ADB

Technical Assistance Report

Project Number: 45124
Regional – Capacity Development Technical Assistance (R-CDTA)
December 2011

Smart Grid Capacity Development

(Financed by the Japan Fund for Poverty Reduction)

Asian Development Bank

ABBREVIATIONS

ADB	–	Asian Development Bank
DMC	–	developing member country
ESS	–	energy storage system
GSEP	–	Global Sustainable Electricity Partnership
HVDS	–	high-voltage distribution system
ISGAN	–	International Smart Grid Action Network
MW	–	megawatt
PPP	–	public–private partnership
TA	–	technical assistance

TECHNICAL ASSISTANCE CLASSIFICATION

Type	–	Regional–Capacity development technical assistance (R-CDTA)
Targeting classification	–	General intervention
Sector (subsectors)	–	Energy (renewable energy, energy efficiency and conservation)
Themes (subthemes)	–	**Economic growth** (promoting economic efficiency and enabling business environment, widening access to markets and economic opportunities); environmental sustainability (eco-efficiency, natural resource conservation, global and regional transboundary environmental concerns); private sector development (public–private partnerships); capacity building (client relations, networks, and partnership development)
Climate change	–	Climate change mitigation
Location (impact)	–	Rural (low), urban (low), national (low), regional (high)
Partnerships	–	Japan Fund for Poverty Reduction, International Smart Grid Action Network, Global Sustainable Electricity Partnership

NOTE

In this report, "$" refers to US dollars.

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I. INTRODUCTION

1. In facing the challenges of energy security and climate change, some developing member countries (DMCs) have taken the lead in promoting renewable energy. At the same time, expectations are raised for smart grid technology out of concern that unstable output of renewable energy will adversely affect the power systems which the power from renewable energy will be fed into. In this context, during the second meeting of the Asia Solar Energy Forum in Tokyo, Japan, in December 2010, several South Asia DMCs asked the Asian Development Bank (ADB) to provide capacity development technical assistance (TA) for developing the smart grid. The concept paper was approved on 20 May 2011[1] and further discussed during the Workshop for Solar Energy and Smart Grid[2] in Jodhpur, India, in September 2011. The design and monitoring framework is in Appendix 1.

II. ISSUES

2. Promoting the availability and use of clean energy is one of ADB's highest priorities. In 2010, ADB funded nearly $1.76 billion worth of projects with clean energy components, exceeding its $1 billion target for the third year in a row. From 2013, ADB will raise the target for clean energy to $2 billion a year. The Asia and Pacific region, where demand for energy is projected to almost double by 2030, could substantially increase the use of clean power from sustainable solar energy and other renewable sources within the next 3 years. For example, the Government of India launched the Jawaharlal Nehru National Solar Mission in 2010 to (i) create an enabling policy framework for deployment of 20,000 megawatts (MW) of solar power by 2022; and (ii) ramp up the capacity of grid-connected solar power generation to 1,000 MW within 3 years, with an additional 3,000 MW by 2017 through the mandatory use of the renewable purchase obligation by utilities backed with a preferential tariff.

3. Several South Asian DMCs requested TA for applying smart grid technology to their power systems. The smart grid is expected to increase the connectivity, automation, and coordination among suppliers, consumers, and networks that perform either wide-area bulk transmission or local distribution tasks. With the development of a smart grid, the concept of a centralized network shifts toward decentralization of the electricity system, as businesses and homes begin generating more wind and solar electricity, enabling them to sell surplus energy back to their utilities. The modernization of networks is necessary for energy efficiency, real-time management of power flows, and to provide the two-way metering needed to compensate local producers of power. Although transmission networks are already controlled on a real-time basis, most are unable to handle challenges such as those posed by the intermittent nature of alternative electricity generation because of its susceptibleness to the weather.

4. The consensus among DMCs is that to mainstream power generation from renewable energy, the smart grid needs to (i) maintain system stability in the grid; (ii) promote rooftop solar photovoltaics; and (iii) reduce technical and commercial losses in distribution grids, and thereby boost energy efficiency. In India, for example, ADB's country operations business plan, 2011-2013[3] stated that energy operations will focus on the generation and transmission of clean and renewable energy to reduce greenhouse gas emissions and increase energy efficiency.

