KNOWLEDGE AND POWER: LESSONS FROM ADB ENERGY PROJECTS

ASIAN DEVELOPMENT BANK

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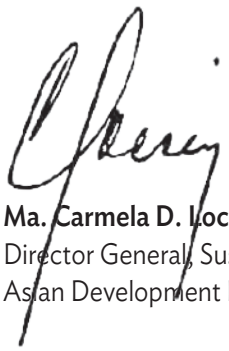
FOREWORD

The Asian Development Bank (ADB), the largest development finance institution in Asia and the Pacific, has been providing project financing to its developing member countries (DMCs) for nearly 5 decades. ADB has accumulated a wealth of knowledge from its development projects, including innovations, good practices, lessons, and ways to tackle challenges during project design and implementation. The capture, sharing, and reuse of this knowledge play an increasingly important role in achieving greater development effectiveness.

Knowledge and Power: Lessons from ADB Energy Projects harvests practical knowledge from operations in the energy sector, which accounted for 26.5% of ADB's total lending commitments from 2008 to 2014. Infrastructure development, including promoting sustainable energy supply, is one of ADB's five core areas of operations under ADB's corporate long-term strategic framework Strategy 2020.

This publication was produced through the regional technical assistance (RETA) project titled Provision of Knowledge Products and Services to Developing Member Countries through Systematic Knowledge Sharing (RETA-8392), which aims to support the systematic capture and sharing of knowledge embedded in ADB's development projects.

Comprising an overview of the energy sector and 15 case stories from different subregions and subsectors, this book focuses on ADB-wide project-level knowledge to promote cross-departmental and cross-DMC learning. We hope the readers, particularly government officials, executing and implementing agencies in DMCs, development partners, and ADB project officers, will find this book informative and useful, and allow it to influence and improve the design and implementation of future energy projects for enhanced development effectiveness.



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This publication was prepared under a partnership between the Energy Sector Group and the task team managing RETA-8392, which was supported by the People's Republic of China Poverty Reduction and Regional Cooperation Fund. It is designed to provide recent and practical insights into the design and implementation of the Asian Development Bank's (ADB) energy projects.

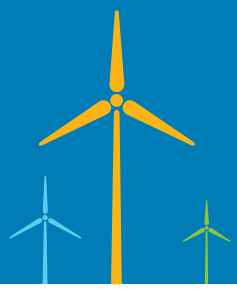
Through its analysis of ADB's project cycle and knowledge cycle, the team suggested options and approaches for further enhancing cross-project learning in ADB. In association with the Energy Sector Group, the team pilot-tested a sector approach to develop an exemplary knowledge product to demonstrate how knowledge embedded in ADB's projects can be systematically harvested. This publication, *Knowledge and Power: Lessons from ADB Energy Projects*, is the result.

For efficient capture and documentation of project-level knowledge, the team proposed guidelines, tips, and a knowledge product template. The development of the 15 case stories followed the same logical structure: context, solutions, results, and lessons. All the projects showcased in this book were recommended by ADB's operations departments and resident missions based on pre-agreed criteria.

Dongxiang Li led the RETA team and Aiming Zhou coordinated formulation of this publication on behalf of the Energy Sector Group. Anthony Jude provided overall guidance on content, Didith Mendoza-Rivera undertook the research and initial write-up, Maria Christina Dueñas and Aleli Rosario provided editorial and production support, and Mary Jane Romero provided administrative assistance. Karen Williams edited the manuscript. Alvin Tubio was responsible for typesetting and graphics generation, and Rocilyn Laccay designed the cover artwork.

The following energy project officers from ADB's operations departments and resident missions provided inputs, insights into operations, and comments on the case stories: Ashok Bhargava, Len George, Shuji Hashizume, Sohail Hasnie, Rehan Kausar, Hisaka Kimura, Xinjian Liu, Kaoru Ogino, Aniruddha Patil, Lazeena Rahman, Annika Seiler, Cinderella Tiangco, J. Michael Trainor, Madeleine Varkay, Yihong Wang, and Priyantha Wijayatunga.

ENERGY IN ASIA: AN OVERVIEW



Worldwide demand for energy has reached unprecedented levels, changing the energy landscape. Nowhere is the growth of energy demand higher than in Asia, and the region is set to surpass the rest of the world's energy consumption before 2035. Much of this demand is met through conventional fossil fuel sources, which increase Asia's greenhouse gas emissions and contribute to climate change. Alongside this, Asia is home to the largest number of people without access to modern energy, with 600 million without access to electricity, and 1.8 billion without access to modern fuels.[1]

Project implementers and stakeholders need to understand the development and needs of the region's energy sector to meet its challenges. They need to know the steps that can be taken to meet demand and expand access to energy, while supporting the region's transition to a low-carbon path of development using sustainable energy.

This overview will help key project implementers understand Asia's energy situation. It offers a snapshot of the region's energy sources and how they are used. It also presents recent developments and challenges that emphasize the urgency and necessity of sustainable energy initiatives. It provides information about efforts by the Asian Development Bank (ADB) to help Asia implement sustainable energy initiatives.

WHERE DOES ASIA'S ENERGY COME FROM?

Generally, Asia draws its energy from conventional fossil fuels (i.e., oil, coal, and natural gas) and naturally renewable sources (e.g., hydro and geothermal power).

CONVENTIONAL ENERGY

Coal. In 1994, coal fueled 40.5% of the Asia and Pacific region's energy needs—by 2009, this had risen to 48.7%.[2] Since the beginning of the 21st century, coal has been the fastest-growing energy source worldwide. Asia is the biggest market for coal worldwide, and currently accounts for 67% of global coal consumption.[3]

1 United Nations Development Programme. 2014. New Hub to Bring Investment and Innovation in Clean Energy to Asia and the Pacific. 18 June. http://www.undp.org/content/undp/en/home/presscenter/pressreleases/2014/06/18/new-hub-to-bring-investment-and-innovation-in-clean-energy-to-asia-and-the-pacific.html (accessed 12 December 2014).

2 Asian Development Bank (ADB). 2013. *Primer Energy Statistics in Asia and the Pacific (1990–2009) and Energy Outlook for Asia and the Pacific.* Manila.

3 World Coal Association. Uses of Coal. http://www.worldcoal.org/coal/uses-of-coal/ (accessed 4 May 2015).

Asia possesses one-fourth of the world's coal reserves.[4] In 2013, coal production totaled 7,822.8 million tons worldwide, a 0.4% increase over 2012 with five of the top 10 coal-producing countries located in Asia (Table 1.1).[5]

Table 1.1: Top 10 Coal Producers (2013e)

Country	Production (Mt)
People's Republic of China	3,561
United States	904
India	613
Indonesia	489
Australia	459
Russian Federation	347
South Africa	256
Germany	191
Poland	143
Kazakhstan	120

e = estimated, Mt = million ton.
Source: World Coal Association.

Coal contains solid combustible, sedimentary, and organic rocks composed mainly of carbon as well as hydrogen, oxygen, sulfur, and moisture.[6] Because coal is a finite source of energy, sustainability is a key issue in its production. Current reserves total 892 billion tons (i.e., 113 years of coal output).[7] Coal consumption causes serious environment issues such as greenhouse gas (GHG) emissions, which contribute to global warming, acid rain, and localized air pollution, along with social impacts such as increased respiratory ailments and mine safety issues.

Oil. Oil accounted for 33.9% of the region's energy supply in 1994, but decreased to 26.2% in 2009 (footnote 2). Oil for energy comprises crude oil, condensates, natural gas liquids, refinery feedstock and additives, and other hydrocarbons (e.g., emulsified, synthetic crude, and mineral oils). Lacking significant oil resources of its own, Asia depends on imports from other regions, particularly the Middle East. Asia's share in total global oil production was only 2.5% at the end of 2013, or about 42.1 billion barrels. Like coal, oil is a finite resource. As of December 2013, proven world oil reserves[8] totaled 1,687.9 billion barrels, enough to meet 52.9 years of global production.[9]

Nuclear energy. In 2004, about 4.1% of the region's energy supply came from nuclear energy. By 2009, this decreased to 3.2%, although the number of nuclear power plants in Asia has slowly increased over the years. Among 40 nuclear plants connected to energy grids worldwide in 1995–2004, 28 were in the People's Republic of China (PRC), Japan, the Republic of Korea, the Russian Federation, India, and Pakistan.[10] In October 2013, East and South Asia had 119 operable nuclear power reactors, 49 under construction, 100 firmly planned, and many more proposed. The greatest growth in nuclear power is expected in the PRC, the Republic of Korea, and India.[11]

4 ADB. 2013. Feeding Asia's Energy Appetite. May. http://www.adb.org/news/op-ed/feeding-asias-energy-appetite-changyong-rhee (accessed 12 December 2015).
5 World Coal Association. Coal Statistics. http://www.worldcoal.org/resources/coal-statistics/
6 International Energy Agency. Coal. http://www.iea.org/topics/coal/ (accessed 12 February 2015).
7 Economic Research Institute for ASEAN and East Asia. 2014. Ensuring Energy Security through Clean Coal. September. http://www.eria.org/press_releases/FY2014/09/ensuring-energy-security-through-clean-coal.html
8 Proven reserves of oil—Generally taken to be those quantities that geological and engineering information indicates with reasonable certainty can be recovered in the future from known reservoirs under existing economic and operating conditions.
9 British Petroleum. 2014. *BP Statistical Review of World Energy 2014.* http://www.bp.com/content/dam/bp/pdf/Energy-economics/statistical-review-2014/BP-statistical-review-of-world-energy-2014-full-report.pdf (accessed 12 July 2015).
10 Asia Pacific Energy Research Centre. 2004. *Nuclear Power Generation in the APEC Region.* http://aperc.ieej.or.jp/file/2010/9/26/Nuclear_Power_Generation_2004.pdf
11 World Nuclear Association. 2013. Asia's Nuclear Energy Growth. http://www.world-nuclear.org/info/country-profiles/others/asia-s-nuclear-energy-growth/

Natural gas. In 1994, natural gas supplied about 10.3% of Asia's energy needs, increasing an average 5.5% per year to 12.0% in 2009.[12] Projections suggest that demand for natural gas will increase at 3.9% per year, reaching 1,463.2 million tons of oil equivalent (Mtoe) in 2035, 2.6 times the 2010 level of 566.7 Mtoe. About 51.7% of the entire growth in natural gas demand between 2010 and 2035 in Asia and the Pacific will come from the PRC, followed by India (13.0%), Indonesia (6.0%), and Japan (4.8%).[13] Natural gas forms when layers of buried plants and animals are exposed to intense heat and pressure over thousands of years. It is nonrenewable because it cannot be replenished at a rate which matches current and projected consumption levels.[14] In late 2013, proven global reserves totaled 185.7 trillion cubic meters, sufficient to meet 55.1 years of production. In Asia and the Pacific, proven natural gas reserves can meet 31.2 years of production.[15]

RENEWABLE ENERGY SOURCES

In recent years, international attention has shifted to renewable energy as a result of increased awareness of the effects of climate change and concerns about energy supply and energy security. Renewable energy (e.g., solar, wind, hydropower, geothermal, and bioenergy) is harnessed from natural resources that are virtually inexhaustible or are replenished.

Hydropower. Hydropower is the world's largest clean energy source, providing 16% of all electricity.[16] In 2011, Asia and the Pacific generated 1,098 terawatt-hours (TWh) (almost 32%) of hydropower, compared with 886 TWh (25%) in Europe.[17] Currently installed or under construction hydropower in Asia totals 542 gigawatts (GW), which potentially could quadruple to 2,204 GW.[18] However, large hydropower plants can have negative environmental and social impacts (e.g., changes in river ecosystem, disruptions in wildlife, and social displacement). In recent years, small-scale hydro installations have been expanding and contributing to increased energy access. Small hydropower plants with a capacity of 10 megawatts (MW) now exist in 148 countries, which could potentially grow to about 173 GW.[19]

Geothermal energy. The Asia and Pacific region is home to some of the world's top producers of geothermal energy. Drawing on the heat of the earth's crust, geothermal energy is used to generate electricity and supply direct thermal energy requirements. Six of the 24 countries producing electricity from geothermal energy are in Asia— the PRC, Indonesia, Japan, Papua New Guinea, the Philippines, and Thailand. These countries produced about 30% of the world's geothermal electricity in 2009.[20]

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12 ADB. 2013. *Energy Statistics in Asia and the Pacific (1990–2009).* Manila. http://www.adb.org/sites/default/files/pub/2013/energy-statistics-1990-2009.pdf

13 ADB. 2013. *Energy Outlook for Asia and the Pacific.* Manila. October. http://www.adb.org/sites/default/files/pub/2013/energy-outlook.pdf

14 United States Environmental Protection Agency. 2013. Clean Energy. http://www.epa.gov/cleanenergy/energy-and-you/affect/natural-gas.html (last updated 25 September 2013).

15 British Petroleum. 2014. Natural Gas Reserves. http://www.bp.com/en/global/corporate/about-bp/energy-economics/statistical-review-of-world-energy/review-by-energy-type/natural-gas/natural-gas-reserves.html

16 International Energy Agency. 2013. Renewables: Hydropower. http://www.iea.org/topics/renewables/subtopics/hydropower/

17 Asian Power. 2011. Hydropower in Asia—Let the Rivers Run. July. http://asian-power.com/environment/commentary/hydropower-in-asia-let-rivers-run

18 ADB. 2013. *Asian Development Outlook 2013: Asia's Energy Challenge.* Manila.

19 United Nations Industrial Development Organization and International Center on Small Hydro Power. 2013. *World Small Hydropower Report 2013.* http://www.smallhydroworld.org/fileadmin/user_upload/pdf/WSHPDR_2013_Final_Report-updated_version.pdf

20 United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP). 2012. *Geothermal Energy Fact Sheet.* http://www.unescap.org/sites/default/files/27.%20FS-Geothermal-energy.pdf (accessed 12 December 2014).

Solar energy. Solar thermal and photovoltaic technologies can convert sunlight into usable heat and electricity. Although solar energy provides a small contribution to energy supply in Asia and the Pacific, it is now the region's fastest-growing energy source, albeit from a low base. Solar energy is enjoying rapid uptake worldwide, and by 2050, it is projected that solar power could provide as much as a quarter of all electricity generation.[21]

Wind energy. Wind turbines harness energy from the wind and convert kinetic energy into electricity. Wind resources are widely available worldwide[22] and its deployment for power has more than doubled since 2008, approaching 300 GW of cumulative installed capacities, providing about 2.5% of global electricity demand.[23]

Projections suggest that wind energy could provide up to 10% of all electricity by 2020. In Asia, the estimated potential of wind energy could generate millions of megawatts of electricity. However, the wind energy subsector in Asia generally produces very little electricity, except in the PRC and India.[24]

Bioenergy. Biological sources or biomass, such as wood and animal dung, are sources of fuel (through burning or other chemical reactions) and electricity, as well as biofuels (e.g., feedstock). Biofuels are solid (e.g., wood, charcoal, and wood pellets) or liquid (e.g., bioethanol and biodiesel). Biomass is used predominantly in developing countries, mostly in the form of wood and agricultural residues. It is the most common fuel for cooking and heating.[25]

In Asia, where most areas are still agricultural, biomass accounted for 8.8% of the total energy supply in 1994, decreasing to 7.4% by 2009. As oil gained greater prominence in the total energy supply mix, consumption of biomass decreased.

Figure 1.1 shows the total energy supply mix in Asia and the Pacific in 1994 and 2009. It also illustrates the region's dependency on each energy source and provides insights into the energy challenges of the region.

HOW DOES ASIA USE ENERGY?

The Asia and Pacific region accounts for around 60% of world energy demand.[26] In a business-as-usual scenario, the region's total primary energy demand will increase steadily, from 4,985.2 Mtoe in 2010 to 8,358.3 Mtoe in 2035 (i.e., 2.1% per year), which is the fastest rate of growth in demand worldwide (footnote 13).

[21] International Energy Agency. 2011. *Solar Energy Perspectives.* http://www.iea.org/publications/freepublications/publication/Solar_Energy_Perspectives2011.pdf

[22] International Energy Agency. Renewables: Wind. http://www.iea.org/topics/renewables/subtopics/wind/ (accessed 14 February 2015).

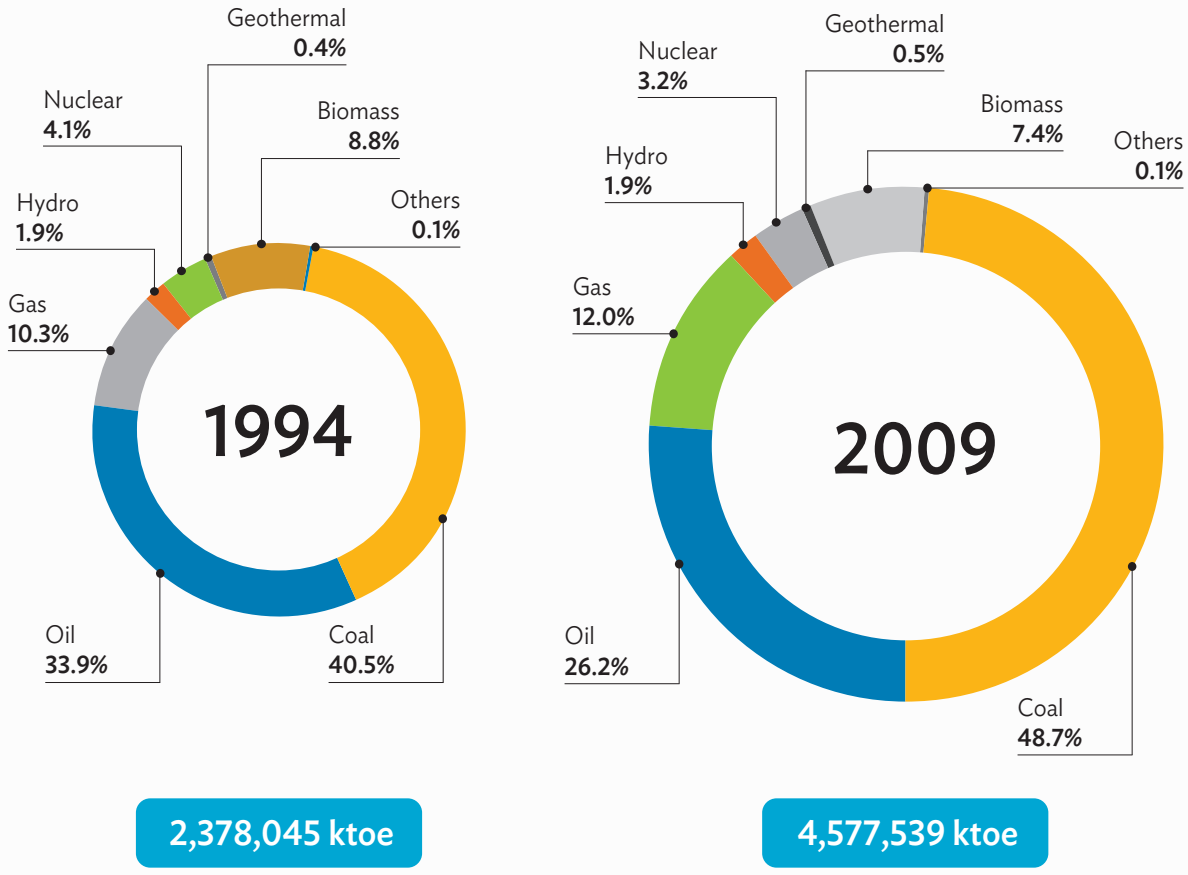
[23] International Energy Agency. 2013. *Technology Roadmap: Wind Energy – 2013 Edition.* http://www.iea.org/publications/freepublications/publication/technology-roadmap-wind-energy---2013-edition.html

[24] ADB. Wind Energy. http://www.adb.org/sectors/energy/programs/clean-energy-program/wind-energy (accessed 22 December 2014).

[25] Food and Agriculture Organization of the United Nations Regional Office for Asia and the Pacific. 2009. *Biomass Energy in the Asia Pacific Region: Current Status, Trends, and Future Setting.* Bangkok, Thailand. http://www.fao.org/3/a-am621e.pdf

[26] Asia-Pacific Economic Cooperation. Energy. http://www.apec.org/Groups/SOM-Steering-Committee-on-Economic-and-Technical-Cooperation/Working-Groups/Energy.aspx (accessed 22 December 2014).

Figure 1.1: **Primary Energy Supply by Source, 1994 and 2009**



ktoe = thousand tons of oil equivalent.
Source: ADB Energy Statistics.

Asia has driven the increasing trend in world energy consumption in the last 2 decades. In 2011, this growth rate was about 5.4% for the Asia and the Pacific region, compared to 3.1% worldwide.[27]

Coal and oil are the fuels of choice in many countries in the region, and projections suggest they will remain dominant until 2035 among nonrenewable sources. Asia has led coal consumption around the world, which has more than doubled since 1980. Asia has surpassed Europe and the former Soviet Union in coal consumption,[28] and coal is expected to be Asia's main source of energy until 2035 (footnote 13). Coal consumption in Asia has been driven by the PRC, where coal usage increased fivefold between 1980 and 2010, accounting for 73% of Asia's consumption and almost half of global coal consumption in 2010 (footnote 26). The same trend is evident

[27] R.F. Aguilera, J. Inchauspe, and R.D. Ripple. 2014. The Asia Pacific Natural Gas Market: Large Enough for All? *Energy Policy* 65: 1–6.
[28] United States Energy Information Administration. 2011. Rising Asian Demand Drives Global Coal Consumption Growth. *Today in Energy*. 20 December. http://www.eia.gov/todayinenergy/detail.cfm?id=4390

in oil consumption: Europe's consumption has decreased, while Asia's oil consumption has grown threefold, driven by oil demand in the PRC and India.[29]

Notably, with demand for natural gas totaling 790 billion cubic meters, the natural gas market in Asia likely will become the second largest market by 2015.[30] Compared to North America and most of Western Europe, which for many years experienced level growth in electricity generating capacity, particularly by nuclear power, some countries in East and South Asia are planning and building new nuclear power reactors to meet increasing demands for electricity.[31]

Energy fuels and powers transport, industries, and residential and commercial establishments. Nonenergy use[32] tends to be largest in economies with large refinery industries.[33] In Asia and the Pacific, industry demanded 1,216.5 Mtoe (37.6%) of all energy in 2010 (footnote 13).Countries with large manufacturing industries for iron and steel, nonmetallic minerals (e.g., aluminum, cement, and glass), paper and pulp, and chemicals generally require more energy.

Transport has the fastest growing energy demand among all sectors in Asia, estimated at 517.7 Mtoe in 2010 and likely to reach 1,003.2 Mtoe in 2035, mainly due to higher incomes and increasing mobility. Road transport consumes the most energy, comprising about 90% (footnote 12). However, demand also increased in other sectors (e.g., residential, commercial, and agriculture). Among these, the combined share of the residential and commercial sectors totaled 1,176.7 Mtoe in 2010.

The overall consumption of nonrenewable sources of energy far exceeds that of renewable sources. Among renewable sources of energy, hydropower is projected to demonstrate the largest growth.

Overall, energy demand and consumption in Asia and the Pacific has risen continuously, from 43% in 2000 to 3,862 Mtoe in 2010. Such increases pose a huge challenge in a region that has the third lowest per capita supply of total primary energy (1,438 kilograms of oil equivalent [koe]) in the world after Africa (737 koe) and Latin America and the Caribbean (1,331 koe).[34] Increased energy use has also lowered air quality due to pollution in many Asian cities. Table 1.2 shows the final energy consumption and energy balances across Asia.

[29] B. Plumer. 2013. These Maps Show How Asia Is Taking Over the Oil Market. *Wonkblog* (blog). *The Washington Post.* 26 August. http://www.washingtonpost.com/blogs/wonkblog/wp/2013/08/26/these-maps-show-how-asia-is-taking-over-the-oil-markets/

[30] International Energy Agency. 2013. *Developing a Natural Gas Trading Hub in Asia: Obstacles and Opportunities.* http://www.iea.org/media/freepublications/AsianGasHub_WEB.pdf

[31] World Nuclear Organization. 2013. Asia's Nuclear Energy Growth. http://www.world-nuclear.org/info/Country-Profiles/Others/Asia-s-Nuclear-Energy-Growth/

[32] Nonenergy use refers to fuels that are used as raw materials in the different sectors and are not consumed as a fuel or transformed into another fuel.

[33] Asia-Pacific Economic Cooperation. 2013. *APEC Energy Demand and Supply Outlook.* 5th ed. Tokyo. http://publications.apec.org/publication-detail.php?pub_id=1389

[34] UNESCAP. 2014. *Statistical Yearbook for Asia and the Pacific.* Bangkok. http://www.unescap.org/stat/data/syb2013/escap-syb2013.pdf

Table 1.2: Energy Consumption by Sector and Energy Balances across Asia

FINAL ENERGY CONSUMPTION BY SECTOR AND ENERGY BALANCES	Final Energy Consumption								TPES Balance							
	Total		Industry		Transport		Residential Use		Total		Production		Imports		Exports	
	Million Tons of Oil Equivalent		% of Total Final Energy Consumption						Million Tons of Oil Equivalent							
	2000	2010	2000	2010	2000	2010	2000	2010	2000	2010	2000	2010	2000	2010	2000	2010
East and Northeast Asia	1,269	2,022	35	43	16	14	27	21	1,838	3,238	1,225	2,430	762	1,114	118	133
China, People's Republic of	769	1,514	38	47	11	12	37	23	1,095	2,456	1,064	2,252	97	386	69	53
Hong Kong, China	9	8	20	22	41	22	13	16	13	14	0	0	22	33	2	1
Japan	345	325	29	28	25	24	14	15	519	497	106	97	435	427	6	18
Korea, Democratic People's Republic of	17	16	67	68	3	2	0	0	20	19	19	21	1	1	0	3
Korea, Republic of	127	157	30	28	21	19	12	13	188	250	34	45	207	267	41	46
Mongolia	2	2	31	34	21	21	28	30	2	3	2	15	0	1	0	12
Southeast Asia	274	399	28	30	23	23	34	27	381	553	452	672	196	318	237	384
Brunei Darussalam	1	2	12	59	48	23	12	8	2	3	20	19	0	0	17	15
Cambodia	3	4	21	21	15	15	64	63	3	5	3	4	1	1		
Indonesia	120	156	25	29	18	23	43	37	155	208	237	381	26	42	107	215
Malaysia	30	43	39	30	35	33	10	10	47	73	74	86	16	39	42	51
Myanmar	11	13	10	10	10	6	78	81	13	14	15	23	1	0	4	9
Philippines	24	24	22	27	34	34	34	26	40	40	20	23	23	22	2	4
Singapore	9	24	34	32	21	12	6	3	19	33	0	0	83	135	42	57
Thailand	50	85	33	31	29	23	15	13	72	117	44	71	37	64	5	13
Viet Nam	25	49	31	36	14	21	48	33	29	59	40	66	9	14	19	21
South and Southwest Asia	551	804	26	29	15	16	43	37	755	1,142	720	1,005	185	376	147	225
Bangladesh	15	23	12	18	7	13	61	53	19	31	15	26	4	6	0	0
India	319	457	27	33	10	12	45	38	457	693	366	519	100	244	9	63
Iran, Islamic Republic of	93	157	20	24	27	26	32	30	123	208	254	349	6	18	136	153
Nepal	8	10	5	4	3	6	90	87	8	10	7	9	1	1	0	0
Pakistan	51	70	22	25	16	16	52	48	63	85	47	64	18	22	1	2
Sri Lanka	7	9	23	25	23	26	45	42	8	10	5	6	4	4	0	
Turkey	58	78	34	29	20	19	30	29	76	105	26	32	52	81	1	7
North and Central Asia	499	549	30	30	17	20	32	25	741	864	1,181	1,622	50	43	481	784
Armenia	1	2	36	18	19	28	26	30	2	2	1	1	2	2	0	0
Azerbaijan	7	7	30	10	11	26	36	44	11	12	19	65	0	0	8	53
Georgia	2	3	16	17	16	29	53	40	3	3	1	1	2	2	0	0
Kazakhstan	22	44	44	46	15	11	9	14	36	75	79	157	8	12	51	91
Kyrgyz Republic	2	3	26	31	16	34	11	5	2	3	1	1	1	2	0	0
Russian Federation	419	446	31	29	18	22	33	25	619	702	978	1,293	33	23	382	602
Tajikistan	2	2	26	27	1	5	16	13	2	2	1	2	1	1	0	0
Turkmenistan	8	12	11	12	23	14	1	1	14	21	46	46	0	0	32	25
Uzbekistan	37	31	21	22	10	10	40	40	51	44	55	55	3	2	7	13
Pacific	82	88	34	30	36	38	13	13	125	143	248	327	32	50	156	233
Australia	70	75	34	30	37	38	13	13	108	125	234	311	26	43	154	229
New Zealand	13	13	33	30	31	36	10	12	17	18	14	17	6	7	3	4
Asia and the Pacific	2,676	3,862	31	36	17	17	32	25	3,839	5,940	3,826	6,056	1,225	1,902	1,140	1,756
Developed countries	428	413	30	28	28	27	14	15	644	640	354	424	468	477	162	251
Developing countries	2,248	3,450	32	37	15	16	35	27	3,195	5,300	3,472	5,632	757	1,425	977	1,508
LLDC	88	113	26	28	12	12	32	29	129	173	211	351	17	21	98	194
LDC	38	50	11	13	8	10	73	68	43	60	40	61	7	9	4	9
ASEAN	274	399	28	30	23	23	34	27	381	553	452	672	196	318	237	384
ECO	279	403	25	27	20	20	34	31	379	555	528	772	90	137	236	344
SAARC	400	569	26	31	11	13	48	41	556	828	440	623	127	277	10	65
Central Asia	81	103	27	30	13	13	27	23	122	163	203	329	17	20	98	182
Pacific island developing economies																
Low-income economies	58	71	28	27	6	9	48	49	67	84	62	84	10	13	5	12
Lower middle-income economies	589	803	26	31	14	16	45	38	811	1,147	773	1,132	186	355	144	329
Upper middle-income economies	1,455	2,385	34	41	15	15	33	24	2,094	3,769	2,583	4,352	250	623	726	1,048
High-income economies	574	604	30	28	26	24	13	14	867	940	408	488	778	912	264	370
Africa	**374**	**503**	**18**	**17**	**14**	**15**	**59**	**58**	**496**	**682**	**883**	**1,174**	**81**	**117**	**452**	**591**
Europe	**1,322**	**1,360**	**27**	**24**	**25**	**26**	**25**	**26**	**1,932**	**1,978**	**1,290**	**1,163**	**1,397**	**1,583**	**668**	**703**
Latin America and the Caribbean	**447**	**563**	**33**	**32**	**31**	**35**	**18**	**17**	**592**	**783**	**843**	**1,003**	**160**	**212**	**401**	**411**
North America	**1,736**	**1,696**	**22**	**20**	**37**	**38**	**17**	**18**	**2,525**	**2,468**	**2,040**	**2,122**	**774**	**804**	**295**	**420**
World	**7,040**	**8,682**	**27**	**28**	**28**	**27**	**26**	**24**	**10,009**	**12,765**	**9,980**	**12,840**	**3,789**	**4,869**	**3,821**	**4,880**

ASEAN = Association of Southeast Asian Nations, ECO = Economic Cooperation Organization, LDC = least developed country, LLDC = landlocked developing country, SAARC = South Asian Association for Regional Cooperation, TPES = total primary energy supply.

Note: The following economies, though included in the original UNESCAP table, were omitted here due to lack of data: Afghanistan; American Samoa; Bhutan; Cook Islands; Fiji; French Polynesia; Guam; Kirbati; the Lao People's Democratic Republic; Macau, China; the Maldives; Marshall Islands; Federated States of Micronesia; Nauru; New Caledonia; Niue; Northern Mariana Islands; Palau; Papua New Guinea; Samoa; Solomon Islands; Timor-Leste; Tonga; Tuvalu; and Vanuatu.

Source: UNESCAP. 2014. *Statistical Yearbook for Asia and the Pacific.* Bangkok. http://www.unescap.org/stat/data/syb2013/escap-syb2013.pdf

ENERGY CHALLENGES IN ASIA

Growing energy demand and consumption have spawned many urgent concerns. Foremost among these are energy poverty, energy insecurity, and environmental sustainability.

Energy poverty. Despite rapid economic growth, Asia is home to millions of people in energy poverty, which is characterized by a lack of access to electricity and/or reliance on traditional biomass fuels for cooking.[35] Nearly half of the people (an estimated 600 million) without access to electricity reside in Asia, and about 1.8 billion people get their primary energy from traditional fuels such as wood, dung, and crop waste. Such fuels are polluting, inefficient, and damaging to the environment. To provide universal access to electricity and clean cooking fuel, it is estimated that annual energy investments must increase fivefold (footnote 18).

Energy security. Despite abundant supplies of coal and renewable energy resources, securing adequate energy is a serious challenge. Asia has only 16% of the world's proven conventional gas[36] reserves and 15% of technically recoverable oil and natural gas. Although many countries in the region have plans to build more renewable energy and nuclear power plants, construction and implementation cannot keep up with the demand for energy. To close their energy gap, many countries import oil and coal, exposing them to volatile international markets. Even then, current oil imports are not enough, further increasing Asia's vulnerability to external energy shocks (footnote 18).

The volatility of oil prices threatens energy security in many countries. When oil prices spike, economic growth slows, while oil-producing nations benefit from high oil prices. Prices can change rapidly—the price of one barrel of oil was an average $100–$110 in June 2014, then decreased to less than $60 in late 2014. This decrease was mainly due to a global surplus in crude oil output resulting from increased shale oil output from the United States, and a refusal of major oil-producing nations to cut production in response. This new source of oil is expected to add about 1 million barrels of oil per day in 2015.

Oil dependency remains risky, because any crisis (e.g., oil embargo or conflict) can threaten an economy. Many countries are reviewing their power policies and road maps, and have initiated construction of power plants fueled by alternate sources of energy (e.g., hydro, coal, natural gas, or geothermal and nuclear power). Figure 1.2 shows how oil prices have shifted through the years.

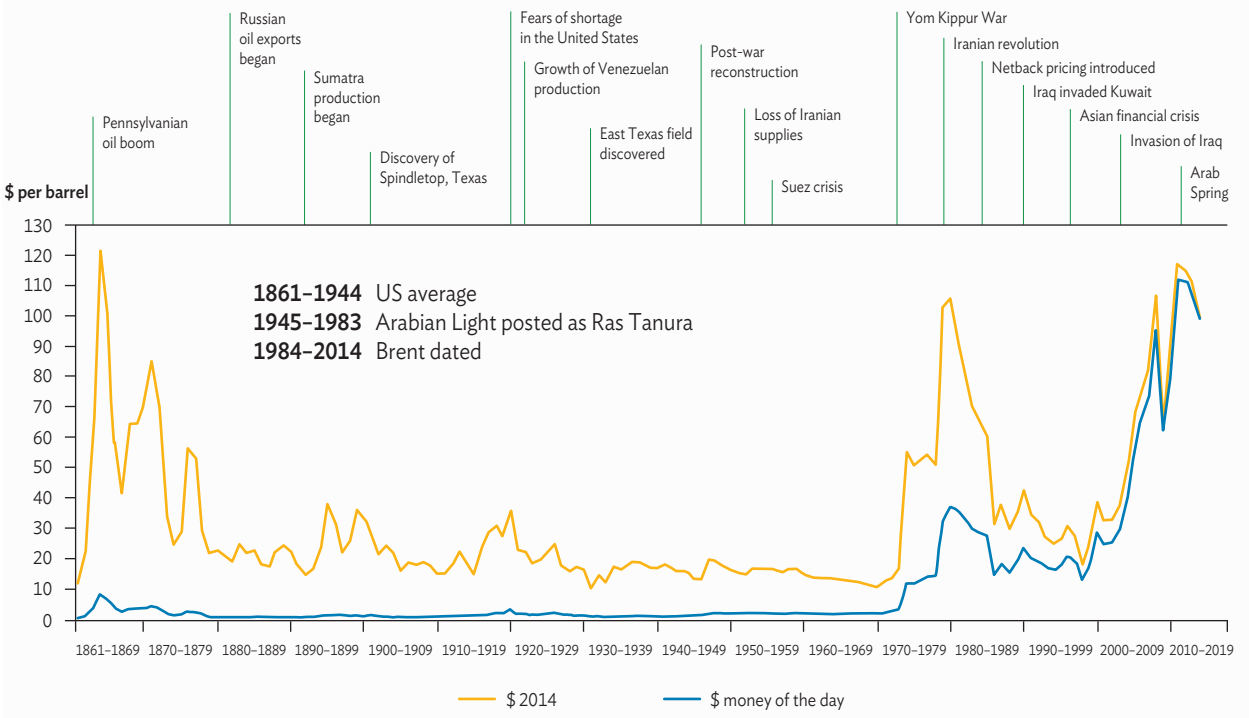
Energy efficiency. The need for energy efficiency has become more urgent as countries across Asia experience energy deficits resulting from growing demand and consumption. It is widely understood to provide cost-effective and substantial increases to energy system capacity by eliminating unproductive uses of energy and energy waste. Opportunities for energy efficiency across industry, transport, and building sectors on both the supply and demand sides can decrease the amount of energy used to perform a task, and lower the amount of energy lost in the supply chain and transmission and distribution stages. This extends across redesign of engineering processes, urban systems, and architectural design.

Sustainability. As fossil fuel usage increases, GHGs and air pollution continue to spread, contributing to global warming and environmental degradation. Environmental sustainability is a key challenge in this era of furious

[35] B.K. Sovacool. 2013. Energy Access and Energy Security in Asia and the Pacific. *ADB Economics Working Paper Series.* No. 383. Manila: Asian Development Bank. http://www.adb.org/sites/default/files/publication/31154/ewp-383.pdf

[36] Gas that can be extracted using traditional methods.

Figure 1.2: Crude Oil Prices (1861–2014)



Source: US Energy Information Administration.

energy demand, and cleaner energy sources and systems are needed, most especially in Asia. Concerted and urgent global action is required to reduce GHG emissions. There is alarming evidence that important tipping points, leading to irreversible changes in major ecosystems and the planetary climate system, may already have been reached or passed.[37]

Other Challenges

Sector governance and reform. Developing countries must have energy policies that are efficient, accountable, transparent, and predictable. This is possible only through good governance and reform in the energy sector. Asia and the Pacific must establish competitive electricity markets and market pricing mechanisms, and encourage private participation and public–private partnerships to expedite the installation of necessary energy infrastructures.

Regional cooperation. Whenever possible, cross-border power trade can ensure energy security and allow countries to optimize their scarce natural resources and address their individual resource limitations. For example, countries with variable power supply and demand based on seasonal conditions, e.g., through changes in the availability of water to power hydro plants or heating and cooling requirements, can benefit from an improved ability to export surplus energy at certain times of the year, and import it when local supply is scarce. Power trade may also reduce the need for new, conventional power plants, which generally affect the environment and the population.

