

Research Note

Financing Renewable Energy in India: A Review of Mechanisms in Wind and Solar Applications*

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Development of markets for, and large-scale use of, renewable energy products and technologies have been hindered by their high up-front capital costs; the renewable energy industry's inadequate access to credit; subsidies for fossil fuels; and low purchasing capacity among potential consumers. While conventional funding and financial instruments such as capital subsidies, donor grants, and tax rebates and similar fiscal incentives have been able to achieve a certain level of penetration, the large-scale use and commercialization of renewable energy products and technologies requires innovative approaches to the selection and delivery of financial instruments and mechanisms. This research note explores four instruments that are likely to be primary sources of finance for the development and commercialization of renewable energy technologies and products in the mid to long term: government finance; international funding (including the Clean Development Mechanism); private-sector finance (including financing through energy service companies); and micro-credit and community-based finance. The challenge of financing is addressed under a life-cycle approach, which looks at financing mechanisms for the phases of: (1) research and development; (2) demonstration; (3) early commercialization; and (4) demand-driven commercialization on two renewable energy sectors that are particularly relevant for developing countries: solar and wind power. Case studies from India are examined in each of the four categories of financing. Findings to date indicate that these four categories all play different roles at different stages of the life-cycle, not only individually, but also in combination. The research so far also shows that the roles of these four financing mechanisms are technology-specific.

Keywords: Renewable energy, energy finance, India, wind power, solar power.

1. Introduction

Developing markets for, and large-scale use of, renewable energy products and technologies have been hindered by the high up-front capital costs; the renewable energy industry's inadequate access to credit; subsidies for fossil fuels on the one hand; and low purchasing power among potential renewable energy consumers on the other. Approaches for addressing these barriers have generally centered on conventional funding and financial instruments such as capital subsidies, donor grants, and tax rebates

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and similar fiscal incentives. For people with low income, aid and grants have long been regarded as the most viable funding mechanisms. In a number of cases, donor governments have made proposals and provided funding to recipient governments. The latter select target communities and a contractor to undertake the installation and necessary training. Lack of maintenance and servicing have often resulted in the failure of projects using this approach.

While the above mechanisms have been able to achieve a certain level of penetration for renewable energy products and technologies, experience has shown that renewable energy development on a large and sustainable scale is only possible if it is not solely dependent on development aid or government subsidy. Other financing models involving private-sector finance and end-user contribution should play an increasing role. In addition to identifying new sources of finance, exploring innovative forms of delivery is another key issue. This paper explores four such financial instruments that are likely to be primary sources of finance for the development and commercialization of renewable energy technologies and products in the mid to long term. These are: government finance; international funding (including the Clean Development Mechanism (CDM)); private-sector finance (including financing through energy service companies); and micro-credit and community-based finance. The aim is to identify innovative mechanisms that: (1) bring down the high initial costs; (2) increase renewable energy's competitiveness against traditional fossil fuels; (3) reduce the transaction costs¹ of renewable energy products and technologies; and (4) ensure sustainability without public aid and direct subsidy.

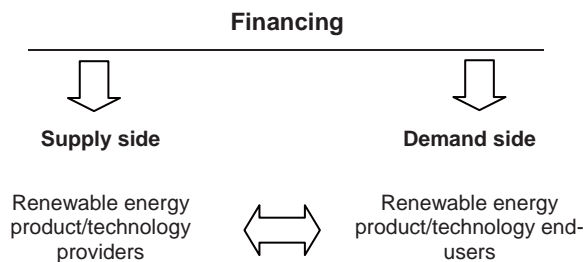


Figure 1. Linkages between financing and the demand and supply sides in relation to renewable energy products and technologies

With regard to financing, there appears to be a relationship of interdependence between the deployment of renewable energy products and technologies and their market demand. The availability of financing for research and development as well as for manufacturing is crucial for reducing the high costs of the systems. Similarly, adequate consumer finance enhances affordability and stimulates further demand, which in turn leads to further development of the renewable energy industry.

Given this inter-linkage between industry and market growth on the one hand and price reduction on the other, in this study the challenge of financing is addressed under a life-cycle approach, which looks at financing mechanisms for the stages of: (1) research and development, (2) demonstration, (3) early commercialization, and (4) demand-driven commercialization. Under this approach, the respective roles of the different financial instruments are examined, as well as their interaction at each stage of the cycle.

