to remove them have also been discussed by Norbert and Painuly [14].

4. A framework for identification of barriers

Before a study of barriers can be taken up, it is important to identify RETs that have potential in a country or a region. Once a technology has been identified for study of barriers, it is important that crucial barriers are not missed during the identification. At the same time, it may not be necessary to study all the barriers and the action needed to overcome them, in detail. In this section we propose a framework that may help in selection of RETs and identifying all the important and relevant barriers for a RET.

4.1. Selection of RETs

4.1.1. Literature survey

The first step may be a review of existing energy strategy and plans, and financial, institutional and legal mechanisms with reference to RETs. The study can indicate various shortcomings in the policies and mechanisms that impede implementation of RETs. In addition to this, a review of national studies and reports related to existing renewable energy projects, their evaluation, reasons for their success and failures is useful for identifying suitable RETs, and barriers to their diffusion. It is obvious that RETs that have significant potential for contribution in a country will be the candidates for the study of barriers and ways to overcome them. The first step therefore is to identify RETs that have potential.

The potential for a RET can refer to its *technological potential, techno-economic potential,* or *economic potential*. The technological potential refers to the case (level of usage) when it is assumed that a technically feasible technology is universally used and constraints such as cost, reliability, and other such attributes that may hinder its application, do not exist. The techno-economic potential refers to the case when it is assumed that a technically feasible and economically viable technology is universally used in a competitive market and constraints such as consumer preferences, social and institutional barriers, financial barriers etc. to its usage do not exist. Finally, economic potential refers to the case when a technology (technically feasible and economically viable) was to be used in an environment free from market failures

and distortions.[1] Current usage level of the technology can be referred to as market potential; a level attained with existing barriers. Thus, technological potential refers to the highest order of theoretically possible usage level, followed by techno-economic potential and economic potential in that order. RET diffusion refers to the phenomenon where we try to move the market potential (current usage level) up this ladder and reduce the gap. There are different barriers that need to be overcome to move from one level to another through various actions by stakeholders and governmental policy measures. Scientific and technological progress in terms of improved technology and reduction in costs can continuously improve all three types of potentials. There may be several additional barriers to diffusion of a RET at a country or regional level depending on availability of resources (material, capital, and skill), technology availability, financing etc.

4.1.2. Criteria for selection of RETs

Adequacy of potential is a pre-requisite and several other factors may have to be considered in a country while selecting RETs for study of barriers. These may include:

- adequate resource base for the RET (solar, bio-mass, hydro, etc);
- available technologies and their costs;
- commercial viability and financing (public, private, international);
- environmental impacts and benefits;
- socio-economic impacts, including job creation;
- coverage of both centralised and decentralised options.

Identification of suitable RETs for a country is an important step and it may involve qualitative and quantitative assessment RETs based on relevant criteria (some of which are suggested above), consultation with the various governmental agencies, NGOs and other stakeholders involved in promoting RETs. Selection of RETs may itself be a lengthy process depending on the extent of renewable energy development in a country, but it is not elaborated upon here.

4.2. Identification of barriers for the study

Apart from the literature survey and study of the existing projects, interaction with various stakeholders is required to identify the barriers. Broadly, the barriers can be identified using the following approaches:

1. *Literature survey*: Literature on similar projects, barriers, case studies at local,

[1] A technology that has been demonstrated with the prototypes is referred to as technically feasible. A technology that renders a positive rate of return (normally considered acceptable) using economic cost and benefit analysis is considered economically viable. Market failures refers to the absence of conditions required for perfect competition in the market, and distortions refers to the deliberate actions that lead to market failure.

regional, national and international level can be referred to. Case studies of similar projects can be quite useful.

2. *Site visits*: Site visits should be made, wherever possible, to study the projects closely. The insight obtained from field study can be valuable in barrier identification.
3. *Interaction with stakeholders*: It is important that stakeholders' perspective is taken into consideration. Stakeholders may include RET industry (manufacturers of plant, equipment and appliances, owners of plant), consumers, NGOs, experts, policy makers (government), and professional associations. The interaction can be through structured interviews and/or questionnaires. This approach is very crucial to identification of the barriers as the perception of stakeholders on barriers may reveal the lacunae in existing policies and help in identification of measures to overcome the barriers.

