

Clean Energy in Asia

Case Studies of ADB Investments
in Low-Carbon Growth

Asian Development Bank

ADB—Supporting Clean Energy throughout Asia and the Pacific

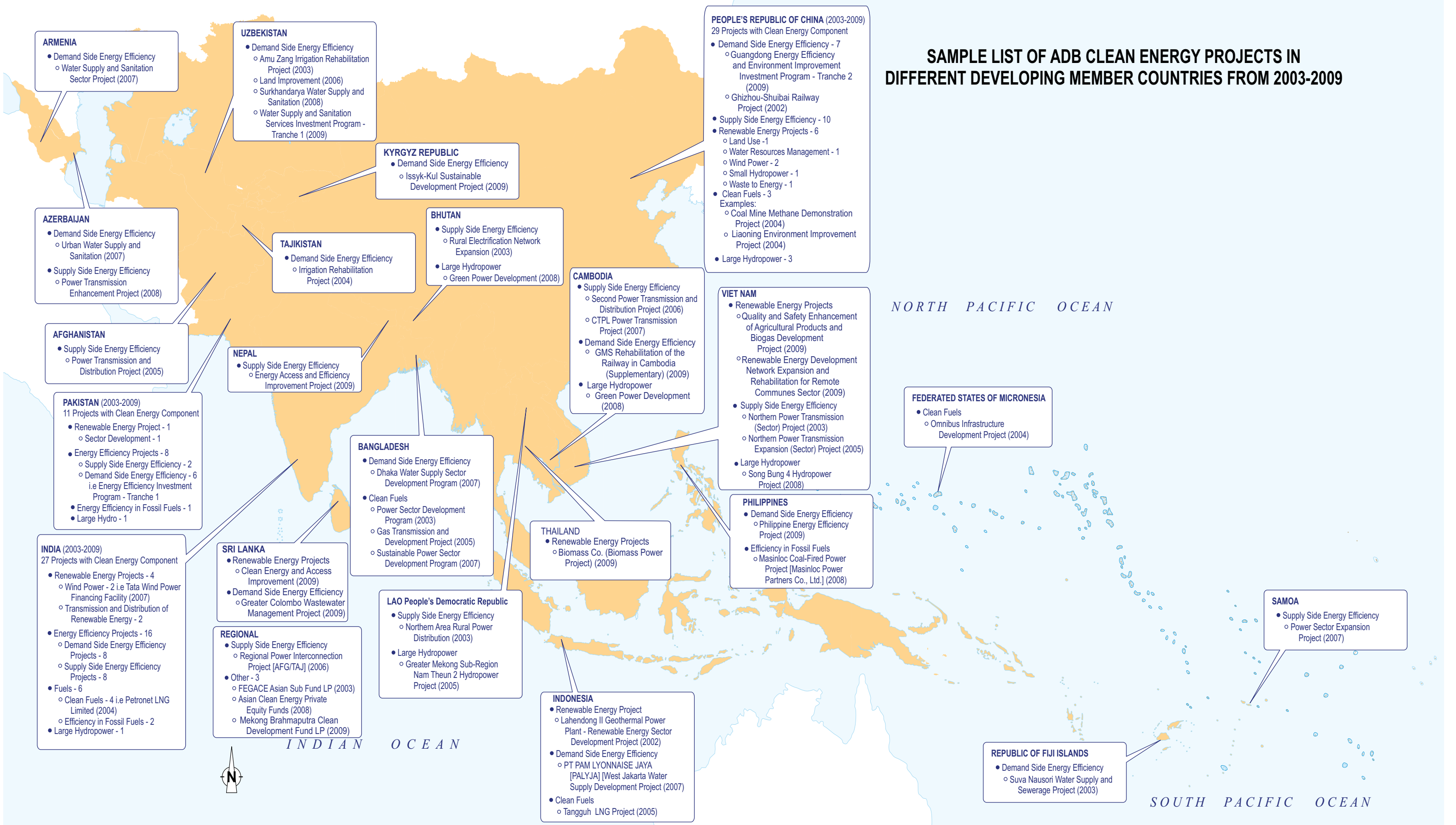
ADB's efforts to support and promote clean energy can be traced back to the hot button environmental issue of greenhouse gases that took root in the public consciousness in the 1990s. In 1995, ADB expressed its policy initiative for the energy sector, which supported increased energy efficiency in production, transportation, and the end use of energy in addition to integrating environmental concerns into energy planning.

The years since have brought clean energy more sharply into focus for ADB and Asia and the Pacific. More than a response to looming climate change,

clean energy is seen as a solution to multiple issues that still weigh on ADB's developing member countries. These issues include energy security through lowered dependency on fossil fuels and bringing modern energy to the millions in Asia that have zero or limited access to it.

Clean energy is defined operationally by ADB as energy efficiency and renewable energy. Energy efficiency is a prime consideration in the region because of aged infrastructure, including both the power plants that generate it and the systems that transmit and distribute power.

**SAMPLE LIST OF ADB CLEAN ENERGY PROJECTS IN
DIFFERENT DEVELOPING MEMBER COUNTRIES FROM 2003-2009**



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Industries and buildings investing in energy-saving measures need the technical and financing support of energy service companies (ESCOs). ADB is supporting ESCOs to encourage this fledgling sector in Asia.

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Note: In this publication, "\$" refers to US dollars.



- Monks at a monastery in Nepal—
Solar-powered lamps enabled
them to study at night

Foreword

The economic success of Asia and the Pacific has resulted in millions lifted out of poverty with Asian nations and economies held up as sterling examples of development. This success would not have been possible without the energy to fuel it, and there lies both the future promise of Asian success and some perils.

Developing Asia's demand for energy has only risen, and is predicted to stand at 2.4% growth per year versus an expected 1.5% for the rest of the world. This level of demand raises great concerns on energy security and combating climate change, and has made energy a high priority in policy decisions by governments and international finance institutions alike. Ultimately, the solution to these concerns must be appropriate for the region and its people; but we understand that in the light of climate change, this demand must be met by a greater commitment to clean energy through renewable power and energy efficiency. Cost and access are also major issues that must be dealt with, as about 800 million people in the region still have no access to electricity.

In response to these challenges, ADB's work in the energy sector has evolved to focus on cleaner and more sustainable energy lending. What began, earlier this decade, as interventions in electricity expansion projects—oil and gas sectors, and power sector reforms—have now advanced to investments in energy efficiency, renewable energy, and access to energy. Today, ADB supports a low-carbon growth path for energy development in Asia and the Pacific—way toward a reliable, secure, and sustainable future for the region.

Our commitment toward these goals is anchored on ADB's Energy Policy, which increases the original target of \$1 billion annual clean energy investment to \$2 billion starting 2013. ADB's Clean Energy Program will meet this target by building on the accomplishments and lessons learned from successful earlier initiatives such as the Asia Least-Cost Greenhouse Gas (GHG) Abatement Strategy; Promotion of Renewable Energy, Energy Efficiency, and GHG Abatement Project; and the Energy Efficiency Initiative. Supported by the Clean Energy Financing Partnership Facility and other initiatives, the program seeks to help developing member countries (DMCs) increase their investments in energy efficiency and renewable energy, access to energy, and energy sector reform, capacity building, and governance. Innovative project approaches and financing that were piloted in DMCs with high clean energy potential are ready to be scaled up and replicated in smaller DMCs. The program is also expanding its assistance to mainstream clean energy components in projects on water supply and sanitation, urban, transport, and agricultural sectors.

This publication features 10 stories from 10 clean energy projects implemented in six countries. Through these stories we hope to share how ADB is striving to change the face of energy lending into a cleaner and more sustainable route toward energy security and low-carbon growth. They also serve to show how developing Asia is contributing to the global effort to identify and implement solutions to combat climate change. We hope the stories told in this publication inspire and guide our colleagues in ADB and our partners in the region. Our common goal is to ensure a better tomorrow for all the people of Asia and the Pacific.

Xianbin Yao
Director General
Regional and Sustainable Development Department

Looking Ahead —and Back

By encouraging innovation and retrofitting, ADB's clean energy programs are helping the shift toward lower-carbon economies and improving life for the poor

The challenge is clear—and daunting. As developing Asia and the Pacific continue to modernize and industrialize, the region's energy needs are expected to double over the next 20 years. The challenge is to meet these needs while trying to stem accelerating greenhouse gas emissions (GHGs) that contribute to climate change.

By promoting clean energy—diversifying from fossil fuels that produce GHGs—the Asian Development Bank (ADB) is helping allay climate change and benefit the poor by cutting electricity bills and improving air, water, and soil quality.

To leverage its assistance—and ADB aims to double clean energy investments to \$2 billion annually from 2013—ADB is supporting clean energy programs with a demonstration effect in a range of fields.

Many of the examples in this publication are taken from ADB's recent, wide-ranging programs to improve energy efficiency in the People's Republic of China (PRC), Nepal, Pakistan, and Philippines. More energy efficiency projects are in the pipeline.

Such programs typically include a mix of support for forward-looking technology as well as for retrofitting. ADB plays a catalytic role in encouraging energy-efficient technologies—in fields such as quality compact fluorescent lamps (CFLs) or light-emitting diode (LED) lighting—until they gain sufficient acceptance and financial viability to attract more private investors and commercial banks.

Similarly, ADB supports retrofitting—replacing aging machinery and systems with newer and more energy-efficient motors, boilers, and transformers, as well as lighting and heating and/or cooling systems. This is another important area where companies can cut costs, energy and reduce pollution, but is slow to take off.

The first few case studies illustrate ways that countries can develop renewable energy from their natural resources. Two stories feature Nepal which, sitting at the foot of the Himalayas, receives an abundance of water and sunshine. An innovative project shows how Nepal is harnessing the sun's energy to power street lights that are often left in the dark by lengthy electricity cuts. New solar powered lamps in major cities are



- **More efficient**—Families in the People's Republic of China (above) benefit from a more efficient district central heating system; Nepal will use solar-powered street lamps to illuminate tourist spots like historic Taumadhi Square (below) in Kathmandu





- **Changes for the better—**
Cooking (above) under a compact fluorescent lamp (CFL) in Manila, Philippines; Village girls (below) in India near a wind energy project that will reduce power outages



expected to reduce traffic accidents and increase personal safety for residents and tourists.

Hydropower provides almost all of Nepal's electricity, but demand still outstrips supply by a wide margin. One hydropower project underscores that it is as important to rehabilitate aging plants as it is to build new ones. In makeovers for two run-of-river projects, the rehabilitation of an excitation system or an automated gate control system can add millions of units of electrical energy annually to the grid.

Wind is a renewable energy source being exploited by India's western coastal states. A case study features two wind energy projects based on an innovative business model of collaboration between a private developer and strategic investors. With ADB loans, two major energy companies have invested in wind farms that are developed and operated by a leading German wind energy firm that also manufactures high-tech windmills in India. It is hoped such a model will spur similar investments in other parts of the country.

Meanwhile, Indonesia, located on the Pacific Ocean's "ring of fire," is making increasing use of its underground steam. On the volcanic island of Sulawesi, ADB is helping the government develop huge geothermal reserves that will meet 50% of the main grid's peak demand. ADB is also helping the government with plans to boost geothermal power's share of the total energy mix—and reduce GHG emissions by at least 26% by 2020.

The use of gas—a cleaner fuel than coal or oil—is the topic of two case studies. In the PRC, a project in Shanxi province demonstrates the latest technologies in capturing methane gas from coal mines—where it can cause deadly explosions—and converting it to a clean, safe, and cheap fuel for transport, lighting, heating or cooling, and cooking. If replicated, this could have a significant impact on mitigating climate change.

In India, ADB is backing a project to import liquefied natural gas to increase energy security and promote clean energy. The project converts liquefied natural gas into compressed natural gas (CNG) and distributes it to transport services as well as to industry and household consumers. A case study shows how downtown Vadodara in Gujarat state is congested with traffic, but is far less polluted than other busy Asian cities because 70% of its three-wheel auto rickshaws and all its inner city buses run on CNG rather than diesel or gasoline.

The use of new technology to produce energy savings is well illustrated in a district central-heating project in Liaoning province, PRC. The project has replaced hundreds of highly polluting coal-fired boilers in several cities with larger and more energy-efficient boilers that employ wet dust collection technology to remove 96% of polluting substances from emissions. The result is the delivery of a more efficient heating service to more people with much less pollution.

In addition to stand-alone energy projects, ADB funds clean energy components of projects in

transport. This sector is one of the largest and fastest-growing sources of GHG emissions, accounting for over 20% of global carbon dioxide emissions. In Asia, transport's share of total carbon dioxide emissions is projected to rise from 12.5% in 2005 to 13.7% by 2030. The increase in demand for private cars and other forms of fossil fuel-burning transport in developing Asia is outweighing the gains of using cleaner fuels such as CNG.

One way to offset this is to encourage use of the railway over the road. A case study shows how an all-electric railway project in PRC's mountainous western province of Guizhou is carrying millions of tons of freight and thousands of passengers that would otherwise travel by oil-consuming trucks, buses, and private vehicles. Using grid-connected power to run a transport system is less GHG-emitting than the internal combustion of engines.

A case study on technology that is producing more energy efficient lighting affects ordinary consumers as well as large power grids. ADB is backing projects to use more high-quality CFLs in several countries. At the same time, it is backing the development of LEDs, solid-state electronic light sources that use semiconductors to emit light when receiving electricity. LEDs are being used in Asia mainly for tunnels, traffic lights and remote controls, but are expected to be used for residences and offices increasingly as technology advances and costs fall.

National campaigns in Pakistan and the Philippines to replace, free of charge, millions of incandescent light bulbs with energy efficient and longer lasting CFLs will reduce electricity consumption. This will lower electricity bills, especially for the poor, who use more electricity for lighting than for appliances. Importantly, this will cut peak demand on power grids by hundreds of megawatts and will be equivalent to creating a "virtual power plant." By turn, this saves millions of dollars in deferred investment in new plants and equipment as well as reduced oil imports.

More efficient lighting will lower electricity bills and cut peak demand on power grids, rather like creating a "virtual power plant."

ADB plays a catalytic role in encouraging energy-efficient technologies until they gain financial viability to attract more private investors and commercial banks.

The final case study shows how ADB is encouraging companies that provide retrofitting services as well as a way of financing them. Although retrofitting brings significant gains, it is catching on only slowly. Retrofitting ranks low among corporate priorities. Moreover, companies do not generally include energy efficiency improvements in their annual maintenance budgets.

To make retrofitting an easier sell, energy service companies (ESCOs) provide innovative financing schemes under which industries pay for retrofitting not with cash but through savings in their energy bills.

But deferred payments mean that ESCOs, especially the smaller ones, also run into cash flow problems. To help them, ADB is assisting ESCOs either directly with loans or indirectly by providing partial credit guarantees to the commercial banks that finance them. In the Philippines, ADB is also helping establish a state-run “super ESCO” that will operate as an ESCO to retrofit public sector projects and provide financial and technical support to ESCOs that service the private sector.

Political and societal will to slow down climate change is growing—but it often takes time to translate will into effectiveness. These case studies show that ADB has an important role in helping countries make this transition.



- Villagers near a geothermal plant in north Sulawesi, Indonesia—Blackouts are frequent on a volcanic island with plenty of hot steam reserves to develop



- Precursor of the future—Solar lamps have been installed on the grounds of a monastery near the ancient Swayambhunath temple in Kathmandu

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Lighting Up the Dark

KATHMANDU, NEPAL

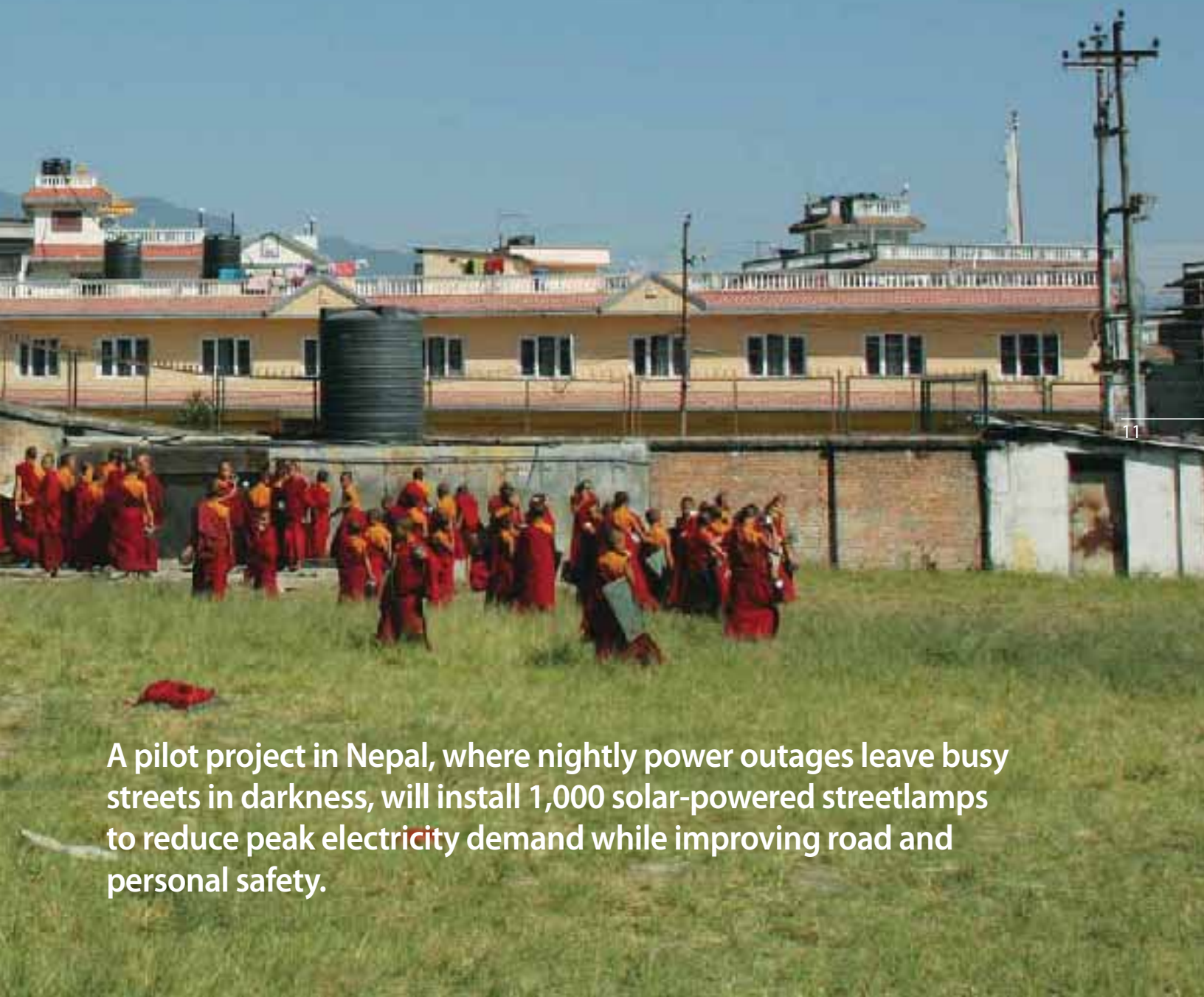
The tranquil grounds of a Buddhist monastery are an unlikely place to glimpse the future of bustling streets in Nepal.

But a monastery near the ancient Swayambhunath temple in Kathmandu has within its grounds solar-powered lamps that will soon be seen in main streets and tourist spots of Kathmandu, Bhaktapur, and Lalitpur.

The monastery's eight lamps—the gift of a benefactor—are charged by the sun and provide free, uninterrupted power at night in a city where nocturnal blackouts are frequent. Some 170 red-robed monks, many of them trainees, use the lamps to study in the evenings.

In the adjoining city of Lalitpur, solar lamps also illuminate the United Nations compound at night. Their main purpose is security. Not only does the glare from 17 lamps deter intruders but they also clarify images recorded on 24-hour closed-circuit television.

From 2010, 1,000 solar streetlamps will be installed around city centers under one component of an Energy Access and Efficiency Improvement Project financed by a \$65 million concessional loan from ADB. The project is cofinanced with grants of \$4.2 million from the Clean Energy Financing Partnership Facility—supported by the governments of Australia, Norway, Spain, and Sweden—and \$300,000 from the Climate Change Fund.



A pilot project in Nepal, where nightly power outages leave busy streets in darkness, will install 1,000 solar-powered streetlamps to reduce peak electricity demand while improving road and personal safety.