[37] United Nations. Global Issues: Climate Change. http://www.un.org/en/globalissues/climatechange/ (accessed 4 May 2015).

THE ENERGY SECTOR AND THE ASIAN DEVELOPMENT BANK

A brief history. ADB has helped shape Asia's energy sector for decades, introducing sustainable approaches to energy development and increased energy access. Since its founding in the 1960s, ADB has promoted economic growth in the Asia and Pacific region, then considered among the poorest regions in the world. ADB's financial assistance to its developing member countries (DMCs) includes grants, technical assistance, and sovereign and nonsovereign (private) loans, among others. Its assistance for the energy sector includes electricity grid expansion programs, support for the oil and gas sectors, training and support for government energy agencies, power sector reforms, governance, and energy efficiency improvements.[38]

As Asian economies grew, they needed more energy infrastructure projects to sustain economic growth. During the 1970s, the world experienced the first in a series of energy crises when many Arab oil-producing countries embargoed oil in response to the United States' support for Israel. In 1979, the Iranian Revolution spurred a second energy crisis. Oil prices jumped from less than $5 per barrel to $10 per barrel in 1973 and reached almost $40 per barrel in 1979. In 1990, Iraq's invasion of Kuwait expanded into the Gulf War, causing a third energy crisis.

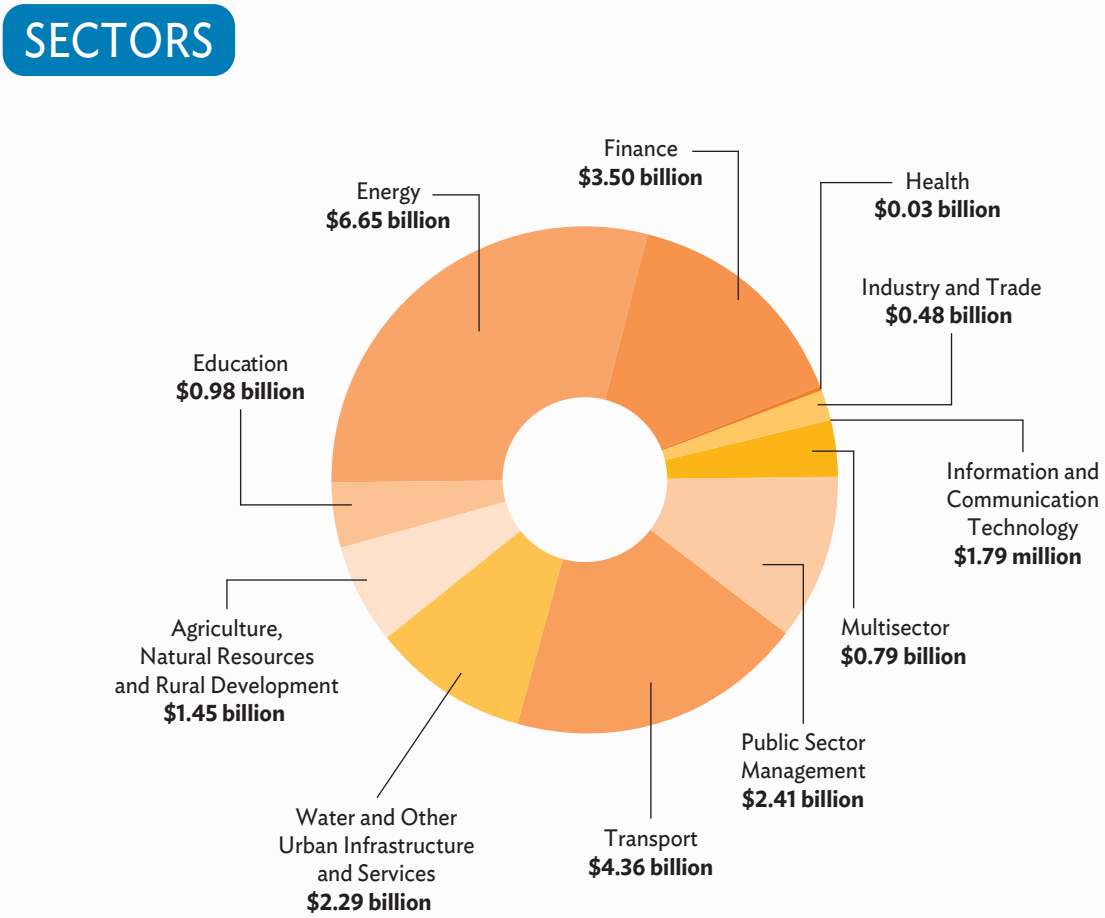
Energy policies. In 1980, ADB conducted a regional energy survey to gather information about the energy situation in developing member countries (DMCs). The results informed ADB's First Energy Policy (1981) and its assistance program. The policy aimed to help Asia overcome the 1970s' energy crisis, develop energy infrastructures and indigenous energy sources, promote energy efficiency, and create markets to attract foreign investment in DMCs.

ADB offered its DMCs more assistance for energy infrastructure projects, especially those that promoted the development of domestic energy sources. In 1995, the First Energy Policy was updated to address changing needs, and recommended balanced infrastructure investment and the development of financially robust and efficient operations. It also integrated demand-side management, rural electrification, environmental protection, and renewable energy for sustainable development.

Successes in the energy sector. ADB has helped its DMCs provide electricity to about 410 million people, increasing the electrification rate in Asia from about 66% in 2002 to 82% in 2010.[39] It helped upgrade and install nearly 30,000 kilometers (km) of high- and medium-voltage transmission lines and more than 100,000 km of distribution lines (footnote 38). In 2009, ADB launched the Energy for All Partnership, which aimed to connect 100 million people to energy and electricity sources by 2015.[40] From 2010 to 2013, ADB-financed projects helped provide an additional 2.4 million households with access to electricity, reduced GHG emissions by 9.4 million tons of carbon dioxide equivalent (CO_2e), and saved 3 gigawatt-hours (GWh) equivalent per year. Moreover, ADB's support to the energy sector has been substantial and increased throughout the years, rising from 16% of its overall financing in 2003–2007 to 26% in 2008–2012. Table 1.3 shows ADB infrastructure financing in 2003–2007 and 2008–2012, when the energy sector had the second largest allocation.[41] In 2014, energy sectors loans totaled $6.65 million, accounting for about 27% of its overall financing for the year (Figure 1.3).

[38] ADB. Our Work with the Energy Sector. http://www.adb.org/sectors/energy/adb-support-energy (accessed 3 November 2014).
[39] Data from International Energy Agency. 2004. *World Energy Outlook 2004.* Paris. The PRC and East Asia had an 88.1% electrification rate while South Asia had 42.1% in 2002.
[40] ADB. Energy for All Initiative. http://www.adb.org/sectors/energy/programs/energy-for-all-initiative (accessed 16 March 2015).
[41] ADB. 2014. *Strategy 2020 Implementation Progress 2008–2012.* January. Manila.

Figure 1.3: ADB Financing by Sector (2014)



Source: Asian Development Bank. 2014. *2014 ADB Annual Report. Improving Lives throughout Asia and the Pacific.* Manila.

Table 1.3: ADB Infrastructure Financing (2003–2007 and 2008–2012)

	2003–2007		2008–2012	
	Total ($ million)	Share of Total (%)	Total ($ million)	Share of Total (%)
Financing for Core Areas of Operation	31,574	85	53,499	82
Infrastructure	24,935	67	46,666	72
• Energy	5,818	16	16,840	26
• Transport and Communications	12,382	33	18,873	29
• Water	3,552	10	6,013	9
• Other Infrastructure	3,184	9	4,941	8

Source: Asian Development Bank. 2014. *Midterm Review of Strategy 2020. Meeting the Challenges of a Transforming Asia and the Pacific.* April. http://www.adb.org/sites/default/files/institutional-document/34149/files/midterm-review-strategy-2020-r-paper.pdf

Table 1.4: Results of ADB-supported Energy Projects (2010–2013)

Installed Energy Generation Capacity (megawatt equivalent)	11,696
Transmission Lines Installed or Upgraded (kilometers)	29,848
Distribution Lines Installed or Upgraded (kilometers)	12,224
New Households Connected to Electricity (number)	2,399,993
Greenhouse Gas Emission Reduction (tons of carbon dioxide equivalent per year)	9,444,698

Source: Asian Development Bank. Results of ADB-Supported Operations in the Energy Sector. http://www.adb.org/sectors/energy/results/data

Table 1.4 shows the results of ADB-supported energy operations in 2010–2013.

Clean energy. ADB has also been at the forefront of clean energy development, helping Asia transition to low-carbon development while ensuring energy security. It introduced advanced technologies for energy efficiency and the deceleration of overall energy demand. It also assisted countries in increasing the share of renewable energy sources in their energy mix to reduce GHG emissions.[42]

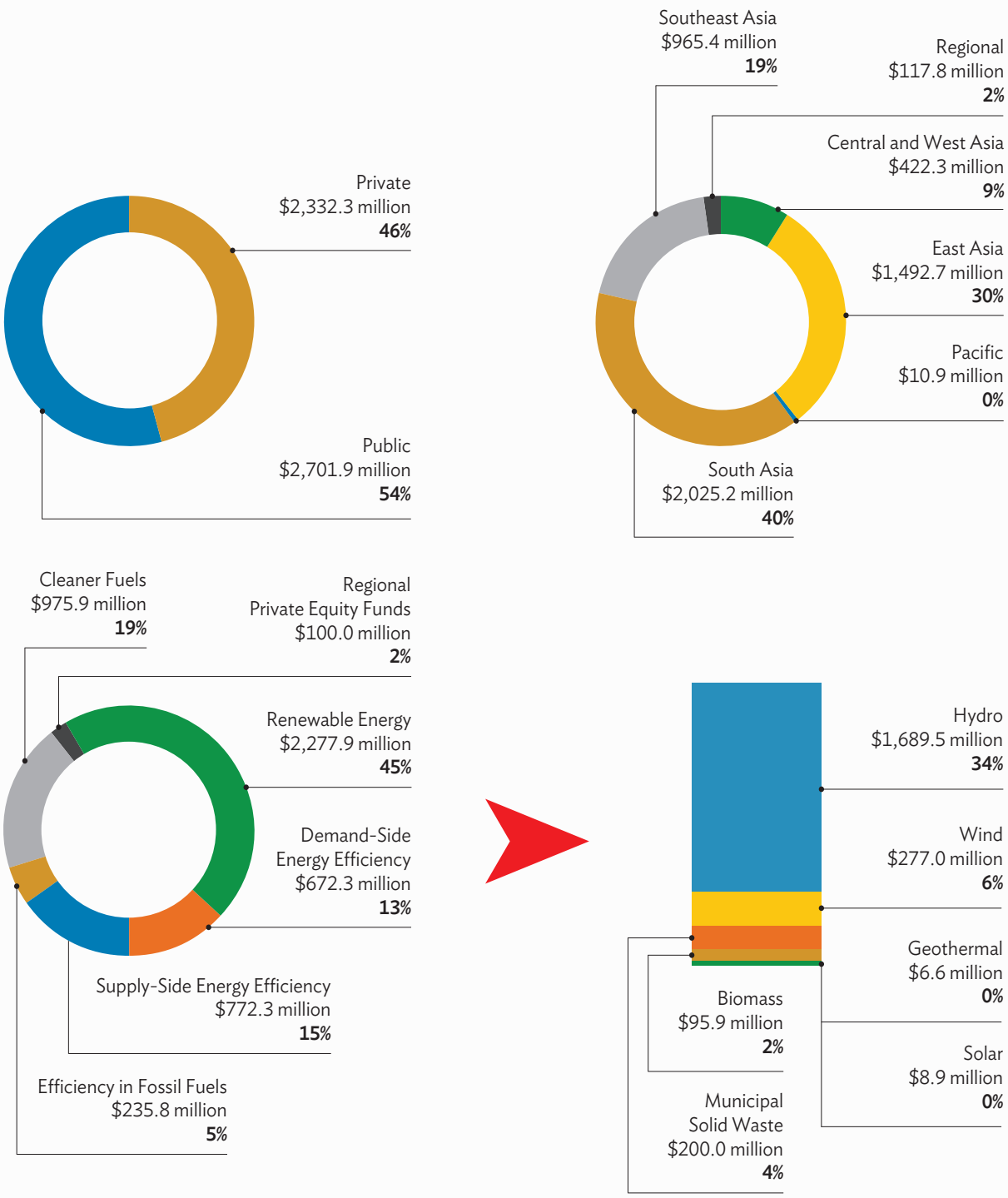
Between the early 1990s and 2005, ADB-financed clean energy projects mostly provided fundamental technical support to help DMCs tackle climate change (e.g., the 1992 technical assistance study on Climate Change in Asia and the Asia Least-Cost Greenhouse Gas Abatement Strategy) (footnote 39). ADB also initiated projects that combined energy access with GHG emission reductions. By 2005, ADB launched the Energy Efficiency Initiative (EEI) to further expand clean energy and promote energy efficiency and renewable energy (footnote 42). Its investment in the sector, particularly in clean energy, increased as it continuously offered assistance for demand and supply energy efficiency technologies. Figure 1.4 illustrates ADB's clean energy portfolio in 2005–2009.

Energy Sector Group. In 2005, ADB created the Energy Community of Practice (CoP), one of 14 CoPs hosted by ADB to generate and share practical knowledge, and one of the most active CoPs in the organization. In 2015, the Energy CoP was reorganized as the Energy Sector Group. It supports project quality control and improvement in operations, maintains a knowledge database and roster of external experts, and assesses sector and thematic skills and knowledge gaps. Sector groups also help design the staff learning and development program, identify knowledge products for external dissemination, and initiate and promote knowledge dissemination activities.

The Energy Sector Group was critical in reviewing the 1995 ADB Energy Policy[43] and preparing the new Energy Policy in 2009.[44] This is in line with Strategy 2020, ADB's long-term strategic framework, which focuses on three strategic agenda: inclusive growth, environmentally sustainable growth, and regional integration. It also helped prepare energy sector indicators for the ADB Results Framework and Development Effectiveness Review, as well as definitions and guidelines that combine energy sector indicators with those from actual projects.

[42] ADB. 2010. *Promoting Clean Energy in Asia and the Pacific: Energy Security, Access, and Low Carbon Development.* Manila.
[43] ADB. 1995. *Bank Policy for the Energy Sector.* Manila.
[44] ADB. 2009. *Energy Policy.* Manila. http://www.adb.org/documents/energy-policy (accessed 10 April 2015).

Figure 1.4: ADB Clean Energy Investment Portfolio (2005–2009)



Note: Totals may not add due to rounding.

Source: ADB database as cited in ADB. 2010. *Promoting Clean Energy in Asia and the Pacific: Energy Security, Access, and Low Carbon Development.* Manila.

These indicators clearly show the progress made by ADB's energy projects. Additionally, the Energy Sector Group actively contributes to ADB's major publications *Energy Statistics in Asia and the Pacific* and the *Energy Outlook for Asia and the Pacific*.

The Energy Sector Group also reviews and produces knowledge products; conducts workshops, seminars, and other knowledge sharing fora on energy-related topics; and leads clean energy and energy efficiency initiatives within the organization and across Asia. It regularly hosts regional knowledge sharing events such as the Regional Energy Efficiency Workshop (held in June 2014) and the annual Asia Clean Energy Forum, now in its 10th year.

STEERING ASIA'S ENERGY SECTOR TOWARD SUSTAINABILITY

From 2000 to 2013, the world's energy consumption rose from 9,979 Mtoe to 13,217 Mtoe (Figure 1.5). Asia's energy consumption grew from 2,929 Mtoe in 2000 to 5,439 Mtoe in 2013.[45] ADB estimates that energy demand in Asia will double by 2030, and fossil fuels will continue to dominate the region's energy supply mix. Thus, there is a need to develop alternative approaches to power and fuel Asia. If business-as-usual continues, Asia will release 22 million tons of carbon dioxide into the atmosphere by 2035 (up from 13.4 million tons in 2010 at a growth rate of 2.0% per year), even as energy deficits paralyze many economies and energy poverty lingers in many remote areas.[46]

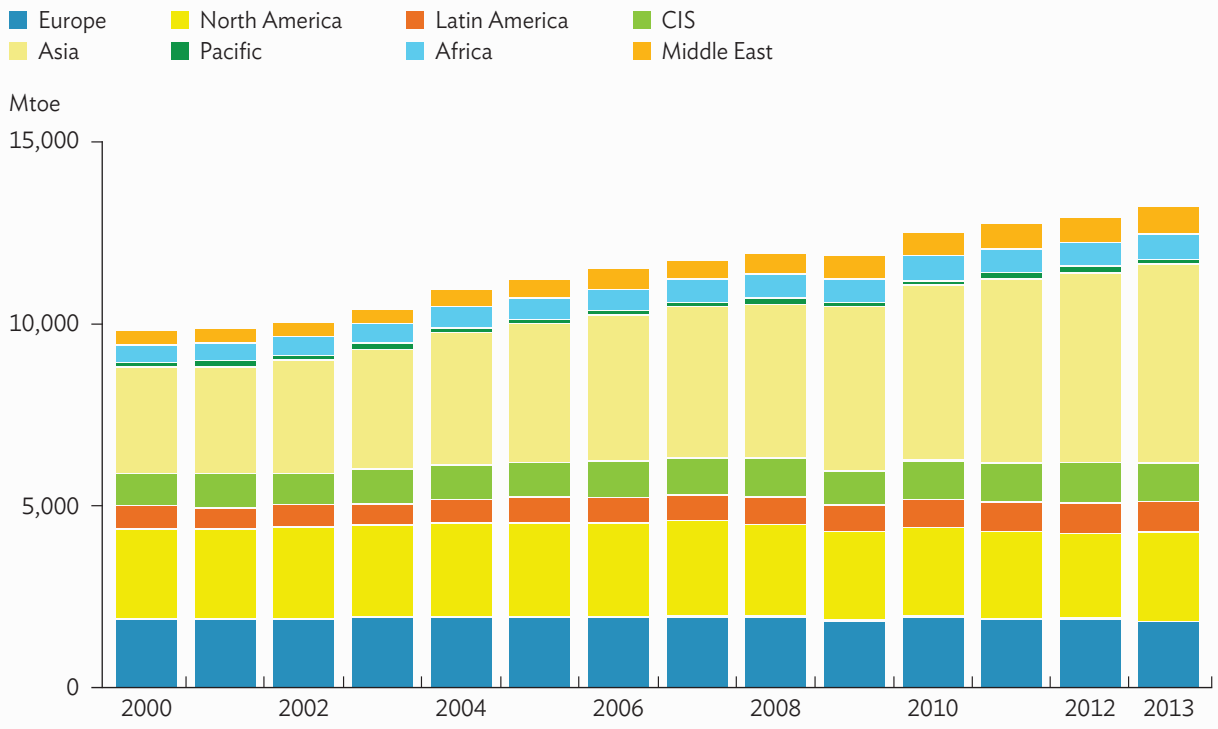
To help address the challenges besetting the energy sector, ADB's new energy policy in 2009 aimed to help DMCs provide reliable, adequate, and affordable energy for economic growth in a socially, economically, and environmentally sustainable way (footnote 38). The energy policy particularly emphasized energy security, aiming to ease the transition to a low-carbon economy and universal access to energy. The policy is guided by three pillars: promoting energy efficiency and renewable energy; maximizing access to energy for all; and promoting sectoral reforms, capacity development, and good governance.

Integrating clean energy and renewable energies into ADB projects. To steer Asia to a clean energy and low-carbon future, ADB promotes energy efficiency and renewable energy with new and advanced technologies to its member countries. ADB has mainstreamed clean energy into its operations and installed a financing mechanism to lower the cost of clean energy projects. It has also introduced technology-oriented initiatives to rapidly diffuse low-carbon technologies in the region (e.g., Asia Climate Change and Clean Energy Venture Capital Initiative, carbon capture and storage, low-carbon technology exchange, solar energy initiative, and scale-up of wind projects).[47]

Broadening access to energy through new technologies and financing models. ADB also works to help provide access to energy for all by supporting projects that broaden access and promote innovative solutions that maximize supply. Therefore, ADB partners not only with governments and development agencies, but also with the private sector to initiate financing and project models that provide wider, reliable, and affordable access to energy.

[45] Enerdata. Total Energy Consumption. Global Statistical Yearbook. https://yearbook.enerdata.net (accessed 4 May 2015).
[46] ADB and APEC. 2013. *Energy Outlook for Asia and the Pacific.* Manila. http://www.adb.org/publications/energy-outlook-asia-and-pacific-2013
[47] ADB. *In Focus: Clean Energy*. http://www.adb.org/sites/default/files/publication/28729/infocus-clean-energy.pdf (accessed 3 May 2015).

Figure 1.5: World Energy Consumption (2000–2013)



CIS = Commonwealth of Independent States, Mtoe = million tons of oil equivalent.

Source: Enerdata. Total Energy Consumption. Global Statistical Yearbook. https://yearbook.enerdata.net

Initiating sector reforms. New technologies, approaches, and strategies in the energy sector can be further enlarged and replicated with complementary capacity building and institutional reforms. Thus, ADB has started to steer the focus of its projects on reforms, education and training, and good governance. This entails restructuring and reforming energy generation and supply systems, mostly in developing countries.

Increasing collaboration. ADB's Clean Energy Program aims to increase regional efficiency and help countries adopt renewable energy sources. In addition, ADB has established clean energy funds and partnerships and launched and conducted knowledge events and activities to promote awareness and use of clean and renewable energies. Examples of these platforms include the Asia Clean Energy Forum and the Asia Solar Energy Initiative.

For further information

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GENERATING POWER INNOVATIVELY

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Sihe Methane Power Generation Plant

COAL MINE METHANE DEVELOPMENT PROJECT

The First Large-Scale Capture and Use of Coal Mine Methane for Power Generation in Asia

- The expansion of coal production and consumption in the People's Republic of China (PRC), fueled by fast-paced economic growth, has increased environmental, health, and safety hazards at coal mines.
- Coal mines emit 6 billion cubic meters of methane per year, causing widespread pollution and acid rain in about a third of the country. In 2002, more than 6,000 miners died in methane-related explosions.
- In 2004, the Asian Development Bank and the PRC established the Coal Mine Methane Development Project to develop new technologies that will demonstrate efficient and effective coal mine methane capture, production, and utilization in power generation and also improve the environment.
- When completed in 2010, the project had significantly contributed to reduced mine-related deaths, improved local air quality and living conditions, and reduced greenhouse gas emissions, while providing reliable energy supply to thousands of households.

CONTEXT

The People's Republic of China (PRC) is the world's largest producer and consumer of coal. Rapid economic growth and an increasing demand for energy has expanded annual coal production, from about 1.3 billion tons in 2002 to 1.7 billion tons in 2003 (22%).[1] Coal fuels about 64% of the PRC's primary commercial energy and generates 75% of all electricity.

As household incomes rise and economic growth continues, so do energy demand and coal production and consumption. Projections suggest that coal consumption will increase to 4.8 billion tons per year by 2020.[2] However, the PRC can no longer use its usual coal production practices because many of its small- and large-scale mines were reaching the end of their lifetime in the early 2000s. In addition, connecting new mining sites to consumers would require new transport infrastructure.

Coal mining is very dangerous because it releases methane, a highly explosive gas produced during coal formation. When coal is mined, methane is released from the coal seams and the surrounding disturbed rock strata.[3] Workers must drain the methane to maintain safe working conditions and avoid explosions. In the early 2000s, as many as 7,000 miners in the PRC died every year in underground accidents, mainly due to methane explosions. By 2013, tightened safety standards reduced the number of deaths to 1,049 (footnote 1).

PROJECT SNAPSHOT

LOAN APPROVAL DATE:
December 2004

LOAN AMOUNT:
$117.4 million

BORROWER:
People's Republic of China

EXECUTING AGENCY:
Shanxi Provincial Government

GEOGRAPHICAL LOCATION:
Jincheng, Shanxi

TYPE OF ENERGY PROJECT:
Conventional energy generation

PROJECT COMPLETION DATE:
2011

Methane is also lethal to the environment because it effectively absorbs and traps heat in the atmosphere. Every year, PRC coal mines release more than 6 billion cubic meters (m^3) of methane, which is 21 times more potent than carbon dioxide (CO_2). Methane contributes to global warming and accounts for 20% of the enhanced greenhouse effect.[4] Coal bed methane (CBM) and coal mine methane (CMM) need to be captured in the PRC's mining sites so that instead of becoming an environmental and health hazard, they can be used to generate power. However, the technologies for capturing methane were new in the 2000s and not used in the PRC.

1 Asian Development Bank. 2004. *Report and Recommendation of the President to the Board of Directors: Proposed Loan to the People's Republic of China for the Coal Mine Methane Development Project.* Manila.
2 The PRC is working to reduce coal in its overall energy mix and has vowed to cap total production capacity at 4.1 billion tons per year by 2015. However, analysts expect total annual production capacity to exceed that level.
3 World Coal Association. Coal. http://www.worldcoal.org/coal/ (accessed 19 December 2014).
4 Environmental Defense Fund. Methane: The Other Important Greenhouse Gas. http://www.edf.org/climate/methane (accessed 19 December 2014).

The Asian Development Bank (ADB) assisted the PRC in exploring possible approaches to cleaner and more efficient coal mining as early as 1996. From 1996 to 2002, ADB provided two technical assistance packages to study the feasibility of a demonstration project to introduce new methane-capture technologies. ADB initiated the Coal Mine Methane Development Project (CMMDP) in 2004. CMMDP curbed methane emissions and helped ensure mine safety, improved the local environment, and helped close the projected energy deficit with new technologies that effectively and efficiently captured methane from coal mining operations and transformed it into energy for power generation.

SOLUTIONS

Selecting a pilot site. ADB's technical assistance packages helped the PRC explore possible sites for demonstration projects. The PRC eventually selected the coal mining area around Jincheng municipality in the PRC's Shanxi province as a pilot site, focusing particularly on the Sihe mine in Jincheng, which is owned and operated by the Jincheng Anthracite Mining Group. The Sihe mine has an estimated coal reserve of 3.5 billion tons, producing about 435,000 m^3 of CMM per day and releasing about 304,000 m^3 into the atmosphere (footnote 1).

The pilot site was identified as a good project demonstration area because Shanxi was among the most polluted and largest coal-producing provinces in 2002. The population of Jincheng municipality, in southern Shanxi, was 2.11 million people, including about 221,500 rural and 97,000 urban poor. The municipality used about 850,000 tons of coal per year; annual emissions of sulfur dioxide (SO_2) and particulate matter totaled about 120,000 tons. In 2001, the municipality qualified for Class II[5] designation for ambient air quality for only 28 days.

Efficient and effective drainage of coal bed and coal mine methane. Methane drainage captures gas and prevents it from entering a mine's airways.[6] To capture CMM at the pilot site, CMMDP used 1,000-meter drilling rigs for advanced directional drilling of long inseam boreholes in the underground coal mine, extending the reach of the gas drainage. Next, workers drilled 1,620 kilometers (km) into the underground coal seams and installed a corresponding length of drainage pipes. To prevent air from entering the drainage system and leaking into the mine, workers used high-density polyethylene (piping with fused seals).[7] This type of pipe is more expensive, but it is safer. The underground infrastructure of gas pipelines yielded a drained CMM recovery rate of 80%, a 100% increase in drainage efficiency over the preproject level.[8]

Drainage systems capture CBM through a series of vertical or horizontal wells drilled directly into the coal seam. Water is first drawn out from the coal seam to reduce pressure and release the methane from its adsorbed state on coal and rock surfaces. Once pressure has been reduced, the released methane can escape more easily to the surface through the wells (footnote 3). Initially, CMMDP planned to build 20 vertical wells and 1 horizontal well. Despite geological and technical challenges it ultimately constructed 100 vertical wells and 80 horizontal wells,

5 Class II standard includes residential mixed-use areas and sets emission limits for SO_2, particulate matter less than 10 microns (PM_{10}), and nitrogen dioxide (NO_2).

6 United Nations. 2010. *Best Practice Guidance for Effective Methane Drainage and Use in Coal Mines.* ECE Energy Series No. 31. New York and Geneva. http://www.unece.org/fileadmin/DAM/energy/se/pdfs/cmm/pub/BestPractGuide_MethDrain_es31.pdf

7 World Bank. 2004. Jincheng Clean Development Mechanism Project Design Document Form. https://wbcarbonfinance.org/Router.cfm?Page=Projport&ProjID=9603

8 ADB. 2012. *Completion Report: Coal Mine Methane Development Project in the People's Republic of China.* Manila.

Coal bed methane capture station in Jincheng

ADB PHOTO LIBRARY

thereby significantly increasing output. CBM from the 100 vertical wells reached 200,000 m^3 per day, with a gas concentration of 99%.

Building a Clean Development Mechanism-registered power plant. In 2008, CMMDP completed construction of a methane-fired power plant on the border of Qinzhuang village, Jiafeng, Shanxi. This 120-megawatt (MW) plant processes about 182.4 million m^3 of CMM and CBM from the Sihe mine per year using internal combustion gas engines (1.5–3.5 MW per engine), waste heat boilers, and steam turbines to convert methane into energy. Based on a meticulous and conservative assessment of expected methane production at the Sihe mine, the plant design is flexible enough to accommodate any variation in methane supply. If the Sihe mine cannot produce enough methane, mines within a few kilometers can supply additional methane to close the deficit.

Registration under the Clean Development Mechanism (CDM) of the Kyoto Protocol (April 2009) (footnote 8) allowed the plant to earn saleable certified emission reduction (CER) credits, each equivalent to 1 ton of CO_2.[9] From April 2009 to the third quarter 2011, verified emission reductions totaled 9.06 million tons of CO_2 equivalent (CO_2e). When the PRC signed the first ever greenhouse gas emission reductions purchase agreement

[9] United Nations Framework Convention on Climate Change. Clean Development Mechanism. http://unfccc.int/kyoto_protocol/mechanisms/clean_development_mechanism/items/2718.php (accessed 20 December 2014).

for a coal mine methane project,[10] estimated CDM revenues of $100 million offset about three-fourths of the total power plant cost of $132 million (footnote 8).

Connecting the power plant to the power grid. The power plant was connected to the Shanxi power grid in March 2008. After trial runs, the power plant and its connection to the power grid fulfilled the requirements of the Shanxi Power Company (October 2008) and national and provincial agencies for environmental, safety, fire protection, and other licensing requirements (December 2008). Commercial operations began in July 2009, and the plant has operated continuously since then.

Energy transmission and distribution. CMMDP also established three collection and three transmission stations. The main station at Gaozhuang includes a 2 x 30,000 m^3 gas storage tank. The stations at Chengzhuang and Duanshi have been operational since April 2009 and July 2010, respectively. The transmission stations are in Zhanglin, the Yangcheng Industrial Zone, and Yangcheng county. The first two are operational; pipelines have been installed at Yangcheng, but construction remains incomplete. For distribution, CMMDP installed a network of pipelines comprising 81.95 km medium-pressure and 29.87 km low-pressure gas pipes. The transmission and distribution facilities supply about 100,000 households and nearly 500 businesses with clean, reliable gas. Connection to poor households was free, and they pay a lower monthly rate for gas. CMMDP has prevented the release of over 3 million tons of CO_2e into the atmosphere per year.[11]

Distribution safety measures. To ensure safety, CMMDP installed a gas leakage monitoring system in the transmission and distribution pipeline. This automated system monitors methane and hydrogen sulfide (H_2S) and triggers an alarm if methane concentrations reach explosive limits and H_2S exceeds designated workplace safety limits (footnote 1).

RESULTS

Enhanced mining safety. Because the efficient capture of CMM and CBM reduced methane in the mine, accidents and deaths declined significantly. Methane capture also reduced mining-associated mortality per million tons of coal production in 2009, from 0.33 to 0.11. By reducing the number of inefficient coal-fired boilers and stoves, CMMDP also contributed to the reduction of health risks associated with coal combustion (e.g., respiratory, cardiovascular, and nervous system disorders).

Reliable gas supply and electricity. CMMDP provides a reliable supply of gas to 70,000 households, 128 boilers, 400 commercial organization, and 2 industries in Jincheng city. In Gaoping, 3,000 households receive gas from CMMDP and about 10,000 more have applied for connection and supply. In Quinshi, 7,000 of 8,000 receive gas from CMMDP. The methane-powered plant also provides reliable electricity, generating 890 gigawatt-hours (GWh; 106% of desired output) in 2011.

[10] World Bank. 2004. China to Reduce Greenhouse Gas Emissions from Coalmine Methane through "First of" Initiative. http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/EASTASIAPACIFICEXT/EXTEAPREGTOPENERGY/0,,contentMDK:20288258~menuPK:574057~pagePK:34004173~piPK:34003707~theSitePK:574015,00.html

[11] ADB. 2014. Methane Turned into Clean Energy in China. *World Coal.* 21 May. http://www.worldcoal.com/news/cbm/articles/Methane_turned_to_clean_energy_in_China_CBM41.aspx#.VGWvbzSUcVA

Zhangling Gas Distribution Station, one of the major outputs of the project

Improving the environment. CMMDP provided many environmental benefits. In 2009, a total of 182.92 million metric tons of CMM was used to produce 773 GWh of electricity, and 30.31 million m^3 of CMM and CBM was used for heating and cooking fuel. CMM and CBM utilization increased gradually, reaching 288.66 million m^3 in 2011. The 120-MW CMM-fired power plant consumed around 226.22 million m^3 of this total to produce 890 GWh of electricity; the rest was used for heating and cooking in 2 industries, about 102,400 households, and 2 commercial establishments.

The power plant has contributed to the reduction of 9.1 million tons of CO_2e, and the plant will achieve an additional 40 million tons of CO_2 reduction during its life cycle (footnote 8). In 2011, CMMDP avoided the emissions of about 288.7 million m^3 of CMM and CBM. By displacing 465,097 tons of standard coal, it reduced carbon emissions by 4.77 million tons CO_2e in 2011. CMMDP also helped clear Shanxi's air, reducing particulate matter (PM_{10}) by 8,313 tons, SO_2 by 5,594 tons, and NO_X by 2,185 tons. In 2011, Jincheng city achieved Class II standard ambient air quality for 354 days, compared with only 28 days in 2001.

Recognition and replication. The 120 MW plant is the largest CMM-based power plant in the world. Its gas supply and distribution components have won national and international awards, including the China Habitat Environment Prize from the Ministry of Housing and Construction (2009) and the Dubai International Award for Best Practices to Improve the Living Environment (2010). CMM and CBM development has expanded rapidly in Shanxi and the PRC.

LESSONS

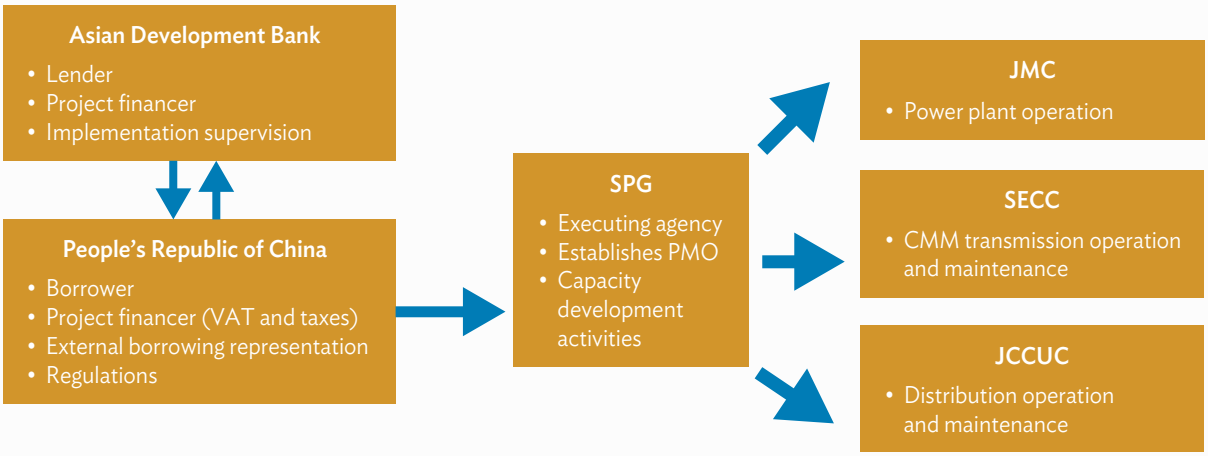
CMMDP demonstrated the importance of tapping new technology. Its innovative mining operations changed the way Shanxi province handles a major environmental, safety, and health hazard.

Considerable benefits from new clean energy technologies. New technologies for installing a CMM drainage system were cost-effective for the project. CMMDP transformed methane from threat to useful energy. Before CMMDP, the Sihe mine vented 70% of its methane into the air, warming the earth. Since project completion, captured methane has been firing a 120 MW power plant, as well as residential and commercial boilers, stoves, and vehicles. In addition, ventilation costs decreased because the mine needs less air to maintain underground safety.

The PRC has started to adopt and increase CMM recovery and is fast becoming the global leader in CMM recovery and use. In 1994, only 130 coal mines in the PRC used CMM drainage and recovery activities. By 2007, this number had more than doubled. In that year, there were about 40 CMM projects in the PRC, a fifth of the world's total.[12]

Project structure. The clear assignment and distribution of roles was a key factor in the success of CMMDP. As executing agency, the Shanxi provincial government established a project management office to coordinate and oversee the complex operation of the project, which has three implementing agencies: the Jincheng Anthracite Mining Group Company operates the power plant, the Shanxi Energy CBM Company Limited (SECC) implements and operates CMM transmission, and the Jincheng CMM Comprehensive Utilization Company Limited (JCCUC), wholly owned by the Jincheng Municipal Government, implements and operates CMM distribution (footnote 1). Figure 2.1.1 illustrates this project structure.

Figure 2.1.1: Coal Mine Methane Development Project: Project Structure



CBM = coal bed methane, CMM = coal mine methane, JCCUC = Jincheng CMM Comprehensive Utilization Company Limited, JMC = Jincheng Anthracite Mining Group Company Limited, PMO = project management office, SECC = Shanxi Energy CBM Company Limited, SPG = Shanxi provincial government , VAT = value-added tax.

Source: ADB.

[12] International Energy Agency. 2009. *Coal Mine Methane in China: A Budding Asset with the Potential to Bloom.* Paris. http://www.iea.org/publications/freepublications/publication/china_cmm_report.pdf

Construction of a large-scale, clean energy power plant as a least-cost alternative. The power plant is massive, the largest methane-fueled power plant in the world. Its capacity was designed to handle the methane output of the Sihe mine. However, this large-scale plant was a least-cost alternative for CMMDP. Previously, the mine was operated by electricity; thus, construction of the methane-powered 120 MW power plant provided long-term savings. The huge capacity of the plant has rendered the construction of captive coal-based power plants unnecessary.

Use of high-quality pipes for safety. In underground mining, safety should be the foremost concern. High-density polyethylene pipes ensure that air will not enter the drainage system and methane will not seep into the underground mines. The pipes also ensured the safety of miners and significantly reduced mining-related deaths.