These measures compliment each other. Therefore, it is recommended that all three approaches be used for the identification of barriers.

Barriers can be explored and analysed at several levels. These have been illustrated in Fig. 1. The top level (first level) is a broad category of barriers and as we go to lower levels, we go into more detail and specifics. Thus at the second level, we have various barriers within a category, and at the third, various elements of these barriers. A bottom-up approach can be used to identify the presence of barriers. This means that to conclude whether a barrier or a barrier category is relevant for a RET or not, presence of at least one of its components at a lower level is necessary. It can be seen that the advantage of decomposition of a barrier into its elements is clarity on causes for presence of a barrier that stakeholders may find easy to understand and respond to. Another advantage is that measures to overcome a barrier can be identified easily. It is also possible to go to a fourth level of analysis where dimension (depth and/or direction, as the case may be) of a barrier element can be explored

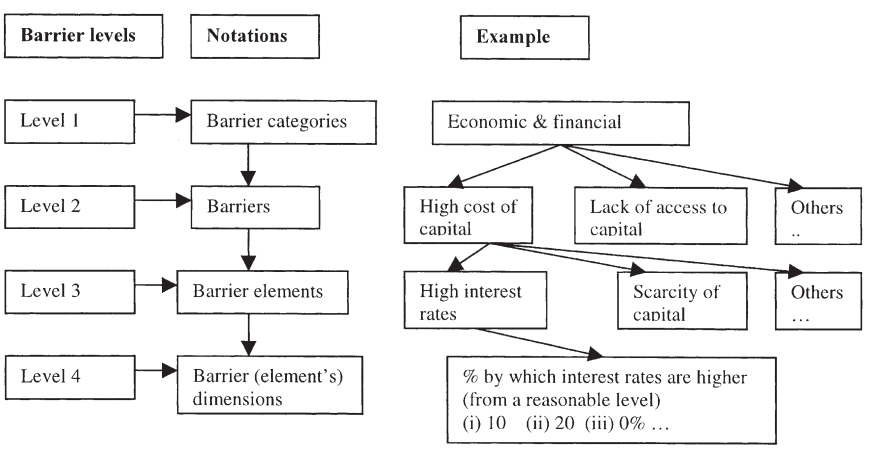

Fig. 1. Barriers levels.

and specifics of barrier removal measure can be worked out (see example in Fig. 1). This also ensures that measures recommended to overcome the barriers are consistent with their dimensions. But this would require that respondents have the capacity and willingness to cooperate.

Major barriers have been categorised and listed in Table 1. The impact of the

Table 1
Barriers to RETs penetration[a,b]

Barrier category	Barriers	Remarks
1. *Market Failure/imperfection*	Highly controlled energy sector	This may lead to lack of investments in RETs.
	Lack of information and awareness	It increases uncertainty, and hence costs.
	Restricted access to technology	Technology not available or available at high cost.
	Lack of competition	Product cost increases.
	High transaction costs	Economic viability of the project may be affected.
	Missing market infrastructure	It may increase cost of product to the consumer.
	High investment requirements	This acts as an entry barrier for entrepreneurs.
2. *Market Distortions*	Favour (such as subsidies) to conventional energy	This affects competitiveness of renewable energy adversely.
	Taxes on RETs	Cost of energy from RETs increases.
	Non-consideration of externalities	Cost of conventional energy is less than what it should be.
	Trade barriers	Cost of RETs may go up, for example due to high taxes on RET imports.
3. *Economic and Financial*	Economically not viable	Cost reduction in RETs needed.
	High discount rates	Incentives may be needed in the initial stages.
	High payback period	Project becomes un-viable.
	Market size small	Economy of scale cannot be achieved.
	High cost of capital	It may affect economic viability.
	Lack of access to capital	No. of producers less, and hence competition and market efficiency may suffer.
	Lack of access to credit to consumers	It may reduce market size.
	High up-front capital costs for investors	Capital costs may also go up due to increased risk perception. Adverse effect on competition and efficiency.
	Lack of financial institutions to support RETs, lack of instruments	Supply of RET products may suffer. Adverse effect on competition and efficiency.