- **More tourist-friendly**—The steep stone steps leading to the Swayambhunath temple will be safer to ascend and descend in the dark (top); Renu Sahi (standing) can keep her stall by the Nyatapola temple in Bhaktapur open longer (left)

The lamps will either replace grid-fed lights or illuminate presently unlit areas. As well as reducing peak demand on an overburdened power grid, the lamps will improve road safety and personal security in high-profile areas frequented by both tourists and low-income vendors.

The solar streetlamps will cost \$2,000 a piece but, once installed, they should provide virtually free, renewable energy for 20 years, recouping their investment within 5 to 7 years, says Priyantha Wijayatunga, an ADB energy specialist working on the project. Maintenance costs will be light though the solar panels will have to be cleaned regularly and batteries will need to be replaced periodically. Importantly, the lamps will provide uninterrupted light in places that especially need it.

In the medieval city of Bhaktapur, for example, solar lamps will illuminate the large, cobblestoned Taumadhi Tole (Temple Square), where vendors ply Gurkha singing bowls, pashmina shawls, and other Nepali handicrafts. The square begins to empty as darkness falls.

But when solar lamps extend daylight, tourists will stay longer and vendors like Renu Sahi, standing at her table of masks beside the five-storied Nyatapola temple, says she will be able to extend her business until 9 pm or later.

The lamps will also strengthen community spirit as people will congregate till much later at night in the square—a trading and social center since camel caravans traveled between the People's Republic of China and India—says Shree Byanju, manager of a prominent local restaurant.

At the Swayambhunath temple in the capital, accessible only by steep flights of uneven stone steps, solar lamps will add a degree of safety.

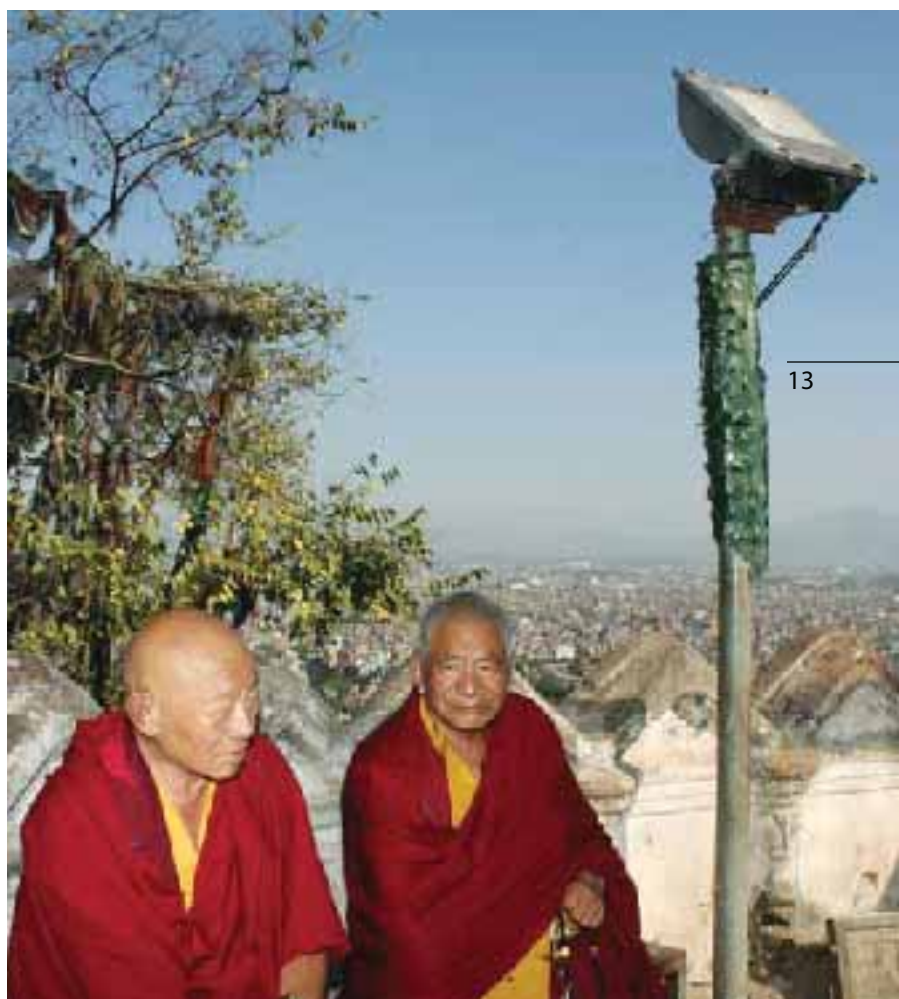
"We have families, including grandparents and children, coming in the evening for *puja* ceremonies (to supplicate the Gods for success in a venture)," says Asok Buddhacharya, who has a food stall only yards away from the stupa's white-washed dome and spire. Going up and down the steps is hazardous in the dark, he says, noting that people have fallen and been taken to hospital for treatment.

Over at congested New Road, which leads to Kathmandu's famed Durbar Square with its palaces and temples, solar streetlights are seen as a traffic aid as well as a deterrent against crime and harassment.

"The risk of an accident is higher during blackouts at night, so solar lamps will improve road safety," says police sub-inspector Prakash Ghimre, who works in the central district. "The lights will also deter pickpockets who like to operate in this area."

A few yards away, Tara Bhat, one of a number of fruit sellers squatting by a wall, says she is sometimes harassed by drunks at night. "I hope the lights will stop them and that we can sell our fruit for longer hours," she says.

- **Beating power cuts**—Consultant Basanta Saptoka stands next to a solar-powered lamp in the United Nations' compound (top); A solar light will replace grid-fed lighting at the Swayambhunath temple (right)





“The risk of an accident is higher during blackouts at night, so solar lamps will improve road safety. The lights will also deter pickpockets who like to operate in this area.”

Prakash Ghimre, police sub-inspector
in the central district of Kathmandu

Solar lamps may also improve personal security for vulnerable people, especially women and children, in certain poorly lit areas, says ADB’s Mr. Wijayatunga.

Some solar lamps are planned for Kathmandu’s Thamel district, where tourists shop and eat, but the positioning of these lamps has yet to be finalized. In narrow, winding streets that lack exposure to the sun, some solar panels may have to be installed on rooftops.

Under the ADB project, some hybrid lamps, using a combination of solar and wind power, will also be installed, but their locations will also be firmed up later.

Generally, the solar lamps will run on 60–80 watt light-emitting diodes, which use far less energy than the current 250-watt sodium vapor lights. In addition to the solar lamps, the ADB-backed project will distribute a million compact fluorescent lamps to households as an energy-efficiency measure to reduce peak demand for electricity. Together, these demand-side management components are expected to reduce CO₂ emissions by an estimated 15,000–20,000 tons annually.

To be sure, this Himalayan country has plenty of solar power potential as it averages some 300 days of sunshine a year. But all photovoltaic panels have to be imported and costs of the technology remain high, especially compared to that other source of renewable energy, hydropower, which mountainous Nepal also possesses in abundance.

The country relies on hydropower for 95% of its energy needs, but lack of investment and delays in implementing generation and transmission projects mean that ever-growing demand has been outstripping stagnant supply for the past few years.

Solar power is a useful supplemental source. In rural areas, the government subsidizes small-scale solar systems for households that don't have access to the power grid. Other solar systems are used in the sparsely populated hills to power water pumps, computer and telecommunication systems, and vaccine refrigerators in health clinics, says Basanta Saptoka, an ADB consultant who used to work for a company supplying solar systems.

In urban areas, too, a growing number of households are buying solar systems on their own account, for backup power and to charge the batteries that run invertors, the most popular backup system after diesel generators.

Aside from residential users, other major electricity consumers—the commercial and industrial sectors—will continue to rely on hydropower.

Even so, the solar streetlamp program, which will be implemented by the Nepal Electricity Authority, the state utility, will make a useful contribution in lowering peak electricity demand. This is important as daily power blackouts—which lasted 16 hours or more last winter—may get longer before load shedding improves.

Although the country faces long, dark winters, one consolation is that the new solar lamps will make life more convenient and safer in the city centers and help generate extra income for those that depend on tourism, one of Nepal's biggest earners.

- **Helping business**—Solar lights will help fruit seller Tara Bhat in Kathmandu (right) and a stone carver in Lalitpur (previous page, top) work longer hours and earn more money

“We have families, including grandparents and children, coming in the evening for *puja* ceremonies.”

Asok Buddhacharya, stall holder (below) at the Swayambhunath temple



MARSYANGDI, NEPAL

Januka Thapa runs a small eatery in the village of Dhaptar, a few kilometers from a hydropower plant in Marsyangdi. Yet every evening, during the restaurant's busiest period, her electricity supply is cut off for 1 or 2 hours.

Customers have to eat by the glow of a kerosene lamp as Ms. Thapa cannot afford either a generator or an inverter to provide backup power.

"The blackouts are bad for business, but we have to live with them," she says.

Frequent and lengthy power outages are part of life in this Himalayan country which, ironically, has one of the world's largest resources of clean and renewable hydropower. Nepal's installed electricity capacity is 634 megawatts (MW) but peak demand is 800 MW. Yet the country, which relies on hydropower for 95% of its energy needs, has the potential to generate 43,000 MW in economically feasible projects.

- The radial gates at Marsyangdi—
The gate control mechanism is to be fixed



River of Power

As the gap widens between Nepal's peak electricity demand and supply, ADB is financing the rehabilitation of aging hydropower plants.

With power demand growing at 9%–10% annually while supply remains stagnant, daily power cuts in the dry winter season lasted 16 hours or more in 2008 and similar blackouts can be expected in future.

Nepal has no shortage of offers to develop its hydropower potential, including agreements with its giant neighbors, the People's Republic of China and India. But major projects, including some backed by multilateral development banks, have been delayed or shelved for reasons that include political uncertainties, opposition over issues such

as resettlement and environment, and funding constraints.

Through a concessional loan of \$65 million for an Energy Access and Efficiency Improvement Project, approved in late 2009, ADB will implement a holistic package which includes rehabilitating aging hydropower plants, building new transmission lines, and promoting energy efficiencies on the demand side.

The project is cofinanced with grants of \$4.2 million from the Clean Energy Financing Partnership Facility—supported by the governments of Australia, Norway, Spain, and Sweden—and \$300,000 from the Climate Change Fund.

A small run-of-river hydropower project at Marsyangdi, 140 kilometers (km) west of Kathmandu, is typical of many older plants. The power station, which has three 23 MW units, began operating in 1989 with German mechanical and electrical parts.

"We are running out of spare parts that were provided at commissioning," says Kapil Manjan, the plant's assistant manager. "If we repair parts locally, this means a unit will be shut down for a longer period than if we had spare parts to hand."



- **Coping with blackouts—** Januka Thapa (left) juggles cooking times in her restaurant where power cuts come at the busiest times; Women in Kathmandu (above) also have to organize their lives around daily outages



- **Quality checks**—Laboratory analyst Kunji Yadav (left) conducts a sediment test to check for silt content before the water enters the reservoir; Technicians at the control room at Marsyangdi power station (above)

The powerhouse's excitation system, which affects the generating performance, is working at around 70% efficiency, says one senior engineer.

Moreover, the automated system for gate control isn't working at the weir and reservoir 7 km away; their manual operation also lowers the plant's efficiency.

The ADB project will rehabilitate the excitation and the weir control systems. It will also repair the automated weir control system at Gandak, a smaller plant with a 15 MW capacity.

"At both plants, the cleaning of the trash rack has to be done manually, which requires the plant to be stopped," notes Priyantha Wijayatunga, an ADB energy specialist. He estimates that the repairs will add 4 million units of electrical energy annually to the power system, equivalent to the consumption of 8,000 households.

The ADB project will also improve access to clean energy by constructing transmission lines, substations, and associated facilities. This will enable the state utility, Nepal Electricity Authority (NEA), to connect 20,000 new households and provide more reliable supply to 1.5 million existing customers.

In addition, strengthening the transmission network in Nepal's midwestern region will improve the ability to import energy from India in the medium term and export surplus energy in the long term.

The ADB project also includes pilot renewable energy and efficient lighting components to relieve peak power demand.

As well as financing solar-powered streetlamps (see story on page 10), it will provide a grant for the distribution of 1 million compact fluorescent lamps (CFLs) mainly to rural households.

By promoting energy-efficient lights—CFLs of between 9 and 20 watts will replace mainly 60-watt incandescent bulbs—this project will relieve peak electricity demand. Together with the solar streetlights, the CFL component is expected to reduce carbon dioxide emissions by between 15,000 and 20,000 tons annually. If successful, the number of distributed CFL lights could be increased to 4–5 million under another project.

The government's long-term target up to 2027 is to generate 4,000 MW to meet domestic demand and to export surplus power to increase foreign exchange earnings.

At present, only 40% of the country's 27 million people have access to electricity services, 33% from the state's grid and off-grid facilities, and 7% from microhydro plants developed mostly by local entrepreneurs.

The government seeks to cover 75% of the population through the national grid, 20% through isolated small and microhydropower systems, and 5% through alternative energy sources.

It will help meet these goals that some companies of the People's Republic of China are seeking joint ventures with Nepal's power producers to develop some hydropower projects while others are financing projects. Companies in India have also partnered with local companies to develop hydropower.

- The Marsyangdi river and the power station—Aging plant needs rehabilitation



But such projects have a lengthy lead time and the NEA expects the power situation to get worse before it gets better. “Load shedding is not so bad during the rainy season; it was about 10–12 hours a week last year,” says Sher Bhat, director of NEA’s systems operations department. “But we expect peak demand to rise and blackouts might average 12 hours a day in February and March 2010, which would be serious.”

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Meanwhile, one benefit of the crisis is that industrial and commercial enterprises are becoming more aware of the need to introduce energy efficiencies in their operations, says Ramesh Nepal, an ADB consultant who carried out energy audits on 350 companies and enterprises under an earlier project.

“Firms can achieve 20% energy savings, though most still prefer cheaper, short-term options and resist the more expensive measures with longer payback periods,” he says. The reluctance of commercial banks to finance energy efficiency investments is another constraint, he adds.

Such attitudes may change, however, if Nepal’s power crisis continues much longer.



“Load shedding is not so bad during the rainy season. It was about 10–12 hours a week last year.”

Sher Bhat, director (above) of Nepal Electricity Authority’s systems operations department

The project addresses major infrastructure barriers to improved energy access by investments in the transmission system, generation rehabilitation, distribution system, and efficiency in supply and demand, towards the goals of reliable and energy efficient power supply.

Rationale

Despite the large hydropower potential, Nepal experiences major generation capacity constraints. The country's generation mix is dominated by run-of-river and daily storage hydropower plants, which represent around 80% of total installed capacity. During the dry season, periods of acute capacity and energy shortages are frequent because of the dominance of these plants. Years of underinvestment in electricity generation, transmission, and distribution facilities have led to chronic supply shortages and network bottlenecks. As a consequence, the quality and reliability of supply provided to end consumers is one of the poorest in South Asia. Electricity supply is characterized by frequent unscheduled interruptions and long periods of scheduled supply outages. The power sector in Nepal presents a severe infrastructure constraint on economic growth.

Description

The project consists of seven components that hope to address three main challenges—energy access, clean energy, and capacity building. The stories presented features two components:

1. **Clean energy plant.** This involves the rehabilitation of run-of-river hydropower plants: a 69-megawatt (MW) plant in Marsyangdi and a 15 MW plant in Gandak, to increase the efficiency of their electricity generation and reduce self-consumption of electricity.
2. **Renewable energy for streetlighting.** 1,000 solar and solar-wind streetlights will be installed in Bhaktapur, Lalipur, and Kathmandu municipal areas to reduce streetlighting demand on the main electricity grid.

The other project components include the construction of transmission lines and distribution substations, distribution of more energy-efficient compact fluorescent lamps, and provision of expert services to the Nepal Electricity Authority to institutionalize public-private partnerships in project areas and project implementation support.

SUMMARY

Total Project Cost: \$93.7 million (with cofinancing from the Clean Energy Financing Partnership Facility and the Climate Change Fund)

Clean Energy Project Outcomes:

- Per capita lighting load reduced by 30% by the end of 2011 against without-project scenario
- Annual energy savings of approximately 23 gigawatt-hours (GWh)
- Minimum 15,000 tons annual CO₂ emissions reduction against the business as usual case by 2012

LESSONS LEARNED

Renewable Energy for Street Lighting Component


1. Small interventions such as rehabilitation of old equipment with more efficient technologies require small investments but produce significant impacts.
2. For a country like Nepal that experiences daily power shortages, improvements to the electricity system such as efforts that will

increase generation capacity and may be implemented within a short period, are worth exploring.

Clean Energy Plan Component

3. Streetlighting is a basic service that is often sacrificed first when system capacity is low. Through this investment, the project was able to:
 - supply the basic need of streetlights in Nepal's project areas.
 - relieve the power grid of capacity by using clean, stand-alone, and self-generating technologies. With Nepal's huge capacity constraints and rolling power cuts, every kilowatt out of the power grid makes a big difference.
 - produce externalities such as improved tourism and other social benefits.
4. The use of solar technology is economically viable especially from the standpoint of comparing the cost of technology versus that of not supplying electricity at all.

| Inputs | Design Outputs | Design Outcomes |
|--------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------|
| \$3.4 million to rehabilitate hydropower stations out of the \$93.7 million total project investment | Rehabilitation of Marsyangdi and Gandak hydropower stations | 4 GWh average increase in annual generation from Marsyangdi and Gandak hydropower plants |
| \$2.3 million for the renewable energy streetlighting component out of the \$93.7 million total project investment | 1,000 solar/solar-wind streetlighting systems installed | Eliminate streetlighting load in selected urban centers by the end of 2011 and save approximately 1 GWh of energy per year |

- 
- A wind farm in Maharashtra state—India is one of Asia's largest wind energy producers

KHANDKE, MAHARASHTRA, INDIA

From afar, they look like giant plants sprouting atop a mountain plain. In fact, the windmills, with their 73-meter “stalks” and 26-meter “petals”—steel towers and rotary blades—are harvesting electricity from the winds that blow through this remote corner of Maharashtra state.

In the nearby village of Kodgaon, which has power outages of up to 12 hours a day, people go about their daily routine. A group of sari-clad women wash clothes at a pond. A man walks by with a large bundle of grass balanced on his head. A boy rides a bicycle past a tethered white Brahman cow. Like thousands of other villages all over India, frequent blackouts also cut Kodgaon's links with the wider world, adding to its sense of isolation.

Today, as India promotes investment in developing renewable sources of energy, modern wind farms with turbine-powered machines are springing up beside agricultural plots where farmers work their fields with ploughs pulled by bullocks.



Harvesting Wind

Energy-starved India is promoting wind power to improve energy security and reduce greenhouse gas emissions. To demonstrate a business model for the private sector, ADB is supporting two major energy companies to develop wind farms in western coastal states.



• **Timeless scenes**—Women washing at the village of Kodgoan (top); Walking and pedaling (above) near the Khandke wind farm—the project feeds power into the state grid

While chronically short of electricity—demand outstrips supply by about 20% during peak hours—India also wants to diversify from fossil fuels to increase energy security and reduce emissions of greenhouse gases by developing home-grown sources of fuel.

India is already Asia's second-largest producer of wind power, behind the People's Republic of China. Its installed wind power capacity was 9,587 megawatts (MW) in 2008, or 3% of total electricity output.

But harnessing wind has its challenges. Although wind is free, clean, and renewable, it is an intermittent source—not “firm,” in the industry's parlance. The technology is still expensive, though advances have already brought costs down significantly. Land acquisition can be subject to long delays over price disputes. The high costs of raw materials like steel and cement do not help,

either. In short, despite its environmental benefits, the commercial margins of the wind business make it hard to attract corporate interest—or commercial banks to finance them.

To fill a financing gap and to demonstrate an innovative business model for the private sector, ADB is backing two major energy companies with loans for wind energy projects.

In Maharashtra state, ADB is lending \$79 million to Tata Power Company, part of the diversified Tata group, to set up wind farms in two districts to generate 85.4 MW of electricity.

In the states of Gujarat and Karnataka, ADB is lending \$105 million to Gujarat Paguthan Energy Corp (GPEC) and CLP Wind Farms (CWF)—both wholly owned subsidiaries of Hong Kong-based CLP Holdings—for wind farms to generate 183.2 MW, one of the largest ventures in the country.

Under the projects, which are being implemented on a turnkey basis by the Indian subsidiary of Germany's Enercon GmbH, one of the largest wind energy enterprises in the world, Tata, GPEC, and CWF sell their electricity to state utilities under 20-year agreements.

"By introducing a business model of collaboration between a private turnkey developer and a strategic investor, we hope this project will encourage other private sector investments in wind generation," says Shantanu Chakraborty, an ADB senior investment specialist.

