Beijing Jingneng Clean Energy Co., Limited – Technical Assessment

Final Report

31 May 2011

Beijing Jingneng Clean Energy Co., Limited
北京京能清潔能源電力股份有限公司

Issue and revision record

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1. Executive Summary

1.1 Introduction

Mott MacDonald Limited (MM) has been appointed by Beijing Jingneng Clean Energy Co., Limited (Beijing Energy) to act as Technical Consultant on the Company's global initial public offering (IPO) project.

Mott MacDonald will be compensated with professional fees for the services and technical advice provided. However, none of the Mott Macdonald directors and staff who contributed to the report has any interest in:

- Beijing Jingneng Clean Energy Co., Limited;
- the asset portfolio that was subject to the technical assessment; or
- the outcome of the Global Offering.

Prior to issuing a final report, the Company and its advisers were provided with the draft of a technical report only for the purpose of confirming the accuracy of data used and factual material.

MM is a world-class multi-disciplinary consultancy engaged in development, focusing on many aspects of everyday life from energy, transport, health and education, water and the environment to building, industry and communications. MM has won recognition for technical excellence in power engineering, water, transportation, building and infrastructure and, in addition to these technical services, also offers a wide range of strategic planning, financial and business development services. MM is a wholly independent international company, with headquarters in the UK, annual turnover in excess of 1 billion Euros, over 14,000 staff and global experience spanning 140 countries. For the third consecutive year, MM has made the top 10 list in the UK's Sunday Times annual '25 Best Big Companies to Work For' employee survey, ranking eighth in 2010.

MM has undertaken over seventy projects in China totaling over 32 GW including wind, hydro, biomass, waste-to-energy, gas-fired and coal-fired power plants.

MM carried out an independent technical assessment of Beijing Energy assets of wind farms and gas-fired power plants. This review of wind farms includes wind resource assessment, power generation, availability, operational and maintenance arrangements, wind turbine technologies, grid connection arrangements and compliance with grid codes. The review of gas-fired power plants includes gas supply, heat and power production, availability, operational and maintenance arrangements, Combined Cycle Gas Turbine (CCGT) technologies, life-limiting issues and major problems, and environmental limitations. The assessment covers eight representative wind farms out of the fifteen operating projects and two operating gas-fired power plants.

The majority of the information from which the report was compiled comprises of documents provided by Beijing Energy, and discussions and meetings with relevant Beijing Energy staff. MM's professional judgment was exercised with regard to the validity and use of all information submitted from external sources. MM's knowledge of the Chinese power sector has been utilized throughout the independent technical assessment process.

Mott Macdonald has selected a core team of specialists to complete the technical appraisal for the Beijing Energy's generation assets. The core team members and their roles are presented below.

Bauer Wu, MSc, BSc is the project manager for this project with 7 years experience in China power sector, acting as the designer and technical consultant in over 15 power plant construction projects, covering coal-fired power plants, oil-fired power plants and wind farms. He also has experience for several hydropower plants technical assessment projects for assets acquisitions and some IPO technical due diligence projects such as Longyuan. The projects are both domestic and overseas.

Scott Love, MSc, BSc is an engineer specializing in renewable energy with more than 5 years of experience in the wind energy sector. His expertise covers a range of activities from design and manufacture of wind turbines to installation, commissioning and servicing. Scott has worked for a wind turbine manufacturer on various projects in the UK, Denmark and in the US. Most notably, in 2008 Scott provided installation supervision, commissioning and training on-site for a test turbine at a world leading wind technology research facility in Colorado. For Mott MacDonald, Scott is a Renewable Energy Engineer working on many aspects of both onshore and off-shore wind projects as well as on other renewable energy projects. Scott's experience includes resource assessment, feasibility studies, due diligence for financing of wind power projects, technology assessment, wind farm construction and operations monitoring.

Dr. Yanmin Song, BSc, MSc, PhD is a highly experienced power system engineer and project manager for over 25 years with solid industrial, commercial and research experience and robust track record in project delivery of deployment, including not only technology, market and commercial considerations, environmental impact, regulatory framework, standardization usage, ICT (Information & Communication Technology) and migration strategy but also societal requirements and governmental edicts. Her expertise covers due diligence work for renewable energy including wind farm, biomass and WtE energy; distributed generator assessment and energy saving issues; grid code and electricity market regulation, especially on grid connection code for wind farm; transmission and distribution (T&D) network planning; electricity market management system (MMS) used in electricity trading market; power plant bidding and decision making support tool; supervisory control and data acquisition/energy management systems (SCADA/EMS) as well as dispatcher training simulator (DTS).

Zoe Zhao, has BSc in Material Engineering and MSc in both Material Engineering and Power Engineering focusing on wind energy. Her expertise covers due diligence work for renewable energy including wind farm and hydropower plant and transmission towers modelling and design. She has been involved in several due diligence projects for IPO in China up to date.

Piya Lertpiyayowong, Registered Professional Engineer, has BSc in Electrical Engineering and MSc in Management Technology focusing on Renewable Energy Technology and Environmental Management. He specializes in Power Purchase Agreement of large-scale power projects in Thailand including both thermal and renewable power projects. He also has a background in erection and testing of Control Systems (DCS and

Mark V) for Gas and Steam Turbines. He was recently involved in setting up of an efficiency measurement scheme for an SPP cogeneration plant that was being developed in Thailand. He also has experience in EPC Contract management and construction-monitoring work from previous experience in EGAT's conventional power projects.

Danai Posomboon has over 20 years experience in power project both in Thailand and abroad. He has in depth understanding of biomass and coal fired plants, covering engineering, construction and operation. He has also undertaken a number of assignments for due diligence review and feasibility study for coal fired power project. He was involved in 2007 IPP bid solicitation in Thailand providing technical support for the proposed 800 MW coal fired project. In addition to thermal power project, Danai has previous experience in combined cycle gas turbine and biomass power plants plus gas pressurization plant. In O&M aspect, he also has experience in operation and maintenance of coal fired plant, cogeneration power plant, combined cycle and bunker oil thermal power plants, and was Plant Manager of a biomass power plant as well as Operations Manager of cogeneration combine cycle power plant.

- Wind resources and geographic coverage—Representative wind farms selected are located in areas with abundant wind resources including Inner Mongolia, Liaoning and northwest of Beijing, as shown in Figure 2.1.

- Wind turbine types—Representative wind farms selected include turbines produced by both domestic and international manufacturers as detailed in Section 3.3 of this report.

- Year of operation—Representative wind farms selected have different operation start dates as detailed in Table 4.1.

- Gas turbine suppliers—Two gas-fired power plants applied different top-class gas turbine manufactures as detailed in Section 3.4.

1.2 Project Participants

Converted from Beijing Jingneng Technology, Beijing Energy was formed in Aug 2010, and is a shareholding subsidiary of Jingneng Group. It was previously known as Beijing Energy Investment, which was formed in 1993. Its business focuses on the investment, construction and operation of all the clean energy projects, and integrates the development and utilization of wind energy, gas-fired power, hydropower, biomass power and heat-supply networks. The development strategy is to strongly accelerate the use of wind power and gas-fired power, and to steadily develop the hydropower, solar PV and other clean energy technologies. Environmental protection and energy conservation business are also covered in its strategic plan. Based on the representative projects reviewed, we consider that Beijing Energy is capable of acting as the owner and operator of the wind farms and gas-fired power plants.

Most of the WTG suppliers chosen by Beijing Energy to supply and maintain the WTGs on its wind farms are well known to the wind industry. However Sewind Co., Ltd. (Sewind) did not have the long track record of the other chosen WTG suppliers as it was only founded in 2006. It has undergone rapid development and one of its parent companies is the Shanghai

Electric Group which has strong equipment manufacturing capability. We therefore considered Sewind acceptable as a WTG supplier. We consider that these WTG manufacturers are capable of delivering their role in the reviewed projects.

Both GE and MHI are famous gas turbine suppliers in the world and have substantial track records. We have no current concerns on their services.

The transmission and distribution network in China is state-owned. The State Grid Corporation of China (SGCC) and the Inner Mongolia Power Company are two of three grid corporations in China, acting as grid operators. We have gained experience working with SGCC and Inner Mongolia Power Company through working on power projects in China and the Hong Kong Electricity Market Development project. Therefore, we have no concerns with regards to the capabilities and experience of China transmission and distribution companies acting as grid operators.

1.3 Wind Turbine Generator (WTG) Technologies

Representative wind farms include WTGs produced by both domestic and international manufacturers. Generally speaking, WTG models reviewed here have a modern design broadly in line with current technology standards and with a rated power range of 750 kW to 2 MW. All installed WTG models have been selected according to site specific conditions.

Beijing Energy uses several models of WTG on its sites, including Goldwind S50/750 and GW77/1500, Sewind SEC/1250, Nordex S70/1500 and S77/1500, Suzlon S82/1500 and so on. As all WTG models used by Beijing Energy except Sewind have substantial track records, we consider the technology of these WTGs as mature and the models should be reliable if operated properly and adequately maintained. As for Sewind, we considered it acceptable as a WTG supplier and details can be referred to section 1.2.

We are aware that the Guanting and Taiyangshan wind farms maybe required to be technically upgraded so that they can perform Low Voltage Ride Through (LVRT) to meet relevant requirement in the latest Chinese Grid Code issued by National Grid. Goldwind has promised that the wind turbine units of Goldwind in Guanting wind farm already have LVRT capability. While, Beijing Energy promised that Taiyangshan wind farm will implement the upgrade, if SGCC's upgrade requirement received.

It is also worth noting that seven of the eight wind farms in the portfolio are located in very cold areas of China and all wind turbines selected for these wind farms are low temperature versions or have operating capability for low temperatures, according to the manufacturer's specifications.

1.4 Wind Resource Assessment

Having reviewed feasibility studies for a selection of eight wind farms within the portfolio, we can conclude that a consistent approach has been adopted towards the wind resource assessment. On the whole, the adopted methodology has been broadly in-line with standard international practice. The Chinese standards have been derived from well-established international publications. However, differences of approach exist where the market in China has differing requirements. For example, the approach taken under the

Chinese standards places less emphasis on the analysis of uncertainty in the energy yield prediction when compared against wider international practice and sometimes the methodology of air density correction of the power curves is not best practice in our opinion. The feasibility studies fail to account for specific grid curtailments and in this respect, they do not realistically represent the actual output of many of the wind farms within this portfolio. As a result more credence should be given to the actual production figures of each wind farm rather than the energy yield estimates of each feasibility study, which make an assumption on grid losses.

There is clear evidence of conservatism in the approach and assumptions made within the feasibility studies we have reviewed in general. In particular, the losses applied to calculate the net energy yields are generous compared to the losses we typically see from our experience of wind farms in other areas of the world. However, where possible future production forecasts should be based on actual production since commissioning.

1.5 Grid Connections Assessment

The transformers at all wind farm step-up substations are appropriately sized and have sufficient capacity to export the maximum power under normal operation scenarios.

It appears that all overhead lines connecting the wind farms visited to the grid connection points have sufficient capacity to export the maximum power under normal operation scenarios, although most wind farms are connected by single circuits. Although it is not compliant with the 'N-1' security contingency in western wind farms, it is noted that in western, the connection lines are belonged to wind farm, who applied "N-1" principle based on its own choice, also there is no compellent regulation requirements. While, in China, the connection lines are owned by the grid company, and almost every wind farm connects to the grid by single curcuits. Also, in the updated version of Chinese Grid Code (Revision) of wind farm grid connection published in December 2009 there is no requirement for the wind farm to meet the 'N-1' security criteria for the transmission network between the wind farm substation and the grid connection point.

All the representative wind farms have appropriate switchgear installed to withstand fault current at both the wind farm step-up substations and the grid connection substations. No issue regarding switchgear rating has been identified at any of the representative wind farms. Appropriate protection schemes have been applied to all wind farms which seems to be the common practice for most Chinese wind farms. Lightning protection equipment has also been installed to prevent lightning damage to the wind farm equipment. No significant issues have been raised regarding the equipment condition.

All WTGs from representative wind farms have controllable power factors at grid connection point as required in the Chinese Grid Code. All representative wind farms have reactive power compensation equipment installed to provide reactive power support as required by the grid connection study report. In addition, all the main transformers are equipped with an on-load tap changer which is able to control voltage between 90% and 110% at the High Voltage winding. Therefore, we would consider that the wind farms have sufficient reactive and voltage control capacity to meet the reactive power demand and voltage regulation as required in the grid code.

As wind speed is variable and difficult to predict, wind farm power output is too. These characteristics of wind power affect grid stability and make scheduling challenging. The higher the wind power penetration in an electricity network, the more pronounced these problems become. In order to address these problems, the grid connection of a wind farm is required to meet the network security operational requirements. A new grid code for connecting wind farms to power networks was issued by the State Grid Corporation of China in February 2009. In the grid code, the wind farm is required to operate within a frequency range of 48Hz to 51Hz. Low voltage ride through (LVRT) capabilities are required such the WTGs can continue to operate for 625ms when the grid voltage drops to 20% of the nominal level. The WTGs are also required to keep operating when the grid voltage rate of change is within ±10% of its rated value.

The updated Chinese Grid Code (Revision) of wind farm grid connection requires an assessment of the power quality and low voltage ride through (LVRT) to ensure that the relevant indices are within the given limits and in accordance with technical standards. The relevant tests are required to be finished before the wind farm is connected to the grid. The Chinese Grid Code (Revision) LVRT stipulated thereunder are only guidelines issued by the State Grid Corporation of China. They are not law, regulations, national standards nor compulsory requirements. Accordingly, compliance with the requirements set out in the Updated CGC is not mandatory. Majority of the Group's wind farms are located in Inner Mongolia which is covered by Inner Mongolia Grid Company, and the Inner Mongolia Grid Company does not have similar requirements. There is no deadline stipulated in the Updated CGC for compliance or completion of any upgrade required.

As per our site visit, only two local power grids, Beijing power grid and Tieling power grids are sufficient to accommodate the wind farms to be connected so that they are able to operate in normal conditions and to export the generated power to the grid as expected. It is noted that it is very common for wind farms in Inner Mongolio to be subjected to grid curtailments. The major reasons for grid curtailments are that in winter, especially during the night, the thermal power plants in Inner Mongolia operate as CHP plants to provide heat to the local district heating systems. Therefore, the power generation from wind farms in Inner Mongolia may have to be curtailed to some extent due to local power grid's insufficient capability to adjust active power. On the other hand, the voltage stability of power system has become the major issue in Inner Mongolia power grid for a large scaled expansion of wind power. We gather that the construction of more interconnection lines which includes the proposed joint venture to establish two high voltage grid lines between West Inner Mongolia and North China. We understand that the local network should have sufficient capability to accommodate Beijing Energy wind power and we would expect that this problem could be solved by future reinforcement of the network. MM noticed that Inner Mongolia local grid has an ambitious upgrading plan which is expected to accept more electricity power. The plan has been started to implement already, and it will efficiently improve the grid connection capability of wind farms.

China wind power sector increased rapidly since year 2007, and since winter of 2009, the grid curtailment problem of Inner Mongolia Grid came out. But, along with the upgrade of Inner Mongolia Grid in 2010, the problem is mitigating gradually. Up to February 2011, Hetao 500 kV substation of Inner Mongolia grid has started commercial operation, which makes the grid curtailment of Wulanyiligeng wind farm mitigate significantly. The upgrade project of

Huitengliang 220 kV substation is expected to start operation in July 2011, and will be upgrade to 500 kV, which will significantly mitigate the grid curtailment of Jixianghuaya wind farm. MM thinks that the grid curtailment problem shall be fully considered in feasibility study stage.

1.6 Performance of Wind Farms

Of the eight representative wind farms we reviewed, two had different wind turbines types, number of units and layouts compared with those quoted in the feasibility study. Two wind farms had just completed commissioning this year and so did not have enough operational data (at least 12 months normal operational data) and one did not have on-grid power generation figures only for phase I separately available because one meter was shared for four phases of this wind farm. We could not assess whether their production of these five wind farms was in line with the forecasted figures in the feasibility studies.

Out of the three remaining wind farms, two had higher annual productions than forecasted in the feasibility study.

Changtu Taiyangshan Wind Farm showed lower performance than expected. We understand from the available information that low average wind speed was the main reason for the low production. According to the feasibility study, the annual average wind speed was 6.74 m/s which is much higher than the actual annual average wind speed 3.78 m/s.

Six of the eight representative wind farms are located in Inner Mongolia with excellent wind regimes. Their performances could be better if there were no grid curtailments which is very common in Inner Mongolia. We would expect this problem to be solved by future reinforcement of the network. However the wind farms located near Beijing and Tieling city in Liaoning province do not have any such concerns.

Overall, the equipments and facilities are well-maintained and of a good standard. The design, construction and installation are in line with our expectations.

1.7 Operation and Maintenance of Wind Farms

We consider the O&M arrangements to be suitable for Beijing Energy operations as they are based on currently recognized best practice models whilst being specifically developed for the Beijing Energy sites. Beijing Energy O&M arrangements for its wind farms are in line with our expectations of Chinese wind farms, even though the Chinese O&M common practice is different with international standards in few points.

The control center in Hohhot is very helpful for improving the operation management level, saving human resources, reducing operation cost, improving operation analysis and control level, improving the steady and healthy operation of wind farms of Beijing Energy in west region of Inner Mongolia. This kind of regional control center is very comply the actual practice of China wind power development, and very possibly to be spread and popularized.

Although we believe that improvements are needed in the preventive maintenance strategy for WTG main components, we believe that the treatment to the outage, the structural organization of O&M, the purchase and storage of spare parts and the QHSE requirements of Beijing Energy wind farms are generally acceptable and well-organized.

1.8 Technical Review of Gas-fired Power Plants

We comment on the key conclusions relating to the Jingfeng CCHP as below:

- We consider the main generating plant items are of proven technology;
- Our review of the technical documents suggests that the overall condition of the plant is generally in accordance with our expectations for a facility of this age and type;
- Availability of the plant is somewhat below average industry standards, however, the definition and regulation of availability in China is different with western;
- The designed output and heat rate figures are in line with our expectations, actual performance values have been proved by in the commissioning test report;
- The plant Capacity Factor is at high level among the similar gas-fired power plants in China. Though, it's slightly lower than western similar western gas-fired power plants, that's because its annual power generation amount is decided by the production plan issued by government authority at beginning of every year. This is mainly due to task of Jingfeng CCGT plant, whose major task is the heat supply to local community, so the majority power generation is completed in heat-supply period;
- Redundancy design in major plant equipment is considered adequate with the exception of the main cooling water pumps;
- The operation records have not indicated any gas supply interruption during the past 4 years;
- MM reviewed the Long Term Spare Parts Management & Service Agreement (LTSPMSA) between plant and MHI. Plant always signs the independent agreement (MM didn't reviewed) of technical support before every schedule outage, which request MHI sends the professional engineers to plant to guide the maintenance. Jingfeng plant has adequate technical force and staff team to complete all the maintenance work under the guide of professional engineers from MHI. This arrangement seems more cost-effective and complies with plant condition, comparing to the Long Term Service Agreement. and
- The Long Term Spare Parts Management & Service Agreement with GT supplier MHI has been reviewed, which is a good guarantee for the spare parts supply. We reviewed the spare parts list of GT, which is quite proper and adequate compare to the similar plants in western.

We comment on the key conclusions relating to the Taiyanggong CCHP as below:

- We consider the main generating plant items are of proven technology;
- Our review of the technical documents suggests that the overall condition of the plant is generally in accordance with our expectations for a facility of this age and type;

- Availability of the plant is somewhat below average industry standards, however, the definition and regulation of availability in China is different with western;
- The designed output and heat rate figures are in line with our expectations, which are proved by actual performance values in the commissioning test report;
- The plant Capacity Factor is at high level among the similar gas-fired power plants in China. Though, it's slightly lower than western similar western gas-fired power plants, that's because its annual power generation amount is decided by the production plan issued by government authority at beginning of every year. This is mainly due to task of Taiyanggong CCGT plant, whose major task is the heat supply to local community, so the majority power generation is completed in heat-supply period;
- Redundancy design in major plant equipment is considered adequate.
- The operation records have not indicated any gas supply interruption during the past 2 years;
- The LTSA with GE is beneficial as specialist support is available to the project. The adoption of condition-based maintenance follows modern industry practices; and
- Spare parts are stored in good condition on site. The full inventory list of spare parts is considered to include complete items, adequate quantity and proper models for all major systems. In particular, the situation regarding major spare parts for the GT including those required for HGPI and major inspections can meet the requirement of regular outage and scheduled outage.

2. Introduction

2.1 Overview

Mott MacDonald Limited (MM) has been appointed by Beijing Jingneng Clean Energy Co., Limited (Beijing Energy) to act as Technical Consultant on the Company's global initial public offering (IPO) project.

MM is a world-class multi-disciplinary consultancy engaged in development, focusing on many aspects of everyday life from energy, transport, health and education, water and the environment to building, industry and communications. MM has won recognition for technical excellence in power engineering, water, transportation, building and infrastructure and, in addition to these technical services, also offers a wide range of strategic planning, financial and business development services. MM is a wholly independent international company, with headquarters in the UK, annual turnover in excess of 1 billion Euros, over 14,000 staff and global experience spanning 140 countries. For the third consecutive year, MM has made the top 10 list in the UK's Sunday Times annual '25 Best Big Companies to Work For' employee survey, ranking eighth in 2010.

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The majority of the information from which the report was compiled comprises of documents provided by Beijing Energy, and discussions and meetings with relevant Beijing Energy staff. MM's professional judgment was exercised with regards to the validity and use of all information submitted from external sources. MM's knowledge of the Chinese power sector has been utilized throughout the independent technical assessment process.

A large number of wind farms as well as gas-fired power plants are included in the asset portfolio and are spread across a wide area of China. These plants were designed by various local design institutes based on the same Chinese standard. The wind turbines and gas turbines were supplied by a number of domestic and international manufacturers. For these reasons it was agreed that the report would be compiled with specific reference to representative projects. These plants were selected to best encapsulate and represent the diversity of all power plants controlled and operated by Beijing Energy. Particular attention was paid to the following factors when selecting the representative power plants:

- Wind resources and geographic coverage—Representative wind farms selected are located in areas with abundant wind resources including Inner Mongolia, Liaoning and northwest of Beijing, as shown in Figure 2.1.
- Wind turbine types—Representative wind farms selected include turbines produced by both domestic and international manufacturers as detailed in Section 3.3 of this report.
- Year of operation—Representative wind farms selected have different operation start dates as detailed in Table 4.1.
- Gas turbine types—Two gas fired power plants applied different top-class gas turbine manufactures as detailed in Section 3.4.

The process of technical assessment was carried out in China and the UK through a variety of procedures including, but not limited to: site visits, data collection, discussion, analysis, and report production.

2.2 Assets Overview

2.2.1 General Overview

To date December 31, 2010, Beijing Energy owns sixteen wind farms with consolidated installed capacity of 1,058.75 MW, and two gas-fired CHP plants with consolidated installed capacity of 1,190.00 MW. All the wind farms are operated by its subsidiaries across China. In 2009, the total electricity generation of consolidated wind power was 802 GWh, and the total electricity generation of consolidated gas-fired CHP was 3,855 GWh.

Wind turbine technologies adopted in the portfolio are from renowned Chinese Wind Turbine Generator (WTG) manufacturers such as Goldwind, Sinovel, United Power, Mingyang, Fengdian, Beizhong and Sewind and international suppliers such as Suzlon and Nordex. The size of the turbines varies from 750 kW to 2.5 MW.