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Table 1 (*continued*)

Barrier category	Barriers	Remarks
4. *Institutional*[c]	Lack of institutions/mechanisms to disseminate information	It leads to non-availability of information with producers as well as consumers.
	Lack of a legal/regulatory framework	Renewable energy producers may face market/economic/financial barriers without this.5y
	Problems in realising financial incentives	This may be due to red tape, leading to economic/financial barriers.
	Unstable macro-economic environment	This may increase risk and uncertainty for new investments. Only products with low payback period may be acceptable.
	Lack of involvement of stakeholders in decision making	This can result in mis-placed priorities.
	Clash of interests	This may lead to powerful lobbies against RETs.
	Lack of R&D culture	This may make adaptation of technology difficult.
	Lack of private sector participation	Lack of competition and inefficiency is possibly due to this.
	Lack of professional institutions	Producers' problems and views on barriers cannot reach the policy makers effectively.
5. *Technical*	Lack of standard and codes and certification	Product quality and product acceptability is affected. Purchase and commercial risk increases, as also negative perception about technology.
	Lack of skilled personnel/training facilities	This can be a constraint for producers.
	Lack of O&M facilities	This can affect product acceptance.
	Lack of entrepreneurs	It may lead to lack of competition and supply constraints.
	System constraints	Market can not be realised by producers.
	Product not reliable.	Market size may get affected.
6. *Social, Cultural and Behavioural*	Lack of consumer acceptance of the product	Market size becomes small.
	Lack of social acceptance for some RETs	Affects market size. For example, gas from urban waste for cooking may not be acceptable to a sizeable segment.

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presence of a barrier on RETs has been indicated in the remark column. The elements of various barriers have been listed in Table 2. The lists can be expanded or shortened depending on the preliminary estimate of the relevance of the items for the RET under investigation. Questionnaires for stakeholders can be formulated or interviews

Table 1 (*continued*)

Barrier category	Barriers	Remarks
7. *Other Barriers*	Uncertain governmental policies	It creates uncertainty and results in lack of confidence. May also increase cost of project.
	Environmental	Environmental damages/pollution may be unacceptable.
	High risk perception for RETs	It increases cost of capital (high financial risk) as well as discount rate of producer.
	Lack of infrastructure	RETs such as wind may need strong infrastructure development such as roads, grid connectivity.

[a] Barriers at sl. nos. 1 and 2 need to be overcome to achieve economic potential of a RET. In addition to these, barriers at sl. nos. 3–7 need to be overcome to achieve techno-economic potential. Technical potential is theoretically maximum potential, difficult to achieve in practice. Scientific and technological developments that reduce costs and address other concerns related to the technology can however reduce the gap between techno-economic and technical potential.

[b] The classification of barriers in a category is not very rigid. Some barriers can belong to more than one category and in some cases, readers may want to assign a barrier to a different category than assigned here. Some barriers may also be related to each other, or in same cases may have a cause–effect relationship even within a level.

[c] In the literature on barriers, this category has been found to include absence of institutional structures and mechanisms as well as practices that act as barriers. Here, both have been included in this category.

structured around these elements of the barriers. The purpose is to find out the relevance of a barrier (elements) for a RET and identify measures that can be taken to overcome them. It may appear that once barriers have been identified, measures to overcome may follow from that, and hence stakeholders' involvement in identifying the measures may not be necessary. However, it is not that simple due to varying experience on problems and perception on possible solutions among the stakeholders. Therefore, stakeholders need to be involved not only in identifying the barriers but also in identifying measures to overcome the barriers. After preliminary identification of barriers through the literature survey, measures to overcome the barriers corresponding to their dimension can also be included in the questionnaires to elicit stakeholders' views on the measures. Some precautions required are: (i) care should be taken to design suitable questionnaire for each category of stakeholders, (ii) to keep provision for addition of barriers and measures to this list by the stakeholders, and (iii) lastly, a useful source of information can be stakeholders' opinion on these issues beyond items covered in the structured questions. Therefore, a provision for that should also be made.

