ADB

Technical Assistance Report

Project Number: 43458
Research and Development Technical Assistance (RDTA)
December 2009

Effective Deployment of Distributed Small Wind Power Systems in Asian Rural Areas

Asian Development Bank

ABBREVIATIONS

ADB	–	Asian Development Bank
DMC	–	developing member country
MDG	–	Millennium Development Goal
NGO	–	nongovernment organization
PRC	–	People's Republic of China
TA	–	technical assistance

TECHNICAL ASSISTANCE CLASSIFICATION

Type	–	Research and development technical assistance (RDTA)
Targeting classification	–	Targeted intervention–MDGs
Sector (subsectors)	–	Energy (renewable energy, energy efficiency and conservation)
Themes (subthemes)	–	**Environmental sustainability** (eco-efficiency, natural resources conservation, global and regional transboundary environmental concerns); economic growth (promoting economic efficiency and enabling business environment; widening access to markets and economic opportunities; knowledge, science, and technological capacities); private sector development (private sector investment, public–private partnerships); capacity development (institutional development; client relations, network, and partnership development)
Climate change	–	Climate change mitigation
Location impact	–	Rural (high), urban (medium), national (medium), regional (medium)

NOTE

In this report, "$" refers to US dollars

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I. INTRODUCTION

1. The Asian Development Bank (ADB) renewed its Energy Policy in 2009,[1] emphasizing three priorities for achieving inclusive and sustainable growth in its developing member countries (DMCs): (i) promoting energy efficiency and renewable energy; (ii) maximizing access to energy for all; and (iii) promoting energy sector reform, capacity building, and governance. ADB has also committed to reinforcing its efforts to facilitate the transfer of low-carbon technologies to DMCs and to double financial support for clean energy projects to $2 billion per year by 2013 to enhance regional energy diversity and security. The proposed research and development technical assistance (TA) on Effective Deployment of Distributed Small Wind Power Systems in Asian Rural Areas will help implement ADB's Energy Policy and assist DMCs in scaling up viable renewable energy development with private sector involvement to improve the quality of life of the poor. It will create opportunities for ADB's sovereign and nonsovereign lending operations, build local capacities, and strengthen regional cooperation on clean energy technology development and deployment. The vice-president (Operations 1) approved concept clearance of the TA on 2 October 2009.[2] The design and monitoring framework is in Appendix 1.

2. The TA builds on ADB's Energy for All Initiative[3] and aims to supply reliable and affordable emission-free electricity to poor communities in remote windy areas at no fuel cost. It will explore innovative and practical approaches to (i) reduce costs of wind power equipment by transferring appropriate technologies and optimizing manufacturing processes; (ii) reshape financing modalities and instruments, and mobilize carbon credits in a pragmatic way; (iii) encourage public–private partnerships to stimulate investment and research and development activities for clean and renewable energy; (iv) displace combustion of biomass and fossil fuels to reduce greenhouse gas emissions; and (v) improve national and village-level capacities for planning, implementing, and maintaining decentralized systems for power generation and distribution. The TA is aligned with ADB's Medium-Term Corporate Strategic Priorities for Research, especially (i) promoting inclusive growth, (ii) addressing climate change, and (iii) coping with rising commodity prices.

II. ISSUES

3. Nearly 1 billion poor people in Asia and the Pacific are still trapped in poverty, without access to electricity that is crucial for job and income opportunities, as well as the delivery of basic education, health, and communication services. Many of these poor people are living in remote mountainous areas (e.g., in Afghanistan, India, and Nepal); deserts and grasslands (e.g., in Kazakhstan, Mongolia, and the northwestern part of the People's Republic of China [PRC]); and ocean islands (e.g., in Indonesia, Philippines, Sri Lanka, and Pacific Islands such as the Cook Islands, the Marshall Islands, and Samoa). In many cases, it is technically difficult or too costly to extend power grids to these remote underdeveloped areas with low volumes of electricity consumption. Local schools, hospitals, processing plants, shops, and other public, commercial, and residential facilities have to rely on diesel power generation. Diesel must be imported from abroad, hauled over long distances, and stockpiled at high inventory costs. Fuel shortages, vulnerability to rising and volatile oil prices, lack of essential spare parts, and inadequate maintenance can frequently interrupt the diesel power supply, resulting in inferior service quality, high operational costs, and excessive environmental pollution. The number of families in villages lacking electricity could increase if the population growth rate outpaces the rural electrification rate. Even a small amount of electricity, provided by tapping into local wind, solar, and biogas resources would lighten up the lives of many poor people in remote areas, especially women and children. Most Millennium Development Goals will not be achieved if the hardships caused by energy poverty are allowed to persist.

[1] ADB. 2009. *Energy Policy*. Manila.
[2] The TA first appeared in the business opportunities section of ADB's website on 27 October 2009.
[3] ADB. 2008. *Energy for All Initiative*. Manila.