Offsetting investment by registering with the Clean Development Mechanism. CMMDP was among the first CMM projects in the world to register with the Kyoto Protocol's CDM. Registration allowed access to a market-based financing instrument that provides additional revenue through the sale of CERs. From April 2009 to the third quarter of 2011, the project's total verified emission reductions reached over 9 million tons of CO_2e and yielded an estimated $100 million in CDM revenues. Thus, CDM sales could recover about 75% ($100 million) of the total power plant cost ($132 million) in less than 3 years.

Keywords

Coal mine methane, methane, mining, energy, People's Republic of China, power plant, methane power plant, Clean Development Mechanism, emissions, climate change, coal

For further reading

- http://www.adb.org/projects/documents/coal-mine-methane-development-project-pcr
- http://www.adb.org/projects/documents/coal-mine-methane-development-project-rrp

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HUANENG TIANJIN IGCC

Syngas purification system

TIANJIN INTEGRATED GASIFICATION COMBINED CYCLE POWER PLANT PROJECT

New Power Generation Technology for Near-Zero Emissions

- Power generation in the People's Republic of China heavily relies on coal. In 2008, coal-based power plants produced 81% of the country's electricity.
- Coal dependency results in severe environmental degradation. A third of the country suffers from acid rain due to emissions from large-scale coal production.
- Coal also aggravates poor air quality in most eastern and central cities, inducing public health hazards. The World Health Organization reports that air pollution contributes to 40% of deaths caused by ischemic heart disease.[a]
- With assistance from the Asian Development Bank, the government initiated the Tianjin Integrated Gasification Combined Cycle Power Plant, which generates lower-cost electricity while reducing emissions from sulfur dioxide, nitrogen oxide, mercury, and particulate matter by 95%. Such type of power plant can also provide a low-cost platform for carbon capture and storage, potentially reducing carbon emissions up to 90%.

[a] World Health Organization. 2014. Seven million premature deaths annually linked to air pollution. 25 March. http://www.who.int/mediacentre/news/releases/2014/air-pollution/en/

CONTEXT

Coal-based energy production increased in the People's Republic of China (PRC), from 0.98 billion tons in 2000 to 2.74 billion tons in 2008. Projections suggest continuing increases as the PRC works to keep pace with an accelerating demand for energy. In the last decade, and particularly during 2001–2005, energy consumption peaked at 9.5%, only slightly less than the growth in gross domestic product (GDP) in 2005.[1]

Electricity generation accounts for the largest consumption of coal in the PRC, using 1.34 billion tons (49% of all coal produced) in 2008. In the same year, coal generated 81% of the country's total electricity.[2]

The PRC's dependence on coal degrades the environment. Coal production for power generation accounts for about 50%, 36%, and 20% of emissions from sulfur dioxide (SO_2), nitrogen oxides (NO_x), and mercury, respectively, and 39% of carbon dioxide (CO_2) emissions.[3] Consequently, the air quality in many cities is poor. A third of the PRC and 45% of its farmland suffer the effects of acid rain resulting mainly from coal-based emissions.

To address the environmental impact of coal, the PRC has been actively improving its energy efficiency and emission reduction measures. It has also been turning to noncarbon and other cleaner energy sources. In 2006, it enacted the Renewable Energy Law which encourages technology for wind, solar, and biomass energy. However, coal likely will continue to dominate power production, even though the projected growth of coal production is environmentally unsustainable. The rapid increase in coal consumption—by more than 250% in the past 6 years—raises serious concerns about SO_2, NO_X, and incremental CO_2 emissions and their local, regional, and global impacts. In addition, waste coal is the PRC's largest solid waste, comprising about 25% of industrial waste (footnote 3).

The country has set out to improve the efficiency of its coal-based power plants, and has closed small, inefficient power plants. Due to prohibitively high costs for capital, operation, and maintenance, the PRC sought assistance from the Asian Development Bank (ADB) in constructing advanced technology coal power plants. In 2008, ADB helped initiate the Tianjin Integrated Gasification Combined Cycle (IGCC) Power Plant Project.

PROJECT SNAPSHOT

LOAN APPROVAL DATE:
February 2010

LOAN AMOUNT:
$116.84 million

BORROWER:
People's Republic of China

EXECUTING AGENCY:
China Huaneng Group

GEOGRAPHICAL LOCATION:
Tianjin City

TYPE OF ENERGY PROJECT:
Power generation

PROJECT COMPLETION DATE:
January 2016

1 Asian Development Bank (ADB). 2007. *Report and Recommendation of the President to the Board of Directors: Proposed Credit Guarantee to the People's Republic of China for the Energy Efficiency Multi-Project Financing Program.* November. Manila

2 ADB. 2009. *Report and Recommendations of the President to the Board of Directors: Proposed Loan and Grant to the People's Republic of China for the Tianjin Integrated Gasification Combined Cycle Power Plant Project.* December. Manila.

3 ADB. 2004. *Technical Assistance to the People's Republic of China for Waste Coal Utilization Study.* Manila.

SOLUTIONS

Technology change. IGCC introduced a shift in technology. Commercially available in the PRC for the first time, IGCC is the most efficient and least polluting advanced clean coal technology.[4]

In IGCC power plants, the gasification of coal into a synthesis gas (i.e., syngas) and subsequent removal of impurities (e.g., SO_2, NO_X, mercury, and particulate matters) can achieve 99% desulfurization efficiency with NO_X discharge only 15%–20% of conventional power plants. Syngas combusts in a highly efficient, combined cycle turbine set, potentially increasing efficiency 4%–5% compared with supercritical plants, leading to significantly lower CO_2 emissions.[5]

Carbon capture and storage. The project added carbon capture and storage (CCS) to separate, capture, transport, and store CO_2. Various international studies report that IGCC power plants with CCS is a least-cost option to cut CO_2 emissions from coal-fired power plants by up to 90%. In IGCC plants, CCS captures CO_2 from coal-fired power plants prior to combustion and stores it in deep geological formations (e.g., depleted oil and gas wells) (footnote 3).

Partnership. The Tianjin Project began as a collaborative effort among all major PRC energy enterprises. The Government of the PRC initiated the partnership when it launched the GreenGen Program in 2005. Aiming to ensure environmentally sustainable capacity for coal-fired power plants, GreenGen leads the research, development, and demonstration of IGCC and CCS technologies, leading to a near-zero emission coal-fired power plant in 2015.

GreenGen is managed by the China Huaneng Group, the PRC's largest electric company, which controls 51% of GreenGen shares. A wholly state-owned enterprise, China Huaneng Group has pioneered clean coal technologies and supercritical and ultrasupercritical plant development and deployment in the PRC. Other GreenGen shareholders include China Datang Corporation, China Huadian Corporation, China Guodian Corporation, China Power Investment Corporation, Shenhua Group Corporation, and China National Coal Group Corporation State Development and Investment Corporation. GreenGen established Huaneng Tianjin IGCC to develop and implement the Tianjin Project. Figure 2.2.1 shows GreenGen's organization chart and Figure 2.2.2 shows the project's onlending arrangement.[6]

Three-phase implementation. GreenGen used a three-phase implementation program. Phase 1 aimed to develop, construct, and implement the 250-megawatt (MW) Tianjin IGCC plant. Preconstruction began in July 2009 and the main construction began in February 2010. The power plant was commissioned on 12 December 2012 and was highly reliable after only 1 year of trial operations. In Phase 2, the China Huaneng Group began construction of a carbon capture, utilization, and storage pilot plant at the Tianjin IGCC power plant. The capture plant is under construction and due for commissioning in late 2015. Concurrently, the China Huaneng Group plans implementation of an industrial-scale IGCC plant that includes a large-scale CCS project (Phase 3).

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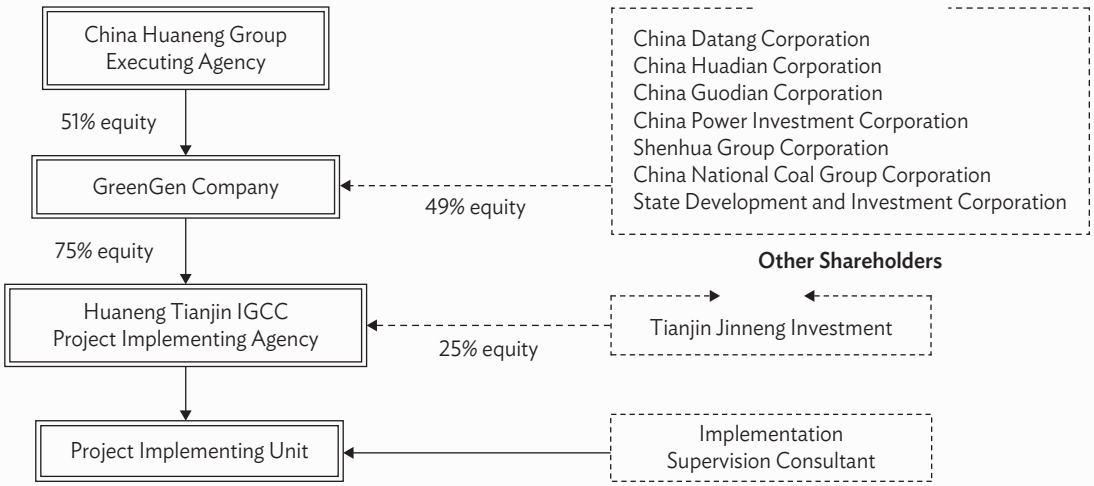
4 ADB. 2010. *Project Administration Manual: Tianjin Integrated Gasification Combined Cycle Power Plant in the People's Republic of China.* May. Manila.

5 Supercritical and ultrasupercritical technology refers to new pulverized coal combustion systems which operate at increasingly higher temperatures and pressures, therefore achieving higher efficiencies than conventional pulverized coal combustion units and significant CO_2 reductions.

6 Onlend refers to when the intermediary lends loaned funds to the ultimate beneficiary.

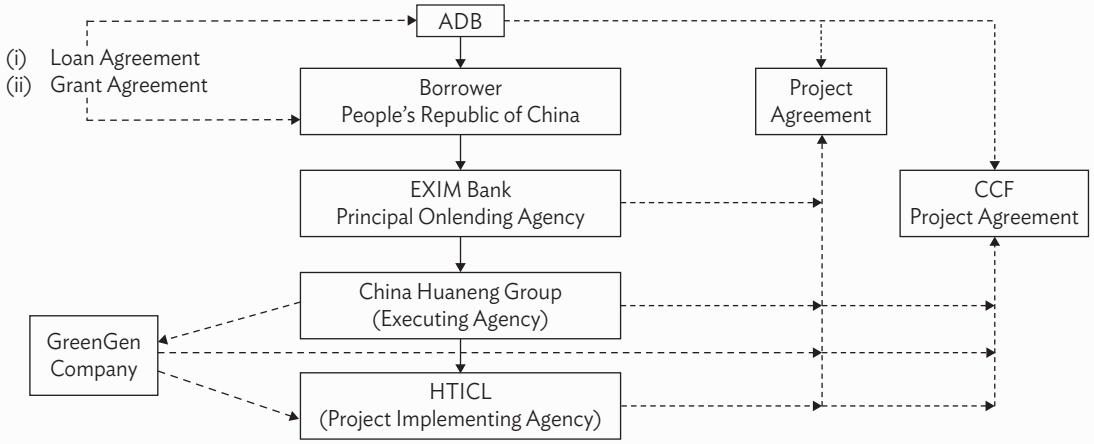
Figure 2.2.1: GreenGen Organizational Setup



IGCC = integrated gasification combined cycle.

Source: Huaneng Tianjin IGCC, as cited in ADB. 2010. *Project Administration Manual: Tianjin Integrated Gasification Combined Cycle Power Plant in the People's Republic of China.* May. Manila.

Figure 2.2.2: Tianjin IGCC Power Plant Project Onlending Arrangement



ADB = Asian Development Bank, CCF = Climate Change Fund, EXIM Bank = Export–Import Bank of China, HTICL = Huaneng Tianjin IGCC Co. Ltd.

Source: Asian Development Bank. 2010. *Project Administration Manual: Tianjin Integrated Gasification Combined Cycle Power Plant in the People's Republic of China.* May. Manila.

The Tianjin IGCC power plant is in the Tianjin Harbor Industrial Park, near the Tianjin Alkali plant. Tianjin was selected due to the project's CCS component and its proximity (150 kilometers) to the Jidong oil field.[7] The Tianjin plant began generating electricity in 2012 and produced an additional 1,200 gigawatt-hours of clean coal energy in 2014.

[7] CCS technology captures and stores CO_2 in deep geological formations such as oil wells.

Financial support for a new technology. ADB loaned the PRC $135 million from its ordinary capital resources. The loan has a 26-year term and a long grace period (6 years).[8] The 6-year reprieve, which is part of ADB's innovative support for the project, differs from other ADB loan terms, especially because construction will require only about 3 years. This intentional arrangement will demonstrate a new, albeit expensive, technology for the PRC (footnote 3). ADB's Climate Change Fund provided an additional $5 million grant to help reduce costs through long-term maintenance contracts with the suppliers of coal gasifiers and gas turbines. The grant also helped recruit international and national consultants to supervise implementation and prepare studies for effective operation of the plant.

RESULTS

A model coal-based power plant. The project constructed a 250 MW IGCC power plant in Tianjin city. The plant quickly achieved reliable operation, and is less expensive than the PRC's natural gas-fired combined cycle plants, while showing the same environmental performance as the latter. This project showed the China Huaneng Group and other large power plant developers that IGCC technology is indeed a way forward for coal-based power in the PRC.

Phase 2 of the project is now under way. It will demonstrate the implementation of a pilot industrial power plant and the cooperation of a power generator and an oil field company in implementing a carbon capture, utilization, and storage project.

Successful implementation of the Tianjin IGCC power plant will show investors, project developers, and policy makers the viability of this new technology. The China Huaneng Group plans to build three more IGCC power plants. This may encourage power generators to replicate the project in other areas of the country. Because the PRC is the world's largest global producer and consumer of coal, it is potentially the largest IGCC market in the world.[9] Larger deployment of IGCC technologies will help reduce the cost.

Lower greenhouse gas emissions. Since 2012, the project has saved 134,000 tons of coal and reduced CO_2 emissions by 372,000 tons per year.[10] Lower greenhouse gas emissions will improve ambient air quality throughout the PRC, especially if other companies replicate the project in other parts of the country.

LESSONS

Longer grace period. ADB provided a 6-year grace period, even though construction required only 3 years. Some may consider this strategy unsound, but project implementers could encounter major financial obstacles, increasing costs that are already high. Thus, the 6-year grace period helped the implementing agency avoid financial distress during initial operation of the plant. This strategy particularly highlights the significance of IGCC technology in the PRC. Continuing the project and establishing a replicable model will help clear a path for near-zero emissions in a country that already experiences poor air quality.

8 ADB. 2010. *Loan Agreement between People's Republic of China and the Asian Development Bank: Tianjin Integrated Gasification Combined Cycle Power Plant Project*. May. Manila.
9 World Coal Association. 2014. Coal Statistics. September. http://www.worldcoal.org/resources/coal-statistics/
10 Global CCS Institute. 2014. Huaneng GreenGen IGCC Project (Phase 3). November. http://www.globalccsinstitute.com/project/huaneng-greengen-igcc-project-phase-3

Longer learning period. IGCC technology is complicated and requires a long learning curve. This project focused on specific technical and management challenges, incorporating lessons from international experts as they conducted technical due diligence during construction and initial operation. The formal cooperation agreement between Huaneng Tianjin IGCC and the owner of the Puertollano IGCC Plant in Spain was very important because it enabled the former to learn about Spain's experience in designing, building, operating, and maintaining its own CO_2 capture project.[11]

Reducing risk without increasing project cost. This project demonstrates that innovative technology can fulfill an urgent need. Because new technologies are always risky, approaches that reduce risk without increasing costs are highly needed. A grant from ADB's Climate Change Fund allowed access to international and national experts for safeguard compliance, project management, monitoring, and reporting, establishing standards for IGCC projects. The grant also allowed immediate technical assistance from suppliers during the first 2 years of project demonstration, a critical phase of project implementation.

Coal gasifier at the plant

[11] ADB. 2013. *Technical Assistance Completion Report: Carbon Capture and Storage Demonstration—Strategic Analysis and Capacity Strengthening.* 23 February. Manila. http://www.adb.org/sites/default/files/project-document/75754/43006-012-prc-tcr.pdf (accessed 28 May 2015).

Keywords

Carbon capture; coal; coal production; energy; gas; gasification; integrated gasification combined cycle power plant; People's Republic of China; power plant efficiency; power plants; Tianjin, PRC

For further reading

- http://www.adb.org/news/adb-prc-sign-loan-grant-documents-power-plant-using-new-coal-technology
- http://www.adb.org/projects/documents/tianjin-integrated-gasification-combined-cycle-power-plant-project-rrp

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GREEN POWER DEVELOPMENT PROJECT

Bringing Benefits to Bhutan and Beyond

Construction of the hydropower plant along Dagachhu River

- The Kingdom of Bhutan is one of a few countries in Asia with large, unexploited hydropower resources. Despite surplus power, many rural households lacked access to electricity in the early to mid-2000s.
- Increasing demand for electricity may reduce the power surplus, potentially decreasing energy exports, which are a primary source of revenue.
- To further promote hydropower, the Government of Bhutan and the Asian Development Bank collaborated in the Green Power Development Project.
- The project developed the first cross-border Clean Development Mechanism project and the first infrastructure-focused public–private partnership in Bhutan. It also helped achieve 100% electrification and established value chain mechanisms that enable hydropower exports to sustain costly domestic rural electrification operations.

CONTEXT

Landlocked and tucked into the Eastern Himalayas, the mountainous terrain of the Bhutan is interspersed with swift-flowing rivers and streams. This landscape includes a very important resource: hydropower. Bhutan is the only country in South Asia having potential to develop hydropower-generated electricity for export to neighboring countries.

Almost all of Bhutan's power generation comes from hydropower, which is a clean energy resource. In 2015, the country has five major hydroelectric power stations with a total installed capacity of about 1,600 megawatts (MW). Although the power stations generate more energy than the country needs, domestic demand has almost doubled since 2008, from 157 MW to 300 MW.

After fulfilling its own needs, Bhutan sells surplus energy to India. Power exports account for 70%–80% of total generation per year. Sales from its power trade represent Bhutan's largest source of revenue. Before the Green Power Development Project started, the energy sector accounted for more than 40% of national revenue and 25% of the gross domestic product (GDP). Hydropower infrastructure development also contributes 25% of GDP through the construction sector.[1] According to Bhutan's Tenth Five-Year Plan, hydropower likely will contribute up to 50% of GDP and 75% of fiscal revenue by 2020.

However, many rural villages were energy poor in the early to mid-2000s, primarily due to the high costs of investment, operation, and maintenance of rural electrification. The electricity rate back in the previous decade was only 40%. The Government of Bhutan aimed to change this with its rural electrification master plan, as outlined in Bhutan's Vision 2020 of 1999, wherein electricity for all prioritized rural electrification. Currently, the country has a 98% rural electrification rate (footnote 1).

PROJECT SNAPSHOT

LOAN APPROVAL DATE:
October 2008

LOAN AMOUNT:
$119 million

GRANT AMOUNT:
$26.3 million

BORROWER:
Kingdom of Bhutan

EXECUTING AGENCIES:
Department of Hydropower and Power Systems, Ministry of Economic Affairs, and Druk Green Power Corporation

GEOGRAPHICAL LOCATION:
Dagana and other districts

TYPE OF ENERGY PROJECT:
Hydropower development, rural electrification

PROJECT COMPLETION DATE:
February 2015

To fund rising social expenditures, the government needed to tap the vast potential of its hydropower resources to generate more tax and dividend revenues from power exports. As royalty from power export, about 12% of power generated from new hydropower plants are provided to the government. This quantum of power is used to subsidize domestic electricity costs, which tend to get higher in remote rural areas where 90% of the poor live. The regulatory pricing system enables Bhutan to distribute hydropower export benefits to domestic users and maintain their affordable electricity prices, particularly for the rural poor.

[1] Asian Development Bank (ADB). 2008. *Report and Recommendations of the President to the Board of Directors: Proposed Loans, Asian Development Fund Grant, Technical Assistance Grant, and Administration of Grant to Bhutan for the Green Power Development Project.* October. Manila.

Although Bhutan has large reserves of hydropower, only 6% has been developed (potential hydropower output is estimated at 26,760 MW), largely due to the high-cost infrastructure for hydropower facilities. Given the government's limited fiscal capacity, such projects had to leverage public and private investments from outside the country. Although Bhutan had adequate experience with hydropower plant operations, it also needed experienced development partners for project preparation and plant construction.

The government sought assistance from the Asian Development Bank (ADB) in 2008. Together, they embarked on the Green Power Development Project, which aimed to help Bhutan promote twin development goals: (i) 100% rural electrification and (ii) exporting an additional 10,000 MW of hydropower to India by 2020.

SOLUTIONS

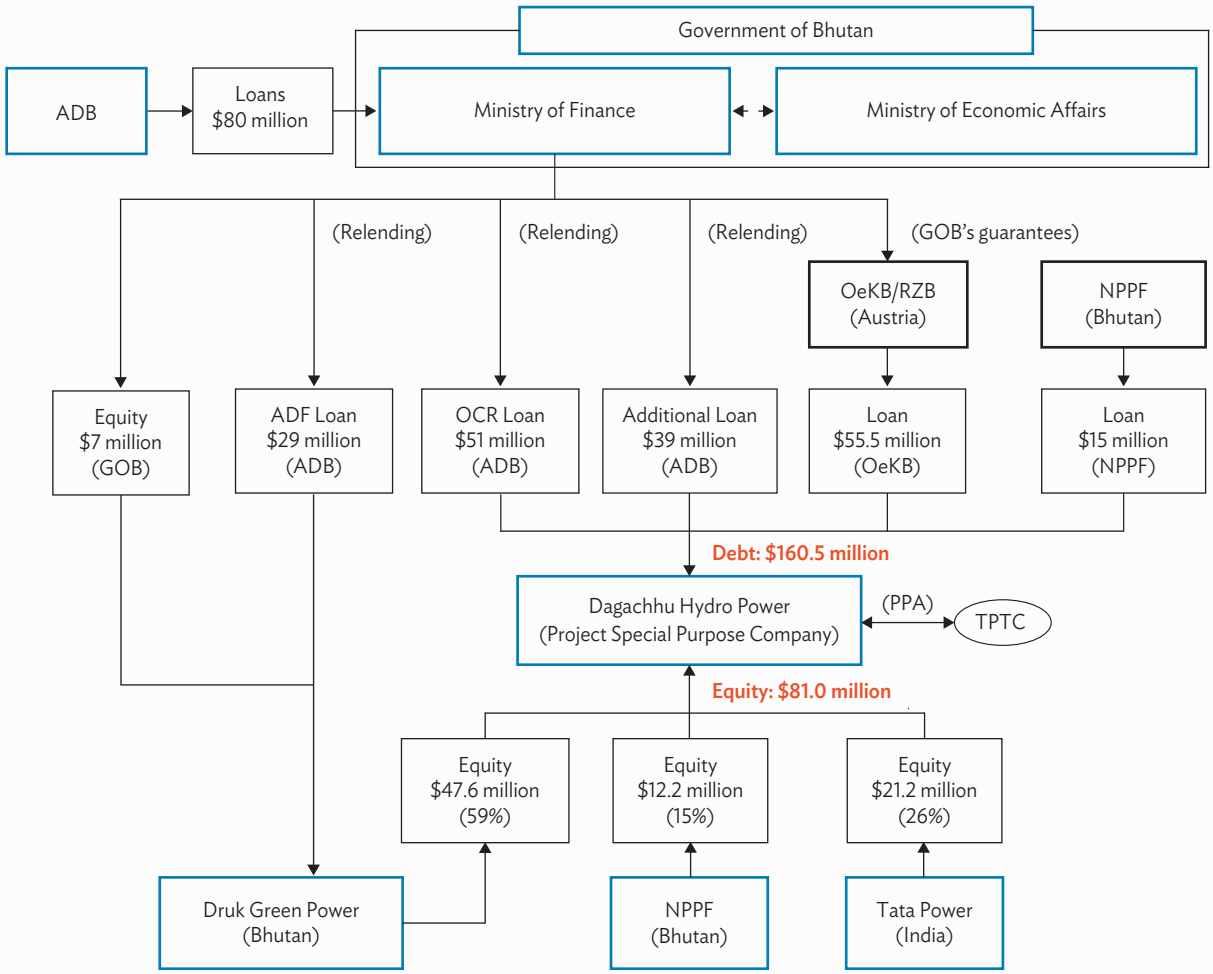
Establishing a conducive policy environment. To fast-track the development of hydropower in Bhutan in a more sustainable way, ADB supported efforts to design a policy framework that encourages private participation through direct foreign investment. Private partners would help strengthen the implementation capacity of Bhutan's hydropower projects and leverage private sector funds. The policy aims to promote investments for hydropower development and maximize revenue for socioeconomic development, domestic and regional energy security, and sustainable production operations, and also to boost sustainable global environment through the use of clean energy. In addition, the policy defines details such as project structure, fiscal incentives, and the bidding process. Bhutan issued the Hydropower Development Policy (July 2008) with these keys provisions including an energy royalty that stipulates the government will receive at least 12% of generated electricity at no cost, and a minimum 30-year concession period.

Public–private partnership. The Green Power Development Project introduced the concept of public–private partnership to Bhutan. To develop the Dagachhu Hydropower Plant, a joint venture was formed between the Druk Green Power Corporation, the state-owned generation company, and the Tata Power Company, a private company in India. The assets of this venture have been placed under the project's special purpose company, the Dagachhu Hydro Power Corporation (DHPC), and the Tata Power Company's subsidiary in India committed to purchase electricity from DHPC (Figure 2.3.1).[2]

The hydropower plant. DHPC promoted the development of the Dagachhu Hydropower Plant, which is the first commercial power generation project in Bhutan, and is expected to encourage other public–private partnerships. Built along the Dagachhu River, the plant now generates electricity for export to India, a long-time power trade partner of Bhutan. The plant design is a run-of-the-river scheme. Its 126 MW installed capacity generates around 500 gigawatt-hours of electricity per year.

[2] ADB. 2013. *Report and Recommendations of the President to the Board of Directors: Proposed Loan for Additional Financing to Bhutan for the Green Power Development Project.* September. Manila.

Figure 2.3.1: Financing Structure and Fund Flow for the Dagachhu Hydropower Development



ADB = Asian Development Bank, ADF = Asian Development Fund, GOB = Government of Bhutan, NPPF = National Pension and Provident Fund of Bhutan, OCR = ordinary capital resources, OeKB = Oesterreichische Kontrollbank Aktiengesellschaft (Austrian export credit agency), PPA = power purchase agreement, RZB = Raiffeisen Zentralbank Österreich AG (Austrian commercial bank), TPTC = Tata Power Trading Company.

Source: ADB estimates.

Cross-Border Clean Development Mechanism Project. In 2010, the Dagachhu plant qualified for certified emission reduction units (i.e., carbon credits) under the Kyoto Protocol's Clean Development Mechanism (CDM). It is the first cross-border project to gain CDM registration. The CDM encourages countries and companies worldwide to develop projects that reduce carbon emissions and mitigate climate change. Selling hydropower energy to India enables the project to displace carbon emissions that otherwise would be produced by coal-fueled power plants in India.[3]

[3] ADB. 2014. Bhutan Hydropower Plant Avoids Fossil Fuel Emissions, Earn Carbon Credits. January. http://www.adb.org/features/bhutan-hydropower-plant-avoid-fossil-fuel-emissions-earn-carbon-credits

Rural grid extension. The rural electrification component aimed to supply electricity to 8,767 consumers (i.e., households, schools, health clinics, monasteries, and rice mills) in 624 villages. The Bhutan Power Corporation, which is the national transmission and distribution utility, built 1,709 kilometers of low-voltage lines to connect individual consumers to the power grid. Eventually, the corporation electrified over 9,500 households, exceeding its original target.

Rural off-grid electrification. The project also supplemented extension of the rural grid in isolated areas where such extension was not financially and economically feasible. The project installed 116 solar photovoltaic systems in very remote mountainous areas, focusing on schools, health clinics, monasteries, and other community facilities to maximize development impacts. The systems used white light-emitting diodes for lighting and capacitors and lithium ion batteries for electricity charging rather than conventional lamps and solar batteries. These new technologies are more energy-efficient and environment-friendly, have longer life spans, and provide more power.

RESULTS

Inclusive growth. The Green Power Development Project improved energy access in far-flung mountainous areas and eased budget allocations for basic services (e.g., health and education). More than 9,500 rural households gained access to electricity, along with more than 100 public facilities and communities, such as schools and clinics. Income from power exports expanded the country's revenue base, enabling Bhutan to pay for costly rural electrification and allowing the government to increase socioeconomic services, improve and expand roads and bridges, and further aid rural development.

Promoting clean energy development and environmental sustainability. As the world's first cross-border CDM project, hydropower exports from the Dagachhu Hydropower Plant replace India's coal-fired power generation, thus decreasing carbon emissions. The project was able to raise additional cash from ADB's Future Carbon Fund. This project demonstrates that countries like Bhutan, Nepal, and the Lao People's Democratic Republic, where clean energy sources provide most of the power, can still benefit from CDM by promoting renewable power generation projects. Pursuing CDM projects is difficult for such countries, particularly in the power sector, because their electricity grid is based largely on renewable energy, which already emits fewer greenhouse gases. Several other projects in Bhutan and Georgia have already replicated this model.

In addition to region-wide climate mitigation, the project has enhanced low-carbon growth within Bhutan by improving energy efficiency in rural areas and reducing rural dependency on firewood and kerosene. Modern clean energy reduces deforestation and greenhouse gas emissions and indoor smoke pollution, which seriously threaten health.

KAORU OGINO

The Dagachhu Hydropower Plant qualified for carbon credits under the Clean Development Mechanism in 2010.

Promoting regional cooperation and integration. The project promotes cross-border power trade to develop clean energy for regional use. It expands the regional economic base by increasing trade and mutual reliance and a mutually beneficial relationship among a wide range of stakeholders. The public–private partnership illustrates that power trade does not solely have to involve governments, but could benefit more with the active participation of the private sector, foreign parties, and commercial and public financial institutions. Using private capital, this model helped investors develop clean hydropower potential for the region.

Awards/Recognition. The project has received international recognition for its climate change benefits. On 25 July 2013, the Development Impact Honors Program of the United States Department of the Treasury recognized the project for "excellence in public–private partnership and innovative solution to critical energy need."[4]

[4] ADB. 2014. Bringing Power to Bhutan's Villages and Beyond. May. http://www.adb.org/features/bringing-power-bhutan-s-villages-and-beyond

ADB PHOTO LIBRARY

The project installed 116 solar photovoltaic systems in remote areas to maximize development impacts.

LESSONS

Private sector participation. The development of hydropower requires large investments. It is difficult for countries like Bhutan, which need to allocate more resources to social development projects (e.g., education, health, rural infrastructure, roads, water supply, etc.), to build large hydropower projects without jeopardizing investment in other sectors. Participation by private companies enables countries to leverage public and private investments and accelerate hydropower development, restrain government expenditure and loans, and generate income from export revenues. In addition, Bhutan's experience in negotiating with the private sector provides fertile ground for study and replication, and teaches about negotiating for commercial trading tariffs and developing shareholder agreements. For example, the private buyer valued a much higher tariff on Bhutan's hydropower export than those previously determined under bilaterally assisted hydropower projects.

Energy-efficient design and technology. Plant design, transmission lines to rural villages, and photovoltaic systems use energy-efficient design and technology. The hydropower plant uses Pelton turbines, which operate via small discharges of river water. Power lines for the grid extension use a less costly single-phase system, which supplies electricity more efficiently because the smaller transformer eases delivery in the mountains. The off-grid rural electrification component uses light-emitting diodes and capacitors, which have longer life spans and are more environment-friendly and sustainable.

Mitigating environmental and social impact during construction. Hydropower plants also yield some social and environmental impacts. The components of the Green Power Development Project required building infrastructure on and along rivers, farms, and forests and had to remove about 4,600 trees from steep mountain slopes. Rather than simply replacing the felled trees, the project planted 10,000 trees. It also donated saplings to the residents. It also built a fish ladder to ensure that local migratory fish can still swim upstream. A nearby stream was kept intact to provide birds and other wildlife with a natural environment.

The local community and people benefited directly from the project because new roads improved access to main roads. Moreover, the project's community development package facilitated a positive outcome between the government and local communities. The government's position provided comfort and demonstrated smooth coordination with many local and central administrative requirements in promoting the hydropower project. The project also involved the communities and increased people's awareness of the environment, safety, and health.

Keywords

Energy, renewable energy, hydropower, energy trade, power trade, energy export, environmental sustainability, inclusive growth, rural electrification, climate change, public–private partnership, regional cooperation, Bhutan

For further reading

- http://www.adb.org/features/bringing-power-bhutan-s-villages-and-beyond
- http://www.adb.org/news/bhutan-hydropower-project-worlds-first-cross-border-clean-development-mechanism-initiative
- http://www.adb.org/projects/documents/green-power-development-project-rrp

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THE PEOPLE'S REPUBLIC OF CHINA'S MUNICIPAL WASTE-TO-ENERGY PROJECT

A Model Approach to Financing a State-of-the-art Technology

Suzhou waste-to-energy plant in Jiangsu Province

- In the People's Republic of China, higher income growth in urban and rural areas resulted in higher demand for energy and generation of more waste.
- One viable solution is waste-to-energy (WTE) technology, which increases electricity generating capacity without increasing greenhouse gas emissions.
- The high cost of WTE technology and lack of interest by international commercial banks hinder the installation of new WTE power plants.
- Using the Asian Development Bank innovative financing approach, a private company developed six WTE plants that process 6,200 tons of municipal solid waste, generating an additional 132 megawatts of power capacity and delivering 630 gigawatt-hours of electricity annually.

CONTEXT

The People's Republic of China (PRC) is the world's largest producer and consumer of energy and coal, and the fourth largest producer and second largest consumer of oil.[1,2] Consequently, pollution, air degradation, and global warming will continue to be one of the PRC's primary concerns.

The PRC also generates the second largest quantity of municipal solid waste (MSW). MSW generally refers to household and commercial garbage and trash within a municipality. Estimates suggest that the PRC produces around 220 million tons of garbage each year. The volume of MSW increases every year as the population increases and the economy grows. Thus, solid waste management is a major expense and continuing challenge.[3]

In 2009, not all MSW were properly collected, segregated, recycled, and disposed. Almost 50% of wastes in the PRC's secondary municipalities ended up in unengineered landfills and waterways.[4] Failure to prevent such disposal practices and to properly manage MSW could cause local, regional, and global environmental problems such as air pollution, soil and groundwater contamination, and greenhouse gas (GHG) emissions.

In the 1980s, the Government of the PRC started to study and address the challenges of energy security and environmental degradation, and urged the pursuit of scientific development, energy conservation, and environmental protection. Waste-to-energy (WTE) technology was viewed as an effective measure against environmental degradation. However, combining good WTE infrastructure with sustainable financing and timely delivery of public services challenged the capacity of local governments. Projections suggest that the market for WTE will increase fourfold, to 47 million tons by 2020, requiring an estimated investment of $10 billion. The PRC's existing 67 WTE plants, which process 11 million tons of MSW annually, cannot meet this increase.

In addition, current WTE technology contributes to urban air pollution. Most WTE plants use locally produced fluidized-bed incinerators that require supplemental fuel (e.g., coal) to burn MSW. Without clean technologies for new WTE plants, environmental degradation will worsen.

PROJECT SNAPSHOT

LOAN APPROVAL DATE:
May 2009

LOAN AMOUNT:
$100 million

BORROWER:
China Everbright Environmental Energy Limited (CEEEL)

EXECUTING AGENCY:
China Everbright International Limited

GEOGRAPHICAL LOCATION:
Jinan, Zhenjiang, Pizhou, Sanya, Suzhou and Jiangyin, PRC

TYPE OF ENERGY PROJECT:
Waste-to-energy

PROJECT COMPLETION DATE:
December 2013

1 Asian Development Bank (ADB). 2013. *Energy Outlook for Asia and the Pacific.* Manila.
2 United States Energy Information Administration. 2014. China Produces and Consumes Almost as Much Coal as the Rest of the World. *Today In Energy*. 14 May. http://www.eia.gov/todayinenergy/detail.cfm?id=16271
3 Solid waste management aims to treat MSW in an environmentally and socially acceptable manner with appropriate clean technologies.
4 ADB. 2009. *Report and Recommendations of the President to the Board of Directors: Proposed Loan and Technical Assistance to the People's Republic of China for the Municipal Waste to Energy Project.* May. Manila. http://www.adb.org/sites/default/files/project-document/65075/43901-prc-rrp.pdf

The government alone cannot continue as the main funding source for WTE with clean technologies. It needs the private sector to develop more WTE plants. Despite policies and incentives favorable to WTE and increased interest by municipal governments, private investors have difficulty getting support from financial institutions, partly because many institutions do not understand WTE and its associated risks. Frequently, banks cannot justify the higher total investment requirement because they lack know-how in quantifying WTE's health and environmental benefits. Higher due diligence costs also hinder financing.

SOLUTIONS

Encouraging private sector participation. The government has encouraged private sector participation through its program for public–private partnerships. A series of laws and regulations, including the Law on the Prevention and Control of Environmental Pollution from Solid Wastes (2004) and the Urban Domestic Waste Management Regulations (2007), provide incentives for investors. The Renewable Energy Law (2005) identified WTE as a key source of renewable energy. The government has also passed regulations that mandate power grid companies to purchase WTE-generated electricity within their area of operation at a premium price. Combined with financial assistance from the Asian Development Bank (ADB) in 2009, these policies paved the way for a WTE project initiated by the PRC's leading private company for environmental protection, China Everbright International Limited (CEIL).[5]

Innovative financing approach for WTE. When CEIL approached ADB for support, ADB recognized the growing potential and strong financial benefits of WTE. CEIL planned to build and operate four MSW-powered WTE plants to achieve an aggregate generating capacity totaling 84 megawatts (MW), and expand two existing WTE plants for an additional 48 MW capacity.

The project size and capital requirement of each project were small relative to transactional costs and the minimum amount ADB usually lends to borrowers. Therefore, ADB used a Portfolio Approach to bundle the individual WTE projects into a single project, enabling CEIL to meet ADB's minimum loan amount and reducing transaction costs.[6] With a single holding company and borrower, ADB is assured payment even if one project defaults. The scheme also requires a guarantee from a creditworthy sponsor, reducing ADB's overall credit risk.

China Everbright Environmental Energy Limited (CEEEL), a special purpose company established to hold CEIL's WTE operations, secured a $100 million A-loan funded by ADB and a $100 million B-loan funded by international banks. The CEEEL loan is covered by a full and irrevocable guarantee from CEIL.