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[1] The TA first appeared in the business opportunities section of ADB's website on 20 May 2011.
[2] A large number of government officials from South Asian DMCs and private sector representatives from developed countries participated in the workshop.
[3] ADB. 2010. *India: Country Operations Business Plan 2011–2013*. Manila.

5. In some DMCs where large-scale renewable energy projects involving wind power, photovoltaics, and concentrated solar power are being developed, there is growing concern over the adverse effects that renewable energy's fluctuating output can have on system frequency and voltage of existing grids. Smart grid technology is expected to mitigate such adverse effects on transmission. System voltage fluctuation, in particular, would be a serious problem for local transmission companies[4] in charge of high-voltage transmission systems directly connected to renewable energy sources. For low-voltage distribution grids, smart grid technology attracts attention as a promising means to reduce technical and commercial loss by using more advanced technologies such as high-voltage distribution systems (HVDS). The smart meter, a major component of smart grid technology, would enable two-way power flow metering and more easily accommodate dispersed power systems such as rooftop photovoltaics in the distribution grid. Smart meters are also expected to be effective tools for data gathering and for distribution analysis. The International Smart Grid Action Network (ISGAN)[5] proposed that ADB conduct joint pilot studies on smart grid components for grid-connected transmission and distribution systems in selected DMCs.

6. Considering off-grid power systems for remote villages and islands in DMCs, fluctuation of system frequency and voltage would be a major obstacle to promoting renewable energy. Both in small-scale remote grids and large-scale interconnected grids, promoting renewable energy such as solar and wind will be key to reducing greenhouse gas emissions. Photovoltaics, in particular, would be optimal for remote grids because the equipment is static and comparatively easy to manage for local people. On the other hand, in small-scale remote grids photovoltaic output fluctuation would be rather large and could substantially affect system frequency and voltage. Smart grid technology could help achieve system stability in such cases. The Global Sustainable Electricity Partnership[6] (GSEP) is currently conducting a feasibility study on mini-grid system with solar photovoltaics and asked ADB for collaboration in developing an innovative public–private partnership (PPP) mini-grid project for environment-friendly rural electrification with large-scale solar photovoltaics.

[4] Fluctuation of system frequency is determined by a real-time imbalance between total system output and demand. Therefore, system frequency fluctuation caused by renewable energy would not be so serious for now because the total installed capacity of renewable energy would still be much lower than the total interconnected system capacity. On the other hand, to maintain the system voltage, system operators should provide adequate reactive power within each local area in the grid. However, output fluctuation of large-scale renewable energy causes an imbalance of reactive power locally, and some countermeasures would be necessary to maintain adequate system voltage.

[5] ISGAN was established by several governments, including those of the People's Republic of China, Germany, India, Japan, the Republic of Korea, Spain, and the United States. ISGAN creates a mechanism for multilateral collaboration to advance the development and deployment of smarter electric grids around the world. By creating a network of national-level stakeholders, ISGAN facilitates a dynamic exchange of knowledge, best practices, technical assistance, and project coordination. It aims to improve the understanding of smart grid technologies, practices, and systems to accelerate their development and deployment, and to promote adoption of related enabling government policies (http://www.cleanenergyministerial.org/ISGAN/).

[6] Created in the wake of the 1992 Rio Summit, the Global Sustainable Electricity Partnership, formerly known as e8, is a nonprofit organization composed of 10 world-leading electricity companies whose mission is to play an active role in global electricity issues within the international framework and to promote sustainable energy development through electricity sector projects and human capacity building activities in developing and emerging nations worldwide (http://www.globalelectricity.org/en/index.jsp).

III. THE TECHNICAL ASSISTANCE

A. Impact and Outcome

7. The impact will be smart grid for renewable energy developed and implemented in South Asian DMCs. The outcome will be improved greater institutional capacity of South Asian DMCs for smart grid development.