Helping the business model are various fiscal and financial incentives that the Government of India and the state governments provided. Moreover, the state governments, in addition to paying well for wind-generated electricity, have stepped up their requirements for clean energy.

From 2010, for example, highly industrialized Maharashtra requires power distributors to procure at least 6% of their input from renewable energy sources. In Karnataka, the minimum requirement is 10%.

The impact of such projects on mitigating climate change can be significant, especially if they are replicated.

The Tata Power project, which involves wind farms at Khandke (50.4 MW) in Ahmednagar district and Bramanvel (35 MW) in Dhulia district, will reduce greenhouse gas emissions by about 129,000 tons

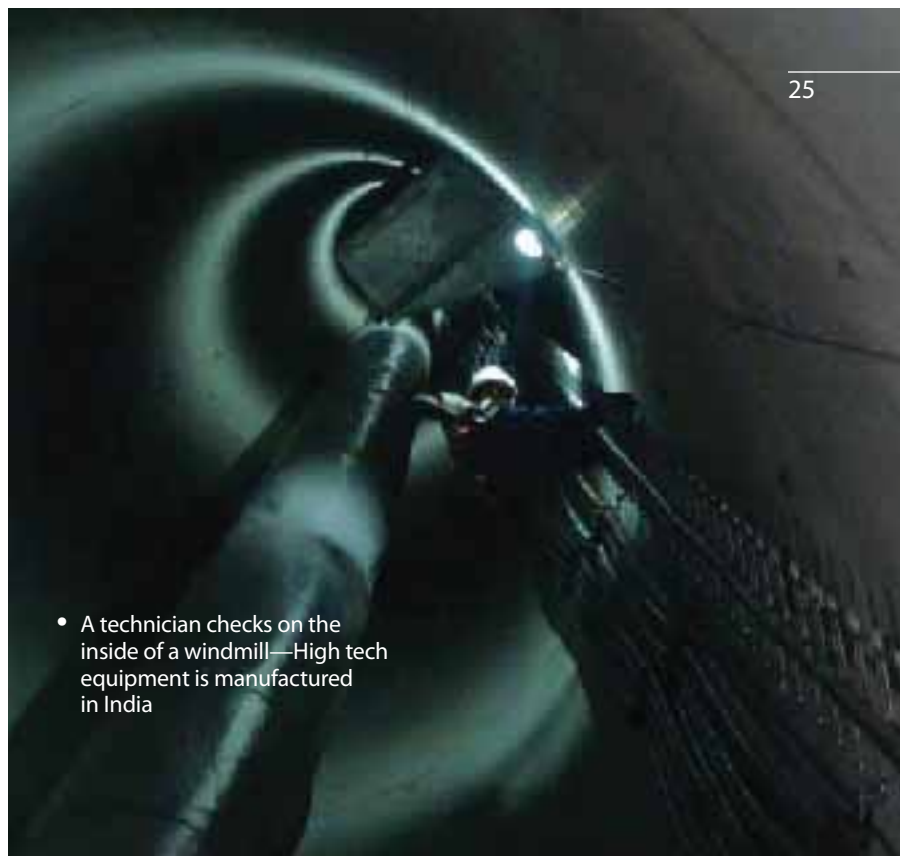
of carbon dioxide annually. This adds up to 2.6 million tons of carbon dioxide during the project's life of at least 20 years.

The GPEC and CWF projects will save about 400,000 tons of carbon dioxide a year or 8 million tons over 20 years. This calculation is based on cutting 4.4 million tons of coal imports over 20 years.

In addition, ADB, through its Carbon Market Initiative—a financing scheme to support the development of clean energy and energy efficiency, and abatement of greenhouse gas—is helping the Khandke project qualify as a clean development mechanism (CDM) project under the Kyoto Protocol with the United Nations Framework Convention on Climate Change.

To strengthen the project's financial viability, ADB is also prepared to purchase up to 50% of Tata's anticipated certified emission reductions (CERs), says Nishant Bhardwaj, a CDM consultant with ADB. Once approved, CERs will form a significant amount relative to the revenue of Rs3.50 (\$0.07) per kilowatt-hour that Tata currently earns in sales to Maharashtra's electricity body.

In Gujarat and Karnataka, GPEC and CLP have already started the CDM registration process by submitting the project design for the first phase to India's Ministry of Environment and Forest.



- A technician checks on the inside of a windmill—High tech equipment is manufactured in India



It is expected that 25% of gross CDM revenues will come from the sale of approximately 8 million tons of CERs over 20 years.

The ADB-backed projects are using the most advanced wind turbines being manufactured in India by Enercon. Their design includes a high-efficiency blade that extracts more energy than conventional blades and reduces noise from the blade tips. It also includes features specifically geared to Indian wind conditions.

Wind conditions vary and Khandke, for example, gets 70% of its generation during the rainy season between May and September when winds are stronger, says site manager Prashant Patil.

Gujarat and Karnataka receive plenty of wind and are among India's leading wind energy-producing states. In Gujarat, Samana phase one (50.2 MW) is in operation and Samana phase 2 (50.2 MW) was due to be commissioned by the end of 2009. In Karnataka, the Saundatti project (82.8 MW) is due to begin generation in the first half of 2010.

In all the projects, the companies own a number of wind turbine generators that are part of larger farms. Power from the generators is transmitted to a substation where it is increased in voltage through a transformer for connection to a high-voltage transmission system that, in turn, feeds the state.

The projects provide jobs for some local people. One farmer, Rameshwar Sripati Ghodke, works as a security guard at Khandke while his wife and daughters run the family farm at nearby Mathni. Mr. Godke says he can earn more from growing wheat, onions, and jowal but his income at Khandke is more predictable.

But the biggest impact on India's large, rural population comes from improving their access to electricity. As one official notes, many rural people are so used to being without power for long periods that they don't know how life would be if they had more electricity.

In Ahmednagar, the nearest town to Khandke, Laxman Gaikwad works in a hotel but returns regularly to the village of Aurangabad, where his family lives. "Without power for a fan, it is hot when the temperature rises above 40°C" he says. "But we are used to this, and we adjust our lives around the power that we get."



- **Feeding the grid**—Khandke site manager Prashant Patil (top) at a substation; Security guard Rameshwar Sripati Ghodke (above) now has a more predictable income than farming

Project Summary

Loan-7253: IND: Tata Power Wind Energy Financing Facility
Project Officer: Takeo Koike, Private Sector Operations Department

This project is the first ADB loan to assist a wind power project in Asia and is expected to increase power generation capacity to mitigate power shortages in India, develop additional renewable energy sources, and promote private sector participation in developing power sector infrastructure.

Rationale

India is the third-largest electricity consumer in Asia with power demand growing rapidly as the economy has expanded at an annual average of 5.6% since 1980. The country continues to suffer from chronic electricity shortages and power quality remains poor. As the power sector has grown, the country has become increasingly dependent on fossil fuels; and with the recent hike in oil and gas prices and the expected fossil fuel shortages in the future, the security of the energy supply in India has generated increasing concern. The environmental concern over excess use of fossil fuels is also rising. In this context, the government has been working proactively to promote the use of renewable energy sources.

Among those available in India, wind energy is a promising source for further development with a gross potential of 45,000 megawatts (MW) and technical wind power potential of 13,000 MW.

Description

The proposed loan is to help the Khandke Bramanvel and Sadawaghapur Wind Power Projects undertaken by the Tata Power Company Limited. The projects include the construction and operation of wind power generation facilities and substation, as well as transmission lines in the selected areas. The benefits of the proposed loan include the addition of 80 MW of power-generating capacity to help reduce the supply deficit in India, the development of new renewable energy sources, which will decrease fossil fuel consumption and reduce the emission of greenhouse gases and other pollutants, the demonstration of successful implementation of large-scale wind power projects by the private sector, and the facilitation of over \$40 million commercial cofinancing for the project.

SUMMARY

Total Project Cost: Rs3 billion

Clean Energy Project Outcomes:

- 2.0 million tons of CO₂ emissions reduction during the minimum project life of 20 years

- Government policies can help streamline the land acquisition process or leasing, can facilitate and make publicly available reliable and long-term wind resource studies, and can improve investment climate by improving creditworthiness of state-owned off takers through sector reform.

LESSONS LEARNED

1. The framework introduced by the government for promoting renewable energy is very critical. Among the noteworthy elements of the framework are:
 - Priority dispatch and mandatory off-take requirements for distribution companies would ensure certainty of dispatch.
 - Feed-in tariff would need to be set at the beginning to ensure certainty of project revenue. It would also need to be set at the level that ensures sufficient project's equity return and debt service capacity.
 - Various tax benefits such as tax exemption, accelerated depreciation, etc. can improve project economics.
2. Development of local manufacturing capability for wind technology would help reduce project cost and achieve more affordable tariff.
3. Availability of long-term local currency financing is essential for promoting renewable energy.
 - The tenor of debt financing would need to be sufficiently long to ensure project's financial viability.
 - Feed-in tariff does not include an escalation factor for financing costs. The exchange rate risk can be mitigated by local currency financing, and the interest rate risk can be mitigated by fixed interest rate financing.

Inputs

Rs3 billion loan to Tata Power Company Limited

Design Outputs

Installation of 80 MW wind power generating facility

Design Outcomes

Additional volume of power generated

Additional volume of renewable energy distributed

Reduction of greenhouse gas emissions by over 2 million tons of carbon dioxide during the minimum project life of 20 years

MANADO, SULAWESI, INDONESIA

Eddy Julianto runs a cold storage operation, one of the larger businesses in Bitung, the main port of northern Sulawesi, Indonesia. He needs electricity to refrigerate the fish that trawlers bring to his warehouse for storage before being dispatched to Jakarta and other parts of this archipelagic country.

"I've had three power cuts this morning and average around seven outages a day," he says. For backup, he has a 1 megawatt (MW) diesel generator, but says its power costs three times that of electricity from the grid operated by PLN, the state utility.

"The only reason we are not expanding is the lack of power and its unreliability," he says. Mr. Eddy is not alone in his plight.

As elsewhere in Indonesia, frequent blackouts are part of life for commercial enterprises and households in the Minahasa grid, the main power system for northern Sulawesi. The reason is that supply often fails to meet peak demand,

particularly in the dry season when rivers dwindle and hydropower drops.

The small Minahasa grid has an installed capacity of 174 MW, fuelled by a mix of geothermal (37%), hydro (34%), and diesel oil resources (29%), according to 2008 figures provided by PLN.

But the margin of reserve is thin and, if things don't go to plan, demand can overwhelm supply.

"Our power shortage situation is serious," says Dadan Koerniadipoera, general manager of PLN in the provincial capital of Manado. "We have lost 20 MW of hydro because of the long drought, one 20 MW geothermal unit is out of action for repair till the end of 2009, and our 57 MW of diesel generators, which are 30 years old, generally run at only 50% capacity. This means we are not meeting peak demand of 154 MW."

All this is set to change soon. PLN hopes to make blackouts a memory in the Minahasa grid by boosting power supply, much of it from geothermal energy. The source of geothermal energy is the steam that is created from the

Working Up Steam

The North Sulawesi project reflects Indonesia's goal of developing the world's largest underground steam resources.



• Workers at the Lahendong plant—Geothermal energy will reduce power cuts



- **Constraining growth**—Loading fish into a Bitung cold storage plant (top) that cannot yet expand; Midwife Angel tends an expectant mother (above) at the health clinic that needs more power; Computer class at the junior high school in Tondangun (top right) where the system trips if overloaded

interaction between underground aquifers and hot rocks. The upward pressure of the steam rotates a turbine that activates a generator, which produces electricity. Geothermal energy is not only clean and renewable—much of the waste brine is re-injected into the reservoir—but also less expensive than fossil fuels.

The main source of geothermal power is the Lahendong field, some 60 kilometers south of Manado. Through a Renewable Energy Development Sector Project, ADB is financing two out of Lahendong's four 20 MW generating plants. One has been operating since 2007. The second is

due to be commissioned in August 2011. This will lift Lahendong's capacity to 80 MW, or enough to meet 50% of peak demand.

Lahendong mirrors Indonesia's policy of prioritizing renewable energy, especially geothermal power which is less vulnerable than hydro to the vagaries of weather.

The government encourages private sector participation and 75% of the new geothermal production is expected to come from independent power producers. But a significant role remains for multilateral banks like ADB, especially in outlying islands that are less attractive for private firms.

For example, ADB's renewable energy project, backed by a loan of \$161 million, also includes two mini-geothermal 2.5 MW units on the island of Flores.

In addition, ADB is mulling loans of around \$500 million for sizable geothermal plants in Java and Sumatra which may also include two 55 MW units for the Kotamogabu field, also in northern Sulawesi.

"Our objective is to promote the expansion of economic and environmentally friendly geothermal power generation, which reduces carbon dioxide emissions from the national power grid and brings more electricity to the poor," says Rehan Kausar, a Jakarta-based ADB infrastructure specialist.

In addition, ADB is helping the government prepare a geothermal sector reform program.

Reserves are abundant in Sulawesi, an island with 19 active volcanoes. Lahendong alone has estimated probable reserves of 350 MW and two more 20 MW plants—numbers 5 and 6—are planned, says PLN's site manager, Maulana, at Tomohon, the town closest to the geothermal field.

- A geothermal power plant at the Lahendong field—
More steam to be developed



However, the pressure of demand is so acute—there is a waiting list of 100 MW and future demand for the Minahasa grid is projected to grow at 8.5% a year—that PLN is supplementing geothermal power with more traditional sources of energy. It will add a 50 MW coal-fired plant and a 20 MW diesel-fueled unit, both targeted to come on stream in 2010.

As more electricity becomes available, the government plans to shut down its antiquated and polluting diesel plant in Bitung. Built in the 1970s, the plant generates only half of its 57 MW capacity, says plant manager Heru Daryoto. Three of the nine units are not working and technicians spend half their time repairing the others. At the front office, where consumers pay their bills, an official says there is a steady stream of complaints about the plant's noise and fumes.

The huge variation in greenhouse gases produced by diesel and geothermal generation has important implications for climate change. Diesel generation produces about 11 times more carbon dioxide than geothermal generation, based on PLN figures for diesel and geothermal consumption and carbon dioxide production per kilowatt-hour.



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“We aim to make blackouts a memory in the Minahasa grid by boosting power supply, much of it geothermal.”

Dadan Koerniadipoera, PLN general manager



- Consultant project manager John Toomey—Lifetime costs for coal and geothermal plants are not too far apart

In 2008, the Minahasa's diesel plants produced 250 gigawatt-hours of power. The replacement of this by geothermal power will reduce carbon dioxide emissions by 160,000 tons a year, says Peter Geoghegan, a consultant senior mechanical engineer working on the project.

In terms of development costs, a coal plant is the least-cost option in the short term, costing about \$1 million per megawatt. By comparison, a geothermal plant costs double to triple that amount. However, when factors such as transportation are included—coal will have to be shipped into Sulawesi—"the lifetime costs for coal and geothermal plants are not too far apart," says John Toomey, ADB's consultant project manager for Lahendong.

As for the fuel costs, diesel comes out way ahead of geothermal. Diesel costs 2,000 rupiah (Rp) (\$0.21) per kilowatt-hour whereas Pertamina sells steam to PLN at prices varying between Rp200 and Rp500 per kilowatt-hour, depending on the price of oil.

All these new energy sources will mean fewer disruptions for Minahasa's grid's nearly 290,000 customers and will bring new consumers, mainly among the poor, into the system.

In the village of Tondangun, for example, the junior high school has one 900 watt connection to service the needs of its staff and 66 pupils. "We have computers, a water pump, and several appliances, but we cannot power all of them at the same time," says the principal, Ms. Julien. "If we try, the power trips."

At a health clinic nearby, Angel, the administrator and *bidan* (midwife), says they operate with enough power to light eight bulbs, but could use more power—for exterior lighting, for example—as the clinic is open day and night.

More electricity would also improve the lives of villagers who receive limited power or none at all. In the village of Pangolombian, community head Djemy Sarese says that 60% of the 2,300 population has direct access to the grid while the remainder relies on informal connections through neighbors.

In one household, Noldi, a house builder, pays Rp15,000 (\$1.60) a month for a hook-up cable from a neighbor. He and his wife Loisy and their two children watch television only in the afternoons because they use their limited power for lighting in the evenings. If he had a direct connection, Noldi could pay the average monthly bill of Rp70,000–Rp100,000 (\$7.40–\$10.50) but he cannot afford the installation costs that can run up to Rp2 million (\$210). If she had more electricity, Loisy would like, in order, a rice cooker, a washing machine, and a refrigerator.

The electrification rate in northern Sulawesi is 64%, says PLN's Mr. Dadan. While everyone would like to see this figure improve, there is one huge constraint. Electricity tariffs in Indonesia are kept low for political reasons. "We produce electricity for Rp1,400 (\$0.15) per kilowatt-hour, but our average sales price is Rp660 (\$0.70) per kilowatt-hour," he says. "The government subsidizes the difference between our production cost and our sales, but the subsidy does not include any margin. So the more energy we produce the more we lose."

In the long term, the government plans to reduce power subsidies, which will increase incentives as well as efficiencies for state utilities and private enterprises.

Meanwhile, businesses like cold storage and hotels and other tourist facilities can soon look forward to an increased—and more reliable—electricity supply provided largely by geothermal sources.

The project finances various core and noncore renewable energy subprojects that will add about 82 megawatt of power generation capacity for Indonesia.

Rationale

Indonesia has a very large number of small power grids where addition of new power-generation capacity using renewable energy resources provides economic and environmental benefits. Implementation of such subprojects will also help restore the power demand and supply balance, and improve the quality of power supply to existing consumers, particularly in the rural regions.

Description

The Lahendong II geothermal power plant featured in this case study is the first to be completed among the eight subprojects to be financed by this project. The eight packages also include the construction and commissioning of hydropower and geothermal power plants and transmission lines for power evacuation which is expected to add about 82 megawatts (MW) in power-generation capacity with 480 gigawatt-hours (GWh) annual energy output. These will be developed in the outer islands of Indonesia and are part of the country's least-cost planning for capacity expansion.

SUMMARY

Total Project Cost: \$256 million

Clean Energy Project Outcomes:

- 480 GWh annual energy savings from expanded renewable energy use of 82 MW

LESSONS LEARNED

1. Geothermal energy development needs long-term commitment from the government and not only from the private sector.
 - The government's commitment to do geothermal exploration demonstrates its willingness to bear part of the risk. This becomes an attractive drive for private sector developers to get into the market.
2. For hydropower projects, a comprehensive assessment of all energy options needs to be undertaken, the results of which should be communicated in a transparent and participatory manner to all stakeholders and beneficiaries.
 - It is important to communicate the impact of such projects on the future development of the area and on locally based industries.
3. National governments should use existing community-driven development programs to launch renewable energy projects at a small scale to enhance rural electrification which remains a challenge across a larger part of developing Asia.
 - Communities are willing to share reasonable costs for small wind/solar/hydropower projects to have access to power in the short time instead of waiting with little hope in sight for being connected to the grid.

Inputs

\$161 million loan out of \$256 million total project cost to finance construction and commissioning of 8 renewable energy packages

Design Outputs

2 geothermal power plants constructed and commissioned

8 mini hydropower plants constructed and commissioned

2 small hydropower plants constructed and commissioned

70 kilovolt (kV) and 20 kV transmission lines built for power evacuation

Distribution systems expanded and upgraded

Design Outcomes

82 MW additional generation capacity

480 GWh annual energy savings

About 76,000 new customers connected from 2003–2005



JINCHENG, SHANXI PROVINCE, PEOPLE'S REPUBLIC OF CHINA

Jincheng taxi driver Wei Jiusheng has cut his fuel costs by half since converting his cab a year ago to run on methane gas rather than gasoline.

He used to pay CNY60 (\$8.80) to drive 100 kilometers on gasoline, but now methane-based fuel covers the same distance for CNY29 (\$4.20).