Using advanced WTE technology. In 2006, CEIL commenced the commercial operation of the PRC's first WTE plant that adopted advanced clean technologies, including grate incinerator technology, a reliable state-of-the-art technology used in the United States and Europe. Grate incineration technology does not require supplemental fuel and uses advanced flue gas[7] emission control to comply with the high standards of European Union II.[8]

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5 CEILS's project investments, operations, technology developments, and equipment manufacturing focus on environmental protection and alternative energy businesses.

6 The Innovative Portfolio Approach for WTE projects was developed by the Private Sector Operations Department, ADB.

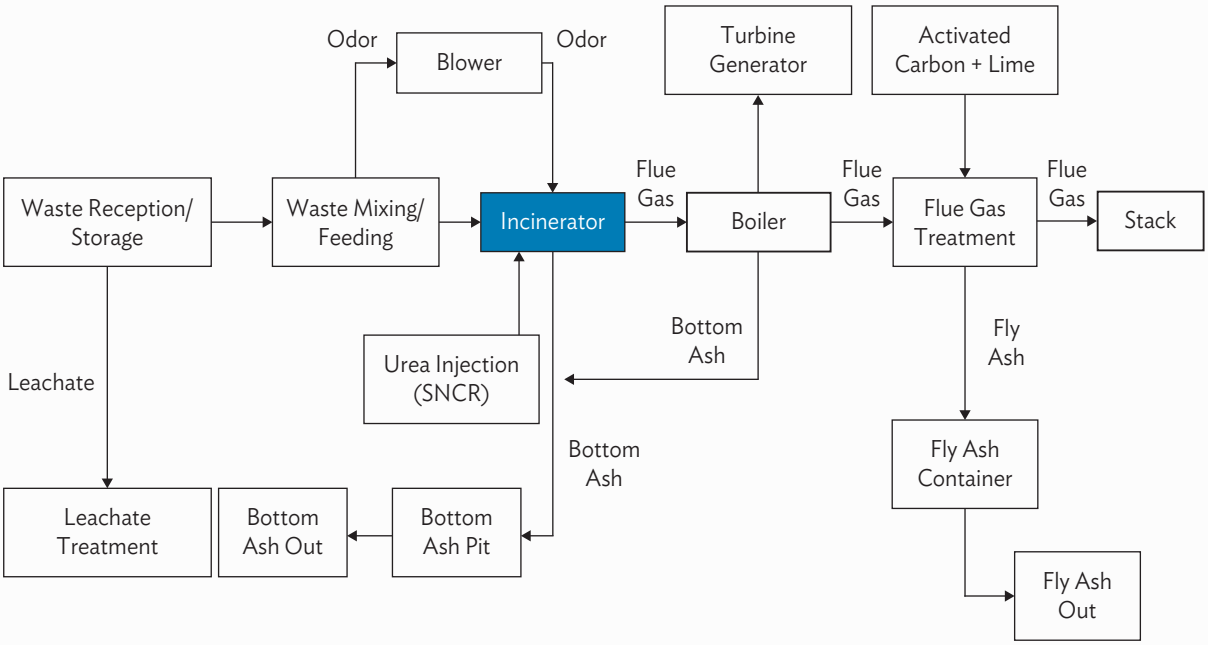
7 Flue gas refers to combustion-product gas resulting from the burning of fossil fuels.

8 These are technical specifications based on consensus among all interested parties (industries, consumers, trade unions, environmental nongovernment organizations, public authorities, etc.). It is carried out by independent standards bodies, acting at national, European, and international levels.

The PRC is the second-largest generator of municipal wastes in the world.

ADB PHOTO LIBRARY

Figure 2.4.1: Waste-to-Energy Conversion Process



SNCR = selective non-catalytic reduction.

Source: CEIL.

Figure 2.4.1 illustrates CEIL's WTE technology and process. During waste incineration, heat produced is recovered from the waste-heat boiler which produces steam to run the turbine generators and generate electricity.[9] Any burnt-out waste residue and/or noncombustible materials exit at the bottom of the incineration system as incinerator bottom ash. This ash is subsequently cooled, mechanically sorted, and stored before disposal or sold to interested companies as reusable raw material (e.g., for brick making).

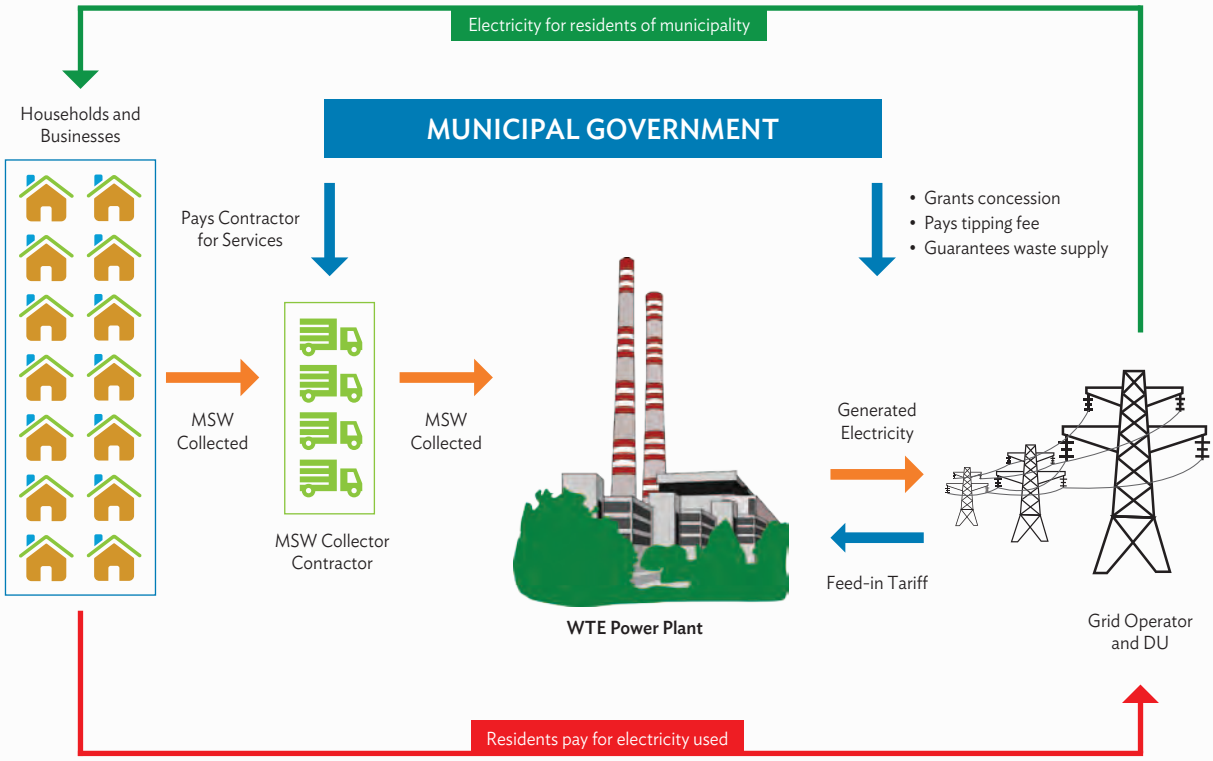
Flue gas generated from the incineration is first treated to remove nitrogen oxides. To prevent the formation of dioxins, waste is incinerated at temperatures exceeding 850°C for more than 2 seconds with sufficient air to allow complete combustion.[10] After the flue gas cools from its heat transfer to the waste-heat boiler, it is treated by a desulfurization unit using lime slurry and activated carbon to neutralize the acid gas and remove organic compounds and bag dust filters to remove dust particulates. The treated flue gas is then discharged into the atmosphere through a stack.

Operation using a waste-to-energy concession model. The WTE project had five major stakeholders: (i) CEIL, (ii) the constituents of the municipality, (iii) the contractor, (iv) the government, and (iv) the power grid operator. To ensure the viability and sustainability of the WTE plant, CEIL needed to address several risks associated with three stakeholders.

[9] Incineration is a widely accepted waste treatment process that burns organic substances at high temperatures to dispose the waste that is brought to their plant. Incineration converts waste into ash, flue gas, and heat.

[10] Dioxins refer to a group of toxic chemical compounds that share certain chemical structures and biological characteristics.

Figure 2.4.2: WTE Concession Model



DU = distribution utility, MSW = municipal solid waste, WTE = waste-to-energy.

Source: RETA 8392 task team.

Under the WTE Concession Model, the municipal government hires a contractor to collect MSW from residents and establishments and delivers it to the WTE plant. CEIL treats and processes the MSW using grate incinerators and advanced clean technologies to produce energy that it sells to the power grid operator. The power grid operator supplies power, partly supplied by the WTE plant, to the distribution utility that serves the municipality (Figure 2.4.2).

In this concession model, the WTE project can earn revenues from two sources: waste tipping fees[11] collected from the municipal governments, and a feed-in tariff (FIT) from the power grid operator.[12] Based on available information, an average a third of WTE revenue derives from waste tipping fees and two thirds come from FIT.

[11] The owner or operator of a landfill charges a tipping fee, also known as a gate fee, for accepting a unit weight or volume of solid waste for disposal, usually by the truckload. Tipping fees rise as the volume of available landfill space depletes, or as it becomes harder to open new landfills due to public opposition and stricter environmental regulations.

[12] Feed-in tariffs are an economic policy created to promote active investment in and production of renewable energy sources. These tariffs typically use long-term agreements and pricing tied to costs of production for renewable energy producers. Long-term contracts and guaranteed pricing shelter producers from some of the inherent risks in renewable energy production, thus allowing more diversity in energy technologies.

Community acceptance through participatory consultation and transparency. Energy projects often encounter resistance or opposition to the installation of power plants due to the wastes and health hazards resulting from the power generation process. To ensure smooth implementation of its WTE projects, CEIL closely coordinated with the municipal government and community leaders, and conducted public consultations in each municipality to explain the project and its benefits to the community. It also shared the project's mitigating and monitoring measures and their results.

Government participation and commitment. Three items in the concession agreement are very important for CEIL: (i) the exclusivity and tenure of the agreement, (ii) the guarantee for MSW supply, and (iii) the tipping fee. CEIL's concession agreement with the municipal government is exclusive, with a tenure of not less than 25 years. The agreement gave CEIL sole access to MSW and provided ample time to recover its investments. It also covered, or warrantied, CEIL against the municipality's failure to deliver the minimum amount of MSW for the WTE. It offsets similar warranties that CEIL would provide to the power grid operator and distribution utility. The municipal government paid CEIL a waste tipping fee for the treatment and disposal of the waste collected and delivered by the contractor.

RESULTS

Less waste, more energy. CEIL's WTE project is ADB's first private sector WTE project. With the financial support of ADB and the absence of any opposition from the hosting communities, CEIL was able to build and operate four new WTE plants in Jinan, Zhenjiang, Pizhou, and Sanya and expand the capacities of the Suzhou and Jiangyin WTE plants. The six plants, most in eastern PRC, have different power capacities, but collectively they increased CEIL's capacity to process MSW by 6,200 tons, yielding an additional 132 MW of power and 630 gigawatt-hours (GWh) of energy per year.

The Jinan WTE plant in the Shandong province is the largest of the new plants covered by the ADB loan. It produces 190 GWh of electricity from its 36 MW power plant, which runs on 2,000 tons of MSW. However, the largest of all CEIL-operated plants is the Suzhou plant, which almost doubled its capacity with the help of the ADB loan. Along with nine other WTE plants, they help address the PRC's waste management and energy supply concerns.

Less emissions. Emissions from these facilities have been strictly controlled, complying with the Chinese national standard (GB18485-2001) and comparable to the European Union II standards (i.e., Directive 2000/76/EC and relevant Annexes/Amendments). Hence, the project helped improve energy security without using fossil fuels that increase greenhouse gas emissions.

More benefits for communities. The efficient collection and processing of MSW using cleaner technology will benefit the urban population, particularly the urban poor who are most vulnerable to environment-induced diseases and least capable of paying for adequate medical attention. Construction and operation of WTE plants also created jobs in the local communities.

Model project. The WTE project is a strong model for private sector participation in public–private partnerships for multiple projects in medium-sized municipalities. The success of the project encourages private investors to invest in WTE with clean technology versus cheaper technologies that still require supplemental fuel.

By mobilizing domestic funds, ADB created awareness among commercial banks about the financial benefits and risks of WTE with clean technologies. The CEIL and ADB partnership taught commercial banks how to package and finance additional WTE projects. On a broader perspective, the project demonstrated a new mechanism for a long-term, reliable solution to address MSW problems, which are common to all municipalities.

LESSONS

Establish a long lasting harmonious relationship with the host community. To avoid opposition, proponents should always be truthful in communicating the scope, benefits, and risks of the project. CEIL has been successful in implementing both WTE and industrial solid and harmful waste landfill projects because they engage the communities. Consequently, CEIL has established a credible brand by continuously working with and helping the communities before, during, and long after project construction.

A financially viable solution to address energy supply requirements, disposal of municipal solid waste, and environmental protection. Some financial risks can discourage investors from venturing into the WTE business, but these risks are manageable. Using the ADB-CEIL-government business model, other investors can successfully venture into the WTE business.

The government and CEIL showed that a strong public–private partnership can mitigate risks and make the WTE industry a profitable and mutually beneficial undertaking. The government did its part by providing an opportunity for the private sector to venture into WTE and granting a sound concession agreement that included a 20-year concession period and a reasonable tipping fee and FIT. CEIL responded to the government's invitation by addressing all WTE-related concerns, including acceptance and approval by the community, the sourcing of funds, and compliance with environmental and safety standards and requirements.

Keywords

Waste to energy, energy, clean energy, clean technology, municipal waste, energy financing scheme, WTE concession model, WTE model, PRC

For further reading

- http://www.adb.org/news/adb-supports-clean-waste-energy-project
- http://www.adb.org/sites/default/files/project-document/65075/43901-prc-rrp.pdf

For further information

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RELIANCE POWER

RAJASTHAN CONCENTRATING SOLAR POWER

A Multi-stakeholder Partnership That Maximizes Solar Power to Fuel India's Economy

India is now tapping the vast potential of solar power to diversify its energy mix while meeting rapidly increasing energy demand.

- India's energy sector faces major challenges, including increasing energy demand amidst energy poverty, dependence on fossil and imported fuels, and heavy pollution.
- The Jawaharlal Nehru National Solar Mission, which aims to maximize solar energy to stimulate India's economy, is a timely response to the problems of its energy sector.
- A multi-stakeholder partnership among the Government of India, the Asian Development Bank, and private companies helped develop the Rajasthan Concentrating Solar Power Project, the world's largest project using compact linear Fresnel reflector technology.
- This technology reflects and concentrates the sun's rays onto solar steam generators that boil water into super steam and drive turbines to produce more than 240,000 megawatt-hours of clean energy per year, helping India secure energy supply while reducing its dependence on fossil fuels.

CONTEXT

India has a vast potential for solar power generation. About 1.89 million square kilometers of its total land area (about 58%) receive an annual average insolation[1] totaling 5 kilowatts per square meter per day (kW/m^2/day). With today's solar technology, 1% of India's land can adequately meet the country's energy needs until 2031.[2]

The Government of India recognizes the immense potential of solar energy. In 2011, it launched the Jawaharlal Nehru National Solar Mission (NSM), which established a national energy target to deploy 20,000 megawatts (MW) of grid-connected solar power by 2022. The NSM aims to harness solar energy to ensure energy efficiency and less reliance on fossil fuels.

Several energy-related challenges make this policy track very timely. India is experiencing a rapid increase in energy demand while nearly a quarter of its population still lacks access to energy.[3] Moreover, India depends heavily on fossil and imported fuels that pollute many of its cities. In May 2014, the World Health Organization listed four Indian cities among 1,600 with the dirtiest air worldwide. With an average 153 micrograms of $PM_{2.5}$ per m^3 (i.e., particulate matter less than 2.5 micrometers in diameter), New Delhi topped the list. $PM_{2.5}$ is highly hazardous because it can penetrate and lodge deep in the lungs.[4]

PROJECT SNAPSHOT

LOAN APPROVAL DATE:
March 2012

LOAN AMOUNT:
$103 million

BORROWER:
Rajasthan Sun Technique Energy Private Limited

GEOGRAPHICAL LOCATION:
Rajasthan, India

TYPE OF ENERGY PROJECT:
Solar power generation

EXPECTED PROJECT COMPLETION DATE:
April 2015 (partially completed in November 2014)

A diversified energy supply mix is crucial in India. Therefore, the NSM set targets to promote solar power aiming to install 2 gigawatts (GW) of capacity by 2013, 10 GW by 2017, and 20 GW by 2022. NSM also aimed to develop a diversified manufacturing base of solar power components. The government initially invited private companies to bid for the right to develop 470 concentrating solar power (CSP) projects. Rajasthan Sun Technique Energy Private Limited (RSTEPL), a subsidiary of Reliance Power Limited, approached the Asian Development Bank (ADB) for financing after winning one bid. The subsequent partnership between ADB and RSTEPL yielded the Rajasthan Concentrating Solar Power Project, the world's largest CSP project using compact linear Fresnel reflector technology (CLFR).

1 The amount of solar radiation reaching a given area.
2 Clean Energy. 2012. *Rajasthan Concentrating Solar Power.* http://www.cleanenergyactionproject.com/CleanEnergyActionProject/Solar_CSP___Concentrating_Solar_Power_Case_Studies_files/Rajasthan%20Concentrating%20Solar%20Power%20Project.pdf
3 International Energy Agency. 2012. *Understanding Energy Challenges in India.* http://www.iea.org/publications/freepublications/publication/India_study_FINAL_WEB.pdf
4 G. Harris. 2014. Cities in India among the World's Most Polluted, W.H.O Says. *The New York Times.* 8 May. http://www.nytimes.com/2014/05/09/world/asia/cities-in-india-among-the-most-polluted-who-says.html?_r=0

RELIANCE POWER

Full commissioning of the Rajasthan solar farm will help the country transition to a renewable energy source and reduce emissions and pollution.

SOLUTIONS

Multi-stakeholder partnership. The Rajasthan CSP project was a collaborative work among partners with clear roles. By establishing the NSM, the Government of India set the policy framework. Foreign development banks, including ADB, and an export credit agency provided financial assistance with substantially longer maturities than local financial institutions. This arrangement enticed RPL to develop CSP and provide the needed equity. Areva Solar provided the necessary technology.[5]

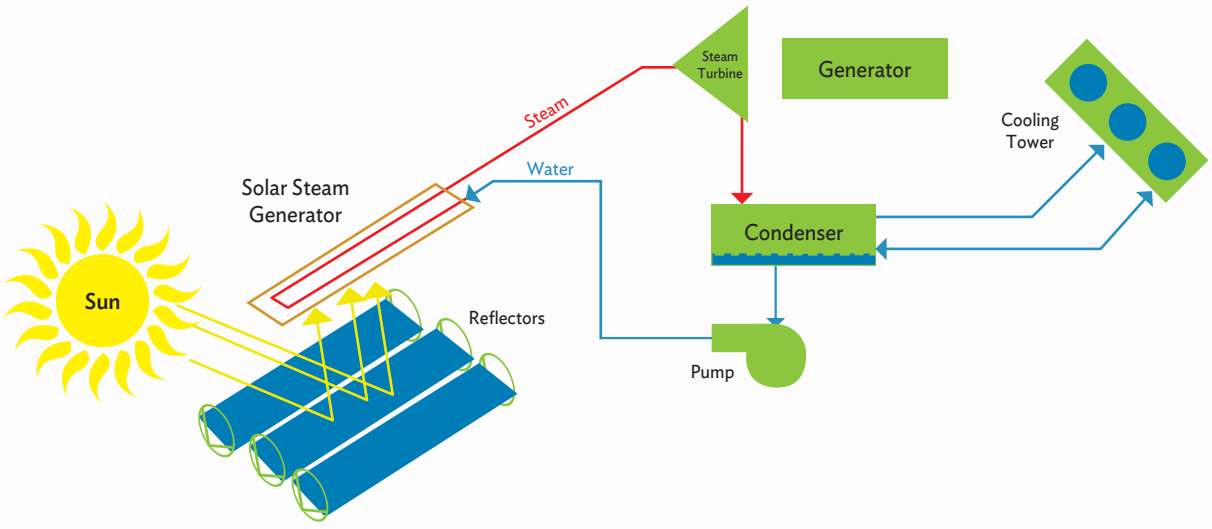
[5] Climate Policy Initiative. 2014. *The Role of Public Finance in CSP Case Study: Rajasthan Sun Technique, India.* March. http://climatepolicyinitiative.org/wp-content/uploads/2014/03/SGG-Case-Study-The-Role-of-Public-Finance-in-CSP-Rajasthan-Sun-Technique-India.pdf

Reliance Power Limited, which established RSTEPL to develop CSP in Rajasthan, has a strong energy portfolio in India and abroad. In March 2011, the company's net worth was Rs168.33 billion (about $3.74 billion). Before approaching ADB for financial assistance, RSTEPL conducted rigid and high-quality preparations for the Rajasthan CSP project. After review and discussions, ADB loaned $103 million to RSTEPL to finance part of the construction of CSP, which has a total cost of about $414.5 million.

Selecting a suitable project site. One challenge in establishing solar power generation plants is finding a suitable tract of mostly level land that is widely exposed to continuous sunlight. The project selected a highly suitable site near Dhursar Village in Pokaran Tehsil, Rajasthan. The site covers about 340 hectares of nearly flat landscape, far removed from highly populated areas but near a national highway, and enjoys long periods of cloudless days. In addition, this site provides higher direct normal irradiance and optimized grid connectivity. Direct normal irradiance at the project site is about 2,071 kilowatt-hours per square meter, one of the highest in India.[6]

Using compact linear Fresnel reflector technology. CLFR technology concentrates the sun's energy to about 40 times its normal intensity onto a steam-generating receiver. Turbines or other engines transform the steam into mechanical energy and then into electricity. CSP uses a series of flat reflectors or mirrors arranged in parallel rows that reflect and concentrate sunlight onto a series of tubes within 35 solar steam generators. The sun's rays heat the water in the tube to 400°C, generating superheated steam, which drives a turbine that produces electricity. The mirrors' position adjusts automatically every day, based on the sun's position, to maximize received sunlight. This technology is the foundation of the 100 MW CSP generation plant in Rajasthan, which is the world's largest CSP plant using linear Fresnel technology and the first completed under the NSM. Figure 2.5.1 illustrates the process of solar power generation.[7]

Figure 2.5.1: Process of Power Generation



Source: Asian Development Bank. 2012. *Final Environmental Examination. Rajasthan Concentrating Solar Power Project.* February. Manila.

[6] Asian Development Bank (ADB). 2012. *Report and Recommendations of the President to the Board of Directors: Proposed Loan to India for the Rajasthan Sun Technique Energy Private Limited Rajasthan Concentrating Solar Power Project.* March. Manila.

[7] ADB. 2012. *Final Environmental Examination: Rajasthan Concentrating Solar Power Project.* February. Manila.

Connecting to the power grid. To connect to the power grid, CSP shares the 30-kilometer, 220-kilovolt, double-circuit transmission line developed by Dahanu Solar Power Private Limited for the 40 MW Dahanu Solar Power Project, which is near the project site. The transmission line passes through several villages without affecting the right of way, households, or trees. All energy generated by the Rajasthan CSP project will be sold to NTPC Vidyut Vyapar Nigam Limited (NVVN) for 25 years at a fixed rate (i.e., Rs11.97 or $0.24 per kilowatt-hour). RSTEPL had already established a power purchase agreement with NVVN, India's designated nodal agency for the procurement of solar power.

RESULTS

Construction of the CSP plant was partially completed on 11 November 2014. Although full commissioning is not expected until April 2015, it is already connected to the power grid and has begun generating power. This operating power plant helps diversify India's energy mix by using renewable energy and harnessing it better using modern technology. It is now helping India reach its target, reducing dependence on fossil fuels by providing at least 242,756 megawatt-hours of solar-generated electricity per year.

Aside from helping India transition to a renewable energy source, CSP helps reduce emissions and pollution. Solar power eliminates fuel combustion, thus avoiding an average 229,368 tons of carbon dioxide emissions per year. CSP also demonstrates the viability of CLFR technology on a much larger scale. India plans to install at least three other CSP power plants by 2015.

LESSONS

Using technology to maximize solar power. Using CLFR, a relatively new CSP technology, is a huge step in India. Although used for commercial operations since 2009, most CLFR projects are small. More than 450 MW of CLFR-based CSP projects are under development worldwide, but only 16 MW is operational. The largest CLFR project in operation is AREVA Solar's 5 MW plant in California. With a capacity of 100 MW, the Rajasthan CSP project is by far the largest in the world. It demonstrates the viability of CLFR technology for utility-scale power generation. Compared to other CSP technologies, CLFR is less complex because it lacks heat exchangers or transfer fluids, U-shaped or curved reflectors, and complex sunlight-tracking systems.

CSP technology helps many countries experiencing energy deficits and rapidly growing demand for energy. CSP can store the sun's energy as heat, allowing it to deliver power when it is needed, balancing supply and demand gaps arising from the fluctuating supply from other renewables, and helping maintain a stable energy supply (footnote 5).

Stimulating the private sector to help reach targets. Power plants are investment-intensive and may further strain government budgets in countries like India, which subsidizes energy for consumers. It is important to entice private sector participation in large-scale energy projects to help the country reach energy targets without draining government budgets. It is also wise to tap the private sector, not merely for financial investments but also for technology and innovations. Industry leaders can offer innovative products and approaches to help a

country meet its energy supply targets. This project illustrates two concrete ways to engage the private sector: setting a conducive policy climate and offering attractive financing schemes.

The need for more information on concentrating solar power. At a time when countries are searching for stable sources of renewable energy, CSP can become a good alternative. However, compared to solar photovoltaic technologies, CSP has not been commercially applicable. Solar photovoltaic technology-based power plants have become more prevalent around the world, with over 100 GW installed capacity. CSP installed capacity (using CLFR and other technologies) is only 2.2 GW worldwide. Thus, CSP projects are more costly compared to photovoltaic, inhibiting investors. There is a need to disseminate more information about CSP, particularly regarding its ability to maximize sunlight capture and adapt to local contexts. This successful project is one more step toward attracting more investments in CSP, increasing its commercial application and reducing investment cost. In addition, this project increases knowledge about CSP, as it demonstrates the feasibility of establishing a utility-scale CSP plant.

Having realistic timelines. A key lesson gained from CSP is the need for realistic timelines. Introducing a new or complex technology in untested markets requires careful planning. Project implementers should not expect rapid completion, due to a longer learning curve and longer time to construct the infrastructure. Completion date targets should consider these factors, which are inherent in novel or complex technologies.

Keywords

Concentrating solar power, solar power, sun, solar, solar energy, renewable energy, India, Rajasthan, energy

For further reading

- http://www.adb.org/news/adb-help-finance-rajasthan-solar-plant-one-largest-india
- http://www.adb.org/projects/details?proj_id=46900-014&page=overview
- http://www.adb.org/projects/documents/rajasthan-concentrating-solar-power-project

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MIKE BARROW

THE PAY-AS-YOU-GO OFF-GRID PROJECT IN INDIA

Addressing Energy Poverty One House at a Time

A rural household with a solar panel from ADB's Off Grid Pay-as-You-Go Solar Power Project

- Many rural villages in India are energy poor. Recent estimates reveal that about 289 million people lack access to electricity and an additional 80 million are underserved. To quickly fill the access gap, the Asian Development Bank initiated a $2 million equity investment in Simpa Networks.
- Simpa installed off-grid solar systems in rural households, coupled with a metering and collection system linked to India's well-developed communications infrastructure. Electricity prices were tailored to households' capacity to pay.
- To keep electricity flowing, the project allowed rural customers with low and irregular incomes to buy energy credits in small packages—akin to sachet purchases—through the short messaging service of their mobile phones.
- The project decentralized access to electricity and made a traditionally expensive technology affordable for the poor. Thousands of households in rural India now have electricity flowing directly into their homes. By the end of 2015, around 15,000 households will benefit from this innovative approach.

CONTEXT

Energy poverty calls for innovative and cost-effective solutions, especially in India, where about a quarter of the population lack electricity. The International Energy Agency reports that 289 million Indians lack access to electricity, especially in rural areas.[1] About 75 million rural households are not connected to the electrical power grid and another 80 million are underserved by electrical utilities.[2]

This lack of access accentuates rural poverty, overburdening meager household budgets because people must pay more to access even simple light. Rural households pay as much as $9 for a month's supply of kerosene for lighting and other electrical needs, accounting for half of per capita consumer expenditures per month (approximately $19–$20) (footnote 2).

PROJECT SNAPSHOT

EQUITY INVESTMENT TO SIMPA NETWORKS:
$2 million

GEOGRAPHICAL LOCATION:
India

TYPE OF ENERGY PROJECT:
Off-grid solar power

India's energy sector reforms prioritize lack of access, energy efficiency, and climate change. The country has made gradual progress in extending the central electricity grid. However, the long-term feasibility of continuing such efforts remains uncertain. Even villages that may gain connection to the grid remain uncertain about when they will be connected.[3] The cost of infrastructure and facilities to expand energy supply is steep, political dynamics make much-needed policy reform complex and difficult (footnote 1), and energy demand continues to surge, further straining government capacity. In July 2012, the national grid broke down, causing the world's largest blackout in recent history. The failure plunged 20 Indian states into darkness, leaving 700 million people without electricity, causing road gridlocks due to lack of traffic signals, stranding hundreds of train commuters, and seriously delaying medical procedures and public and private transactions.[4] Even so, India's electricity demand is expected to increase from 900 billion kilowatt-hours in 2011 to 1,400 billion kilowatt-hours by March 2017.[5]

The poor urgently need access to energy. Therefore, India must implement strategic measures to avoid pushing the rural poor further into the spiral of poverty. Because most rural villagers can afford only enough electricity to power two light bulbs and a cell phone charger (footnote 3), new measures must expand access and affordability. In addition, expanding access should not compromise service reliability.

In January 2013, the Asian Development Bank (ADB) initiated Off Grid Pay-as-You-Go Solar Power, a $2 million equity investment in Simpa Networks that will close the gaps in energy access with the assistance of the private sector. This will facilitate the provision of solar energy to India's energy-poor households using a prepaid "sachet," or small packaging, marketing platform.

1 International Energy Agency. 2012. *Understanding Energy Challenges in India. Policies, Players, and Issues.* http://www.iea.org/publications/freepublications/publication/India_study_FINAL_WEB.pdf

2 Asian Development Bank (ADB). 2013. *Knowledge Showcases: Affordable Pay-as-You-Go Solar Power for India's Energy-Poor Homes.* August. Manila. http://www.adb.org/sites/default/files/pub/2013/affordable-solar-power-india-energy-poor-homes.pdf

3 Princeton University. 2014. *Rural Energy Alternatives in India: Opportunities in Financing and Community Engagement for Renewable Energy Microgrid Projects.* https://wws.princeton.edu/sites/default/files/content/591f%20Rural%20Energy%20Alternatives%20in%20India.pdf

4 H. Pidd. 2012. India Blackouts Leave 700 Million without Power. *The Guardian.* 31 July. http://www.theguardian.com/world/2012/jul/31/india-blackout-electricity-power-cuts

5 R. Sharma and E. Yep. 2011. India to Add 17 GW Renewable Energy in 2012–17. *The Wall Street Journal.* 5 May. http://www.wsj.com/articles/SB10001424052748703992704576304661127159344

SOLUTIONS

Tapping the private sector. Simpa already offers a simple, affordable, commercially sustainable, and clean energy solution to address lack of access to electricity in off-grid and largely rural areas. Established in November 2010 and incorporated in Delaware, United States, Simpa operates in India through Simpa Energy India, a 100% subsidiary.[6] ADB's investment will allow Simpa to extend the off-grid power solution already piloted in a Karnatakan village to other parts of the country, and also raise capital from other private equity firms during the next 3 years. Thus, ADB's assistance will help India provide access to clean, reliable, and affordable energy via solar home systems (SHSs) in 15,000 rural households by 2015. Tapping the private sector can also stimulate more venture capital funding in India to make services such as electricity affordable.

Using a renewable source. The project offers poor rural households an optimal solution to their electricity woes. SHSs include a solar panel, a battery that stores solar energy, wires connected to the home, a charge regulator, and compact fluorescent and/or light-emitting diode lamps. It also includes the Simpa small electronic controller that locks energy flow from the battery. The controller has a keypad for entering unlock or recharge codes and a simple liquid crystal display that shows the energy credit balance available for use.

Sachet pricing scheme. One SHS costs about $200–$400. To have the system installed in the home, a customer just needs to pay about 10%–20% of the cost of the system. After installation, users can buy energy credits in small increments or quantities, according to their preference, in amounts as low as Rs.50 (about $0.87). The minimum energy credit available for purchase is Rs.10 (about $0.002).[7] Individual payments accumulate toward the final purchase price. After receiving full payment, the system unlocks permanently and continues to produce electricity without further charge or fees. Simpa calls this mode of pricing "progressive payment scheme." It not only allows consumers to buy electricity at retail prices, but also makes it easier for customers to transform incremental payments into a household asset. This scheme considers the low and irregular incomes of rural residents, who can afford only small amounts of commodities.

Piggybacking on a developed communications network. When a household needs more energy, it can use a mobile phone's short messaging service to purchase credits and unlock the SHS. A return message provides a code to unlock the controller and make electricity flow into the household again. Piggybacking on the country's well-developed communications infrastructure facilitates payment and collection in a dispersed customer base such as in India, where rural villages are scattered along vast tracts of land. As of June 2012, India had a well-developed mobile telecommunications network that serves more than 930 million mobile phone users and 14 mobile network operators (footnote 6).

[6] ADB. 2012. *Report and Recommendations of the President to the Board of Directors: Proposed Equity Investment to India for the Simpa Networks Off-Grid Pay-As-You-Go Solar Power Project.* December. Manila. http://www.adb.org/sites/default/files/projdocs/2013/46931-014-ind-rrp.pdf

[7] S. Advani. 2013. Simpa Networks Offers Clean Energy through a Prepaid Payment Platform. *Entrepreneur India*. 30 January. http://simpanetworks.com/2013/02/17/entrepreneur-simpa-networks-offers-clean-energy-through-a-prepaid-payment-platform/ (accessed 26 October 2014).

MIKE BARROW

This roof-mounted solar is part of a solar home system, which also includes a solar battery, wires connected to the home, a charge regulator, and compact fluorescent and/or light-emitting diode lamps.

RESULTS

Increased access to energy. Energy is crucial to households, as it brings invaluable and often immeasurable benefits. Increased access to electricity (i) improves education and allows students to study beyond sunset, (ii) helps improve health by replacing smoky kerosene, and (iii) boosts productivity, allowing even small household-based businesses to extend business hours. In October 2014, Simpa had more than 5,000 active customers and delivered 40 megawatt-hours hours of clean energy to rural households. Estimates suggest that this project will provide about 15,000 households with off-grid, prepaid access to electricity by 2015.

Increased funds for the energy sector. Benefits extend beyond rural electrification. Hinged on partnership with the private sector, the project is expected to stimulate participation in the provision of innovative off-grid solutions to India's energy poverty. By 2017, the project will have stimulated $20 million of venture capital and private equity funds invested in companies operating in India's energy sector.

Decreased greenhouse gas emissions. Solar power is environment-friendly because it does not pollute the air with carbon, methane, or particulate emissions and contribute to climate change. Between 2012 and 2022, the project will have reduced carbon emissions by at least 2,900 tons per year.

A woman loads up on electricity using her mobile phone.

MIKE BARROW

LESSONS

Use a simple business model. A key lesson from this project is its business model. Tapping India's large rural electricity market required a business model designed for accessibility, affordability, and sustainability. Although simple, Simpa's business model has far-reaching effects on the expansion of energy access. First, Simpa developed an SHS that can accommodate the simple energy needs and capacity to pay of rural households. Second, the price of the SHS was tailored to rural buying preferences. Third, the model maximized the telecommunications infrastructure for metering and collection. Thus, low up-front and recurring costs for households and microgrid developers enticed both customers and investor-resellers. Furthermore, the prepaid system for energy purchase is flexible enough for the buyer and assures payment to the investor.

This simple business model is replicable across countries with large swaths of land and large populations that lack access to electricity. Simpa can easily expand its simple process of SHS installation, metering, and collection through mobile phone to other Asian countries. Moreover, other companies can replicate Simpa's process.

Make access to electricity affordable and simple. This project's pay-as-you-go aspect makes products and services more accessible and affordable for rural consumers. The system's prepaid feature may also entice more private sector investments. Using this strategy, households would have access to electricity when and how much they want it. Because households pay before receiving the power, investors would receive up-front payment for energy that will be used.

Use a clean and efficient technology. The project offers advantages from a business or household perspective. Because it uses solar energy as a source for electricity, it also targets environmental sustainability. Installing SHSs in households was a strategic move that minimized the system's carbon footprint and did not entail large infrastructure construction. SHSs are not connected to the national grid, so additional power demands from rural areas do not burden the country's already strained energy infrastructure. In addition, the system's decentralized nature offers a reliable electrical supply to rural households and decreases their vulnerability to blackouts.

Keywords

Solar power, off-grid solar power, sun, solar, solar energy, renewable energy, India, energy, pay-as-you-go electricity

For further reading

- http://www.adb.org/projects/documents/proposed-equity-investment-simpa-networks-grid-pay-you-go-solar-power-project
- http://adb.org/sites/default/files/pub/2013/affordable-solar-power-india-energy-poor-homes.pdf

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C. TIANGCO

SAMARKAND SOLAR POWER PLANT PROJECT

Central Asia's First Solar Power Plant

ADB President Takehiko Nakao (sixth from right) visits Uzbekistan Solar Furnace Parkent District, Uzbekistan, 22 November 2013.

- In the Republic of Uzbekistan, increasing demand and aging thermal power plants contribute to growing energy deficiencies.
- Solar energy is a sustainable option for bridging the gap that, until recently, has been overlooked. Solar development in Uzbekistan was limited to academic research since its independence in 1991.
- Now, Uzbekistan aims to become a regional hub for solar energy. With assistance from the Asian Development Bank (ADB), Uzbekistan established the International Solar Energy Institute, developed a road map for solar energy development with action plans and enabling policies, and a pipeline of solar projects.
- Through ADB financing, Uzbekistan will build its first large-scale solar power plant even as it continues to increase research and institutional capacities for the finance, design, implementation, operation, and maintenance of this modern infrastructure. The planned 100-megawatt solar power plant will be among the world's largest photovoltaic power plants, with a gross annual output of at least 159 gigawatt-hours.

CONTEXT

Uzbekistan, one of the world's most energy- and carbon-intensive countries, relies on fossil fuels to supply 89% of its electricity demand. Hydropower supplies 11%. More than 50% of its thermal power plants were built before 1982, and 10% were built after 1997. Deterioration of the country's aging thermal power plants and higher energy demand have contributed to a growing electric power deficiency in Uzbekistan.