B. Methodology and Key Activities

8. The regional capacity development TA aims to promote smart grid development to mainstream renewable energy and boost energy efficiency in South Asian DMCs. The TA will help (i) promote an understanding by all stakeholders of the smart grid's potential as a catalyst for mainstreaming renewable energy and boosting energy efficiency in the subregion, (ii) determine the key actions required to accelerate its development, (iii) formulate the institutional and business models for development and deployment of smart grid technology, and (iv) establish the mechanisms to promote technology transfer to developing countries and to deepen research and development in South Asian DMCs.

9. This initiative will cover (i) high- and middle-voltage transmission grid management to absorb large amounts of intermittently generated power from renewable energy sources; (ii) distribution-level grid management to mainstream distributed, grid-connected renewable energy projects and reduce technical and commercial losses in the network; and (iii) mini-grid development in remote and rural areas with renewable energy systems.

10. To implement such projects, a well-organized and systematic knowledge management program will be critical and it will need to involve (i) DMC governments, (ii) private sector and research and development agencies, and (ii) developed countries and development partners. The key activities of the proposed TA are outlined in paras. 11–15.

11. Feasibility studies of the pilot projects for smart grid development will be conducted with other partners. ISGAN asked ADB to jointly develop a pilot program for stabilizing the transmission grid to mainstream renewable energy and boost energy efficiency. GSEP proposed that ADB collaborate in developing a PPP mini-grid project for rural electrification in Maldives. In collaboration with ISGAN and the private sector (GSEP), the TA will conduct various feasibility studies on applicable smart grid components at three different levels—high-voltage transmission, low-voltage distribution, and mini-grid development in rural areas.

12. For high-voltage transmission, it is envisaged to conduct feasibility studies on applicable smart grid components such as energy storage systems (ESS) and/or renewable energy operation centers. As mentioned in para. 5, stabilizing the system voltage would be important for local transmission companies that will be in charge of transmission systems directly connected to renewable energy sources. In order to maintain adequate system voltage, it would be effective to utilize batteries as ESS and/or adjust the reactive power output of the existing grid-connected power plants such as thermal and hydro. For adequate coordination of large-scale renewable energy generation, ESS and/or existing power plants, the renewable energy operation center would be the key component. With such a control center, system operators can gather data from renewable energy facilities on a real-time basis and control renewable energy generation, ESS and/or existing power plants in an integrated manner.

13. For low-voltage distribution, it is envisaged to conduct feasibility studies on applicable smart grid components such as HVDS and smart meters. As mentioned in para. 5, reducing distribution loss and encouraging widespread dissemination of rooftop photovoltaics would be major issues for distribution companies in DMCs. Upgrading existing distribution systems to HVDS would be an effective measure to reduce technical loss. Smart meters would help accumulate data such as voltage and current in distribution grids. These data can be utilized for analysis of commercial loss and voltage fluctuation caused by reverse power flow from rooftop photovoltaic installations into distribution grids. Smart meters are also expected to conduct two-way metering for surplus power from rooftop photovoltaics to utilities' distribution grids.

14. As for mini-grid development in rural areas, it is envisaged to conduct feasibility studies on a combination of photovoltaic and conventional thermal plants. As mentioned in para. 6, to maintain system stability in a mini-grid with large-scale photovoltaic power generation, it is absolutely indispensable to compensate for the intermittence of photovoltaic output. In many cases, conventional thermal power plants such as diesel generators and/or gas turbines are the main power sources in existing mini-grids. Therefore, integrated control of photovoltaics and existing diesel generators and/or gas turbines would be the effective means of compensating for the intermittence of photovoltaic output.

15. Knowledge management programs will be conducted to share the best practice of pilot projects and promote technology transfers from developed countries to DMCs. Through extensive consultation, the TA will support development of a PPP coordination mechanism among the public sector agencies, the international and domestic private sector, and international development partners. Some international workshops will be held to (i) promote private sector participation, (ii) call for support from other development partners, and (iii) disseminate best practices to other regional DMCs.

C. Cost and Financing

16. The TA will be financed on a grant basis by the Japan Fund for Poverty Reduction in the amount of $1,400,000 equivalent, and administered by ADB. The expected contributions from the private sector (GSEP) would be equipment, technical study, and organizing workshops on pilot projects for mini-grid systems. The expected contribution from ISGAN would be counterpart staff. The expected contributions from the governments of participating DMCs would be counterpart staff, office accommodation and transport.