¹ Transaction costs here mean all the costs, besides the cost of the technology itself, that are required for taking technology and/or products to the user, including marketing, advertising, and awareness creation.

This is done by reviewing selected past and ongoing projects and programs and other financing initiatives in the four categories of financing selected. Cases studies are examined from India, which is one of the leading developing countries in the area of renewable energy.

Though there are many renewable energy technologies that have potential in developing countries and are currently in use, this study focuses on the financing of grid-connected wind power and off-grid solar photovoltaic (PV) power projects. For grid-connected wind power, detailed case studies were undertaken in the states of Tamil Nadu and Karnataka. Studies of the off-grid solar power sector covering decentralized applications (comprising solar home lighting systems (SHS) and photovoltaic-based mini-grids) were undertaken in the states of Rajasthan and West Bengal respectively.

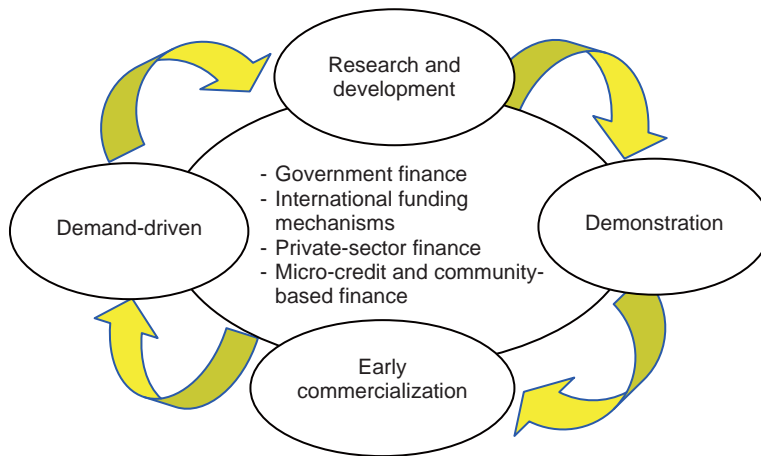


Figure 2. Renewable energy life-cycle flow chart

2. Renewable energy in India: policies, institutions, and financing

Renewable energy policy in India is driven by the need for energy security; diversified and growing energy needs; the presence of large unserved and poorly-served populations; abundant renewable resources; and opportunities under clean climate initiatives. The Ministry of Non-conventional Energy Sources (MNES), set up in 1992,² is the Government's nodal agency for all matters concerning the promotion of non-conventional/renewable energy. Complementing the efforts of the MNES at the central level, state governments add manpower and financial resources to promote the renewable energy programs in their respective states through state nodal agencies (SNAs); these are involved in designing, implementing, and supporting renewable energy programs. The MNES co-ordinates with the SNAs by providing policy guidelines as well as finance, either allocated as subsidies or given under other programs. These programs are often implemented with the involvement of the Department of Rural Development, state electricity boards, community-based organizations, non-governmental organizations (NGOs), and others. In order to provide concessional financial support to the renewable energy sector,

² The Department of Non-conventional Energy Sources (DNES), established in 1982, was upgraded to a ministry in 1992.

the MNES has set up a financial institution, viz., the Indian Renewable Energy Development Agency Ltd. (IREDA).

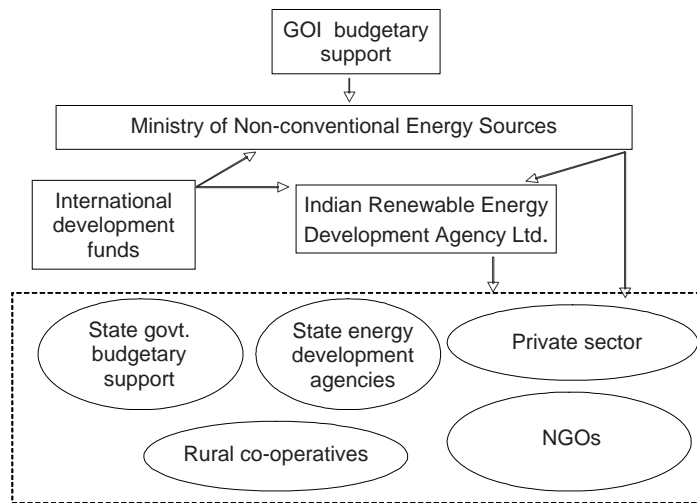


Figure 3. Financing institutions and mechanisms in India's renewable energy sector