Mr. Wei is far from alone in saving costs since the Jincheng municipal government began implementing in 2009 an antipollution policy requiring that taxis and buses be replaced with

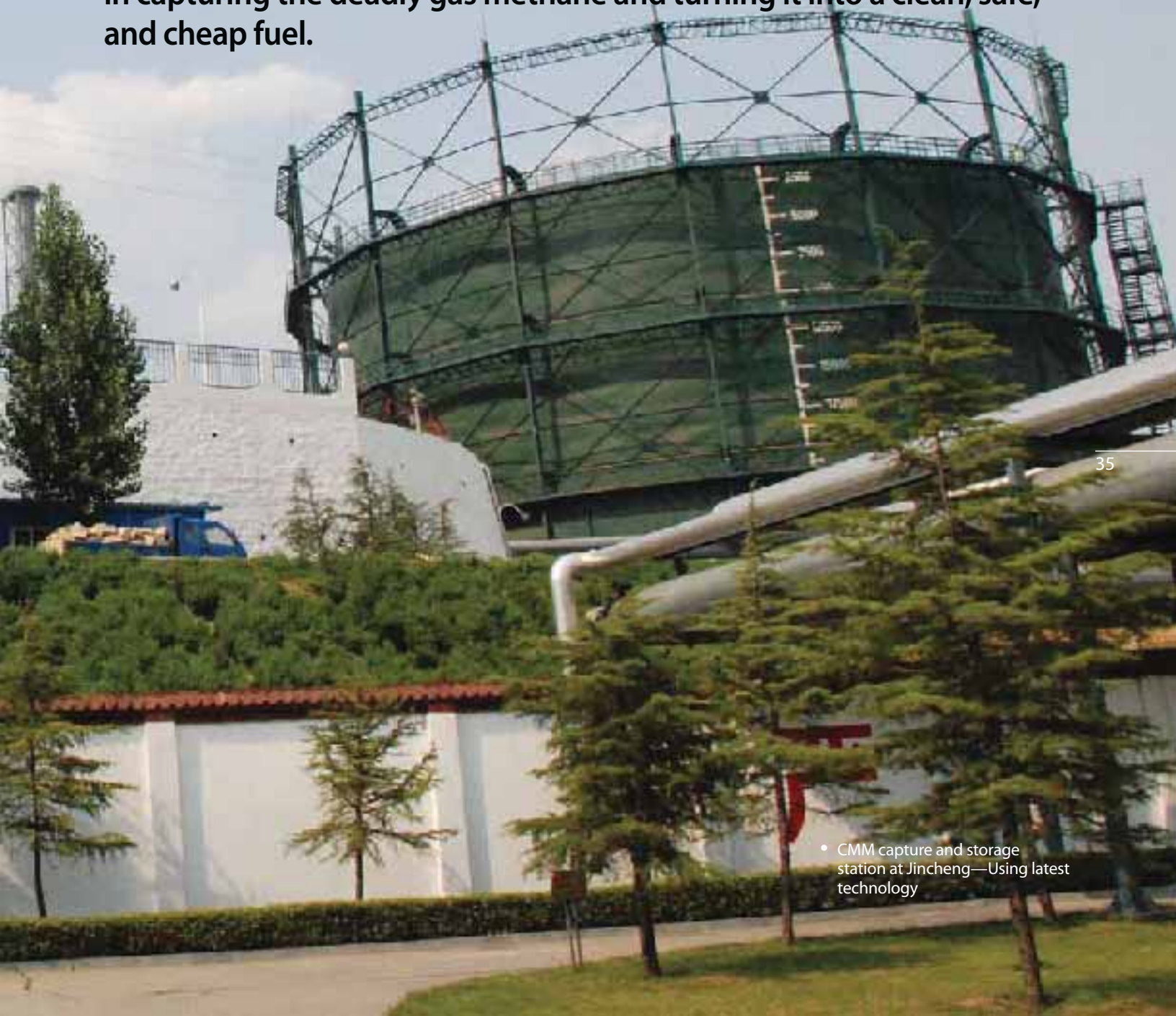
bi-fueled vehicles that consume methane gas and gasoline, with the latter used as a backup fuel.

On Jincheng's main street, a three-star hotel is now using a methane gas-fueled boiler for its heating and cooling systems instead of a coal-fired boiler—and consequently has reduced costs while improving efficiency and working conditions.

These are examples of how residents and businesses in this city of 2.2 million people in southeast Shanxi province, People's Republic of China (PRC), are benefiting from a groundbreaking

From Pollution to Solution

In the largest coal-producing province of the People's Republic of China, an ADB-backed project is demonstrating the latest technologies in capturing the deadly gas methane and turning it into a clean, safe, and cheap fuel.





- Safer fuel**—Taxi driver Wei Jiusheng in front of a methane gas station (above) that has halved his fuel costs; Part of the CBM capture station at Jincheng (right)



project to convert methane, a deadly gas that kills thousands of coal miners each year, into a clean, safe, and cheap fuel for transport, heating and cooling systems, and cooking.

Importantly, the citizens of Jincheng are inhaling air with fewer greenhouse gas emissions due to an ADB-financed Coal Mine Methane Demonstration Project that showcases new technologies for producing and using methane.

Methane gas, found in coal beds, is highly explosive. To keep miners safe, methane needs to be drained before and during underground mining operations. Even so, at least 5,000 miners die each year in the PRC from accidents, mainly caused by methane explosions.

The PRC is the world's largest producer and consumer of coal and vents more than 13 billion cubic meters of methane annually. More than 70% of PRC's energy supply comes from coal, which produces methane, a greenhouse gas about 22 times more potent than carbon dioxide. Largely as a result, many cities fail to meet minimum standards for air quality and acid rain falls on about a third of the country.

But methane can be a boon as well as a bane. Capturing and removing it from coal mines not only improves the safety and efficiency of mining operations as well as aboveground air quality. It also provides a clean fuel with high energy

content. Compared to other fossil fuels, it does not produce acid rain or soot. Methane can replace coal, wood fuel, synthetic "waste" gas, and petroleum-based fuels. It is the main constituent of natural gas, a popular and clean energy source.

To meet the government's commitment to address climate change by developing clean and renewable alternatives to coal, the 11th Five-Year Plan (2006–2010) aimed to cut pollution by 10% and energy intensity by 20%.

One way of achieving this can be found in Jincheng, a major city in the largest coal-producing province of Shanxi. As early as the 1990s, its largest coal-mining company, Jincheng Anthracite Mining Group, owned by the Jinmei Group, started experimenting in methane-rich coal mines with ways to capture and use the gas.

ADB approved a \$117.4 million loan in 2004 for a project to demonstrate the latest technologies for doing this. The gas is called coal mine methane (CMM) when released into mine shafts by underground coal seams during mining operations, and coal bed methane (CBM) when released through bore holes drilled from the surface into underground coal seams.

The new technologies include improved CBM production from vertical surface wells and directionally drilled wells from the surface into underground coal seams; improved CMM drainage

- A worker monitors operations at the Jincheng CBM capture and distribution station—Turning a dangerous gas into a safe fuel



through the use of underground directional drilling and other modern equipment and materials; CMM-based power generation using internal combustion gas engines; and transmission and distribution of CMM for residential, commercial, and industrial use.

The ongoing project captures and produces CMM for a 120-megawatt (MW) power plant—the world's largest methane power plant—as well as distributing it to consumers in Jincheng. It also produces CBM, mostly as transport fuel.

Significantly, as a means to mitigate climate change, the project avoids greenhouse gas emissions from 265 million cubic meters of methane or at least 4.4 million tons of carbon dioxide emissions as it saves the burning of over 430,000 tons of coal a year, according to experts.

Additional benefits from the sale of carbon credits under the Clean Development Mechanism will provide an estimated total revenue of more than \$100 million until 2012.

As a clean and safe fuel, methane is being widely used by residential and industrial and/or commercial consumers.

For example, Jincheng East Glassware Company upgraded its four furnaces in 2008 to be fueled by methane instead of coal. The switch is saving the company CNY1,000 (\$147) a day in fuel costs.

"At least as important, production quality has improved as the temperature of the furnaces has been stabilized with a consistent gas supply," says general manager Li Yuqing. The efficiency of using raw material has also increased by 20%. Mr. Li explains that the furnace temperature for making glassware is 1,550°C. The gas-fueled furnace has only a 10°C difference in the temperature compared to a coal-fueled oven. This ensures that the glass melts evenly without imperfections, such as bubbles.

The air quality in the glass manufacturer's workshops has improved and the incidence of respiratory diseases among workers has dropped.

Housewives and restaurant chefs also use methane gas for cooking and, with more easily controlled flames, do not have to worry about explosions and can focus on improving their work.

CMM has been distributed to 80% of Jincheng households since the end of 2008. The switch



- A technician at the Jincheng methane power plant (left)—The largest of its kind in the world

to methane gas from coal has seen the average annual cost of fuel per family fall nearly fivefold to CNY350 (\$50) from CNY2,000 (\$290). Cooking with methane is also safer, more efficient, and quicker. “The gas not only saves money but also liberates women from spending so much time over the stove,” says Wang Keping, director of Jincheng Finance Bureau. “Women have more time for other activities and entertainment.”

This is the experience of Tian Xianping, a 52-year-old resident in the Shengyun residential complex, which houses 800 families. Over the last 10 years, Ms. Tian first cooked with honeycomb briquettes of coal and later switched to 15-kilogram cylinders of liquefied natural gas (LNG). Handling the LNG cylinders every month was heavy work as two of her children moved to other cities and were unable to help her. Today, she uses piped methane gas. “This is so convenient. You can use it whenever you want throughout the day, and gas makes it so easy to clean the kitchen,” says Mrs. Tian. Now that cooking is less of a chore, she sometimes has friends over for dinner.

The Jincheng municipal government plans to cover the city with CMM distribution pipelines to supply over 60,000 households for heating and cooking by 2011. It will also provide compressed gas products to places as far as Shenzhen in southern PRC and Hong Kong, China.

“The success of this project will not only have a significant impact on climate change and the improvement of miners’ safety but also demonstrate that central and local governments can work effectively with companies toward a common goal,” says Merlita Pajarillo, an ADB energy specialist.

Due to government incentives, 5 billion cubic meters of methane were captured in PRC coal mines in 2008, 14 times that of 2005, according to the China Coal Information Institute, a government think tank.

If Jincheng’s technologies can be replicated for other coal mines across the country, they will be a major contributor to PRC’s drive to clean its air.



“Production quality has improved as the temperature of the furnaces has been stabilized with a consistent gas supply.”

Li Yuqing, general manager (above) of glassware company

The project will establish a coal mine methane development project at Jincheng, Shanxi Province, People's Republic of China, using new technologies that are not yet used in the country and which can be catalyzed and replicated in other areas.

Rationale

The People's Republic of China (PRC) is one of the biggest producers and users of coal in the world. In 2003, it produced 1.7 billion tons of coal. At that time, PRC coal mines annually released more than 13 billion cubic meters (m³) of methane, a greenhouse gas that is about 22 times more potent than carbon dioxide (CO₂), thereby aggravating climate change. Coal mines also contribute to the country's worsening air quality. Coal mining practices in the PRC also pose safety concerns. At least 5,000 miners die each year from underground accidents—mostly methane explosions because methane is highly explosive and needs to be removed during coal mining operations. Through coal mine methane (CMM) and coal

bed methane (CBM) technologies, environmental and safety challenges from coal mining can be addressed.

Description

The project will cover all aspects of effective and efficient CMM and CBM production, capture, and use by applying the latest technologies for wells, drainage, internal combustion gas engines, and transmission and distribution. Composed of three components—production of CMM and CBM for a 120-megawatt power plant, CMM transmission and distribution, and institutional strengthening and capacity building—the project demonstrates the capture of methane gas for use in power generation, household, commercial, industrial, and transport on a commercial scale. It can potentially generate a minimum of 4.4 million tons of CO₂ equivalent emission reduction per year, which also allows it to show how certified emissions reduction can be obtained for such projects under the Clean Development Mechanism of the Kyoto Protocol.

SUMMARY

Total Project Cost: \$237 million

Clean Energy Project Outcomes:

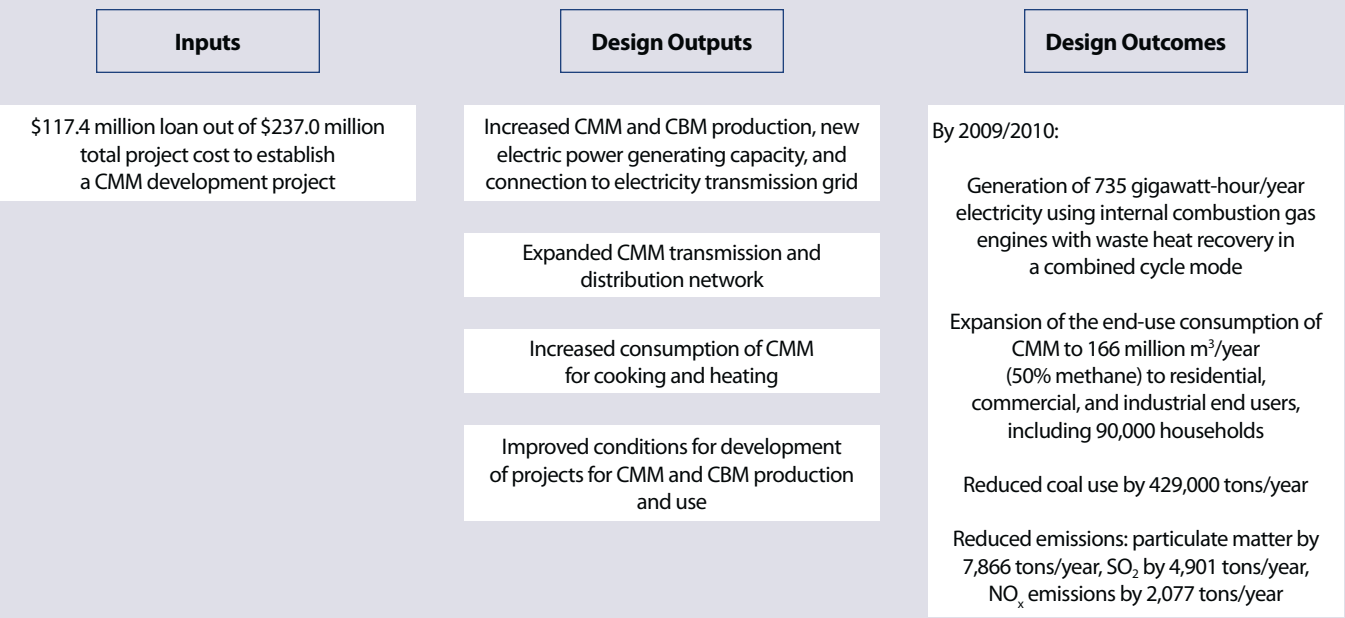
- 265 million m³ per year of methane captured
- CO₂ emissions reduction of 612,058 tons per year

LESSONS LEARNED

1. Use of available modern technologies in capturing hazardous methane gas when carefully considered and properly implemented can produce attractive returns to project developers while addressing concerns on climate change, energy security, and safety of mine workers.
 - The project also demonstrates that methane provides a convenient, safe, clean, and cheaper alternative fuel to domestic users. The popular acceptance of methane gas use

speaks well of the project's success and is a testament that the project design model can be replicated.

2. Providing technical support in projects that promote use of new technologies is important. Obtaining assistance from recognized technology experts will mitigate technical and operational risks.
3. Critical assessment, during project planning, of methane gas supply and quality will avoid delays associated with the resulting design changes and repeat of the approval process. A thorough evaluation of the least-cost option for the pipeline routes and location of gas receiving facilities will improve the project's financial viability and reduce implementation time.
4. Changes in regulations not anticipated during project design and approval can have adverse implications on the project. Certain latitude or contingency provisions that will allow changes to be made during project implementation should be considered.



Cleaning Up the Air

A photograph of a busy street in Vadodra, India. In the foreground, a green and yellow auto-rickshaw is prominent, with 'CNG' and the number '549' visible on its front. A man is riding a motorcycle next to it. In the background, a red and white bus is visible, along with other auto-rickshaws and trees. The title 'Cleaning Up the Air' is overlaid in large black text at the top.

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In India, an ADB-supported project in Gujarat state is doubling production of natural gas to provide a cleaner and cheaper fuel to more households, transport services, and industrial enterprises.

- Compressed natural gas makes downtown Vadodara less polluted than other Asian city centers



VADODARA, GUJARAT, INDIA

The streets of downtown Vadodara pulsate with buses and auto rickshaws—yet the air is less polluted with traffic fumes than in many other Asian cities. The reason: most of the inner city’s public transport runs on compressed natural gas (CNG), which is cleaner than gasoline or diesel.

In an ammonia plant on the city’s outskirts, a state-run enterprise has substituted natural gas for naphtha for the past 4 years—and would use more gas to increase production if it were available. Among ordinary citizens, tens of thousands of households have switched to cooking with natural gas rather than more expensive kerosene.

Driven by government policy to use cleaner fuels, India is switching from oil and coal to natural gas to meet energy needs that grew at a yearly average of 4.5% over the past decade. Natural gas contributes only 8% to the country’s energy requirement compared to nearly 90% by oil and coal. The government wants to lift the share of natural gas to 15% by 2012 and 20% by 2025.

To support the government’s goals of reducing greenhouse gas (GHG) emissions and strengthening energy security by diversifying to domestically processed cleaner fuels, India’s first liquefied natural gas (LNG) import and regasification terminal at Dahej started operations in April 2004.



- Workers at Petronet's complex at Dahej—India's first liquefied natural gas import and regasification operation



"The share of gas is still low and we expect gas demand to rise exponentially over the next 10 to 20 years."

Rajender Singh, head of Petronet's Dahej and Kochi operations

The project, owned by Petronet LNG Limited and supported by equity and debt financing by ADB, imports LNG, mostly from Qatar, converts it back into gas, and sells the gas to off takers for distribution to industry, transport services, and household consumers.

Starting with a capacity of 5 million metric tons per annum (MMPTA), Petronet doubled its capacity to 10 MMPTA in 2009 after adding two storage tanks and a jetty at Dahej. Petronet is building a second terminal at Kochi, Kerala with an initial capacity of 2.5 MMPTA, expandable to 5 MMPTA.

Already, the project is playing a sizable role in helping India switch to LNG. In 2008, Petronet supplied customers with 9,274 million cubic meters of natural gas, equivalent to 20% of India's natural gas consumption and 78% of total gas imports.

The contribution toward climate change mitigation is significant, notes Pradeep Perera, an ADB senior evaluation specialist. The LNG displaced fuels including naphtha, coal, heavy

furnace oil or diesel equal to around 6,983 kilotons, which would have emitted 21.7 million tons of GHG emissions. LNG, which emits lower amounts of GHGs, produced 16.3 million tons of GHG emissions, resulting in GHG savings of 5.3 million tons a year.

After financing a feasibility study for the venture, ADB has taken a 5.2% equity stake (equivalent to an initial investment of about \$10 million) in Petronet and is also currently financing its Dahej expansion program with a loan of Rs6.75 billion.

Half of Petronet's shares are held by four Indian state oil companies, with Gaz de France, which provides technical expertise, holding 10% of the equity. The remaining 40% is held by ADB and other private interests following an initial public offering.

"Petronet represents a classic example of a public-private partnership that operates as commercially as a private sector entity with an independent board," says Shantanu Chakraborty, a senior investment specialist for ADB.

Although the economic slowdown has seen LNG prices fall in tandem with crude oil prices, Petronet

buys most of its LNG under 25-year contracts with Qatar—it purchases 15% of its LNG shipments on the spot market—and sells to off takers under long-term agreements. Petronet has been operationally profitable from the first year.

The government is seeking other ways to expand the role of natural gas. It allowed Shell to build the country's second LNG terminal—with a 2.5 MMTPA capacity—at Hazira, Gujarat.

Moreover, India is negotiating with several countries to procure LNG and is exploring with others to import gas by pipeline.

In addition, domestic gas production is on the rise, following the discovery of major offshore gas fields. Even so, domestic supply—current production is 80 million standard cubic meters per day—is unlikely to prevent the gap between supply and demand from widening.

For this reason, Petronet is not overly concerned with growing competition. "Per capita energy consumption in India is very low compared to more advanced economies and we expect energy consumption to continue going up as living standards rise," notes Rajender Singh, head of



- **Varied applications—** Housewives (left) are cooking with natural gas; Farmers (below) use subsidized fertilizer made with cheaper natural gas rather than naphtha

Petronet's output not only contributes to India's energy diversification but also helps meet many development needs.



• Bus fleet manager Narendra Rana—CNG-powered buses are cheaper to run and less polluting

Petronet's Dahej and Kochi operations. "Also, the share of gas is still low and we expect gas demand to rise exponentially over the next 10 to 20 years."

To increase earnings, Petronet also plans to build a 1,000 megawatt power plant at Dahej to use some of the energy currently being vented during the regasification process.

To be sure, Petronet's output not only contributes to India's energy diversification but also helps meet many development needs.

Vadodara is using more gas than most other cities in India because of its proximity to gas pipelines

and to Petronet's terminal at Dahej, 150 kilometers away on the coast.

