



HUANENG TIANJIN IGCC

TIANJIN INTEGRATED GASIFICATION COMBINED CYCLE POWER PLANT PROJECT

New Power Generation Technology for Near-Zero Emissions



Syngas purification system

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

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

CONTEXT

Coal-based energy production increased in the People's Republic of China (PRC), from 0.98 billion tons in 2000 to 2.74 billion tons in 2008. Projections suggest continuing increases as the PRC works to keep pace with an accelerating demand for energy. In the last decade, and particularly during 2001–2005, energy consumption peaked at 9.5%, only slightly less than the growth in gross domestic product (GDP) in 2005.¹

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

The PRC's dependence on coal degrades the environment. Coal production for power generation accounts for about 50%, 36%, and 20% of emissions from sulfur dioxide (SO₂), nitrogen oxides (NO_x), and mercury, respectively, and 39% of carbon dioxide (CO₂) emissions.³ Consequently, the air quality in many cities is poor. A third of the PRC and 45% of its farmland suffer the effects of acid rain resulting mainly from coal-based emissions.

To address the environmental impact of coal, the PRC has been actively improving its energy efficiency and emission reduction measures. It has also been turning to noncarbon and other cleaner energy sources. In 2006, it enacted the Renewable Energy Law which encourages technology for wind, solar, and biomass energy. However, coal likely will continue to dominate power production, even though the projected growth of coal production is environmentally unsustainable. The rapid increase in coal consumption—by more than 250% in the past 6 years—raises serious concerns about SO₂, NO_x, and incremental CO₂ emissions and their local, regional, and global impacts. In addition, waste coal is the PRC's largest solid waste, comprising about 25% of industrial waste (footnote 3).

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

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

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

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

PROJECT SNAPSHOT

LOAN APPROVAL DATE:

February 2010

LOAN AMOUNT:

\$116.84 million

BORROWER:

People's Republic of China

EXECUTING AGENCY:

China Huaneng Group

GEOGRAPHICAL LOCATION:

Tianjin City

TYPE OF ENERGY PROJECT:

Power generation

PROJECT COMPLETION DATE:

January 2016

SOLUTIONS

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

In IGCC power plants, the gasification of coal into a synthesis gas (i.e., syngas) and subsequent removal of impurities (e.g., SO₂, NO_x, mercury, and particulate matters) can achieve 99% desulfurization efficiency with NO_x discharge only 15%–20% of conventional power plants. Syngas combusts in a highly efficient, combined cycle turbine set, potentially increasing efficiency 4%–5% compared with supercritical plants, leading to significantly lower CO₂ emissions.⁵

Carbon capture and storage. The project added carbon capture and storage (CCS) to separate, capture, transport, and store CO₂. Various international studies report that IGCC power plants with CCS is a least-cost option to cut CO₂ emissions from coal-fired power plants by up to 90%. In IGCC plants, CCS captures CO₂ from coal-fired power plants prior to combustion and stores it in deep geological formations (e.g., depleted oil and gas wells) (footnote 3).

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

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

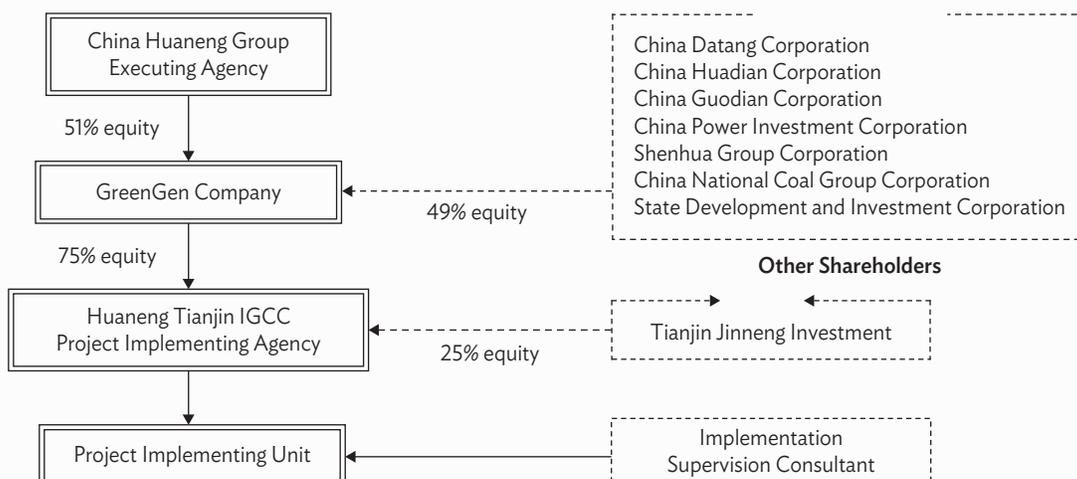
Three-phase implementation. GreenGen used a three-phase implementation program. Phase 1 aimed to develop, construct, and implement the 250-megawatt (MW) Tianjin IGCC plant. Preconstruction began in July 2009 and the main construction began in February 2010. The power plant was commissioned on 12 December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