4. Nevertheless, many of these remote areas are endowed with abundant, inexhaustible, and free wind resources. Distributed small wind power systems, normally with a rated capacity of less than 100 kilowatts, have been successfully used for decades in developed countries[4] and have contributed significantly to the reduction of rural poverty in the PRC.[5] They can be supplied by more than 200 manufacturers in the world. Accumulated technical expertise and manufacturing capacities can be readily mobilized, and some of the existing small wind turbine models can be quickly adapted and renovated, to improve access to electricity in Asia's windy poor rural communities.

5. Deployment of distributed small wind power systems does not depend on current and future capacities of power grids for off-loading, does not need to go through cumbersome processes for tariff determination and adjustments, does not require strong infrastructure support and special equipment (e.g., large trucks and heavy cranes) to transport and install big components (e.g., towers, turbine nacelles, and long blades), and does not require building access roads. Small wind power systems need only small foundation plots. Land acquisition and resettlements are rare. It is less knowledge-intensive and skill-demanding to install, operate, maintain, and repair these small systems. They can be implemented in a modular way within a few months and do not involve high speeds, temperature, pressure, voltage or loads.

6. Deployment of distributed small wind power systems will avoid the substantial investment needed for generating, transmitting, and distributing electricity produced from centralized combustion of fossil fuels. Financial costs and environmental damage embedded in line losses (normally more than 10% for rural consuming end points) in voltage conversion and long distance transmission are eliminated, when electricity is produced and consumed in the same neighborhood. In places where rich wind resources cannot be harnessed by constructing large-scale wind farms—because of infrastructure bottlenecks, impossible grid integration, or lack of capacity to handle large power projects—these small systems can provide a practical solution in helping utilize indigenous renewable resources more quickly and effectively to supply clean, reliable, and affordable electricity to reduce poverty in poor rural communities.

7. Three fundamental challenges must be addressed to facilitate effective deployment of distributed small wind power systems in remote windy poor areas. First, the current costs are too high, in either power terms (about $4,000 per kilowatt) or energy terms (about $0.20 per kilowatt-hour). Leading manufacturers of small wind power systems are often located in developed countries where labor and material costs are high, zoning and permitting constraints are stringent, and tax burdens are heavy. Hence, the market size remains small. Shipping the systems and spare parts across oceans to Asia will impose additional handling costs, export and import duties, and time delays. It is possible and desirable, with concerted efforts, to cut the overall energy costs by about 50% through design improvement, optimization in manufacturing and installation, and enhancement of operation and maintenance.

8. Second, poor rural communities cannot afford the heavy up-front investment and do not have adequate access to financing. It is not easy for the poor to meet the requirements of commercial banks on creditworthiness or asset securitization. Carbon credits are difficult to obtain for sparse singular installations because of the high transaction costs and procedural uncertainties. Existing financial instruments, from formal or informal channels, including banks, microcredit institutions, and other cooperative arrangements, shall be assessed and modified when they are used to finance energy access projects in rural communities. Innovative financing modalities need to be designed and carbon credits mobilized to make small wind power

[4] For example, in the early part of the 20th century, the United States had about 3 million windmills in operation, supplying water for homes, farms, and livestock.

[5] According to the World Wind Energy Association, the PRC has manufactured and operated more than 300,000 small wind turbines, accounting for about 80% of the world's total installation.

systems more implementable and affordable. Grants from international development organizations and governments that are generally being extended for low-carbon development and poverty reduction programs can also be used to reduce the up-front costs.

9. Third, as demonstrated by the past experiences, small wind power systems are usually not sustainable without private sector participation. Public–private partnerships are essential for accelerating engineering innovation, cost reduction, resource mobilization, project construction, and capacity development. Modified implementation mechanisms, such as aggregated planning, financing, installation, and maintenance through a build-own-operate-transfer modality, or implementation by experienced renewable energy service companies, can be viable ways to help poor communities harness indigenous renewable energy resources and empower themselves. Ensuring local project participation and ownership, while exploring additional income-generating opportunities through the new access to electricity, will further enhance the cost-effectiveness and sustainability of small wind power systems. National and village-level institutional capacities will need to be strengthened to enable replication of the pilot demonstration projects in other areas with similar conditions.

III. THE PROPOSED TECHNICAL ASSISTANCE

A. Impact and Outcome

10. The impact of the TA will be the improvement of economic, environmental, and health conditions of poor rural communities in remote windy areas. The TA outcome will be enhanced access to clean, reliable, and affordable electricity in windy poor villages currently without electricity by effectively deploying small wind power systems. By 2020, small wind power systems will serve at least 2.5 million poor people and avoid about 1.25 million tons of carbon dioxide emissions per year.