While waiting for customers near Vadodara's central bus station, Vishinath Jagtap, an auto-rickshaw driver for 20 years, says he switched to a CNG-powered three-wheeler from a petrol-run model 5 years ago. He says he has doubled earnings as a result, since CNG is cheaper than petrol and because many passengers prefer to use a less-polluting vehicle. The downside, he says, is that CNG tricycles cost more than a petrol tricycle and that he has to queue up longer to refuel because CNG dispensing stations are still few.

At the central bus station, Narendra Rana is manager for a privately owned fleet of nearly 100 CNG-powered buses that ferry passengers to and from downtown. The buses cost 15% more than those that run on diesel, he says, but they are cheaper to fuel, need less maintenance, and cause less air and noise pollution.

Since Vadodara was chosen, along with Delhi and Mumbai, to pilot-test CNG vehicles, the number of gas-fueled vehicles has gone up rapidly. Today, an estimated 70% of the city's three-wheelers and all its inner city buses run on CNG.

Among the general public, apart from commuters, tens of thousands of households are opting to use natural gas for cooking over kerosene.

Some 80% of natural gas is consumed by power and fertilizer plants and demand is growing from other industrial clients in the glass, ceramics, automobiles, and sponge iron industries.

At the ammonia plant of Gujarat State Fertilizers and Chemicals in Vadodara, R.K. Shah, deputy general manager (projects), says they have substituted natural gas for naphtha in making fertilizer and petrochemicals, mainly because of the much lower price of gas.

The government subsidizes the price of natural gas to produce 650 tons of fertilizer a day—about half the ammonia plant's capacity—to farmers at affordable prices, he adds. Even so, analysts note that India has to import most of its fertilizer at premium prices, underscoring unmet demand.

As other urban centers and industries increasingly follow Vadodara's example, natural gas will continue to displace oil-based liquids to benefit the general public as well as industry, agriculture, and transport.

By providing additional natural gas to industrial and household users, the project aims to help India increase energy supply, shift to cleaner energy away from more polluting energy, and improve energy security by diversifying the energy base.

Rationale

Coal continues to be the predominant source of primary energy in India, taking up a 54.5% share in the mix. Recent environmental concerns and spiraling oil prices have boosted natural gas as a source of energy. While its share of 7.7% in the country's primary energy mix is lower than the world average of 23.7%, growth for natural gas has been faster than for any other fuel. This is expected to increase to 15% by 2011–2012 and to 20% by 2024–2025, provided that gas is made available from domestic and imported

sources. India's natural gas demand was met by domestically produced gas and new reserves have been discovered. Despite this, the domestic supply is not likely to keep pace with demand and the country needs to import significant amounts of gas either as LNG or via pipeline. With the start-up and initiative of the company, PLL, the country's importation of the fuel started.

Description

The project involves expanding an existing PLL-owned import and regasification terminal for liquefied natural gas (LNG) at Dahej, Gujarat in India. The terminal's current capacity is 5 million metric tons per annum (MMTPA) and hopes to be expanded initially to 7.5 MMTPA and later to 10 MMTPA.

SUMMARY

Total Project Cost: Rs6.75 billion

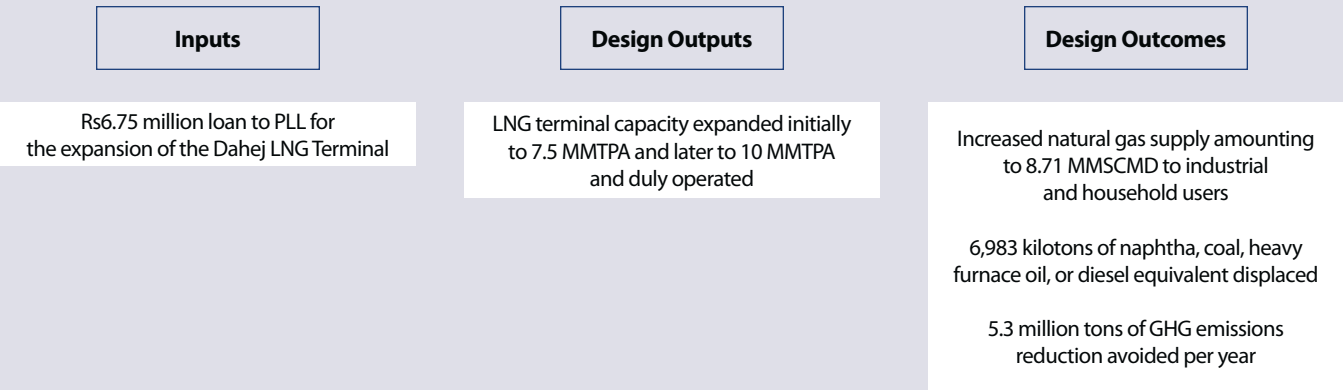
Clean Energy Project Outcomes:

- 5.3 million tons annual greenhouse gas emissions reduction from fuel switching

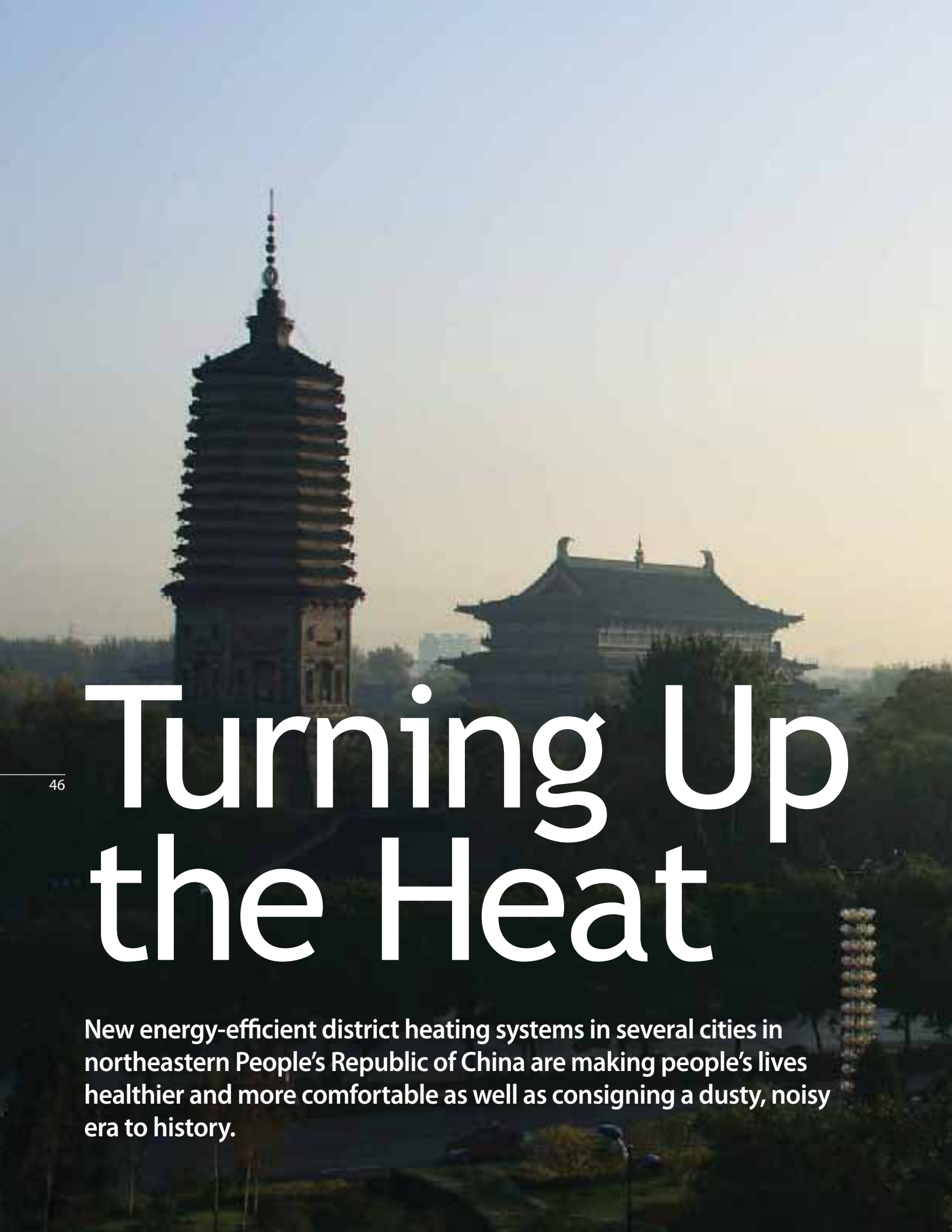
LESSONS LEARNED

1. For large-scale projects with a clean-energy component, robust contractual structures with creditworthy entities, both on the input and off-take sides, is critical to project success and financial viability.
2. A well-managed and widespread downstream distribution network is critical for LNG projects to reach out to end users in a cost-effective manner.

3. It is important for demonstration projects with multiple stakeholders to be structured within a well-defined public–private partnership framework. Success of the Petronet LNG transaction stems from:
 - strong government support by way of off-taking responsibilities,
 - management efficiencies and corporate governance provided by a professional management team, and
 - technical expertise provided by an experienced strategic stakeholder.



GHG = greenhouse gas, MMSCMD = million standard cubic meters per day, MMTPA = million metric tons per annum.



Turning Up the Heat

New energy-efficient district heating systems in several cities in northeastern People's Republic of China are making people's lives healthier and more comfortable as well as consigning a dusty, noisy era to history.

As well as cold weather, winter brings much inconvenience to an elderly couple in an old apartment block in Liaoyang, a midsize city in the northeastern province of Liaoning, People's Republic of China (PRC).

The radiators in the flat of Qin You-li, a retired welder, and his wife Wang Shu-zi, are warmed by hot water piped in from an aging, noisy boiler that services over 280 households in the neighborhood.

When it works, the boiler operates intermittently during the day, emitting discordant sounds and spraying the area with unfiltered coal dust. When it breaks down, as it often does, residents have to find other ways to keep warm in often below-zero temperatures. "The heating goes off at 9 p.m. and comes on again at 6 a.m.," says Ms. Wang. "There is sometimes ice on the window when I get up at 5.30 a.m. to go and take care of my father, who lives nearby."

The 2.8 megawatt (MW) boiler is over 20 years old and operates well below capacity, says Xiao Zhuang, a technician who maintains it. "I have to do a lot of repairs and there are many complaints about the noise and the dust," he says.

In another neighborhood, Zhao Yong-cheng, a retired casual worker, has since 2007 been living with his wife and daughter in an apartment connected to a modern central heating system that provides uninterrupted heating. "Before this, I lived in a home where, to keep warm, I had to cut wood to feed a small furnace," says Mr. Zhou. "My mother coughed all winter from the smoke." He has acquired goldfish, saying the pets survive more easily in the comfortable and constant temperature of his new environment.

The contrasting experience of the two families reflects the drive of the PRC government to install more efficient heating systems that curb pollution, thus improving people's lives.



- Director Zhou Wei beside a 58 MW upgraded boiler—The new system has lifted energy efficiency by 30%

Modern heating systems will reduce air-related diseases and deaths, particularly among women and the elderly who spend more time at home.

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In a cold-climate province, the Liaoning Environmental Improvement Project, financed by a \$70 million loan from ADB, is bringing modern heating technology to Liaoyang and the cities of Anshan, Benxi, Fuxin, and Yingkou.

By closing down more than 400 old, small coal-fired boilers, and using larger and more efficient boilers and new pipelines, the project is battling pollution caused by decades of heavy industrialization and residential use of small boilers. Liaoning has 3% of PRC's population but is one of the highest energy-consuming provinces.

Zhao Guang-wei, general manager of Liaoyang Real Estate Heating Company, the state-owned firm operating the new heating system, recalls when the skies above the city's 400-year-old White Pagoda was more contaminated than at any time in history.

"I worked in an office near one of the old boilers," he says. "When the workers went home, their faces and clothes were black. I could see a thin layer of dust on the ground and the winter sky was gray or dark yellow."

Significantly, the past few years have seen the closure of 174 old boilers scattered around Liaoyang—and the end of a dusty, noisy era.

The new system uses chain-grate stoker boilers, each with a 58 MW capacity, housed in modern plants where wet dust technology removes 96% of polluting substances from emissions.

The new boilers have a heating efficiency of over 80%, compared to 45%–50% of the old boilers, says Zhou Wei, director of the Beicaoku plant in northeast Liaoyang. The new machinery also has a burn rate of 95%, compared to 70%–80% of the small boilers.

The overall 30% rise in efficiency translates into substantial fuel savings—and reduced pollution. Operating only during the five coldest months, Beicaoku consumes 150,000 tons of coal to heat 4.8 million square meters. By comparison, says Mr. Zhou, the 71 old boilers it replaced used to eat up 120,000 tons of coal to heat 2.5 million square meters.

The impact on climate change is significant. The closure of 412 boilers in the five Liaoning cities results in avoided yearly emissions of greenhouse gases totaling around 437,400 tons of CO₂; 18,200 tons of total suspended particulates; 2,500 tons of SO₂; and 1,700 tons of NO₂, according to ADB. Over its project life, the benefits are expected to reach CNY823.8 million at 2003 prices.

Outside the plant, Mr. Zhou points to smoke rising from a tall chimney. The height of the chimney means the smoke, he notes, is more effectively dispersed than from the shorter chimneys of the old boiler houses.

The Beicaoku plant, together with its sister unit in southwest Liaoyang, carries hot water through 42 km of pipes and heat exchangers into residents' homes. Their network extends over an area of 9.6 million square meters, four times that covered by the small boilers.

That translates into 110,000 households, or 350,000 people, which is most of Liaoyang's urban population of 500,000. Many of the other households are already served by an earlier, smaller heating project.

The city plans to add two 86 MW boilers, says the heating company's Mr. Zhao. "We are building for future demand as well as current customers,"

he says. "New apartment blocks are under construction and Liaoyang is growing by 300,000–500,000 square meters a year."

Despite rapid progress, a few thousand households remain outside the networks, using old-fashioned methods of heating.

In one neighborhood, a woman stands over a brick oven in the smoke-blackened corner of her kitchen. This is how most people heated their homes not so long ago, feeding small furnaces with wood or coal. The heat travels through pipes to warm a *kang* (traditional stone bed) in the next room. Much of the smoke escapes through a chimney but some remains, to the detriment of the household's health.

Unquestionably, better air under modern heating systems will reduce air-related diseases and deaths, particularly among women and the elderly who spend more time at home. Improved health leads to fewer medical bills and higher productivity with fewer days off for sickness.

Such health improvements are confirmed by Dr. Lin Xi-mei at a health clinic that opened in Liaoyang's Tian Qi district in 2007.

"We had more respiratory complaints, especially in winter, when the old boilers were used," she says. "In the place where I used to work, the heating was on and off and it was too cold. In this clinic, the temperature is always around 19–20°C and our patients, many of them elderly, are more comfortable."

The younger generation is also benefiting from the new system. "One old boiler was yards away from our main dormitory," says Wang Qing-shan,



"I worked in an office near one of the old boilers. When the workers went home, their faces and clothes were black. I could see a thin layer of dust on the ground and the winter sky was gray or dark yellow."

Zhao Guang-wei, general manager
of Liaoyang Real Estate Heating Company

“We closed the air ventilator after students complained about the smoke. When the boiler broke down for days, the students would go somewhere else to keep warm.”

Wang Qing-shan, professor and director
at Liaoning Building Profession and Technology College



a director at the Liaoning Building Profession and Technology College, which has 3,400 boarding students from all over the country. “It was very disruptive. We closed the air ventilator after students complained about the smoke. When the boiler broke down for days, the students would go somewhere else to keep warm.”

Since the boiler was replaced by the new system in 2006, students’ grades have improved, says Professor Wang. Outside, students are playing sports, including basketball, in cleaner air since another boiler near the sports field was removed.

Modern central heating is only one of the government’s energy-efficiency measures to clean the air. Key indicators suggest it is succeeding. In 2002, none of Liaoning’s major cities met national air standards. Today, at least half of them do, and the rest are catching up.

- **Cleaner air**—Professor Wang Qing-shan (left) says student grades have improved since the new heating system replaced the old boiler and chimney behind him; Students breathe purer air while playing basketball at Liaoning Building Profession and Technology College (below)



The project aims to improve the efficiency and reliability of Liaoning Province's gas and central heating supply, and facilitate the production and commercial use of coal mine methane (CMM) and coal bed methane (CBM).

Rationale

The People's Republic of China (PRC) has severe environmental problems, including air pollution associated with rapid economic growth, heavy reliance on coal as the primary fuel, and use of obsolete technology. Liaoning Province suffers from severe air pollution due to its dependence on coal as the primary fuel for its many heavy industries and small coal-fired heating boilers. These boilers are mostly used for urban heating, the demand for which has grown rapidly because of rising incomes, privatization of residential housing, and growth of the housing sector. In Liaoning Province, majority of urban heating supplies come from 5,000 inefficient, coal-fired heating boilers, which aggravates air pollution in the urban areas.

Description

The project covers four cities and consists of four components: (i) CBM and CMM development and utilization in Fuxin; (ii) gas distribution improvement in Benxi; (iii) improvement of the city central heating supply in Benxi, Fuxin, Liaoyang, and Yingkou; and (iv) institutional reforms and corporate governance improvement for all implementing agencies. The city central heating component featured in the case study aims to build large, efficient boilers to facilitate closure of 412 existing small coal-fired boilers in Anshan, Benxi, Liaoyang, and Yingkou. Policy dialogue with the government during project processing has focused on (i) maximizing benefits to the poor and ensuring sufficient heating by establishing specific gas and heating assistance programs, (ii) implementing market-based heating tariff reforms and improving billing collection in project cities, and (iii) promoting private sector participation.

SUMMARY

Total Project Cost: \$171 million

Clean Energy Project Outcomes:

- Average 20% efficiency improvement in heating supply in project areas
- 285,281 tons coal savings per year
- 3,396 tons of sulfur dioxide; 2,218 tons of nitrogen oxides; and 24,545 tons of total suspended particulates avoided per year
- 1.2 million tons of CO₂ equivalent avoided per year

LESSONS LEARNED

1. Removal of subsidies in gas distribution and heating and the approval of heating and gas tariffs are necessary.
 - Despite reforms in the heating and gas distribution sectors, many companies remain subsidized. Removal of subsidies and approval of tariffs that would allow full cost recovery should be addressed to ensure long-term sustainability of the services.

2. A clean environment is essential for sustainable economic growth.
 - PRC's recent economic growth will be hampered if urban pollution is not abated. District heating and gas supply are two essential public services, and demand in urban areas will multiply as the public sees the need for a cleaner environment.
3. The project has been achieving its objectives of improving the air quality of the targeted cities in Liaoning Province.
 - Air quality has continuously improved with the closure of coal-fired boilers; more efficient gas transmission and distribution systems; and reduced coal use. Air quality improvement will reduce the morbidity and mortality rate of air-related diseases and associated medical costs, loss of working days, and human suffering in the project beneficiary areas. The poor, elderly, children, and women, who are more vulnerable, will benefit from the replacement of coal and wood. With reduced coal use resulting from the energy efficiency improvement, the impact on climate change and energy security is also significant.

| Inputs | Design Outputs | Design Outcomes |
|-----------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|
| \$122 million out of \$171 million loan for the City Central Heating Component of the project | Augmented central heating systems in four project areas | Closure of 412 small, inefficient coal-fired boilers |
| | Increased CBM/CMM production and utilization | Average 20% efficiency improvement in heating supply in project areas |
| | Rehabilitated and expanded gas distribution systems | Production of 63 million m ³ per year of CBM/CMM and use of methane for residential, commercial, and industrial purposes |
| | Developed institutional and financial tariff reform action plan and privatization plan | Reduced line loss from 17% to 13% in Benxi |
| | Implemented assistance programs for poor households | Gas and heating services to 2.48 million urban population, including 183,934 urban poor |

- People board a passenger train at Liupanshui—The authorities may consider adding more

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Rail Trumps Road

A train link in southwest People's Republic of China has significantly reduced vehicular pollution as well as travel time and energy costs for freight and passengers.



LIUPANSHUI, GUIZHOU, PEOPLE'S REPUBLIC OF CHINA

The narrow, winding road is only 7 kilometers (km) long, but it takes time to drive along because it is packed with smoke-belching trucks hauling coal from a mine to a railway station. When it rains or snows, the vehicles slip and slide on the muddy track, causing accidents. The gravel road has twice been repaired, but cannot withstand the assault of heavy vehicles for long.

Congested mountain roads—and the pollution of the traffic—were a feature of western Guizhou, a province known for its picturesque karst topography of hills and underground rivers.

Then, in 2002, a new train line opened up a shortcut through the mountains between Liupanshui and Baiguo and, by diverting people and goods from road to rail, has changed life considerably.

The more direct route also carries regional, or transit, cargo as it joins more circuitous rail networks that link the inland provinces of the People's Republic of China (PRC) with sea ports in the south.