2.2.2 Selection of Representative Wind Farms

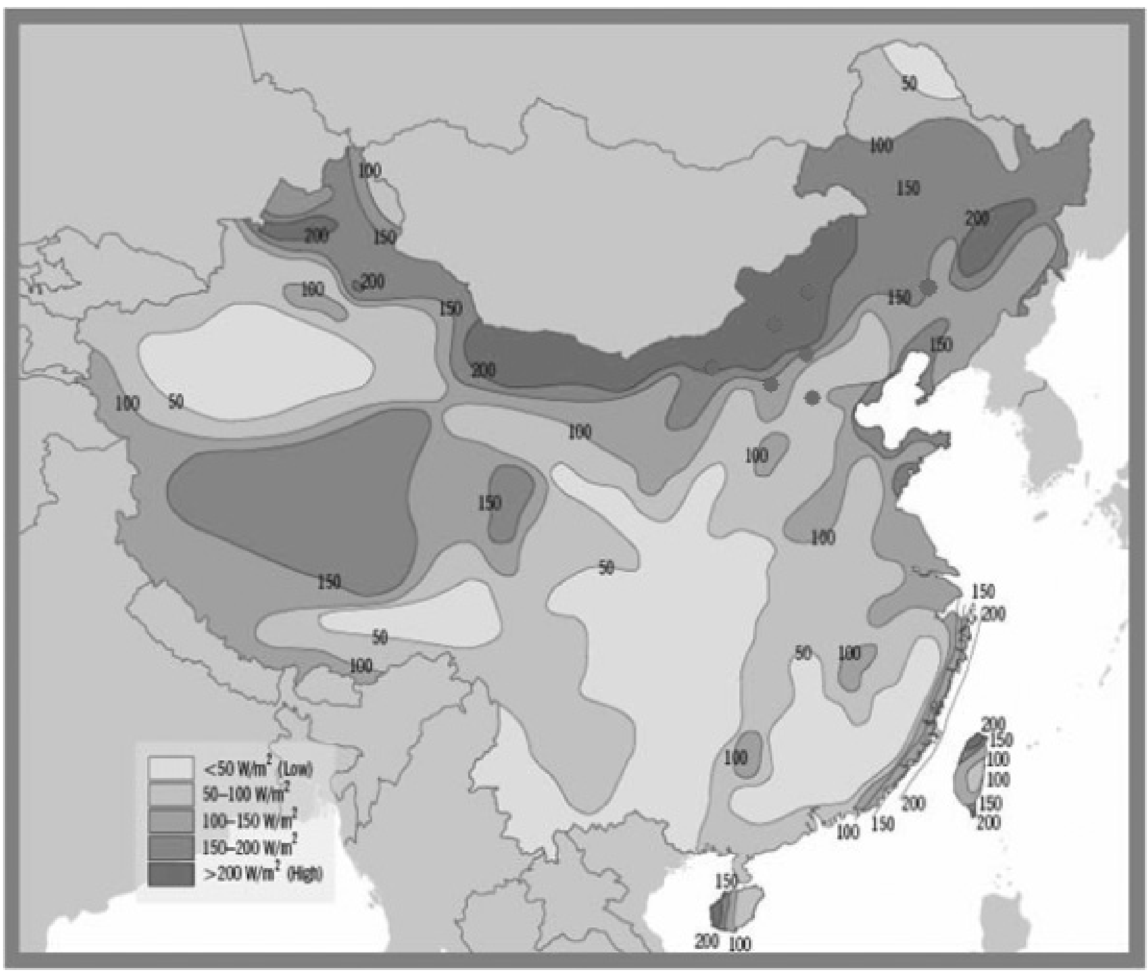
Due to the large number of projects involved in the asset portfolio, it was decided that a representative sample of eight wind farms will be assessed as part of our due diligence.

When selecting the representative wind farms the following factors were considered:

- Wind resources;
- Geographic coverage;
- Wind Turbine Generator (WTG) supplier; and
- Year of operation.

China has abundant wind resources, with the Global Wind Energy Council (GWEC) report "Global Wind 2009 Report", estimating exploitable onshore wind resources at approximately 2,380 GW. According to a survey undertaken by the Chinese Renewable Energy Industries Association (CREIA) and the Business Council for Sustainable Energy (BCSE), wind resources are distributed as shown in Figure 2.1. Higher resources are located in the Northern parts of China such as Inner Mongolia, Xinjiang, Gansu Hexi Corridor, some areas of Qinghai-Tibetan Plateau, Northeast China, Hebei, and along the East China coast region from Shangdong to Fujian Provinces. The color tone in Figure 2.1 represents wind density.

Figure 2.1: Wind Resources Distribution in China and Representative Projects' Location



Source: BCSE/CREIA 2006

As indicated by the red marks in Figure 2.1 we have selected representative projects located in the wind abundant areas of Inner Mongolia, Liaoning and northwest of Beijing.

MM select the wind farms visited and assessed based on the criteria as below:

(1) All the wind farms we have visited are operating; this is because operating wind farms have actual operation records such that MM can evaluate its real performance and the accuracy of the forecast. In evaluating which wind farm to

visit, MM has taken into account all wind farms that are worth visiting and assessing using the criteria described below.

(2) The wind turbines of major manufactures such as GoldWind, Sinovel, Nordex and Suzlon are all visited and assessed. These suppliers provided majority of wind turbines for Beijing Energy's wind farms, 452 sets out of 779 wind turbines in operating, about 58%, also In addition, these turbine manufacturers have signed contract with Beijing Energy to provide majority of the latter's developing wind farms' wind turbine needs.

(3) If two wind farms use the same wind turbine model from the same supplier, then, only one of these two wind farms is necessary to be evaluated, in MM's view.

(4) The wind farms selected are distributed across the whole developed and developing region of Beijing Energy's business, from west of Inner Mongolia to Liaoning Province.

(5) All wind turbine models from the main wind turbines suppliers mentioned in (2) have been assessed.

(6) If different phases of same wind farm use the same wind turbine model from the same supplier, then, MM believes assessment of one phase can already represent all phases.

(7) As of June 2010, which is MM's wind farm assessment selection time point, there were 16 wind farms in operation. MM visited 8 out of 16, about 50%. The installed capacity of wind farms MM visited is 660.8 MW, which compares to Beijing Energy's total of 1058.8 MW as of June 2010, thus about 62.4% of the latter's operating wind farm capacity has been visited.

(8) The wind farms we selected are located in the areas, where wind energy density range from 50 to 200W/m^2. So these wind farms can represent the wind power performances in different wind regime.

2.3 Report Structure

This report provides a detailed review of key information relating to the construction and operation of the projects. It is structured as listed below:

- Project Participants;
- WTG Technologies;
- Wind Resources Assessment;
- Grid Connection Assessment;
- Performance of the Wind Farms;
- Operation and Maintenance Execution;
- Technical Review of Gas-fired Power Plants; and

2.4 Status of this Document

This Report presents a review of documents and other information available at the date of this report. MM has collected all available documents and information from Beijing Energy, and visited the sites of all projects. All primary technical problems have been taken into consideration, and complete technical analysis and assessment have been implemented. After adequate communication with every relevant party, MM issued the final version of this report.

3. Project Participants

3.1 Introduction

This section of the report reviews the Project participants and considers their suitability and capability for the roles envisaged. The report considers Beijing Energy and main WTG suppliers as well as gas turbine suppliers. Information has been gathered from our work, discussion with the participants and also from a review of information available on the internet. We have not considered the strength of any participants or their suitability from a financial standpoint.

3.2 Beijing Jingneng Clean Energy Co,. Limited

Converted from Beijing Jingneng Technology, Beijing Energy was formed in Aug 2010, and is a shareholding subsidiary of Jingneng Group. It was previously known as Beijing Energy Investment, formed in February 1993. Its business focuses on the investment, construction and operation of all the clean energy projects, and integrates the development and utilization of wind energy, gas-fired power, hydropower, biomass power and heat-supply networks. The development strategy is to strongly accelerate the business of wind power and gas-fired power, meanwhile, steadily develop the hydropower, solar PV, other clean energy technologies and environmental protection and energy conservation business are also covered in its strategic plan.

To date December 31, 2010, Beijing Energy owns sixteen wind farms with consolidated installed capacity of 1,058.75 MW, and two gas-fired CHP plants with consolidated installed capacity of 1,190.00 MW. All the wind farms are operated by its subsidiaries across China. In 2009, the total electricity generation of consolidated wind power was 802 GWh, and the total electricity generation of consolidated gas-fired CHP was 3,855 GWh.

In CWEA's report dated March 2010, Beijing Energy was ranked 6th operator in China in terms of installed capacity of wind power in year 2009.

Based on the representative projects reviewed, we consider that Beijing Energy is capable of acting as the owner of the wind farms and gas-fired power plants.

3.3 WTG Suppliers

Beijing Energy uses many different WTGs supplied by international and domestic manufacturers for its wind farms. WTG selection is a crucial step in ensuring sufficient performance in terms of power quality, technical availability, grid compliance, maximization of energy yield etc. Beijing Energy manages all procurement and engineering activities of WTGs centrally from its headquarters in Beijing, and its regional subsidiaries operate those WTGs. The following sub-sections assess the capability of all WTG manufacturers utilized on the representative wind farms we visited.

3.3.1 Xinjiang Goldwind Science & Technology Co., Ltd.

The history of Xinjiang Goldwind Science & Technology Co., Ltd. (Goldwind) can be traced back to 1998. It is a leading wind turbine manufacturer and whole technical solutions provider in China. Its core business includes research, development, manufacture and sale of WTGs. It also provides wind power consultancy services as well as developing wind farms which can be sold as packages to wind farm operators and investors. Goldwind is also involved in design and construction, wind farm planning and consultancy services.

Goldwind purchased Vensys in Germany in 2008. By the end of 2009 Goldwind owned two production bases in Xinjiang province and Beijing respectively, five assembly factories in Baotou of Inner Mongolia, Jiuquan of Gansu province, Xi'an of Shanxi province, Chengde of Hebei province and Ninxia province. It also has a factory in Germany.

As of May 27, 2010, 7,773 Goldwind WTGs have been sold and over 6,000 Goldwind WTGs had been installed in 19 provinces across China. The new installed capacity in 2009 was 2,726.5 MW and the cumulative installed capacity was 5,351.05 MW by 2009. According to CWEA's report dated March 2010, Goldwind ranked the second in terms of both new installed capacity in 2009 and cumulative installed capacity from 2007 to 2009. According to a trusted source dated in March 2010, Goldwind ranked fifth in terms of new installed capacity in 2009.

3.3.2 Sinovel Wind Group Co., Ltd.

Sinovel is one of China's major WTG manufacturers, with its headquarters in Beijing, and branches or factories in Tianjin, Dalian of Liaoning province, Baotou, Xing'anmeng and Bayannaoer of Inner Mongolia, Dongying of Shangdong province, Yancheng of Jiangsu province and Jiuquan of Gansu province. It is actively engaged in development, design, manufacture, marketing, sale and operation & maintenance of both onshore and offshore WTGs.

Sinovel has a significant track record and a large number of installed units. In 2009, Sinovel supplied 3,510 MW and has supplied 5,652 MW of the cumulative installed capacity. According to CWEA's report dated March 2010, Sinovel ranked first in terms of both new installed capacity in 2009 and cumulative installed capacity from 2007 to 2009. According to a trusted source dated in March 2010, Sinovel ranked third in terms of new installed capacity in 2009 and its global market share was 3.5% in terms of cumulative installed capacity.

3.3.3 Suzlon

From its beginning in 1995 in India, Suzlon has developed to become a leading global wind power company with over 14,000 people in 21 countries.

The recent acquisition of REpower In 2009 gave the Indian-owned company a stronger foothold in Europe. By the end of 2009, Suzlon had installed 9,671 MW across the world.

According to a trusted source dated March 2010, this Indian company was ranked as fifth main WTG supplier with a global market share of 9.1% (including the REpower acquisition) in terms of total cumulative installed capacity worldwide.

For the wind farms with Suzlon turbines in this portfolio, the turbine were supplied by Suzlon's wholly-owned subsidiary company, Suzlon Energy (Tianjin) Limited which was commissioned in 2007. The plant manufactures rotor blades, nacelles, nacelle covers, control panel systems, hubs and generators. It already has several projects with a total capacity of 825 MW which is equivalent to almost 600 WTGs. Suzlon supplied capacity in 2009 was 293 MW and cumulative installed capacity was 605 MW, giving it a ninth place ranking in the Chinese market.

3.3.4 Nordex

Nordex was founded in 1985 in Denmark and develops larger and more economical wind turbines. Now more than 3,700 Nordex turbines with a total-rated output of more than 4,800 MW are already operational in 34 countries across the world. Nordex has offices and subsidiaries are located in 18 countries. Hundreds of 2.3 – 2.5 MW Nordex wind turbines have been installed around world.

Nordex has operated in China since 1995 and set up a joint venture in Xi'an for wind turbine assembly in 1998. In 2006 the joint venture Nordex (Yinchuan) Wind Turbine Co., Ltd. was founded and assembles 1.5 MW wind turbines. In January 2007 Nordex set up a factory for blade production of its 1.5 MW wind turbines in Dongyin city of Shandong province. Presently there is 430 staff working for Nordex in China.

Nordex has started its business in China since 1995. Nordex has installed more than 350 WTGs since 1985 in China with the cumulative installed capacity of 443.9 MW by May 30, 2009. Nordex mainly supply wind turbines of Nordex S70 and S77 series in China market.

3.3.5 Sewind Co., Ltd.

Shanghai Electric Group Co., Ltd. and China Huadian Engineering Co., Ltd. established a joint venture company—Sewind Co., Ltd. in September 2006. It is a professional engineering company covering WTG design, manufacturer, technical consultancy and Engineer, Procure and Construct of projects.

Sewind has a production and assembly facility in Lingang and can produce 1,500 units per year. A second production facility base located in Jiangsu province is being constructing and will be completed by August 2010. It will be used to produce 2 MW and 3.6 MW offshore WTGs. At the beginning of 2006, D6 – 1.25 MW technology was introduced from Dewind into Sewind through obtaining its license. In 2007, it jointly developed 2 MW WTG with Germany Aerodyn which is suitable for wind regime in China. Currently, Sewind can manufacture WTGs with the capacity of 1.25 MW, 2 MW and 3.6 MW.

The new installed capacity of Sewind in 2009 was 280.5 MW and the cumulative installed capacity was 475.5 MW. According to CWEA's report dated March 2010, Sewind ranked eleventh in terms of new installed capacity in 2009 and ranked twelfth in terms of cumulative installed capacity from 2007 to 2009.

3.3.6 Conclusion

Most WTG suppliers chosen by Beijing Energy to supply and maintain WTGs on its wind farms are well known to the worldwide wind industry and we consider that these WTG manufacturers are capable of delivering their role in the reviewed projects. Although Sewind did not have the long track record of the other chosen WTG suppliers as it was only founded in 2006, it has undergone rapid development in the past four years and is a subsidiary of Shanghai Electric Group which has strong equipment manufacturing capability. We therefore considered Sewind acceptable as a WTG supplier. All other WTG models chosen by Beijing Energy have substantial track records and we consider the technology used as mature and the models as reliable if operated properly and adequately maintained.

3.4 Gas Turbine Suppliers

3.4.1 General Electric

General Electric (GE) is the world's leading supplier from USA in the power generation and transmission & distribution market including operation and maintenance services especially for its gas turbine. GE has been established for over 130 years. Currently, GE provides services in 120 countries and installed gas turbine more than 6,000 units worldwide with accumulated over 200 million fired hours of operating experience.

For gas turbines, GE is capable of manufacturing units ranging from 26 MW to 480 MW each for small to large scale of power plants. GE has a good reputation as a gas turbine manufacturer and O&M service supplier for its gas turbine in international market and we have no current concern on GE services.

3.4.2 Mitsubishi Heavy Industries Limited

Mitsubishi Heavy Industries Limited (MHI) is the world's leading Japanese supplier in the power generation market and operation and maintenance services especially for its gas turbine. MHI is an affiliated company of Mitsubishi Group who has been founded for over 125 years with 92 affiliated companies. Currently, MHI provides has more than 33,000 employees and installed gas turbine more than 500 units worldwide.

MHI is capable of manufacturing units a wide range of gas turbines, from 6 MW to 300 MW for very small to large scale of power plants. MHI has a good reputation as a gas turbine manufacturer in international market and we have no current concern on MHI services.

3.4.3 Conclusion

Both GE and MHI are famous gas turbine suppliers in the world and have substantial track records. We have no current concerns on their services.

3.5 Grid Operators

To date, there are three Grid Corporations in China, including

- State Grid Corporation of China (SGCC)
- China Southern Power Grid Co. Ltd. (CSG)

- Inner Mongolia Power Company

They consist of 38 transmission grid companies and 3,171 distribution network companies. The transmission grid companies are responsible for the operation and management of the transmission grids at a provincial level and above; and the distribution network companies (power supply companies) are responsible for the operation and management of the distribution network and supplying electricity to the customers.

3.5.1 Grid Operators in Selected Projects

As detailed in section 2.2.2, the eight wind farms we visited are distributed in regions covering from the North east to the North China. These wind farms have been connected to the 220kV, 110kV and 66kV transmission & distribution network owned by SGCC and the Inner Mongolia Power Company.

The grid operators for the selected wind farm have been listed in Table 3.1, including local, provincial and regional Grid companies affiliated either to SGCC or to the Inner Mongolia Power Company.

Table 3.1: Grid Operators in Representative Wind Farms

Items	Wind Farm	Capacity (MW)	Grid Operator				Connected Point Voltage
			Local	Provincial	Regional	National	
1	Saihan Wind Farm Phase I	49.5 MW	Xixi Power Supply	Inner Mongolia Power Company	N/A		220 kV
2	Zheligentu Wind Farm Phase I	48.75 MW	Xilin Power Supply	Inner Mongolia Power Company	N/A		220 kV
3	Jixianghuaya Wind Farm Phase I	49.5 MW	Xilin Power Supply	Inner Mongolia Power Company	N/A		220 kV
4	Jixianghuaya Wind Farm Phase II	49.5 MW	Xilin Power Supply	Inner Mongolia Power Company	N/A		220 kV
5	Chayouzhong Wind Farm Phase I	49.5 MW	Wulanchabu Power Supply	Inner Mongolia Power Company	N/A		220 kV
6	Wulanyiligeng Wind Farm	300 MW	Bayannao'er Power Supply	Inner Mongolia Power Company	N/A		220 kV
7	Changtu Taiyangshan Wind Farm	49.5 MW	Tieling Power Supply	Liaoning Electric Power Company	Northeast China Grid Company Limited	SGCC	66 kV
8	Lumingshan Guanting Wind Farm Phase I	49.5 MW	N/A	Beijing Power Supply	North China Grid Company Limited	SGCC	110 kV

3.5.2 State Grid Corporation of China (SGCC)

Founded on December 29, 2002 by the State Council, SGCC is responsible for construction and operation of power grids, and providing secure and reliable power supply for economic development. SGCC supplies electricity to 88% of the national area, in twenty-six provinces. It also provides power services to one billion customers. By the end of 2009, it owned and managed five regional electric power grid companies and twenty-six provincial-level electric power grid companies. The owned transmission line at 110 kV and above was 553,382 km. In 2009, SGCC sold 2,274.8 TWh of electricity and had annual revenue of RMB 1,265.98 billion. Therefore, we consider that SGCC is capable of acting as the grid operator.

3.5.3 Inner Mongolia Power Company

As an independent provincial Grid Corporation, the Inner Mongolia Power Company is responsible for investment and construction of the transmission and distribution networks in western Inner Mongolia. The eastern power grid is operated by Northeast China Power Grid Company in SGCC. By the end of 2009, it owned transmission line at 110 kV and above was more than 20,000 km. In 2009, the Inner Mongolia Grid Company sold 100.7 TWh of electricity and had annual revenue of RMB 31.9 billion. Therefore, We have no concerns with regards to the capabilities and experience of Inner Mongolia Grid Company.

3.5.4 Conclusion

The transmission and distribution network in China is state-owned. The State Grid Corporation of China (SGCC) and the Inner Mongolia Power Company are two of three grid corporations in China, acting as grid operators. We have gained experience working with SGCC and Inner Mongolia Power Company through working on power projects in China and the Hong Kong Electricity Market Development project. Therefore, we have no concerns with regards to the capabilities and experience of China transmission and distribution companies acting as grid operators.

3.6 General Conclusion

Converted from Beijing Jingneng Technology, Beijing Energy was formed in Aug 2010, and is a shareholding subsidiary of Jingneng Group. It was previously known as Beijing Energy Investment, which was formed in February 1993. Its business focuses on the investment, construction and operation of all the clean energy projects, and integrates the development and utilization of wind energy, gas-fired power, hydropower and heat-supply networks. The development target is to strongly accelerate the use of wind power and gas-fired power, and to steadily develop the hydropower, solar PV and other clean energy technologies. Environmental protection and energy conservation business are also covered in its strategic plan. Based on the representative projects reviewed, we consider Beijing Energy is capable of acting as the owner of the wind farms and gas-fired power plants.

Most of the WTG suppliers chosen by Beijing Energy to supply and maintain the WTGs on its wind farms are well known to the wind industry. However Sewind did not have the long track record of the other chosen WTG suppliers as it was only founded in 2006. It has undergone rapid development and one of its parent companies is the Shanghai Electric

Group which has strong equipment manufacture capability. We therefore considered Sewind acceptable as a WTG supplier. We consider that these WTG manufacturers are capable of delivering their role in the reviewed projects.

Both GE and MHI are famous gas turbine suppliers in the world and have substantial track records. We have no current concerns on their services.

The transmission and distribution network in China is state-owned. The State Grid Corporation of China (SGCC) and the Inner Mongolia Power Company are two of three grid corporations in China, acting as grid operators. We have gained experience withing with SGCC and Inner Mongolia Power Company through working on power projects in China and the Hong Kong Electricity Market Development project. Therefore, we have no concerns with regards to the capabilities and experience of China transmission and distribution companies acting as grid operators.

4. Wind Turbine Technologies

4.1 Key Wind Turbines Involved

As detailed in Table 4.1, representative wind farms include WTGs produced by both domestic and international manufacturers. Most WTG models reviewed have a modern design broadly in line with current technology standards and with a rated power range of 750 kW to 1.5 MW. All installed WTG models have been selected according to site specific conditions.

Table 4.1: WTGs installed in Representative Wind Farms

Ref	Wind farm	Capacity (MW)	Operation Date	Manufacturer	WTG Model	Rated Power (kW)	WTG Quantity
1	Saihan—Phase I	49.5	2009	Goldwind	S50/750	750	30
					GW77/1500	1,500	18
2	Zheligentu—Phase I	48.75	2009	Sewind	SEC/1250	1,250	39
3	Jixianghuaya—Phase I	49.5	2009	Nordex	S77/1500	1,500	33
4	Jixianghuaya—Phase II	49.5	2009	Suzlon	S82/1500	1,500	33
5	Chayouzhong—Phase I	49.5	2009	Nordex	S70/1500	1,500	33
6	Wulanyiligeng	300	2009	Goldwind	GW77/1500	1,500	200
7	Changtu Taiyangshan	49.5	2009	Sinovel	SL1500/77	1,500	33
8	Lumingshan Guanting—Phase I	49.5	2009	Goldwind	GW77/1500	1,500	33

4.1.1 Goldwind S50-750 and GW77-1500

Goldwind started its business by procuring the expertise from German wind turbine manufacturers in 1998. It first licensed Repower's 48 kW to 750kW turbine technology in 2002 and then acquired a license in 2003 from Vensys for its 62-1.2 MW turbine, and subsequently for the low wind speed version 64-1.5 MW.

The early Goldwind model S50 is based on Repower's standard doubly-fed induction generator and stall control system. Although the technology is relatively old, and its stall blades do not allow the speed control and thus power control, we consider that the technology is mature and this model is proven to be reliable. Along with MW-sized wind turbines with pitch control becoming more and more popular, S50 is no longer Goldwind's key WTG model.

GW77 has been developed on Vensys's design concept which is based on a gearless wind turbine system having a synchronous permanent magnet generator that operates with a direct drive system without gearbox, intermediate shaft and couplings, which are usually subject to failure and need intensive maintenance activity. The use of permanent-magnet excitation eliminates the need for excitation coils, slip rings, and the generation of direct current for excitation purposes.

As the technology of the GW77 is well-established, we consider this model to be reliable for its application in the reviewed projects. The main technical parameters are summarized in Table 4.2.

Table 4.2: Technical Summary of Goldwind S50-750 and GW77-1500

	S50	GW77
Hub Height	60m	65m
Rotor Diameter	50m	77m
Rated Power	750kW	1,500kW
IEC Classification IEC	IEC IIA	IEC IIA
Certification	China Classification Society	China General Certification Center
Cut-in Wind Speed	3.5m/s	3m/s
Nominal Wind Speed	14 - 15m/s	11m/s
Cut-out Wind Speed	25m/s	22m/s
Generator	Double fed asynchronous generator	Permanent magnet direct drive synchronous generator
Gearbox	One planetary stage + two helical gear stages	Gearless direct drive
Gearbox Ratio	1:70.022	N/A
Power Regulation and Control	Stall	Electromechanical blade pitch
Operating Ambient Temperature	-30°C ~ +40°C	-30°C ~ +40°C
Standby Ambient Temperature	-40°C ~ +50°C	-40°C ~ +50°C

4.1.2 Sinovel SL1500

In 2009, Sinovel's installed capacity was 3,510 MW and was mainly based on the wind turbines of the SL 1500 WTG series. Sinovel developed its WTG technology jointly with the established German manufacturer Fuhrländer and is produced under a licence agreement with AMSC Windtec. The SL1500 is a three blades, horizontal shaft WTG with a double-fed generator, active pitch, and active yaw system with variable speed operation. The WTG is available in a normal and a low temperature version.

Overall, we consider the design of the SL1500 to be in line with the industry standards. The main technical parameters are summarized in Table 4.3.

Table 4.3: Technical Summary of Sinovel SL1500 LTV

	SL1500
Hub Height	70m
Rotor Diameter	77m
Rated Power	1,500kW
IEC Classification IEC	IEC III
Certification	Germanischer Lloyd
Cut-in Wind Speed	3m/s
Nominal Wind Speed	11m/s
Cut-out Wind Speed	20m/s
Generator	Double fed asynchronous generator, water cooling
Gearbox	Two planetary stages + one spur gear stage
Gearbox Ratio	1:104.1
Power Regulation and Control	Electromechanical blade pitch
Operating Ambient Temperature	-30°C ~ +45°C
Standby Ambient Temperature	-45°C ~ +45°C

4.1.3 Suzlon S82-1500

Suzlon produces the S82-1.5 MW WTG mainly for the Indian and Chinese market. As of January 31, 2010, Suzlon announced a total of 6,622 WTG installed worldwide; among these 1,212 were of the S82 model.