B. Methodology and Key Activities

11. The TA will be implemented in four DMCs to be determined during the TA implementation. The participating DMCs shall have (i) demonstrated strong commitment to developing renewable energy and increasing access of the poor to modern energy services; (ii) clearly identified poor communities with abundant wind resources;[6] and (iii) established stable macroeconomic and conducive business environments for developing, manufacturing, or deploying small wind power technologies and systems. The key TA activities include the following:

(i) Needs and resource assessment:
- (a) assessing socioeconomic conditions and infrastructure bases in typical windy poor rural communities currently lacking access to electricity;
- (b) identifying and selecting priority locations for effectively deploying small wind power systems;
- (c) analyzing demand patterns and load management requirements to improve the efficiency of future electricity uses, such as utilization of the most efficient lighting, pumping, and refrigeration facilities; and
- (d) mapping wind, solar, and biogas resources and load distribution in selected poor communities for adequacy verification, system configuration, mini-grid planning, and optimal micro-siting of small wind power systems.

(ii) Integration and optimization of the system supply chain:

[6] The initial assessment of wind resources in many Asian countries (e.g., Cambodia, Lao People's Democratic Republic, Maldives, Mongolia, Nepal, Philippines, the PRC, Sri Lanka, Thailand, and Viet Nam) have been conducted, indicating that wind resources are commercially exploitable in many poor communities not yet connected to the power grid.

(a) evaluating technical designs, installation requirements, and operational processes of small wind power systems, and exploring possibilities to increase electricity output, simplify maintenance, minimize capital and operational expenses, and improve system reliability and durability;[7]

(b) comparing different approaches to energy storage and balancing to cope with intermittency difficulties of stochastic wind power;[8]

(c) examining suitable ways to integrate the complementary benefits of wind, solar, and biogas resources to optimize cost-effective energy systems, and improve predictability and reliability of electricity supply;

(d) addressing negative environmental impact of conventional batteries that have been used in many off-grid renewable energy projects; and scrutinizing possibilities to improve their efficiency, safety, and environmental friendliness; and

(e) reviewing manufacturing, delivery, and servicing procedures to seek opportunities to cut energy costs, through, for instance, modularized and standardized design, manufacturing localization, and achievement of economies of scale in mass production.

(iii) Improvement in financing instruments and delivery mechanisms:

(a) designing innovative financing mechanisms to reduce capital costs, mitigate risks, and enhance financial viability;

(b) exploring ways to mobilize grant assistance, activate carbon credits in a programmatic way, and secure regulatory incentives;

(c) experimenting with a financial leasing modality to minimize collateral requirements and enable periodic debt amortization through the collection of service charges; and

(d) assisting in building public–private partnerships and the build-own-operate-transfer modality for smooth implementation and sustainable operation.

(iv) Construction of six pilot projects in the following areas to generate demonstration effects for rapid replication in other suitable locations:

(a) remote mountainous areas,

(b) deserts and grasslands, and

(c) ocean islands.

(v) Policy recommendations and capacity building activities:

(a) recommending policies to DMCs and the international community on how to facilitate transfers of low-carbon technologies and strengthen regional cooperation to create a favorable regulatory framework and business environment for maximizing the use of indigenous renewable resources, and to produce global public goods in clean energy to mitigate global warming and climate change; and

(b) conducting dissemination and capacity building activities to engage more poor communities, financial institutions, private sector partners, and nongovernment organizations; and to expedite deployment of distributed power generation systems exploiting wind and other indigenous renewable energy resources.

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[7] Including examining engineering and financial gains by incorporating most recent developments in rotor and blade aerodynamics, airfoils, direct-drive permanent magnet generators, intelligent power electronics and control subsystems, compact materials, extended support towers, and noise-reduction techniques.

[8] Including evaluating the suitability of air compression, flywheels, and hydrogen conversion energy storage technologies, and exploring direct uses for pumping and purifying water, desalinating seawater, heating houses during harsh winters, and producing ice and salt for coastal fishing families.

C. Cost and Financing

12. The TA is estimated to cost the equivalent of $3.87 million, including $1.10 million budgeted for establishing six pilot projects.[9] The TA will be financed on a grant basis by ADB's Technical Assistance Special Fund ($2.62 million from TASF–IV and $1.25 million from TASF–other sources). The cost estimates and financing plan are in Appendix 2.[10]

D. Implementation Arrangements

13. The TA will be implemented over 2.5 years, between January 2010 and June 2012. ADB will be the executing agency for the TA. The Private Sector Operations Department, East Asia Department, and Regional and Sustainable Development Department will work together to carry out all TA activities, in close collaboration with other operations departments and resident missions, and in full compliance with ADB safeguard policies. Each participating DMC may designate an existing agency responsible for providing energy to the rural people as the implementing agency for the TA project. ADB will start TA activities in a DMC only after receiving a TA support letter from its government.