D. Implementation Arrangements

17. ADB will be the executing agency for the TA, which will be carried out by a team of consultants. The implementing agencies are to be determined according to the pilot projects of the TA[7]. The Energy Division of the South Asia Department will supervise the work of the consultants in close coordination with the Regional and Sustainable Development Department and other operational ADB departments in order to share the output of similar TAs on smart grid in other regions covered by ADB.

18. ADB will hire a consulting firm to conduct a feasibility study on smart grid development for transmission, distribution, and mini-grid systems. The consulting work will comprise about 15 person-months of international consulting and 22 person-months of national consulting to

[7] For example, public-owned local transmission companies can be implementing agencies for the pilot projects for high-voltage transmission, public-owned local distribution companies for low-voltage distribution and governments for mini-grid development.

provide (i) technical support for identification of the necessary smart grid components for transmission (e.g., a renewable energy operation center), for distribution (e.g., HVDS and smart meter), and for the mini-grid (e.g., an integrated control system for a combination of photovoltaic and conventional thermal power; (ii) capacity development for implementing agencies to formulate technical specifications for smart grid components; and (iii) monitoring of and reporting on TA activities and output. The national consultants will work with the international consultants to provide information on local power systems.

19. ADB will also hire an individual international consultant as a PPP specialist for 5 person-months and two national consultants as PPP coordinators for 4 person-months each, who will (i) coordinate domestic and foreign private sector and government agencies to assist smart grid development; (ii) coordinate the TA with the partners, e.g., ISGAN and GSEP; and (ii) execute knowledge management programs such as organizing international workshops and supporting publication of the reports of the feasibility study on the pilot projects of the TA.

20. Two individual international consultants will be hired for 3 person-months each to conduct financial analyses and environmental and social safeguard assessments for pilot projects.

21. The selection of consultants will be conducted in accordance with ADB's Guidelines on the Use of Consultants (2010, as amended from time to time) and disbursement under the TA will be done in accordance with ADB's *Technical Assistance Disbursement Handbook* (2010, as amended from time to time). The consulting firm will be chosen using the quality- and cost-based selection method at the standard quality–cost ratio of 80:20. All equipment procured under the TA will be turned over to the implementing agencies after TA completion. Advance contracting will be used to expedite the mobilization of the consultants.

22. The TA will be implemented over 36 months from January 2012 to December 2014. The outline terms of reference for consultants are in Appendix 3. Implementation progress will be reported as outlined in Appendix 3.

IV. THE PRESIDENT'S DECISION

23. The President, acting under the authority delegated by the Board, has approved ADB administering technical assistance not exceeding the equivalent of $1,400,000 to be financed on a grant basis by the Japan Fund for Poverty Reduction for Smart Grid Capacity Development, and hereby reports this action to the Board.

DESIGN AND MONITORING FRAMEWORK

Design Summary	Performance Targets and Indicators with Baselines	Data Sources and Reporting Mechanisms	Assumptions
Impact Smart grid for renewable energy developed and implemented in South Asian DMCs	By 2017: Installed capacity of renewable energy in the South Asia subregion increased to at least 5,500 MW of large-scale solar power generation (2010 baseline: 0 MW)	Statistics and reports of the government agencies	**Assumption** Smart grid and renewable energy technology is accepted by governments as a means to achieve low-carbon development while meeting other goals such as energy security and better electrification.
Outcome Improved greater institutional capacity of South Asian DMCs for smart grid development	By 2014 (project completion): Smart grid development design and action plan formulated for pilot project areas in India and Maldives, among others.	Statistics and reports of the government agencies	**Assumption** Barriers of policy, technology, and finance for mainstreaming solar power projects are overcome and the capacity of the stakeholders is well developed.
Outputs 1. Feasibility studies of pilot projects for smart grid development conducted	By 2014: At least one feasibility study developed and completed for each of the following (i) high–voltage transmission; (ii) low-voltage distribution, and (iii) mini-grid development in rural areas involving PPP.	Reports on feasibility studies; annual reports of power utilities	**Assumptions** Partnerships are formed with external institutions such as ISGAN that have expertise in the necessary areas. Relevant private sector bodies (e.g., developers, suppliers, and financiers) participate.
2. Knowledge management programs formulated	By 2014: At least two international workshops held to disseminate information on best practices At least two business models developed in the area of smart grid technology	Workshop reports TA completion report	
Activities with Milestones **1. Feasibility studies** 1.1 Inception and design of feasibility study, 1 month after contract 1.2 Consultation with ISGAN and GSEP, 3 months after initiation 1.3 Completion of feasibility study, 12 months after initiation 1.4 Tripartite meeting, 15 months after initiation 1.5 Review of the outcome, 18 months after initiation			**Inputs** $1.4 million from Japan Fund for Poverty Reduction (administered by ADB)