The wind turbine is designed for a medium wind speed regime and features a robust design with pitch regulated blade operation and a 3-stage gearbox with flexible coupling to the asynchronous induction generator.

As the technology of the S82 is well-established, we consider this model to be reliable for its application in the reviewed projects. The main technical parameters are summarized in Table 4.4.

Table 4.4: Technical Summary of Suzlon S82-1500

	S82
Hub Height	78m
Rotor Diameter	82m
Rated Power	1,500kW
IEC Classification IEC	IEC IIIA
Certification	Germanischer Lloyd
Cut-in Wind Speed	4m/s
Nominal Wind Speed	14m/s
Cut-out Wind Speed	20m/s
Generator	Single fed induction generator, air cooling
Gearbox	One planetary stage + two helical gear stages
Gearbox Ratio	1:95.09
Power Regulation and Control	Electromechanical blade pitch
Operating Ambient Temperature	-30°C~ +40°C
Standby Ambient Temperature	-40°C~ +50°C

4.1.4 Nordex S70/S77 CCV-1500

Nordex 1.5 MW WTG has a three blades, horizontal shaft with a double-fed generator, active pitch, and active yaw system with variable speed operation. The design concept for S70 originated in 1997 with the rotor diameter of 70 m. This design was based on Nordex blade pitch technology and rotor speed control system and thus ensures wind turbines can operate in harsh climates. S77 is an updated version of S70 with the rotor diameter of 77 m. Its longer blade and pitch control technology makes it a good choice for medium wind speed areas.

Nordex 1.5 MW S70/S77 CCV WTGs were designed specially to adapt to the harsh climate in north China. Wind turbines installed in north China require the ability to operate in very low temperature, high wind speeds and wind directions changing fast most of the year. The operating ambient temperature of S70/S77 CCV is from -30°C to +45°C and the standby ambient temperature is from -40°C to +50°C.

Overall, we consider the design of the S70/S77 CCV to be in line with the industry standards and adapted to the harsh climate in north China. The main technical parameters are summarized in Table 4.5.

Table 4.5: Technical Summary of Nordex S70/77 CCV-1500

	S70	S77
Hub Height	65m	61.5m
Rotor Diameter	70m	77m
Rated Power	1,500kW	1,500kW
IEC Classification IEC	IEC IIA	IEC IIA
Certification	TUV	TUV
Cut-in Wind Speed	3.5m/s	3.5m/s
Nominal Wind Speed	13m/s	12.5m/s
Cut-out Wind Speed	25m/s	25m/s
Generator	Double fed asynchronous generator	Double fed asynchronous generator
Gearbox	One planetary stage + two helical gear stages	One planetary stage + two helical gear stages
Gearbox Ratio	1:94.7	1:104.078
Power Regulation and Control	Electromechanical blade pitch	Electromechanical blade pitch
Operating Ambient Temperature	-30°C~+45°C	-30°C~+45°C
Standby Ambient Temperature	-40°C~+50°C	-40°C~+50°C

4.1.5 Sewind SEC-1250

SEC-1250 was manufactured by Sewind Co., Ltd. through procuring D6-1250 wind turbine model from the Germany wind turbine manufacturer DeWind. The first D6-1250 was manufactured in September 2000. The design concept of DeWind is to provide integrated series of wind turbines for wind farms to optimize the inputs and outputs.

Based on SEC-1250 normal temperature version, the new SEC-1250 low temperature version was developed to adapt to the cold weather in north China. Its operation temperature is from -30°C to +40°C and the survival temperature is from -30°C to +40°C. To achieve this goal, six heating fans are installed in nacelle, main components and towers are made of low temperature materials and Shell arctic 32 low temperature oil is used in hydraulic system.

As the technology of the D6-1250 is well-established, we consider that the technology for SEC-1250 is mature and proven and this model to be reliable. The main technical parameters are summarized in Table 4.6.

Table 4.6: Technical Summary of Sewind SEC-1250 LTV

	SEC-1250
Hub Height	68m
Rotor Diameter	64m
Rated Power	1,250kW
IEC Classification IEC	IEC IIIA
Certification	DIBT
Cut-in Wind Speed	2.8m/s
Nominal Wind Speed	12.3m/s
Cut-out Wind Speed	23m/s
Generator	Double fed asynchronous generator
Gearbox	One planetary stage + Two spur gear stages
Gearbox Ratio	1:53.1
Power Regulation and Control	Hydraulic pressure pitch
Operating Ambient Temperature	-30°C~+40°C
Standby Ambient Temperature	-40°C~+40°C

4.2 Conclusions

Representative wind farms include WTGs produced by both domestic and international manufacturers. Generally speaking, WTG models reviewed here have a modern design broadly in line with current technology standards and with a rated power range of 750 kW to 2 MW. All installed WTG models have been selected according to site specific conditions.

Beijing Energy uses several models of WTG on its sites, including Goldwind S50/750 and GW77/1500, Sewind SEC/1250, Nordex S70/1500 and S77/1500, Suzlon S82/1500 and so on. As all WTG models used by Beijing Energy except Sewind have substantial track records, we consider the technology of these WTGs as mature and the models should be reliable if operated properly and adequately maintained. As for Sewind, we considered it acceptable as a WTG supplier and details can be referred to section 1.2.

We are aware that the Guanting and Taiyangshan wind farms maybe required to be technically upgraded so that they can perform Low Voltage Ride Through (LVRT) to meet relevant requirement in the latest Chinese Grid Code issued by National Grid. Goldwind has promised that the wind turbine units of Goldwind in Guanting wind farm already have LVRT capability. While, Beijing Energy promised that Taiyangshan wind farm will implement the upgrade, if SGCC's upgrade requirement received.

It is also worth noting that seven of the eight wind farms in the portfolio are located in very cold areas of China and all wind turbines selected for these wind farms are low temperature versions or have operating capability for low temperatures, according to the manufacturer's specifications.

5. Wind Resources Assessment

5.1 Introduction

Each wind farm within the portfolio has a feasibility study report which contains sections on wind resource assessment and energy yield assessment.

For this portfolio, we have reviewed wind resource and energy yield assessments within the feasibility studies for a selection of eight wind farms. Rather than involving a quantitative and detailed analysis involving remodeling or recalculation of the energy yields, our review focuses on the adopted methodology and assumptions. We have also reviewed the applicable Chinese standards, which set out recommended practices in China, in order to comment on the approach compared to wider international practice.

The wind resource assessments form a key component of the feasibility studies, and can provide a useful insight into the expected generation, particularly where limited production data is available. However, where we have been provided with sufficient production data (at least 1 year of normal operation), we have used this as an indicator for future production forecasts since there can often be changes to the wind farm design, or turbine type which compromises the preconstruction estimate.

5.2 Chinese Standards for Wind Resources Assessment

There are two main standards for wind resource assessment in China;

- GB/T 18709-2002—Methodology of Wind Resource Measurement for Wind Farm; and
- GB/T 18710-2002—Methodology of Wind Resource Assessment for Wind Farm.

The former covers data collection and reporting, while the latter outlines the procedures for long-term correction, data screening, data processing and reporting.

The wind resource assessments for the wind farms in this review were carried out by different Chinese design institutes. However, the methodology and reporting of results are common to all studies and are based on the Chinese standards listed above.

5.2.1 Methodology of GB/T 18709-2002

The standard GB/T 18709-2002 covers on the standard approach to meteorological mast configuration and sensor placement, including some guidance on sensor alignment and mitigation of the influence from tower shading. We have observed in previous projects that fewer masts were used in the Chinese measurement campaigns compared to our preferred practice. However, in most of the sites we assessed for this portfolio, the measurement campaigns were often with more than one met mast considered in feasibility studies, showing evidence of good practice.

5.2.2 Methodology of GB/T 18710-2002

GB/T 18710-2002 is the Chinese standard for wind resource assessment which outlines the methodology for processing the wind data and reporting the results. The standard covers reference data requirements and long-term corrections as well as data screening, the formulae for extracting relevant parameters (wind shear, turbulence intensity) and reporting of the results. GB/T 18710-2002 references a number of documents including NREL/SR-440-22223—Wind Resource Assessment Handbook. This is an American publication issued by the National Renewable Energy Laboratory of the U.S. Department of Energy and provides a good overview of the measurement based wind resource assessment method. Much of GB/T 18710-2002 is derived directly from this document and hence the approach to wind resource assessment in China is largely consistent with international practice.

Measure-Correlate-Predict(MCP) techniques adopted in the feasibility studies for the wind farms of this portfolio are based on the correlation analysis of long-term meteorological observation data and relevant historic annual wind speeds. Long-term correlation of the site data is often based on a comparison of historic annual wind speeds, although in some projects reviewed more sophisticated techniques were employed. This depends on the quality and consistency of the reference data records available. In several of the reviewed feasibility studies, where Beijing Energy could not achieve confidence in the reference data available, site collected data (of at least one year) was used as the basis for the energy calculations. This shows evidence of diligence in approach.

The culmination of GB/T 18710-2002, in terms of energy yield, is reporting of the average annual windspeed, the wind direction, power density (W/m^2) and diurnal and seasonal profiling. In order to calculate the energy yield from a wind farm, it is necessary to calculate the wind speed distributions at each wind turbine location and to integrate these over the power curve for the chosen wind turbine. The wake losses must then be modeled, and other losses, such as electrical efficiency and availability, must be considered in order to arrive at a net energy yield.

5.3 Feasibility Studies for the Representative Wind Farms

Between July 21 and 25, 2010 we conducted site visit for a selection of eight of the wind farms within the portfolio. During or after these visits Beijing Energy provided us with the original feasibility study for each wind farm. We also requested the production and availability figures, evidence of power curve performance and details on the operational performance of each wind farm including significant downtime, major component failure, grid curtailments etc.

We reviewed the wind resource and energy yield studies for each of the visited wind farms to determine the approach, consistency or otherwise with the as-built details like WTG models and layout and to form an overall opinion on the adequacy. However, in the cases where there was at least 1 year of normal production data available we focused more heavily on those figures for our consideration of the future energy yield forecasts.

5.3.1 Wind Resource

In each of the feasibility studies we reviewed, annual average values for wind speed and wind direction at the site were obtained from single or multiple met masts located on or near the site. In most cases, however, these met masts were decommissioned after the feasibility. There was one notable exception for the Saihan wind farm, for which we were provided wind speed and direction data for the operational period. On the whole met masts were well placed to represent the wind regime at each site and gaps in the data were fairly minimal in duration. Often, the approach taken in the feasibility studies was to consider multiple met masts on or around the site and select the best met mast as the source of short term wind data for the site. In some of the studies, this involved correlation of the site met masts to ensure consistency. We are satisfied with this approach.

The range of measurements heights in all cases was good, either equal to or close to the actual hub heights of the turbines.

In each case the wind speed distributions were modeled by WasP, which is a software package developed by Riso, the Danish wind institution and is considered to be an industry standard tool for modeling the variation in wind flow considering details on topographic and ground cover variation in non-complex environments.

We noticed that for Saihan Wind Farm Phase I and Zheligentu Wind Farm Phase I the WTG models and layouts considered in the feasibility study differed from the actual WTG models and layouts of the as-built wind farm. In these cases, we could not directly compare the preconstruction energy yield estimates with the actual production of the wind farm presented to us by Beijing Energy. As a result for Saihan Wind Farm Phase I and Zheligentu Wind Farm Phase I we focused more heavily on the production values for the operational period when considering the energy yield forecasts. This is dealt with in section 7.2.1 and 7.2.2.

The difference in the wind turbines types, number of units and layouts of the two wind farms to their feasibility studies is due to the fact that turbine manufacture chose through tendering procedure after project approval is not same as the recommended wind turbine manufacture in the feasibility study report, which is normal situation happens during project implementation. However, the difference in the wind turbines types, number of units and layouts of the two wind farms to their feasibility studies had not and will not effect the operation of the two wind farms.

5.3.2 Energy Yield

The power curves used in the feasibility studies are supposed to be standard power curves provided by the WTG manufacturers. We consider these to be a reasonable basis for prediction at the feasibility study stage. For eight representative wind farms, the power curves used in some feasibility studies were often not listed numerically and some of the origins were not stated. We understand from Beijing Energy that this is due to the need to maintain fairness in the open bidding process for wind turbine selection. To appreciate the accuracy of a wind resource assessment, it is important to understand whether the power curve is theoretical or derived from measurement, and whether it is guaranteed by the manufacturer. By way of conservatism, the energy yield predictions in Beijing Energy's feasibility studies have generally been reduced by 5% which is in line with Chinese practice. We consider that this practice provides some comfort and compensation for the lack of detailed information on the power curves.

The wind farms sites we visited were spread across a range of different locations and at different levels of elevation above sea level. As air density changes with altitude, so does the performance of the power curves for each turbine, requiring a correction on the power curve when considering the energy yield analysis. Many of the feasibility studies we reviewed employed an inaccurate approach to this density correction. A simple scaling factor was derived from comparison of the site air density with density at standard sea level conditions. This factor was then applied to the power output according to the standard power curve. In our opinion, this approach is not an accurate or robust way of calculating the real impact of air density on a wind turbine power curve and can lead to an over-estimate of the energy lost due to lower air density at high altitude sites, resulting in conservative energy yield forecasts.

Wake modeling was carried out using WasP software, the industry standard method. During our site visits, we enquired as to the presence of other wind farms in the surrounding area. In many cases, there were either further extensions to the wind farm in question or other wind farms in the vicinity. None of the feasibility studies considered their presence. This would lead to an underestimation of the extent of the wake losses.

The overall losses applied to each project vary depending on the site specifics. Many of the feasibility studies consider losses for areas such as wake losses, controller (yaw error) and turbulence, blade contamination, wind farm power consumption and inter-array losses, cold weather shut-down and availability.

However, we noted that there was no consideration of losses due to grid curtailments for those wind farms in Inner Mongolia. We understood that it was mainly because there was no grid curtailment when most of these feasibility study reports were prepared. China wind power sector increased rapidly since year 2007, and since winter of 2009, the grid curtailment problem of Inner Mongolia Grid came out. But, along with the upgrade of Inner Mongolia Grid in 2010, the problem is mitigating gradually Up to Feb 2011, Hetao 500 kV substation of Inner Mongolia grid has started commercial operation, which makes the grid curtailment of Wulanyiligeng wind farm mitigate significantly. The upgrade project of Huitengliang 220 kV substation is expected to start operation in Jul 2011, and will be upgrade to 500 kV, which will significantly mitigate the grid curtailment of Jixianghuaya wind farm. MM thinks that the grid curtailment problem shall be fully considered in feasibility study stage. Where possible, we would prefer to base the production forecasts on actual production data from at least 1 year of operating history. Typically in the feasibility studies, assumed losses are around 28% of the gross energy production, which we consider to be generous in our opinion. Nevertheless, where there were grid curtailments in place, more credence should be given to the actual production figures of each wind farm.

Uncertainty analyses are important for making commercial decisions about wind farm performance, particularly where external debt financing is sought, as they describe the probability, and hence degree of risk associated with a prediction. Adherence to published industry standards does not immunize an energy yield assessment from uncertainty as sources of error are endemic in the process and are not necessarily consistent from site to site. Debt financers will typically base production forecasts on a higher confidence prediction since they will not benefit from any upside in revenues. Conversely, a large utility with a large portfolio of wind farms such as Beijing Energy or an equity investor, will base revenue projections on central-estimate (P50) production forecasts. Chinese standards do not have specific requirements for uncertainty analysis and only central estimates (P50) are provided in the feasibility studies. We have however observed a tendency for conservatism in the energy yield forecasts carried out for Beijing Energy which is reflected in the production data and grid curtailments were not considered in some feasibility studies. We prefer to use production data as an indicator of future performance where sufficient data is available (one year normal operation). The details of energy yield for each wind farm can be referred to chapter 7.

5.4 Conclusions

Having reviewed feasibility studies for a selection of eight wind farms within the portfolio, we can conclude that a consistent approach has been adopted towards the wind resource assessment. On the whole, the adopted methodology has been broadly in-line with standard international practice, with some slight deviations in a small number of areas. The Chinese standards have been derived from well-established international publications. However, differences of approach exist where the market in China has differing requirements. For example, the approach taken under the Chinese standards places less emphasis on the analysis of uncertainty in the energy yield prediction when compared against wider international practice and sometimes the methodology of air density correction of the power curves is not best practice in our opinion. As a result more credence should be given to the actual production figures of each wind farm rather than the energy yield estimates of each feasibility study, which make an assumption on grid losses.

There is clear evidence of conservatism in the approach and assumptions made within the feasibility studies we have reviewed in general. In particular, the losses applied to calculate the net energy yields are generous compared to the losses we typically see from our experience of wind farms in other areas of the world. However, where possible future production forecasts should be based on actual production since commissioning.

6. Grid Connection Assessment

6.1 Introduction

Our grid connection assessment focuses on the factors which may affect power export to the grid from the wind farms and to identify risks which may affect normal operation of the wind farms. There are usually three key aspects to be considered:

- Power transferring capacity of wind farm including whether all equipments, i.e. main transformers, export cable/overhead line have been rated appropriately to export full generation from the wind farm;

- Grid Codes and essential requirements for wind farms, including whether there are sufficient reactive power sources available from the wind farm, so that the wind farm is capable of maintaining the required power factor at the grid connection point for the given voltage ranges and real power output, voltage control capacity, low voltage ride through (LVRT) and power quality indices of the two wind farms connected to SGCC; and

- Capability of the local power network in view of voltage/frequency deviation, system overloading and potential operational issues which may be caused by the grid connection of the wind farm.

Our assessment on the grid connection was for the eight representative wind farms and has been undertaken based upon:

- documents provided by Beijing Energy;
- meetings and discussions with relevant staff of Beijing Energy;
- site visits to the eight representative power plants; and
- relevant data and information from the public domain, together with our general knowledge in this field and specifically of the Chinese power sector.

We have used the following data as part of our assessment:

- feasibility study reports;
- grid connection study reports;
- single line diagrams of grid connections;
- single line diagrams of internal energy collection systems in the wind farms;
- grid connection agreement;
- grid codes and essential requirements for wind farms;
- renewable energy policy of the Chinese Government;
- feedback to our questionnaire; and
- site visit records.

It is assumed that all data collected from the site visits are the latest available. During our assessment, no any independent simulation or calculation have been carried out to validate the inputs and results in the studies conducted by different Chinese design institutes which are independent third parties to Beijing Energy.

6.2 Key Issues Addressed in Grid Connection Studies

Through our data review and analysis, we noted that the eight representative wind farms are properly connected to 220 kV, 110 kV or 66 kV transmission and distribution network.

We summarized several key issues addressed in Grid Connection Studies as following.

6.2.1 Equipment Capacity of the Wind Farm Step-up Substation

Capacity of a step-up main transformer

Selection of a step-up main transformer in the substation at the wind farm site should ensure the transformer has sufficient capacity to transfer the power generated to the local grid as well as providing flexibility in voltage regulation and reactive power compensation. The step-up transformers at all wind farms have sufficient capability to export full power from the wind farm to the grid, and are equipped with on-load tap changers which are able to maintain required voltage level at the wind farm step-up substation.

Capacity of the wind farm cable/overhead lines

Once the grid connection point is chosen, conductor type and size of the transmission circuit should be identified. Conductors of a circuit between the wind farm substation and the grid connection point should be designed to have a thermal rating adequate to meet the requirement to export the maximum apparent power output from the wind farm.

It appears that all overhead lines connecting the wind farms visited to the grid connection points have sufficient capacity to export the maximum power under normal operation scenarios, although most wind farms are connected by single circuits. Although it is not compliant with the 'N-1' security contingency in western wind farms, it is noted that in western, the connection lines are belonged to wind farm, who applied "N-1" principle based on its own choice, also there is no compellent regulation requirements. While, in China, the connection lines are owned by the grid company, and almost every wind farm connects to the grid by single curcuits. Also, in the updated version of Chinese Grid Code (Revision) of wind farm grid connection published in December 2009 there is no requirement for the wind farm to meet the 'N-1' security criteria for the transmission network between the wind farm substation and the grid connection point.

'N-1' security contingency is a typical steady-state test and it means that the power system can operate either within emergency loading and voltage limits immediately after loss of any transmission line or transformer or generator, or with normal limits after system adjustments.

Other equipment capacity

Fault level calculation has been used to choose appropriate switchgear ratings so that the switchgear is capable of withstanding potential fault currents at the wind farm substation.

6.2.2 Reactive Power Compensation and Voltage Control

Reactive Power Compensation and Voltage Control

Reactive power compliance is an important technical requirement for the wind farm to be connected to the power grid. Maintaining the required power factor needs sufficient reactive power compensation. The purpose of the reactive power compliance study is to examine whether there are sufficient reactive power sources available from the wind farm, so that the wind farm is capable of maintaining the required power factor at the grid connection point for the given voltage ranges and real power output. If study results reveal any insufficiency, reactive power compensation schemes should be considered when designing the grid connection scheme. Even though detailed reactive power studies are not performed for most Chinese wind power projects as they are elsewhere in the world, Chinese Grid connection studies usually provide requirements of reactive compensation schemes under typical operating modes.

Capacity of Low Voltage Ride Through (LVRT) and Power Quality

Design principles adopted in wind generators differ from conventional synchronous generators. Connection of numerous WTGs in a wind farm may cause voltage deviation, voltage fluctuation, flicker, and harmonics issues which have impact on the power supply quality of local power grid. The updated Chinese Grid Code (Revision) of wind farm grid connection requires an assessment of the power quality and LVRT to ensure that the relevant indices are within the given limits and in accordance with technical standards. We are aware that the Guanting and Taiyangshan wind farms maybe required to be technically upgraded so that they can perform Low Voltage Ride Through (LVRT) to meet relevant requirement in the latest Chinese Grid Code issued by National Grid. Goldwind has promised that the wind turbine units of Goldwind in Guanting wind farm already have LVRT capability. While, Beijing Energy promised that Taiyangshan wind farm will implement the upgrade, if SGCC's upgrade requirement received.

6.2.3 Local Power Grid Operation

The feasibility study reports have shown that the power system analysis including the 'N-1' security criteria has been carried out for the transmission network at the grid connection point in each wind farm project in order to assess the steady and dynamic performance of the local power network that the wind farm is connected to.

Connection of wind farms to power networks has a local effect on voltage levels and reactive power flows. However, the primary purpose of the power system operation is to deliver the active power economically and reliably from generation resources to the customers. Clearly, the introduction of distributed and variable wind farms will impact on the scheduling of conventional power system operation and on the accommodation of the local power network.

As per our site visit, most local power grids except for Beijing power grid and Tieling power grids are not sufficient to accommodate the wind farms to be connected so that they are able to operate in normal conditions and to export the generated power to the grid as expected. It is noted that it is very common for wind farms in Inner Mongolio to be subjected to grid curtailments. We understand that the generation supply and demand balance in winter and voltage stability of power system may be major reasons for the curtailments.

In winter, especially during the night, the thermal power plants operate as CHP plants to provide heat to the local district heating systems, the power generation from wind farms in Inner Mongolio may have to be curtailed to some extent due to insufficient capability to adjust active power. On the other hand, the voltage stability of power system has become the major issue in Inner Mongolia power grid for a large scaled expansion of wind power. We understand that the local network should have sufficient capability to accommodate Beijing Energy and we would expect that this problem could be solved by future reinforcement of the network.

6.3 Grid Connection Assessment on Each Wind Farm

6.3.1 Introduction

As part of our desk study and site visits, taking into account of the generation—demand balance and local network constraints, we will provide our assessment on the key grid connection issues and consequently identify the potential risks and operational issues for each wind farm.

6.3.2 Saihan Wind Farm Phase I

6.3.2.1 Equipment Capacity

Saihan Wind Farm Phase I has thirty Goldwind S50—750 kW WTGs and eighteen Goldwind S77—1.5 MW WTGs installed with a total capacity of 49.5 MW. Each turbine is connected to a WTG step-up transformer via underground cables. These cables are rated appropriately in order to carry maximum output from each individual turbine. Then these turbines are connected to their own 35 kV collection trunk line circuits. These circuits consist of overhead line connection only, and are rated appropriately to carry the maximum output from the wind turbines.

A step-up substation has been constructed with one 120 MVA—220/35 kV transformer with an on-load tap changer. The 35 kV collection lines are connected to the 35 kV bus bar at the substation and then stepped up to 220 kV via the main transformers.

The extension of Saihan wind farm Phase II of 49.5 MW has been installed at the same site and shared the 220 kV step-up substation. The main transformer is sized at 120 MVA. The size of the transformer will support the full output of the units, which is 99 MW. Therefore, we consider that the transformer is sufficiently rated to export the full power from the wind farm to the grid.

Saihan Wind Farm Phase I is connected to the 220 kV Wenduer substation via one 18 km 220 kV overhead line with the type LGJ-400 and the thermal rating of 200 MVA. We consider that the circuit is sufficient to export all power generated by the wind farm to the grid.

The fault withstanding capability for switchgear installed in the wind farm is 40/31.5 kA. Hence the circuit breakers should be able to withstand the fault currents. Appropriate protection schemes have been applied to the wind farm which seems to be the common practice for most Chinese wind farms. Lightning protection equipments have been installed to prevent lightning impact on the wind farm equipment. No significant issues have been raised regarding the equipment condition.