A widening gap between supply and demand. Uzbekistan needs to tap alternative sources of energy. Projections suggest that its oil reserves will last only until 2026, natural gas reserves could be depleted by 2045, and coal reserves may only be available until 2065. Uzbekistan's vast idle land area exposed to high levels of solar irradiance provides an opportunity for solar power to help address the country's energy security concerns. Uzbekistan's President Islam Karimov issued Presidential Decree 4512 (1 March 2013) mandating the creation of advanced solar industries to support the country's goals of becoming an international knowledge and technology hub for solar energy and attaining a 21% renewable energy capacity by 2031, including at least 4 gigawatts of solar capacity.[1] Although Uzbekistan was known for research and development of the solar furnace in 1983, when it was still part of the former Soviet Union, no significant change has occurred since it gained independence in 1991.[2] Solar energy development was limited to academic research.

Uzbekistan sought technical and financial assistance from the Asian Development Bank (ADB) to develop the country's solar energy sector and build its first solar power plants. ADB helped Uzbekistan (i) create the International Solar Energy Institute (ISEI), which was envisioned as the region's solar research and knowledge hub; (ii) develop a road map which detailed action plans, enabling policies, and a pipeline of solar projects, and (iii) develop the 100-megawatt (MW) Samarkand Solar Power Project, the region's first solar photovoltaic (PV) power plant (Map 2.7.1).

PROJECT SNAPSHOT

LOAN APPROVAL DATE:
November 2013

TOTAL PROJECT COST ESTIMATE:
$310 million

LOAN AMOUNT:
$110 million

BORROWER:
Republic of Uzbekistan

EXECUTING AGENCY:
SJSC Uzbekernego

GEOGRAPHICAL LOCATION:
Samarkand

TYPE OF ENERGY PROJECT:
Solar photovoltaic power plant

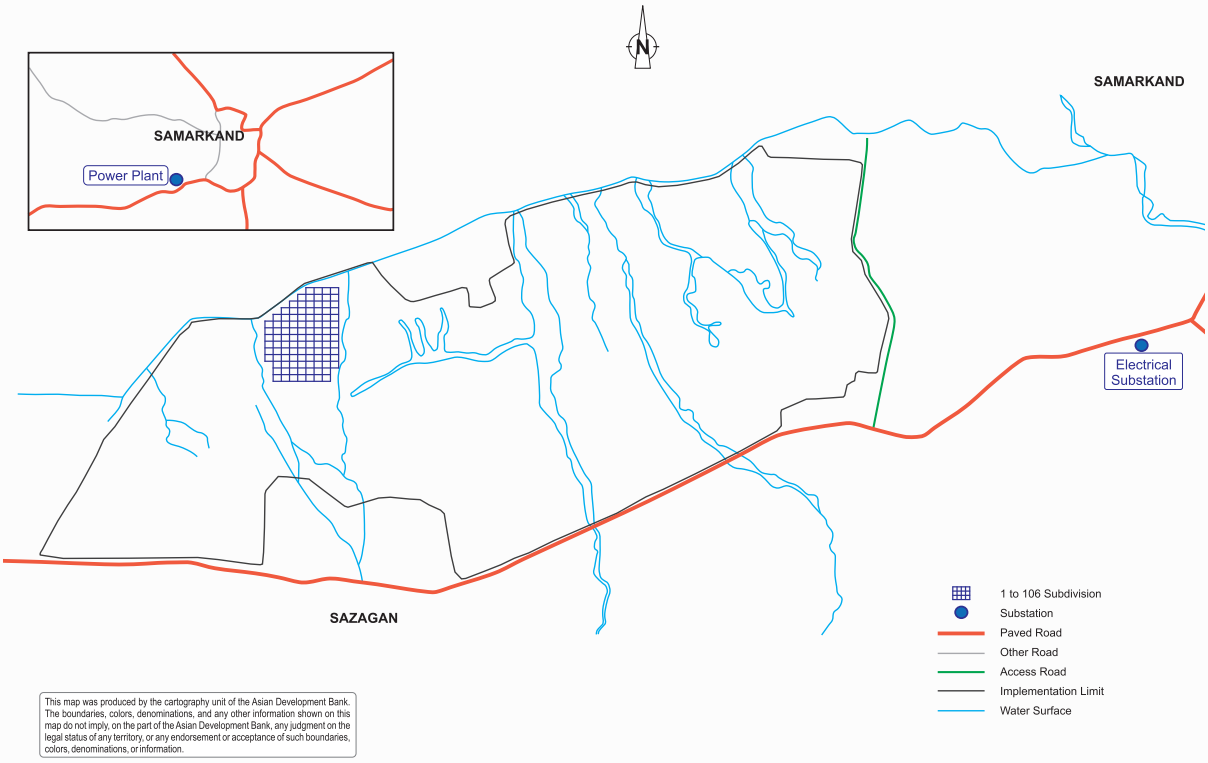
EXPECTED COMMISSIONING DATE:
2016

EXPECTED PROJECT LOAN COMPLETION DATE:
2019

[1] Asian Development Bank. 2013. *Report and Recommendations of the President to the Board of Directors: Proposed Loans to the Republic of Uzbekistan for the Samarkand Solar Power Project.* Manila.

[2] A solar furnace has parabolic mirrors, or heliostats, that use concentrated solar power to produce very high temperatures (as high as 3,500°C). Solar furnaces are usually used to produce hydrogen fuel or for foundry applications and high-temperature material testing.

Map 2.7.1: Samarkand Solar Power Project



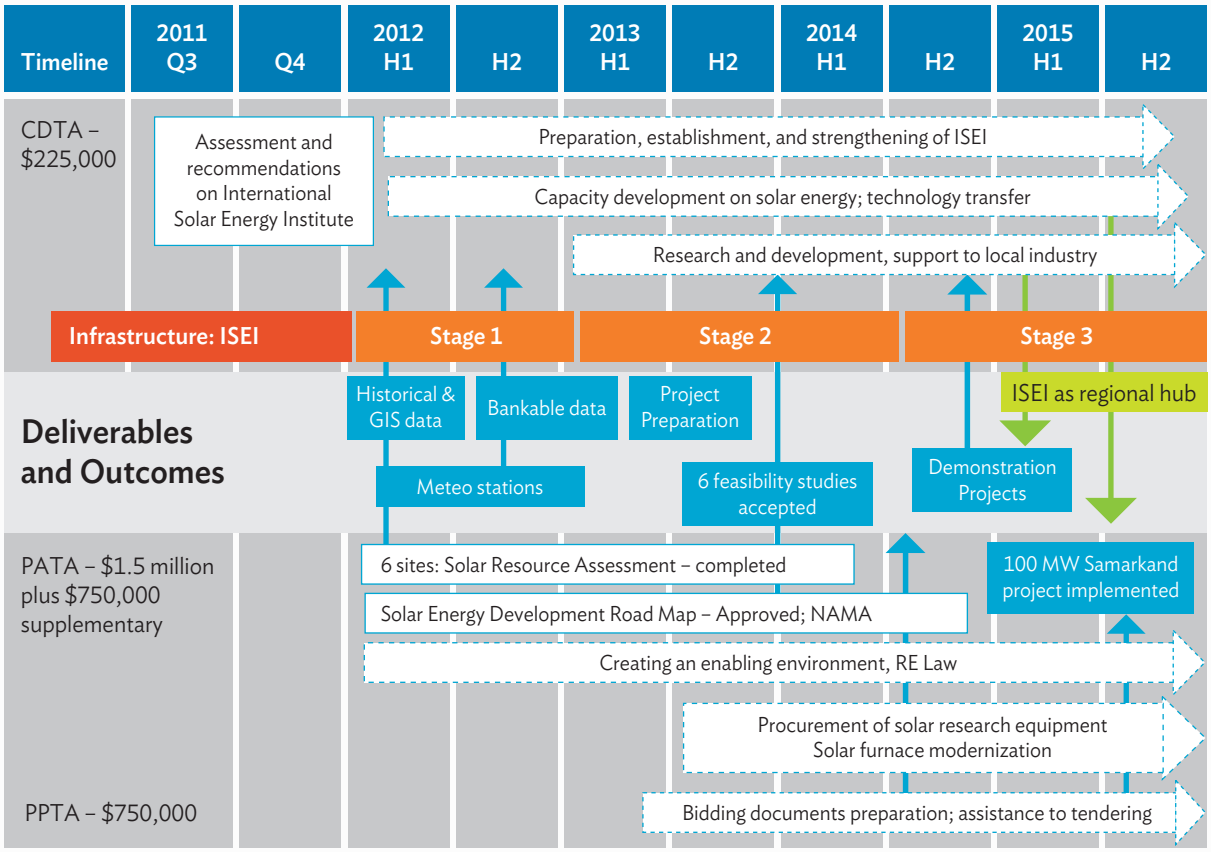
Source: ADB. 2014. Uzbekistan: Solar Power Development. Report presented at the 7th Meeting of the Asia Solar Energy Forum. Seoul, Republic of Korea. 15–17 October 2014.

SOLUTIONS

Strengthening solar energy knowledge and research capacity. ADB used technical assistance to help Uzbekistan expand its institutional capacity for solar energy (Figure 2.7.1). Designated as executing agency for the first technical assistance, the Scientific-Production Association on Solar Physics (Physics Sun) also designed ISEI, including its vision, organization structure, mandates and responsibilities, and institutional charter.[3] ISEI is envisioned as a regional hub for solar knowledge and technology and the single focal point for solar technology in Uzbekistan and Central Asia. ADB's second technical assistance conducted feasibility studies to create a pipeline of solar projects and also developed the solar road map. It is enhancing solar research by modernizing the solar furnace and heliostat fields, designing a PV bed facility and certification laboratory, and procuring relevant equipment.

[3] Established on 1 May 1993, the Institute of Material Sciences SPA "Physics - Sun" Academy of Sciences Republic of Uzbekistan (IMS-Uz) provides the basic structure of research activity at an Academy of Sciences. It conducts research under the scientific and methodical management of the Presidium, which is the branch of physical and mathematical sciences at the academy. The institute includes six scientific laboratories, three departments, and a pilot production facility that include the unique Big Solar Furnace (thermal capacity = 1 MW).

Figure 2.7.1: ADB Assistance to Uzbekistan Solar Energy Development – Synergy, Outcomes, and Status



ADB = Asian Development Bank, GIS = geographic information system, ISEI = International Solar Energy Institute, MW = megawatt.

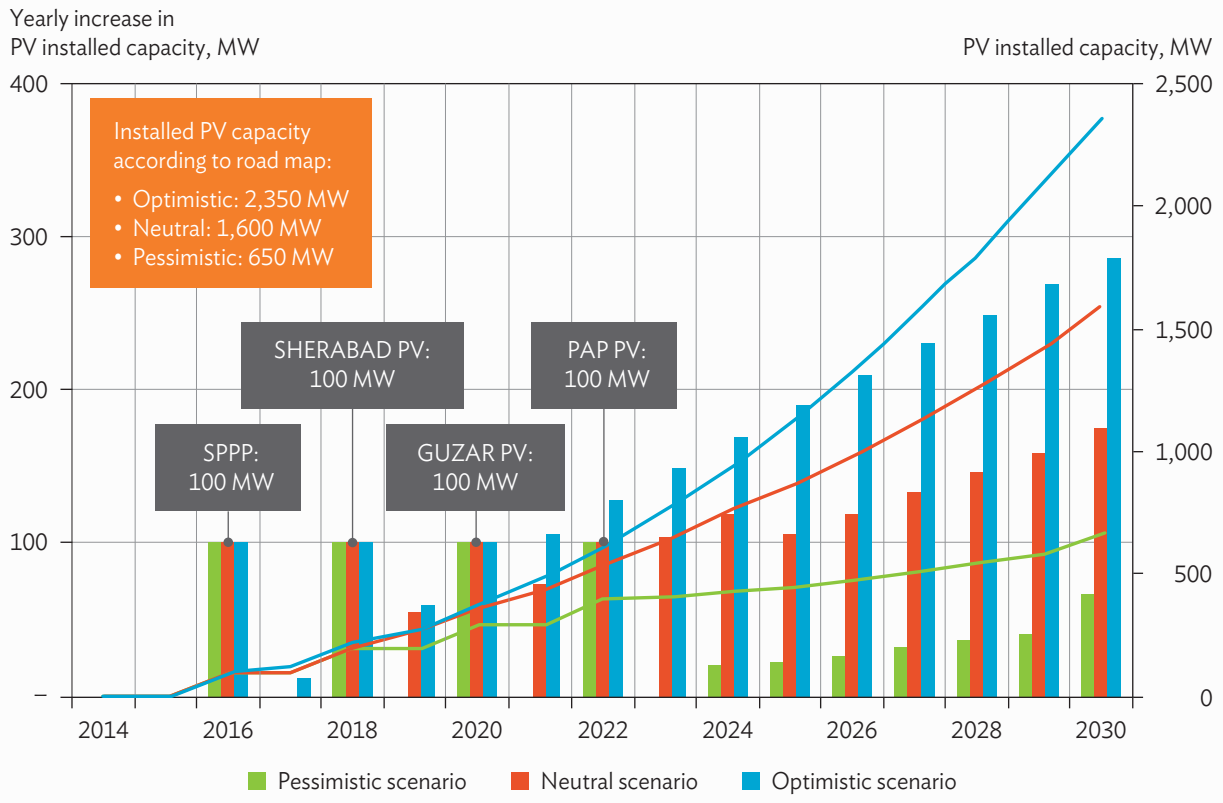
Source: Cinderella Tiangco, ADB.

Establishing the International Solar Energy Institute. ISEI was established on 1 March 2013. The ISEI director and deputy director were brought to countries with leading solar expertise and technologies for training and networking for future collaboration. Physics Sun retained its mandate to operate the solar furnace and conduct basic research on solar energy to differentiate itself from ISEI. ADB helped ISEI obtain funding for the PV test bed facility in Namangan.

Creating a road map for solar energy development. ADB's second technical assistance helped formulate a road map with multi-agency action plans and a pipeline of solar projects to enable the Government of Uzbekistan reach its solar targets (Figure 2.7.2). The pipeline of projects, including forecasted PV and concentrating solar power (CSP) installed capacity (the two major solar power technologies), was created based on solar resource assessments and mapping with geographical information systems layers (Figure 2.7.3). Requirements for solar power development including investments, irradiation, land, water, labor, and other inputs were assessed.

Selection of suitable project sites. Solar power plant sites must satisfy certain criteria to ensure optimum output at lowest cost (i.e., irradiation levels; size and topography; availability of water, transmission lines, and other resources; and proximity to load centers). It is necessary to measure on-site solar resources to determine the potential

Figure 2.7.2: Photovoltaic Technology in Solar Roadmap



CSP = concentrating solar power, MW = megawatt, PV = photovoltaic.

Assumptions:

– Neutral: Uzbekistan's renewable energy plus conventional = 100% of Conservative Scenario of consumption in 2030

– Optimistic: Installed PV capacity reaches the 15% of installed capacity (Grid stability)

– Pessimistic: Uzbekistan's renewable energy plus conventional = 95% of Conservative Scenario of consumption in 2030

– PV/CSP (Power) = 5 (Following IEA world forecast); Quadratic growth

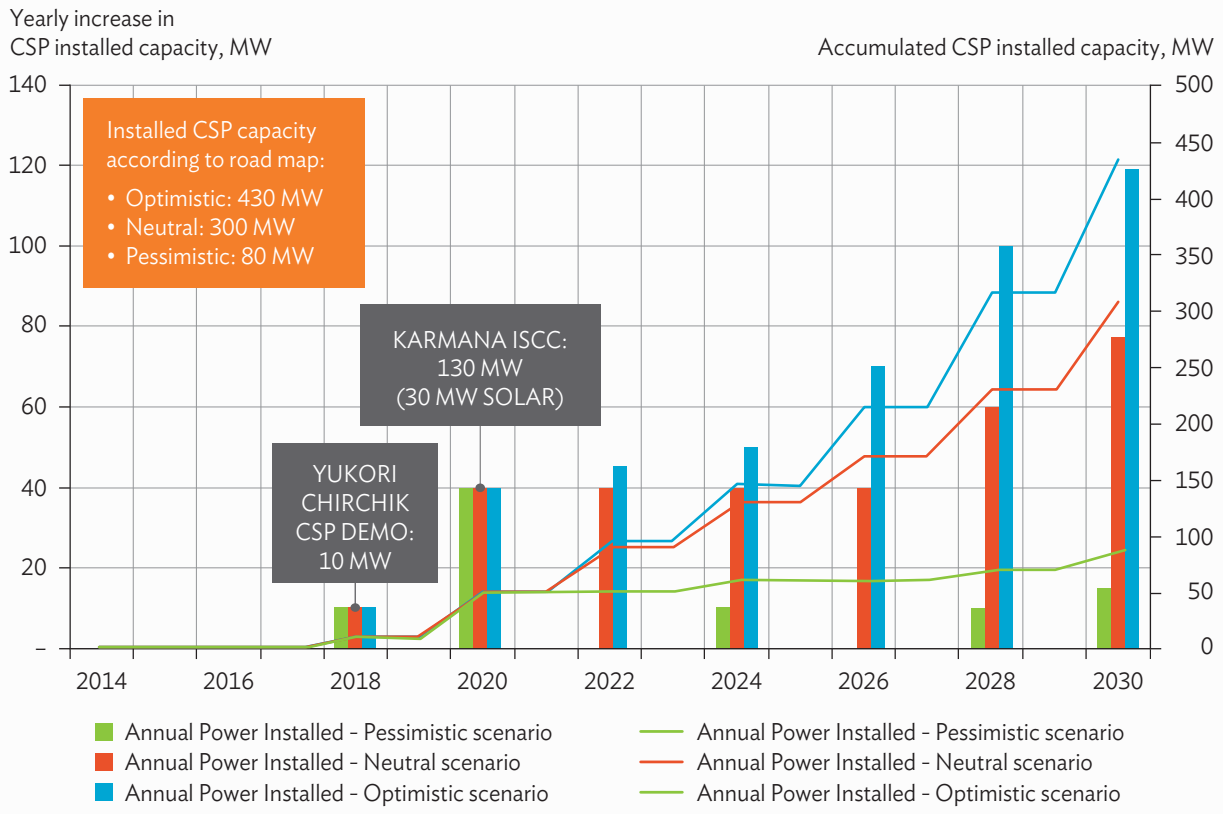
Source: Cinderella Tiangco, ADB.

capacity and the optimum plant site corresponding to the chosen technology. To determine the most suitable technology for Uzbekistan, ADB's second technical assistance assessed solar irradiance at six meteorological ground stations near potential sites. Direct normal irradiance (DNI) and global horizontal irradiance (GHI) were measured at these stations for 12 months.[4] DNI is correlated with CSP potential, while the GHI determines PV potential. The assessment identified the suitable areas for both CSP and PV solar energy power plants.

Land availability is a critical part of solar project development. The total area of available land generally defines the capacity of the solar power plant. CSP plants require more land than PV plants, due to turbines, generators, steam condensers, and other related equipment and infrastructure. Location is also important because it determines

[4] Direct normal irradiance is solar radiation that travels in a straight line from the sun at its current position in the sky. Global horizontal irradiance is the total amount of shortwave radiation received from above by a surface horizontal to the ground.

Figure 2.7.3: Concentrating Solar Power Technology in Solar Roadmap



CSP = concentrating solar power, MW = megawatt, PV = photovoltaic.

Assumptions:

– Neutral: Uzbekistan's renewable energy plus conventional = 100% of Conservative Scenario of consumption in 2030

– Optimistic: Installed PV capacity reaches the 15% of installed capacity (Grid stability)

– Pessimistic: Uzbekistan's renewable energy plus conventional = 95% of Conservative Scenario of consumption in 2030

– PV/CSP (Power) = 5 (Following IEA world forecast); Quadratic growth

Source: Cinderella Tiangco, ADB.

workforce availability and cost of transport infrastructure, grid connection, and water supply. In Uzbekistan, about 3.8 million hectares of land meet the minimum technical requirement for hosting solar energy.

Water supply is another important factor. PV power plants require water to regularly clean PV panels for optimum efficiency. CSP plants, which transform thermal energy to electricity, need water to clean, produce steam, and cool the steam condensers. Lacking nearby water resources, power plants must use a costly dry-cooling method. The cost of both water supply and infrastructure needed to connect the plant to a water source affect the total operating and maintenance costs.

Selection of solar power plant technology. PV technology converts solar energy to direct current electricity using a semiconductor layer, or PV cell. A PV system contains interconnected cells that form a PV module, and a set of additional application-dependent components (e.g., inverters, batteries, electrical components, and mounting

systems). Commercial PV modules consist of wafer-based crystalline silicon or thin films. Installation of PV systems uses either fixed-tilt structures or one- and two-axis tracking system structures. In contrast, CSP technology uses parabola-shaped mirrors to concentrate incoming direct solar radiation on a focal line. Because it uses only direct solar irradiance, CSP technology works best in areas that enjoy clear skies almost all year.

After conducting due diligence to assess the resources and requirements of the different types and configurations of solar power plants in the six study areas, the project determined that Uzbekistan's first solar power plant will be a 100 MW crystalline, fixed-tilt tracking, PV power plant in the Pastdorgom and Nurabad districts of Samarkand province. This option offered the simplest technology, required lower investment, simplest maintenance, least water resources, and posed the least risk. The level of institutional capacity was a significant factor in selecting PV with fixed-tilt tracking over other configurations of PV and CSP technologies.

Capacity development and workforce. Although forecasts suggest a need for almost 1,200 PV professionals in 2015, Uzbekistan lacks sufficiently trained human resources to cover this demand, necessitating a specialized training program for engineers. Therefore, the project conducted institutional capacity building efforts, and trained 60 local solar experts to operate the solar power plant. More intensive and comprehensive capacity building will be carried out during the implementation phase.

RESULTS

Foundation of Uzbekistan's vision for solar energy development. With assistance from ADB, Physics Sun and ISEI prepared and submitted the Uzbekistan Solar Energy Development Roadmap for presidential approval. The road map details the country's strategies to modernize, upgrade, and rehabilitate the electric grid in preparation for projected electricity generation and demand. It also specifies plans for building solar energy-related capacity in different sectors (e.g., financial and local industry) and centers for excellence that will initiate educational and training programs for potential solar energy experts. The road map also includes plans to develop build-operate-transfer and design-build-operate agreements to alleviate Uzbekenergo investment.[5]

The establishment of ISEI and the solar energy road map are Uzbekistan's initial steps in attaining energy security and becoming an international knowledge and technological hub for solar energy. Collaboration and consultation with all stakeholders will continue until the necessary enabling policies have been enacted and the industry starts to develop.

Photovoltaic power plant. Completion of the power plant, which is scheduled for 2016, will directly benefit Samarkand province. Construction will generate new jobs, 70% of which can be filled by locals. Demand for PV professionals will increase because the ratio between installed capacity of PV and CSP will reach 5:1 in 2030. Potentially, Samarkand's industrial hub will create a new industry for PV power plants. Moreover, additional energy supply will stimulate economic activity. Current supply suppresses demand and constrains the growth of small and medium-sized enterprises.

[5] Uzbekenergo refers to State Joint-Stock Company Uzbekenergo, a vertically integrated, state-owned utility that manages Uzbekistan's power sector.

Nationally, the project can improve the sustainability of Uzbekistan's energy supply and increase the generation of renewable energy. The estimated gross output of the Samarkand solar energy power plant is estimated at 159 gigawatt-hours per year. Solar energy development will also lead to fuel savings, reduced fuel imports, and lower carbon emissions. To enable a match between suitable carbon financing and support for capacity building, a Nationally Appropriate Mitigation Action is undergoing development based on the solar energy development road map, for inclusion in the United Nations Framework Convention on Climate Change next.

LESSONS

An effective planning and communication tool. A road map helps identify barriers and risks to objectives or goals. It also proposes actions and sets priorities to reach goals and targets taking into account the needs of main stakeholders. By itself, the road map preparation process verifies potential and identifies strengths and weaknesses. It also provides growth scenarios, analysis, and validation, and reviews the availability of natural resources. Uzbekistan's journey toward its goals of attaining energy security through renewable energy and becoming an international knowledge and technology hub for solar energy has just begun. Through the development and use of a road map, all stakeholders will understand Uzbekistan's vision for solar industry, enabling the country to maximize opportunities and speed the solar power development process.

Technology development in context. Although solar power is not a new concept, it is new in Uzbekistan. Conducting comprehensive due diligence of the country's capabilities and resources enables the systematic and sustainable development of solar technology in the Uzbekistan context.

Keywords

Solar power, solar energy, solar power plant, photovoltaic, irradiance, energy, solar power development, Uzbekistan

For further reading

- http://adb.org/projects/details?page=details&proj_id=45120-003
- http://www.adb.org/sites/default/files/project-document/79763/45120-003-rrp.pdf

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ADB PHOTO LIBRARY

Indonesia is developing three geothermal power units with a total capacity of 320 megawatts.

SARULLA GEOTHERMAL PROJECT

Tapping Indonesia's Geothermal Resources

- Increasing energy demand in Indonesia can potentially curtail economic growth. Dependence on fossil fuels exposes Indonesia to frequent changes in the price and supply of oil and coal, and increases greenhouse gas emissions that contribute to climate change.
- Indonesia urgently needs to diversify its energy supply mix to sustainably meet increasing demand. Rising prices for oil and coal have already cost Indonesia $18.55 billion in 2012, nearly twice the cost of energy subsidies in 2010.
- In 2014, the Asian Development Bank, the Government of Indonesia, a private sector developer, and commercial banks collaborated to tap the vast potential of geothermal energy.
- This partnership is expected to result in three geothermal power plants with a total capacity of about 320 megawatts. The added capacity will help Indonesia address electricity shortages and energy poverty, reduce dependence on fossil fuels, and harness largely untapped geothermal resources.

CONTEXT

Indonesia has shown strong economic growth in recent years. Its annual gross domestic product (GDP) grew an average 6% per year in 2009–2012,[1] while electricity demand increased 9% per year, casting a dark shadow on the sustainability of economic growth.[2] Higher demand exposes Indonesia to frequent shifts in the availability and cost of oil and coal, higher greenhouse gas emissions, and increased vulnerability to climate change. Indonesia depends heavily on coal and oil for its energy supply. In 2009, oil was the country's dominant source of energy (32%); coal accounted for 19%. Notably, the share of coal is increasing strongly, at the expense of oil.[3]

The global rise in oil prices has already strained Indonesia's coffers. In 2012 and 2013, the electricity subsidy reached Rp103.3 billion and Rp101.2 trillion,[4] respectively.[5] In fiscal year 2013, the Government of Indonesia allocated $18 billion to petroleum product subsidies and $9 billion to electricity subsidies, equaling around 2.5% of GDP and 25% of total government expenditures.[6] When global oil prices dropped in late 2014, Indonesia raised oil prices and decreased its energy subsidies.[7] In addition, increased demand for energy exacerbates the power crisis already felt in some regions (e.g., North Sumatra and Bali), where power shortages have caused frequent blackouts for more than a year. Indonesia also experiences energy poverty because a significant portion of its population, primarily those living in rural areas and the outer islands, lack access to electricity (footnote 2).

PROJECT SNAPSHOT

LOAN APPROVAL DATE:
December 2013

LOAN AMOUNT:
$350 million ($250 million from ADB ordinary capital resources, $80 million from the ADB Clean Technology Fund, and $20 million from Canadian Climate Fund for the Private Sector in Asia under the Clean Energy Financing Partnership Facility)

BORROWER:
Sarulla Operations Limited (SOL), Sarulla Power Asset Limited, Kyuden Sarulla Private Limited, OrSarulla Incorporated, and PT Medco Geopower Sarulla

GEOGRAPHICAL LOCATION:
Sarulla Geothermal Working Area, North Sumatra Province

TYPE OF ENERGY PROJECT:
Geothermal energy

EXPECTED PROJECT COMPLETION DATE:
August 2018

1 Asian Development Bank (ADB). 2013. *Proposed Loan and Administration of Loans to Sarulla Operations Limited, Sarulla Power Asset Limited, Kyuden Sarulla Private Limited, OrSarulla Incorporated, and PT Medco Geopower Sarulla for the Sarulla Geothermal Power Development Project in the Republic of Indonesia.* Manila. www.adb.org/sites/default/files/projdocs/2013/42916-014-rrp.pdf

2 World Wide Fund for Nature. June 2012. *Igniting the Ring of Fire: A Vision for Developing Indonesia's Geothermal Power.* http://awsassets.wwf.or.id/downloads/geothermal_report.pdf

3 ADB. 2011. *Trends in Energy Efficiency.* http://www05.abb.com/global/scot/scot316.nsf/veritydisplay/1a65dd16a3c538acc125786400514251/$file/indonesia.pdf

4 Approximately $10.3 million and $1.009 trillion, respectively, based on July 2013 currency equivalents.

5 Perusahaan Listrik Negara. 2013. *Annual Sustainability Report.* http://www.pln.co.id/dataweb/AR/ARPLN2013-Sustainability.pdf

6 International Institute for Sustainable Development. 2014. *Indonesia Energy Subsidy Review.* March. http://www.iisd.org/gsi/sites/default/files/ffs_indonesia_review_i1v1.pdf

7 Bloomberg. 2014. Interview with Indonesian Finance Minister Bambang Brodjonegoro. http://www.bloomberg.com/video/indonesia-to-cut-fuel-subsidies-by-year-end-minister-gQWdr8BwROmjfdZa8rn4kA.html

Indonesia clearly needs to diversify its energy mix and increase energy supply to meet demand. Fortunately, Indonesia has rich geothermal resources owing to its location at the edge of the Pacific plate, where geothermal energy is estimated at about 29 gigawatts (GW) and equivalent to 40% of the geothermal resource base worldwide. Indonesia has worked hard to tap this resource, but the steep cost of investment and lack of government capacity hinder further development.

In 2014, the Asian Development Bank (ADB) collaborated with the Government of Indonesia, private sector developers, and commercial banks to finance the Sarulla Geothermal Power Project. The project is now helping Indonesia develop steam resources and construct, operate, and maintain three geothermal power generation units with a total capacity of about 320 megawatts (MW) (footnote 1). The Sarulla Geothermal Power Project is in the Tapanuli Utara district of North Sumatra province. It is the largest single-contract geothermal power project in the world to date.[8]

SOLUTIONS

Stimulating private sector participation. Indonesia has long recognized the urgency of diversifying its energy supply mix as well as the opportunities offered by its rich geothermal sources. In 1993, Indonesia engaged Union Oil Company of California (UNOCAL) to explore the country's geothermal resources. When the Asian financial crisis affected the country's financial position, UNOCAL sold its concession back to Perusahaan Listrik Negara (PLN), the government-owned electricity utility. Consequently, the government issued a policy statement encouraging private sector participation in the exploration of geothermal resources exploration, thus allowing PLN to invite qualified companies to join in an independent power producers' (IPPs) bidding process to attain the Sarulla development rights. In 2006, a consortium formed by Itochu Corporation, Ormat International, and Medco Power Indonesia won the right to explore and develop the geothermal site at Sarulla. Kyushu Electric Power Company joined the consortium in 2007. The sponsors jointly developed the Sarulla project through its operating company, Sarulla Operations Limited (SOL).

Conducting a preliminary study. SOL conducted a preliminary assessment of the power plant site to guide project planning and implementation. The assessment scrutinized wells that will be used for production to determine the types of equipment needed to produce steam and plan for other equipment should abnormal conditions arise during the steam production process. The study developed a plan for distributing steam to power plants for conversion into steam and then electricity. It also assessed the topography to determine the optimal locations for the plants and the boundaries of construction activities.

Finding financing. Developing geothermal resources requires an immense up-front investment as the drilling program essentially advances the cost of fuel supply. Drilling hikes up the up-front capital cost for geothermal plants, which can reach more than three times the amount invested in conventional coal and oil plants. This challenge is invariably balanced by limited ongoing operating cost during the lifetime of the project.

[8] Kable. 2014. Sarulla Geothermal Power Project, Indonesia. http://www.power-technology.com/projects/sarullgeothermalpowe/ (accessed 28 December 2014).

SARULLA OPERATIONS LIMITED

A combination of loans from ADB, the Japan Bank for International Cooperation, the Clean Technology Fund, and local commercial banks is financing the integrated construction of the three geothermal power generating units in Sarulla.

The developers asked ADB and the Japan Bank for International Cooperation (JBIC) to financially support the Sarulla Geothermal Power Project in 2007. In 2011, with the support of an extended political risk guarantee by JBIC, the developers sought financing from commercial banks. During financial structuring, the project benefited from concessional support from the Clean Technology Fund (CTF) and the Canadian Climate Fund for the Private Sector in Asia. Through a combination of loans from these lending facilities, the project was able to raise $1.17 billion to finance the integrated construction of three separate power-generating units. This financing structure was considered a breakthrough because financing for large-scale projects is typically arranged on a staged or phased basis.

Preliminary testing, development activities, and construction of the power plants are under way in the project site.

ADB's $80 million concessional funding was crucial because the project could not service additional senior debt due to low tariffs and sponsors could not contribute more equity. Mezzanine loans from CTF ($80 million) and the Canadian Climate Fund for the Private Sector in Asia ($20 million) helped retain the project's bankability given the costs of integrated financing. It was CTF's first loan deployment in Indonesia and a clear demonstration of CTF's added value. The loans benefit from the support of a 20-year business viability guarantee letter from the Ministry of Finance, which backstops the offtake[9] obligations of the national electric utility buying the generated power (footnote 1).

[9] Offtake is the purchase of bulk power by an electricity distributor or energy company from a particular generating project.

Formulating a joint operating contract. In a 30-year joint operating contract (JOC), PT Pertamina Geothermal Energy, the project's state-owned concession holder, grants SOL the right to use and explore the geothermal field.[10] The JOC, which is the largest contract for a geothermal power project that capitalizes on the large-scale potential of highly productive geothermal resources, also governs development of the geothermal steamfield and provides the framework and scope for construction of the geothermal plant.[11] The scope of work included the construction of three plants at two locations, Silangkitang (220 MW) and Namora (110 MW), as well as transmission lines from both plants to PLN's grid. The project has three phases: The first phase would be in operation in 2016, the second phase in 2017, and the third phase would be operational in 2018.[12] The consortium has already started preliminary testing and development activities at the site. It initiated construction of the power plants in the second half of 2014.

Finalizing an energy sales contract. In addition to the JOC, SOL entered into a power purchase agreement with PLN. The contract states that SOL initially will sell electricity to PLN for $0.067 per kilowatt-hour and allows incremental increases (2% per year) for 30 years.[13]

Finalizing the energy sales contract is a major milestone. However, the rising prices of raw materials and increasing cost of power plant equipment and well redrilling rendered the original tariff, established by SOL during the bidding stage, unfeasible. Therefore, SOL presented a tariff adjustment proposal to PLN in July 2008. After several rounds of negotiation, a Principle Agreement formalized the final adjustments on 1 April 2010.

Construction design. At the outset, the project defined the construction work required to develop the geothermal power plant. The design included building new well pads[14] and improving existing pads, drilling new wells, building access roads, and installing all necessary equipment and pipelines. Construction began in June 2014 and will continue for about 3 years.[15]

RESULTS

When completed, the Sarulla Geothermal Energy Project will (i) address electricity shortages in some areas, particularly North Sumatera and energy poverty in rural areas; (ii) reduce dependence on fossil fuels by diversifying the energy supply mix, and (iii) maximize geothermal energy.

10 Ormat Technologies. 2013. The 330 MW Sarulla Geothermal Power Project in Indonesia Signed Project Agreements. April. http://www.ormat.com/news/latest-items/330-mw-sarulla-geothermal-power-project-indonesia-signed-project-agreements

11 Baker & Mckenzie. 2013. Baker & McKenzie Advises on the Sarulla Geothermal Power Project in Indonesia. April. http://www.bakermckenzie.com/news/SarullaGeothermalPowerProjectIndonesia/

12 Perseo. 2013. PLN Signs Power Purchase Agreement of PLTP Sarulla with Medco – Ormat – Itochu – Kyushu Consortium. http://www.pln.co.id/eng/?p=2959

13 L.X. Richter. 2013. PLN and Pertamina Sign Contract on Sarulla Project. *Think Geo Energy*. http://thinkgeoenergy.com/archives/14774

14 Well pads are areas that have been cleared for drilling meant for extraction. A well pad may consist of multiple wells.

15 ADB. 2013. *Environmental Impact Assessment: Sarulla Geothermal Power Development Project.* October. http://www.adb.org/sites/default/files/projdocs/2013/42916-014-esia.pdf

Decrease dependence on fossil fuels. When the power plants are operational, they will help reduce Indonesia's dependence on fossil fuels. By tapping an abundantly available and renewable energy source, the project will provide the country a 330 MW increase in electricity supply from geothermal energy.[16] Thus, this largest geothermal power plant contract in Indonesia will demonstrate the viability of geothermal energy as an answer to the country's energy needs.

Cleaner source of energy. Geothermal power plants typically emit less than 10% of the greenhouse gases (GHGs) emitted by fossil-fueled thermal plants. Once completed, the Sarulla Geothermal Project is expected to avoid 1.3 million tons of carbon dioxide emissions per year, and will be well positioned to capitalize on any carbon trading credits that may become available.[17]

Improvement in local economy. Increased electricity supply will directly benefit the local government and community where the project site is situated. Increased access to electricity can perk up businesses, thereby generating more jobs. This multiplier effect to the local economy can provide higher incomes for businesses and households alike.

LESSONS

Ensure environmental and social aspects of the projects are addressed ahead of time. Geothermal energy projects are complex and require extensive drilling and construction. Many will require land acquisition, not only for the power plant but also for related facilities such as transmission lines and towers. These facilities may rest on land with rich vegetation inhabited by indigenous people. To meet the environmental and social safeguards requirements of ADB and JBIC, the project developers designed a resettlement plan that will not immediately relocate residents affected by the project site. The project will procure land through negotiated settlements and take it in stages as construction progresses. The project also committed to re-vegetate any areas affected by construction.[18]

Need for strong sponsors with commitment to the country. The project site was initially explored by UNOCAL, which reduced its losses by selling back its exploration rights during the Asian financial crisis, thus delaying Indonesia's energy plans. This experience shows the importance of strong and firmly committed sponsors who can source financing in a creative or innovative manner to keep a project running. Strong collaboration and a comprehensive feasibility plan demonstrated that investments in the largely unexplored geothermal sector can be beneficial in the long run, not just to the developers but also to all stakeholders.