The Government has been pursuing a multi-layer strategy for promoting renewable energy, especially through the private sector. Components of the strategy include:

- Provision of budgetary resources by the Government for demonstration projects;
- Encouraging the involvement of industry and the scientific establishment in indigenous research and development for new and emerging technologies and improvement of available technologies; and promoting access to technology development elsewhere, thereby avoiding reinventing the wheel;
- Extending institutional finance through IREDA and other financial institutions for commercially viable projects, with private sector participation; and external assistance from international and bilateral agencies;
- Promoting private investment through fiscal incentives, tax holidays, depreciation allowances, facilities for wheeling and banking of power for the grid, and remunerative returns for power supplied to the grid; and
- Allowing one hundred percent foreign direct investment in manufacturing as well as setting up of power projects.

As of March 2003, the achievements in terms of installed capacity for grid-connected wind energy systems and for solar PV stand at 1,807 MW and 121 MWp respectively. Further, the Government is keen on increasing the share of renewable energy in the country's installed power generation capacity by an additional 10,000 MW by 2012. A draft of the renewable energy policy statement has been submitted by MNES for approval. Within the long-term vision, this policy statement seeks to set out the major application areas and near-term targets for the period up to the end of the Eleventh Five Year Plan

in 2012. One of the major application areas is the electrification of 18,000 remote villages. In another initiative, the Ministry of Power (MoP) has set up a mission called REST—for Rural Electrification Supply Technology—the basic objective of which is to accelerate complete electrification of all villages by 2012 using local renewable energy sources and decentralized technologies.³ Such target-oriented programs, along with the introduction of the Electricity Act 2003,⁴ which come into force on June 2, 2003, are expected to facilitate development of the renewable energy market in India.

The Electricity Act 2003 has several provisions favorable to renewable energy, including rural electrification. It provides for local generation and distribution of electricity by *panchayats* (formally elected village-level governing bodies), rural franchisees, NGOs, and user associations by involving local communities in managing electricity distribution. Under the proposed open-access scheme expected to be in place by the middle of 2004, independent power producers (IPPs) can set up renewable energy power plants for captive use, third-party sale, power trading companies, and for own transmission and distribution in both rural and urban areas. The Act also directs central government to prepare national electricity and tariff policies that include renewable energy-based power, and the MNES is currently in the process of developing the same for renewable energy. The most important feature—and the highlight—of the Act is that it empowers the state electricity regulators to promote renewable energy and to specify a percentage of the total consumption of electricity in the area of a distribution licensee that the licensee should aim to purchase from renewable energy sources. This is considered a major boost for promotion of the renewable energy sector in India. In this liberalized electricity market, the financing mix for renewable energy is likely to change, as new financing institutions and new mechanisms are expected to appear. These and related issues will be discussed in more detail in the full research paper that will be written at the conclusion of the current research.

3. Case studies and financing roadmap for off-grid solar PV

3.1. Case studies

The review of financing for research and development, demonstration, and early commercialization was supported by a detailed literature search, interviews, and discussions. For the commercialization stage, a few case studies were undertaken covering projects that present a sustainable and replicable model of financing. The cases were selected on the basis of their capacity to promote financing by end-users themselves as well as on their contribution to the development of a system of operation and maintenance at the community level.

a. Solar PV mini-grids, a combination of government and community financing—Sunderbans, West Bengal

The case study of solar PV-based mini-grids in Sunderbans describes a model of combining government and community financing to promote renewable energy in India. Since PV technology is very expensive, it is often beyond the reach of poor people even if credit facilities are available. On the