6.3.2.2 Reactive Power Compensation Capacity and Voltage Control Capacity

The total capacity of the reactive power compensation device installed at the site is 24 Mvar. In addition, the transformer is equipped with an on-load tap changer which is able to control voltage between 90% and 110% at the HV winding. Therefore, we would consider the wind farm has sufficient reactive capacity and voltage control capacity to meet the reactive power demand and voltage regulation as required in the grid code.

6.3.2.3 Local Power Grid Operation

As described in Section 3.5.3, Inner Mongolia Power Company is an independent provincial Grid Corporation. Saihan Wind Farm Phase I is located in Soniteyouqi, the western area of Xilin Gol in Inner Mongolia. It is connected to Xixi Power Grid in the western Inner Mongolia power grid via 220 kV transmission line, and hence it is dispatched by Inner Mongolia Power Company.

There is insufficient electricity capacity installed in Soniteyouqi where the electricity consumption exceeds production. Therefore, the grid connection of Saihan Wind Farm Phase I is a useful complement to electricity consumption. We do not expect curtailments from local dispatch center to happen on Saihan Wind Farm Phase I under normal circumstances. However, in winter, many thermal power generators have to be kept in operation in order to supply both electricity and heat in the area where Saihan Wind Farm Phase I is located. As a result, the power output from Saihan Wind Farm Phase I may have to be curtailed to some extent due to local power grid's insufficient capability to adjust active power and the requirement of supplying heat by thermal power plants. On the other hand, the voltage stability of power system has become the major issue in local power grid for a large scaled expansion of wind power. We understand that the local network should have sufficient capability to accommodate Beijing Energy and would expect that this problem could be eliminated in the medium term by future reinforcement of the network.

6.3.3 Zheligentu Wind Farm Phase I

6.3.3.1 Equipment Capacity

Zhelingentu Wind Farm Phase I has thirty-nine Sewind SEC/1250 kW WTGs installed with a total capacity of 48.75 MW. Each turbine is connected to a WTG step-up transformer via underground cables. These cables are rated appropriately in order to carry maximum output from each individual turbine. Then these turbines are connected to their own 35 kV collection trunk line circuits. These circuits consist of overhead line connection only, and are rated appropriately to carry the maximum output from the wind turbines.

A step-up substation has been constructed with one 100 MVA – 220/35 kV transformer with an on-load tap changer. The 35 kV collection lines are connected to the 35 kV bus bar at the substation and then stepped up to 220 kV via the main transformers.

The extension of Zhelingentu wind farm Phase II of 49.5 MW has been installed at the same site and shared the 220 kV step-up substation. The main transformer is sized at 100 MVA. The size of the transformer will support the full output of the units, which is 98.25 MW. Therefore, we consider that the transformer is sufficiently rated to export the full power from the wind farm to the grid.

Zhelingentu Wind Farm Phase I is connected to the 220 kV Ming'antu substation via one 35 km 220 kV Zheming overhead line with the type LGJ-400 and the thermal rating of 300 MVA. We consider that the circuit is sufficient to export all power generated by the wind farm to the grid. According to the last version of Chinese Grid Code (Trial) published in 2006, the transmission network between the wind farm substation to the grid connection point is not required to meet the 'N-1' security criteria.

The fault withstanding capability for switchgear installed in the wind farm is 50/31.5 kA. Hence the circuit breakers should be able to withstand the fault currents. Appropriate protection schemes have been applied to the wind farm which seems to be the common practice for most Chinese wind farms. Lightning protection equipments have been installed to prevent lightning impact on the wind farm equipment. No significant issues have been raised regarding the equipment condition.

6.3.3.2 Reactive Power Compensation Capacity and Voltage Control Capacity

The total capacity of the reactive power compensation device installed at the site is 44.48 Mvar. In addition, the transformer is equipped with an on-load tap changer which is able to control voltage between 90% and 110% at the HV winding. Therefore, we would consider the wind farm has sufficient reactive capacity and voltage control capacity to meet the reactive power demand and voltage regulation as required in the grid code.

6.3.3.3 Local Power Grid Operation

As described in Section 3.5.3, Inner Mongolia Power Company is an independent provincial Grid Corporation. Zhelingentu Wind Farm Phase I is located in Zhengxiangbaiqi, the southern area of Xilin Gol in Inner Mongolia. It is connected to Xilin Power Grid in the western Inner Mongolia power grid via 220 kV transmission line, and hence it is dispatched by Inner Mongolia Power Company.

Xilin Gol has abundant wind resources. At present, the total wind farm capacity connected into the Xilin Power Grid reaches more than 600 MVA. Except for meeting the local demand, the surplus electricity from the wind farm will be exported to the main transmission grid of Inner Mongolia power grid for provincial or national use. We do not expect curtailments from local dispatch center to happen on Zhelingentu Wind Farm Phase I under normal circumstances. However, in winter, many thermal power generators have to be kept in operation in order to supply both electricity and heat in the area where Zhelingentu Wind Farm Phase I is located. As a result, the power output from Zhelingentu Wind Farm Phase I may have to be curtailed to some extent due to local power grid's insufficient capability to adjust active power and the requirement of supplying heat by thermal power plants. We understand that the local network should have sufficient capability to accommodate Beijing Energy and would expect that this problem could be eliminated in the medium term by future reinforcement of the network.

6.3.4 Jixianghuaya Wind Farm Phase I and II

6.3.4.1 Equipment Capacity

With thirty-three NORDEX S77/1500 kW WTG and thirty-three Suzlon S82/1500 kW WTG installed respectively, Jixianghuaya Huitengliang Wind Farm Phase I and Phase II have a total installed capacity of 99MW. Each turbine is connected to a WTG step-up transformer via underground cables. These cables are rated appropriately in order to carry maximum output from each individual turbine. Then these turbines are connected to their own 35 kV collection trunk line circuits. These circuits consist of overhead line connection only, and are rated appropriately to carry the maximum output from the wind turbines.

One step-up substation has been constructed at the site with two 50 MVA – 220/35 kV transformers equipped with one on-load tap changer. The 35 kV collection lines are connected to the 35 kV bus bar at the substation, and then stepped up to 220 kV via the main transformers.

The main transformers are sized at 100 MVA. The size of the transformers will support the full output of the units, which is 99 MW. Therefore, we consider that these transformers are sufficiently rated in order to export the full power from the wind farm to the grid.

The step-up substation is connected to the 220 kV Huitengliang grid substation via one 36 km 220 kV Jiliang overhead line with the type LGJ-240x2 and the thermal rating of 400 MVA which is sufficient for the power evacuation from the wind farm to the grid. According to the last version of Chinese Grid Code (Trial) published in 2006, the transmission network between the wind farm substation to the grid connection point is not required to meet the 'N-1' security criteria.

The fault withstanding capability for switchgear installed in the wind farm is 50/31.5 kA. Hence the circuit breakers should be able to withstand the fault currents. Appropriate protection schemes have been applied to the wind farm which seems to be the common practice for most Chinese wind farms. Lightning protection equipments have been installed to prevent lightning impact on the wind farm equipment. No significant issues have been raised regarding the equipment condition.

6.3.4.2 Reactive Power Compensation Capacity and Voltage Control Capacity

The total capacity of the reactive power compensation device installed at the site is 20 Mvar. In addition, the transformer is equipped with an on-load tap changer which is able to control voltage between 90% and 110% at the HV winding. Therefore, we would consider the wind farm has sufficient reactive capacity and voltage control capacity to meet the reactive power demand and voltage regulation as required in the grid code.

6.3.4.3 Local Power Grid Operation

As described in Section 3.5.3, Inner Mongolia Power Company is an independent provincial Grid Corporation. Jixianghuaya Wind Farm is located in Abagaqi, the southwest area of Xilin Gol in Inner Mongolia. It is connected to Xilin Power Grid in the western Inner Mongolia power grid via 220 kV transmission line, and hence it is dispatched by Inner Mongolia Power Company.

Xilin Gol has abundant wind resources. At present, the total wind farm capacity connected into the Xilin Power Grid reaches more than 600 MVA. Except for meeting the local demand, the surplus electricity from the wind farm will be exported to the main transmission grid of Inner Mongolia power grid for provincial or national use. We do not expect curtailments from local dispatch centre to happen on Jixianghuaya Wind Farm Phase I and Phase II under normal circumstances. However, in winter, many thermal power generators have to be kept in operation in order to supply both electricity and heat in the area where Jixianghuaya Wind Farm is located. As a result, the power output from Jixianghuaya Wind Farm may have to be curtailed to some extent due to local power grid's insufficient capability to adjust active power and the requirement of supplying heat by thermal power plants. On the other hand, the voltage stability of power system has become the major issue in local power grid for a large scaled expansion of wind power. We understand that the local network should have sufficient capability to accommodate Beijing Energy and would expect that this problem could be eliminated in the medium term by future reinforcement of the network.

6.3.5 Chayouzhong Wind Farm Phase I

6.3.5.1 Equipment Capacity

Chayouzhong Wind Farm Phase I has thirty-three NORDEX S70 – 1500 kW WTGs installed with a total capacity of 49.5 MW. Each turbine is connected to a WTG step-up transformer via underground cables. These cables are rated appropriately in order to carry maximum output from each individual turbine. Then these turbines are connected to their own 35 kV collection trunk line circuits. These circuits consist of overhead line connection only, and are rated appropriately to carry the maximum output from the wind turbines.

A step-up substation has been constructed with one 120 MVA – 220/35 kV transformer with an on-load tap changer. The 35 kV collection lines are connected to the 35 kV bus bar at the substation and then stepped up to 220 kV via the main transformers.

The extension of Chayouzhong wind farm Phase II of 50 MW has been installed at the same site and shared the 220 kV step-up substation. The main transformer is sized at 120 MVA. The size of the transformer will support the full output of the units, which is 99.5 MW. Therefore, we consider that the transformer is sufficiently rated to export the full power from the wind farm to the grid.

Chayouzhong Wind Farm Phase I is connected to the 220 kV Desheng substation via one 10 km 220 kV overhead line with the type LGJ-240 and the thermal rating of 300 MVA. We consider that the circuit is sufficient to export all power generated by the wind farm to the grid. According to the last version of Chinese Grid Code (Trial) published in 2006, the transmission network between the wind farm substation to the grid connection point is not required to meet the 'N-1' security criteria.

The fault withstanding capability for switchgear installed in the wind farm is 50/31.5 kA. Hence the circuit breakers should be able to withstand the fault currents. Appropriate protection schemes have been applied to the wind farm which seems to be the common practice for most Chinese wind farms. Lightning protection equipments have been installed to prevent lightning impact on the wind farm equipment. No significant issues have been raised regarding the equipment condition.

6.3.5.2 Reactive Power Compensation Capacity and Voltage Control Capacity

The total capacity of the reactive power compensation device installed at the site is 24 Mvar. In addition, the transformer is equipped with an on-load tap changer which is able to control voltage between 90% and 110% at the HV winding. Therefore, we would consider the wind farm has sufficient reactive capacity and voltage control capacity to meet the reactive power demand and voltage regulation as required in the grid code.

6.3.5.3 Local Power Grid Operation

As described in Section 3.5.3, Inner Mongolia Power Company is an independent provincial Grid Corporation. Chayouzhong Wind Farm Phase I is located in Chahaeryouyizhongqi, Wulanchabu city in Inner Mongolia. It is connected to Wulanchabu Power Grid in the western Inner Mongolia power grid via 220 kV transmission line, and hence it is dispatched by Inner Mongolia Power Company.

Wulanchabu city has abundant wind resources. At present, the total wind farm capacity connected into the Wulanchabu Power Grid is around 500MVA. Except for meeting the local demand, the surplus electricity from the wind farm will be exported to the main transmission grid of Inner Mongolia power grid for provincial or national use. We do not expect curtailments from local dispatch center to happen on Chayouzhong Wind Farm Phase I under normal circumstances. However, in winter, many thermal power generators have to be kept in operation in order to supply both electricity and heat in the area where Chayouzhong Wind Farm Phase I is located. As a result, the power output from Chayouzhong Wind Farm Phase I may have to be curtailed to some extent due to local power grid's insufficient capability to adjust active power and the requirement of supplying heat by thermal power plants. On the other hand, the voltage stability of power system has become the major issue in local power grid for a large scaled expansion of wind power. We understand that the local network should have sufficient capability to accommodate Beijing Energy and would expect that this problem could be eliminated in the medium term by future reinforcement of the network.

6.3.6 Wulanyiligeng Wind Farm

6.3.6.1 Equipment Capacity

Wulanyiligeng Wind Farm has two hundreds Goldwind JF77/1500 kW WTGs installed with a total capacity of 300 MW. Each turbine is connected to a WTG step-up transformer via underground cables. These cables are rated appropriately in order to carry maximum output from each individual turbine. Then these turbines are connected to their own 35 kV collection trunk line circuits. These circuits consist of overhead line connection only, and are rated appropriately to carry the maximum output from the wind turbines.

A step-up substation has been constructed with three 100 MVA – 220/35 kV transformers with an on-load tap changer. The 35 kV collection lines are connected to the 35 kV bus bar at the substation and then stepped up to 220 kV via the main transformers.

The size of the transformer at 300 MVA will only just support the full output of current units, which is 300 MW.

Wulanyiligeng Wind Farm is connected to the 220 kV Delingshan substation via one 95 km 220 kV overhead line with the type LGJ-240 and the thermal rating of 400 MVA. We consider that the circuit is sufficient to export all power generated by the wind farm to the grid.

The fault withstanding capability for switchgear installed in the wind farm is 50/31.5 kA. Hence the circuit breakers should be able to withstand the fault currents. Appropriate protection schemes have been applied to the wind farm which seems to be the common practice for most Chinese wind farms. Lightning protection equipments have been installed to prevent lightning impact on the wind farm equipment. No significant issues have been raised regarding the equipment condition.

6.3.6.2 Reactive Power Compensation Capacity and Voltage Control Capacity

The total capacity of the reactive power compensation device installed at the site is 60 Mvar. In addition, the transformer is equipped with an on-load tap changer which is able to control voltage between 90% and 110% at the HV winding. Therefore, we would consider the wind farm has sufficient reactive capacity and voltage control capacity to meet the reactive power demand and voltage regulation as required in the grid code.

6.3.6.3 Local Power Grid Operation

As described in Section 3.5.3, Inner Mongolia Power Company is an independent provincial Grid Corporation. Wulanyiligeng Wind Farm is located in Wulatezhongqi, Bayannaoer city in Inner Mongolia. It is connected to Bayannaoer Power Grid in the western Inner Mongolia power grid via 220 kV transmission line, and hence it is dispatched by Inner Mongolia Power Company.

Bayannaoer city has abundant wind resources. At present, the electricity production exceeds the consumption in Bayannaoer city. Except for meeting the local demand, the surplus electricity from the wind farm will be exported to the main transmission grid of Inner Mongolia power grid for provincial or national use. We do not expect curtailments from local dispatch center to happen on Wulanyiligeng Wind Farm under normal circumstances. However, in winter, many thermal power generators have to be kept in operation in order to supply both electricity and heat in the area where Wulanyiligeng wind farm is located. As a result, the power output from Wulanyiligeng wind farm may have to be curtailed to some extent due to local power grid's insufficient capability to adjust active power and the requirement of supplying heat by thermal power plants. On the other hand, the voltage stability of power system has become the major issue in local power grid for a large scaled expansion of wind power. We understand that the local network should have sufficient capability to accommodate Beijing Energy and would expect that this problem could be eliminated in the medium term by future reinforcement of the network. But, along with the upgrade of Inner Mongolia Grid in 2010, the problem is mitigating gradually. Up to Feb 2011, Hetao 500 kV substation of Inner Mongolia grid has started commercial operation, which makes the grid curtailment of Wulanyiligeng wind farm mitigate significantly.

6.3.7 Changtu, Taiyangshan Wind Farm

6.3.7.1 Equipment Capacity

Changtu Taiyangshan Wind Farm has thirty-three Sinovel SL1500/77 WTGs with a total capacity of 49.5 MW. Each turbine is connected to a WTG step-up transformer via underground cables. These cables are rated appropriately in order to carry maximum output from each individual turbine. Then these turbines are connected to their own 35 kV collection trunk line circuits. These circuits consist of overhead line connection only, and are rated appropriately to carry the maximum output from the wind turbines.

A step-up substation has been constructed with one 63 MVA – 66/35 kV transformer with an on-load tap changer. The 35 kV collection lines are connected to the 35 kV bus bar at the substation and then stepped up to 66 kV via the main transformers. The main transformer is sized at 63 MVA. The size of the transformer will support the full output of the units, which is 49.5 MW. Therefore, we consider that the transformer is sufficiently rated to export the full power from the wind farm to the grid.

Changtu Taiyangshan Wind Farm is connected to the 66 kV bus bar at the 220 kV Changtu substation via one 7.5 km 66 kV Changtai overhead line with the type LGJ-300 and the thermal rating of 85.3 MVA. We consider that the circuit is sufficient to export all power generated by the wind farm to the grid. According to the last version of Chinese Grid Code (Trial) published in 2006, the transmission network between the wind farm substation to the grid connection point is not required to meet the 'N-1' security criteria.

The fault withstanding capability for switchgear installed in the wind farm is 40/31.5 kA. Hence the circuit breakers should be able to withstand the fault currents. Appropriate protection schemes have been applied to the wind farm which seems to be the common practice for most Chinese wind farms. Lightning protection equipments have been installed to prevent lightning impact on the wind farm equipment. No significant issues have been raised regarding the equipment condition.

6.3.7.2 Reactive Power Compensation Capacity and Voltage Control Capacity

The total capacity of the reactive power compensation device installed at the site is 10 Mvar. In addition, the transformer is equipped with an on-load tap changer which is able to control voltage between 90% and 110% at the HV winding. Therefore, we would consider the wind farm has sufficient reactive capacity and voltage control capacity to meet the reactive power demand and voltage regulation as required in the grid code.

6.3.7.3 Local Power Grid Operation

Changtu Taiyangshan Wind Farm is located in Changtu County, the northern area of Tieling city in Liaoning province. It is connected to Tieling power grid in Liaoning power grid via 66 kV overhead line, and hence it is dispatched by Liaoning Electric Power Company.

At present, the electricity production exceeds the consumption in Tieling city. Except for meeting the local demand, the surplus electricity from the wind farm will be exported to the main transmission grid of Liaoning power grid for provincial or national use. We do not expect curtailments from local dispatch center to happen on Changtu Taiyangshan Wind Farm under normal circumstances.

6.3.8 Lumingshan Guanting Wind Farm Phase I

6.3.8.1 Equipment Capacity

Lumingshan Guanting Wind Farm Phase I has thirty-three Goldwind S77 – 1.5 MW WTGs installed with a total capacity of 49.5 MW. Each turbine is connected to a WTG step-up transformer via underground cables. These cables are rated appropriately in order to carry maximum output from each individual turbine. Then these turbines are connected to their own 35 kV collection trunk line circuits. These circuits consist of overhead line connection only, and are rated appropriately to carry the maximum output from the wind turbines.

A step-up substation has been constructed with two 50 MVA and 100 MVA – 110/35 kV transformers with an on-load tap changer. The 35 kV collection lines are connected to the 35 kV bus bar at the substation and then stepped up to 110 kV via the main transformers.

The extension phases of Lumingshan Guanting wind farm of 100.5 MW has been installed at the same site and shared the 110 kV step-up substation. The main transformer is sized at 150 MVA. The size of the transformer will only just support the full output of the units, which is 150 MW. Therefore, we consider that it is likely that the transformer will be overloaded when all WTGs simultaneously produce at their nominal power range; indeed it is possible for WTGs to produce power at a higher level than the nominal power rating, depending on the grid power factor at the time.

Lumingshan Guanting Wind Farm Phase I is connected to the 110 kV Kangzhuang substation via one 10 km 110 kV overhead line with the type LGJ-400 and the thermal rating of 500 MVA. We consider that the circuit is sufficient to export all power generated by the wind farm to the grid.

The fault withstanding capability for switchgear installed in the wind farm is 40/31.5 kA. Hence the circuit breakers should be able to withstand the fault currents. Appropriate protection schemes have been applied to the wind farm which seems to be the common practice for most Chinese wind farms. Lightning protection equipments have been installed to prevent lightning impact on the wind farm equipment. No significant issues have been raised regarding the equipment condition.

6.3.8.2 Reactive Power Compensation Capacity and Voltage Control Capacity

The total capacity of the reactive power compensation device installed at the site is 15 Mvar. In addition, the transformer is equipped with an on-load tap changer which is able to control voltage between 90% and 110% at the HV winding. Therefore, we would consider the wind farm has sufficient reactive capacity and voltage control capacity to meet the reactive power demand and voltage regulation as required in the grid code.

6.3.8.3 Local Power Grid Operation

Lumingshan Guanting Wind Farm is located in the boundary of the northwest Beijing and Huailai County in Hebei province. It is connected to Beijing power grid in North China power grid via 110 kV overhead line, and hence it is dispatched by Beijing Power Supply.

Lumingshan Guanting Wind Farm is located at the end of Beijing power grid which has abundant wind resources. Therefore, the grid connection of Lumingshan Guanting Wind Farm Wind Farm is a useful complement to electricity consumption. We do not expect curtailments from local dispatch center to happen on Lumingshan Guanting Wind Farm under normal circumstances.

6.4 Conclusions

The transformers at all wind farm step-up substations are appropriately sized and have sufficient capacity to export the maximum power under normal operation scenarios.

It appears that all overhead lines connecting the wind farms visited to the grid connection points have sufficient capacity to export the maximum power under normal operation scenarios, although most wind farms are connected by single circuits. Although it is not compliant with the 'N-1' security contingency in western wind farms, it is noted that in western, the connection lines are belonged to wind farm, who applied "N-1" principle based on its own choice, also there is no compellent regulation requirements. While, in China, the connection lines are owned by the grid company, and almost every wind farm connects to the grid by single curcuits. Also, in the updated version of Chinese Grid Code (Revision) of wind farm grid connection published in December 2009 there is no requirement for the wind farm to meet the 'N-1' security criteria for the transmission network between the wind farm substation and the grid connection point.

All the representative wind farms have appropriate switchgear installed to withstand fault current at both the wind farm step-up substations and the grid connection substations. No issue regarding switchgear rating has been identified at any of the representative wind farms. Appropriate protection schemes have been applied to all wind farms which seems to be the common practice for most Chinese wind farms. Lightning protection equipment has also been installed to prevent lightning damage to the wind farm equipment. No significant issues have been raised regarding the equipment condition.

All WTGs from representative wind farms have controllable power factors at grid connection point as required in the Chinese Grid Code. All representative wind farms have reactive power compensation equipment installed to provide reactive power support as required by the grid connection study report. In addition, all the main transformers are equipped with an on-load tap changer which is able to control voltage between 90% and 110% at the High Voltage winding. Therefore, we would consider that the wind farms have sufficient reactive and voltage control capacity to meet the reactive power demand and voltage regulation as required in the grid code.

The updated Chinese Grid Code (Revision) of wind farm grid connection requires an assessment of the power quality and low voltage ride through (LVRT) to ensure that the relevant indices are within the given limits and in accordance with technical standards. The relevant tests are required to be finished before the wind farm is connected to the grid. We are aware that the Guanting and Taiyangshan wind farms maybe required to be technically upgraded so that they can perform Low Voltage Ride Through (LVRT) to meet relevant requirement in the latest Chinese Grid Code issued by National Grid. Goldwind has promised that the wind turbine units of Goldwind in Guanting wind farm already have LVRT capability. While, Beijing Energy promised that Taiyangshan wind farm will implement the upgrade, if SGCC's upgrade requirement received.

As per our site visit, only two local power grids, Beijing power grid and Tieling power grids are sufficient to accommodate the wind farms to be connected so that they are able to operate in normal conditions and to export the generated power to the grid as expected. It is noted that it is very common for wind farms in Inner Mongolio to be subjected to grid curtailments. The major reasons for grid curtailments are that in winter, especially during the night, the thermal power plants in Inner Mongolia operate as CHP plants to provide heat to the local district heating systems. Therefore, the power generation from wind farms in Inner Mongolia may have to be curtailed to some extent due to local power grid's insufficient capability to adjust active power. On the other hand, the voltage stability of power system has become the major issue in Inner Mongolia power grid for a large scaled expansion of wind power. We gather that the construction of more interconnection lines between Inner Mongolia Network and North China Network in near future might be one solution for this issue. We understand that the local network should have sufficient capability to accommodate Beijing Energy wind power and we would expect that this problem could be solved by future reinforcement of the network. MM noticed that Inner Mongolia local grid has an ambitious upgrading plan which is expected to accept more electricity power. The plan has been started to implement already, and it will efficiently improve the grid connection capability of wind farms.

China wind power sector increased rapidly since year 2007, and since winter of 2009, the grid curtailment problem of Inner Mongolia Grid came out. But, along with the upgrade of Inner Mongolia Grid in 2010, the problem is mitigating gradually. Up to Feb 2011, Hetao 500 kV substation of Inner Mongolia grid has started commercial operation, which makes the grid curtailment of Wulanyiligeng wind farm mitigate significantly. The upgrade project of Huitengliang 220 kV substation is expected to start operation in Jul 2011, and will be upgrade to 500 kV, which will significantly mitigate the grid curtailment of Jixianghuaya wind farm. MM thinks that the grid curtailment problem shall be fully considered in feasibility study stage.