[16] ADB. 2013. *Environmental Impact Assessment: Sarulla Geothermal Power Development Project.* http://www.adb.org/sites/default/files/projdocs/2013/42916-014-esia.pdf

[17] J. Surtani et al. 2014. *Sarulla-Energising the Geo-Sector. Project Finance International Special Report.* May. http://www.pfie.com/sarulla-re-energising-the-geothermal-sector/21144994.fullarticle

[18] ADB. 2013. *Final Resettlement Report: Proposed Loan to Sarulla Operations Limited, Sarulla Power Asset Limited, Kyuden Sarulla Private Limited, OrSarulla Incorporated and PT Medco Geopower Sarulla for the Sarulla Geothermal Power Development Project in Indonesia.* October. Manila. http://www.adb.org/sites/default/files/project-document/79108/42916-014-ino-rp-01.pdf

Need for a strong understanding of the geothermal sector. In countries like Indonesia, the Philippines, and Japan, accessible and available geothermal energy remained largely untapped owing to lack of know-how and capacity. It is important to have a partner which has extensive knowledge about geothermal energy, which may be quite a complicated resource to access. It is important to have some drilling expertise. In this project, Kyushu Electric and Ormat have extensive experience harnessing geothermal energy. They have the technology and equipment to maximize efficient use of the varied composition of geothermal fluid, which in this case includes steam, brine, and gases. They also know how to reinject geothermal fluid into the reservoir, maintaining sustainability and mitigating the negative effect of gases.

Volatility of prices associated with power plant construction. The rising cost of raw materials, power plant equipment, and drilling activities are major causes of construction delay in geothermal power plants. For the Sarulla Geothermal Power Project, SOL had to request tariff adjustments when the contract price became unviable. Several rounds of negotiation were necessary before the government and SOL could agree on a mutually beneficial tariff. Therefore, budget allocations for such projects must include the possibility of price increases or a contingency fund to cover the funding gap.

Keywords

Geothermal, geothermal energy, energy, renewable, energy financing, financing, Sarulla, Indonesia

For further reading

- http://www.adb.org/projects/documents/sarulla-geothermal-power-generation-project-rrp
- http://www.adb.org/news/adb-supports-renewable-energy-investing-indonesian-geothermal-plant

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YAP RENEWABLE ENERGY DEVELOPMENT PROJECT

Breaking the Reliance on Fossil Fuels

A photo montage of the wind farm at the proposed project site.

- Electricity is expensive in Yap State in the Federated States of Micronesia, largely due to remoteness and dependence on fuel imports.
- In 2013, the Federated States of Micronesia and the Asian Development Bank (ADB) initiated the Yap Renewable Energy Development Project to reduce Yap's dependence on fuel imports.
- ADB is assisting Yap State in diversifying its energy mix through the introduction of an 825-kilowatt (kW) wind farm and a 300 kW solar farm, as well as installation of new efficient diesel generation to replace its aged existing plant.
- Upon completion of the planned investments, Yap may reap fuel savings of up to 250,000 gallons of diesel fuel per year.

CONTEXT

Yap State (Yap) is one of four small island states comprising the Federated States of Micronesia (FSM). A combination of forces threatens Yap's energy sector, including strong typhoons, remoteness, and volatile oil prices. Yap depends heavily on diesel imports to power its main island, which hosts 65% of the state's population.[1]

On Yap's main island, 97% of the population has access to electricity, which is distributed through an integrated network operated by Yap State Public Service Corporation (YSPSC), a state-owned utility. YSPSC has an installed capacity totaling 8.3 megawatts (MW); its peak load totals 2.4 MW. In 2010, electricity tariffs were $0.353 per kilowatt-hour (kWh) for residential customers, $0.423 per kWh for commercial clients, and $0.737 per kWh for government entities.[2]

Yap's remote location and dependence on diesel fuel contribute significantly to the steep cost of electricity and impose a great burden on Yap's small economy. In 2013, the state's most expensive import was diesel (footnote 2), accounting for about 15% of gross domestic product. The high cost of electricity hinders investments and tourism, pinches household budgets, and increases overhead for industry and business.

Strategically harnessed and maximized, Yap's abundant supply of sunlight and wind could increase renewable energy and reduce oil dependence. Thus, in 2013 FSM and the Asian Development Bank (ADB) collaborated to develop the Yap Renewable Energy Development Project. This 5-year project is due for completion by 2017.

PROJECT SNAPSHOT

LOAN APPROVAL DATE:
June 2013

LOAN AMOUNT:
$9 million

BORROWER:
Yap State guaranteed by the Federated States of Micronesia

EXECUTING AGENCY:
Yap State Public Service Corporation

GEOGRAPHICAL LOCATION:
Yap State

TYPE OF ENERGY PROJECT:
Power generation using renewable energy, conventional power plant efficiency

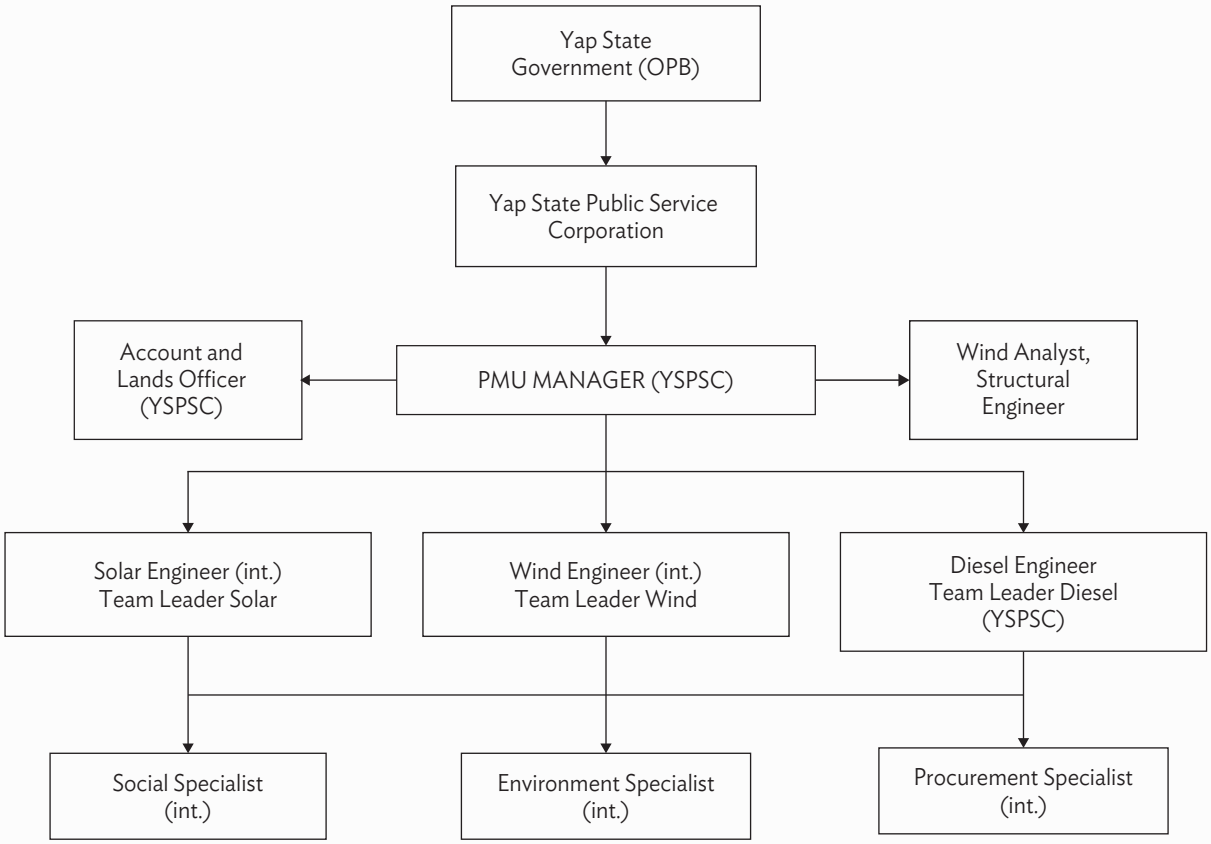
PROJECT COMPLETION DATE:
June 2017

SOLUTIONS

Wind power. The project conducted a comprehensive assessment of Yap's wind resources and selected a site about 1 kilometer northwest of Colonia, on a ridge 150 meters above sea level. The assessment included more than 2 months of wind data, long-term measurements at the Yap Airport Meteorological Station, topographical information, on-site terrain complexity, and slope and surface roughness (footnote 2). In a wind flow model,

1 ADB. 2013. *Report and Recommendations of the President to the Board of Directors: Proposed Loans to the Federated States of Micronesia for the Yap Renewable Energy Development Project.* May. Manila.
2 ADB. 2012. *Strengthening the Capacity of Pacific Developing Member Countries to Respond to Climate Change.* Consultant's report. October. Manila.

Figure 2.9.1: Yap Renewable Energy Development Project Organization Structure



int = International, OPB = Office of Planning and Budget, PMU = project management unit, YSPSC = Yap State Public Service Corporation.

Source: ADB. 2013. *Project Administration Manual: Yap Renewable Energy Development Project in the Federated States of Micronesia.* May. Manila.

WAsP[3] and WindPRO[4] software predicted a 25-meter variation in wind speed at the proposed site, and determined an optimal area for the new wind farm. Overall, the study reported with 90% probability that wind machines with a capacity totaling 1.4 MW could produce average net energy totaling 2,127 megawatt-hours per year.

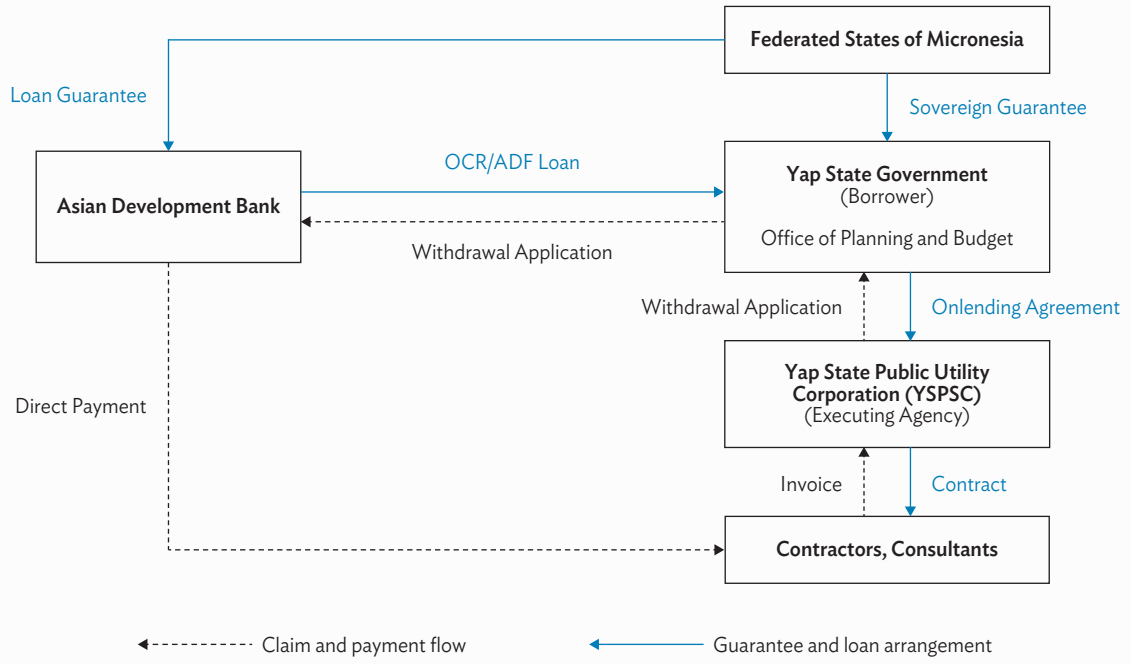
Based on a supplementary geotechnical study to ensure maximum wind availability and typhoon-proof operation, the layout of the initial 825-kilowatt (kW) wind farm considered turbine spacing, number of turbines, annual energy production, wake loss, and steep slopes. Additional wind turbines could produce another 550 kW.

Solar power. A solar power feasibility study used satellite measurements to determine the cost effectiveness of solar power at 2011 fuel prices. The project trained local companies to build the solar installations and establish local maintenance capacity (footnote 2). Roof-mounted solar photovoltaic panels on 11 government buildings, including schools, courthouses, and a sport center, will have a total capacity of 300 kW (Map 2.9.1).

[3] WAsP software is commonly used in the wind energy industry to assess wind resource and the effect of terrain on wind energy production.

[4] WindPRO software is used in wind energy project design and planning.

Figure 2.9.2: Yap Renewable Energy Development Project Fund Flow



ADF = Asian Development Fund, OCR = ordinary capital resources.

Source: ADB. 2013. *Project Administration Manual. Yap Renewable Energy Development Project in the Federated States of Micronesia.* May. Manila.

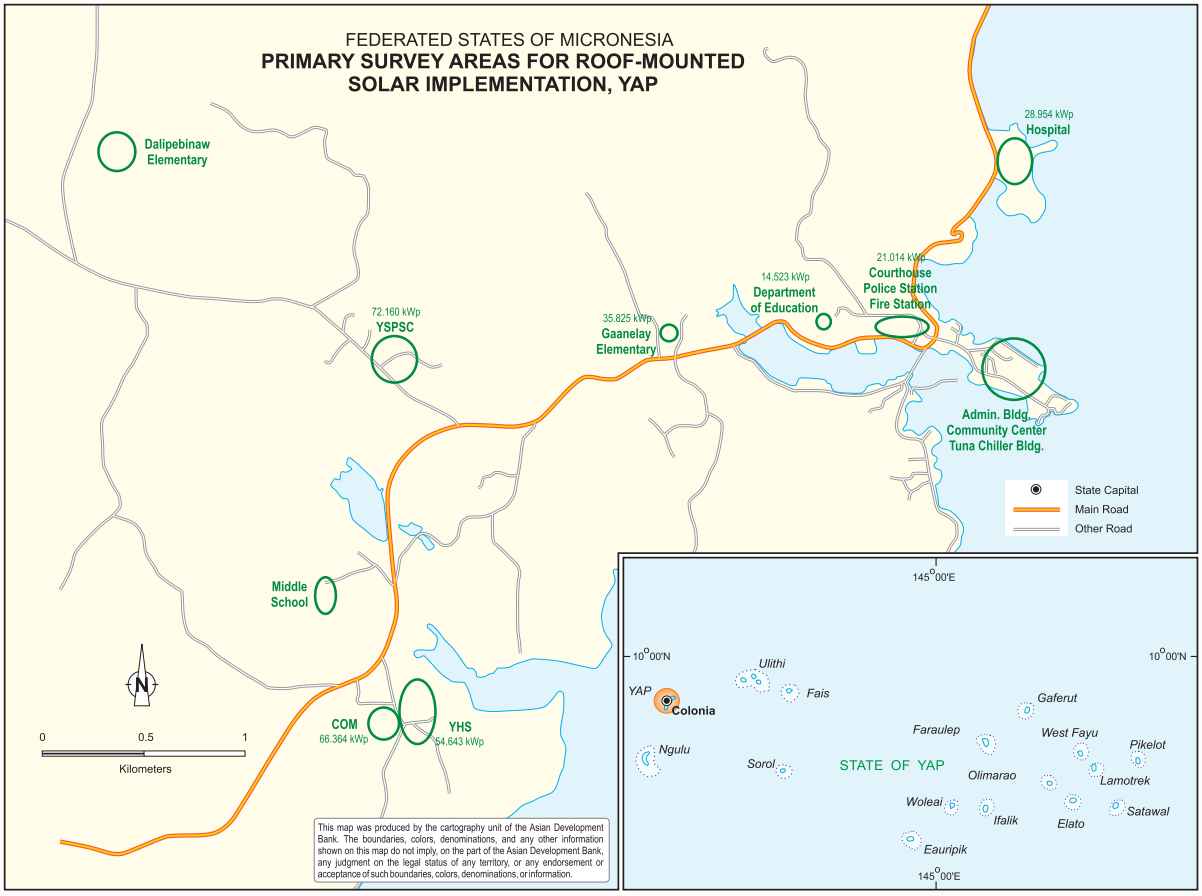
Roof installations provide the most rapid, low-cost, and typhoon-proof approach. In addition, the varying orientation of the roofs allows for a more even collection of energy over the day than an array with the panels all oriented in the same direction.

Because the solar panels to be installed are made of polycrystalline cells, the panels' inverters will be sealed against salt air and will be capable of providing full output in Yap's ambient air conditions. A digital data logger will measure solar radiation (footnote 2). Estimates suggest that solar power will generate 0.46 gigawatt-hours (GWh) per year, equal to 4.0% of current energy delivery.

Diesel power. To improve the efficiency of Yap's diesel-fired power plant, the project will largely replace YSPSC's diesel generator with a smaller and highly efficient 2.6 MW unit that closely matches Yap's 1.5 MW base load. An upgraded powerhouse control and switching system will reduce outages and generally improve reliability (footnote 2).The new generator will provide 9.9 GWh of electricity per year. During off-peak hours, it will achieve significantly higher fuel efficiency compared with the current 15.0 kWh and 13.8 kWh per gallon diesel generators (footnote 2).

Focal persons and teams for three types of power generation development. The Yap Renewable Energy Development Project aims to develop solar (300 kilowatts) and wind energy (1.4 MW) as well as a modern diesel engine suitable to Yap's base load. A YSPSC project management unit, comprising designated focal persons for each project component, will implement all project activities. Figure 2.9.1 shows the project organization structure. Figure 2.9.2 illustrates its fund flow.

Map 2.9.1: Aerial Map of Government Buildings Included in the Planned Solar Panel Installation



Note: Also surveyed was the Yap Sports Complex located 4.87 miles in a direction of 62.33° from the YSPSC office. Project total is 303,493 kilowatt peak.

Source: Asian Development Bank. 2012. *Strengthening the Capacity of Pacific Developing Member Countries to Respond to Climate Change.* Consultant's report. October. Manila.

RESULTS

Energy savings. Once all of these power-generating components are operational, they will provide thousands of fossil fuel savings for the small island-state. The enhanced diesel power generation plants will provide savings of up to 66,000 gallons per year through increased fuel efficiency. Fully installed, the 1.4 MW wind turbines will save up to 151,000 gallons per year, and the solar arrays will save an additional 33,000 gallons per year.

Reduction of greenhouse gas emissions. The project will also reap benefits for the environment. Renewable energy and increased efficiency of Yap's diesel-fired power plants will decrease greenhouse gas emissions. Specifically, a 250,000-gallon reduction will eliminate 2,500 tons of carbon dioxide emissions per year.

Other potential benefits. The development of Yap's energy sector will bring about stable power tariffs, benefiting the state's population. It will also help residents reduce dependency on kerosene lamps for lighting, which they often use to reduce electricity expenses. Thus, a reliable power supply will help households as well as businesses.

LESSONS

Electricity stability. One of the key lessons in this project is planning the practical amount of solar or wind power that can be added into the energy mix so that power instability will not be a threat to electricity generation. To avoid grid instability, any power generation project must include proper controls. The size and type of renewable energy farms require thorough assessment and planning, and the criteria for grid connection must be well studied, published, and strictly enforced.

Climate change. Energy generation projects must include features for adaptation to climate change. This is especially true for renewable energy projects, because they rely on nature for power. These considerations can maximize wind availability and solar irradiation. Construction and installation of the wind farm factored in the increasing frequency and force of typhoons in the Pacific, and wind turbines were designed to prevent wind damage. Roof-mounted solar panels use roof angles to minimize additional framing and vulnerable gaps. In addition, they are less vulnerable to cyclone damage than ground-mounted arrays, mainly because they are flushed against the roof and the back of each panel is well protected. Further, wind flowing over a large roof tends to be less turbulent than that passing around ground-mounted panels that tilt to best accept the solar input (footnote 2).

Energy buffer. Remote and typhoon-battered islands should consider developing an energy buffer, because prolonged and extreme weather events can cause major damage to renewable energy plants and delay oil transport. This project not only improved the performance of Yap's diesel-fired power plants, but also increased fuel storage, thus providing a buffer against isolation during a power blackout resulting from damaged renewable energy facilities.

Keywords

Energy, renewable energy, wind farm, solar farm, wind power, solar power, wind turbines, solar panels, solar energy, wind energy, Pacific, Federated States of Micronesia, Yap

For further reading

- http://adb.org/projects/details?page=overview&proj_id=44469-013
- http://www.adb.org/sites/default/files/project-document/65075/43901-prc-rrp.pdf

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TRANSMITTING POWER ACROSS BORDERS

A power substation in Hazaribugh, Dhaka

BANGLADESH–INDIA ELECTRICAL GRID INTERCONNECTION PROJECT

South Asia's First Interconnection of Two National Grids

- The People's Republic of Bangladesh is grappling with energy deficiencies in the face of rapidly increasing demand for energy. Securing its energy supply demands action to strengthen power generation capacity, upgrade the transmission and distribution network, and diversify energy sources.
- The Asian Development Bank helped Bangladesh secure energy supply through the Bangladesh–India Electrical Grid Interconnection Project, an initiative that enabled Bangladesh to import 500 megawatts of electricity from India.
- To connect the transmission networks of both countries, the project installed more than 100 kilometers of 400-kilovolt double circuit transmission line between electricity substations in Baharampur, India and Bheramara, Bangladesh.
- Successfully completed during the third quarter of 2013, the project provides Bangladesh with more affordable electricity while reducing its energy deficiency.

CONTEXT

Bangladesh has a rapidly growing market-based economy and is among the Next Eleven countries.[1] However, insufficient domestic power supply threatens sustained growth. In 2009–2010, major cities such as Dhaka frequently endured 12-hour power disruptions. Therefore, Bangladesh urgently needs to find ways to bridge its energy gap. As a stopgap measure, the Government of Bangladesh tapped rental power plants with a rated capacity totaling 50–100 megawatts (MW) or less. However, the plants were unfeasible as a long-term strategy because they provided minimal electricity at significantly greater expense than other energy sources

In 2009, the dependable power-generating capacity in Bangladesh was only 3,800 MW of electricity against a peak demand that totaled about 5,500 MW, implying a peak deficit of 1,700 MW.[2] With help from the private sector, the government plans to provide more power from a mix of sources (e.g., imported coal, liquefied natural gas, and renewable energy including solar photovoltaic systems). A nuclear power plant scheduled to open in 2018 will help meet long-term energy needs. To complement its infrastructure plans, the country is also planning to implement a fuel price reform to correct electricity tariff rates that are significantly lower than supply costs. This strategy aims to promote energy conservation and efficiency initiatives that could reduce demand.

However, implementation of such initiatives will require a significant amount of time; even upon completion, they may not satisfy projected demand for energy, forcing Bangladesh to find energy sources outside its own territory. Studies by the Asian Development Bank (ADB) for the South Asian Association for Regional Cooperation (SAARC)[3] and by the United States Agency for International Development (USAID)[4] for its South Asia Regional Initiative in Energy showed that a regional approach would provide more comprehensive, cost-effective, and sustainable solutions to Bangladesh's energy security problem. In 1997, ADB initiated a discussion about interconnecting the power systems of Bangladesh and India. India, Bangladesh's neighboring country, had a 156,780 MW installed energy capacity in January 2010; already planned power plants will add another 80,000 MW by 2017. In 2014, India

PROJECT SNAPSHOT

LOAN APPROVAL DATE:
August 2010, with additional financing approved in September 2013

LOAN AMOUNT:
$100 million with an additional $12 million

BORROWER:
Government of Bangladesh

EXECUTING AGENCY:
Power Grid Company of Bangladesh

GEOGRAPHICAL LOCATION:
Bheramara, Bangladesh to Baharampur, India

TYPE OF ENERGY PROJECT:
Grid interconnection

PROJECT COMPLETION DATE:
October 2013

1 Goldman Sachs Investment identified the Next Eleven as countries having the highest potential to become part of the largest economies in the 21st century.

2 Asian Development Bank (ADB). 2010. *Proposed Loan to People's Republic of Bangladesh for the Bangladesh–India Electrical Grid Interconnection Project.* August. Manila. http://www.adb.org/sites/default/files/project-document/63167/44192-01-ban-rrp.pdf

3 Established on 8 December 1985, SAARC was the first regional cooperation initiative in South Asia. Member countries include Afghanistan, Bangladesh, Bhutan, India, the Maldives, Nepal, Pakistan, and Sri Lanka.

4 USAID is the leading US agency for ending extreme global poverty and enabling resilient democratic societies to realize their potential.

announced that it will generate 100,000 MW of solar power and 60,000 MW of wind power by 2022. Projections suggest that India's energy demand will increase 3% per year, from 692 million tons of oil equivalent (Mtoe) in 2010 to 1,442 Mtoe in 2035.

SOLUTIONS

Improving bilateral relations. The Bangladesh–India Electrical Grid Interconnection Project prioritized strengthening relations between Bangladesh and India to lay the groundwork for cross-border cooperation. Following an unsuccessful attempt to interconnect the grids in 1997, ADB consistently supported initiatives and created opportunities to bring Bangladesh, India, and other South Asian countries together. In 2001, ADB advocated the South Asia Subregional Economic Cooperation (SASEC)[5] program and actively supported SAARC's South Asia Regional Energy Cooperation program. In 2004, a memorandum of understanding enabled ADB to support SAARC's regional cooperation activities, based on mutually agreed priorities such as energy, transport, trade, and investment. Conducted under various bilateral and multilateral initiatives for more than a decade, many of these steps helped create awareness and emphasized the need for regional cooperation in the power sector of South Asian countries. Three important studies identified the possibility of interventions related to regional energy cooperation including cross-border power transmission interconnections, and quantified the technical and economic benefits.[6] This process helped build consensus on the need for a regional electricity network and the development of electricity markets for optimal investments and utilization of the region's vast and varied energy resources.

In January 2010, a joint communication by the prime ministers of Bangladesh and India declared important breakthroughs in cooperation between the two countries, including India's provision of electricity to Bangladesh through a cross-border grid interconnection. This interconnection was facilitated with the assistance of ADB.

Choosing an optimal location and mode of interconnection. To ensure efficient and effective delivery, the project first had to determine the location and mode of interconnection. Therefore, the Power Grid Company of Bangladesh (PGCB)[7] and the Power Grid Corporation of India (PGCIL)[8] formed a technical team to study and provide recommendations.

The team considered two options: (i) connecting northeastern India with eastern Bangladesh, or (ii) connecting eastern India with western Bangladesh. Ultimately, it favored the second option because it was better able facilitate power exportation to Bangladesh from different generating stations in India and also distribute power to Bangladesh's load centers. Hence, the interconnection would start in Baharampur, West Bengal, India and end in Bheramara, Bangladesh, requiring a 125-kilometer transmission line.

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5 With financial assistance from ADB, the SASEC program was launched in 2001 to support regional cooperation activities between Bangladesh, Bhutan, India, and Nepal. SASEC expanded its energy sector activities to include Sri Lanka in 2010. In 2014, SASEC expanded all of its activities to include both the Maldives and Sri Lanka.

6 ADB. 2012. *Energy Trade in South Asia: Opportunities and Challenges.* Manila; ADB. 2013. *South Asia Regional Power Exchange Study.* Manila; ADB. 2013. *Technical Assistance for South Asia Subregional Economic Cooperation Cross-Border Power Trade Development.* Manila.

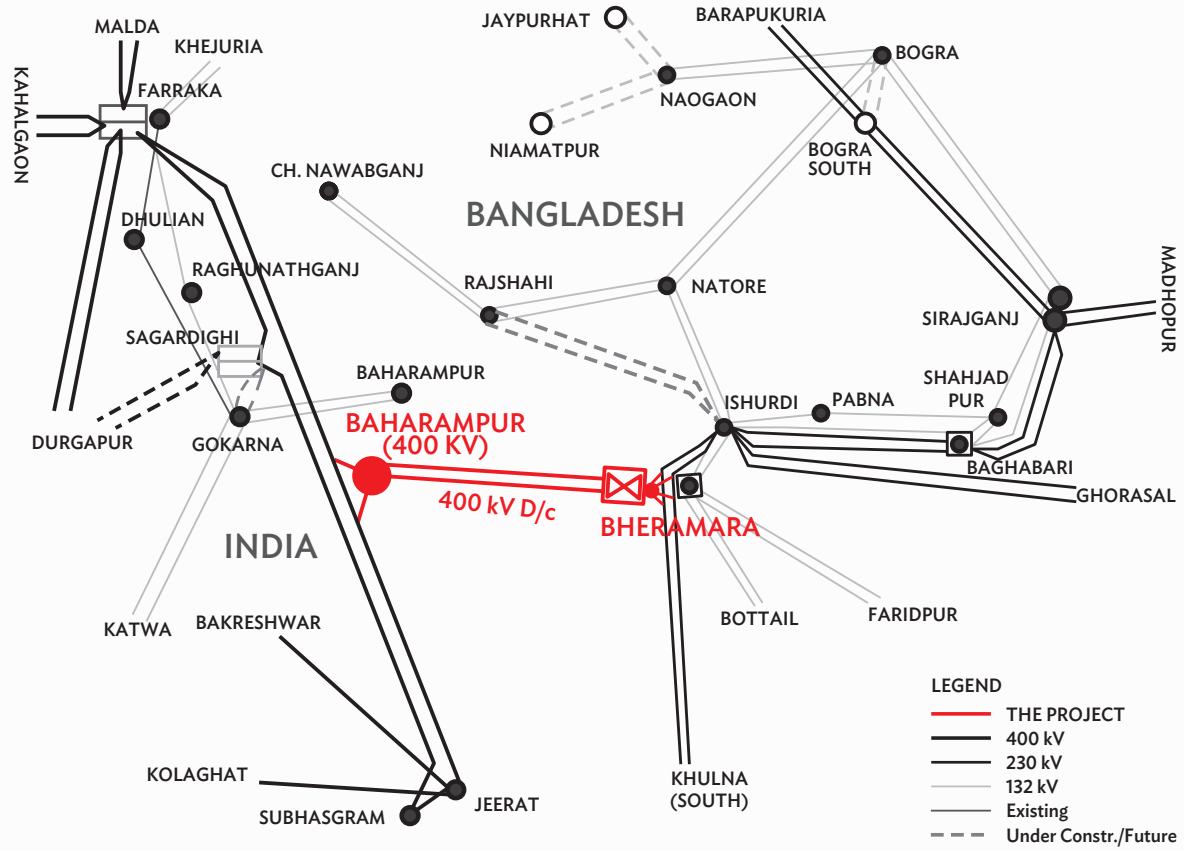
7 PGCB is responsible for operation, maintenance, and development of the transmission system's distribution capacity.

8 PGCIL, which functions under the Ministry of Power, is India's central transmission utility.

To determine the mode of interconnection, the technical team studied the grid characteristics of both countries. Using synchronous interconnection, both grids would operate at the same nominal frequency and voltage, and faults in one grid would affect the other. In contrast, an asynchronous interconnection would facilitate complete control of the power exchange between both grids in either direction, allowing independent operation. Asynchronous interconnection would also negate the need for additional equipment to protect one system against damaging faults and surges from the other system. Therefore, the team selected an asynchronous high-voltage direct current (HVDC) link.

Next, the team had to choose between two general types of asynchronous interconnection: (i) HVDC transmission between two converter stations connected at either end to an alternating current system (HVDC bipole), or (ii) an HVDC back-to-back interconnection to alternating current systems on either side, without intervening transmission. Based on technical, operational, and economic considerations, the team agreed to adopt the back-to-back interconnection. India built a 400-kilovolt (kV) switching station in Baharampur to tap one end of a 400 kV direct current (DC) transmission line. The other end of the line was connected to a 400 kV transmission line at the India–Bangladesh border and ends at the 500 MW HVDC back-to-back substation and 230 kV switching station in Bheramara, Bangladesh (Figure 3.1.1).

Figure 3.1.1: **Bangladesh–India Electric Interconnection Single Line Diagram**

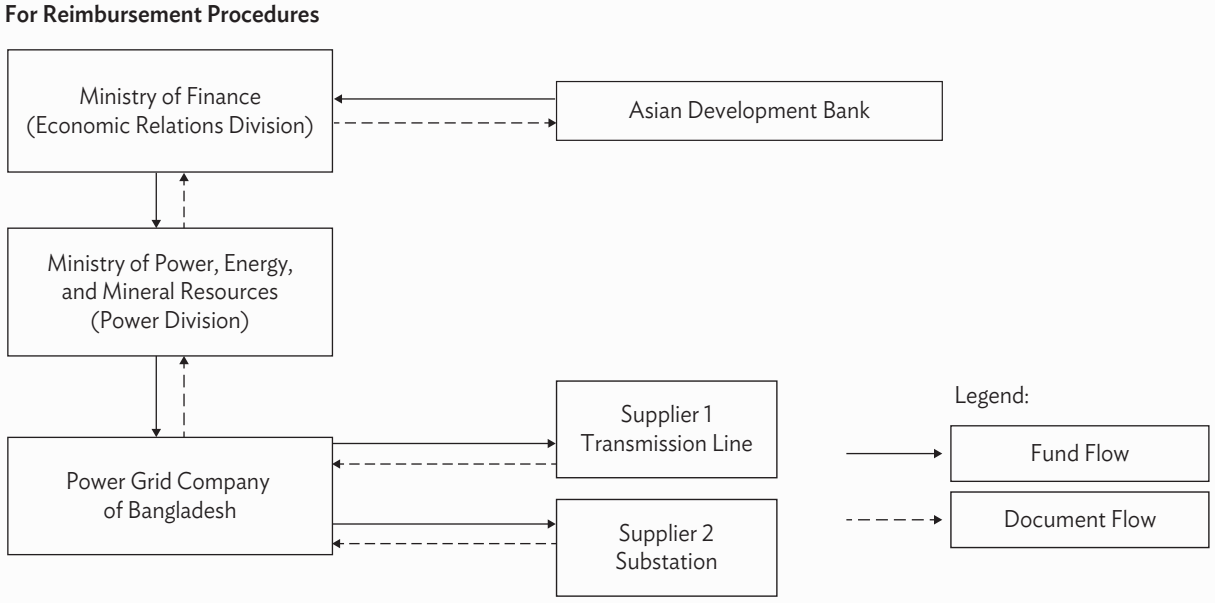


kV = kilovolt.

Source: Asian Development Bank. 2013. An Overview of Energy Cooperation in South Asia. *South Asia Working Paper Series* No. 19. Manila.

Project design and technical implementation. Major physical components of the project include the DC transmission line in Bangladesh, the back-to-back HVDC substation, and a DC interconnection at Bheramara which links with the transmission network in Bangladesh. The project management unit headed by Project Director Kazi Hassan had to address unanticipated challenges (e.g., a large number of *hartals* or labor strikes) and complete the interconnection. Another important project component is the capacity building provided to the PGCB, the executing agency for the project. Under the contract, PGCB officers learned to manage post-installation operation of the HVDC system. Because this project is the first HVDC system in Bangladesh and the first such HVDC interconnection in South Asia, resulting in the first procurement of power from India to Bangladesh, the staff of the Bangladesh Power Development Board (BPDB), Power Division, and other agencies also received training in electricity trading. PGCIL provided technical support for design, monitored implementation, and aligned objectives. Figures 3.1.2 and 3.1.3 illustrate the project fund flow and organization structure.

Figure 3.1.2: Bangladesh–India Electrical Grid Interconnection Project Fund Flow

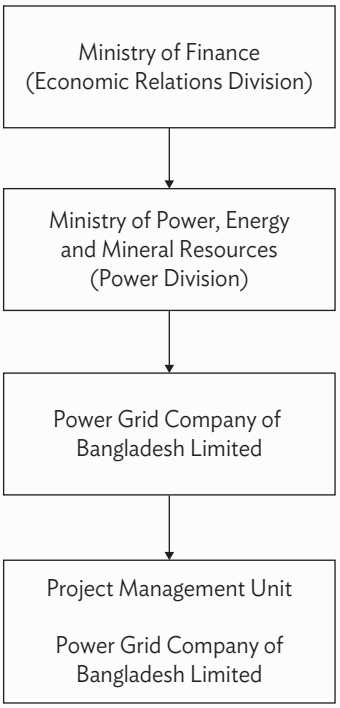


Source: Asian Development Bank. 2013. *Project Administration Manual: SASEC Bangladesh–India Electrical Grid Interconnection Project in the People's Republic of Bangladesh.* August. Manila.

Finalizing power purchase agreements. On 27 July 2010, a Bulk Power Transmission Agreement between PGCIL and BPDB formalized the interconnection of power grids, but the countries also needed to finalize two power purchase agreements (PPAs). Initially, representatives could not agree on terms (e.g., tariff, source, period or duration, etc.) that stipulated 250 MW for each PPA. After lengthy negotiations, both countries agreed on the terms of the first PPA. In March 2012, India's National Thermal Power Corporation (NTPC), through its wholly owned subsidiary, NTPC Vidyut Vyapar Nigam, and BPDB signed a government-to-government PPA for the sale of 250 MW of power from India to Bangladesh for 25 years from the unallocated share of central sector power projects across India. The tariff for this power will be based on regulated tariffs in India, including applicable

transmission and wheeling charges. According to a second PPA, PTC will deliver 250 MW to Bangladesh from December 2013 onward, with tariffs based on a competitive bid. Both tariffs are significantly lower than the marginal cost of power.

Figure 3.1.3: Bangladesh-India Grid Interconnection Project Organization Structure



Source: Asian Development Bank. 2013. *Project Administration Manual: SASEC Bangladesh–India Electrical Grid Interconnection Project in the People's Republic of Bangladesh.* August. Manila.

RESULTS

After completion of the interconnection infrastructure on 5 October 2013, 500 MW of power began flowing from India to Bangladesh. This first-ever interconnection of two national grids in South Asia also includes the region's first cross-border HVDC transmission line. Although the initial power transfer did not entirely solve Bangladesh's energy deficiency problem, it reduced the deficiency by 500 MW. In addition, electricity from the interconnection costs less than that bought from the rental plants.

More importantly, the electrical link laid the groundwork for a regional energy market. Ajay Guha, a former lead energy specialist for ADB, views the Bangladesh–India interconnection as an important step toward achieving a functioning regional electricity network in South Asia that would showcase better utilization of the region's diverse but unevenly distributed energy resources. This project is a key step forward in regional power sharing and cooperation. Using lessons learned from this first project, Bangladesh is now working to attain additional power from India to further reduce its energy deficiency through more complex power transfer arrangements between the two countries.

LESSONS

Potential for economic cooperation. Cooperation between Bangladesh and India overcame barriers to reach a purchase power agreement. India gained revenue by selling its available energy to Bangladesh, and Bangladesh reduced its energy deficiency, thereby supporting economic growth. This mutually beneficial project enabled both countries to maximize other opportunities for dialogue and economic cooperation. This case shows that the energy market can generate quick wins for regional economic cooperation and pave the way for more cooperation in other sectors.

Interagency cooperation. PGCB and PGCIL worked together to determine connection points, possible routes for the proposed transmission line, location of the intermediary substation, and a suitable mode for interconnection. The joint working group and joint steering committee closely monitored project design and implementation, contributing significantly to timely completion of the project.

ADB PHOTO LIBRARY

A high-tension tower along the Bangladesh–India Grid Interconnection

ADB. 2010. *Bangladesh–India Grid Interconnection Project.* May. Manila.