14. The TA requires 150 person-months of consultant inputs (30 international and 120 national). The international consultants are expected to transfer knowledge and experience to the national consultants, who will be responsible for implementing the pilot demonstration projects. ADB will engage the consultants in accordance with its Guidelines on the Use of Consultants (2007, as amended from time to time). Any equipment and materials to be financed by the TA will be procured in accordance with ADB's Procurement Guidelines (2007, as amended from time to time). On completion of the TA project, the equipment will become the property of the government and participating local institutions and/or communities. Disbursements under the TA project will be made in accordance with ADB's *Technical Assistance Disbursement Handbook*.[11] Appendix 3 gives the outline terms of reference for the consultants.

15. Semiannual TA progress reports will be provided for timely monitoring and evaluation. Good practices and lessons learned through the TA project will be disseminated by demonstration of pilot projects, capacity building activities, workshops, international conferences, and wide distribution on the internet and through multimedia tools.

IV. THE PRESIDENT'S RECOMMENDATION

16. The President recommends that the Board approve the provision of technical assistance not exceeding the equivalent of $3,870,000 on a grant basis for Effective Deployment of Distributed Small Wind Power Systems in Asian Rural Areas.

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[9] Comprising the costs of feasibility studies; design; statutory approvals; equipment for power generation, storage, and distribution; installation; and arrangement for operations and maintenance.

[10] The governments of DMCs and project beneficiaries in the host countries that participate in the TA project are expected to provide in-kind and/or cash contributions to facilitate implementation of TA activities. However, such contemplated in-kind government counterpart contributions have not been included in the cost estimates and financing plan in Appendix 2.

[11] ADB. 2008. *Technical Assistance Disbursement Handbook.* Manila.

DESIGN AND MONITORING FRAMEWORK

Design Summary	Performance Targets/ Indicators	Data Sources/ Reporting Mechanisms	Assumptions and Risks
Impact Improved economic, environmental, and health conditions of poor rural communities in remote windy areas	By 2020, small wind power systems will serve at least 2.5 million poor people and avoid about 1.25 million tons of carbon dioxide emissions per year. Electricity and energy use indicators, economic and income growth rates, and health status of the poor communities Acceleration in achieving the MDGs	National and international economic, energy, and environmental statistics Human development index MDG progress reports	**Assumptions** Communities and governments uphold commitment to poverty reduction, environmental protection, and mitigation of global warming and climate change. Developed countries proactively support transferring low-carbon technologies. Institutional capacities to implement TA recommendations are sufficient.
Outcome Enhanced access to clean, reliable, and affordable electricity in poor windy villages currently without electricity by effectively deploying small wind power systems	Improved efficiency and effectiveness for delivering energy access Initial successes of six pilot projects by 2012 Private sector participation secured More energy access projects implemented in participating DMCs	Data on access to electricity in participating countries Performance records of the pilot projects Annual reports of private sector entities. National reports on energy access	**Assumptions** Consensus can be achieved among stakeholders on the road map for deploying small wind power systems. Private sector participants can be mobilized. Pilot projects can be planned, implemented, and operated with high performance quality and within budgets.
Outputs 1. Needs assessment for typical windy poor rural communities currently lacking adequate access to electricity	Data on socioeconomic conditions and infrastructure bases collected and analyzed	Poverty surveys Needs assessment reports in participating DMCs	**Assumptions** ADB's Energy for All Initiative has identified the locations and characteristics of the poor communities without access to electricity in Asia and the Pacific, especially in the mountainous areas, desert and grasslands, and ocean islands. Wind resources are readily available and commercially exploitable in many poor communities not yet covered by the power grid. Some of the existing small wind power systems are mature and can be transferred, renovated, and adapted for use in Asia.
2. Identification and selection of priority locations	Six suitable locations have been identified, analyzed, and prioritized.	Reports on criteria, procedure, and results for location selection	
3. Analysis of electricity demand patterns and load management requirements	Suggestions to improve the efficiency of future electricity uses have been formulated.	Reports on future electricity uses and efficiency improvement measures	
4. Assessment of wind, solar, and biogas resources and load distribution in selected poor communities	Renewable energy resources and load distribution are mapped	Wind, solar, and biogas resource data and maps of load distribution for the selected locations	