7. Performance of Wind Farms

7.1 Definition of WTG Availability

Availability ratio of the WTGs, as defined in the "Assessment Code of Wind Power Equipment Reliability" issued by China Electricity Council (CEC), is calculated according the following formula:

$$\text{Availability Factor} = \frac{AH}{PH} \times 100\%$$

AH: Available Hours means the hours when the WTG is considered as available to produce power;

PH: Physical Hours means the total hours during the availability measurement period.

The Available Hours are defined as being applied when the wind turbines are in their prearranged status, without consideration of the actual of power output. All outages due to the wind, the grid, or other conditions being unavailable are not covered according to this definition. This is not the internationally recognized standard methodology although we understand that it is the normal calculation method used within the Chinese wind power sector. Beijing Energy followed this method to calculate and assess the performance of the WTGs in its wind farms as would all other Chinese developers and producers.

We understand that Beijing Energy collects the average availability of all wind turbines as for the whole wind farm from the turbine SCADA system at each site. Then, it uses the data gathered to assess the performance and, operation and maintenance of each wind farm.

7.2 Wind Farms Performance—Generation and Availability

7.2.1 Saihan Wind Farm Phase I

Saihan Wind Farm is located in Suniteyouqi of Xilinhot in Inner Mongolia. It consists of two phases:

- Saihan Wind Farm Phase I (total capacity of 49.5 MW with thirty Goldwind S50/750 kW WTGs and eighteen GW77/1500 installed, fully commissioned in June 2009)

- Saihan Wind Farm Phase II (total capacity of 48 MW with twenty-four Beizhong FD80/2000 kW WTGs installed, operational since November 2009)

Under our scope of work, we have reviewed Saihan Wind Farm Phase I.

7.2.1.1 Generation and Availability

Saihan Wind Farm Phase I is constructed on very flat and simple terrain and scrub/ desert land with the site varying in altitude 1140 m above sea level (ASL). From our appreciation of the terrain during our site visit, we do not have any concerns regarding shading, channeling or excessive gradient which could lead to adverse wind conditions such as severe wind shear, inflow angles or turbulence.

The site is subjected to very low temperatures in winter. The operating ambient temperature of Goldwind S50 and GW77 is from -30°C to +40°C and the standby ambient temperature is from -40°C to +50°C which is similar to other wind turbine models as low temperature version although there is no special low temperature version for Goldwind. During January to March of 2010, the extreme cold weather led GOLDWIND S50 wind turbine hydraulic accumulator failure. The total downtime of 30 S50 wind turbines is 568 hours. Beijing Energy has replaced all failed S50 wind turbine accumulators by using cold-resistant model accumulator. There was not a similar failure happened during the operation testing from November 2010 to February 2011. The low temperature in early winter in 2010 resulted to failures of GOLDWIND GW77 wind turbine's pitch system proximity switch, cooling system, and converter. The total downtime of 18 GW77 wind turbines is 266 hours. Beijing Energy had fixed these problems by adopting electric auxiliary heating system already.

There is a compound area at the site which contains the substation, control building, store buildings, offices and other site facilities. The wind farm company which is the subsidiary of Beijing Energy employs one wind farm manager and two O&M teams operating in shift patterns; working fifteen days on with seven days leave. Each team comprises a team leader and six engineers/ technicians. The wind farm compound has very good facilities which are suitable for housing the teams and are well maintained.

Although proper graded roads do not continue beyond the entrance to the compound, during our visit we were able to visit a number of turbines and the substation building without any issue. We have confirmed with Beijing Energy that there are no problems for a crane to access in the wind farm and conduct a lift.

Goldwind is a leading Chinese wind turbine manufacturer with a good track record and a significant number of units in China. In response to our enquiries during the site visit, Beijing Energy informed us that they experienced problems on the power converter for six of the GW77/1500 WTG units. The repair was carried out by Goldwind during comissioning and according to Beijing Energy resulted in only a few hours downtime in each case. There no outage found due to the fault of convertor during the commercial operation period. They also reported the failure and subsequent replacement of the UPS (Uninterruptable Power Supply) on eight of the S50/750 WTG units.

We would normally expect to review monthly production reports either from the WTG manufacturer or compiled by the wind farm company itself, which include details of any significant downtime or component failures and any remedial work carried out that month. Beijing Energy has supplied us some of their monthly production reports.

During our site visit, Beijing Energy informed us that the power curve performance on one of the S50/750 WTGs is below the warranted power curve. According to Beijing Energy, Goldwind is carrying out adjustments to the pitch control system and will pay liquidated damages if they cannot fix the problem.

During our site visit, we noticed some cracks in the concrete around the foundations of one of the WTGs. Although the cracks appear to be minor, we consider that there may be an increased risk of water ingress, which could lead to problems especially in the winter months when freezing and thawing of any water could potentially lead to more severe issues. Beijing Energy has checked all WTGs foundations and found some has the same problem. However they considered these small cracks are only in the surface of aprons. There is no impact on foundations currently. Beijing Energy has provided us Foundation Concrete Mixture Proportion Test Report and Foundation Concrete Compression Test Report which were done by the third party. Both reports show the foundation concrete are qualified. Although there seems no problem now, we still suggest to check these foundations concrete on a regular basis.

Two met masts were considered for the wind resource analysis of the site, although only one (met mast #8) was eventually used for wind data from September 09, 2006 to September 08, 2007 to calculate the power production forecast and its integrity ratio was 93.9%. One of these masts (met mast #6, located near WTG no. C05 in phase I) was kept operational after the feasibility study had been completed, providing another source of wind resource data for the operational period other than wind data measured by the WTG anemometers.

At the time of our visit, the WTGs of Saihan Wind Farm Phase I were covered by a manufacturer's warranty with a two year warranty period. Goldwind guarantee a 95% availability level, although we understand that scheduled maintenance and grid downtime are excluded from this figure. They only reflect the turbine availbility for the whole wind farm and only as per the definition of availability in the turbine supply contract. During our site visit, Beijing Energy provided us two power curves for S50 and GW77 separately from SCADA system. They appeared to be broadly consistent with the standard power curves from the manufacturer.

The average annual wind speed at the hub height of the WTGs (65 m) has been calculated to be 7.79 m/s and the net capacity factor to be 0.29, which is typical for an onshore wind farm. The wind speed, availability and production data provided by Beijing Energy shows that the average turbine availability after comissioning was 98.11% (as shown in Table 7.1 below), higher than the warranted availability 95%. Since the actual constructed wind farm features different models and numbers of WTG units when compared with the feasibility study, the future production forecasts can only be based on actual production data.

It should be noted that there is only one meter for on-grid generation from both Saihan Phase I and II installed in the wind farm substation. The on-grid generation figures in Table 7.1 was calculated by wind farm staff which we consider reasonable but may be not accurate enough.

Table 7.1: Operational Data of Saihan Phase I

Date	Average WTG Availability (%)	Total Generation (MWh)	On-grid Generation (MWh)	Equivalent Full-load Hours	Capacity Factor	Average Wind Speed at 65 m (m/s)
2010-06	99.39	6,865.1	6,783.2	137	0.19	6.02
2010-05	99.44	16,105.1	16,006.9	323	0.43	8.82
2010-04	99.18	15,626.7	15,488.8	313	0.43	8.73
2010-03	99.92	12,577.3	12,283.0	248	0.33	8.88
2010-02	96.43	5,245.0	4,853.0	98	0.15	7.02
2010-01	95.60	11,857.0	11,306.5	228	0.31	8.63
2009-12	98.66	9,769.8	9,350.5	189	0.25	8.97
2009-11	91.81	13,381.6	13,059.9	264	0.37	9.19
2009-10	99.27	13,735.9	13,570.4	274	0.37	8.36
2009-09	99.54	9,428.0	9,317.7	188	0.26	7.23
2009-08	99.24	7,166.9	7,063.0	143	0.19	5.98
2009-07	98.45	6,362.8	6,262.4	127	0.17	5.78
2009-06	98.52	10,949.2	10,838.2	219	0.30	7.67
Total/Average	**98.11**	**139,070.4**	**136,183.3**	**2751**	**0.29**	**7.79**

In response to our request for information on grid curtailments, we were informed by Beijing Energy that it is very common for wind farms in Inner Mongolia to be subjected to grid curtailments. We understand that the curtailments usually occur at night in the winter months when demand for heat generation in the region is at a peak. At these times of peak demand, the electrical generation from wind farms is sacrificed for thermal power stations which operate closer to the centers of demand and operate as CHP plants, providing heat to the local district heating systems. We have been provided with documents which outlines the details of curtailments imposed by the grid company in Inner Mongolia issued on October 20, 2009 and March 15, 2010 separately. According to them, grid cutailment time was from 11pm to 7am the next day and grid curtailment capacity depended on the power demands at that time for Saihan Wind Farm.

It is that the most significant impact of the grid curtailments imposed by the grid company occur in the winter months, when part of the estimated potential output of the wind farm was lost. The biggest loss happened in February 2010 when there was Chinese New Year and power demand was lower than normal because most factories were closed for the holiday.

7.2.1.2 Conclusions

Wind turbines in Saihan Wind Farm Phase I were supplied by a well-recognized Chinese wind turbine manufacturer Goldwind that employs proven technologies. The O&M arrangements are well-managed with very good facilities at the site. For the issue of the small cracks we observed in one of the WTG foundations, Beijing Energy has checked all WTGs foundations and found some has the same problem. However they considered these small cracks are only in the surface of aprons. There is no impact on foundations currently. And according to foundation concrete test reports, it is qualified. Although there seems no problem now, we still suggest to check these foundations concrete on a regular basis.

Aside from this issue we are of the opinion that the wind farm was built to a good standard. Since commissioning was completed in June 2009, the wind farm capacity factor has been 0.29 which is typical for an onshore wind farm, the average WTG availability has been 98.11% which was higher than warranty availability 95% and the average wind speed at hub height has been 7.79 m/s which showed very good wind resource here. Although the most significant impact of the grid curtailments imposed by the grid company occurred in the winter months, a few part of the potential output of the wind farm, it is very common in Inner Mongolia and we would expect that this problem could be solved by future reinforcements of the network.

7.2.2 Zheligentu Wind Farm Phase I

Zheligentu Wind Farm is located in Zhengxiangbaiqi of Xilinhot in Inner Mongolia. It consists of two phases:

- Zheligentu Wind Farm Phase I (total capacity of 48.75 MW with thirty-nine Sewind SEC/1250 WTGs installed, operational since July 2009)

- Zheligentu Wind Farm Phase II (total capacity of 49.5 MW with thirty-three United Power UP-82/1500 kW WTGs installed, operational since December 2009)

Under our scope of work, we have reviewed Zheligentu Wind Farm Phase I.

7.2.2.1 Generation and Availability

Zheligentu Wind Farm Phase I is constructed on very flat and simple terrain and scrub/desert land with little vegetation. The site varies in altitude between 1230 – 1250 m ASL. From our appreciation of the terrain during our site visit, we do not have any concerns regarding shading, channeling or excessive gradient which could lead to adverse wind conditions such as severe wind shear, inflow angles or turbulence.

The site is subjected to very low temperatures in winter. We have confirmed that all WTGs are low temperature version. The operating ambient temperature of Sewind SEC/1250 is from -30°C to +40°C and the standby ambient temperature is from -40°C to +40°C. According to Beijing Energy, there was no downtime because of the extremely cold weather up to date.

There is a compound area at the site which contains the substation, control building, store buildings, offices and other site facilities. The wind farm company which is the subsidiary of Beijing Energy employs one wind farm manager and three O&M teams operating in shift patterns; working two weeks on and one week off. Each team comprises a team leader and three engineers/ technicians. The wind farm compound has very good facilities which are suitable for housing the teams and is well maintained.

Although proper graded roads do not continue beyond the entrance to the compound, during our visit we were able to visit a number of turbines and the substation building without any issue. We have confirmed with Beijing Energy that there are no problems for a crane to access in the wind farm and conduct a lift.

Sewind is a Chinese wind turbine manufacturer with a limited track record and number of installed units in China but belonging to a parent company with significant track record and experience in power generation. In response to our enquiries during the site visit, Beijing Energy informed us that they experienced problems during commissioning on the converter systems and control system signal cables. There were instances of individual monthly WTG availability which dropped below 90%, due to defects in power electronics components with long lead times. These have since been fully rectified.

We would normally expect to review monthly reports either from the WTG manufacturer or compiled by the wind farm company itself, which include details of any significant downtime or component failures and any remedial work carried out that month. Beijing Energy has supplied us with some of their monthly production reports.

During our site visit, we noticed some clear signs of oil/lubrication leakage on some of the WTGs. Upon raising this with Beijing Energy, we were told that the leakage was due to the insufficient torque of some bolts in the hydraulic and lubrication systems. These Sewind SEC/1250 WTGs were manufactured in the summer when bolts torque was enough. However in the winter there was tiny shrink for these equipments because of the cold weather. So bolts torque was not enough and oil leakage happened. Beijing Energy informed us that they has fastened those bolts as soon as they found this problem and no oil leakage happened since then.

A single met mast was considered for the wind resource analysis of the site, although this was removed in October 2009 after the feasibility study had been completed. Wind data from March 10, 2006 to March 9, 2007 was used in feasibility study to calculate the power production forecast and its integrity ratio was 99.994%.

At the time of our visit, the WTGs were covered by Sewind's warranty with a two year warranty period, guaranteeing a 96% availability level, although we understand that scheduled maintenance and grid downtime are excluded from this figure. Beijing Energy provided us with a selected power curve for one of the SEC/1250 WTGs from the SCADA system. It appeared to be broadly consistent with the standard power curves from the manufacturer.

Average annual wind speed at the hub height of the WTGs (68 m) has been calculated to be 6.76 m/s and the net capacity factor to be 0.24, which is typical for an onshore wind farm. The wind speed, availability and production data provided by Beijing Energy shows that the average WTG availability since operational was 98.28% (as shown in Table 7.3 below), higher than the warranted availability 96%. Since the actual constructed wind farm features different models and numbers of WTG units when compared with the feasibility study, the future production forecasts can only be based on actual production data. It was noticed that the average availabilities and wind speeds in July and August of 2009 were not available because the SCADA system was not updated and did not have this function at the very beginning of the commissioning period.

It should be noted that there is only one meter for on-grid generation from both Zheligentu Phase I and II installed in the wind farm substation. The on-grid generation figures in Table 7.3 was calculated by wind farm staff which we consider reasonable but may be not accurate enough.

Table 7.2: Operational Data of Zheligentu Phase I

Date	Average WTG Availability (%)	Total Generation (MWh)	On-grid Generation (MWh)	Equivalent Full-load Hours	Capacity Factor	Average Wind Speed at 65 m (m/s)
2010-06	98.57	4,250.8	4,211.1	86	0.12	4.80
2010-05	99.56	13,006.0	12,908.8	265	0.36	7.25
2010-04	99.39	13,856.5	13,726.0	282	0.39	7.58
2010-03	98.76	10,412.5	10,282.5	211	0.28	7.30
2010-02	98.53	4,483.5	4,363.9	90	0.13	5.63
2010-01	96.81	10,339.0	10,099.7	207	0.28	7.88
2009-12	96.00	10,788.6	10,478.5	215	0.29	7.20
2009-11	96.59	9,889.3	9,705.8	199	0.28	6.96
2009-10	99.06	1,0736.3	10,622.9	218	0.29	6.67
2009-09	99.51	8,576.8	8,494.1	174	0.24	6.30
2009-08	N/A	5,027.8	4,987.1	102	0.14	N/A
2009-07	N/A	4,299.8	4,263.8	87	0.12	N/A
Total/Average	**98.28**	**105,666.6**	**104,144.2**	**2,136**	**0.24**	**6.76**

In response to our request for information on grid curtailments, we were informed by Beijing Energy that it is very common for wind farms in Inner Mongolia to be subjected to grid curtailments. We understand that the curtailments usually occur at night in the winter months when demand for heat generation in the region is at a peak. At these times of peak demand, the electrical generation from wind farms is sacrificed for thermal power stations which operate closer to the centers of demand and operate as CHP plants, providing heat to the local district heating systems. According to documents which outlines the details of curtailments imposed by the grid company in Inner Mongolia issued on October 20, 2009 and March 15, 2010 separately, grid curtailment time for Zheligentu Wind Farm was from 11 pm to 7 am the next day and grid curtailment capacity depended on the power demands at that time.

It is clear that the most significant impact of the grid curtailments imposed by the grid company occur in the winter months, when part of the estimated potential output of the wind farm was lost. The biggest loss happened in February 2010 when there was Chinese New Year and power demand was lower than normal because most factories were closed for the holiday.

7.2.2.2 Conclusions

The wind turbines installed in Zheligentu Wind Farm Phase I were supplied by an emerging Chinese WTG manufacturer Sewind with a limited track record and installed capacity but belonging to a parent company with significant experience in the power sector. Our opinion is that the WTG technology installed for phase I is in accordance with international standards and the site facilities and O&M setup are of a high standard. Assessment of the production data supplied to us by Beijing Energy suggests that the performance of the wind farm to date has been normal to reasonable, affected mainly due to grid curtailments as much 2% to 48% loss of the potential output of the wind farm.

Since operational in July 2009, the wind farm capacity factor has been 0.25, the average availability has been 98.28% which was higher than warranty availability 96% and the average wind speed at hub height has been 6.76 m/s. Although the most significant impact of the grid curtailments imposed by the grid company occurred in the winter months, it is very common in Inner Mongolia and we would expect that this problem could be solved by future reinforcement of the network.

During our site visit, we noticed some clear signs of oil/lubrication leakage on some of the WTGs. Upon raising this with Beijing Energy, we were told that the leakage was due to the insufficient torque of some bolts in the hydraulic and lubrication systems. Beijing Energy informed us that they has fastened those bolts as soon as they found this problem and no oil leakage happened since then.

7.2.3 Jixianghuaya Wind Farm Phase I and II

Jixianghuaya Wind Farm is located in Abagaqi, the southwest area of Xilin Gol in Inner Mongolia. Jixianghuaya Wind Farm consists of two phases:

- Jixianghuaya Wind Farm Phase I (total capacity of 49.5 MW with thirty-three Nordex S77/1500 kW WTG installed, operational since March 2009)
- Jixianghuaya Wind Farm Phase II (total capacity of 49.5 MW with thirty-three Suzlon S82/1500 kW WTG installed, commissioned on December 18, 2009)

Under our scope of work, we assessed the performance of Jixianghuaya Wind Farm Phase I and Phase II.

7.2.3.1 Generation and Availability

Jixianghuaya Wind Farm Phase I and Phase II are built on the desert grassland with an altitude of approximately 1350 m ASL. The terrain does not present any concerns regarding shading, channeling or excessive gradient which could cause adverse wind conditions, such as severe wind shear, inflow angles, or turbulence.

Due to the cold high pressure in Inner Mongolia, the climate is very cold, resulting in long periods of subzero temperatures. As a result, this area has a long and cold winter. Having been controlled by cold high pressure for a long time, Xilinhot has become a major channel of cold air from northern to southern area. There is the wind year-round in the area, more in spring and winter, wind resources are abundant. We were told by Beijing Energy that all WTGs are low temperature versions. We got the information from Beijing Energy that the cumulative downtime because of the extremely cold weather up to date was about 100 hrs. Beijing Energy has confirmed that this kind of fault has been resolved through increasing the approach of electrical heating devices.

A control building is located near the step-up substation of the wind farm. This building includes the control center, offices, spare parts store, switchgear housing, and other site facilities. Beijing Energy employs one wind farm manager and twelve operational personnel, deployed in three teams of four people. The building and facilities are of a high standard and appear to be well-maintained.

Site roads are in good condition. We were also informed that diggers have to be used to clear the access and site roads of snow during the winter months. However, when we visited the site in July 2010, we were able to visit the control building, site facilities and wind turbines.

Wind resource data at the sites was recorded from four met masts installed on site before the construction. However, the wind data measured by the sensors on these masts has not been used to monitor records during the operational period after construction started. The wind data measured by the anemometers on the WTGs is used to monitor the wind during the operational period. We have been provided with the wind resources data since January 2009.

In response to our request for information on grid curtailments, we were informed by Beijing Energy that it is very common for wind farms in Inner Mongolia to be subjected to grid curtailments. We understand that the curtailments usually occur at night in the winter months when demand for heat generation in the region is at a peak. At these times of peak demand, the electrical generation from wind farms is sacrificed for thermal power stations which operate closer to the centers of demand and operate as CHP plants, providing heat to the local district heating systems. According to documents which outlines the details of curtailments imposed by the grid company in Inner Mongolia issued on October 20, 2009 and March 15, 2010 separately, grid cutailment time for Jixianghuaya Wind Farm was from 11pm to 7am the next day and grid cutailment capacity depended on the power demands at that time.

Currently the WTGs are covered by the manufacturer's warranty which guarantees the WTG availability at 95%. The warranty period is for two years. The average wind speed at hub height (70 m) has been calculated to be 7.6 m/s and the net capacity factor is calculated to be 25%; which is reasonable for an onshore wind farm. According to the production, wind, and availability data provided by Beijing Energy from SCADA system and listed in Table 7.5, Jixianghuaya Wind Farm Phase I has shown an average availability of 96.26% since January 2009. Most monthly availabilities are above the 95% guaranteed value. Comparing the actual annual generation of 114,930 MWh in 2009 with the annual forecast 113,807 MWh in the feasibility study, we find that the electricity generated by Jixianghuaya Wind Farm Phase I is a bit higher than targeted production.

Table 7.3: Operational Data of Jixianghuaya Wind Farm Phase I

Date	Average WTG Availability (%)	Total Generation (MWh)	Average Wind Speed at 70 m (m/s)
2009-01	82.07	4,923.9	7.57
2009-02	92.48	8,147.4	8.01
2009-03	96.84	11,513.4	7.37
2009-04	97.74	11,420.8	7.05
2009-05	94.56	14,389.0	8.59
2009-06	96.57	8,711.3	8.09
2009-07	97.63	8,247.5	6.63
2009-08	98.54	8,001.4	5.97
2009-09	98.48	11,223.8	8.15
2009-10	97.68	10,069.8	7.40
2009-11	98.54	10,633.1	8.01
2009-12	98.98	7,649.2	7.64
Total/Average in 2009	**95.84**	**114,930**	**7.54**
2010-01	91.91	8,789.9	8.4
2010-02	96.71	5,485.3	6.8
2010-03	99.40	12,230.5	8.3
2010-04	99.15	11,436.5	8.0
2010-05	98.02	11,928.7	8.4
2010-06	97.36	5,970.3	6.0
Total/Average	**96.26**	**170,771.8**	**7.6**

Since Jixianghuaya Wind Farm Phase II has only been operational since May 2010, there has been insufficient data (that is at least 12 month of normal operational data) we are therefore unable to comment on wind farm performance.

It is worth noting that the calculation of availability, as presented by Beijing Energy, includes a few caveats such as wind turbines considered as available when they are actually down due to scheduled maintenance.

7.2.3.2 Conclusions

Equipment at Jixianghuaya Wind Farm Phase I and Phase II was supplied by manufacturers well-known by the industry; that employs proven technologies or has credible track records within the market. We are of the view that the turbine technologies are in accordance with current industry standards, and the sites were built to a high standard. O&M is well-managed. The electricity production at Jixianghuaya Wind Farm Phase I is a slightly higher than the predicted. Since commissioning in Jixianghuaya Wind Farm Phase II was completed in April 2010, there has been insufficient data (at least 12 month of normal operational data) available to comment on the wind farm Phase II performance.

7.2.4 Chayouzhong Wind Farm Phase I

Chayouzhong Wind Farm is located in Chahaeryouyizhongqi of Wulanchabu in Inner Mongolia. It consists of two phases:

- Chayouzhong Wind Farm Phase I (total capacity of 49.5MW with thirty-three Nordex S70/1500kW WTGs installed, operational since July 2009)

- Chayouzhong Wind Farm Phase II (total capacity of 50MW with forty Suzlon S64/1250kW WTGs installed, operational since June 2009)

Under our scope of work, we have reviewed Chayouzhong Wind Farm Phase I.

7.2.4.1 Generation and Availability

Chayouzhon Wind Farm Phase I comprises 33 Nordex S70/1500 WTG units constructed on rolling hills, relatively complex in parts with mostly flat scrub/ desert land terrain. The site varies in altitude between 2000 m and 2131 m ASL (above sea level). From our appreciation of the terrain during our site visit, we do not have any concerns regarding shading, channeling or excessive gradient which could lead to adverse wind conditions such as sever wind shear, inflow angles or turbulence.

The site is subjected to very low temperatures in winter. The client has told us that all WTG's are low temperature versions. The operating ambient temperature of Nordex S70 CCV is from -30°C to +45°C and the standby ambient temperature is from -40°C to +50°C. According to Beijing Energy, there was no downtime because of extreme cold weather up to date.

There is a compound area at the site which contains the substation, control building, store buildings, offices and other site facilities. The wind farm company which is the subsidiary of Beijing Energy employs one wind farm manager and three teams operating in shift patterns. Each team comprises a team leader and three engineers/ technicians; working two weeks on and one week off. The staff from Beijing Energy work closely with the Nordex engineers. Nordex have one site manager and two engineers based 12 km from the site. Nordex also monitor faults remotely in their service center in Beijing. The wind farm compound has very good facilities which are suitable for housing the teams and is well maintained.