Regional cooperation needs strong champions. Each nation has its own utility technical standards to facilitate interconnection within the country. Since countries were previously dependent on energy generated internally, there was no need to develop a regional utility standard. As economies expanded worldwide, the demand for energy increased and created generating capacity problems. Previously, countries solved power deficiencies with thermal power plants that used expensive imported fuels such as oil, coal, and gas. However, with the diverse natural energy resources within a particular region and an already-established cross-border interconnection, more countries realized that cross-border interconnection of power grids could optimize energy usage for both suppliers and users.

In this project, choosing the mode of cross-border grid interconnection was a significant challenge. In addition to ensuring that disturbances in one system would not affect the other system, asynchronous interconnection allowed adequate operational flexibility for connecting the power systems of different countries.

Keywords

Power grid interconnection, electrical grid, electrical grid interconnection, cross-border grid interconnection, regional cooperation, energy market, asynchronous interconnection, Bangladesh, India

For further reading

- http://www.adb.org/projects/documents/bangladesh-india-electrical-grid-interconnection-project-bangladesh-rrp
- http://www.adb.org/news/india-electricity-flows-bangladesh-first-south-asian-hvdc-cross-border-link

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SOHAIL HASNIE

WEST KALIMANTAN POWER GRID STRENGTHENING PROJECT

Reducing Indonesia's Oil Dependency While Fostering Regional Cooperation

Construction of the Bengkayang Substation

- Oil fuels all power generation in West Kalimantan and a quarter of such generation in Indonesia.
- Oil dependency makes the country vulnerable to volatile market prices. In 2007 and 2008, high oil prices forced Indonesia to switch off many of its oil-based power plants, causing massive blackouts.
- The Asian Development Bank, through the West Kalimantan Power Grid Strengthening Project, is assisting Indonesia secure power supply through a cross-border power trade agreement with its neighbor, Malaysia.
- The project will provide cheaper and reliable electricity to West Kalimantan and its neighboring areas, increase access, and contribute to regional cooperation among Southeast Asian countries.

CONTEXT

In West Kalimantan, Indonesia, oil fuels all power generation, negatively affecting both the environment and the economy. Because oil is the most costly fuel for power generation, its dominant use in West Kalimantan has resulted in high electricity costs. The average cost of power generation is more than $0.25 per kilowatt-hour (kWh).[1]

This high cost presents a major obstacle to the ability of P.T. Perusahaan Listrik Negara (PLN), the state electric utility, to invest in new assets and maintain current assets, hampering electricity supply and economic growth, especially since West Kalimantan urgently needs additional electricity to meet increasing demand, which will reach 600 megawatts (MW) by 2020, from about 200 MW in 2012 (footnote 1). Even if the country decides to develop its abundant coal resources, it will take time because development of this resource will require about 7–10 years.

Overdependence on oil exposes the country to price shocks. When global oil prices soared in 2007 and 2008, oil-based power generation became too costly for Indonesia. The government had shut down some of its oil-fired power plants, leading to rotating blackouts nationwide. Oil dependency also has environmental repercussions because fossil fuels emit greenhouse gases, contributing to climate change and harming health.

PROJECT SNAPSHOT

LOAN APPROVAL DATE:
August 2013

LOAN AMOUNT:
$49.5 million

BORROWER:
Indonesia

EXECUTING AGENCY:
P.T. Perusahaan Listrik Negara

GEOGRAPHICAL LOCATION:
West Kalimantan

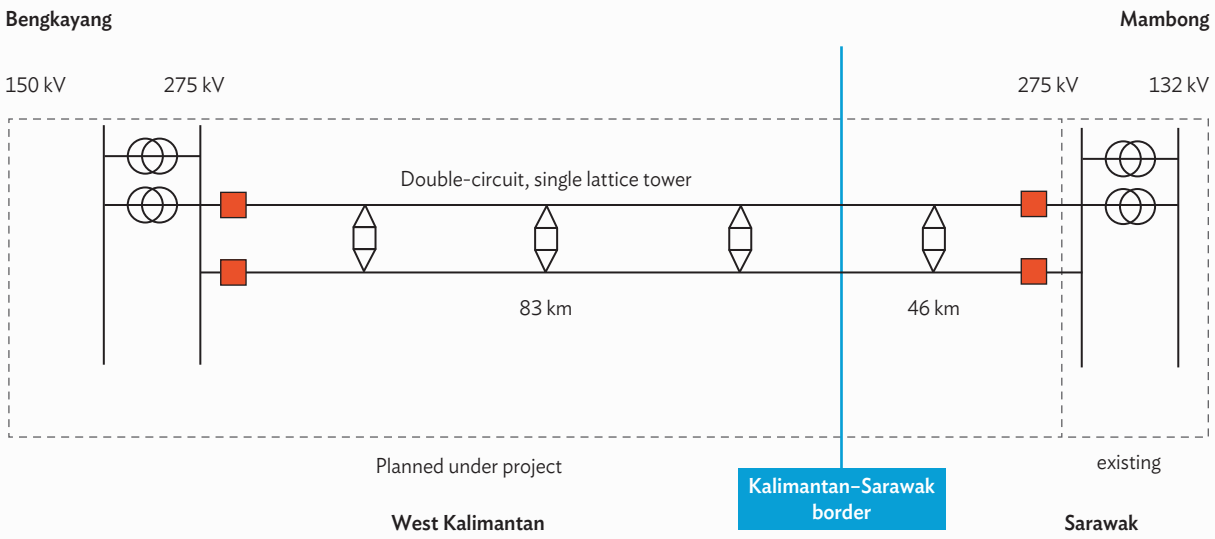
TYPE OF ENERGY PROJECT:
Cross-border power trade – regional interconnection

PROJECT COMPLETION DATE:
January 2016

West Kalimantan explored cross-border power supply as a way to meet rising demand for electricity at a lower cost. To extend energy supply to the West Kalimantan grid, PLN aims to import 230 MW of low-cost (about $0.10 per kWh) hydropower-generated electricity from Sarawak, Malaysia, to the West Kalimantan grid. Through financing from the Asian Development Bank (ADB), the West Kalimantan Power Grid Strengthening Project helped Indonesia build a transmission line from Bengkayang, West Kalimantan to the Malaysian border. Malaysia will finance transmission line extension from the border to Mambong, Sarawak.

[1] Asian Development Bank (ADB). 2013. *Report and Recommendations of the President to the Board of Directors: Proposed Loan and Administration of Loan and Grant to the Republic of Indonesia for the West Kalimantan Power Grid Strengthening Project.* August. Manila.

Figure 3.2.1: Schematic Diagram of Proposed Regional Interconnection



HVTL = high voltage transmission line, km = kilometer, kV = kilovolt.

Source: Asian Development Bank. 2011. *Initial Environmental Examination: Strengthening West Kalimantan Power Grid.* July. Manila.

SOLUTIONS

Power exchange agreement. In 2012, PLN and its counterpart in Malaysia, Syarikat SESCO Berhad (SESCO) signed a 20-year power exchange agreement that stipulates take-or-pay and take-and-pay prices[2] during Phase 1 (i.e., first 5 years). PLN will purchase from SESCO about 50 MW of capacity as base load on a take-or-pay basis and another 180 MW of capacity under a take-and-pay contract. Phase 2 provides for long-, medium-, or short-term purchases of a maximum capacity of 230 MW (footnote 1).

Cross-border interconnection. The project will connect Indonesia and Malaysia using a 275-kilovolt (kV) regional interconnection high voltage transmission line (HVTL) between Bengkayang, West Kalimantan and Mambong, Sarawak. To provide access to electricity in West Kalimantan, the project will also construct two 150 kV HVTLs, from Bengkayang to Ngabang and from Ngabang to Tayan.[3]

[2] Take-or-pay amounts are like capacity payments in that payments for full amounts have to be made even if only a portion of the contract amount is consumed. Take-and-pay allows the buyer to pay only for the amounts used.

[3] ADB. 2011. *Initial Environmental Examination: Strengthening West Kalimantan Power Grid.* July. http://www.adb.org/sites/default/files/project-document/74164/41074-013-ino-iee-01.pdf

275 kilovolt Transmission towers in West Kalimantan connecting to Sarawak, Malaysia

SOHAIL HASNIE

The project will augment the existing 275/150 kV substation at Mambong in Sarawak while constructing a new 275/150/20 kV substation in Bengkayang, West Kalimantan. Further extension of the grid within West Kalimantan will require construction of a new 150/20 kV substation in Ngabang and a four-line feeder extension in the 150 kV Tayan and Bengkayang substations. Potentially, the grid interconnection could exchange an estimated 230 MW per hour between the two systems. A $2 million grant component will provide 8,000 new households with access to electricity by 2016.[4]

[4] ADB. 2013. ADB's First BIMP-EAGA Project to Bring Clean Energy to West Kalimantan. News release. http://www.adb.org/news/adbs-first-bimp-eaga-project-bring-clean-energy-west-kalimantan

Construction of the HVTL corridor. The power grid corridor consists of 83 kilometers (km) of 275 kV transmission line connecting West Kalimantan and Sarawak, and 145 km of 150 kV HVTLs within West Kalimantan. The HVTL corridor will traverse a rural landscape, with flat to moderately hilly terrain and few secondary urban centers.

Because the corridor is adjacent to existing roads, the transmission lines will have minimal impact on the area through which it passes. The route also avoids sensitive ecosystems (e.g., parks and protected forests, houses and schools, and high concentrations of high-value economic trees). No houses or other structures were relocated.

The project includes four contract packages. Package 1 covers construction of the 275 kV transmission line between Bengkayang substation and the border at Sarawak, East Malaysia. Package 2 covers construction of the 275/150 kV substation at Bengkayang. Package 3 deals with the 150 kV transmission line between Bengkayang substation, the new Ngabang substation, and the substation in Tayan. Package 4 includes construction of the 150/20 kV substation at Ngabang and the Tayan substation extension.

Project implementation. As the executing agency, PLN is responsible for overall project implementation. One project management unit handles all procurement, planning, project supervision, monitoring, accounting, and consolidated reporting, and also coordinates with the project's Sarawak counterpart. A second project implementation unit supervises day-to-day operations and fulfills monitoring and reporting requirements. Figure 3.2.2 shows the project organization structure, and Figure 3.2.3 illustrates the fund flow.[5]

Regional power trade and cooperation. The 275 kV interconnection between West Kalimantan and Sarawak mainly supports power trade between Indonesia and Malaysia. However, this project is part of a larger endeavor by the Association of Southeast Asian Nations (ASEAN) Power Grid Interconnection Development Project. The ASEAN project encourages economic use of energy resources for mutual benefit, while enhancing power system security and creating opportunities for energy trading in the ASEAN electricity market.

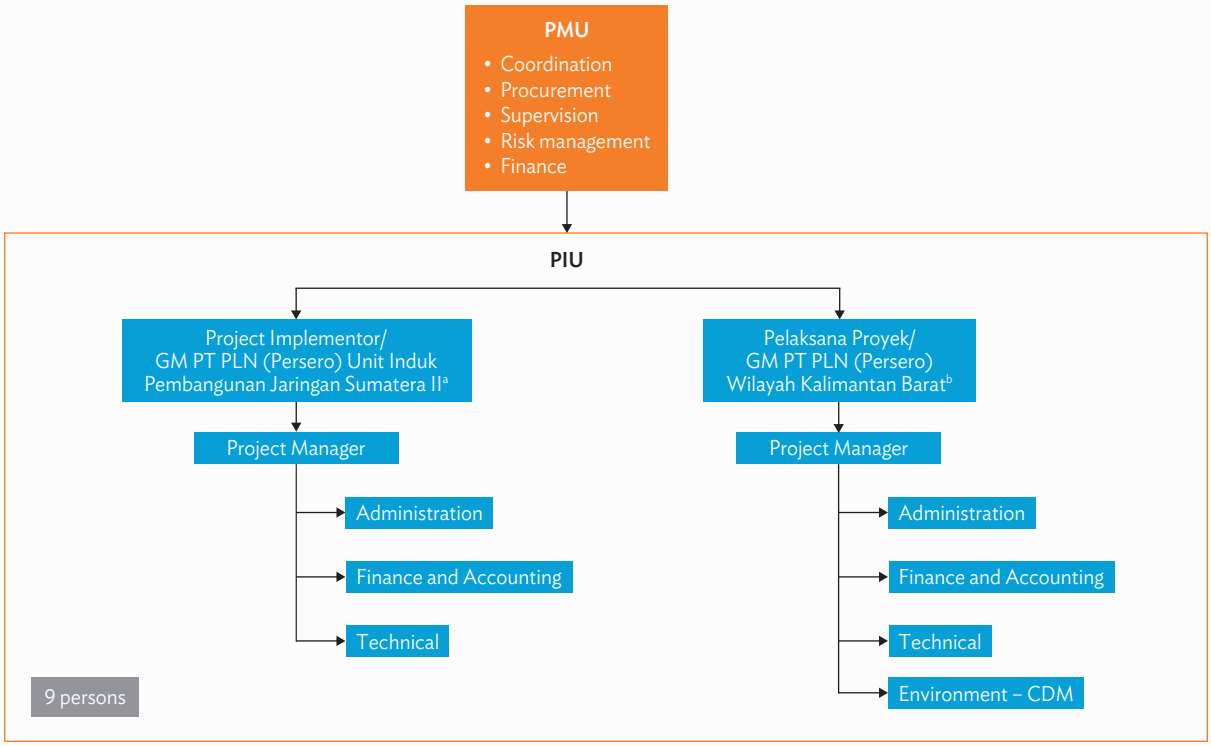
The interconnection between West Kalimantan and Sarawak is one of many power projects that will comprise an envisioned ASEAN power grid. Although ASEAN's member states have vast energy resources, many areas still experience energy poverty. A joint approach in developing a borderless electricity industry will help member countries secure their energy supply in the midst of surging power demand.[6]

RESULTS

Improved energy supply for Indonesia. West Kalimantan Power Grid Strengthening Project will augment electricity supply to West Kalimantan and its adjacent provinces and increase reliability. The 150 kV HVTLs to Ngabang and Tayan will bring access to electricity to many households, and the grant component will connect about 8,000 new households to the power grid, potentially reducing connection charges and connection time. Reliable power will create construction and maintenance jobs, boost the local and national economy, contributing to industrial growth and increasing trade, especially in rubber factories. Such activities will generate jobs, especially

[5] ADB. 2013. *Project Administration Manual: West Kalimantan Power Grid Strengthening Project in Indonesia.* July. Manila.
[6] Association of Southeast Asian Nations. n.d. *Program No. 1: ASEAN Power Grid.* http://www.asean.org/news/item/programme-area-no-1-asean-power-grid

Figure 3.2.2: West Kalimantan Power Grid Strengthening Project Organization Structure



PIU = project implementation unit, PMU = project management unit.

[1] Sumatera II Regional Transmission Construction Unit.

[2] West Kalimantan Regional Unit.

Source: ADB. 2013. *Project Administration Manual: West Kalimantan Power Grid Strengthening Project in Indonesia.* Manila.

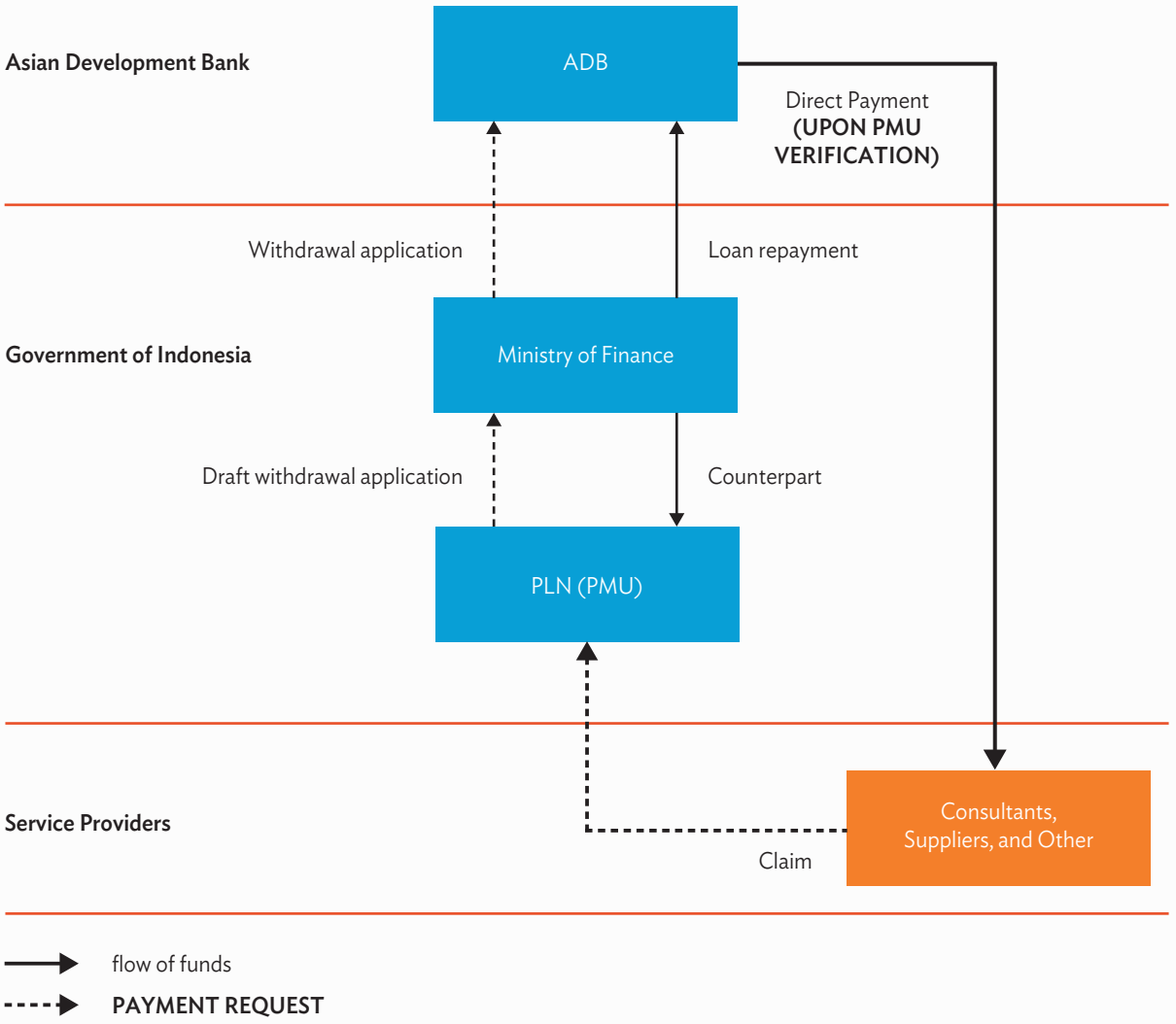
for low-income groups. Increased access to electricity will improve basic public services such as education, health, and water supply (footnote 1).

Increased income and exporting power for Malaysia. This interconnection project will also benefit Malaysia, which has long-term plans for power export. Low-cost power generation will earn Sarawak about $33 million (footnote 1).

Reduced cost of electricity production. Imported electricity will help West Kalimantan reduce the marginal cost of electricity production, from more than $0.25 per kilowatt-hour to about $0.18 per kilowatt-hour. Depending on oil prices, PLN potentially will save about $100 million and reduce its government subsidies.

Reduced carbon footprint. Indonesia heavily relies on oil for power, especially for West Kalimantan. Power from Malaysia will significantly reduce West Kalimantan's reliance on oil-fueled power plants. The project will help the island of Borneo reduce its carbon footprint by avoiding emissions that would otherwise have been produced by oil-based power generation plants.

Figure 3.2.3: West Kalimantan Power Grid Strengthening Project Fund Flow



ADB = Asian Development Bank, PLN = P.T. Perusahaan Listrik Negara, PMU = project management unit.

Source: ADB. 2013. *Project Administration Manual: West Kalimantan Power Grid Strengthening Project in Indonesia.* Manila.

LESSONS

Reducing fossil-fuel dependency through regional cooperation. Many countries in Asia remain heavily dependent on fossil fuels (e.g., oil and coal) for power generation. Overreliance increases vulnerability to price shocks, carbon emissions, and pollution. With surging power demand, increased use of fossil fuels and lack of budget to maintain and rehabilitate distribution assets will further aggravate these effects. In Indonesia, exorbitant prices led to power outages in late 2000. Project implementers should consider renewable alternatives to power generation, within the country and elsewhere. Although West Kalimantan could continue to develop coal-fired power plants locally, it opted to access electricity from cleaner hydropower in Malaysia; lower prices and a smaller carbon footprint will offset the initial investments. Moreover, grid interconnection, in this case, can be implemented faster than coal power development, which could take about 7–10 years.

Careful planning. Project implementers planned the transmission corridor carefully to minimize the impact of construction and operation on farmland, communities, and international borders. They also implemented mitigation measures and a rigorous environmental evaluation to minimize environmental impact and avoid relocations.

Development of power trade and regional cooperation. As demand for energy continues to increase in many countries, development of local energy sectors may lag, thus causing power gaps. Countries may encounter difficulty in providing adequate energy, due to insufficient or absent finance or energy resources. International power trade may help solve these issues.

Power trade can yield both regional and national benefits, including regional cooperation. A regional grid such as that planned for the ASEAN Power Grid Interconnection Development Project, can tap the energy resources of member states and improve quality of life by accessing various sources of energy from other countries.

Keywords

Energy, energy trade, power trade, power grid, power grid interconnection, regional cooperation, hydropower, Indonesia, Malaysia

For further reading

- http://www.adb.org/news/adbs-first-bimp-eaga-project-bring-clean-energy-west-kalimantan
- http://www.adb.org/projects/documents/strengthening-west-kalimantan-power-grid-initial-environmental-examination
- http://www.adb.org/projects/documents/west-kalimantan-power-grid-strengthening-project-rrp

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TVS

PROMOTING ENERGY EFFICIENCY

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Workers conduct a massive retrofit of an iron plant to recapture previously wasted energy in Guangdong, PRC.

ENERGY EFFICIENCY MULTI-PROJECT FINANCING IN THE PEOPLE'S REPUBLIC OF CHINA

Reducing Energy Consumption in a Rapidly Growing Economy

- Energy consumption in the People's Republic of China (PRC) is growing at an alarming rate, almost as fast as the country's economic growth.
- The PRC aims to address this rapid surge through energy efficiency measures. It sought the help of the Asian Development Bank (ADB) to jump-start energy efficiency projects.
- ADB introduced the concept of energy financing to the PRC through a program that provides banks partial credit guarantees and technical assistance for marketing and appraising private sector energy efficiency projects.
- The program partnered with a local commercial bank supported by technical expertise to promote energy efficiency. Workshops, training, and knowledge sharing are under way to improve the bank's capacity to identify and finance energy efficiency projects.

CONTEXT

During the last decade, energy consumption in the People's Republic of China (PRC) surged dramatically to 9.5% in 2001–2005, only slightly lower than growth in gross product.[1] This accelerated pace created a strong demand for electricity. Per capita electricity consumption increased from 993 kilowatt-hours (kWh) in 2000 to 2,650 kWh in 2008.[2] This has serious ramifications for the country's economy and environment as serious health issues now exist given the poor air quality resulting from burning coal for power generation and for district heating.

The government views energy efficiency as a major response to rapidly growing energy consumption. It issued policies for energy conservation, such as the Green Building Action Plan, which seeks to develop 1 billion square meters (m^2) of new green building floor area by 2015, 14 times higher than the existing 69.5 million m^2 in 2012.[3] Its 11th Five-Year Plan (2006–2011) prioritized energy conservation, high-efficiency, and energy security. It also issued the Medium and Long-Term Energy Conservation Plan, a conceptual road map for improving energy efficiency and promoting 10 types of energy efficiency projects. The plan identified the industry, transport, and building sectors as having the most potential for energy efficiency improvements. The government also revised the Energy Conservation Law and the comprehensive Energy Law (2008).[4]

PROJECT SNAPSHOT

PROGRAM APPROVAL DATE:
December 2007

PARTIAL CREDIT GUARANTEE:
Up to CNY800 million

EXECUTING AGENCY:
Commercial banks

GEOGRAPHICAL LOCATION:
People's Republic of China

TYPE OF ENERGY PROJECT:
Energy efficiency

PROJECT COMPLETION DATE:
Ongoing

However, energy efficiency projects still face several difficulties, primarily due to lack of financing and awareness. Local commercial banks are reluctant to lend funds to energy financing projects.

Energy efficiency remains an unfamiliar concept for many banks. It involves a wide range of technologies and strategies that banks perceive as risky. The banks' lack of training and information only aggravates the situation; they have not introduced or promoted any energy efficiency finance products. Even among senior management, awareness of energy financing is low, thus no resources have been provided for the introduction and implementation of energy financing schemes. In addition, banks believe that the highly technical nature of energy efficiency projects will increase the cost of due diligence. Therefore, proponents of energy efficiency projects encounter difficulty in availing loans. Even if they can borrow, the financing term is short or requires high collateral (footnote 1).

1 Asian Development Bank (ADB). 2007. *Report and Recommendation of the President to the Board of Directors: Proposed Credit Guarantee to the People's Republic of China for the Energy Efficiency Multi-Project Financing Program.* November. Manila.
2 ADB. 2010. *Project Administration Manual: Tianjin Integrated Gasification Combined Cycle Power Plant Project in the People's Republic of China.* May. Manila.
3 ADB. 2013. *People's Republic of China: Energy Efficiency Multi-Project Financing Program (Financed by the Clean Energy Fund under the Clean Energy Financing Partnership Facility).* October. Manila.
4 National People's Congress of the People's Republic of China. *Law of the People's Republic of China on Energy Conservation.* Database of Laws and Regulations. www.npc.gov.cn/englishnpc/Law/2009-02/20/content_1471608.htm (accessed 25 February 2015).

Thus, the Asian Development Bank (ADB) helped mobilize available domestic funds in the PRC through the Energy Efficiency Multi-Project Financing Program, which supports investment in energy efficiency and increases awareness among commercial banks and energy end users.

SOLUTIONS

An innovative program. The program involves ADB's partnership with selected banks, providing them with up to CNY800 million[5] in partial credit guarantees (PCGs) to develop energy financing. ADB also engaged a private sector energy management company to provide technical assistance to its partner banks. The combined forces of the two partners ensured the availability of energy financing and technical competence in assessing energy efficiency projects.

Project financing structure. Through the program, ADB will mobilize funds for energy efficiency projects by providing a PCG to each partner bank, sharing the credit risks associated with such types of projects. Partner banks will formulate agreements and frameworks that will provide borrowers and/or energy end users with increased access to finance for energy efficiency projects. Because many local banks lack technical skill in assessing such projects, the program will tap the technical skills of a private sector energy management company (Figure 4.1.1).

Clear and delineated roles. The technical partner offers comprehensive technical input to each energy efficiency project financed by a partner bank. It is responsible for sourcing projects for the partner bank, including marketing, energy audit, technical due diligence, setting the energy policy for end users, and equipment procurement. The partner bank is responsible for credit assessment, further due diligence, and loan approval.

Focus on a specific segment. ADB has long identified the PRC as a priority country with high potential for energy efficiency and clean energy investments. Through consultative meetings with stakeholders in the energy efficiency market, ADB learned that the PRC needs energy efficiency investments in a range of market segments with distinct credit characteristics and investment requirements. Given the country's limited experience in energy efficiency financing, the program initially focused on the energy efficiency of buildings to fast-track learning among banks. The huge market potential in this area matches the interests and capacity of commercial banks. Since urban areas are responsible for about 75% of all energy use and GHG emissions worldwide, focusing on energy efficiency of buildings will considerably reduce energy consumption. With the PRC's rapid urbanization, energy-efficient buildings will have a large and long-lasting cumulative impact. Retrofitting buildings with energy-saving improvements can yield up to 20%–40% energy savings.[6]

[5] When the project was approved (December 2007), CNY1.00 was equivalent to $0.13.

[6] ADB. 2011. ADB Supports Shanghai Pudong Development Bank Lending for Green Buildings. News release. 16 May. Manila. http://www.adb.org/news/adb-supports-shanghai-pudong-development-bank-lending-green-buildings

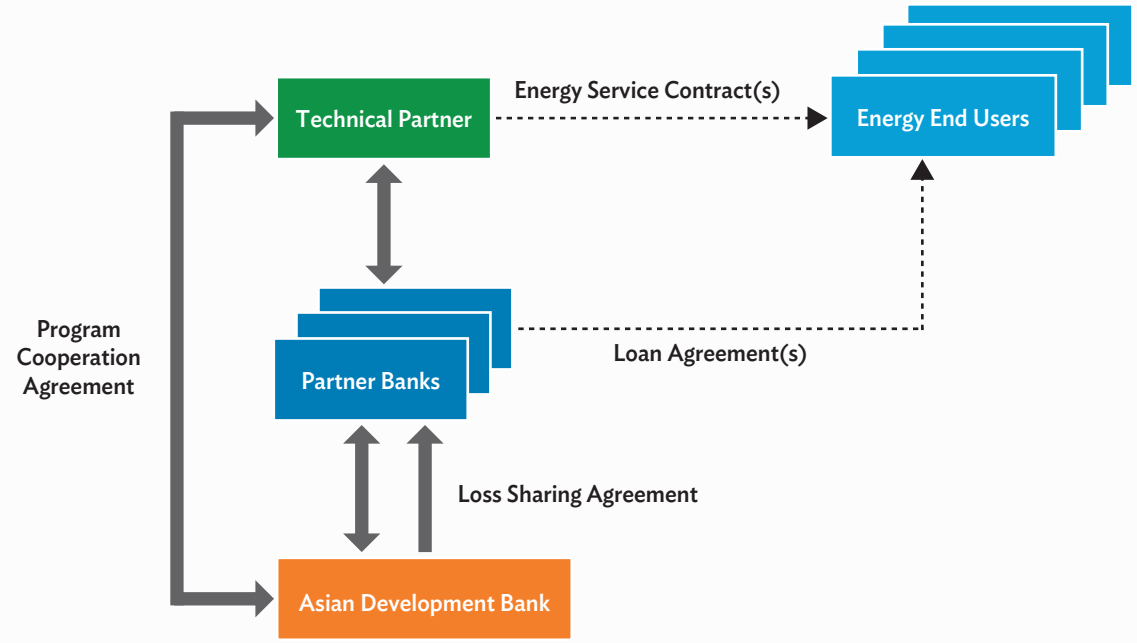
ADB PHOTO LIBRARY

State-of-the-art LED lighting is developed in the laboratory of Guangdong Real Faith Lighting Company.

Capacity building. The program introduced a technical assistance package that focused on supporting partner banks in the structuring, credit evaluation, and monitoring of energy efficiency loans. Initiated in 2014, this technical assistance will end in 2016. Several workshops shared knowledge and promoted energy efficiency activities among stakeholders, including financial institutions, government agencies, energy end users, and technology providers. Training included sessions on energy efficiency finance for bank headquarters and main branches, covering an introduction to energy-saving technologies in buildings, the economics of energy-saving equipment, sector analysis, international best practice in structuring energy efficiency loans, assessing energy efficiency cash flows, and marketing energy efficiency financial services. Additional topics will include credit underwriting, risk assessment, and portfolio management and reporting practices. The training will also help partner banks fine-tune a special unit for this program and develop and design an incentive mechanism for end borrowers.[7]

[7] ADB. 2013. *Technical Assistance to the People's Republic of China for the Energy Efficiency Multi-Project Financing Program* (Financed by the Clean Energy Fund under the Clean Energy Financing Partnership Facility). October. Manila.

Figure 4.1.1: Energy Efficiency Multi-Project Finance Program Structure



Source: Untitled PowerPoint presentation provided by Aiming Zhou.

RESULTS

Partnerships. The program now has the Shanghai Pudong Development Bank (SPDB) as the local bank partner, with a PCG limit of CNY300 million. Thus far, SPDB has reviewed more than 10 projects, with two approved pilot energy efficiency loans for the building sector. It also established a special credit evaluation channel, a marketing channel, and various new procedures. In partnership with ADB, SPDB has conducted various internal training workshops (footnote 6). This successful partnership is instrumental to increasing end users' access to energy efficiency loans.

A technical partner, Johnson Controls (JCI), gives partner banks much needed and ongoing technical assistance. JCI is a global leader in delivering integrated energy efficiency solutions.[8]

Increased capacity of partner bank. Training sessions for energy efficiency finance are well under way, and scheduled workshops will disseminate the lessons learned. Both trainings and workshops will be completed by 2016. Concurrently, the program has been developing a building energy efficiency manual for credit analysis and loan processing of various energy efficiency projects.

[8] ADB. 2008. ADB, Standard Chartered Bank Promote Private Sector Investment in Energy-Efficient Projects in PRC. 3 May. News release.

Projected increase in private sector investments. The program envisions that lending for energy efficiency projects without ADB's partial credit guarantee will reach at least CNY500 million, and guaranteed loans will exceed CNY1.8 billion by 2018. In addition, the targeted repayment rate for energy efficiency loans will exceed 95%. These investments should produce at least 500 million m^2 of retrofitted buildings by 2020, and 15% of new buildings will comply with the green building standard (footnote 7).

LESSONS

Flexibility in credit criteria. A major lesson from this program is the need for flexible credit criteria. Many banks have credit requirements (e.g., short payment periods and high collateral) that can hinder energy efficiency financing. For example, local banks frequently collateralize 200% of the loan amount. Others are rigid in implementing short payment periods. Flexibility will allow banks to accommodate the highly technical nature of energy efficiency projects.

Awareness and capacity for energy efficiency projects. Program implementers can help more banks accommodate energy finance projects by increasing the latter's awareness about energy efficiency financing. Banks also need specialized credit training to readily assess and process energy efficiency projects. Systematic training will enhance energy efficiency capabilities and create better awareness among commercial banks.

Availability of technical partner. This case story demonstrates the importance of a readily available technical partner, especially during the initial phase of program implementation. A technical partner can provide training on energy efficiency finance, risk assessment, portfolio management, and reporting practices. In addition, a technical partner can actively support banks in the appraisal and risk assessment of energy efficiency projects. Thus, the technical partner can further enhance banks' performance beyond lecture- or training-based knowledge sharing.

Keywords

Energy, energy financing, energy efficiency, energy loans, energy lending, green buildings, retrofitting, People's Republic of China, PRC

For further reading

- http://www.adb.org/projects/documents/proposed-credit-guarantee-energy-efficiency-multi-project-financing-program
- http://www.adb.org/news/adb-supports-shanghai-pudong-development-bank-lending-green-buildings

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Solar panels in Guangdong generate energy savings and improve the environment.

GUANGDONG ENERGY EFFICIENCY AND ENVIRONMENT IMPROVEMENT INVESTMENT PROGRAM, TRANCHE 1

Providing Additional Power Capacity through Energy Savings

- Guangdong province has the largest and fastest growing economy in the People's Republic of China (PRC).
- Rapidly growing demand has outstripped power generation capacity in Guangdong.
- In 2008, the PRC partnered with the Asian Development Bank to create a "virtual power plant," which aimed to save 532 gigawatt-hours (GWh) of energy per year and an equivalent 107 megawatt (MW) of capacity.
- The program exceeded its targets after completion of Tranche 1 in 2011. It generated an equivalent capacity of 130 MW with an annual energy savings of 651 GWh.

CONTEXT

The People's Republic of China (PRC) became the world's largest energy consumer in 2008. Electricity consumption increased from 340 kilowatt-hours (kWh) in 1983 to 1,840 kWh in 2005.[1] Although the capacity of installed power generation rose more than 8% per year in the past 2 decades, it still failed to meet demand. More than half of the PRC's provinces experience power shortages, especially during peak summer hours.

Increased demand also caused much environmental damage. Fossil fuels account for more than half of the PRC's energy supply mix, increasing greenhouse gas (GHG) emissions and pollutants. The PRC's coal-fired power plants account for 50% of the PRC's sulfur dioxide, 80% of nitrogen oxide, and 26% of carbon dioxide emissions (footnote 1), which contribute to global warming and are linked with a number of respiratory illnesses. They also cause acid rain, which affects a third of the country. Fossil fuel combustion also pollutes the air—about 48% of cities in the PRC now fail to meet national air quality standards.

Increased energy consumption has led to more fuel imports. In 2013, the PRC imported 327.1 million tons of coal. Projections suggest that oil imports will increase to about 13.1 million barrels per day in 2030, up from 3.5 million barrels per day in 2006. By 2015, the PRC likely will import about 22% of its natural gas supply, rising to 54% by 2030 (footnote 1).

PROJECT SNAPSHOT

LOAN APPROVAL DATE:
June 2008

LOAN AMOUNT:
$35 million

BORROWER:
People's Republic of China (PRC)

EXECUTING AGENCY:
Guangdong Provincial Government

GEOGRAPHICAL LOCATION:
Guangdong, PRC

TYPE OF ENERGY PROJECT:
Energy efficiency

PROJECT COMPLETION DATE:
December 2011

In 2008, the PRC and the Asian Development Bank (ADB) embarked on an energy efficiency program to improve the PRC's energy security and environment. Dubbed the Multitranche Financing Facility (MFF): Guangdong Energy Efficiency and Environment Improvement Investment Program (Tranche 1), it focused on creating additional system capacity through an efficiency power plant (EPP) in Guangdong province. It financed up to $100 million to create an EPP equivalent to 107 megawatts (MW).

EPP is a strategic option that would help any country increase its power generation capacity without building additional power plants. Because an EEP is a virtual power plant, building an EPP does not mean constructing power generation infrastructure. Rather, it entails investments in conservation and efficiency measures that reduce energy demand and yield energy savings equivalent to the capacity generated by an actual power plant. Conservation measures include retrofitting electrical equipment for power savings and using more energy-efficient equipment and technologies.

[1] Asian Development Bank (ADB). 2008. *Report and Recommendations of the President to the Board: Proposed Multitranche Financing Facility and Administration of Grant from the Clean Energy Fund to the People's Republic of China for the Guangdong Energy Efficiency and Environment Improvement Investment Program.* April. Manila.

SOLUTIONS

Choosing Guangdong. Guangdong is in southern PRC. Its population (92 million) has grown an average 2.2% per year since 1995. Its economy is the largest and fastest-growing among all of the PRC's provinces. In 2007, before the project started, Guangdong's installed generation capacity totaled 59.3 gigawatts (GW), one of the biggest in the PRC. However, power demand has grown 13% per year since 1995, and Guangdong imports its coal, oil, and electricity (100%, 80%, and 20%, respectively) from other provinces. Power demand has outpaced capacity, causing severe power shortages during peak summer hours. High fossil-based energy consumption harms Guangdong's environment. About 86% of the province experienced acid rain in 2005 and nearly all of its cities have increasingly failed to meet national air quality standards. Guangdong was thus chosen as the best site because the project would help expand power generation capacity in the PRC's largest provincial economy and secure energy supply without further harming the environment. It was envisaged that the success of this project would potentially spur more cities in the country to explore EPPs.