3 As of March 31, 2003, 72,715 villages were yet to be electrified.

4 Full text available at the Ministry of Power, India, website: <http://powermin.nic.in/>.

other hand, PV is also the most user-friendly and field-matured technology to be used in remote locations for developmental applications such as for the provision of electricity for the basic needs of lighting, communication, clean water supply, education, primary health services, and a few commercial activities. Since village electrification is primarily considered to be a social responsibility of the Government, funding for such projects mainly comes in the form of government subsidies. This presents yet another dilemma, as the unfavorable cost-economics of PV technology do not always justify their use. The funding pattern of Sunderbans mini-grid projects is an attempt to overcome this problem in a unique manner based on a fee-for-service approach that matches the paying capacity of the user to the level of services provided, and an effective use of varied developmental funding for setting up the utility. West Bengal Renewable Energy Development Agency (WBREDA), the state agency for executing off-grid electrification projects, has leveraged an MNES subsidy (central funding) to take care of the initial cost of the generating unit, while WBREDA's own resources (state funding) and local developmental funds were mobilized to lay the distribution networks. Revenue collection from the sale of electricity, which is done through the account of the co-operative society in the rural bank, provides for the lifetime costs of the operation and maintenance of the facility. The combination of the central subsidy for renewables, state subsidy, and local area development funds is in the ratio of 70:20:10. Each consumer invests about US\$45 towards application fees for receiving the connection and internal wiring. The monthly fixed tariff is about US\$2.50 for consuming 18–20 kWh of electricity. The financing arrangement is complemented by a unique institutional structure involving the technology provider, local entrepreneurs, and the community for operation and maintenance, sale of electricity, billing, and revenue collection. Transparency in transactions, involvement of multiple stakeholders in planning and managing the scheme, and consumer satisfaction are the backbone of this institutional structure.

b. Developing a market-oriented institutional and financial model for decentralized solar systems—Rajasthan, Uttaranchal

This case study addresses the limitations of delivery mechanisms currently practiced in conventional government subsidy-driven programs. A unique institution called the Energy Service Network (ESN) has been the focus of Uttam Urja, a project for implementation of renewable energy technology systems in rural areas through NGOs. The ESN is an entrepreneurial model conceived by The Energy and Resources Institute (TERI) and funded by the India-Canada Environment Facility. The project focuses on developing a grassroots ESN comprising local NGOs, dealers, and retailers of commonly used electronic gadgets. These local enterprises offer custom-made products and services in remote rural areas. Currently, the setting up of the ESN is being facilitated and co-ordinated by TERI, which is focusing on enhancing the capacity of the network's members. Once the ESN has been established, it will consolidate its network with existing financial intermediaries and manufacturers of solar home lighting systems. The project addresses the limitations of the subsidy regime, particularly with respect to technology customization and innovative delivery mechanisms. It presents a package of energy products and services to rural people rather than providing just the technology, as has been the case in various other initiatives undertaken by the Government. The delivery of such a package has necessarily involved the provision of easy credit; customized products; and quality repair, maintenance, and advisory services through building and engaging local capacity and local economies.

c. Financing solar PV systems through rural finance institutions—Karnataka, Kerala, and Andhra Pradesh

The business model of SELCO-India, a solar energy service company (ESCO) operating in southern India since 1995, aims to develop an innovative consumer finance scheme through rural credit institutions, with loans available from local banks and co-operatives, along with a sales, installation, and maintenance network in the villages. Since most end-users in rural areas cannot afford to buy a solar PV system up-front, this business model allows staggered payments over a three to five-year period, with loans provided by rural financial institutions. SELCO offers a lease-to-own scheme wherein the consumer pays one-quarter of the system cost up-front, while the rest is given to him or her by the financial institution as a loan at 12.5 percent interest per annum. An important and effective part of SELCO's strategy has been to form tie-ups with financial institutions like the Syndicate Bank to provide loans for solar PV systems. One such partner is the Malaprabha Grameen Bank (MGB), a rural development bank with 200 branches in Dharwad and Belgaum districts of Karnataka, known for its innovative micro-credit schemes.