The access roads to the WTGs are rough and may need remedial work in places to ensure access, expecially in winter months when visibility of the site road parameters may be obscured by snow. We were informed that there is a clear plan in place to use diggers to clear the access and site roads of snow during the winter months. However, we understand that last winter there was a reduction in access to all WTGs for a number of weeks, despite the use of a digger. We were able to visit all the areas we required during our site visit in July 2010. We have confirmed with Beijing Energy that there are no problems for a crane to access in the wind farm and conduct a lift.

Nordex is a leading European wind turbine manufacturer with a good track record and a significant number of installed units worldwide. In response to our enquiries during the site visit, Beijing Energy informed us that they replaced the gearboxes on two WTG units following the detection of a fault by the Nordex engineer in October 2009. It took around half a month to replace the gearboxes in both units. No compensation was paid by Nordex for this downtime period.

We would normally expect to review monthly reports either from the WTG manufacturer or compiled by the wind farm company itself, which include details of any significant downtime or component failures and any remedial work carried out that month. Beijing Energy has supplied us with all their monthly production reports.

Four met masts were considered for the wind resource analysis of the site, although only one was eventually used for the wind data from January to December 2002 to calculate the power production forecast. None of these masts were kept operational after the feasibility study had been completed and so there was no wind speed data for the operational period other than wind data measured by the nacelle anemometers on each WTG.

At the time of our visit, the WTGs of Chayouzhong Wind Farm Phase I were covered by a manufacturer's warranty from Nordex with a two year warranty period. Nordex guarantees a 95% availability level, although we understand that scheduled maintenance and of course grid downtime are excluded from this figure. Beijing Energy provided us the power curve for Nordex S70 from SCADA system. It appeared to be broadly consistent with the standard power curves from the manufacturer.

Average annual wind speed at the hub height of the WTGs (65 m AGL) has been calculated to be 9.22 m/s showing good wind resource in this area and the net capacity factor to be 0.30, which was good for an onshore wind farm. The wind speed, availability and production data provided by Beijing Energy shows that the average availability since operational was 94.96% (as shown in Table 7.6 below). Except for the initial 5 months in the comissioning period and a poor month in December 2009, all months were above the warranted availability level of 95% for the wind farm as a whole. It was noticed that the average availability in June 2009 was not available because the SCADA system was not updated and did not have this function at the very beginning of the commissioning period.

Since the actual constructed model and numbers and layout of WTG units are the same compared with the feasibility study, the production forecast in the feasibility study report can be compared with the actual production. From July 2009 to June 2010, the actual on-grid power production for the whole year was 139,514.35 MWh. In the feasibility study report the annual on-grid power generation forecast was 123,490 MWh which was lower than the actual production. However since the feasibility study did not account for any losses due to grid curtailment, we suggest that the future production forecast is based on actual production figures.

It should be noted that there is only one meter for on-grid generation from both Chayouzhong Phase I and II installed in the wind farm substation. The on-grid generation figures in Table 7.6 was calculated by wind farm staff which we consider resonable but may be not accurate enough.

Table 7.4: Operational Data of Chayouzhong Phase I

Date	Average WTG Availability (%)	Total Generation (MWh)	On-grid Generation (MWh)	Equivalent Full-load Hours	Capacity Factor	Average Wind Speed at 65 m (m/s)
2010-06	98.93	8,292.7	8,238.8	168	0.23	7.20
2010-05	99.10	17,270.0	17,176.4	349	0.47	9.75
2010-04	97.18	16,595.9	16,489.6	335	0.46	9.60
2010-03	98.79	15,534.2	15,391.9	314	0.42	11.12
2010-02	95.83	6,923.3	6,722.2	140	0.20	9.40
2010-01	95.64	15,898.6	15,705.9	321	0.43	10.88
2009-12	93.42	12,754.3	12,561.5	258	0.34	11.16
2009-11	95.71	13,586.9	13,439.4	274	0.38	9.70
2009-10	89.20	12,952.3	12,862.3	262	0.35	9.74
2009-09	93.52	7,814.0	7,754.3	158	0.22	7.93
2009-08	92.90	3,697.7	3,666.4	75	0.10	6.27
2009-07	89.25	4,831.3	4,796.4	98	0.13	7.34
2009-06	N/A	4,755.0	4,709.24	96	0.13	9.73
Total/Average	**94.96**	**140,906.14**	**139,514.4**	**2,818**	**0.30**	**9.22**

In response to our request for information on grid curtailments, we were informed by Beijing Energy that it is very common for wind farms in Inner Mongolio to be subjected to grid curtailments. We understand that the curtailments usually occur at night and in the winter months when demand for heat generation in the region is at a peak. At these times of peak demand, the electrical generation from wind farms is sacrifriced for thermal power stations which operate closer to the centers of demand and operate as CHP plants, providing heat to the local district heating systems. According to documents which outlines the details of curtailments imposed by the grid company in Inner Mongolia issued on October 20, 2009 and March 15, 2010 separately, grid cutailment time was from 11pm to 7am the next day or 11:30pm to 9am the next day and grid cutailment capacity depended on the power demands at that time.

It is clear that the most significant impact of the grid curtailments imposed by the grid company occur in the winter months, when part of the estimated potential output of the wind farm was lost. The biggest loss happened in February 2010 when there was Chinese New Year and power demand was lower than normal because most factories were closed for the holiday.

7.2.4.2 Conclusions

The wind turbines installed for Chayouzhong Wind Farm Phase I were supplied by a well-known European WTG manufacturer Nordex with a proven track record and significant installed capacity worldwide. Our opinion is that the WTG technology installed for phase I is in accordance with international standards and the site facilities and O&M setup are of a high standard.

Since operational started in June 2009, the wind farm capacity factor has been 0.30 which was good for an offshore wind farm. The average availability has been 94.96% which was a bit lower than warranty availability 95% mainly due to lower availability in first five months of commissioning period. The average wind speed at hub height has been 9.22 m/s showing a very good wind resource here. Although the most significant impact of the grid curtailments imposed by the grid company occurred in the winter months, it is very common in Inner Mongolia and we would expect that this problem could be solved by future reinforcement of the network.

7.2.5 Wulanyiligeng Wind Farm

Wulanyiligeng Wind Farm is located in Wulatezhongqi of Bayannaoer in Inner Mongolia. It comprises two hundred Goldwind GW77/1500 kW WTG units and it started in operation in November 2009.

7.2.5.1 Generation and Availability

Wulanyiligeng Wind Farm was constructed on very flat and simple terrain and scrub/ desert land with the site varying in altitude between 1290-1380 m ASL (above sea level). From our appreciation of the terrain during our site visit, we do not have any concerns regarding shading, channeling or excessive gradient which could lead to adverse wind conditions such as sever wind shear, inflow angles or turbulence.

The site is subjected to very low temperatures in winter. The operating ambient temperature of Goldwind GW77 is from -30°C to +40°C and the standby ambient temperature is from -40°C to +50°C which is similar to other wind turbine models as low temperature version although there is no special low temperature version for Goldwind. According to Beijing Energy, there was no downtime because of the extremely cold weather up to date.

There is a compound area at the site which contains the substation, control building, store buildings, offices and other site facilities. The wind farm company which is the subsidiary of Beijing Energy employs twenty staff in total including one wind farm manager and three teams operating in shift patterns; working two weeks on and one week off. Each team comprises a team leader and six to seven engineers/ technicians. The wind farm compound has very good facilities which are suitable for housing the teams and is well maintained.

Although proper graded roads do not continue beyond the entrance to the compound, the access roads to the wind turbines appear to be in reasonably good condition. During our visit we were able to visit a number of turbines and the substation building without any issue.

Goldwind is a leading Chinese wind turbine manufacturer with a good track record and a significant number of installed units in China. In response to our enquiries during the site visit, Beijing Energy informed us that there were major component failures for the pitch motors of two WTGs and the pitch reduction device of one WTG. All of them have been replaced yet. We would normally expect to review monthly reports either from the WTG manufacturer or compiled by the wind farm company itself, which include details of any significant downtime or component failures and any remedial work carried out that month. Beijing Energy provided us their monthly production figures to us.

We understand from the Beijing Energy that under Chinese Grid Code all the WTGs must have capability for low voltage ride through (LVRT). But the deadline has not been confirmed yet. It is our understanding that the Goldwind GW77/1500 WTG models installed in Wulanyiligeng Wind Farm do not currently have this capability.

During our site visit, we noticed some cracks in the concrete of the foundations of one of the WTGs (#87). Although the cracks appear to be minor, we consider that there may be an increased risk of water ingress, which could lead to problems especially in the winter months when freezing and thawing of any water could potentially lead to more severe issues. However Beijing Energy considered these small cracks are only in the surface of aprons. There is no impact on foundations currently. Beijing Energy has provided us Foundation Concrete Mixture Proportion Test Report and Foundation Concrete Compression Test Report which were done by the third party. Both reports show the foundation concrete are qualified. And Beijing Energy emphasized that they also pay close attention to this issue and will pour concrete to fill those cracks. In addition they observe the foundation settlement every year.

Three met masts were considered for the wind resource analysis of the site, although only one was eventually used for the wind data from May 2006 to June 2007 to calculate the power production forecast and its integrity ratio was 100%. None of these masts were kept operational after the feasibility study had been completed and so there was no wind speed data for the operational period other than wind data measured by the WTGs.

At the time of our visit, the WTGs of Wulanyiligeng Wind Farm were covered by the manufacturer Goldwind's warranty with a two year warranty period. Goldwind guarantee a 95% availability level, although we understand that scheduled maintenance is excluded from this figure. Beijing Energy provided us the power curve for Goldwind GW77 from SCADA system. It appeared to be broadly consistent with the standard power curves from the manufacturer.

The wind speed, availability and production data provided by Beijing Energy shows that the average availability since operational was 96.81% (as shown in Table 7.8 below). Average annual wind speed at the hub height of the WTGs (65 m) has been calculated to be 8.15 m/s showing good wind resource in this area and the net capacity factor to be 0.23, which was normal for an onshore wind farm. Except for initial 2 months in the commissioning period, all months were above the warranted availability level of 95% for the wind farm as a whole.

Although the actual constructed model and numbers and layout of WTG units are the same compared with the feasibility study, the operation period has been less than one year up to date. So the operation data was not enough compared with the figures in the feasibility study. However since the feasibility study did not account for any losses due to grid curtailment, we suggest that the future production forecast is based on actual production figures.

Table 7.5: Operational Data of Wulanyiligeng

Date	Average WTG Availability (%)	Total Generation (MWh)	On-grid Generation (MWh)	Equivalent Full-load Hours	Capacity Factor	Average Wind Speed at 65 m (m/s)
2010-06	98.30	54,192.4	53,834.1	179	0.25	7.13
2010-05	98.36	71,478.5	71,031.5	237	0.32	8.16
2010-04	97.72	65,986.0	65,387.4	218	0.30	7.85
2010-03	98.20	40,456.3	39,818.9	133	0.18	8.79
2010-02	97.19	26,160.3	25,331.0	84	0.13	7.53
2010-01	97.32	50,733.1	49,854.0	166	0.22	8.45
2009-12	94.70	54,352.4	53,542.9	178	0.24	8.99
2009-11	92.72	52,530.9	51,981.3	173	0.24	8.31
Total/Average	**96.81**	**415,889.9**	**410,781.0**	**1,369**	**0.23**	**8.15**

In response to our request for information on grid curtailments, we were informed by Beijing Energy that it is very common for wind farms in Inner Mongolia to be subjected to grid curtailments. We understand that the curtailments usually occur at night in the winter months when demand for heat generation in the region is at a peak. At these times of peak demand, the electrical generation from wind farms is sacrificed for thermal power stations which operate closer to the centers of demand and operate as CHP plants, providing heat to the local district heating systems. According to documents which outlines the details of curtailments imposed by the grid company in Inner Mongolia issued on October 20, 2009 and March 15, 2010 separately, grid curtailment time was from 11pm to 7am or 8:30am the next day and grid curtailment capacity depended on the power demands at that time.

In each monthly operational report compiled by the Client, figures have been provided to represent the lost production due to grid curtailments occurring that month. This is shown in Table 7.9. We enquired as to the methodology applied by the Client in calculating the lost production and broadly agree with their approach.

It is clear that the most significant impact of the grid curtailments imposed by the grid company occur in the winter months, when part of the estimated potential output of the wind farm was lost. The biggest loss happened in February 2010 when there was Chinese New Year and power demand was lower than normal because most factories were closed for the holiday.

7.2.5.2 Conclusions

The wind turbines installed for Wulanyiligeng Wind Farm were supplied by a well recognized Chinese wind turbine manufacturer Goldwind that employs proven technologies. The O&M arrangements are well managed with very good facilities at the site. For the issue of the small cracks we observed in one of the WTG foundations, Beijing Energy considered these small cracks are only in the surface of aprons. There is no impact on foundations currently. And according to foundation concrete test reports, it is qualified. Beijing Energy emphasized that they also pay close attention to this issue and will pour concrete to fill those cracks. In addition they observe the foundation settlement every year. Aside from this issue, we are of the opinion that the wind farm was built to a good standard.

Assessment of the production data supplied to us by Beijing Energy suggests that the performance of the wind farm to date has been normal to reasonable, affected mainly due to grid curtailments between 18% and 67% loss of the potential output of the wind farm. It is very common in Inner Mongolia in winter and we would expect that this problem could be solved by future reinforcement of the network. Since commissioning was completed in March 2010, there has been insufficient data (at least 12 months of normal operational data) available to allow us to comment fully on the performance of the wind farm relative to the predicted annual output in the feasibility study.

7.2.6 Changtu Taiyangshan Wind Farm

Changtu Taiyangshan Wind Farm is located in Changtu County, the northern area of Tieling city in Liaoning province. With thirty-three Sinovel SL1500/77 WTGs installed, the total capacity at the site is 49.5 MW. It has been operational since July 2009.

7.2.6.1 Generation and Availability

Changtu Taiyangshan Wind Farm is built on the hills and mountains with an altitude of approximately 468 m ASL. The terrain does not present any concerns regarding shading, channeling or excessive gradient which could cause adverse wind conditions, such as severe wind shear, inflow angles, or turbulence.

Changtu County is located on the north bank of Liaohe River. Due to its special geographical location, the southwest monsoon runs in spring and summer and the northeast monsoon runs through the whole territory in autumn and winter. The wind resources in the area are abundant. The site is subjected to very low temperatures in winter. We were told from Beijing Energy that all WTGs are low temperature versions. According to Beijing Energy, there was no downtime because of the extremely cold weather up to date.

A control building is located near the step-up substation of the wind farm. This building includes the control center, offices, spare parts store, switchgear housing, and other site facilities. Beijing Energy employs one wind farm manager and twelve operational personnel, deployed in three teams of four people. The building and facilities are of a high standard and appear to be well-maintained.

The access roads on site are rough and may need remedial work in places to ensure access, especially in winter months when visibility of the site road parameters may be obscured by snow. We were also informed that diggers have to be used to clear the access and site roads of snow during the winter months. However, when we visited the site in July 2010, we were able to visit the control building, site facilities and wind turbines.

We understand from Beijing Energy that under Chinese Grid Code (Revision) all the WTG's must have capability for low voltage ride through (LVRT). It is our understanding that Sinovel WTG models installed at the site do not currently have this capability. Beijing Energy promised that Taiyangshan wind farm will implement the upgrade, if SGCC's upgrade requirement is received, in order to meet the relevant requirements.

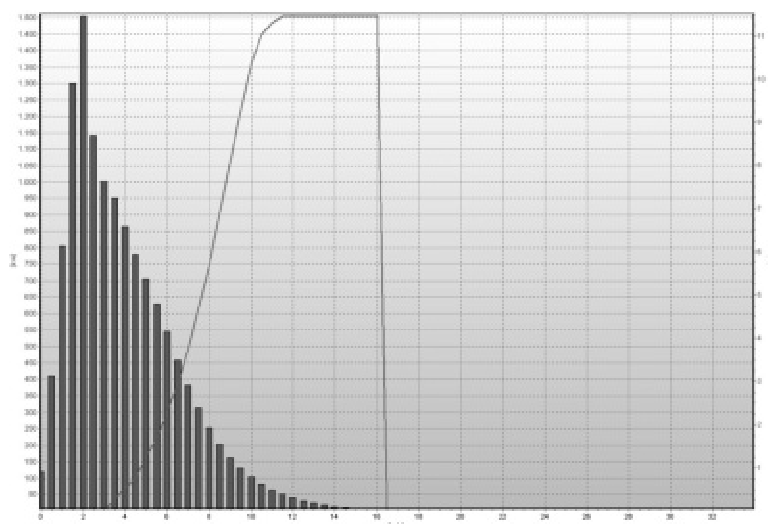
Wind resource data at the sites was recorded from two met masts installed on site before the construction. However, the wind data measured by the sensors on these masts has not been used to monitor records during the operational period after construction started.

The wind data measured by the anemometers on the WTGs is used to monitor the wind during the operational period. We have been provided with the wind resources data since July 2009.

In response to our request for information on grid curtailments, we were informed by Beijing Energy that there are no active curtailments being imposed on Changtu Taiyangshan Wind Farm.

Beijing Energy provided us with power curves from the SCADA system. We can see from Figure 7.1 that rated wind speed of No.12 WTG was around 11 m/s. Also the curve has shown that cut-in speed and cut off speed to rated speed were 3 m/s and 16.5 m/s and wind turbines usually operate within this range.

Figure 7.1: Power Curve of No.12



Currently the WTGs are covered by a manufacturer's warranty which guarantees the WTG availability at 95%. The warranty period is for two years. The average wind speed at hub height (70 m) has been calculated to be 6.74 m/s and the net capacity factor is calculated to be 25%; which is reasonable for an onshore wind farm. According to the production, wind, and availability data provided by Beijing Energy from SCADA system and listed in Table 7.10, Changtu Taiyangshan Wind Farm has shown an average availability of 98.39% since July 2009. All monthly availabilities are above the 95% guaranteed value. It is noted from Table 7.10 that the average wind speed at 70 m is 3.78 m/s which is much lower than the average wind speed of 6.74 m/s in the feasibility study report. Comparing the actual annual generation of 79,435.58 MWh with the annual forecast 99,000 MWh in the feasibility study, we find that the electricity generated by Changtu Taiyangshan Wind Farm is lower than targeted production. We understand from data review and analysis that it was mainly due to the wind speed during the operational period which was lower than the long-term average wind speed.

Table 7.6: Operational Data of Changtu Taiyangshan Wind Farm

Date	Average WTG Availability (%)	Total Generation (MWh)	Average Wind Speed at 70 m (m/s)
2009-07	98.91	3,930.5	3.00
2009-08	99.14	3,915.8	3.15
2009-09	99.04	6,150.8	3.94
2009-10	98.66	6,010.8	3.88
2009-11	97.85	8,796.8	4.74
2009-12	98.61	4,902.8	3.43
2010-01	98.58	6,694.0	2.40
2010-02	97.79	4,962.7	2.80
2010-03	98.49	9,368.8	4.00
2010-04	98.43	10,767.4	4.80
2010-05	97.20	10,205.7	5.16
2010-06	97.95	3,729.6	4.00
Total	98.39	79,435.6	3.78

It is worth noting that the calculation of availability, as presented by Beijing Energy, includes a few caveats such as wind turbines considered as available when they are actually down due to scheduled maintenance.

7.2.6.2 Conclusions

Equipment at Changtu Taiyangshan Wind Farm was supplied by manufacturers well-known by the industry; that employ proven technologies or has credible track records within the market. We are of the view that the turbine technologies are in accordance with current industry standards, and the sites were built to a high standard. O&M is well-managed. The electricity production at Changtu Taiyangshan Wind Farm is lower than the prediction. We understand from data review and analysis that lower annual average wind speed is the main reason for the lower performances.

7.2.7 Lumingshan Guanting Wind Farm Phase I

Lumingshan Guanting Wind Farm is located around Guanting Reservoir in the boundary of Beijing and Huailai county of Hebei province. It consists of four phases:

- Lumingshan Guanting Wind Farm Phase I (total 49.5 MW with thirty-three Goldwind GW77/1500 WTG installed, operational since January 2008 and commissioned since July 2008);
- Yanqing Difengsu Wind Farm (total 15 MW with ten Goldwind GW82/1500 WTG installed, operational since January 2010);
- Lumingshan Guanting Wind Farm Phase II (total 49.5 MW with thirty-three Goldwind GW82/1500 WTG installed, operational since March 2010); and
- Lumingshan Guanting Wind Farm Phase II Jiami (total 36 MW with twenty-four Goldwind GW82/1500 WTG installed, under testing and debugging).

Under our scope of work, we assessed the performance of Lumingshan Guanting Wind Farm Phase I located in the south of Guanting Reservoir.

7.2.7.1 Generation and Availability

Lumingshan Guanting Wind Farm Phase I comprises thirty-three Goldwind GW77/1500 WTG units constructed on relatively flat terrain along the south of Guanting Reservoir. The site features areas of crops, including large corn fields, which are harvested annually with the site varying in altitude between 476 – 479 m ASL. From our appreciation of the terrain during our site visit, we do not have any concerns regarding shading, channeling or excessive gradient which could lead to adverse wind conditions such as severe wind shear, inflow angles or turbulence, although the influence of the crops should be considered when considering future production forecasts.

Unlike many of the sites in Inner Mongolia, this site was not subjected to very low temperatures in winter and so would be unlikely to require low temperature versions of the WTGs.

There is a compound area at the site which contains the substation, control building, store buildings, offices and other site facilities. The substation and SCADA facility was located a short distance across the road from the main compound. The wind farm company which is the subsidiary of Beijing Energy employs one wind farm manager and two O&M teams, each team comprising a team leader and thirteen engineers/ technicians. The large teams reflect the fact that there are four phases. The wind farm compound has very good facilities which are suitable for housing the teams and is well maintained.

During our visit we were able to visit a number of turbines and the substation building without any issue. For one of the WTGs visited during our site visit, there was insufficient room to allow a crane to setup, due to the encroachment of crops from the nearby corn fields. However Beijing Energy has replied us that if crane is needed they will pay the crops' owners to use the land temporarily. Otherwise there are no problems for this issue.

Goldwind is a leading Chinese wind turbine manufacturer with a good track record and a significant number of installed units in China. But according to the operational report for Lumingshan Guanting Wind Farm Phase I, the annual average WTG availability in the first year 2008 was only 84.29%. We were informed that Lumingshan Guanting Wind Farm Phase I was the first wind farm which installed Goldwind GW77 and it has been in operational gradually since January 2008. So in the first year there were some components failures and Goldwind engineers keeped on improving them all the time such as DP connector, converter controller, pitch cabinet, water cooling system, control parameters and so on. We can see that the annual average WTG availability has been much bigger since 2009.

We understand from Beijing Energy that under Chinese Grid Code all the WTGs must have capability for LVRT. The deadline has not been confirmed yet. It is our understanding that the Goldwind models installed at Lumingshan Guanting Wind Farm Phase I already have this capability according to Goldwind promise.

Six met masts were considered for the wind resource analysis of the site, although only one was eventually used for the wind data from August 2004 to July 2005 to calculate the power production forecast. Although one of these masts (located in the center of the wind farm near the reservoir) was kept, wind data was measured only by WTG anemometers after the feasibility study completed.

At the time of our visit, the WTGs of Lumingshan Guanting Wind Farm Phase I were covered by the manufacturer Goldwind's warranty with a 4 year warranty period from the end of 2007 to the end of 2011. In the first year of this warranty period, Goldwind was in charge of all O&M works covering not only wind turbines but also substation etc. Then in the remaining years of this warranty period, Goldwind was only in charge of O&M works covering their wind turbines. Now most O&M works can be done by Beijing Energy staff themselves and Goldwind engineers support them. It is different as usual. Beijing Energy provided us the power curve for Goldwind GW77 from SCADA system. It appeared to be broadly consistent with the standard power curves from the manufacturer. Goldwind guarantee a 95% availability level in year 1 and 98% level in years 2-4, although we understand that scheduled maintenance and grid downtime are excluded from this figure. The wind speed, availability and production data provided by Beijing Energy shows that the average WTG availability since operating was 95.69% (as shown in Table 7.11 below). Average annual wind speed at the hub height of the WTGs (65 m) has been calculated to be 6.37 m/s.

It should be noted that the values for total generation provided in Table 7.11 represent the gross energy production rather than the net production which account for electrical losses from the inter-array cabling and substation and so on. We would prefer to see net production metered only for phase I. However, we understand that there is only a single metering point for all phases of Lumingshan Guanting Wind Farm. However the net capacity factor based on on-grid power generation should be a bit lower than 0.27 which is typical for an onshore wind farm.

Although the actual constructed wind farms have the same models and numbers and layout of WTG units when compared with the feasibility study, the actual production can not be compared with the forecast in the feasibility study report because the actual on-grid power generation figures were not available.

In response to our request for information on grid curtailments, we were informed by Beijing Energy that there are no active curtailments being imposed on phase one of the wind farm.