Activities with Milestones	Inputs
2. Knowledge dissemination 2.1 Consultation with ISGAN and GSEP, 1 month after contract validation 2.2 Agenda setting, 1 month after initiation 2.3 Review of best practices, 3 months after initiation 2.4 First workshop held, 12 months after initiation 2.5 Second workshop, 32 months after initiation	Private sector (GSEP), ISGAN, and government: In-kind contributions such as equipment, technical study, organizing workshops, and counterpart staff.

ADB = Asian Development Bank, DMC = developing member country, GSEP = Global Sustainable Electricity Partnership, ISGAN = International Smart Grid Action Network, MW = megawatt, PPP = public–private partnership, TA = technical assistance.
Source: Asian Development Bank

COST ESTIMATES AND FINANCING PLAN
($'000)

Item	Total Cost
Japan Fund for Poverty Reduction[a]	
1. Consultants	
a. Remuneration and per diem	
i. International consultants[b]	650.00
ii. National consultants[c]	120.00
b. International and local travel	130.00
c. Reports and communications	80.00
2. Equipment[d]	60.00
3. Seminars, workshops, and training	140.00
4. Surveys	10.00
5. Miscellaneous administration and support costs	70.00
6. Contingencies	140.00
Total[e]	**1,400.00**

[a] Administered by the Asian Development Bank.
[b] Assuming 26 person-months of international consultants at $25,000 per month.
[c] Assuming 30 person-months of national consultants at $4,000 per month.
[d] Equipment will comprise personal computers, photocopiers, projectors
[e] Excludes in-kind contribution from recipient DMCs in the form of office accommodation and counterpart staff, among others.
Source: Asian Development Bank estimates.

OUTLINE TERMS OF REFERENCE FOR CONSULTANTS

A. Introduction

1. Regional technical assistance (TA) for Smart Grid Capacity Development, administered by the Asian Development Bank (ADB), will require the services of a consulting firm comprising four international and three national consultants. Three individual international consultants and two individual national consultants will also be hired for the TA.

B. Consultants

2. The consultants should have extensive experience in and/or suitable knowledge of (i) institutional and commercial aspects pertaining to smart grid development; (ii) transmission systems, distribution systems, and renewable energy development in South Asian developing member countries (DMCs); and (iii) ADB's policy, guidelines, and operations manual. The consultants should have extensive consultation with stakeholders, i.e., the private sector, government agencies, and development partners. The terms of reference for this aspect include, but are not limited to:

1. Consulting Firm

3. **International smart grid development specialist (transmission)** (team leader, 6 person-months). The specialist will:

(i) consult with South Asian DMCs to determine the implementing agencies for the conduct of pilot feasibility studies on transmission, distribution, and off-grid;
(ii) propose three smart grid pilot feasibility studies on transmission grids, including concept and action plan, in a quality acceptable to ADB and the implementing agencies;
(iii) assist the agencies in executing power system analyses such as load flow and system stability, taking into account the specific characteristics of local transmission grids and large-scale renewable energy projects; and
(iv) help the agencies identify applicable smart grid components, e.g., a renewable energy operation center, energy storage systems, power conditioner, advanced metering infrastructure, forecasting system for renewable energy output—to mitigate the adverse effects of large-scale renewable energy on the existing power system (voltage fluctuation).