5. Measures to overcome barriers

It may not be possible to achieve technical potential but research and development can reduce the gap between techno-economic potential and technical potential. In most of the cases, the aim is to achieve or move closer to techno-economic potential.

Table 2
Elements of various barriers

Barriers	Barrier elements
1. *Market Failure*	
Highly controlled energy sector	Governmental monopoly of energy sector, private sector entry restricted, monopoly of energy supplier and/ or distributor, electricity generation, transmission and distribution controlled, lack of private sector investment.
Lack of awareness and information	Lack/low level of awareness, inadequate information on product, technology, costs, benefits & potential of the RET, O&M costs, financing sources etc. Lack of agencies, or agencies ill equipped to provide information. Also, feedback mechanism may be missing or inadequate. Lack of knowledge/access to RET resource assessment data, implementation requirements.
Restricted access to technology	Technology not freely available in the market, technology developer not willing to transfer technology, problems in import of technology/equipment due to restrictive policies/taxes etc.
Lack of competition	Regulations prohibiting entry in the energy sector, unwieldy requirements for entry, governmental monopoly, barriers created by existing suppliers.
High transaction costs	Related to gathering and processing information, procedures and delays, technology acquisition, implementation etc., poor infrastructure, red tape, costs underestimated in economic analysis.
Poor market infrastructure	Missing or under-developed supply channels, logistic problems, lack of product visibility, lack of availability, difficult procurement (by consumers), inconvenient product location etc., lack of liberalisation in energy sector, mismanaged energy sector.
High investment requirements	Economies of scale only at high investment level.
2. *Market Distortions*	
Favourable treatment to conventional energy	Conventional energy is subsidised, consumers pay below marginal cost, average cost pricing is done, and low taxes compared to RETs.
Taxes on RETs	RET production is taxed unfavourably, high import duties on equipment, other direct/indirect taxes on RETs.
Non-consideration of externalities	Negatives externalities (pollution, damage from this) from conventional energy not considered in pricing, positive impacts of RETs not valued, free rider problem with positive externalities.
Trade barriers	Tariff and non-tariff barriers on import/export of RETs.
3. *Economic and Financial*	
Economically not viable	High cost of product (say energy produced) making it un-competitive, resource (material, labour, capital) costs are higher than expected, high implementation/adaptation costs, high user costs, inadequate resource base, competition for resources.
High discount rates	Equipment manufacturers/RE producers/consumers have high discount rate, risk/uncertainty is perceived as high.
High payback period	Low rate of return, inadequate incentives, high tax on profits.
Market size small	Market potential small, limited/difficult access to international market, market barriers within the country, potential not realised, proper assessment of RET market not done.

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Table 2 (*continued*)