Table 7.7: Operational Data of Lumingshan Guanting Phase I

Date	Average WTG Availability (%)	Total Generation (MWh)	Equivalent Full-load Hours	Capacity Factor(1)	Average Wind Speed at 65 m (m/s)
2010-06	96.74	3,598.7	73	0.10	4.68
2010-05	99.00	8,649.1	175	0.23	6.11
2010-04	98.40	11,246.3	227	0.32	6.83
2010-03	99.07	11,673.0	236	0.32	6.80
2010-02	97.04	10,011.2	202	0.30	6.20
2010-01	94.92	17,716.0	358	0.48	8.21
2009	96.05	100,080.6	2,022	0.23	6.01
2008	84.29	80,221.7	1,621	0.19	6.12
Total/Average	**95.69**	**243,196.6**	**4,913**	**0.27**	**6.37**

Note:

(1) Capacity Factor* here has been calculated based on total generation since on-grid power generation figures were not available.

7.2.7.2 Conclusions

The wind turbines installed for Lumingshan Guanting Wind Farm Phase I were supplied by a well recognized Chinese wind turbine manufacturer Goldwind that employs proven technologies. The O&M arrangements are well managed with very good facilities at the site. Although the actual constructed wind farms have the same models and numbers and layout of WTG units when compared with the feasibility study, the actual on-grid power generation figures were not available and comparison can not be made due to only one metering point in wind farm substation for all phases. However we can know that the net capacity factor should be a bit lower than 0.27 which is typical for an offshore wind farm.

We have informed about the reason for the low availability 84.29% in the first year. It was because Lumingshan Guanting Wind Farm Phase I was the first wind farm which installed Goldwind GW77 and it has been in operational gradually since January 2008. So in the first year there were some components failures and Goldwind engineers keeped on improving them all the time. We can see that the annual average WTG availability has been much bigger since 2009. In all we are of the opinion that the wind farm was built to a good standard.

7.3 General Conclusions

Of the eight representative wind farms we reviewed, two had different wind turbines types, number of units and layouts compared with those quoted in the feasibility study. Two wind farms had just completed commissioning this year and so did not have enough operational data (at least 12 months normal operational data) and one did not have on-grid power generation figures only for phase I separately available because one meter was shared for four phases of this wind farm. We could not assess whether their production of these five wind farms was in line with the forecasted figures in the feasibility studies.

Out of the three remaining wind farms, two had higher annual productions than forecasted in the feasibility study.

Changtu Taiyangshan Wind Farm showed lower performance than expected. We understand from the available information that low average wind speed was the main reason for the low production. According to the feasibility study, the annual average wind speed was 6.74 m/s which is much higher than the actual annual average wind speed 3.78 m/s. There is a considerable deviation, in the coming years the wind conditions may change.

Six of the eight representative wind farms are located in Inner Mongolia with excellent wind regimes. Their performances could be better if there were no grid curtailments which is very common in Inner Mongolia. We would expect this problem to be solved by future reinforcement of the network. However the wind farms located near Beijing and Tieling city in Liaoning province do not have any such concerns.

Overall, the equipments and facilities are well-maintained and of a good standard. The design, construction and installation are in line with our expectations.

8. Operation & Maintenance Execution of Wind Farms

8.1 Introduction

For the operation of its wind farm, Beijing Energy has a general strategy to rely on WTG manufacturers during the warranty period, before handing it over to their own O&M team on site. However, Guanting provided the 100 WTG used for this project and has signed a long term wind turbine maintenance agreement with Goldwind.

The warranty period for the Beijing Energy wind farms, provided by the WTG manufacturers, is two years. This is in line with our experience of other wind farms and industry standards, and acceptable for proven WTG technologies except Sewind. We consider a three year warranty to be reasonable for Sewind who did not provide a satisfactory track record. Or if Beijing Energy were planning to form a long term maintenance agreement, we would be satisfied with two years.

The O&M team will maintain the electrical equipment after expiry of the warranty period. A part from the Goldwind direct drive GW77, the technology is mature, so few faults have occurred on the devices. More attention needs to be given to the direct drive, which is based on a new concept. The voltage level, current and capacity of electrical equipments except WTG are all standard specifications. Before starting O&M work, the technicians will be trained by the manufacturer, and then further during work, based on the regulations issued by headquarters. In our view, the safety and performance targets should be achieved based upon adequate experience of technicians and compliance with proper procedures laid out by WTG manufacturers.

The road access maintenance is sub-contracted to a local transportation service and maintenance company, which is common practice. As required by the industry regulations, the export lines connected to the grid are maintained by the local grid company. Local resources are hired on a part-time basis, to monitor the condition of the WTG, in some wind farms.

8.2 O&M Structural Organization

We believe the staffing levels are adequate for each site. The number of permanent employees at each wind farm site is set by Beijing Energy's Headquarter based on internal principles (refer to table 8.1), and then approved by Jingneng Group. Staff are recruited and trained by the Beijing Energy's headquarters, which ensures control of the qualification and competency of the employees on site. Project companies propose an organizational structure which is then to be approved by Beijing Energy's Headquarters. They assign the general manager and other senior managers. Other O&M employees are hired by each project company.

Table 8.1: Human Resources Configuration for Wind Farms with Different Capacity

Capacity	100 MW	130 MW	300 MW
General Manager	1	1	1
Deputy General Manager	None	1	1
Execution Supervisor	1	1	1
General Manager Assistant	3	3	3
Senior O&M Staff	1 for each shift, totally 3	2 for each shift, totally 6	3 for each shift, totally 9
Intermediate O&M Staff	2 for each shift, totally 6	3 for each shift, totally 9	4 for each shift, totally 12
Junior O&M Staff	1 for each shift, totally 3	1 for each shift, totally 3	2 for each shift, totally 6
Total	17	24	33

Three divisions are usually set for production, maintenance and execution. The O&M team usually has three shifts, one foreman for each shift with two or three O&M employees who are in charge of both operation and maintenance. Daily requirements are therefore satisfied, i.e. replacement of consumable parts. This organization set-up minimizes reaction time for small maintenance tasks on the WTGs and manufacturer support is given during major overhauls. It also improves the availability of the turbines which is good for the revenues. Most of the wind farms visited were still covered by the warranty fee.

8.3 O&M Arrangements

High availability is critical for a wind turbine. A number of factors can affect this availability; the operational & maintenance (O&M) arrangements are likely to have a very high impact. Liquidated damages are the key protection against poor availability. Care is needed for the definition of 'availability' during the WTG supply contract negotiation. The contracted availability calculation will typically exclude a number of events, allowing the Supplier to limit its responsibilities over events outside their control (e.g. grid outages). During site visits we raised these points and requested evidence of the relevant documentation. Most of Chinese wind farms applied this kind of definitions in the WTG supply contracts, even they are not comply with western practice.

Beijing Energy has set a control center in Hohehot, which monitors and controls seven wind farms and despatch the power generation according to the order from local grid company. The control center adopts open, layered and distributed system structure, total distribution database. The whole system is divided into two main layers, primary control layer of control center and distributed layer of wind farms. It achieves the real-time function from control center to every wind farm, through the different software, hardware system structure and system software, also through the integrated network communication program and operation control mode.

The configuration of primary hardware of the control center is: 2 servers of real-time database, 2 servers of history database, 4 operator work station, 1 charger work station and 1 engineer work station. 2 servers of real-time database mainly implement the collection and treatment of real-time data, and provide real-time data service to operator work station and charger work station; 2 servers of history database mainly implement the long-term storage of the operation data of wind farm monitoring system and all equipments systems of control center, also provide the service of data searching and collection; 4 operators work station mainly implement the man-machine dialog between the operator in control center and the wind farms, also implement the real-time monitoring and controlling. 1 charger work station, mainly implement the man-machine dialog between the dispatcher in control center and dispatcher in grid company, and implement the real-time monitoring and control function, also, release the operation order to operator work station to implement the relevant despatch and management work; 1 engineer work station implement the system maintenance, system program modification and test operation of new science research project.

This control center can directly control the real-time operation information of every wind turbine of these seven wind farms, including all the parameter of the wind turbine SCADA system. So far, this control center has completed the connection of the information interfaces in these seven wind farms which were related to the wind turbines of nine models of seven brands. The key condition data of wind turbines like wind speed, active power and electricity, rotating speed, frequency, voltage, power factor, current, temperature, angle, reactive power and electricity, deviation value, speed, emergency conditions, etc are sent to the control center from every wind turbine per 15 minutes. The monitoring and control system summarizes and records these operation data automatically, in order to analysis, compare and select optimization.

Except remote collection, monitoring and record of the operation data of every wind turbine, the control center also has been authorized to remote control every wind turbine of these seven wind farms, including the methods of startup, shut down, power generation, active power, yawing angle, etc. The wind turbine can be shut down directly and the maintenance team on site will be sent to repair, if emergency alert is found. When the fault is fixed, the maintenance team on site will report to control center, the control center will give the operation order then. When the speed reaches in the design range and the operation data of wind turbines are received by the control center, the control center will adjust the operation condition of wind turbines of every wind farm according to the despatch order from the despatch department of Inner Mongolia Grid Company, in order to make them reach despatch requirement of active power and reactive power of seven wind farms.

The weather forecast system of this control center adopts the weather forecast data from European. The weather forecast of coming 48 hours will be updated per 12 hours. The modeling scale of this weather forecast system can reach to 45 km x 45 km, and Beijing Energy has planned to improve to 5 km x 5 km soon. Comparing with the actual power generation, the accuracy of this weather forecast can be above 80%, when there is no despatch limit from grid. This accuracy has reached the upper level of same system in Europe.

This control center of Beijing Energy is the first established regional center of centralize monitoring and controlling of wind farms. The communication between the control center and wind farms as well as the grid company is using the data networking specially using in electricity grid, which assured the reliability of the transmission of data and order. Meanwhile, this system using original grid despatch communication channel as backup, once the communication fault occurred in control center, the grid despatch department can still despatch the seven wind farms directly. The advantages of this control center are:

First, saving human resources, no need to set operator on duty specially, only the professional O&M team is needed. At least, three employees are reduced in each wind farm, and more than twenty employees are saved in these seven wind farms;

Second, the complete control and monitoring of wind turbines of every model of every brand can be implemented, easy to compare the operation conditions of the wind turbines of same brand and same model, make the complete and general assessment within big scale. Find the abnormal operation condition among the huge history data, then set the rational emergency value and provide the improve guidance to the future operation.

Third, find the differences, advantages and disadvantages through the recording, analysis, comparing, summarizing and assessment of the reliability, power generation, generation efficiency, active power, fault rate and power curve, in order to provide the advice to the procurement of wind turbines in future.

Four, the professional operation and analysis people are only needed to be centralized in this control center to analysis, assess and control the operation of every wind turbines of seven wind farms. The quantity of professional analysis people can be reduced, as well as their transportation between wind farms. Meanwhile, it's also helpful to improve the professional level of these operation and analysis people. Furthermore, it's helpful to improve the operation management level of wind farms.

Five, through the weather forecast system of this control center, the weather forecast of these seven wind farms can be implemented at the same time. If there no control center, the weather forecast system should be bought for each wind farm, which means the cost will be much higher. Meanwhile, it's also helpful to manage the power generation as a whole, in order to reach the optimization.

Six, the main operation data of these seven wind farms can be summarized and selected through this control center, then transmit the key data which should be concerned by the headquarter of Beijing Energy to them. It could save the report work of every wind farm and also save the select and summarize work of Beijing Energy headquarter.

In December 2010, Beijing Energy organized several professional authorities of wind power sector and the operation center of Inner Mongolia Grid Company to do an acceptance test to this control center. In the conclusion of the acceptance test report, the authorities and Inner Mongolia Grid Company has agreed that this control center project passed the acceptance test.

Generally speaking, this control center is very helpful for improving the operation management level, saving human resources, reducing operation cost, improving operation analysis and control level, improving the steady and healthy operation of wind farms of Beijing Energy in this region. This kind of regional control center is very comply the actual practice of China wind power development, and very possibly to be spread and popularized.

Training programs arranged by the manufacturers are included in all O&M arrangement documents reviewed. These are comprehensive, and include at least four weeks training in factories and on site, covering most topics and problems that may occur on site.

The training covers using the maintenance manual, keeping records of faults, operation and control of turbines, erection method for replacement parts, maintenance procedures, trouble shooting, and spare part management. We understand that Beijing Energy staff also assists the manufacturer's team during scheduled and unscheduled maintenance. We are satisfied that experience can be gained by the team through this arrangement.

Beijing Energy headquarters issue and publish the O&M regulations applied to each wind farm. The key sections of these regulations are written on boards and hung on the wall of relevant facilities at each site, which we were happy to find since this makes it easier for O&M staff to find and follow them. All the main operational aspects are covered, e.g. the WTG, electrical equipments, I&C equipment, accommodation facilities etc, which are drafted based on relevant national and industry standards, codes and WTG manufacturers O&M requirements. We are satisfied with the regulations applied by Beijing Energy to the projects sites.

As previously discussed, most of the wind farms we visited continue to be maintained by the manufacturers, having started commercial operation during the past two years, they are still in their warranty period. According to the maintenance records we saw on site, and interviews with the manufacturers' onsite staff, the scheduled maintenance has been carried out in accordance with definitions in the agreements. We note that the WTG Maintenance form elaborates on inspection and items which are to be checked by the manufacturer maintenance staff regularly. The form is comprehensive and includes all the main items. After expiry of the warranty period, site personnel from Beijing Energy will undertake the regular maintenance of WTGs, with the exception of Guanting wind farm, which has a long-term O&M agreement with the WTG manufacturer. Most of the WTG suppliers have a regional service center nearby the wind farms, so manufacturer servicing will still be accessible. We expect the manufacturer to respond rapidly to service requests as Beijing Energy is one of the major wind power producers in China.

In our view, plant maintenance by an external specialized company allows for more confidence in the quality of the service and is in line with industry practice at Western wind farms. However, we acknowledge that few companies have significant track record in the Chinese market. If Beijing Energy could consider and compare the quality, cost and efficiency of maintenance to be provided by the sub-contractor and them in the future when the qualified sub-contractor available, it's will be more adaptable to international practice.

In order to make it cost-effective, Beijing Energy is considering managing this service in some wind farms and sub-contracting maintenance service to WTG manufacturers at other wind farms which use large numbers of WTG from the same manufacturer. This may contribute to its ambitious plans for future growth and could help consolidate the rapid expansion of its wind portfolio that has taken place in recent years. However, careful thought must be put into this balance and a financial comparison must be made, in line with local conditions and flexible negotiation with WTG manufactures. This strategy is used by other companies with large wind portfolios. We consider that it is necessary, for training and O&M, to have a corporate strategy and guidance documents defining best practice principles during these activities, in order to ensure the same quality of maintenance and to share experience. Beijing Energy indicates that the guidance documents of O&M is in the drafting stage, and will be issued before the end of 2010. Currently, the O&M procedure and work of Beijing Energy wind farms follow two national O&M standards which are called 'DL/T 666-1999 Code on Operation of Wind Farm' and 'DL/T 797-2001 Code on Operation of Wind Farm' which were issued by the national authority.

At most of the visited wind farms, the storage of spare parts is well-registered, well-managed and well-recorded. The consumable parts e.g. sensors, tools, brake pieces and sealing are purchased by the site project company regularly at a fixed rate or a capped price. According to Beijing Energy headquarters' plan, spare parts procurement is a key part of its annual budget for O&M. Headquarters manage and purchase the major spare parts e.g. generators and gearboxes. The normal spare parts procurement which is based on the necessity, utilization frequency, supply period, domestic or import, consumable rate, is separately managed. In our view, the management of the spare parts by Beijing Energy seems efficient, practical and cost-effective. The major parts like generator and gearbox is integrately managed by Beijing Energy headquarter, due to the low fault rate, high cost and long supply period. However, for this sort of major component, Beijing Energy is lack of the complete strategy of the prediction of fault, the pre-arranged planning of emergency, the integrately storage and distribution. The extension of warranty agreement with manufactures is in negotiation.

We considered Beijing Energy quality control to be adequate. We also gained confidence in this matter from the high energy yield and availability of the representative wind farms. The procurement, construction, recruitment and training are controlled by Beijing Energy headquarters and demonstrates good management capabilities. The Health, Safety and Environmental (HSE) system is well-established and well-implemented among the wind farms. The personal protection equipment (PPE) is sufficient on site and the employees are required to follow procedures before they start working on site.

During our sites visit, other teams of safety assessors were checking the safety procedures and monitoring the risks at each wind farm site. An annual safety assessment is undertaken by HSE teams formed by external experts and invited by Beijing Energy. Their work seems very professional, detailed and careful. We are comfortable with Beijing Energy internal control procedures. Some sites have become tourist attractions and they have all been tactfully integrated into the surrounding environment. No major impact has been recorded on the environment after construction period or during operation. Quality, Health & Safety and Environmental manuals and relevant system files have been written and executed in accordance with Beijing Energy QHSE system requirements.

8.4 Conclusions

We consider the O&M arrangements to be suitable for Beijing Energy operations as they are based on currently recognized best practice models whilst being specifically developed for the Beijing Energy sites. Beijing Energy O&M arrangements for its wind farms are in line with our expectations of Chinese wind farms, even though the Chinese O&M common practice is different with international standards in few points.

The control center in Hohhot is very helpful for improving the operation management level, saving human resources, reducing operation cost, improving operation analysis and control level, improving the steady and healthy operation of wind farms of Beijing Energy in west region of Inner Mongolia. This kind of regional control center is very comply the actual practice of China wind power development, and very possibly to be spread and popularized.

Although we believe that improvements are needed in the preventive maintenance strategy for WTG main components, we believe that the treatment to the outage, the structural organization of O&M, the purchase and storage of spare parts and the QHSE requirements of Beijing Energy wind farms are generally acceptable and well-organized.

9. Technical Review of Gas-fired Power Plants

9.1 Jingfeng CCHP Power Plant Phase I

The Jingfeng Power Plant Phase I is a single shaft gas-fired CCHP power station comprising of one Mitsubishi M701F gas turbine (GT), one heat recovery steam generator (HRSG) and one steam turbine (ST) in combined cycle operation. The plant is situated in China's capital city Beijing and has a nominal total power generating capacity of 408.8 MW (gross).

The Jingfeng Power Plant is owned by Beijing Jingfeng Natural Gas-fired Power Co., Ltd., an incorporated and wholly owned subsidiary company of Beijing Energy.

Since 2007 the Jingfeng Power Plant has a natural gas supply contract with Beijing Gas Group Company to supply NG fuel to the plant which is delivered from the Yamen estuary Gas Pipelines at Lu Village Gate station, to site via a transmission pipeline. NG is received at the Gas Regulating and Metering Station (RMS) located in the plant area, about 500 m from the Gas Turbine house. Both the NG pipeline and the RMS are owned and operated by the Beijing Jingfeng Natural Gas-fired Power Co., Ltd. The NG is supplied at an inlet pressure of 16 bar_g. A compression station is installed in the plant, which boosts the gas pressure to meet the operating requirement of the gas turbine. The facilities and equipments inside the boundary of plant are belonged to the Jingfeng, who have to maintenance them. The gas supplier will maintain and resolve the faults if the accidents happen to facilities and equipments belonged to Jingfeng, and cost will be beared by Jingfeng.

The electricity offtaker is the Beijing Electricity Company (BEC) who is owned by Beijing local government. The Beijing Electricity Company provides the 220 kV single circuit overhead transmission lines which are connected to 220kV switchyard located at the plant. There is no record of output restriction due to transmission constraints.

9.1.1 Plant Construction and Configuration

9.1.1.1 Plant Construction

The plant was constructed completely in 2006 under a turnkey EPC contract by Mitsubishi, a reputable Japanese engineering contractor and process plant equipment supplier, having substantial experience in undertaking power plant and industrial process plant turnkey projects at home and abroad.

9.1.1.2 Plant Configuration

The CCGT unit is of a single-shaft design. The configuration consists of one gas turbine (GT) unit, one heat recovery steam generating (HRSG) unit and one steam turbine

(ST) unit. The GT and ST are coupled with generator in a single shaft (GT-ST-GEN). Balance of plant (BOP) facilities include the usual systems such as main and closed loop cooling water, water treatment, compressed air, fire protection, transformers and 220 kV station switchyard, and the distributed control system (DCS).

The following sub-sections give an overview of the main plant equipment and systems:

Gas turbine generator (GT)

The GT unit is a Mitsubishi M701F model with dry low NO_x combustion design. It has a single fuel combustor burning only natural gas. The GT is capable of both base load and two-shift operations and has a rated capacity of 270.3 MW at ISO conditions.

The hydrogen cooled generator is directly coupled to the steam turbine shaft.

The GT itself is the most significant plant item. From GT supplier (MHI) information, we understand that the fleet of similar GTs amounts to 101 units in total around the world, which have accumulated about 47,200 hours of operation collectively as of the end of 2006. We are not aware of any significant fleet issues outstanding, and consider the GT to be proven technology.

Heat recovery steam generator (HRSG)

The HRSG was supplied by Dongfang-Hitachi and consist of 3-pressure parts; high pressure, intermediate pressure and low pressure with reheat process and natural circulation type, designed to be suitable for operation in association with the GT under base load and two-shift operation regimes. Exhaust gas from the GT is ducted to the HRSG where it is used to generate steam for the steam cycle.

Two 100% duty boiler feed pumps supply feed water to the HP drum of the HRSG.

Steam turbine generator (ST)

The ST unit was supplied by Mitsubishi (MHI) and is capable of operating in full load and sliding pressure modes. The ST is designed in two-casing design having a combined HP and IP turbine casing and a double flow LP turbine section and a condenser with a circulating cooling water supply. There is no steam extraction from the ST. A total enclosed water-to-hydrogen cooled generator is coupled to the ST. Rated output of the unit is 138.5 MW. The ST has a 100% steam dump bypass system to the condenser. This is provided for start-up, shut-down and for dumping the steam into the condenser in an emergency. Two 100% duty condensate extraction pumps are provided to deliver the main condensate from the condenser hotwell to the LP drum of the HRSG.

Fuel gas compression system

A compressor station is provided to continuously supply compressed fuel gas at 38 bar_g to the GT. Major equipment of the system comprises 2 x 100% duty fuel gas compressors, fuel gas filters and liquid knock-out vessels.

Main cooling water system

The main CW system is a closed circuit cooling system. The 2 x 50% duty main CW pumps draw water from the cooling water basin to the main condenser to condense turbine exhaust steam. As there is no redundancy in the main CW pumps, loss of one CW pump could potentially restrict the generation capacity of the steam cycle. The extent of derating in such case depends on the available capacity margin in the remaining CW pump and the prevailing site conditions.

The source of the makeup water is approximately half from underground water, while the other half from a petrochemical factory adjacent to plant. We understand that in case the underground water supply will be decreased in the future, the Petrochemical Plant will not be able to increase water supply to Jingfeng power plant for makeup water. So the trend of reducing level of underground water will directly impact to the power plant. However, we need Jingfeng to confirm on the water reserve capacity for supplying to Jingfeng makeup water.

The source of the makeup water is from Yanhua and Sanyuan petrochemical factories adjacent to the power plant. As per information received on October 13, 2010, the annual capacity of water supply is 5 million cubic meters and the annual water consumption of power plant is 1.5 million cubic meters. It is considered the capacity of water supply is adequate for the power plant in long term operation. The underground water is also supplied to the power plant for around 300 in-house staff accommodation at annual capacity of 110,000 m^3. It is considered that the capacity of water supply is adequate for the purpose.

Closed cooling water system

The closed CW system supplies cooling water to various equipment (cooling points) located throughout the plant via a closed-loop piping system and transfers the heat load to the auxiliary cooling water via the water/water closed cooling water coolers.

Water treatment system

The water treatment system concise of 3 sets of ultrafiltration (108 m^3 / hr), 2 sets of ultrafiltration (125 m^3/ hr), 3 sets of reverse osmosis (73 m^3/ hr), 2 set of reverse osmosis 85 m^3 / hr, 3 sets of ion exchange (40 m^3 / hr).

W note that the water treatment plant capacity is sufficient.

Transformers and 220 kV station switchyard

Generator transformers of the GT and ST are connected by overhead lines to the corresponding feeder circuits in the 220 kV switchyard. The high voltage (HV) side of the auxiliary transformer connects to the GT transformer while the low voltage (LV) side connects to the 6.0 kV switchgear and provides power for normal start-up of station loads and services. The transformers basic specifications are outlined in Table 9.1:

Table 9.1: Plant Unit Transformer Specification

Item	Value/Type
Rating (MVA)	520
Voltage and tapping range (+ and -) (kV)	242±2×2.5%/20
On or off load tap changer	Off Load
Cooling method	ODAF
Transformer losses at rated output (MW)	408

Generated power is metered at the switchyard and transferred to 220 kV transmission lines.

Distributed Control System

The FOXBORO distributed control system (DCS) provides for the start-up, normal emergency shutdown, automatic and manual operation, sequential interlocking, data acquisition, control, supervising and monitoring of the plant. The DCS is typical of that found on similar CCGT power plants and we have no major concerns relating to this equipment.

9.1.1.3 Summary

The configuration of the BOP systems are in line with our expectations for CCGT plant of this type with the exception of the lack of redundancy in the CW pumps which could result in a loss of capacity as discussed above. Also, we have little concern about the stability of the makeup water supply in future due to the underground water supply, as we explained in section 'main cooling water system'.