4. **National transmission system engineer** (8 person-months). The engineer will assist the team leader in all aspects of the above terms of reference.

5. **International smart grid development specialist (distribution)** (3 person-months). The specialist will:

(i) with the team leader, consult with South Asian DMCs to determine the implementing agencies for the conduct of pilot feasibility studies on distribution;
(ii) propose three smart grid pilot feasibility studies on distribution grids, including concept and action plan, in a quality acceptable to ADB and the implementing agencies;

(iii) assist the agencies in undertaking power system analyses such as load flow and system stability, taking into account the specific characteristics of local distribution grids and grid-connected, distributed renewable energy systems; and
(iv) help the agencies identify applicable smart grid components, e.g., high-voltage distribution systems, smart meters, energy storage systems, power conditioner, to reduce technical and commercial loss in distribution systems and promote grid-connected, distributed renewable energy systems.

6. **National distribution system engineer** (8 person-months). The engineer will assist the international smart grid development specialist (distribution) in all aspects of the above terms of reference.

7. **International smart grid development specialist (off-grid)** (3 person-months). The specialist will:

(i) with the team leader, consult with South Asian DMCs to determine the implementing agencies for the conduct of pilot feasibility studies on isolated mini-grid systems;
(ii) propose three smart grid feasibility studies on mini-grids, including concept and action plan, in a quality acceptable to ADB and the implementing agencies;
(iii) assist the agencies in executing power system analyses such as load flow and system stability, taking into account the specific characteristics of the isolated mini-grid systems and distributed, renewable energy systems, including energy requirement and usage patterns; and
(iv) help the agencies identify necessary smart grid components, e.g., integrated control systems for a combination of photovoltaic and conventional thermal power, smart meters, energy storage system, power conditioner, forecasting system for solar power output.

8. **National off-grid power system engineer** (6 person-months). The engineer will assist the international smart grid development specialist (off-grid) in all aspects of the above terms of reference.

9. **International power system control specialist** (3 person-months). The specialist will:

(i) assist implementing agencies in analyzing existing control systems for transmission, distribution, and mini-grids; and
(ii) help the agencies determine necessary improvements to existing control systems in order to manipulate transmission systems with large-scale renewable energy, distribution systems with smart meters, and mini-grid systems with distributed renewable energy.

2. Individual Consultants

10. **International public–private partnership specialist** (5 person-months). The specialist will:

(i) develop a coordination mechanism for the domestic and foreign private sector, including financiers, developers, and technology providers, and with government agencies to facilitate smart grid development;

(ii) undertake extensive consultations with stakeholders, particularly central and state governments, regulatory agencies, international and national private sector investors, and development partners;
(iii) consult with the International Smart Grid Action Network, the Global Sustainable Electricity Partnership, and other relevant agencies to develop and implement joint pilot programs; and
(iv) organize international workshops to disseminate knowledge and best practices to other DMCs.

11. **National public–private partnership coordinator** (two, 4 person-months each). The coordinator will assist the international public–private partnership specialist in all aspects of the above terms of reference.

12. **International financial specialist** (3 person-months). The specialist will:

(i) conduct financial analysis to assess viability of the pilot projects for a smart grid in transmission, distribution, and mini-grids; and
(ii) prepare analyses for the report on economic and financial issues.

13. **International environmental and social safeguard specialist** (3 person-months). The specialist will:

(i) conduct assessments on the environmental impact, involuntary resettlement impact, and impacts on indigenous people of the pilot projects for a smart grid in transmission, distribution, and mini-grids; and
(ii) prepare analyses for the report on environmental and social safeguard issues in accordance with ADB standards.

C. Reporting Requirements

14. The following reports will be produced for each assignment at key stages of TA implementation:
(i) an inception report within 1 month of TA commencement,
(ii) a midterm report within 18 months of TA commencement,
(iii) a draft final report within 30 months of TA commencement, and
(iv) a final report at the end of the 33rd month of the TA, incorporating all comments received.

15. Each consultant will submit five copies of each report, and three digital copies of the final version of each report on CD-ROM, to ADB in English.