Implementing energy efficiency subprojects. To create the EPP, Guangdong implemented eight energy efficiency subprojects for Tranche 1, which retrofitted, upgraded, and replaced appliances and equipment owned by end users, industries, and commercial establishments. It also implemented subprojects on waste-to-energy measures. The municipal government established the EPP Project Management Office (EPPPMO) to handle overall implementation of the energy efficiency subprojects. For Tranche 1, eight agencies ran subprojects as subborrowers.[2] Upon completion, the subprojects created an EPP capacity of 130 MW, saving 651 gigawatt-hours (GWh) per year.[3]

Strategic lending mechanism. Many companies do not seek loans for energy efficiency projects because it takes funding away from their core business operations. They would rather seek funding for business expansion or the establishment of a new business. To address this, the program used a financial intermediary loan scheme with strengthened implementation supervision and a simplified process for subproject appraisal. This scheme not only made funding for retrofits available to companies, but also gave Guangdong needed flexibility to quickly complete energy efficiency projects. It functioned as a revolving fund; new subprojects could be financed as subloans for each repaid subproject, multiplying energy savings.

Using ADB loan proceeds, the project established a special single-purpose trust fund managed by a financial intermediary, the Guangdong Finance Trust Company (GFTC). EPPPMO and GFTC appraised subproject applications and GFTC onlent[4] to financially viable EPP subprojects. Repayments of subloans, net of transfers to GPG for servicing the ADB loan, were used for further onlending. The trust was available only for EPP projects and could not be mixed with other trust funds.

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2 Guangzhou Zhiguang Electric Company implemented retrofits on 168 variable-speed and variable-frequency industrial motor drive systems for large electricity end users. Guangzhou Jinguan Company retrofitted the heating, ventilation, and air conditioning (HVAC) systems for commercial buildings and upgraded 88 sets of industrial motor drive systems. Zhuhai Secopower Transformer Company replaced 88 sets of transformers with high efficiency models for end users. Guangdong Zhongyu Technology Company installed 13,631 sets of distribution transformer station monitoring terminals for power grid utilities. Kaiping Fulai Electric Company installed 144 sets of reactive power compensators for large direct end users. Guangdong Haihong Transformer Company replaced inefficient transformers with 1,318 sets of high efficiency models. Two agencies, the Zhuhai Charlie Energy-saving Company and Guangdong SGIS Songshan Company, implemented a waste heat recovery subproject and refitted industrial boilers.

3 ADB. 2013. *Completion Report: Guangdong Energy Efficiency and Environment Improvement Investment Program, Tranche 1 in the People's Republic of China.* August. Manila.

4 Onlending refers to passing on loans to the institution requiring funding for a project or program. In turn, these intermediaries again onlend the money to a lower level of government or to users.

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The project helped Guangdong Province replace traditional light bulbs used in many streetlights with light-emitting diodes.

RESULTS

Upon completion in 2011, Tranche 1 generated EPP capacity totaling 130 MW and energy savings totaling 651 GWh per year, exceeding the initial target of the entire investment program (i.e., 532 GWh of energy savings per year and an equivalent 107 MW in capacity).

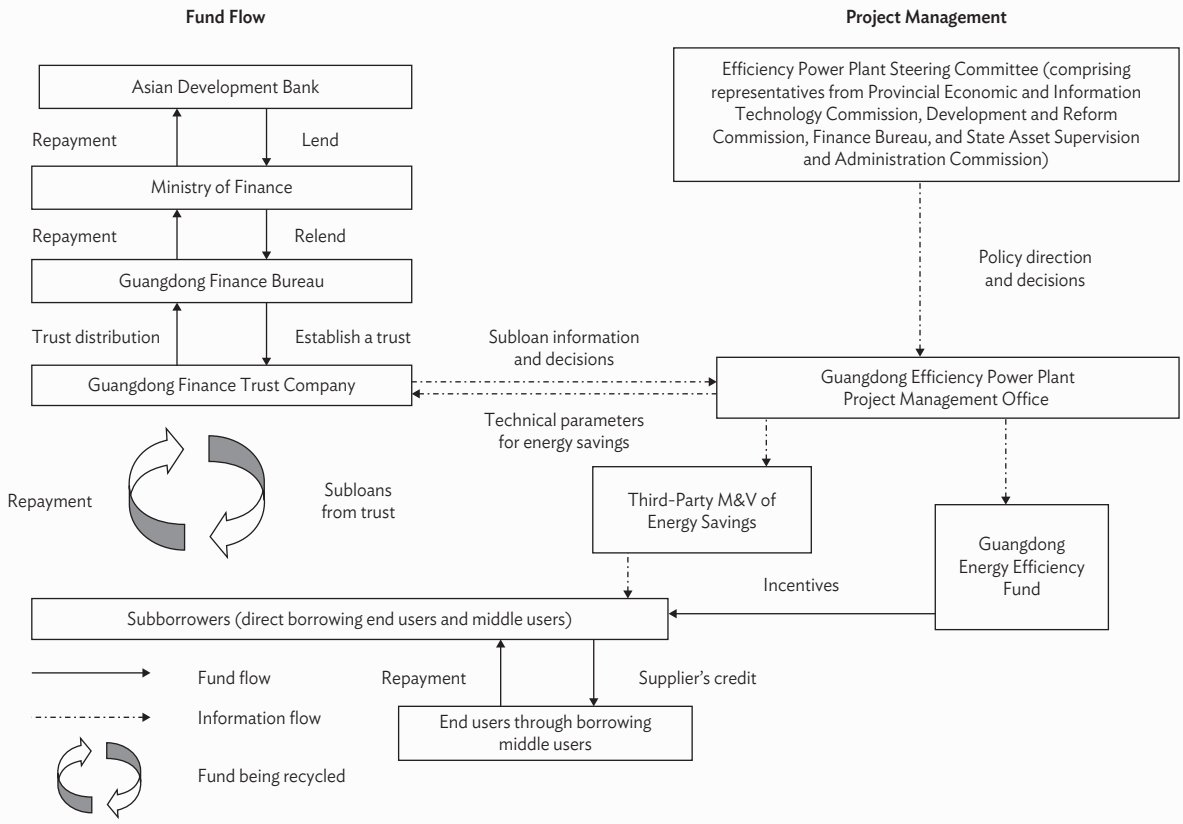
In addition, the project demonstrated how EPPs can be created in a systematic way. It tasked two entities for two aspects of program implementation. EPPPMO appraised the technical feasibility of the subprojects and subproject implementation, whereas GFTC appraised the financial viability of subborrowers and onlending. Thus, each entity complemented and supplemented the other. EPPPMO ensured smooth project implementation and timely loan repayment by subborrowers, freeing loan availability for next subproject borrower. This partnership facilitated more energy saving projects.

Moreover, the project facilitated development of two energy service companies (ESCOs). At the outset, two ESCO subborrowers implemented waste heat recovery and industry energy-efficiency retrofitting projects. By 2011, two other subborrowers had established their own ESCOs (footnote 3).

Guangdong's EPP model has attracted attention from other PRC municipalities, and many made study visits to learn about the EPP model. Figure 4.2.1 illustrates the program management and fund flow that facilitated the project's success.[5] Shandong and Hebei provinces have already replicated Guangdong's EPP model.

[5] ADB. 2009. *Project Administration Manual: Guangdong Energy Efficiency and Environment Improvement Investment Program, Tranche 1 in the People's Republic of China.* March. Manila.

Figure 4.2.1: Guangdong Energy Efficiency and Environment Improvement Investment Program, Tranche 1 Project Fund Flow and Management Structure



M&V = measurement and verification.

Source: ADB. 2009. *Project Administration Manual: Guangdong Energy Efficiency and Environment Improvement Investment Program, Tranche 1 in the People's Republic of China.* March. Manila.

LESSONS

Creating a replicable model. The structure of Guangdong's EPP model was straightforward. The project created a trust company and a project management office with distinct but complementary tasks in facilitating energy efficiency projects. Together, they were able to exceed project expectations, demonstrating that a simple structure with clear-cut delineations can ease implementation, especially in areas where EPP is relatively unknown. EPP project implementation is easier for subproject borrowers because it simplifies the whole EPP process, from loan request to completion. Other municipalities can easily replicate the model.

Savings and onlending. Subborrowers who successfully implement EPP subprojects can anticipate both energy and financial savings. Their loans yield monetary benefits, and full repayment is rolled over to the next borrower, expanding loan availability for other agencies seeking funds to implement their own EPP projects.

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The SGIS Songshan Company carried out a waste heat recovery subproject, along with industrial boiler retrofits.

A variety of efficiency power plant projects. By encouraging private companies to implement their own energy efficiency projects, the project was able to yield different kinds of energy efficiency measures. The project gave agencies wide enough parameters to propose initiatives suited to their own companies. Thus, the municipality was not confined to lighting fixture retrofits, but rather could implement a variety of energy-efficient measures that benefited the companies, the immediate community, and the environment.

Keywords

Energy efficiency, efficiency power plant, Guangdong, energy savings, energy, environment improvement, clean energy, climate change, emissions, pollution, People's Republic of China, PRC

For further reading

- http://www.adb.org/projects/documents/guangdong-energy-efficiency-and-environment-improvement-investment-program-rrp
- http://www.adb.org/features/shifting-energy-goalposts-prcs-Guangdong
- http://www.adb.org/projects/documents/mff-guangdong-energy-efficiency-environment-improvement-investment-program-t1-pcr

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THE PHILIPPINE ENERGY EFFICIENCY PROJECT

Lighting Up the Philippines in an Efficient Way

A technician from the Department of Energy tests a compact fluorescent lamp.

- Amid a looming energy gap resulting from increasing demand for energy, power consumers in the Philippines are burdened with one of the most expensive electricity rates in Asia, if not the world.
- With assistance from the Asian Development Bank, the government implemented the Philippine Energy Efficiency Project as an interim measure to mitigate a projected energy supply deficiency and reduce power consumption in residential and public sectors.
- The project retrofitted 135 government office buildings and almost 4,000 public park and streetlights with energy-efficient lighting systems, distributed 8.6 million compact fluorescent lamps nationwide, and established a green labeling system for buildings.
- These actions yielded a cumulative energy savings totaling 321 gigawatt-hours per year and facilitated development of the Green Building Rating System, which has certified 32 government buildings for sustainability.

CONTEXT

In the Philippines, higher power demand is stretching generation capacity. Although energy consumption likely will double between 2009 and 2030, forecasts suggest that average demand for electricity will increase 4.79% per year, requiring 10,500 megawatts (MW) of generating capacity in 2013–2030.[1] In 2015, projected demand will reach 9,011 MW, exceeding actual demand in 2014 (i.e., 8,717 MW). Therefore, the country could have an almost 300 MW deficit in 2015, especially during peak usage months (March–May).[2]

The Philippines has one of the most expensive power rates in the world ($0.26 per kilowatt-hour in 2013). The steep cost of power results from reliance on imported fuel for power generation, scattered geography, inefficient transmission and distribution systems in some areas, a regulatory framework that contains a complex margin of protection mechanisms for supply and transmission companies, and debt and cost recovery issues for legacy infrastructure (footnote 1). Given the impending shortage of energy supply, the cost of electricity will likely increase.

The need to address the projected shortfall is urgent. However, delayed implementation of the Electric Power Industry Reform Act of 2001, which deregulated the power sector to attract private companies to invest heavily in power generation, means that no new major power generating plant will come online until 2016. Fourteen power plants that could provide at least 2,500 MW of additional capacity are in the pipeline, but they will become operational only after 2016. Therefore, the government and the private sector must work to manage electricity consumption and implement energy efficiency programs.

PROJECT SNAPSHOT

LOAN APPROVAL DATE:
January 2009

LOAN AMOUNT:
$31.1 million

BORROWER:
Republic of the Philippines

EXECUTING AGENCY:
Department of Energy

GEOGRAPHICAL LOCATION:
Metro Manila, Luzon, Visayas, and Mindanao

TYPE OF ENERGY PROJECT:
Energy efficiency

PROJECT COMPLETION DATE:
December 2013

SOLUTIONS

Implementing short-term strategies. One of the short-term strategies taken by the government was the promotion and implementation of energy efficiency initiatives. With assistance from the Asian Development Bank (ADB), the Philippines packaged such initiatives under the Philippine Energy Efficiency Project (PEEP). The PEEP planned to retrofit government office buildings, public parks, and traffic light systems with energy-efficient lighting systems (EELS),[3] distribute compact fluorescent lamps (CFLs) to residents nationwide, establish integrated building and industry efficiency rating standards, and set up an energy service company (ESCO).

1 Asian Development Bank. 2013. *Country Operations Business Plan: Philippines, 2014–2016.* October. Manila. http://www.adb.org/sites/default/files/linked-documents/cobp-phi-2014-2016-ssa-02.pdf

2 Department of Energy. 2014. Measures to Address 2015 Tight Supply Proposed. *Government of the Philippines Official Gazette.* 24 July. https://www.doe.gov.ph/news-events/news/press-releases/2438-measures-to-address-2015-tight-supply-proposed

3 EELS refers to a lighting system that utilizes both natural and electric sources of light and controls to provide the desired level of illumination and comfort to the occupants of the room.

Overcoming initial obstacles. Initially, the PEEP aimed to distribute 13.0 million CFLs for free nationwide to replace high energy consuming incandescent bulbs. The government also planned to claim Clean Development Mechanism (CDM) credits for the program. As CFLs had penetrated the lighting market in urban residential areas because of another national project (i.e., the Philippine Efficient Lighting Market Transformation Project), the PEEP reduced the number of CFLs for distribution from 13.0 million to 8.6 million. It no longer availed of CDM credits for the collection of the incandescent bulbs as well.

The government also planned to create an ESCO to develop and implement energy efficiency projects for public sector clients, and support the development of other ESCOs through financial and technical advisory support. However, the plan ended prematurely due to changing priorities at the Department of Energy (DOE).

These initial obstacles allowed for the reallocation of a significant portion of the $7.5 million budget earmarked for the ESCO creation to retrofitting of additional government buildings. The balance was allocated to retrofitting public lighting and traffic lighting systems.

Focus on retrofitting. Retrofitting government office buildings with EELS was the PEEP's most successful component. The program initially aimed to upgrade the lighting systems in 40 government office buildings in order to contribute a 7,000 megawatt-hours reduction in energy demand and cut the government agencies' electricity expense at least $1.7 million per year. Reduced energy demand was also expected to lower greenhouse gas (GHG) emissions by 5,000 tons per year.

Lighting loads in buildings and residences account for about 30%–40% of the Philippines' total electricity consumption. Office buildings built before 2000 were more likely to have fluorescent lamps with magnetic ballasts and, in most cases, incandescent bulbs with minimal use of natural lighting. Therefore, the DOE raised the target to 135 government buildings,[4] increasing energy savings and lowering emissions.

Retrofitting began in September 2012 and was completed in June 2013. Three key factors contributed to the successful implementation of the project: enabling government policies, an efficient project implementation plan, and availability of financial resources.

- *Enabling government policies.* Government policies fully supported retrofitting government office buildings with EELS. On 25 October 2004, years before program implementation began, former President Gloria Macapagal-Arroyo issued Administrative Order 110 (AO 110),[5] directing the institutionalization of a government energy management program. AO 110 mandated a 10% reduction in the cost of the government's monthly energy consumption for a minimum 3 years starting January 2005 and authorized the use of EELS. Due to budget constraints, most government agencies complied with AO 110 by using less air conditioning and turning lights off during lunch breaks and immediately after regular working hours. However, not all buildings were equipped with EELS.

[4] Government of the Republic of the Philippines, Department of Energy. 2012. Philippine Energy Efficiency Project: Expected Outcomes. May. http://www.phileep.org/index.php/expected-outcomes

[5] Government of the Republic of the Philippines. 2004. Administrative Order No. 110. October. https://www.gov.ph/2004/10/25/administrative-order-no-110-s-2004/

Issued on 9 July 2007, Administrative Order 183 (AO 183)[6] mandated all government agencies to use EELS. However, not all former government buildings have been retrofitted to comply with AO 183, mainly due to budgetary constraints.

- *Efficient project implementation.* In 2008, 140 government office buildings had not yet complied with AOs 110 and 183. Although available resources for the program covered only 40 buildings, the project implementation support consultant—the International Institute for Energy Conservation-Asia—developed a selection criteria to prioritize buildings for retrofitting. These buildings include government hospitals, schools and universities, and local government offices. A common set of selection criteria helped determine which buildings offered the greatest reduction in energy at the least cost, thereby accommodating more buildings in the program. After inspecting office buildings and recording their lighting loads and fixtures, the cost of replacing them with EELS was computed. Estimated energy consumption, potential savings, payback period, and the annual potential GHG emission reduction per building were calculated. A total of 135 government office buildings qualified for prioritization. The list also provided the DOE with a retrofitting budget requirement for each building, enabling identification of successive buildings when additional funds became available.

The Philippine Energy Efficiency Project distributed 8.6 million compact fluorescent lamps nationwide.

PEEP's most successful component focused on retrofitting of government buildings.

The DOE prepared a project implementation plan that was applied to all retrofitting projects. The plan included activities related to procurement, scheduling and installation, testing, and validation. An ADB-approved international competitive bidding process awarded the contract to supply, install, and commission EELS for government office buildings to a single entity. To ensure quality, all equipment and design was covered by a 2-year warranty.

[6] Government of the Republic of the Philippines. Administrative Order No. 183. http://www.gov.ph/2007/07/09/administrative-order-no-183-s-2007/

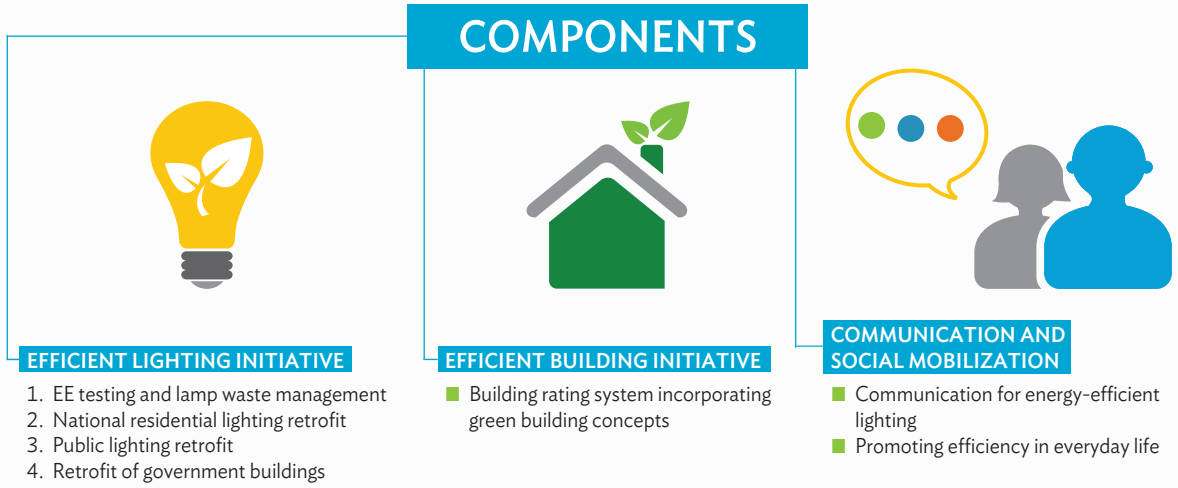
Close coordination between the contractor, the DOE, and other government counterparts and stakeholders was critical to efficient project implementation. Coordination also helped circumvent potentially negative impacts on building occupants, avoiding unwarranted delays.

Upon completion of EELS, the DOE and building representatives jointly inspected and validated all 135 buildings to ensure compliance with the lighting specifications for each building, check the electrical integrity of the new installations, and measure the resulting luminance. The project prepared inspection reports and validated documents such as delivery receipts, invoices, and official receipts before issuing a certificate of acceptance to the contractor.

Retrofitting began on 13 September 2012, a month behind schedule due to a delay in securing the necessary government permits. The retrofitting program was completed within 10 months. Some delays were attributed to customization, ongoing renovations, and schedule constraints.

PEEP also helped local government units replace old streetlights and traffic lights with more efficient lighting systems, establishing a model for standardizing public lighting and large-scale implementation. Local government units distributed 8.6 million CFLs to households. Figure 4.3.1 shows the main components of the project.

Figure 4.3.1: Components of the Philippine Energy Efficiency Project



EE = energy efficiency.

Source: E. Reyes. 2012. Philippine Energy Efficiency Project. Presentation at the PEEP-EBI Inception Workshop. 23 October. F1 Best Western Premier Hotel, Bonifacio Global City, Taguig City.

RESULTS

Between January 2009 and December 2013, the project retrofitted 135 government office buildings and almost 4,000 public park and streetlights with EELS. It also distributed 8.6 million CFLs nationwide and established an efficient building rating system for new and retrofitted buildings, based on similar ratings models in many other countries, and certified 32 government buildings as "green."

Retrofitted government office buildings reduced the cumulative lighting load about 2.72 MW (34%), or 9.6 GWh, per year, saving almost a third of the buildings' average energy consumption. The average level of illumination improved 50%. The payback period for the investment was 2 years without lighting replacement units and 4 years with replacement. Thus, government agencies complied with AOs 110 and 183, reduced electricity costs, and helped mitigate impending power shortages. This saving would not have materialized without strong collaboration between ADB and the DOE during project implementation.

LESSONS

Enabling policy. Notably, an enabling government framework for energy efficiency contributed to the project's success. The government-decreed AOs provided directions on energy management at a time when energy efficiency was an unfamiliar concept among public agencies. It also became a starting point for projects such as PEEP to initiate more energy efficiency activities. Government energy policies, a road map, laws, and executive legislation are critical for providing a robust and sound legal basis for project proponents and stakeholders.

Flexibility. A flexible approach to project design and scope is essential. Initially, external forces made adjustments necessary. Although the original plan included only 40 buildings, the project management team expanded the target to 135 building while maintaining implementation efficiency.

Energy efficiency lighting is a sound investment. EELS will result in significantly lower energy demand, consumption and, more importantly, energy savings. Whether borrowing from the markets or using internal resources to implement energy efficiency measures, EELS is a feasible option when considering return on investment and payback period. This success may further stimulate the government to retrofit cooling and refrigeration systems and motor loads of government buildings while involving the private sector.

Keywords

Energy efficiency, compact flourescent lamp, CFL, energy-efficient lighting systems, EELS, retrofitting, green buildings, Philippines

For further reading

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- http://www.adb.org/features/bright-idea-energy-reduction

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SUPPORT TO INDONESIA EXIMBANK

Building Capacity for Energy Efficiency

Compact fluorescent bulbs use only 20%–33% of the electric power used by ordinary light bulbs, and last 8–15 times longer.

- Energy efficiency in Indonesia needs to be mainstreamed in the face of its increasing energy consumption and greenhouse gas emissions.
- The industry sector has the highest rate of energy consumption in the country, comprising 40% of the total in 2009.
- The Asian Development Bank partnered with Indonesia Eximbank to pioneer energy efficiency financing, focusing first on export-oriented companies.
- Indonesia Eximbank now offers a groundbreaking program for energy efficiency financing program that integrates loans with technical assistance on energy efficiency project conceptualization and energy audits. If this is implemented across various industries in the country, it could create a virtual power plant with a capacity of up to 2,500 megawatts.

CONTEXT

Despite potential to offer a $4 billion market for commercial banks and the industry sector, mainstreaming energy efficiency in Indonesia has been a slow process.[1]

Energy efficiency manages and restrains energy consumption. An appliance or equipment is energy-efficient if it produces the same output or service using less electricity or fuel compared to older versions of the same fixture. For example, a compact florescent light (CFL) uses less energy (20%-33%) than an incandescent bulb to produce the same amount of light.[2]

One possible reason why energy efficiency has not taken off in the country, despite the benefits it offers is the difficulty of getting the buy-in of stakeholders since energy subsidies in the country have increased in recent years. In 2009, fuel, electricity, and liquefied petroleum gas (LPG) subsidies totaled IDR45.04 trillion (about $5.06 billion), IDR53.72 trillion (about $6.04 billion), and IDR7.78 trillion (about $0.87 billion), respectively.[3]

Indonesia needs an energy efficiency financing program due to increased energy consumption and a power supply mix that remains dependent on fossil fuels. Except during the 1997 global financial crisis, primary energy consumption has increased 3.5% every year since 1990 and final energy consumption has grown at the same rate. In 2009, oil provided 32% of all energy, compared to coal (19%), biomass (27%), natural gas (18%), and primary electricity (hydroelectricity and/or geothermal) (4%). The choice of fuel has serious implications for supply security, sustainability, and climate change, and power supply shortages have already begun to surface near Java. In addition, carbon dioxide emissions increased more than 7% every year during the 1990s, reaching 270 million tons in 2000.[4]

The industry sector is one of Indonesia's largest energy consumers (Figure 4.4.1). The share of industry in final energy consumption is increasing and reached 40% in 2009. In comparison, the combined share of households, services, and agriculture decreased from 55% in 1990 to 43% in 2009, while the share of transport is 18% (up from 14% in 1990).[5] Even if companies curbed usage, delivery constraints and lack of understanding in the banking sector limits access to energy efficiency financing.

PROJECT SNAPSHOT

LOAN APPROVAL DATE:
March 2011

LOAN AMOUNT:
$200 million

BORROWER:
Indonesia Eximbank

EXECUTING AGENCY:
Indonesia, Eximbank

GEOGRAPHICAL LOCATION:
Indonesia

TYPE OF ENERGY PROJECT:
Energy efficiency

PROJECT COMPLETION DATE:
March 2015

1 Asian Development Bank (ADB). 2009. ADB Conference Promotes Investments in Indonesia's Energy Efficiency Sector. News release. 26 November. Manila. http://www.adb.org/news/adb-conference-promotes-investments-indonesias-energy-efficiency-sector

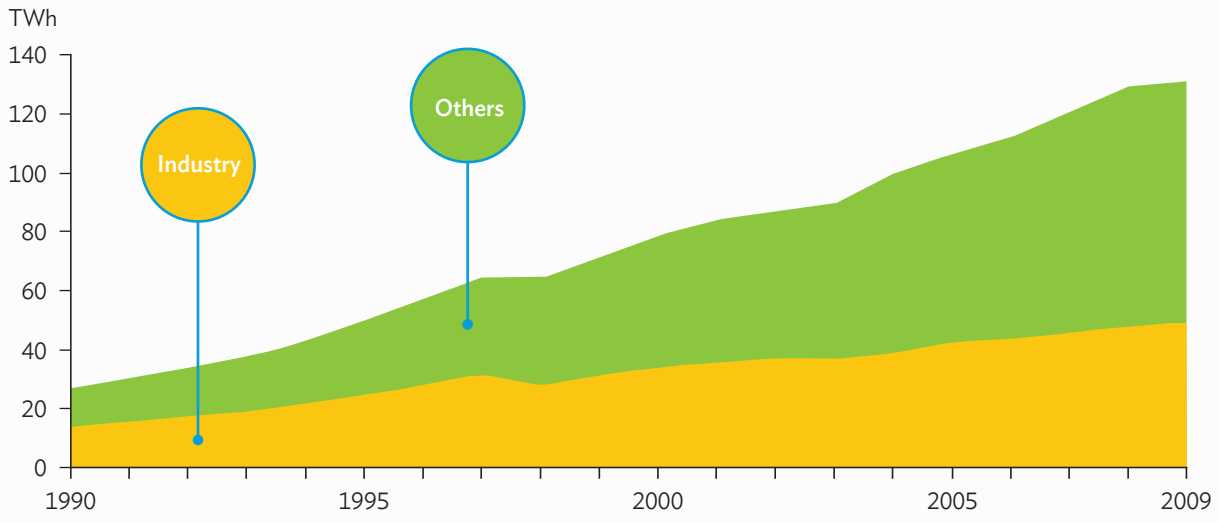
2 International Energy Agency. Energy Efficiency. http://www.iea.org/topics/energyefficiency/ (accessed 14 November 2014).

3 Asia-Pacific Economic Cooperation. 2012. *Peer Review on Energy Efficiency in Indonesia.* June. http://aperc.ieej.or.jp/file/2013/7/23/PREE_201206_Indonesia.pdf

4 World Bank. 2013. Indonesia and Energy. http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/EASTASIAPACIFICEXT/EXTEAPREGTOPENERGY/0,,contentMDK:20506301~pagePK:34004173~piPK:34003707~theSitePK:574015,00.html#Protecting_environment

5 ABB. 2011. *Trends in Global Energy Efficiency. Country Reports: Indonesia.* www05.abb.com/global/scot/scot316.nsf/veritydisplay/1a65dd16a3c538acc125786400514251/$file/indonesia.pdf

Figure 4.4.1: Electricity Consumption Trends by Sector



TWh = terrawatt-hour.

Source: Enerdata, as cited in ABB. 2011. *Trends in Global Energy Efficiency. Country Reports: Indonesia.*

Thus, in 2011, the Asian Development Bank (ADB) used the banking industry as an entry point to introduce a technical assistance package that aimed to increase awareness, build capacity, and demonstrate the viability of energy efficiency finance to commercial banks. Such assistance is part of ADB's up to $200 million investment in Indonesia Eximbank (Eximbank),[6] the country's export credit agency, which functions as a quasi-government body that provides funding, guarantees, and/or insurance, as well as supporting advisory services to Indonesian enterprises into exports.[7] ADB's partnership with Eximbank became the gateway for mainstreaming energy efficiency programs in the industry sector.

SOLUTIONS

Raising awareness on energy efficiency financing. Although ADB first introduced the concept of energy efficiency financing to Eximbank in 2011, its work on raising awareness was already under way in Indonesia. In 2009, an ADB conference, "Financing $4 billion Energy Efficiency Solutions in Indonesia," gathered nearly 200 representatives of commercial banks, government, and major industries to facilitate new financing opportunities for energy efficiency and renewable energies. This first step was crucial because the concept of energy efficiency financing was fairly new in Indonesia. It also tapped the services of a recognized international expert with an established track record successfully implementing solutions for energy efficiency finance across a

[6] ADB. 2011. *Proposed Loan and Administration of Technical Assistance Grants to Indonesia Eximbank.* March. Manila. http://www.adb.org/sites/default/files/projdocs/2011/44906-01-ino-rrp.pdf

[7] Indonesia Eximbank. 2014. Indonesia Eximbank in Brief. http://www.indonesiaeximbank.go.id/en/about-us/indonesia-eximbank-in-brief

range of economies. This was an essential step in securing participation because the proposed lending tools had to comply with Eximbank's loan documentation and risk management procedures.

Building capacity for energy efficiency financing. Capacity-building activities for this project are groundbreaking in a sense, since these were the first of such series of training in Indonesia by an international financial institution. Numerous workshops within Eximbank specifically targeted the knowledge void on energy efficiency among staff and management. Participants received hands-on training in the development and application of energy efficiency finance products and the evaluation of projects. The workshops also provided guidance on marketing and promotion of energy efficiency financial products. To deepen knowledge, mentoring sessions within Eximbank's divisions were conducted because the financing programs required structural and behavioral changes within the bank. To close the knowledge gap, ADB provided capacity-building activities at both the supply side (i.e., within the bank) and the demand side (i.e., for Eximbank's clients, local service providers, contractors, vendors, and other commercial banks).

Development of Eximbank's Energy Efficiency Project Finance Program. The training workshops and mentoring sessions were instrumental in developing the Eximbank's Energy Efficiency Project Finance Program (EEPFP), which aimed to reduce barriers to energy efficiency financing for export industries. EEPFP is a loan program that targets companies using three significant features: (i) low collateral, (ii) free technical assistance, and (iii) generation of positive cash flow. Companies seeking EEPFP loans need not present collateral because the savings generated by an energy efficiency project are sufficient. They also receive free technical assistance in concept development and/or an investment-grade audit that includes a comprehensive cost/savings analysis of potential energy savings opportunities. EEPFP helps generate positive cash flow by ensuring that savings from an energy efficiency project cover the monthly loan installments. These features were designed to encourage export companies to apply for energy efficiency project loans.[8]

Development of the Energy Efficiency Savings Guarantee. To encourage commercial banks to participate in the joint financing of energy efficiency projects, a savings guarantee was integrated into the program. This reduces the risks commercial banks face in accepting new cash flow generated from the savings made by the projects, which is the main source of repayment and collateral of the borrower company. The guarantee covers any shortfalls between the project savings and the amount needed for the borrower company to service the loan to the bank. It guarantees that cash flow generated by new energy efficiency project will increase borrowers' credit capacity.

Implementation of the first energy efficiency project loan. Eximbank implemented its first energy efficiency project EEP loan in January 2014, lending PT Tiga Pilar Sejahtera Food (AISA), a publicly listed food company, Rp16 billion ($1.31 million) to reduce its energy consumption through six energy efficiency measures. These measures, which include retrofitted lighting, insulation, and temperature-control equipment, will help AISA save up to Rp6.3 billion in energy costs per year.[9]

[8] D.S. Batipiran. 2012. *Energy Efficiency Project Finance Program*. http://asiacleanenergyforum.org/acef2013/images/stories/2013pdf/Day-3/Session-19/Dilan-Batuparan.pdf

[9] T. Sipahutar. 2014. Eximbank Starts Energy Financing Program. *Jakarta Post*. 25 January. http://www.thejakartapost.com/news/2014/01/25/eximbank-starts-energy-financing-program.html

RESULTS

Availability of financial instruments for energy efficiency. Energy efficiency financing is a hugely untapped opportunity in Indonesia, but no commercially viable project or financing scheme had been put in place prior to the integrated technical assistance support. If companies relied on their own funds to finance such projects, they would need to divert resources from their core operations. Consequently, few to none took the risk of shouldering projects, and lack of knowledge and limited expertise were significant hurdles. Doubts about quantifying the energy efficiency to amortize loan repayment caused many companies to hesitate. Using Eximbank's EEPFP, companies can access a financial instrument designed for their specific needs and capacities.

Companies' readiness for ISO 50001. The International Organization for Standardization (ISO) recently targeted energy management as a global priority to save energy and reduce greenhouse gas (GHG) emissions (footnote 6). ISO 50001 emphasized the importance of energy efficiency by developing an energy management system.[10] Through technical assistance for project conceptualization and energy audits, Eximbank's EEPFP can facilitate exporters' compliance with this new standard.

Reducing energy consumption and greenhouse gas emissions. ADB estimates that energy efficiency could reduce demand by 2,500 megawatts, roughly equivalent to the electricity shortfall calculated by Indonesia's state electricity company (footnote 6). Lower energy consumption will, in turn, contribute significantly to lower GHG emissions.

LESSONS

Sufficient lead time. As of March 2015, the technical support to Indonesia Eximbank has been running for 3 years. This is a relatively short time, considering the project team was required to undertake a case-by-case approach to capacity development and project due diligence, in order to analyze the costs-benefits of each transaction under the energy finance facility, in close consultation with Eximbank's finance officers and managers. The EEPFP also formed a close liaison with the management and operating division teams in the exporting companies/borrowing client. The customized approach to energy efficiency finance requires intensive capacity development and generous implementation timelines to support "proof of concept" by both the project developer and the financier.

Subsidies may slow down energy efficiency projects. Because long repayment periods under low energy tariff regimes deter energy savings, an energy efficiency knowledge gap may persist in subsidized markets.[11] Subsidies become a disincentive to managing energy consumption. In this area, Indonesia will need policies favoring the growth of energy efficiency to support smooth and gradual penetration of energy efficiency across industries with varying sources and intensity.

Forming a competent team. The sustainability of energy efficiency financing is predicated upon an integrated team, particularly in a pioneering country. For future replication, project implementers must remember that the finance team will be the go-to unit of businesses. Thus, building a competent team is paramount. The energy

[10] International Organization for Standardization. 2011. ISO 50001 – Energy Management. http://www.iso.org/iso/home/standards/management-standards/iso50001.htm

[11] T. Dreessen. 2012. EEP Finance Program of: Indonesia Eximbank (IEB). Presentation to the 2012 Clean Energy Forum. 6 June. ADB, Manila.

efficiency team is a one-stop shop where companies can access, develop, and process project loans.

Establishing a comprehensive loan framework for energy efficiency financing. In addition to the energy efficiency team, Indonesia needs to develop sound loan and guarantee products. In this context, loan products must not only have attractive financing terms, but also need to integrate technical assistance for project conceptualization and feasibility. This is essential, especially in areas where energy efficiency is a novel and untried concept. Compared to other types of financing instruments, energy efficiency loans require more information from borrowers. Implementation requires judicious planning on energy efficiency measures because the novelty of specialized financing may be considered higher risk. Appropriate planning influences the amount of savings that a project can generate. The savings provide cash flow to the company which also serves as collateral and payment. These are the major requirements for loan approval. Thus, a comprehensive loan framework is a prerequisite for facilitating the development of energy-efficient finance.

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Energy efficiency could reduce Indonesia's energy demand by 2,500 megawatts.

Improved knowledge base for energy efficiency financing. Knowledge about energy efficiency financing is the pillar of a successful loan program. Backed by skills and know-how, a comprehensive loan framework will help ensure that staff is ready to offer and explain energy efficiency financing and competent to help prospective clients throughout the entire process. An improved knowledge base can help overcome the confidence barrier in accessing loans or joint financing by other banks.

Keywords

Energy, energy financing, energy efficiency, energy efficiency financing, energy efficiency projects, Indonesia, Eximbank, Indonesia Eximbank

For further reading

- http://adb.org/projects/details?proj_id=44906-014&page=overview
- http://adb.org/projects/details?page=details&proj_id=44906-014
- http://www.adb.org/projects/documents/nonsovereign-loan-indonesia-eximbank-0

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Knowledge and Power

Lessons from ADB Energy Projects

"As the largest development finance institution in Asia and the Pacific, the Asian Development Bank (ADB) has provided to its developing member countries (DMCs) over $28 billion in loans and grants for energy-related projects from 2008 to 2014. Though significant, this amount only represents a relatively small fraction of the DMCs' huge investment requirements in the energy sector.

ADB's value addition through its operations is far beyond the amount of money it provides—it is with the wealth of knowledge and suitable practices that it brings to its DMCs. This publication features 15 recent noteworthy projects as case stories (contexts, solutions, results, and lessons) that were implemented in Bangladesh, Bhutan, the People's Republic of China, India, Indonesia, the Federated States of Micronesia, the Philippines, and Uzbekistan in the areas of energy efficiency, solar energy, geothermal, waste-to-energy, advanced coal technology, and electricity interconnection. This is definitely a must-read for policy makers, project managers, and development partners in the world of energy."

Yongping Zhai, Technical Advisor (Energy), Asian Development Bank

About the Asian Development Bank

ADB's vision is an Asia and Pacific region free of poverty. Its mission is to help its developing member countries reduce poverty and improve the quality of life of their people. Despite the region's many successes, it remains home to the majority of the world's poor. ADB is committed to reducing poverty through inclusive economic growth, environmentally sustainable growth, and regional integration.

Based in Manila, ADB is owned by 67 members, including 48 from the region. Its main instruments for helping its developing member countries are policy dialogue, loans, equity investments, guarantees, grants, and technical assistance.

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