9.1.2 Operational History

9.1.2.1 Capacity and Availability

The plant began commercial operation on May 1, 2006 and is intended to operate in the variable load regime. As per our information received for plant operation, long shutdown period comes from scheduled outage. MM reviewed the technical summary of 8000 equivalent hours maintenance in year 2006 and technical summary of 32000 equivalent hours maintenance in year 2008, which are recognized as complete content, careful test, qualified inspection, proper technical guidance and meet the technical requirements. Based on the information provided, capacity and availability factors for the past 5 years are tabulated in Table 9.2.

Table 9.2: Capacity & Availability Factor of Jingfeng CCGT Power Plant

Year	2006	2007	2008	2009	(To June 6,) 2010
Capacity Factor (%)	30	39	56	47	53
Availability Factor (%)	84	77	87	98	91
Net Generation (GWh)	1,080	1,418	2,016	1,695	939

Outages

The historical outage data for the plant indicates:

- For the first six months of 2010, there was one scheduled outage period of about 16 days and no recorded forced outages;
- In 2009, there was one scheduled outage period of about 6 days and no recorded forced outages;
- In 2008, there was one scheduled outage period of about 22 days and 4 forced outages with a total period about 47 hrs;

- In 2007, there was one long scheduled outage period of about 83 days and 3 forced outages with a total period of about 20 hrs; and

- In 2006, there was one schedule outage period of about 36 days and 3 forced outages with a total period of about 97 hrs.

The reported plant availability figures are generally below the value of 93%—94% that we would expect as a long term average from our experience of similar power plant worldwide. The long scheduled outages are the main cause of plant non-availability, which should be possible to better optimize. However, it's noted that the definition of availability of whole plant in China is different with western market, and also the regulations of availability of PPA and grid despatch apply different principle.

The plant Capacity Factor at an average of 45% is at high level among the similar gas-fired power plants in China. Though, it's slightly lower than western similar western gas-fired power plants, that's because its annual power generation amount is decided by the production plan issued by government authority at beginning of every year. In accordance with verbal information provided during our visit, under the PPA, plant income is based on exported energy volume only with no plant availability or capacity payment. The plant is therefore not compensated if BEC despatches to decrease the purchased energy volume in a period. On the other hand there is no penalty payment in case the plant is unable to supply power to BEC. This is mainly due to task of Jingfeng CCGT plant, whose major task is the heat supply to local community, so the majority power generation is completed in heat-supply period.

9.1.2.2 Output

The design value of the capacity output of CCGT unit is 403.394 MW at ISO conditions (15°C; 1.013 bar_a; 60% RH; cooling water 15°C). The test value of the commissioning test report issued by NCEPRI (North China Electric Power Research Institute) is 408.252 MW, which meets the design requirement.

9.1.2.3 Heat Rate

The guaranteed heat rates at various plant loads are shown in the Table 9.3 below.

Table 9.3: Plant Guaranteed Heat Rate of Jingfeng CCGT Power Plant

%Load	30	50	75	100
Guaranteed Heat Rate (kJ/kWh)	8,595	7,101	6,539	6,263

The design value of the heat rate of CCGT unit is 6266 kJ/kWh at ISO conditions (15°C; 1.013 bar_a; 60% RH; cooling water 15°C). The test value of the commissioning test report issued by NCEPRI (North China Electric Power Research Institute) is 6264.59 kJ/kWh, which meets the design requirement.

9.1.3 Asset Condition

Based on our visual investigation the condition of the plant is generally in accordance with what we would expect for a facility of this type and age. All area of the plant is kept clean and is provided with suitable safety signs and a security system. Most of the indoor and outdoor equipment is in service without significant corrosion and damage and no abnormal sound. From the recorded data available there is no indication of major concerns or significant investments required relating to plant items.

9.1.4 Operation and Maintenance

The plant has 448 employees; 95 employees at management level; 126 operational employees; 188 employees for maintenance; and 39 employees as specialist contractors. This staffing level is significantly higher than the industry standard for similar western power plants. The majority of routine maintenance and inspection work is performed by in-house staff.

The plant uses Chinese specialist software (Management Information System) for O&M management. The system provides event data recording, maintenance planning and equipment ordering for the procurement process including monitoring, tracking and reporting.

MM reviewed the Long Term Spare Parts Management & Service Agreement (LTSPMSA) between plant and MHI. The LTSPMSA regulates the warranty period of every GT component, as well as the requirement of key component supply. plant always signs the independent agreement (MM didn't reviewed) of technical support before every schedule outage, which request MHI sends the professional engineers to plant to guide the maintenance. Jingfeng plant has adequate technical force and staff team to complete all the maintenance work under the guide of professional engineers from MHI. This arrangement seems more cost-effective and comply with plant condition, comparing to the Long Term Service Agreement.

It is a common industry practice (and usually a mandatory condition for lending institutions) for power plant operators to enter into some form of Long Term Service Agreement (LTSA) with the GT supplier. The LTSA can vary from a contract to supply parts at certain prices, through to a full support service where the GT manufacturer will supply standard and emergency parts, coupled to supervising and executing the overhauls. The merits are predictable costs and performance guarantees during the maintenance cycle. The downsides are higher costs and less freedom on operation and maintenance. The type of LTSA depends on relative costs and benefits and life management strategy.

The GT has been in service for four years and has accumulated actual operating hours (AOH) of about 26,392 hours, and equivalent operating hours (EOH) of about 32,441 hours. A combustion inspection (CI) and hot gas path inspection (HGPI) has been carried out. Routine exchange of life limited parts was carried out and no major problems were reported. The first GT major inspection is required to take place at 48,000 EOH and will be carried out during the next two years.

The HRSG is required to be inspected every year. Safety valves must also be tested annually.

It is indicated in the operation reports and other relevant documents that condition-based monitoring techniques are being implemented in the plant. This change in maintenance strategy is in line with modern power industry practice. Although this will increase short-term capital investment in monitoring equipment, analysis tools and staff training, the investment should pay off in the long term by lower maintenance costs and improved plant reliability due to the capability of the O&M team to identify impending equipment failures.

9.1.5 Spares

During our visit inspection it was apparent that there is a significant quantity of spares held on site. The Long-Term Service Agreement with GT supplier MHI has been reviewed, which is a good guarantee for the spare parts supply. We reviewed the spare parts list of GT, which is shorter than the western similar plants in western.

9.1.6 Environment, Health and Safety

The plant has been designed to meet the environmental limits on air emissions, effluent discharge and noise as set out in the Chinese Government Regulation. In particular, the actual NO_x emission level report has been within the range 17 ~ 35 ppm, below the regulation limit of 42 ppm. No major issue or environmental citation was noted during our review of operation records and relevant documents provided in the data room.

Heath and Safety record is 870 days with no lost-time injury.

9.1.7 Conclusions

We comment on the key conclusions relating to the Jingfeng CCHP as below:

- We consider the main generating plant items are of proven technology;
- Our review of the technical documents suggests that the overall condition of the plant is generally in accordance with our expectations for a facility of this age and type;
- Availability of the plant is somewhat below average industry standards, however, the definition and regulation of availability in China is different with western;
- The designed output and heat rate figures are in line with our expectations, actual performance values have been proved by in the commissioning test report;
- The plant Capacity Factor is at high level among the similar gas-fired power plants in China. Though, it's slightly lower than western similar western gas-fired power plants, that's because its annual power generation amount is decided by the production plan issued by government authority at beginning of every year. This is mainly due to task of Jingfeng CCGT plant, whose major task is the heat supply to local community, so the majority power generation is completed in heat-supply period;
- Redundancy design in major plant equipment is considered adequate with the exception of the main cooling water pumps;
- The operation records have not indicated any gas supply interruption during the past 4 years;

- MM reviewed the Long Term Spare Parts Management & Service Agreement (LTSPMSA) between plant and MHI. Plant always signs the independent agreement (MM didn't reviewed) of technical support before every schedule outage, which request MHI sends the professional engineers to plant to guide the maintenance. Jingfeng plant has adequate technical force and staff team to complete all the maintenance work under the guide of professional engineers from MHI. This arrangement seems more cost-effective and comply with plant condition, comparing to the Long Term Service Agreement.; and

- The Long Term Spare Parts Management & Service Agreement with GT supplier MHI has been reviewed, which is a good guarantee for the spare parts supply. We reviewed the spare parts list of GT, which is quite proper and adequate compare to the similar plants in western.

9.2 Taiyanggong CCHP Power Plant

Taiyanggong Power Plant is a multi-shaft gas-fired CCHP power station comprising two GE GT PG9351FA and two HRSGs in combined cycle with one ST. The plant is situated in Beijing and has a nominal total gross power generating capacity of 784.7 MW at ISO conditions.

The plant is owned by Beijing Taiyanggong Natural Gas- fired Power Company, its 74% equity interest being held by Beijing Energy Investment Company with the remaining 26% being held by GD Power Development.

The fuel for the plant is natural gas and the natural gas supplier is Beijing Gas Company, which is owned by the Beijing local government. Gas, delivered to site via a transmission pipeline, is received at the regulating and metering station (RMS) located in the plant area. Both the pipeline and the RMS are owned and operated by the Beijing Taiyanggong Natural Gas-fired Power Company. The gas is supplied at a pressure range of 22 bar_g. A compressor station installed in the plant boosts the gas pressure to that required by the GT.

The electricity offtaker is the Beijing Electricity Company (BEC) which is owned by the Beijing local government. BEC provides the 220 kV double circuit overhead transmission lines which are connected to the 220kV switchyard located at the plant. There is no record of output restriction due to transmission constraints.

9.2.1 Plant Construction and Configuration

9.2.1.1 Plant Construction

The plant was completed in 2007 under a turnkey EPC contract by General Electric (GE). GE is a main reputable engineering contractor and process plant equipment supplier having substantial experience in undertaking power plant and industrial process plant turnkey projects.

9.2.1.2 Plant Configuration

The CCGT unit is of a multi-shaft design. The combined cycle configuration consists of two GT, two HRSG and one ST in a multi- shaft. Balance of plant facilities include the usual systems such as main and closed loop cooling water, water treatment, compressed air, fire protection, transformers and 220 kV switchyard, and the distributed control system (DCS).

The following sub-sections give an overview of the main plant equipment and systems:

Gas turbine generator (GT)

The GT units are two GE PG9351FA model with dry low NO_x combustion design. This GT has a single fuel combustor burning only natural gas. The GTs are capable of both base load and two-shift operations and each GT has a rated capacity of 254.5 MW at ISO condition.

The hydrogen cooled generator is directly coupled to the GT shaft.

Heat recovery steam generator (HRSG)

The HRSG is supplied by Hangzhou Boiler Group and is of 3-pressure, reheat, natural circulation type, designed to be suitable for operation in association with the GT under base load and two-shift operation regimes. Exhaust gas from the GT is ducted to the HRSG where it is used to generate steam for the steam cycle. LP superheating generates steam for the LP steam turbine and also District Heating.

Two 100% duty HP boiler feed pumps supply feed water to the HP drum of the HRSG.

Two 100% duty IP boiler feed pumps supply feed water to the IP drum of the HRSG.

Steam turbine generator (ST)

The ST unit is supplied by Harbin and is capable of operating at full load and sliding pressure modes. The ST is of two-casing design having a combined HP and IP turbine casing and a double flow LP turbine section and a condenser with a circulating cooling water supply. There is one steam extraction from the IP Steam Turbine. A totally enclosed water-to-hydrogen cooled generator is coupled to the ST. Rated output of the unit is 275.6 MW. The ST has a 100% steam dump bypass system to the condenser. This is provided for start-up, shut-down and for dumping the steam into the condenser in an emergency. Three 50% duty condensate extraction pumps are provided to deliver the main condensate from the condenser hotwell to the LP drum of the HRSG.

Fuel gas compression system

A compressor station is provided to continuously supply compressed fuel gas pressure at 32 bar_g as required by the GT, (one compressor per GT). Major equipment of the system comprises 2 x 100% duty fuel gas compressors, fuel gas filters and liquid knock-out vessels.

Main cooling water system

The main CW system is a closed circuit cooling system. The 3 x 50% of 2 duty and 1 standby for main CW pumps draw in cooling water from the basin to the main condenser to condense turbine exhaust steam. This is typical of that found on similar CCGT power plants and we have no major concerns relating to this equipment.

Closed cooling water system

The closed CW system supplies cooling water to various equipment (cooling points) located throughout the plant via a closed-loop piping system and transfers the heat load to the auxiliary cooling water via the heat exchangers. The source of cooling water is the reclaimed water from municipal waste-water treatment utility, which could meet the supply quantity requirement. Also, the reclaimed water could be used after water quality pre-treatment. This is an impressive solution for raw water supply, which reuses the water and thus conserves water resources in Beijing.

Water treatment system

The water source are all come from reclaim water from Beijing municipal system. The water treatment plant production capacity is 27 m^3/hr and the plant configuration comprises of Ultra Filter, Reverse Osmosis, Ion Exchanger and also has 2x500m^3 Storage Tanks.

Transformers and 220 kV station switchyard

Generator transformers of the GT and ST are connected by overhead lines to the corresponding feeder circuits of the 220 kV switchyard. The auxiliary transformer provides power for normal start-up of station loads and services.

Distributed Control System

The FOXBORO distributed control system (DCS) provides for the start-up, normal emergency shutdown, automatic and manual operation, sequential interlocking, data acquisition, control, supervising and monitoring of the plant. The DCS is typical of that found on similar CCGT power plants and we have no major concerns relating to this equipment.

9.2.1.3 Summary

The configuration of the balance of plant systems are in line with our expectations for CCGT plant of this type with the exception of the lack of redundancy in the CW pumps which could result in a loss of capacity as discussed above.

9.2.2 Operational History

9.2.2.1 Capacity and Availability

The plant was constructed in 2007 and began commercial operation on May 20, 2008 and is intended to operate in the variable load regime. Based on the information provided, capacity and availability factors for the past three years are tabulated in Table 9.4:

Table 9.4: Capacity and Availability Factor of Taiyanggong Power Plant

Year	2008	2009	(to June 6,) 2010
Capacity Factor (%)	25	32	52
Availability Factor (%)	88	87	95
Net Generation (GWh)	1,187	2,160	1,770

Outages

The historical outage data for the plant indicates:

- For the first six months of 2010, unscheduled outages totaled 124 hours while scheduled outages were 1,111 hours. The longest unscheduled outage of 70 hours was due to damage to GT #1 carbon brush;
- In 2009, scheduled outages of about 1,111 hours occurred while unscheduled outages totaled 43 hours. The longest unscheduled outage of 24 hours was due to a fault of on the generator protection; and
- In 2008, the scheduled outages were 738 hours and unscheduled outage 14 hours.

The reported plant availability figures are generally below the value of 93%—94% that we would expect as a long term average from our experience of similar power plant worldwide. (Although lower figures during the first two years are not unusual due to 'teething' problems.) However, it's noted that the definition of availability of whole plant in China is different with western market, and also the regulations of availability of PPA and grid despatch apply different principle.

The plant Capacity Factor is at high level among the similar gas-fired power plants in China. Though, it's slightly lower than western similar western gas-fired power plants, that's because its annual power generation amount is decided by the production plan issued by government authority at beginning of every year. In accordance with verbal information provided during our visit, under the PPA, plant income is based on exported energy volume only with no plant availability or capacity payment. The plant is therefore not compensated if BEC despatches to decrease the purchased energy volume in a period. On the other hand there is no penalty payment in case the plant is unable to supply power to BEC. This is mainly due to task of Taiyanggong CCGT plant, whose major task is the heat supply to local community, so the majority power generation is completed in heat-supply period.

9.2.2.2 Output

The design value of gross capacity output of the whole unit is 706.12 MW at 100% basic load at design conditions (-4.2°C; 1.024 bar_a; 43% RH; cooling water 16°C). The test value of the commissioning test report issued by TPRI (Xi'an Thermal Power Research Institute Co., Ltd) is 722.063 MW, 2.26% higher than the design value.

9.2.2.3 Heat Rate

The design value of gross heat rate of the whole unit is 5074.4 kJ/kWh at 100% basic load at design conditions (-4.2°C; 1.024 bar_a; 43% RH; cooling water 16°C). The test value of the commissioning test report issued by TPRI (Xi'an Thermal Power Research Institute Co., Ltd) is 4954.4 kJ/kWh, 1.84% lower than the design value.

9.2.3 Asset Condition

With only two years of operation, we would expect the plant to be in good condition and from our site inspection and the data available there is no indication of major concerns or significant investments required relating to plant items. The facilities and environment of Taiyanggong plant is really nice and clean. Taiyanggong is a demo CCGT Plant and a exhibition center of clean energy in China, which represent the highest level of similar plants.

9.2.4 Operation and Maintenance

The plant has 141 employees; 2 employees at management level (Managing Director and General Manager); 79 employees in operation, maintenance and technician; 7 employees in financial team; and 53 employees in administration and human resource team. This staffing level especially administration staffs is significantly higher than the industry standard for similar western power plants that is generally required around 76 employees: 5 employees at management level; 24 operational employees; 40 employees for maintenance; 7 administrative employees. The figure is 4 shift of operation team and the majority of routine maintenance and inspection work is performed by in-house staff. For minor and major maintenance program, the sub-contractor will be employed.

The plant uses Chinese specialist software (Management Information System) for O&M management. The system provides event data recording, maintenance planning and equipment ordering for the procurement process including monitoring, tracking and reporting.

Taiyanggong has signed a long-term Maintenance agreement with GE, for ten years under which GE will be in charge of the maintenance of GT.

From the data provided the current actual operating hours of GT1 is 9,841 while the equivalent figure for GT2 is 9,122 hours. It is indicated in the operation reports and other relevant documents that condition-based monitoring techniques are being implemented in the plant. This change in maintenance strategy is in line with modern power industry practice. Although this will increase short-term capital investment in monitoring equipment, analysis tools and staff training, the investment should pay off in the long term by lower maintenance costs and improved plant reliability due to the capability of the O&M team to identify impending equipment failures.

9.2.5 Spares

During our visit inspection it was apparent that there is a significant quantity of spares held on site, which are stored in good condition. We reviewed full inventory list of spare parts, instruments and tools, which are considered to include complete items, adequate quantity and proper models for all major systems. In particular, the situation regarding major spare parts for the GT including those required for HGPI and major inspections can meet the requirement of regular inspections and scheduled inspections.

9.2.6 Environment, Health and Safety

The plant has been designed to meet very low environmental limits on air emissions, effluent discharge and noise as set out in the Government Regulation. In particular, the actual NO_x emission level reported is less than 20 mg/M^3, well within the limit of 100 mg/M^3. No major issue or environmental incidents were noted during our review of operational records and relevant documents provided in the data room.

9.2.7 Conclusions

We comment on the key conclusions relating to the Taiyanggong CCHP as below:

- We consider the main generating plant items are of proven technology;

- Our review of the technical documents suggests that the overall condition of the plant is generally in accordance with our expectations for a facility of this age and type;

- Availability of the plant is somewhat below average industry standards, however, the definition and regulation of availability in China is different with western;

- The designed output and heat rate figures are in line with our expectations, which are proved by actual performance values in the commissioning test report;

- The plant Capacity Factor is at high level among the similar gas-fired power plants in China. Though, it's slightly lower than western similar western gas-fired power plants, that's because its annual power generation amount is decided by the production plan issued by government authority at beginning of every year. This is mainly due to task of Taiyanggong CCGT plant, whose major task is the heat supply to local community, so the majority power generation is completed in heat-supply period;

- Redundancy design in major plant equipment is considered adequate.

- The operation records have not indicated any gas supply interruption during the past 2 years;

- The LTSA with GE is beneficial as specialist support is available to the project. The adoption of condition-based maintenance follows modern industry practices; and

- Spare parts are stored in good condition on site. The full inventory list of spare parts is considered to include complete items, adequate quantity and proper models for all major systems. In particular, the situation regarding major spare parts for the GT including those required for HGPI and major inspections can meet the requirement of regular inspections and scheduled inspections.

Appendices

Appendix A. List of Key Documents Reviewed

Ref	Document Title
1	Beijing Energy's feedback to MM's Questionnaires for eight respective wind farms
2	Feasibility study report for each wind farm
3	Grid connection report for each wind farm
4	Wind Turbine Supply Agreement for each wind farm
5	WTG tech Specification for several wind farms
6	Power Curve from SCADA system for each wind farm
7	Reliability Evaluation Code for Wind Power Generating Equipment (Trial)
8	Single Line Diagram for each wind farm
9	Wind resource data from nacelle for each wind farm
10	WTG Layout for each wind farm
11	Operational monthly data (availability, generation, curtailment) for each wind farm
12	Spare parts list for each wind farm
13	Technical specification (main transformer, WTG transformer, inter-array cables, export cables) for several wind farms
14	Grid connection agreement for each wind farm
15	Grid Code for connecting the Wind Farm
16	Grid curtailment instructions issued by Inner Mongolia Power Company
17	SGCC and Inner Mongolia Power Company's websites
18	Safety requirement and assessment of Wind Farm Grid Connection
19	QA list from Beijing Energy
20	MM internal information
21	Information from public website
22	Foundation Concrete Mixture Proportion Test Report for Saihan phase I and Wulanyiligeng wind farms
23	Foundation Concrete Compression Test Report for Saihan phase I and Wulanyiligeng wind farms
24	State Electricity Regulatory Commission's website
25	Monthly operation reports of gas-fired plants
26	Price purchase agreements of gas-fired plants
27	Gas purchase contracts of gas-fired plants
28	Water purchase contracts of gas-fired plants
29	Heat sales contracts of gas-fired plants
30	Consents of EIA
31	PID drawings of gas-fired plants
32	NG analysis reports of gas-fired plants
33	Emission standards of noise, waste water and waste gas pollution
34	Feasibility study report of gas-fired plants
35	Maintenance and unscheduled outage records of Jingfeng CCHP Plant

Ref	Document Title
36	Annual overhaul records of Jingfeng CCHP Plants
37	Commissioning test report of Jingfeng CCHP Plant
38	Summary of main maintenance work in the future
39	Layout drawings of gas-fired plants
40	Technical data sheet of main equipments and systems of gas-fired plants

Glossary

AGL	Above Ground Level
AOH	Actual Operating Hours
ASL	Above Sea Level
BCSE	Business Council for Sustainable Energy
BEC	Beijing Electricity Company
BOP	Balance Of Plant
CCGT	Combined Cycle Gas Turbine
CCHP	Combined Cooling Heating and Power
CHP	Combined Heat and Power
CI	Combustion Inspection
CREIA	Chinese Renewable Energy Industries Association
CSG	China Southern Power Grid Co., Ltd.
Cut-in Wind Speed	Wind speed at which a wind turbine begins to generate electricity.
Cut-out Wind Speed	Wind speed at which a wind turbine ceases to generate electricity.
CW	Cooling Water
CWEA	China Wind Energy Association
DCS	Distributed Control System
DFIG	Double-Fed Induction Generator
EIA	Environmental Impact Assessment
EOH	Equivalent Operating Hours
EPC	Engineer, Procure and Construct
GB/T	Guobiao/Tujian, Chinese National Standard, Recommended
GE	General Electric Company, Energy
Gearbox Ratio	Ratio of the speed of rotation of the powered gear to that of the final gear
GL	Germanischer Lloyd
GT	Gas Turbine
GWEC	Global Wind Energy Council
HGPI	Hot Gas Path Inspection
HP	High Pressure

HRSG	Heat Recovery Steam Generator
Hub Height	Distance from the ground to the center-line of the turbine rotor
IEC	International Electrotechnical Commission
IMPC	Inner Mongolia Power Company
IP	Intermediate Pressure
IPO	Initial Public Offering
ISO	International Organization for Standards
LP	Low Pressure
LTSA	Long Term Service Agreement
LVRT	Low Voltage Ride Through
MCP	Measure Correlate Predict
MHI	Mitsubishi Heavy Industries Limited
MM	Mott MacDonald Limited
NCEPRI	North China Electric Power Research Institute
NG	Natural Gas
NO_x	Nitrogen Oxides
OEM	Original Equipment Manufacturer
O&M	Operation and Maintenance
PPA	Power Purchase Agreement
PRC	People's Republic of China
QHSE	Quality, Health & Safety and Environment
Rated Power	Maximum power that a WTG can produce at constant wind speed
RH	Relative Humidity
RMS	Gas Regulating and Metering Station
SCADA	System Control and Data Acquisition
SGCC	State Grid Corporation of China
ST	Steam Turbine
UK	United Kingdom
UPS	Uninterruptible Power Supply
WAsP	Wind Atlas Analysis and Application Program
WTG	Wind Turbine Generator

bar	Bar (a unit of pressure equal to 100 kPa)
GW	Giga Watt (electric)
GWh	Giga Watt hour (electric generation)
Hz	Hertz (frequency)
kA	kilo Ampere (power)
km	kilometre (length)
kV	kilo voltage (electric)
m	meter (length)
m^2	square meter (area)
m/s	meter per second (velocity)
MPa	Mega Pascal (pressure)
MW	Mega Watt (electric)
MWh	Mega Watt hour (electric generation)
MVA	Mega Volt Ampere (apparent power)
MVar	Mega Volt-ampere reactance (reactive power)
ppm	Parts per million (concentration)