Barriers	Barrier elements
High cost of capital	High interest rates, scarcity of capital, governmental policies on cost of capital, lack of access to cheap capital, risk perception by financial institutions, macro-economic parameters such as inflation rate, demand for credit etc.
Lack/inadequate access to capital	Distorted capital markets, governmental policies, poor creditworthiness, and poor regulations.
Lack of access to credit to consumers	Under-developed credit market, poor credit worthiness, poor recovery regulations.
High up-front capital costs for investors	High-risk perception, lack of financing instruments/institutions.
Lack of financial institution, instruments	Under-developed capital markets, restricted entry to capital markets, unfavourable regulations.
4. *Institutional*	
Lack of institutions and mechanisms	Lack of institutions/mechanisms to generate and disseminate information, lack of interest/capacity in existing institutions, lack of institutions to promote and enhance market (say international market), need for specialised agencies at planning level, operational level (ESCOs), lack of a regulatory body in the energy sector.
Lack of a legal/regulatory framework	Missing or ineffective regulatory body, regulations inadequate to promote RETs, unfavourable regulations for RETs (restrictions related to aesthetic, safety and other considerations), lack of implementation of regulations, unwieldy regulations.
Problems in realising financial incentives	Complicated procedure, red tape, corruption.
Unstable macroeconomic environment	High inflation rate, unstable polity, high price fluctuations, balance of payment problems, unstable currency, uncertain exchange rates, lack of coherent economic policies, uncertain economic growth.
Lack of involvement of stakeholders in decision making	Stakeholders' consultation culture missing, stakeholders dispersed, difficult communication, fear of opposition.
Clash of interests	RETs competing with conventional energy, threat to utility dominance, threat to utility profit, powerful lobbies against RETs, threat of transfer of control over energy, powerful lobbies for conventional energy, decoupling of investor–consumer interests (investor does not save and consumer cannot invest; e.g. SWH, tenant may not).
Lack of R&D culture	R&D facilities missing, lack of capacity for R&D, lack of appreciation of R&D role in technology adaptation.
Lack of private sector participation	Governmental policies, lack of capacity, better opportunities, restrictive regulations.
Lack of professional institutions	Absence of professional/manufacturers' associations, ineffective consumer bodies, indifferent bureaucracy, lack of feedback to policy makers to promote RETs.
5. *Technical*	
Lack of standard, codes and certification	Lack of institution/initiative to fix standards, lack of capacity, lack of facilities for testing/certification.
Lack of skilled personnel	Lack of experts to train, lack of training facilities, inadequate efforts.

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Table 2 (*continued*)

Barriers	Barrier elements
Lack of O & M facilities	Lack of skilled personnel, lack of capacity.
Lack of entrepreneurs	Relatively low profitability, unwieldy/restrictive regulations.
System constraints	Capacity limitation with current grid system, integration problems (for example, for intermittent nature of electricity from RETs with the grid), lack of skill.
Product unreliable	Bad quality, lax quality control, missing or inadequate standards, bad work ethics, resource quality problems.
6. *Social, Cultural and Behavioural*	
Lack of consumer acceptance	Unknown product, aesthetic considerations, products lacks appeal, resistance to change, cultural reasons, high discount rates of consumers (due to risk and existing norm for PBP), inadequate information.
Lack of social acceptance	Lack of social acceptance for some RETs, technology seen as alien and of no use, lack of local participation, preference for traditional energy.
7. *Other Barriers*	
Uncertain governmental policies	Uncertainty in policies, un-supportive policies, inadequately equipped governmental agency, red tape, lack of governmental faith in RETs, lack of policies to integrate RET products with the global market, inadequately equipped governmental agency to handle the product.
Environmental	Ecological aspects (example water requirements for biomass production), local pollution (example, noise, visual impact in the case of wind energy), competition for resources (example, for land in the case of biomass production).
High risk perception for RETs	Uncertain new technology, uncertain benefits, high investment risks, irreversibility of investment and a lack of flexibility of plant and machinery for other usage.
Lack of infrastructure	Problems related to availability of infrastructure such as roads, connectivity to grid, communications, other logistics

Imperfections and distortions in the market coupled with unfavourable financial, institutional and regulatory environments imply that governmental intervention is not only desirable but also a must to promote RETs. The role of governments in technology transfer has been outlined in the IPCC special report on technology transfer [15], which is relevant for renewables too. The role includes generic actions to remove barriers, building human and institutional capacity, setting up research and development infrastructure, creating an enabling environment for investment, and providing information and mechanisms to promote RETs.

Policy approaches to achieve the techno-economic potential can either remove the barriers or create conditions where the market is forced to act, ignoring the barriers. The former normally works at the micro level addressing the barriers directly, and the latter mostly at macro level addressing the barriers indirectly. For example, setting up information centres, establishing codes and standards etc. address the barriers directly, whereas increasing energy prices through pollution taxation addresses the barriers indirectly.