Where no other type of financing is available, SELCO has set up its own financing arm offering loans at a low interest rate, with IREDA re-financing 2.5 percent per annum using low-cost World Bank funds available through the photovoltaic lending program of IREDA. As rural customers are at the lowest level of the financing ladder, doorstep financing through rural financial institutions (registered farmers' cooperative societies or cooperative banks) contributes to reducing the borrowing transaction costs, thus increasing affordability for rural customers. The SELCO financing scheme has succeeded in responding to consumer willingness to pay for better lighting services by providing financing adapted to the repayment capability of rural people. Central to the approach has been the successful partnership developed with rural financing institutions and local solar entrepreneurs and technicians. This builds confidence, on the side of both lenders and borrowers, in the viability of the technology and its business profitability.

d. Consumer financing for solar PV systems through low-interest bank lending—UNEP Solar Power Initiative

This \$7.6 million initiative was launched in March 2003 between the United Nations Environment Programme (UNEP) and two of India's largest banking groups to help 18,000 southern Indian households finance clean and reliable electricity from solar power. The UNEP program is made possible with support from the United Nations Foundation (UNF) and the Shell Foundation.

Under the UNEP program, households are able to purchase SHS at an interest rate of approximately 5 percent per annum, compared with the normal consumer lending rates of 11–12 percent. The Syndicate Bank and Canara Bank offer new low-interest loans under the program, which is aimed at buying down the financing cost of SHS. These two banks are credited with introducing many of the most innovative rural financial products through an extensive network of rural branches and though linkages with self-help groups in Karnataka and Kerala.

3.2. Financing roadmap for off-grid solar PV

The roadmap to commercialization of decentralized solar applications (for example, solar lanterns, home lighting systems, street lights, water pumps, and decentralized power plants supplying both AC and DC electricity) in India has gone through three phases: research and development; demonstration and technology push; and early commercialization or market transformation. It is now entering a fourth: the demand-driven phase.

During the *research and development* phase, India undertook a national-level effort to develop and promote technologies that were relevant to the needs of the Indian population, while simultaneously undertaking a detailed resource assessment exercise. Academic and research institutions, state and central government agencies, and others were involved in basic development and promotion work supported by a dedicated fund at the national level. Focus was on systems such as solar lanterns and solar PV water pumps.

The *demonstration and technology push* phase concentrated on field trials, demonstrations, post-installation evaluation, training and workshops, support to the industry, testing and certification, and so on. The aim of all these activities was to create a national-level infrastructure to bring the technologies into the mainstream, and thus institutions such as the Rural Electrification Corporation and energy development agencies were roped in. Most of the activities in this phase were supported by full government subsidies. International aid and donor funding also supported some pilot projects.











The next phase, *early commercialization* or market transformation, essentially concentrated on the identification and removal of barriers to widespread utilization of renewable energy technologies. Specific steps were taken on policy aspects, quality control, market support infrastructure, and others to facilitate this. The highlights of this phase were focus on product development; availability of finance for entrepreneurs and customers; and setting up of hardware supply and after-sales service networks. The subsidy-driven efforts in this phase were supplemented by initiatives such as the Photovoltaic Market Transformation Initiative of the International Finance Corporation (IFC), providing consumer finance, working capital, and risk sharing (for example, payment default guarantees) to the entrepreneurs. Other initiatives such as project finance from the World Bank Line of Credit through IREDA and innovative delivery schemes such as fee-for-service models using mini-grids, with the SNA taking the role of an ESCO, also provided a push to this phase.

The decentralized solar market is now slowly moving towards a *demand-driven commercialization* scenario, where manufacturers are offering product and financing packages that are tailor-made for specific categories of consumers. While providing for the basic energy needs of the rural population is considered the thrust area for the Government, the private sector is emerging as a key player in the delivery of energy products and services through commercial approaches such as ESNs. Innovative concepts such as enterprise development on both the supply and demand sides, as well as micro-financing through self-help groups, are slowly taking shape. This phase is also seeing the removal of subsidies on some popular products such as solar lanterns, which are now being sold on their own merits. While the CDM is emerging as a new instrument for financing commercially attractive projects,

development programs such as electrification of remote villages are being planned with a combination of central and state-level funding.

Product customization and innovations in delivery mechanisms required for the village electrification program are promoted through a joint government-industry-NGO action research phase, for example, under the REST mission of the Ministry of Power. Hence, the roadmap to commercialization sees a cyclic process where the funding and financing mechanisms become attuned to the requirements of a particular phase. Table 1 summarizes the above discussion.