Design Summary	Performance Targets/ Indicators	Data Sources/ Reporting Mechanisms	Assumptions and Risks
5. Technical evaluation of and cost reduction exploration	Technical designs, installation requirements, and operational processes of small wind power systems by the global top five manufacturers have been scrutinized.	Data from industry associations and market surveys Technology evaluation and improvement report	High up-front and operational costs can be cut through design enhancement, manufacturing localization, and maintenance improvement.
6. Comparison of different approaches for energy storage and balancing	Ways to cope with intermittency difficulties of stochastic wind power have been analyzed.	Report on suitable approaches for energy storage	Smooth cooperation with private sector manufacturers and developers can be established and maintained.
7. Examination of suitable ways to integrate wind, solar, and biogas resources	Predictability and reliability of electricity supply from renewable energy sources have been improved.	Report on hybrid power generation from multiple renewable energy resources	**Risk** Negative environmental impact of the conventional batteries that are used for small wind power systems need to be handled appropriately.
8. Environmental impact assessment on uses of conventional batteries	Environmental impacts of conventional batteries have been addressed.	Environmental impact assessment and management report	
9. Investigation of manufacturing, delivery, and servicing procedures	Opportunities to cut the energy cost have been explored.	Manufacturing optimization report	
10. Design of innovative financing mechanisms	Access to financing has improved.	Financial and risk management report	
11. Assistance in building public–private partnerships and build-own-operate-transfer modality	Private sector participation has been ensured for smooth implementation and sustainable operation.	Report on the energy access delivery mechanism through public–private partnerships	
12. Policy recommendations	Suggestions have been formulated and adopted.	Policy recommendation report on scaling up distributed small wind power systems	
13. Construction of pilot demonstration projects	Six pilot projects have been completed with high quality and within budgets.	Pilot project configuration and performance reports	
14. Dissemination and capacity building activities	Six workshops and three training programs have been conducted.	Workshop reports and training materials	

Activities with Milestones	Inputs
1.1 Collecting necessary data and analyzing future trends on demographic structure, socioeconomic development, access to energy, infrastructure development, pollution emissions, and poverty reduction in selected ADB DMCs with high concentration of windy poor rural communities currently lacking adequate access to electricity (March 2010). 1.2 Analyzing past efforts and experience in addressing energy access (May 2010). 1.3 Preparing needs assessment reports for participating DMCs (July 2010). 2.1 Selecting six representative poor communities without access to electricity but with abundant wind resources, focusing on remote mountainous areas, desert and grasslands, and ocean islands (April 2010). 2.2 Conducting field trips and stakeholder consultations (June 2010). 2.3 Determining local partners for pilot demonstration projects (July 2010). 2.4 Preparing reports on criteria, procedure, and results for location selection (August 2010). 3.1 Analyzing electricity demand patterns and load management requirements in selected windy and poor communities (July 2010). 3.2 Suggesting measure to improve the efficiency of future electricity uses, such as utilizing most efficient lighting, pumping, and refrigeration facilities (August 2010). 3.3 Preparing reports on future electricity uses and efficiency improvement measures (September 2010). 4.1 Assessing wind, solar, and biogas resources and their exploitability in the selected poor communities (August 2010). 4.2 Mapping out renewable energy resources and load distribution (September 2010). 4.3 Verifying resource adequacy (September 2010). 4.4 Proposing system configuration, mini-grid layout, and optimal micro-siting of small and hybrid wind power systems (October 2010). 4.5 Estimating the contributions from developing indigenous renewable energy resources in a distributed way to local economic development, environmental protection, and reduction of pollution emissions (November 2010). 4.6 Preparing wind resources assessment and development planning reports (December 2010). 5.1 Collecting necessary data and information on existing technologies and manufacturers of small wind systems (March 2010). 5.2 Evaluating operational and financial performance of selected small wind power systems currently in operation (May 2010). 5.3 Analyzing current research and development efforts and future trends of small wind power technologies (June 2010). 5.4 Examining product characteristics, installation requirements, operational processes, and cost structures of small wind power systems produced by the top five leading manufacturers in the world (September 2010). 5.5 Exploring possibilities and approaches to increase electricity output, simplify maintenance, minimize capital and operational expenses, and improve system reliability and durability with a target to reduce energy costs by about 20% (October 2010). 5.6 Suggesting improvement measures for operation management, maintenance, and repairs (November 2010). 5.7 Examining robustness against inclement weather and natural disasters, such as severe thunderstorms, typhoons, and sand storms (November 2010). 5.8 Preparing the technology evaluation and improvement report on distributed small wind power systems (December 2010).	ADB: – Significant inputs by ADB staff in TA management – Grant of $3.87 million Participating DMCs: – In-kind contributions – Government personnel in coordinating TA activities and providing guidance to implement demonstration projects Contribution from private sector partners Contributions from NGOs and local communities