The measures required to promote RETs thus follow from (a) identification of barriers through administration of questionnaires/interview of the stakeholders, and (b) feedback from stakeholders on the measures to overcome the barriers, obtained by extending the questionnaire/interview to include questions related to the possible measures. Finally, policy actions need to be designed and implemented to operationalise the measures identified to overcome the barriers. Some of the policy actions taken by various governments and implicit barrier removal measures in these are discussed below. Measures taken by IEA countries have been discussed in IEA [16,17]. Several possibilities may exist and the one that best suits a country should be chosen. Several of these measures have been explored by the Global Environment Facility (GEF) through support to RET projects in different countries (see [2] for details).

5.1. Energy sector liberalisation

This is a broad term encompassing several policy measures such as restructuring of the energy sector, opening up to introduce competition and removing other controls. Some examples of the specific policies are; creating separate entities for generation and distribution in the electricity sector, allowing private sector entry and diluting or removing controls on energy pricing, fuel use, fuel import, and capacity expansion etc. Institutional measures such as setting up independent regulatory bodies may be needed for success of these policy actions. The basic purpose of liberalisation is to increase efficiency of the energy sector through facilitating market competition. The initial impact of such measures may be unfavourable to RETs due to increased competitiveness. However, in the long term a liberalised energy market may provide a better environment for the healthy growth of RETs.

5.2. Guaranteed markets

Since renewable energy is not able to compete in the energy market with existing barriers, energy suppliers may be required by law to include a part of the energy from renewables in their supply mix. Examples of such measures are the Non-Fossil Fuel Obligation (NFFO) law in the UK, Electricity Feed Law (EFL) in Germany, and Renewable Portfolio Standard (RPS) in the US. The NFFO guarantees predetermined electricity prices for competitively selected renewable energy projects. It promotes reduced cost of RETs due to competitive process for project selection. Any extra cost to the electricity companies is reimbursed by a small charge to all electricity consumers. Five NFFO orders have been issued since the law was passed in 1989. The costs of generating electricity under NFFO contracts have been halved; NFFO-5 contracts were at an average of 2.71 p/kWh compared with the average pool selling price of 2.60 p/kWh in 1998 [18]. NFFO has now been succeeded by the New & Renewable Energy Policy. EFL required electricity network operators to buy all the electricity from renewables at premium prices. In April 1998, the EFL was changed slightly and now utilities are not required to accept more than 5% of their total electricity from renewable sources. In February 2000, the EFL was

replaced by the Renewable Energy Law, which provides a guaranteed price for electricity from renewables [19]. RPS requires each retail supplier of electricity to provide a specified percentage of renewable energy in its electricity supply portfolio. The obligations have been made tradable through renewable energy credits (RECs) with a view to introducing flexibility and reducing costs. A variation of these mechanisms is two-way metering, which is under consideration in some EU countries. In this, distributed electricity generation (generally at household level) can be used to meet own demand and surplus electricity can be fed back to the grid, allowing the household meter to run backwards. The buyback rate is thus 100% of the utility price [16]. Although these measures may improve economic efficiency of RETs, the impact in the short run is an increased cost of electricity.

5.3. Economic/financial incentives

Several governments provide capital subsidies for installation of renewable energy systems. However the capital subsidies need to have a defined phase out time frame to ensure efficiency improvements in RETs. For example, capital subsidies for wind energy in Denmark were phased out in 10 years time. Tax exemption, credit facilities and third party financing mechanisms are other measures in some IEA countries [16]. Incentive-based renewable energy programmes are in operation in several developing countries. The World Bank's renewable energy programmes in Indonesia (solar home system project), Sri Lanka, Laos etc. are incentive-based programmes. The ESMAP programme in Africa, sponsored by UNDP, World Bank and other donors is another example of use of financial incentives to promote renewable energy. Several developing countries such as India, China etc. have their own incentive-based renewable energy programmes. Developing countries such as Uganda, Zimbabwe etc. have also provided micro-credits to consumers through revolving funds.

5.4. Government investments

In countries where governments are major players in the energy sector, they have made national plans and strategies for promotion of RETs. Governments have also made investments through specialised agencies created for RET development.