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

⁵ Supercritical and ultrasupercritical technology refers to new pulverized coal combustion systems which operate at increasingly higher temperatures and pressures, therefore achieving higher efficiencies than conventional pulverized coal combustion units and significant CO₂ reductions.

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

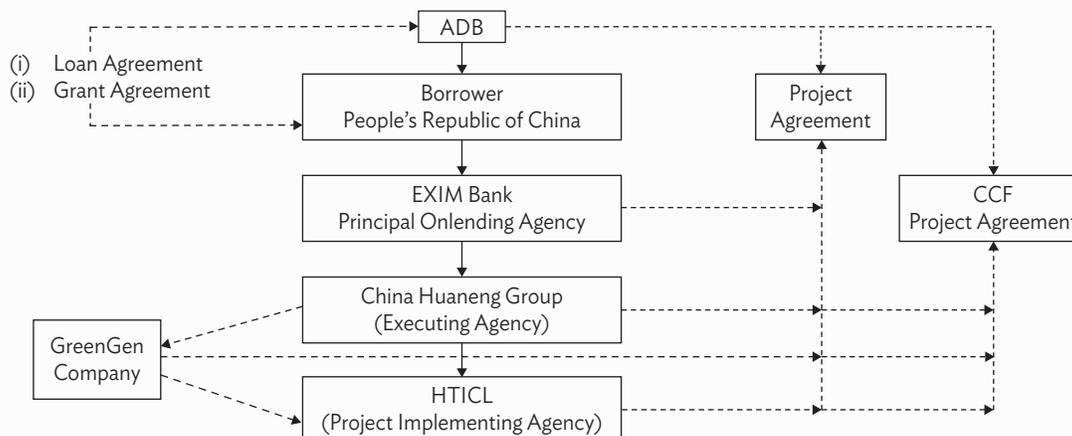
Figure 2.2.1: GreenGen Organizational Setup



IGCC = integrated gasification combined cycle.

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

Figure 2.2.2: Tianjin IGCC Power Plant Project Onlending Arrangement



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

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

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

⁷ CCS technology captures and stores CO₂ in deep geological formations such as oil wells.

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

RESULTS

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

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

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

Lower greenhouse gas emissions. Since 2012, the project has saved 134,000 tons of coal and reduced CO₂ emissions by 372,000 tons per year.¹⁰ Lower greenhouse gas emissions will improve ambient air quality throughout the PRC, especially if other companies replicate the project in other parts of the country.

LESSONS

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

⁸ ADB. 2010. *Loan Agreement between People's Republic of China and the Asian Development Bank: Tianjin Integrated Gasification Combined Cycle Power Plant Project*. May. Manila.

⁹ World Coal Association. 2014. *Coal Statistics*. September. <http://www.worldcoal.org/resources/coal-statistics/>

¹⁰ Global CCS Institute. 2014. *Huaneng GreenGen IGCC Project (Phase 3)*. November. <http://www.globalccsinstitute.com/project/huaneng-green-gen-igcc-project-phase-3>

Longer learning period. IGCC technology is complicated and requires a long learning curve. This project focused on specific technical and management challenges, incorporating lessons from international experts as they conducted technical due diligence during construction and initial operation. The formal cooperation agreement between Huaneng Tianjin IGCC and the owner of the Puertollano IGCC Plant in Spain was very important because it enabled the former to learn about Spain's experience in designing, building, operating, and maintaining its own CO₂ capture project.¹¹

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



Coal gasifier at the plant

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

Keywords

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

For further reading

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

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