Table 1. Evolving financing roadmap of decentralized solar energy (residential/community sector)

| Life-cycle phase | Financing instruments | | | |
|---------------------------------|---|---|---|---|
| | Government finance | International funding mechanisms | Private-sector finance, including ESCOs | Micro-credit and community-based financing |
| Research and development |  | | | |
| Demonstration |  |  | | |
| Early commercialization |  |  |  | |
| Demand-driven commercialization |  |  |  |  |

4. Case studies and financing roadmap for grid-connected wind power

The financing roadmap for grid-connected wind power is discussed below, following a similar approach to that for off-grid solar PV.

4.1. Case studies

a. Public-sector financing (through IREDA) for wind power development—Tamil Nadu

India has witnessed an exponential growth in its wind power sector. Synergy between various factors—viz., promotional policies of the Government, a conducive environment for private sector involvement, supportive financing instruments, access to technology, and institution and capacity building—have been the critical instruments fuelling this growth. Among the states where wind energy could be viable, Tamil Nadu has taken the lead in exploiting this potential. Since 1985–86, the Tamil Nadu State Electricity Board (TNEB), the state utility, has successfully implemented grid-connected wind farms under demonstration projects with MNES support. The success of these demonstration projects has attracted record private investment in the wind sector. The TNEB has further facilitated investment by identifying potential sites, developing infrastructure (grid evacuation, grid connection, sub-station facilities, and so on) for implementation of GWEGs (grid-connected wind electric

generators), and announcing attractive state-level policies for wheeling and banking of power, third-party sales, and so on. Fiscal and financial incentives from the MNES, coupled with financing from IREDA, has further boosted the progress of installation of GWEGs in Tamil Nadu. IREDA's achievement in financing wind power projects is remarkable. IREDA has financed 210 grid-connected wind power projects aggregating to 475 MW in Tamil Nadu alone, which is 22 percent of the wind power projects it has financed in all of India. The cumulative installed capacity in Tamil Nadu is 895 MW,⁵ representing 53 percent of India's installed capacity in the wind sector.

b. Wind-power development by the private sector, a combination of the CDM and public-sector financing—Karnataka

The Clean Development Mechanism, a recent international financing tool for additional revenue from climate-friendly projects that is one of the flexibility mechanisms of the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC), has drawn attention from the private sector for leveraging the financial viability of wind energy projects. Enercon (India) Ltd. has proposed implementing a 15 MW grid-connected wind power project in the state of Karnataka, based on the CDM. Enercon participated in the Royal Dutch Government's public procurement tender, CERUPT, and its project has been selected for supplying certified emissions reductions (CERs). The project is located in Vanivilas, falling within the Jogimatti wind zone. The projected revenue from CERs is US\$1.2 million⁶ for 10 years, with total CERs generation of 0.24 million over 10 years, at a rate of €5.35⁷ per CER credit. The total investment in the project is US\$16 million. The project proposes to achieve financial closure from IREDA with a debt-to-equity ratio of 2.38. The project also envisages an advance payment from CERs revenue to the tune of 50 percent of the total revenue from CERs on a discounted basis, which will serve as a part of the project equity. Though the financial viability does not improve substantially with the CER credits (CER revenue is at the rate of only Rs.0.15/kWh), it is still attractive to Enercon (India) Ltd. to go ahead with such a project because it offers several benefits; advance payments are expected to supplement the equity and improve cash flow, and partially cover the risk of delayed payment by the utility and/or the assumed annual increase in the power tariff. Further, the revenue from CERs for wind power projects has the potential to cover annual operation and maintenance costs. Hence, the equipment manufacturers are presently developing the concept of a free annual maintenance contract for the private investor who would thus not need to worry about expenditure on operation and maintenance. In turn, the private investor would authorize the equipment manufacturer to develop a CDM project and earn CER credits for its wind farms. Windmill manufacturers and promoters in India are also looking forward to such opportunities under the CDM.

4.2. Financing roadmap for grid-connected wind power

Research and development is normally the starting phase of any sectoral development. The MNES combined the objectives of rapid commercialization and phased indigenization of wind energy technology in India from the initial stage. Government funding for research and development led to the

5 As of September 2002.

6 Based on a conversion rate of US\$1 = 48 Rs.

7 Based on a conversion rate of €1 = 50 Rs.








creation of a massive wind resource database and development of grid-connected wind electric generators within the country. Even at present, government funding is available for research and development for both of these activities, but is now targeted at developing high-end wind energy technologies with better efficiency and performance. Thus it is critical to have government funding support for research and development during the initial stage as well as during technology development stages.