Because of the hilly, rocky terrain, the single track railway was challenging and expensive to build. Over 60% of its 118 km length consists of 50 tunnels and 102 tunnels. Its \$392 million cost was backed by loans from ADB and State Development Bank of the PRC.

But the effort and cost of the Guizhou–Shuibai railway project are paying off. Over the last 8 years, the railway project has spurred the development of natural resources estimated at 5 billion tons—while opening up markets and social services to hitherto remote, impoverished areas. Most importantly, the scheme underscores how much more efficiently a railway can transport people and goods than trucks and buses in terms of travel time and energy costs.

A train can cut in half the time of a road journey. It takes, for example, over 4 hours to make the 160 km journey by train from Liupanshui to Hungguo. The same trip by bus on the 210 km road—for the winding road is longer than the more direct route of the railway track—takes easily double that. Moreover, it rains heavily in summer and snows in winter in Guizhou, so landslides and slippery surfaces can make road travel slower and more hazardous.

“The passenger trains are generally packed and the authorities may consider increasing their number.”

Tang Yan Qun, station head (below) at Liupanshui



In terms of costs relative to volume, trains also come out far ahead. A freight train can carry 2,400 tons of coal, equivalent to 60 trucks transporting 40 tons each, says Yang Xue-Wen, who is in charge of cargo loading and unloading operations for the Guizhou–Shuibai Railway Company. He says that while a train runs on cheap electricity—at a cost of CNY0.21 per ton-km—a truck consumes an average of 50 liters of diesel per 100 km, depending on its load and road conditions. Diesel costs around CNY6 a liter. Moreover, coal companies pay for a one-way journey by train but for a round-trip for the trucks they own.

By other measures, of course, roads do have their advantages. Trucks, buses, and motorcycle taxis offer shippers and travelers more flexibility in frequency, timing, and destination. Trains run less frequently, on fixed timetables, and only to destinations along the track.

To be sure, shippers keep a closer eye on the advantages and disadvantages of these modes of transport.

For one major cement enterprise based outside Liupanshui, the choice between rail and road is clear. “Before the railway opened, we sent 100% of our cement to Hengguo by road. Now it’s 100% by rail,” says Zhou Jian-Xin, deputy chief of marketing for Lafarge, a French–Chinese joint venture. As a



- A passenger station passes through Yushe station—Opening up the hinterland to markets and social services



- **Other options**—A bus (top) at Yushe is expensive but more flexible than the train; The railway increases job mobility for Lin Jiang (above, left), who lives in Hungguo but works in Yushe

result, he says, transport costs have fallen from CNY200 per ton-km by road to CNY35 by rail.

However, the cement company still maintains a fleet of trucks for deliveries to clients, such as construction companies, that are not located close to a railway station. Also, a good chunk of the cement goes by road to Liupanshui, a city that is still growing at around 8% in 2009 despite the slowdown.

While carrying freight is the primary goal of the Guizhou–Shuibai project, providing easier access from the hinterland to urban areas is another important aim. Besides providing some 200 km of supporting roads, the railway project offers rural folk a cheaper and faster way to go to other places to find jobs or sell goods, or to seek better health care or schooling.

For example, Lin Jiang lives in Hungguo, but works in Yushe. When he returns home to see his family 2 weekends a month, he takes a train, which costs



- One of Guizhou's winding mountain roads—The railway has staved off congestion and pollution

only CNY10 for the 4-hour trip. He wouldn't dream of taking buses as they would take twice the time and cost many times more.

At busy Liupanshui station, 3,000 people a day buy tickets for one of the six pairs of passenger trains running daily under the Guizhou–Shuibai service, according to station head, Tang Yan Qun.

The passenger trains are generally packed, she says, and the authorities may consider increasing their number. But one constraint is that passenger trains lose revenue as fares are kept low.

On the freight side, it is a different story. Eleven pairs of freight trains travel daily on the line and still they cannot meet growing demand. Coal makes up over 95% of the freight.

Guizhou–Shuibai's single track is designed to handle 16 pairs of trains a day so the line is already running slightly over capacity. Six "buffer" stations that will have sidings where a train can stop while another passes through are being built. This would allow an increase in freight throughput. There is also talk of some day adding a second rail track.

The tariff for freight is currently CNY0.36 per ton-km for local traffic and CNY0.16 for transit traffic. To help the company recoup its high investment, this is higher than the rate charged by other state railways but lower than rates estimated before the project started. Nonetheless, the railway makes enough profit on freight to cover losses on the passenger side.

As well as meeting economic development and societal goals, the railway—like others backed by ADB—is helping keep people and cargo off the road and thus reduce carbon emissions.

Including the Guizhou–Shuibai project, ADB has provided loans totaling \$2.9 billion to build around 7,500 km of national and provincial railway lines. According to formulas of the International Energy Agency, railways are saving 24 tons of carbon dioxide for every million ton-km of freight and 25.4 tons for every million passenger-km.

Thus, while promoting the development of coal and other minerals, the Guizhou–Shuibai railway is also doing its part to mitigate climate change.

This project provided a more reliable and economic transport infrastructure for people and goods to energy-deficient areas of Guizhou and neighboring provinces, thereby facilitating the establishment of related industries, which has boosted employment and income-generating opportunities.

Rationale

The People's Republic of China (PRC) is the world's third-largest country in land area, with an extensive transport system comprising railways, highways, inland waterways, civil aviation routes, and petroleum and gas pipelines. However, the density of the transport network is among the lowest in the world. The dynamic growth of the economy has rapidly increased demand for transport services. Despite the government's efforts to increase transport capacity, constraints and bottlenecks affect all transport modes. These challenges limit the delivery of people and goods across the country. The project area in western Guizhou, for example, has huge reserves of good quality coal and other natural resources. Inadequate transport infrastructure has primarily constrained the

production of the coal mines and the development of other natural resources. A secondary effect is low traffic and passenger travel which also limited industry development and economic growth in the areas.

Description

The project, completed in 2004, constructed a new standard-gauge single-track electrified railway line between Liupanshui and Baiguo, which links up to three other railway lines. Associated roads and other facilities were also built. These combined lines have provided a shortcut for transporting export goods from Sichuan, Guizhou, and other provinces in northwest PRC to the nearest seaports. Its main outcome is the establishment of a cost-effective mode of transport for mining and other industrial outputs and passengers in the project area. Aside from the construction of railway line and related facilities, the project scope also comprised institutional strengthening of the Guizhou Shuibai Railway Corporation, the resettlement of affected people, environmental protection and mitigation measures, and consulting services.

SUMMARY

Total Project Cost: \$392.6 million

Clean Energy Project Outcomes:

- 101,541 tons of oil equivalent annual energy savings
- 259,595 tons CO₂ reduced per year

LESSONS LEARNED

1. Introducing railways in areas that are rich in natural resources with limited accessibility have significant economic and social benefits. It stimulates high economic growth and provides increased opportunities for jobs, access to markets, health and education facilities.

2. In remote and difficult terrains, railways as a mode of transport have significant cost, safety, and time benefits. Railways provide a more affordable, safe, clean, and year-round access to the communities living in these areas.
3. Railways can offer more efficient, low-emission transport solutions for long distance freight and passenger traffic.
4. The impact of rail projects is significantly enhanced when supported by improved logistics services that enable multimodal transport solutions and leverage the comparative advantage of different modes.

Inputs

\$392.6 million actual project costs

Design Outputs

Design, construction, and maintenance of the 121 km Liupanshui–Baiguo Railway

Construction of connecting service and/or access roads to various parts of the Project

Various institutional strengthening mechanisms, i.e., computerized management information and financial accounting

Design Outcomes

Increased freight and passenger volumes

MANILA, PHILIPPINES

The year 2009 saw governments in Pakistan and the Philippines begin ADB-assisted national drives to replace incandescent light bulbs with more energy-efficient and longer-lasting compact fluorescent lamps (CFLs).

At the same time, ADB is supporting a project to help light-emitting diodes (LEDs)—a solid-state electronic light source that is generally more efficient than CFLs—gain wider acceptance in Asia's mainstream lighting markets.

Governments are encouraging households to accept free CFLs—30 million in Pakistan and 13 million in the Philippines—in exchange for their old, inefficient incandescent bulbs.

CFLs, which use around 20% of the electricity of the incandescent bulb to produce the same light, lower consumption and bring down electricity bills, which especially helps the poor.

They also significantly reduce peak demand on power grids, which is like creating “virtual power plants” without the cost and hassle of building and operating them. In turn, fuel savings mean fewer emissions of greenhouse gases.

The rise of the high-quality CFL—the ADB projects are introducing a CFL that will last for 10,000 hours, 2–3 times longer than lower-quality counterparts—also means slow extinction for the incandescent bulb.

The Philippine Energy Efficiency Project is cofinanced with a \$1.5 million grant from the Asian Clean Energy Fund, under the Clean Energy Financing Partnership Facility, supported by the Government of Japan. The Pakistan Energy Efficiency Program is cofinanced with 150 million euros from the Agence Française de Développement.



ADB is helping several Asian countries switch from incandescent bulbs to more energy efficient compact fluorescent lamps or CFLs. It is also supporting LEDs as the “next big thing” for Asia’s lighting sector

Cheaper, Better Lighting

- More energy efficient—Real Faith Opto CEO Jim Kim shows off their LED street lamps



Australia has banned the incandescent bulb—due to be phased out by 2010—in a bid to cut greenhouse gas emissions by 4 million tons by 2012. The Philippines became Asia's first developing country to begin phasing out incandescent bulbs from early 2010.

ADB-assisted CFL programs are also in place in the Cook Islands and in the pipeline for other countries. Nepal will begin a pilot project to distribute 1 million CFLs in 2010 and ADB is discussing CFL programs with Viet Nam and Lao People's Democratic Republic.

Although CFLs are for everyone, the "Switch to CFL" campaign in the Philippines began in Tondo, a low-income area near Manila port.

The reason is that the poor stand to gain the most from energy-efficient light bulbs. On average, lighting accounts for 60% of a low income earner's electricity bill and 20% of the bill of a middle or high-income earner, who also uses power for appliances such as air-conditioners, washing machines, and microwave ovens.

At the launch, Philippine Energy Secretary Angelo Reyes showed a chart comparing the family cost of using CFLs and incandescent bulbs. The monthly

bill for using five CFLs is 58.50 pesos (\$1.25), compared to 270 pesos (\$5.70) for 5 incandescent bulbs. The savings of 210 pesos, he noted, can buy 8–10 kilograms of rice.

Such figures strike a chord in a country where 30 million live below the poverty line, earning \$1.35 or less a day—and where electricity tariffs are among the highest in Asia.

One Tondo family that had switched a few weeks earlier to the new CFLs was already reporting a drop in its electricity bill.

"Our electricity charge fell from 1,500 pesos (\$32) to 900 pesos (\$20)," says Vic Aragon, showing bills for the previous two months. Mr. Aragon, who lives with his wife Virgie and seven of their nine children in cramped premises, is a seaman who has been out of work for several months. The family relies on a \$450 monthly remittance from their eldest son, also a seaman, but this does not cover basic living expenses of 26,000 pesos (\$553) a month, says Mrs. Aragon. For this family, a lower power bill makes a difference.

Tondo residents are already frugal in their use of electricity. Grace Bacalangco, whose husband earns 350 pesos (\$7.40) a day as a company driver,



- **Useful savings**—Virgie and Vic Aragon (previous page) have lowered their electricity bill by 40%; Manila residents (right) line up to exchange incandescent bulbs for CFLs

says their power bill varies between 1,000 pesos (\$21) and 1,200 pesos (\$25) a month, a big chunk of their expenses. “We do everything we can to cut down on electricity,” says Ms. Bacalangco, who exchanged 3 incandescent bulbs for 3 CFLs under the program. “One of our children goes to high school and finishes homework as quickly as possible before it gets dark,” she says. “After dinner, we all watch TV with the lights off.”

Although savings are important to such consumers, the project has more significant impact at national level.

By replacing 13 million incandescent bulbs with 15-watt CFLs, the project can shave up to 450 megawatts (MW) from peak loads, or save 534,000 megawatt hours annually, by 2011.

The Philippines’ total generating capacity is about 16,000 MW but demand is growing at 6% annually and the Philippine Department of Energy (DOE) expects power shortages in Luzon and Visayas by 2012. The CFL project will help offset the 4,000 MW of additional generation capacity required to meet new demand.

“If you replace a million incandescent bulbs with CFLs for \$1.5 million and you cut electricity demand by 50 MW, the impact is the same as building a ‘virtual power plant’ that would cost \$50 million to build and another \$2 million to \$3 million a year to operate,” says Sohail Hasnie, an ADB Principal Energy Specialist.

The prospect of reduced electricity consumption does not appear to worry the privately-owned utilities and electricity cooperatives that sell power. In fact, the DOE, which is implementing the CFL program, is using privately-owned utilities and electric cooperatives to help distribute CFLs outside Metro Manila.

“Lower consumption may reduce revenue in the short term, but it will also flatten peak demand in the evenings,” says Ralph Paguio, a vice-president for Cagayan Electric Light and Power Company. “This means we can reduce or defer investments in equipment like sub-stations and transformers to meet peak demand.”



The government estimates that, by investing \$46.5 million in energy efficiency, it can defer \$450 million of investments in new power plants, as well as save \$100 million annually in fuel costs.

In Pakistan, the need to create “virtual power plants” is even more urgent. Pakistan suffers from a chronic power deficit—which reached 5,000 MW in 2009—and households and businesses experience power outages of more than 12 hours a day. The lack of power is a major constraint on economic development and has closed many factories, producing social unrest.

The 30 million CFLs planned for distribution in 2010 are expected to reduce peak demand by 1,094 MW from 2011, and save 2,670 GWh of electricity annually.

In contrast to the Philippines, which will rely for CFL distribution on a mix of NGOs and church groups as well as utilities, CFLs in Pakistan will be handed out by the utilities.

“Distribution will be aggressive, with the utilities going from door to door, exchanging incandescent bulbs for CFLs,” says Bayanjargal Byambasaikhan, an ADB energy specialist.

In the Philippines, distribution will be supported by a social mobilization program—under which volunteers raise awareness of CFL benefits—but consumers have to go to collection centers to exchange old bulbs for the new variety, says Mario Marasigan, Director of the DOE’s Renewable Energy Management Bureau.



• **Raising energy efficiency**—Lifting weights (above) under a CFL; Grace Bacalangco (below) cuts home electricity consumption wherever possible



Since fluorescent lamps contain mercury—although the project CFLs contain between 2 and 4 milligrams of mercury, much lower than the 8 to 15 milligram level of inferior CFLs—safe disposal facilities are needed to prevent contamination of groundwater or rivers. In the Philippines, the ADB-backed project will expand a mercury recycling unit at Angeles City, 60 kilometers northwest of Manila and Mr. Marasigan foresees the setting up of similar units around the country.

In Pakistan, ADB assistance includes a component to create CFL waste management capacity by attracting entrepreneurs to the recycling business.

The impact of the energy efficiency programs on the environment will be significant in both countries. They are expected to reduce carbon emissions, over the crediting periods, by about 700,000 tons in the Philippines and 5 million tons in Pakistan.

Moreover, ADB is helping the Philippines develop the program as a Clean Development Mechanism Program of Activities under the Kyoto Protocol. ADB's Asia Pacific Carbon Fund and Future Carbon Fund are considering buying a portion of carbon credits generated under this program till 2020. "This could be one of the biggest contributions of the Philippines in mitigating the adverse impacts of climate change," notes Josh Carmody, Principal Finance Specialist of ADB's Regional and Sustainable Development Department.

All these benefits stem from the act of replacing one light bulb for another. As ADB's Mr. Hasnie says, "The beauty of this program is its simplicity. You exchange bulbs and it's win-win-win for the consumer, the government and the utility."

Meanwhile, in a factory in Foshan City, Guangdong Province, People's Republic of China, technicians wearing plastic caps, gowns and slippers are working in a "clean room" as they monitor, by computer screen and microscope, the delicate process of soldering chips onto circuit boards.

A sterile environment is paramount for the assembly of minuscule components—some chips are the size of a grain of salt—that have to be kept dust-free. So is secrecy in the highly-competitive business of making LED products. Manufacturers jealously guard their assembly techniques, and photography is generally prohibited in the plants.

The reason is that LEDs, which are even more energy efficient than CFLs, represent the “next big thing” in the lighting sector.

Nearby, one of this company’s products—LED street lamps—is on view along a suburban street of Foshan City. To those passing through, the road looks little different from any other. But at night, an acute observer will notice that, although the street lamp heads are smaller than elsewhere, they appear to be brighter.

Under a demonstration program, the municipal authority has installed 75 LED lamps to replace sodium vapor lights. Although at least twice as expensive, each 112-watt LED lamp uses less than half the electricity of a 250-watt high-voltage sodium lamp, thus soon recouping its higher initial cost.

“The LED lamps use less energy than sodium lamps though they look brighter because they emit energy from a smaller source,” says Chen Kai-ping, an engineer with the Foshan Chancheng environment sanitation bureau. “Since LEDs are solid, with no glass or moving parts, they don’t break—or break down—easily. They need less maintenance and last 5 times longer than sodium lamps.”

By cutting electricity use, LED street lamps help to reduce carbon emissions. In 2009, the PRC’s Ministry of Science and Technology began a campaign to install 100,000 LED street lamps in 10 cities. If the scheme is successful, this number could rise significantly in the coming years.

“LEDs are the light of the future. They are 50% more efficient than traditional lighting,” says Jim Kim, chief executive officer of Real Faith Opto, a Foshan-based company which made the LED street lamps for the demonstration project. The company is owned by Guangdong Real Faith Enterprises Group, one of the province’s larger enterprises, which has been involved in the LED industry since 2008.

The experience of Real Faith Opto, one of hundreds of LED makers in the southern province of Guangdong, largely reflects that of the industry.

At present, outdoor LED products like street lamps and tunnel lights make up over 90% of the output of the Real Faith group, which also provides lighting for large screens, store windows, and appliance makers. But the really big market in its sights is that of LED lighting for homes and offices.

“As the technology improves and costs come down, we expect residential and commercial demand to take off,” says Mr. Kim. “This will happen soon as lighting efficiency is improving by 30% a year while costs are dropping by 20%.”

The PRC is an ideal litmus test for LEDs. It is already the world’s biggest manufacturer of LEDs. The PRC makes some LED chips and will soon be manufacturing the high-performance chips that are used in street lamps, for example. These chips are currently imported from half a dozen companies in Japan, Europe and the United States.

A key factor is that the government, recognizing its value as an energy saver, is prioritizing LED development. The need to reduce emissions is



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- **Next big thing**—Monitoring the assembly of high-performance LED chip and circuit board (top); Shanghai’s 8.9-kilometer tunnel between Pudong and Chongming Island uses 6,000 LED lights (bottom)



- **Assembling LEDs**—Monitoring through a microscope (top) and testing quality (above)

undoubtedly a driving force. Coal-fired plants generate 80% of the PRC's electricity and in 2006 the country overtook the United States as the world's largest emitter of greenhouse gases.

LED lighting is also one of the industries supported by the ADB, which is providing a \$100 million loan for a Guangdong Energy Efficiency and Environment Improvement Program. The program is cofinanced with grants of \$800,000 from the Clean Energy Financing Partnership Facility—supported by the governments of Australia, Norway, Spain, and Sweden—and \$1.2 million from the Climate Change Fund.

Aimed at bringing energy-efficient technology to major consumers in a heavily industrialized province, the ADB-backed program supports improvements on both the demand and supply side. LED is regarded as a key way to cut power demand and avoid emissions.

"LED technology promises great energy savings and we are working with a borrower to achieve a strong demonstration effect," says Hongliang

Yang, an ADB energy specialist working on the project. "The PRC is huge and, if consumers reduce electricity consumption by even a small amount, this translates into massive savings on a national scale."

Indeed, the projected energy efficiency benefits arising from one of Real Faith Opto's programs could be a microcosm of the wider world. The company will match a \$7.35 million loan from ADB with its own resources to fund a program to provide 31,250 LED street lights of different capacities. Every year, these lights will save 1.36 MW of electricity or 6,775 MW hours. In turn, this will translate into annual cost savings of \$2.18 million and, importantly, avoided emissions of 5,285 tons of carbon dioxide, 61 tons of sulfur dioxide, 13.5 tons of nitrogen oxide, and 22.7 tons of total suspended particulates.

Full implementation of ADB's investment program—including all components—is expected to lower coal consumption by 175,813 tons annually and produce energy savings of 533 gigawatt hours. End-users should also shave an estimated \$43 million from their electricity bills.