Activities with Milestones	
6.1 Comparing different approaches to energy storage and balancing (June 2010). 6.2 Analyzing improved ways to cope with intermittency difficulties of stochastic wind power (August 2010). 6.3 Examining direct uses of small wind power systems for pumping and purifying water, desalinating seawater, powering electrolysis for hydrogen, heating houses during harsh winters, and producing ice and salt for coastal fishing families (October 2010). 6.4 Exploring different approaches for effective energy storage, adoptable for distributed small wind power systems, such as air compression, flywheels, and hydrogen conversion energy storage technologies (November 2010). 6.5 Preparing a report on suitable approaches for energy storage (December 2010). 7.1 Examining suitable ways to integrate wind, solar, and biogas resources (August 2010). 7.2 Analyzing cost savings and output increases through integrating small wind power systems with other renewable sources, such as solar and biogas energy (October 2010). 7.3 Examining ways to improve predictability and reliability of electricity supply from renewable energy sources (November 2010). 7.4 Preparing a report on hybrid power generation from multiple renewable energy resources (December 2010). 8.1 Evaluating environmental costs and benefits from deploying small wind power systems (July 2010). 8.2 Scrutinizing the negative environmental impact of conventional batteries (August 2010). 8.3 Proposing practical solutions for managing environmental side effects (September 2010). 8.4 Exploring the possibilities for improving the efficiency and safety of batteries (October 2010). 8.5 Preparing an environmental impact assessment and management report on distributed small wind power systems (December 2010). 9.1 Examining the current arrangements for manufacturing, delivering, and servicing small wind systems (June 2010). 9.2 Analyzing the cost structure in each step of the manufacturing, delivering, and servicing process (August 2010). 9.3 Identifying opportunities for quality enhancement and cost reduction in the manufacturing process, through, for instance, modularized and standardized design, manufacturing localization, and achievement of economies of scale in mass production (October 2010). 9.4 Assisting in building the capacity of regional or local wind power manufacturing companies to design and install small wind power systems in rural areas (December 2010). 9.5 Summarizing approaches for technological improvement and cost reduction in the manufacturing process in the manufacturing optimization report (March 2011). 10.1 Evaluating financial costs, benefits, and risks of distributed small wind power systems (August 2010). 10.2 Reviewing typical instruments for financing small wind power systems in the current financial market (October 2010). 10.3 Summarizing policy incentives, such as direct subsidies, tax privileges, and loan supports (guarantees and interest rate reduction) for deploying small wind power systems (November 2010). 10.4 Analyzing possible programmatic carbon credit supports for small wind power systems (November 2010). 10.5 Designing innovative financing tools, such as financial leasing, to minimize collateral requirements and enable periodic debt amortization through the	

Activities with Milestones	
collection of service charges, and to enable quick and large-scale deployment of small wind power systems (December 2010). 10.6 Constructing a financial analysis model in Excel to simulate cash flows and to calculate financial indicators, such as internal rates of return and debt-service coverage ratios (February 2011). 10.7 Proposing measures to mitigate associated risks (March 2011). 10.8 Preparing the financial assessment and risk management report on distributed small wind power systems (April 2011). 11.1 Conducting consultations with public and private sector partners (July 2010). 11.2 Assisting with building public–private partnerships to facilitate implementation (September 2010). 11.3 Analyzing modified implementation mechanisms, such as aggregated planning, financing, installation, and maintenance to ensure efficiency and sustainability (October 2010). 11.4 Designing a build-own-operate-transfer modality to deploy distributed small wind power systems in remote windy poor rural communities (November 2010). 11.5 Preparing a report on the energy access delivery mechanism through public–private partnerships (December 2010). 12.1 Reviewing legal, regulatory, and policy environments for deploying small wind power systems in selected areas (April 2010). 12.2 Analyzing fiscal and financial incentives for adopting small wind power systems in selected areas (May 2010). 12.3 Learning and sharing international experiences in developing small wind power systems (July 2010). 12.4 Examining policy options and evaluating their potential effectiveness for deploying small wind power systems (September 2010). 12.5 Proposing how to facilitate transfers of low-carbon technologies and strengthen regional cooperation (October 2010). 12.6 Preparing the policy recommendations report on scaling up distributed small wind power systems, taking into account the specific issues of each participating DMC (December 2010). 13.1 Formulating the proposals for the first three pilot projects (July 2010). 13.2 Conducting feasibility studies and environmental impact assessments for the first three pilot projects (October 2010). 13.3 Obtaining statutory approvals (December 2010). 13.4 Procuring and contracting for the construction (March 2011). 13.5 Validating the first three pilot projects (June 2011). 13.6 Constructing the next three pilot projects with necessary remedies (October 2011). 13.7 Preparing the pilot project configuration and performance reports (December 2011). 14.1 Conducting three workshops on small wind power systems, one each on the resources, technologies, and financing mechanism (December 2010). 14.2 Conducting three on-site dissemination workshops (December 2011). 14.3 Conducting three training programs on planning and implementing small wind power projects (June 2012). 14.4 Delivering other policy advice and capacity building activities to engage more poor communities, financial institutions, private sector partners, and NGOs (June 2012).	

ADB = Asian Development Bank, DMC = developing member country, MDG = millennium development goal, NGO = nongovernment organization, TA = technical assistance.