5.5. Information and awareness campaigns

Several countries have initiated informative programmes to promote renewable energy. The stakeholders can be educated and supplied with the necessary tools to evaluate the RETs and design implementation. The campaigns are both general in nature as well as targetting specific RET product promotion.

5.6. Standards and regulations

Deregulation of the electricity industry to allow renewable energy producers access to the grid has been carried out in several countries. Regulatory measures to provide

a guaranteed market for renewable energy have been taken, and standards formulated to boost confidence in RET products.

5.7. Institutional measures

Specialised agencies to plan and promote RETs have been created in several countries. Regulatory agencies have also been set up in response to the need for liberalisation of the energy sector. Other measures include promotion of energy service companies (ESCOs) that address several barriers such as lack of up-front financing, credit facilities, and technical knowledge.

5.8. Research and development

Since high cost is a major barrier to RET penetration, R&D programmes have been set up to make it more competitive. Long-term RET technology costs can be reduced through research.

5.9. Facilitating measures

Several facilitating measures have been taken by governments. These include financing for feasibility studies, planning and fixing targets for renewable energy contribution, resource assessment for RETs at national and regional levels, siting of renewable energy systems, technology demonstrations etc. Skill development through training in various aspects of RETs (such as technical, regulatory, managerial, financial skills etc.) has been arranged by some governments and also facilitated through GEF projects.

5.10. Moral and ethical considerations

These measures include green pricing schemes, and voluntary actions. Green pricing schemes have been set up in some IEA countries that offer consumers to pay more for renewable electricity. Thus, the increased cost of energy from renewable sources is borne by consumers voluntarily. In the case of voluntary actions, utilities or energy suppliers make a voluntary commitment to increase the use of renewable energy. The target so fixed can be made binding through agreements.

It is suggested that the questionnaires for interaction with stakeholders should include possible measures to overcome the barriers to obtain the stakeholders' perspective on measures to overcome barriers. The response from stakeholders on barriers as well as measures can be varied. It is therefore important to synthesise and harmonise the responses carefully, to arrive at the recommendations. Pilot testing of questionnaires is also important to avoid misinterpretation of questions.

The response from stakeholders can be obtained on appropriate scales depending on the analysis requirements. However, it should be noted that response on a ratio or interval scale requires a high degree of judgement compared to response on an ordinal scale. For example, an ordinal scale specifying responses such as very

important, important, desirable, and not relevant is one of the simple and easy to use scales for finding the relevance of barriers and measures to overcome them.

6. Summary

RETs are cost-competitive with conventional energy sources in several applications, but despite this it has not been possible to tap their full potential. Developing countries, where access to energy is still not available for large populations, may provide vast potential for the growth of renewable energy, even if it succeeds in tapping a fraction of the potential market for energy. In developed countries also, where efforts are being made to increase the share of renewable energy due to environmental and sustainability considerations in energy usage, renewable energy may have a big market. However, several barriers, which may vary across countries, impede the penetration of RETs. The barriers need to be identified and overcome before this potential can be realised. A framework for this purpose has been proposed in the paper.

The process of barrier identification starts with selection of RETs for the study of barriers through a literature survey on RETs and related projects in the country. The study of barriers and measures to overcome the barriers should be carried out using a literature survey, site visits and interaction with the stakeholders. The stakeholders include the RET industry (manufacturers of plant, equipment and appliances, owners of plant), consumers, NGOs, experts, policy makers (government), and professional associations. The response from stakeholders can be obtained through structured interviews or questionnaires. It is important that all the relevant barriers are considered and their dimensions are revealed during the interaction with the stakeholders. Major barriers such as market barriers, economic and financial barriers, institutional barriers, and technical barriers have several elements (causes for presence of those barriers). Dimension (direction and depth) of these elements may vary across RETs and countries/regions. As a result, measures to overcome the barriers may also be unique to a country/region. Stakeholders' responses should be able to identify the barrier elements and their dimensions to the RETs under investigation. Stakeholder views on measures to overcome the barriers should also be obtained.

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