"Electricity demand is growing faster than supply and if peak demand can be lowered by hundreds of megawatts, this reduces the need to build more polluting power plants," says ADB's Mr. Yang.

Real Faith Opto, which has 350 staff, including an R&D unit, has notched up notable deals during its short history. For example, it provided LED lights for Shanghai's high-profile 8.9 km tunnel between Pudong and Chongming Island. This required 6,000 LED lights, a record for a tunnel at the time. Since beginning operations, the company has sold 10,000 LED tunnel lights and 8,000 LED street lamps. Looking ahead, the company plans to be making high-performance chips within three years, says Mr. Kim. This will help expand its niche in a fast-growing market.

"We expect the LED share of the lighting market to rise from 5% to one third in 3–5 years," says Mr. Kim. Such projections are based on a remarkable track record. The market value of LED products in PRC jumped 47% to CNY 35 billion (\$5.1 billion) in 2008. This is expected to rise to CNY 50 billion (\$7.4 billion) in 2009, says Mr. Kim. Over half of LED products are exported, with the rest feeding a large domestic market.

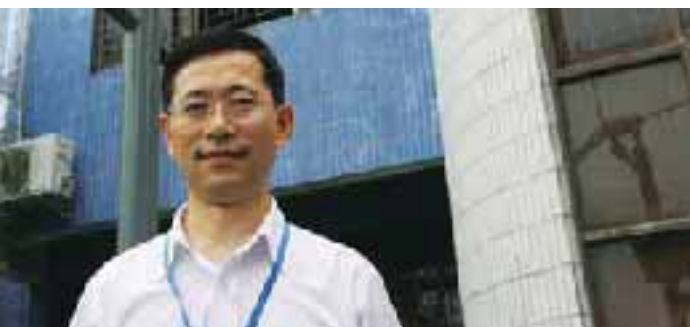
Although the first LEDs were made in the 1960s, the technology has improved with every generation. One area for improvement, according to experts, remains the ability of LEDs to dissipate heat.

"If light inside a chip cannot escape, it transforms to heat and builds up," says Kathryn M. Conway, a lighting consultant to ADB. "Heat inside the chip also reduces the amount of light created, so the best LEDs have optical and thermal pathways to guide the light and heat out. Good LED chip design increases efficiency."

Even with such issues, 2009 was a watershed year for the worldwide LED industry. For the first time, high-performance LED bulbs for home and office use became widely available in retail stores in many developed countries.

"As an experiment, I replaced all my CFLs with screw-in LED lamps," says Ms. Conway, who lives in upstate New York. "It was not cheap—the LED lamps cost six times as much as the CFLs—but the lighting part of my electricity bill dropped by 50%. Also, unlike glass CFLs, LEDs won't shatter and they are free of mercury."

Ms. Conway is in the vanguard of a trend that is expected to mushroom as LED bulbs become less expensive and more efficient. "Typically, it takes about 10 years for a new light source to be accepted and offered at a reasonable price," she says. No doubt, PRC manufacturers like Real Faith Opto are keeping a close eye on such developments.



"LEDs are the light of the future. We expect their share of the lighting market to rise from 5% to one-third in 3–5 years."

Jim Kim, chief executive officer of Real Faith Opto

The Fixers

A man in a light blue short-sleeved button-down shirt is working on large, dark brown, tiered electrical insulators. He is looking down at his work with a focused expression. The background is a dimly lit industrial space with various pipes and machinery, suggesting a factory or workshop environment. The lighting is warm and somewhat dramatic, highlighting the man and the equipment he is working on.

Industries and buildings investing in energy-saving measures need the technical and financing support of energy service companies (ESCOs). ADB is supporting ESCOs to encourage this fledgling sector in Asia.

A man in a light blue shirt is working on machinery in a factory setting. The background is dark and industrial, with various mechanical parts and tools visible. The lighting is warm and focused on the man and his work.

ZHUHAI, GUANGDONG PROVINCE, PEOPLE'S REPUBLIC OF CHINA

During a trip to the United States many years ago, Zhao Ruwen noticed that the hotel where he was staying was recycling heat from its air-conditioning system instead of venting it.

As a hotel manager responsible for energy services, he asked about the system with a view to promoting it back home in the People's Republic of China (PRC).

That experience changed his career. Today, he is president of an energy service company (ESCO), which is advising companies on how to save energy and costs and, importantly, is providing an innovative way to finance such improvements.

ESCOs, a young industry in the PRC, typically offer large energy users free energy audits to identify and recommend cost-effective energy-saving measures. Once the energy users agree, ESCOs develop energy-saving proposals. When an ESCO implements these proposals, it receives payment as a proportion of the energy expenditure saved over a period of time, generally between 3 and 8 years.

Retrofitting aging and obsolete machinery—such as motors, transformers, boilers, and lighting and air-conditioning systems—is one of the most cost-effective ways to cut down power and costs. ADB, which supports ESCOs in different energy efficiency projects, estimates that every megawatt (MW) of avoided power generation reduces investment in energy supply by over \$2 million. Moreover, the impact on climate change is significant. Every megawatt-hour saved means an avoided consumption of 330 kilograms (kg) of coal, and emissions of 780 kg of carbon dioxide, 9 kg of sulfur dioxide, 2 kg of nitrogen oxide, and 3.4 kg of total suspended particulates.

Although the benefits of retrofitting are significant, awareness of them is growing only slowly.

"It's hard for a chief engineer to sell energy efficiency to his management," says Hongliang Yang, an ADB energy specialist. "In the mind-set of those running a commercial building, or an industrial enterprise, spending on retrofitting ranks low in their priorities and cannot compete with expansion expenditure like a new process line or raw material orders."



- Shipyard operation at Jiangnan City—New transformers reduce power inefficiencies

In addition, Mr. Yang notes that commercial and industrial enterprises do not generally include energy efficiency improvements in their annual maintenance budgets—another reason such projects are dependent on external financing.

To make it an easier sell, ESCOs offer financing schemes under which industries pay for retrofitting not with cash but through savings in their energy bills.

For example, Mr. Zhao's company, Zhuhai Charlie Energy Protection Co. Ltd., which specializes in retrofitting industrial boilers and air-conditioning systems, offers the following typical deal to clients. The company will shoulder the cost of retrofitting a boiler, which may bring down the cost of steam production by 20%. In return, it will receive as payment the equivalent to 80% of the energy savings for 5 to 8 years. This payment will include a 50% profit margin. After this payback period, energy users keep the full benefit of reduced energy consumption.

Although the result can be win-win for all parties, the deferred payment system can lead to cash-flow problems, especially for smaller ESCOs.

Established in 1990 as one of the first ESCOs in Guangdong, Zhuhai Charlie has 35 technical staff and contracts out the retrofit work.

"Energy services are a young industry in Guangdong and the growth of companies that provide them has been severely limited by lack of capital," says ADB's Mr. Yang. "Many had to close because they couldn't build the equity needed to sustain their business." Commercial banks are also reluctant to lend to ESCOs as they lack understanding of the technologies and production processes and are often unable to properly evaluate the risk, he adds.

For this reason, ADB includes support for Mr. Zhou's ESCO in its broad-based Guangdong Energy Efficiency and Environment Improvement Program to bring energy-efficient technology to a heavily industrialized province.

ADB has lent Zhuhai Charlie \$1.47 million to finance retrofit projects—70% industrial boilers and 20% air conditioners—that together will save 6,706 MW annually or 1.2 MW. The resulting annual reduction in emissions will be approximately 5,230 tons of carbon dioxide, 61 tons of sulfur dioxide, 13 tons of nitrogen oxide, and 23 tons of total suspended particulates.

As ESCO contracts—under which ESCOs finance the front-end cost of energy-saving equipment and users pay the ESCO with savings from energy expenditure—gain acceptance, some manufacturers, too, are cutting similar deals.

For example, one Zhuhai-based solar power company did an ESCO deal to provide a building-integrated photovoltaic system and small solar power station for Dong'ao Island. Under its contract, the company paid the front-end costs and retained 100% of the energy savings for 5 years. Around a third of the company's contracts are structured similarly, say officials.

In another case, a Guangdong manufacturer of LED lighting products, Real Faith Opto, has been negotiating ESCO terms to provide LED streetlamps to a municipal authority. Under this deal, the company would finance the up-front costs and be paid in saved electricity costs for 3–5 years. It would be the first such deal for Real Faith Opto but officials say it may be the precursor for others.

In the Philippines, ADB is helping a fledgling ESCO industry indirectly. Only a handful of ESCOs are operating in the country and, while some are small, inexperienced, and lack capital, others are supplier-driven, which means they are promoting the equipment of a single manufacturer.

ADB is supporting the setting up of a “super ESCO” under an \$8 million component of its Philippine Energy Efficiency Project. The super ESCO, which will be like a financial institution with energy expertise, is being set up in the Department of Energy under the wing of the state-owned Philippine National Oil Company.

The new body will have a dual function. It will act as a normal ESCO in developing public sector projects. Also, instead of competing with them in a nascent ESCO market, the super ESCO will provide privately owned ESCOs with financial and technical support to service the private sector.

Especially in developing countries with less mature ESCO markets, private ESCOs would typically prioritize privately owned enterprises over government agencies as clients, says Sohail Hasnie, an ADB principal energy specialist working on the Philippine project.

The super ESCO will play a role in implementing a major component of the Philippines’ energy efficiency program, which is to retrofit some 42 government buildings. The lighting retrofits in these government buildings will produce savings of about 7,000 MW annually.

In encouraging retrofits, ADB can cite its own experience. At its Manila headquarters, ADB invested \$3.27 million to modify air-conditioning, lighting, and computer systems for 2,000 staff that cut costs by up to \$730,000 annually. The payback period was less than a year for lighting and around 4 years for air-conditioning. In 6 years, these changes saved 2 years’ worth of electricity—33 million kWh, equivalent to 18,000 tons of avoided CO₂ emissions.

Apart from the PRC and the Philippines, ADB is also considering assistance to ESCOs in countries such as India and Indonesia.

In addition, ADB is providing partial credit guarantees in the PRC to banks that finance ESCOs. This is to encourage lending to ESCOs among commercial banks that are more accustomed to lending against fixed assets rather than prospective project cash flows.

Changing banks’ and clients’ attitudes is a gradual process. “Through the efforts of governments and multilateral banks, we have to improve our awareness strategy and better package energy efficiency solutions as a business model that works even on a pure commercial basis,” says Mr. Yang. “Aside from improvements to the bottom line, another way to sell the energy efficiency business model to CEOs is to highlight the corporate social responsibility and climate change impacts of energy efficiency projects.”

ESCOs are already playing a major role in countries such as Japan, the United Kingdom, and the United States. In Guangdong, where large industrial and commercial enterprises account for more than 70% of the province’s electricity consumption, the provincial government has an aggressive program to reduce energy consumption by 16% per unit of gross domestic product between 2006 and 2010.

ESCOs have a valuable role by helping energy users improve energy efficiency and reduce the consumption of electricity, fuels, and other forms of energy. But they also need help to overcome the financing barrier and thus be able to grow bigger and stronger.



“We shoulder the cost of retrofitting and receive payment from energy savings over a period of years.”

Zhao Ruwen, head of a Zhuhai-based ESCO

Project Summary

Rationale

The People's Republic of China (PRC), Pakistan, and the Philippines are three countries that ADB has identified as having the highest potential for clean energy investments in Asia and the Pacific. Challenges to energy security and climate change continue to hamper these countries' environmental sustainability and economic growth.

The Philippines. The country will need to fill more than 6,700 megawatts (MW) of power supply deficits from 2008 to 2013 as electricity demand is projected to double by 2030 (from 2007). In a business-as-usual scenario, most of this demand growth will have to be met by imported oil and coal. The government is focusing on increasing generation from indigenous renewable energy sources and promoting energy efficiency to meet this challenge and to contribute to climate change mitigation. About 1,000 MW of virtual generating capacities can be created through various demand-side and supply-side energy efficiency measures such as efficient-lighting programs.

Pakistan. The country uses 15% more energy than India and 25% more than the Philippines (for each dollar of gross domestic product). Many parts of the country are experiencing power

outages; energy wastage is a high cost to the economy, businesses, and consumers and its reduction requires major and immediate shifts in policies, investment, and consumption patterns. Energy efficiency is a least-cost and quickest low-carbon solution to bridge the energy gap in the country. It is currently a strategic priority of the government as it aims to cut Pakistan's high dependence on oil imports and avoid investment in expensive and inefficient rental power generation based on fossil fuels with the goal of energy security combating climate change, and job and industry creation.

People's Republic of China. Currently, the PRC has the second-largest energy demand in the world; it is projected to become the largest energy consumer soon after 2010. Approximately 63% of the primary energy demand is met by coal, and 82% of electricity is generated from coal. This has resulted in serious environmental issues such as acid rain and air pollution. Aside from this, carbon dioxide emissions from power generation account for 25% of greenhouse gas emitted from the PRC. The PRC currently accounts for 5.1% of global carbon emissions; this is estimated to increase to 28% by 2030. Rapid implementation of energy conservation measures, including implementation of efficiency power plants, will lower the burden for later addressing the consequence of carbon emission and climate change.

Loan-2507: PHI: Philippine Energy Efficiency Project Project Officer: Sohail Hasnie, Southeast Asia Department

The project aims to implement an energy efficiency program, with focus on efficient lighting, to reduce peak load power demand and contribute to greenhouse gas mitigation.

Description

In addition to the compact fluorescent lamp (CFL) distribution program featured in the case study, the project also includes retrofitting about 40 government-owned buildings with efficient lighting, introducing energy-efficient lamps for public lighting,

setting up a laboratory for testing energy-efficient appliances and a lamp waste management facility, establishing a super energy service company, and promoting an efficient-building initiative. To support these initiatives, a communication and social mobilization program will be implemented with a grant from ADB. Pending the approval of the Clean Development Mechanism Executive Board, the CFL distribution component of the project will be the first in Southeast Asia to be approved under the mechanism.

SUMMARY

Total Project Cost: \$46.5 million (with cofinancing from the Clean Energy Financing Partnership Facility)

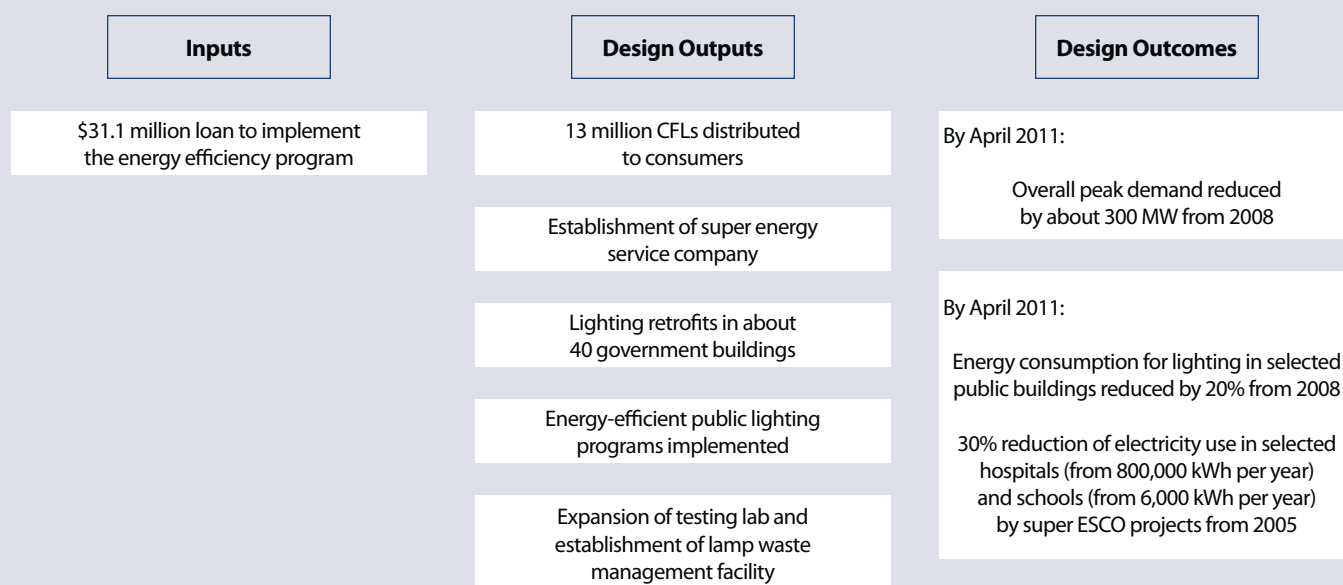
Clean Energy Project Outcomes:

- 534,000 MWh annual energy savings
- 300,000 tons CO₂ emissions reduction

LESSONS LEARNED

1. The innovative design fundamentals of the Philippine CFL project are summarized in three points:
 - Bulk procurement of CFLs allowed ADB to purchase the bulbs at 60% below the market price.
 - The project is elevating the standard for CFLs. The lamps that are currently available in the market have standard rated lifetime of 6,000 hours. The CFLs in the project are rated at 10,000 hours.

- As a public sector project, implemented by the government, the opportunity to sell carbon credits is maximized.
2. Communicating the purpose and benefits of the project to different stakeholders—i.e., government, business sector, communities, etc.—during project design and implementation is important to get their support and participation in the project.
 - Energy efficiency is a highly technical topic that needs to be communicated clearly and properly to stakeholders. During project design, the benefits of energy efficiency efforts, measured in kilowatt-hours, should be quantified in money terms to better communicate the message to nontechnical stakeholders.
 - A multi-stakeholder and social mobilization approach is critical in gaining acceptance and support for the project from a wide and varied group of beneficiaries.



Loan-2552/2553: PAK: Pakistan Energy Efficiency Investment Program Multi-tranche Financing Facility
Project Officer: Bayanjargal Byambasaikhan, Central and West Asia Department

The investment program is the first initiative in Pakistan to integrate energy security and climate change into a common strategic platform aiming for a dynamic business environment for clean energy technology.

Description

Key program features aim to (i) mainstream energy efficiency into national planning and public investments; (ii) transform the clean energy market in Pakistan by breaking down financial barriers and

finance priority projects; (iii) engage the private sector in clean energy investments and services; and (iv) create sustainable financing partnerships with investors and financiers, including development partners. Tranche 1 of the investment program will finance the National Compact Fluorescent Lamp (CFL) Project which will replace about 30 million incandescent bulbs in the domestic sector with efficient, high-quality CFLs, and the Investment Program Management Support Project, which will help the government manage the program and execute projects under each tranche.

SUMMARY

Total Project Cost: \$1.18 billion

Clean Energy Project Outcomes:

- 2,670 GWh electricity saved annually starting 2011
- 1 million tons CO₂ reduced starting 2010

LESSONS LEARNED

1. Energy efficiency projects needs a champion. Identifying and supporting a political and institutional champion with cross-

sector policy and planning mandate would be key to successful program design.

2. From the Pakistan experience, the private sector must take a leadership role during the design and implementation as well. Continued policy dialogue with all stakeholders thus is necessary.
 - This process takes time and effort. Oftentimes, interagency coordination is weak, and consensus building can be complicated as all parties have varying interests when it comes to energy use and energy efficiency.

Project Summary (continued)

| Inputs | Design Outputs | Design Outcomes |
|-------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
| \$85 million for the CFL Project component out of the \$1.18 billion Investment Program to mainstream energy efficiency in Pakistan | Electricity peak demand reduced by 1,094 MW and 2,670 GWh electricity saved annually starting in 2011 | Households average energy bill cut by 25% from 2010 |
| | GHG emissions cut by 1 million tons CO ₂ starting in 2010 | Grid-connected customers receive uninterrupted and quality power supply from 2013 |
| | Minimum energy performance standards for equipment and appliances established and harmonized with international standards from 2010 to 2014 | Clean technology investments increase by 20% per year starting in 2010 |
| | National energy efficiency policy coordination and road map management function established in the Planning Commission by 2009 | Energy bills lowered by 30% for businesses from 2011 |
| | 10-year national energy efficiency action plan adopted by 2010 | Improved financial and operating performance of sector utilities from 2011 |
| | Public procurement guidelines revised to mandate energy efficiency by 2011 | Commercial energy service companies established by 2011 |
| | 918,942 toe (38,474 Terajoules) energy saved annually from reducing gas, oil, and coal use in homes and industries starting in 2012 | |
| | 601,671 toe (25,191 TJ) energy saved annually from reducing losses in power generation and gas transmission starting in 2013 | |

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Loan-2426: PRC: MFF: Guangdong Energy Efficiency and Environment Improvement Investment Program—Tranche 2
Project Officer: Hongliang Yang, East Asia Department

The investment program aims to finance an efficiency power plant in Guangdong province, which is equivalent to 107 megawatts in capacity.