COST ESTIMATES AND FINANCING PLAN
($'000)

Item	Total Cost
Asian Development Bank Financing[a]	
1. Consultants	1,225.00
a. Remuneration and per diem	1,140.00
i. International consultants	540.00
ii. National consultants	600.00
b. International and local travel	75.00
c. Reports and communications	10.00
2. Equipment	1,275.00
a. Measurement and analysis devices[b]	175.00
b. Pilot and demonstration projects[c]	1,100.00
3. Training, seminars, conferences, and workshops[d]	275.00
4. Surveys and study tours[e]	760.00
5. Representative for contract negotiations	15.00
6. Miscellaneous administration and support costs	90.00
7. Contingencies	230.00
Total	**3,870,000.00**

[a] Financed by the Asian Development Bank's Technical Assistance Special Fund ($2,620,000 from TASF–IV and $1,250,000 from TASF–other sources). In-kind contributions of participating developing member countries are not included.

[b] Includes wind and solar resource measurement devices, turbine and battery testing devices, and other relevant devices.

[c] Includes costs of design, system procurement, installation, and operation and maintenance arrangements.

[d] Includes honorarium and travel costs for resource persons and facilitators, participants' travel costs, staff travel costs as resource persons and/or speakers, and logistical costs.

[e] Includes needs assessment, wind resource assessment, technology evaluation, and manufacturing surveys.

Source: Asian Development Bank estimates.

OUTLINE TERMS OF REFERENCE FOR CONSULTANTS

1. For this research and development technical assistance (TA) on Effective Deployment of Distributed Small Wind Power Systems in Asian Rural Areas, the Asian Development Bank (ADB) will engage consultants in accordance with its Guidelines on the Use of Consultants (2007, as amended from time to time). Three international consultants (30 person-months total) will be engaged individually. National project implementation teams in participating developing member countries (DMCs) consisting of national consultants (72 person-months total) will be engaged as firms. An energy project coordinator (24 person-months) and renewable energy specialist (24 person-months) will be engaged individually. Detailed terms of reference will be finalized before recruitment.

A. International Consultants

1. Renewable Energy Technologies Specialist (15 person-months)

2. The tasks of the renewable energy technologies specialist will include the following:
   (i) summarizing international experiences on utilizing hybrid wind-solar-biogas power systems;
   (ii) evaluating technical designs, installation requirements, and operational processes of existing small wind power systems supplied by leading manufacturers;
   (iii) exploring possibilities to increase electricity output, simplify maintenance, minimize capital and operational expenses, and improve system reliability and durability with a target to reduce energy costs by about 20%;
   (iv) examining engineering and financial gains by incorporating the most recent developments in rotor and blade aerodynamics, airfoils, direct-drive permanent magnet generators, intelligent power electronics and control subsystems, compact materials, extended support towers, and noise reduction techniques;
   (v) analyzing complementarities among wind, solar, and biogas energy within a rural context, and evaluating the improvement in energy output predictability;
   (vi) comparing different approaches to energy storage and balancing to cope with intermittency difficulties of stochastic wind power, including evaluating the suitability of air compression, flywheels, and hydrogen conversion energy storage technologies;
   (vii) exploring direct uses for pumping and purifying water, desalinating seawater, heating houses during harsh winters, and producing ice and salt for coastal fishing families;
   (viii) examining the negative environmental impact of conventional batteries that have been used in many off-grid renewable energy projects. and scrutinizing possibilities to improve their efficiency, safety, and environmental friendliness;
   (ix) based on the information and recommendation provided by the national consultants, and under the guidance of the project team, proposing renewable energy systems most appropriate for the targeted communities;
   (x) conducting capacity building activities on technological issues; and
   (xi) carrying out other relevant works assigned by the project team.

2. Manufacturing Optimization Specialist (9 person-months)

3. The tasks of the manufacturing optimization specialist will include the following:
   (i) reviewing the manufacturing, delivery, and servicing procedures of small wind power systems;

(ii) reviewing international technical standards and norms, standardized factory acceptance tests, and most recent technical trends regarding manufacturing of parts and components of small wind power systems;
(iii) proposing measures to significantly cut wind equipment cost, through, for instance, standardized design, modularized installation, and achievement of economies of scale in mass production;
(iv) identifying key technologies to be transferred and appropriate approaches (e.g., licensing, equity participation, joint research and development) for such transfers;
(v) identifying opportunities and analyzing costs and benefits for component contract manufacturing and outsourcing;
(vi) recommending strategies and action plans for manufacturing localization;
(vii) conducting capacity building activities on manufacturing issues; and
(viii) carrying out other relevant works assigned by the project team.