Demonstration phase: The MNES made relentless efforts in encouraging state governments to implement grid-connected wind energy generator projects and provided grants for the same. These demonstration projects were successful in showcasing the Government's objective in commercializing the wind power sector, proving the techno-economic viability of wind power projects, and attracting the private sector to invest substantial sums.

Early commercialization phase: Wind power is about to take off as a successfully commercialized technology in India. Financing was difficult in wind power projects during the initial phase of development. The MNES's efforts in establishing a public-sector financing entity, IREDA, provided the right opportunity for private companies to avail themselves of long-term soft loans for implementing wind power projects. IREDA played a pivotal role in staging the implementation of GWEG projects on a larger scale in the country. This initiative convinced other private financing institutions and nationalized banks of the viability, and even attractiveness, of supporting the wind energy sector. Of late, they have entered the market and have already funded a number of successful wind power projects. Recently, the CDM has attracted private companies to implement wind power projects and access additional revenue by selling CERs to developed countries to meet their binding UNFCCC emission reduction targets. CDM as a financing tool has yielded a few projects for Indian companies, though it is yet to create adequate impact among investors in India as it is still in the nascent stage.

Demand-driven commercialization phase: It is expected that the MNES will phase out subsidies and other incentives once the wind power sector reaches full commercialization, and that the role of private finance will grow in the funding of larger-scale wind power projects. International funding mechanisms such as the CDM are expected to supplement the efforts of private financiers. As this process takes place, the role and scope of government funding is changing. In the initial stages, the MNES alone was funding research and development activities, but now private sector equipment manufacturers have also started investing in research and development. However the private sector's investment is directed towards developing high-end GWEGs, viz., mega-sized turbines, large-sized rotor blades, reactive power-free electrical systems, and so on. The MNES remains a major source of funding for wind resource assessment to identify more potential sites for implementing wind power projects, including offshore projects. Table 2 summarizes the above.

Table 2. Evolving financing roadmap of grid-connected wind power (industrial sector)

| Life-cycle phase | Financing instruments | | | |
|---------------------------------|---|---|---|--|
| | Government finance | International funding mechanisms | Private-sector finance, including ESCOs | Micro-credit and community-based financing |
| Research and development |  | | | |
| Demonstration |  | | | |
| Early commercialization |  |  |  | |
| Demand-driven commercialization | |  |  | |



















5. Discussions and conclusion



The findings of this research to date indicate that government finance, international funding mechanisms, private-sector finance, and community-based finance all play different roles at different stages of the renewable energy development cycle, not only individually but also in various combinations. The research also shows that the role of these four financing mechanisms is technology-specific and varies depending on whether wind or solar applications are considered. The authors would like to alert readers to the fact that this research note only aims to identify the role of the various financing instruments at the different stages of the cycle. It is hoped that a quantification of the share of financing from the respective financial instruments, as well as drawing of policy conclusions on what category of finance best addresses specific barriers at each stage of the cycle, will be provided when the research is completed. Informed by the Indian experience, an innovative financing mix could then be envisioned for other countries that are initiating policies for a sustainable and demand-driven renewable energy development strategy.

Government financing

Government financing has been crucial at all phases of development of both off-grid solar and wind power, except for the full commercialization of wind power. For solar energy, the technology is still beyond the reach of many potential customers and many new market segments are constantly opening where government support is required. In fact, the solar power sector is currently going through two parallel stages: demand-driven commercialization and a subsidy-driven, socially-oriented rural electrification market for which Government support is crucial. Removal of subsidy can only be envisaged in terms of gradual policy change. As a result, the innovation that can be observed with

Table 3. The role of different financing sources in the cycle: comparison of solar energy (decentralized; residential/community sector) and wind energy (industrial sector)

| Life-cycle phase | Financing instruments | | | |
|---------------------------------|---|---|---|---|
| | Government finance | International funding mechanisms | Private-sector finance, including ESCOs | Micro-credit and community-based financing |
| Research and development |   |  | | |
| Demonstration |   |  | | |
| Early commercialization |   |   |   | |
| Demand-driven commercialization |  |   |   |  |

Key:  = solar energy;  = wind energy.