Description

The initiative to retrofit streetlights using efficiency light-emitting diodes (LEDs) bulbs is one of the six subprojects that have been selected for financing from the second tranche of this investment program. The second tranche of this multitranche financing facility will finance equipment retrofits and use renewable energy to replace conventional energy sources. This investment program will

finance an efficiency power plant (EPP) in Guangdong province, equivalent to 107 megawatts (MW). Energy savings from an EPP will contribute toward improved energy security as lesser new power supply capacity will be needed to meet future demand. In aggregate, this will reduce the need to construct and operate a conventional coal-fired power plant. An EPP can improve local and subregional environments because of lower greenhouse gas emissions from avoided coal use. The first tranche of the program will finance eight subprojects that will retrofit existing equipment with more energy-efficient ones.

SUMMARY

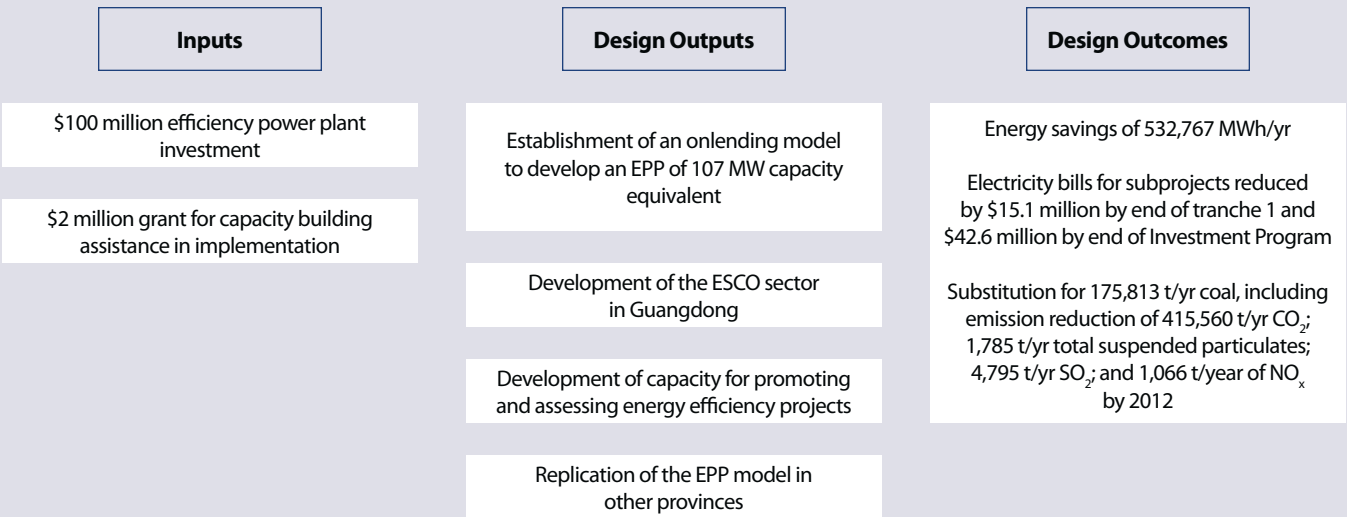
Total Project Cost: \$100 million (with cofinancing from the Clean Energy Financing Partnership Facility and the Climate Change Fund)

Clean Energy Project Outcomes:

- 532,767 MWh per year energy savings
- 175,813 tons per year coal savings
- 415,560 tons per year CO₂ equivalent by 2012

LESSONS LEARNED

1. Having a separate financial intermediary and project management office facilitates better selection of sub-borrowers and implementation of subprojects.
 - The financial intermediary serves as a “financial agent” that assesses the financial viability of sub-borrowers and is in charge of funds administration. The project management office is responsible for overall implementation of the subprojects and the technical aspects of the investment program.
2. ADB lending allows energy service companies (ESCOs) to leverage more funds with other sources.
 - With ADB funds, ESCOs get seed capital that strengthens their financial standing to access domestic financing sources.
3. The project is scaling up and expanding the traditional ESCO concept by involving energy efficient product and technology manufacturers to extend services beyond those of their products just as ESCOs do.
4. The success of the Investment Program cannot be achieved without a high sense of local ownership, effective leadership in project management offices, timely government support, and policy reforms on project selection and approval procedures.





Enabling Low-Carbon Technology Diffusion in the Region

As reflected by the increasing amount of ADB's clean energy investments, the acceptance and enthusiasm for clean energy is high among DMCs. However, there is much room for improvement in the scaling up of clean energy technology transfer and deployment. ADB is strategically positioned to help rapid diffusion of low carbon technologies. Toward this goal, the following programs and approaches will be implemented:

- **Asia Cleantech Exchange to Promote Low-Carbon Technology Transfer**

ADB is proposing to establish ACE: Asia Cleantech Exchange to support willing buyers and sellers of low-carbon technologies to facilitate technology transfer and rapid diffusion of these technologies in Asia and the Pacific. This would function in the commercial space with little direct public funding and would be the first of its kind to target low-carbon technologies and a large number of developing countries. A feasibility study with technical inputs from McKinsey & Company has been completed, which concludes that such an intervention

is feasible and will accelerate transfer of low-carbon technologies to developing countries.

- **Carbon Capture and Storage (CCS)**

ADB is working in partnership with the Global CCS Institute–Australia to assist developing member countries, prepare road maps for CCS demonstration projects, policies, and legal and regulatory frameworks. The road maps will identify and help overcome barriers to commercial-scale deployment of CCS in the region

- **Solar Energy Initiative**

ADB is proposing a \$500 million fund intended to catalyze greater levels of investment and break down the barriers to commercial-scale deployment of solar energy technology in the region. This initiative seeks to identify and develop some 3,000 megawatts of solar power projects by 2012 at an estimated cost of \$9 billion. It will also keep the region up-to-date with the newest technological developments in solar energy. Further, it will design ways to incentivize and finance the rapid diffusion

of solar technology for power generation, at the scale of national power grid systems and distributed stand-alone generation. The Asia Solar Energy Forum will be conducted and will serve as a knowledge-sharing platform for learning and exchanging experiences on key issues.

- **Quantum Leap in Wind**

The Quantum Leap in Wind initiative will develop country-specific road maps for large-scale deployment of wind power leading to an additional 1 GW of installed wind power in priority countries within 5 years with total investment of over \$1.0 billion from ADB and others. Quantum Leap will promote large and small wind projects that are grid-connected and off-grid, implemented through the public and private sectors. These projects will provide reliable electricity to more than 5 million people and will avoid an estimated 2 million tons of carbon dioxide emissions per year.

- **Small Wind Initiative**

ADB is implementing a regional technical assistance program to explore effective ways to utilize indigenous renewable energy resources, mostly wind and solar power, to supply electricity to and improve living standards of poor communities in remote areas that are not covered by power grids because of technical or financial difficulties. Three countries—Mongolia, Nepal, and the Philippines—have been selected to conduct pilot tests.

- **Asia Clean Energy Venture Initiative**

ADB has created a task force to evaluate the merits of a venture capital fund to invest in developers of advanced clean-energy and other climate change-related technologies in the region. The preliminary idea is to consider equity investments to start up companies through fund managers, coupled with grant-supported technical assistance. The task force will report back to ADB management in mid-2010 to decide whether such a scheme could be useful and successful in promoting technology innovation, transfer, and diffusion in Asia and the Pacific to address climate change.

- **Renewable Energy Certificate**

ADB's Clean Energy Program will promote this market-based instrument in the region to support renewable energy development. To increase the flexibility in meeting renewable

energy development targets in selected DMCs, this initiative will provide assistance to establish legal and regulatory frameworks for a RECs system, which allows renewable electricity generators to unbundle the environmental attributes of renewable energy from the electricity and make them tradable in a trading market.

- **Strengthening Clean Energy Governance and Regulation**

ADB's Energy Policy 2009 also emphasizes energy sector reforms, capacity building and governance as the third pillar for implementation. Initiatives to highlight the cross-cutting role of good governance and regulation to improve access to energy, promote energy efficiency and renewable energy, and lower greenhouse gas emissions are planned such as the Asia Pacific Clean Energy Regulatory Dialogue. Governance and policy work has always been a priority for ADB, no matter what the sector. A robust foundation that provides clear guidelines and incentives for clean energy is necessary for DMCs to progress down a path of low-carbon growth.

PROGRAMS

Asia Least-Cost Greenhouse Gas Abatement Strategy (ALGAS) Project

Fund sources: Global Environment Facility (GEF) through the UNDP, ADB, and the Government of Norway

- Assisted the 11 developing member countries (DMCs) prepare inventories of greenhouse gas (GHG) sources and sinks in accordance with IPCC guidelines, developed national portfolios of technical assistance and investment projects on GHG abatement options

Promotion of Renewable Energy, Energy Efficiency, and GHG Abatement Projects (PREGA)

Fund sources: ADB and the Government of the Netherlands through REACH

- Identified project opportunities, increased understanding of country-specific barriers to, and facilitated building of national capacities on renewable energy, energy efficiency, and GHG abatement (REGA) technologies and financing modalities such as Clean Development Mechanism (CDM) in participating DMCs

Clean Development Mechanism Facility

Fund source: ADB

- Established to provide DMCs opportunities to access additional financial resources through efficient emissions reduction by bridging the gap between buyers and sellers, ensuring a fair return for GHG abatement initiatives and assisting them to meet their commitments under the Kyoto Protocol

Energy Efficiency Initiative (EEI)

Fund sources: ADB and Climate Change Fund

- Surpassed ADB's clean energy investment target of \$1 billion with around \$1.6 billion in 2008 and \$1.2 billion in 2009

Carbon Market Initiative

Fund sources: Governments of Austria, Finland, Japan, Luxembourg, Spain, and Switzerland

- In 2009, the Technical Support Facility supported over 65 projects and about 50 CDM project opportunities have been identified

Energy for All (Efa)

Fund sources: Government of the Netherlands through REACH and the Government of Japan through Asian Clean Energy Fund

- Supported 9 projects across 10 countries and leveraged \$173.5 million investment in access to energy for the poor as of the end of 2009

Clean Energy Program

Fund sources: ADB and Climate Change Fund

- Toward implementing the Energy Policy 2009 and in support of Strategy 2020, this program redefines the role and thrusts of the Energy Efficiency Initiative as it expands ADB's clean energy investments in smaller DMCs and mainstream clean energy projects in investments in water supply and sanitation, urban, transport, and agriculture sectors, and monitor clean energy projects and achievements against indicators of the Energy Policy

FINANCING FACILITIES

Renewable Energy, Energy Efficiency, and Climate Change Program (REACH)

Fund sources: Governments of Canada, Denmark, Finland, and the Netherlands

- Supported 28 projects across 22 countries totaling about \$20.26 million in allocations; 20 projects (~\$12 million in total) have been completed by the end of 2009

Clean Energy Financing Partnership Facility (CEFPF)

Fund sources: Governments of Australia, Japan, Norway, Spain, and Sweden

- Since it started operations in the last quarter of 2007, it has helped catalyze about \$528 million in clean energy investments

Asia Pacific Carbon Fund (APCF)

Fund sources: Fundo Português de Carbono (Portugal), Swedish Energy Agency (Sweden), The Grand-Duchy of Luxembourg, Climate Cent Foundation (Switzerland), The Ministry for Foreign Affairs of Finland, Belgium, on behalf of the Flemish Region, and The Kingdom of Spain

- As of the end of 2009, APCF has entered cofinancing contracts with 35 CDM projects, expected to increase generation of renewable energy in DMCs by over 1,000 megawatts

Climate Change Fund (CCF)

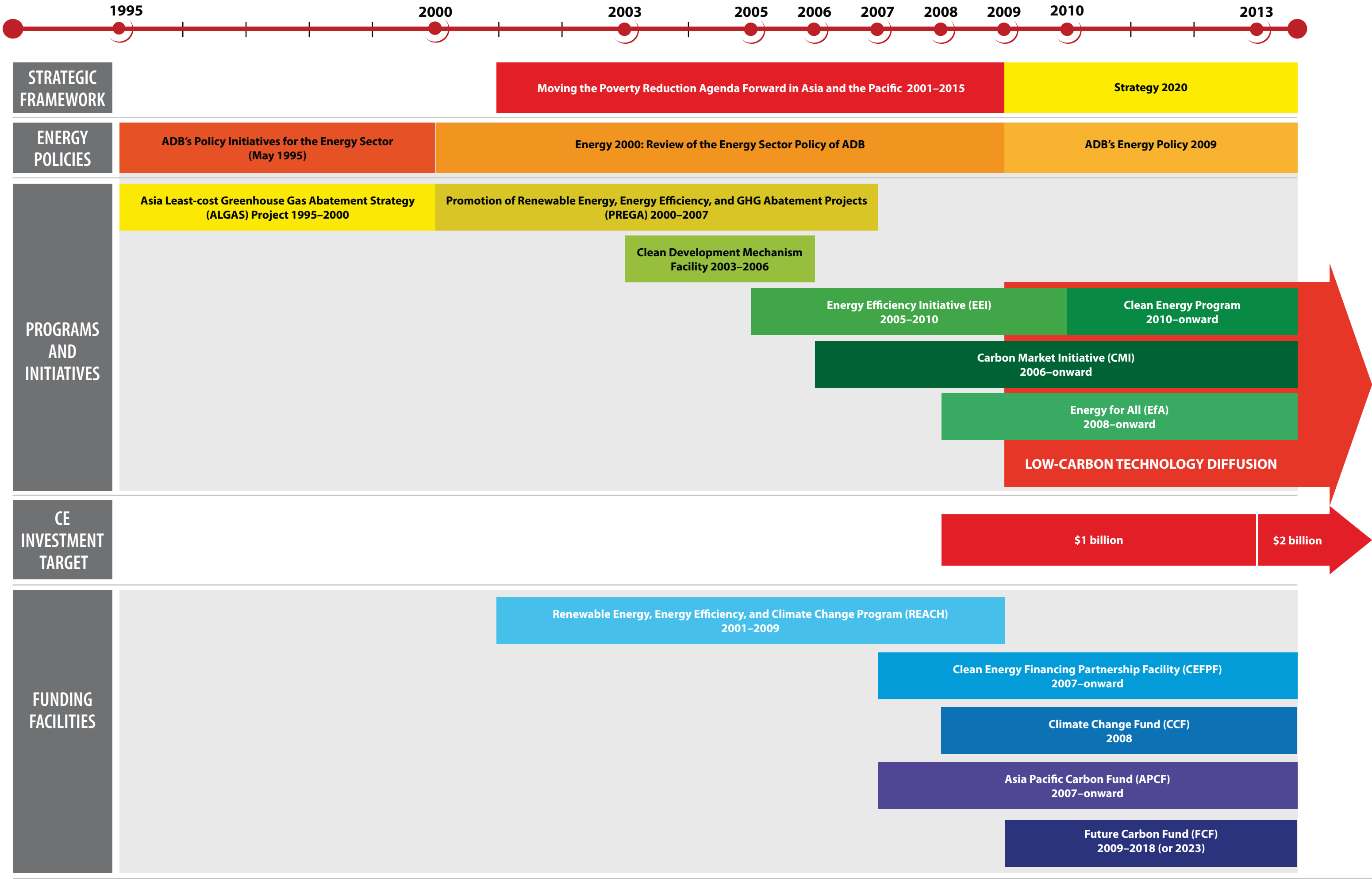
Fund source: ADB

- An allocation of \$40 million from ADB's ordinary capital resources net income was used to establish this special fund

Future Carbon Fund (FCF)

Fund sources: Governments of the Flemish Region of Belgium, Finland, Sweden, and the Republic of Korea

- FCF is considering at least 22 priority projects for up-front financing and 49 more in the pipeline; has received \$80 million in total commitments as of the end of 2009



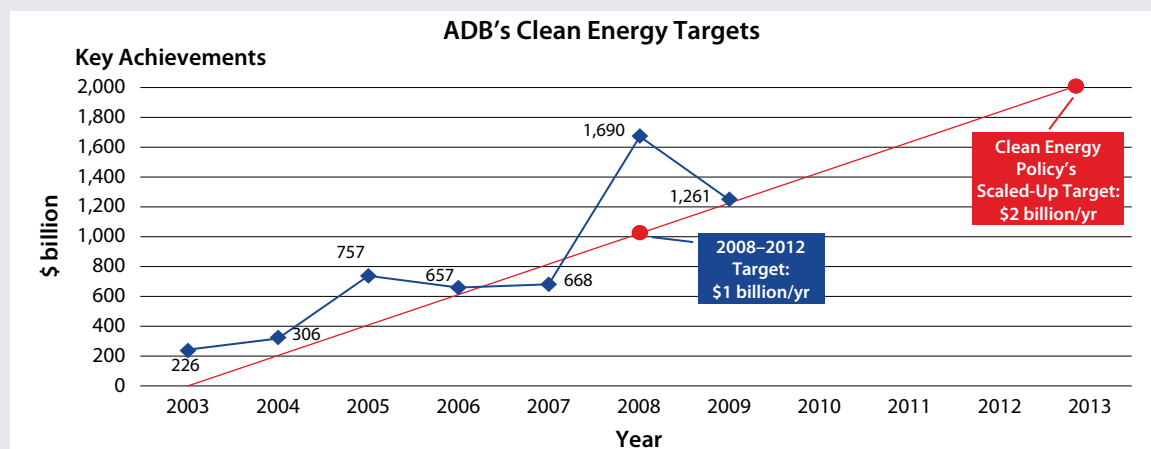
Evolution of ADB's Clean Energy Program

In the early 1990s until 2005, the Asian Development Bank (ADB) provided fundamental preparatory support to its developing member countries (DMCs) for addressing climate change. Initiatives such as the 1992 technical assistance (TA) study on Climate Change in Asia were carried out. Another initiative was the Asia Least-cost Greenhouse Gas Abatement Strategy (ALGAS) from 1995 to 2001, which improved the capacity of DMCs to prepare baseline inventories of greenhouse gas (GHG) emissions and sinks to meet the requirements of the UN Framework Convention on Climate Change. In addition, the Promotion of Renewable Energy, Energy Efficiency, and GHG Abatement Project, which supported investments in renewable energy, energy efficiency and GHG abatement technologies aimed to increase the poor's access to energy services and help reduce GHG emissions. These initiatives were implemented in line with ADB's Policy Initiatives for the Energy Sector, which was launched in 1995 with the aim to integrate environmental considerations in all energy sector activities for sustainable development. This policy was reviewed in 2000, which then aligned ADB's energy sector operations with the three pillars of its poverty reduction strategy.

In 2005, ADB launched its Energy Efficiency Initiative (EEI) to (i) expand ADB's clean energy program, (ii) build greater capacity in ADB's operations departments to develop clean energy projects, and (iii) establish new and innovative financing instruments for clean energy investments. The TA to operations departments

provided capacity building, planning, policy development, regulatory, and communications support to develop a pipeline of clean energy projects and create the enabling environment for increasing clean energy investments in DMCs. EEI set the annual ADB clean energy investment target at \$1 billion. This was surpassed in 2008 by \$690 million. This achievement signified ADB's interest in expanding its clean energy portfolio and was reflected to the new Energy Policy 2009. The policy listed as one of its pillars, the "promotion of energy efficiency and renewable energy" and increased the annual clean energy target to \$2 billion by 2013. In 2009, ADB's clean energy portfolio exceeded the target again with \$1.26 billion worth of investments. This shows that energy divisions in operations departments have incorporated such investments into their portfolios. Clean energy priorities have also been reflected in the projects of other sectors, notably the transport and urban sectors.

EEI's role and thrusts has been redefined as ADB's Clean Energy Program (CEP) and will move toward implementing the Energy Policy 2009 in support of Strategy 2020. The CEP will (i) expand ADB's clean energy investments in smaller DMCs, (ii) increase the program's assistance to demand side clean energy components and projects in water supply and sanitation, transport, urban, agriculture, and other sectors; and (iii) tracking the pipeline of clean energy projects and monitor achievements against ADB's institutional indicators on poverty reduction and development and those specific to the Energy Policy 2009.



Clean Energy in Asia: Case Studies of ADB Investments in Low-Carbon Growth

Asia's relentless demand for energy raises great concerns over energy security and combating climate change. As part of the solution, ADB is funding projects that help countries develop clean energy through renewable power and energy efficiency. This publication features 10 clean energy stories that reduce greenhouse gases as well as improve lives for the poor.

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 substantially reduce poverty and improve the quality of life of their people. Despite the region's many successes, it remains home to two-thirds of the world's poor: 1.8 billion people who live on less than \$2 a day, with 903 million struggling on less than \$1.25 a day. 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.