3. Energy Financial Specialist (6 person-months)

4. The tasks of the energy financial specialist will include the following:
(i) analyzing the cost structure of the small wind power systems, including both the up-front investment and operation and maintenance costs;
(ii) estimating financial, economic, and environmental benefits of the small wind power systems;
(iii) calculating the payback period, financial and economic internal rates of return, debt service coverage ratio, and other financial indicators of a typical pilot project;
(iv) examining common practices and community affordability of electricity service charges;
(v) designing innovative financing mechanisms that are acceptable to commercial banks, with satisfactory debt service coverage;
(vi) identifying key risk factors and designing mitigation measures to enhance financial robustness;
(vii) analyzing the availability and channels of grant assistance and regulatory incentives;
(viii) assisting in evaluating programmatic carbon credits;
(ix) examining the feasibility and viability of a financial leasing modality to minimize collateral requirements and enable periodic debt amortization through service charges;
(x) analyzing the incentives for private sector participation;
(xi) calculating the financing requirements for scaling up the pilot projects to serve 2.5 million poor people;
(xii) recommending policies to on how to facilitate transfers of low-carbon technologies and strengthen regional cooperation to create a favorable regulatory framework and business environment for maximizing the use of indigenous renewable resources, and to produce global public goods in clean energy to mitigate global warming and climate change;
(xiii) conducting capacity building activities on financial and economic issues; and
(xiv) carrying out other relevant works assigned by the project team.

B. National Consultants

1. National Consultants for Project Implementation (72 person-months)

5. Three teams of national consultants for project implementation will be engaged, each as a firm to implement the project activities in the participating DMCs. Each team will be composed of

- (i) a senior renewable energy specialist and national team leader (10 person-months),
- (ii) a renewable energy engineer (6 person-months),
- (iii) an energy economist (2 person-months),
- (iv) a financial specialist (2 person-months),
- (v) an environmental specialist (2 person-months), and
- (vi) a social development specialist (2 person-months).

6. The national consultants should have extensive and up-to-date knowledge of domestic energy policies, ongoing programs, market dynamics, renewable energy technologies, social development issues, financial management requirements, accounting practices, and so on. The consultants should have hands-on experience and verifiable track records in developing renewable energy projects in rural areas.

7. The national consultants will carry out the following activities:

- (i) providing background information and assisting the international consultants and the project team in data collection and designing the project framework;
- (ii) identifying at least three poor and windy rural communities without adequate access to electricity as candidate locations for implementing pilot projects to deploy small wind power systems;
- (iii) assessing socioeconomic conditions, infrastructure bases, energy demand and consumption baselines, environmental situations, and poverty reduction challenges in the selected poor communities;
- (iv) analyzing demand patterns and load management needs to improve the efficiency of future electricity uses, such as utilization of the most efficient lighting, pumping, and refrigeration facilities;
- (v) assisting in installing measurement devices for indigenous renewable energy (wind, solar, and biogas) resources; keeping, summarizing, and presenting measurement records; verifying resource adequacy; and supplying sufficient and reliable data for system planning and optimal micro-siting of small wind systems;
- (vi) assisting in stakeholder consultations;
- (vii) preparing feasibility studies and obtaining statutory approvals for the pilot projects;
- (viii) constructing pilot projects as decided by the project team;
- (ix) monitoring and evaluating social, economic, and environmental impacts of the pilot projects;
- (x) conducting dissemination, outreach, and capacity building activities to raise awareness among stakeholders of the importance of increasing access to modern energy services, and to engage more poor communities in expediting the development of distributed power generation systems from wind and other renewable sources;
- (xi) showcasing the results of the demonstration projects;

(xii) making country-specific policy recommendations to scale up deployment of small wind power systems, taking into account the specific issues of each participating DMC; and
(xiii) carrying out other relevant works assigned by the project team.

2. Renewable Energy Specialist (24 person-months)

8. The tasks of the renewable energy specialist will include the following:
(i) assisting in building up public–private partnerships to improve the efficiency and effectiveness of the energy access delivery mechanisms;
(ii) designing and refining the build-own-operate-transfer modality for smooth implementation and sustainable operation of the distributed small wind power systems in windy and poor communities;
(iii) assisting in adopting the hybrid wind-solar-biogas power systems to meet the needs and resource conditions in the remote windy rural communities;
(iv) assisting in optimizing the manufacturing processes;
(v) assisting in designing and implementing the six pilot projects;
(vi) assisting in preparing the procurement plan; negotiating with the technology suppliers; and installing, commissioning, and arranging for repair and maintenance of the demonstration projects; and
(vii) carrying out other relevant works assigned by the project team.

3. Energy Project Coordinator (24 person-months)

9. The tasks of the energy project coordinator will include the following:
(i) assisting the project team in planning, coordinating, and monitoring activities of the international and other national consultants;
(ii) maintaining project documents and records;
(iii) preparing and managing financial accounts for the TA, including scrutinizing invoices presented by vendors and the international and national consultants;
(iv) organizing and implementing capacity building activities, including six workshops, three training programs, on-site demonstration showcases, and study tours;
(v) designing and organizing information dissemination activities; and
(vi) carrying out other relevant works assigned by the project team.

10. The energy project coordinator will prepare progress reports and case studies, with inputs from the national consultants for project implementation.