respect to government finance is in the area of modes of delivery. This involves innovative combinations of central government subsidy with local development funds and end-user fees, as in the Sunderbans solar PV mini-grids case; or a combination of subsidies with loan-ownership models. A parallel study being undertaken in China reveals a new mode of delivery relying on competitive bidding among potential suppliers of solar systems in seven western provinces (Xinjiang, Qinghai, Gansu, Inner Mongolia, Shaanxi, Sichuan, and Tibet), with the objective of finding the optimal use of government subsidy. Bidding among potential suppliers of PV systems there has led to a reduction in the price of village power systems from about US\$20/Wp to about US\$15/Wp.⁸

International funding mechanisms, including the Global Environment Facility and CDM

For solar power applications, international funding mechanisms have been involved in demonstration, early commercialization, and full commercialization, but not in research and development and product/technology development phases. One of the possible reasons is that the goals of research and development at macro level are common irrespective of where it is taking place. To elaborate further, the focus of global research and development is on new materials, improved processing, and fabrication techniques and on new solar cell designs to reduce the cost of the technology. Such investment-oriented research and development usually takes place in industrialized countries only. Foreign aid and investment are received either for the demonstration of a product, with a hidden agenda of technology push, or for the commercialization stage, where a certain level of return is assured. The same arguments hold good for the wind power sector, except for the fact that the Government of India took the lead in the demonstration stage of wind power development and hence foreign aid has not been so significant. It is noteworthy that while international funding mechanisms such as the Global Environment Facility

⁸ "Up-grading renewable electrical energy program for village levels in China by use of government financing and bidding based on market regulation," RISPO Good Practices Inventory, <http://www.iges.or.jp/APEIS/RISPO/inventory/db/pdf/0040.pdf>.

have initially focused on financing demonstration projects, recent initiatives such as the UNEP Solar Power Initiative have come to be involved on the side of consumer financing, with the objective of facilitating access to commercial lending from banks.

Private finance, including energy service companies

Private finance, including from energy service companies, only comes at the stages of early or demand-driven commercialization for both solar and wind power sectors. Private-sector finance has been most prominent in the solar power sector, where consumer financing schemes are being developed for various applications. For a large share of the market in rural areas, private sector finance comes in the form of lease-to-own models wherein the consumer pays part of the system cost as an up-front payment and the rest is covered through loans by financial institutions, or through financing schemes designed by energy service companies themselves. Direct consumer access to lending by financial institutions appears to be limited. Manufacturers and distributors generally serve as go-between institutions between end-users and financial institutions in facilitating access to loans. In the wind power sector, private financiers have been involved in large-scale projects both by Indian project developers and through joint ventures. Once the private sector is involved, it invests in product customization as it sees the direct linkage between growth of a particular market and development of suitable products for that market. The wind power sector has already witnessed this phenomenon; it is also starting to be seen in some small pilot projects in the solar power sector.

Micro-credit and community-based finance

Micro-credit and community-based finance have not played any role in the development of wind power applications. This is understandable, because communities only invest once they are the owners of a scheme. Since this study has only looked at grid-connected wind power projects, there have been no instances where a community has directly benefited by these projects. Unlike decentralized solar PV, grid-connected power projects are owned by the state, utility, or project developer, and their investments are considered as either government or as private sector. As for decentralized solar applications, community-based financing comes into play in various forms—in combination with government subsidy, as in the Sunderbans PV mini-grids case, or through loans from banks and rural finance institutions. Since the high up-front costs still make solar power systems unaffordable for low-income communities that can only rely on micro-credit and community financing schemes, leveraging local finance would still have to be considered as part of a financing package involving some form of public or international financing. Alternatives would include staggered financing schemes through lease-to-own models.

As stated in section 3, this research has not reached a stage where strategic policy options can be introduced. At the present stage, it has examined the existing financing options with respect to the various stages of the production–commercialization life-cycle. The research should now attempt to analyze the implications of policy instruments such as the liberalization of the energy market for these financing mechanisms. The interactions of these two streams should point at strategic policy options that would facilitate innovative financing mechanisms for the development of the renewable energy sector. Given that a similar study is also being undertaken in China, it is hoped that the final comparative

analysis will provide insights into specific policy measures and country-specific circumstances that explain achievements in removing the financial barriers for the development of renewable energy.