China Longyuan Power Group Corporation Limited

Technical Assessment

Final Report

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China Longyuan Electric Power Group Corporation

Technical Assessment

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Glossary

ASL	Above Sea Level
CAMS	Chinese Academy of Meteorological Science
CDM	Clean Development Mechanism
CERs	Certified Emission Reductions
CFXS	Chifeng Xinsheng Wind Power Generation Co., Ltd
CHP	Combined Heat and Power
COD	Commercial Operation Date
DCS	Distributed Control Systems
FD	Forced Draft
FGD	Flue-gas Desulphurisation
FRP	Fiberglass Reinforced Plastic
GB/T	Guobiao/Tuijian, Chinese National Standard, Recommended
GE	the General Electric Company, Energy
GGH	Gas-Gas Heater
GIS	Gas Insulated Switchgear
GL	Germanischer Lloyd
GSJY	Gansu Jieyuan Wind Power Generation Co., Ltd.
ID	Induced Draft
IEC	International Electrotechnical Commission
IPE	Implementation in Production and Erection
JLLY	Jilin Longyuan Wind Power Generation Co., Ltd
JSLY	Jiangsu Longyuan Wind Power Generation Co., Ltd
LYZ	Longyuan Zhangjiakou Wind Power Generation Co., Ltd.
LYB	Longyuan Baotou Wind Power Generation Co., Ltd.
LYP	Longyuan Pingtan Wind Power Generation Co., Ltd.
MCP	Measure Correlate Predict
MM	Mott MacDonald Group Limited
NCAR	National Centre for Atmospheric Research
NOx	Nitrogen Oxide
O&M	Operation and Maintenance
PDRC	Provincial Development and Reform Commission
PI	Point Inspection

SCADA	System Control and Data Acquisition
SCR	Selective Catalytic Reduction
SLY	Shenyang Longyuan Wind Power Generation Co. Ltd
SO_2	Sulfur Dioxide
TC	Technical Consultant
XJTF	Xingjiang Tianfeng Power Generation Joint Stock Company
WAsP	Wind Atlas Analysis and Application Program
WTG	Wind Turbine Generator
Units	
g	gram (mass)
GJ	Gigajoule (energy)
GWh	Giga Watt hour (electric generation)
kA	kilo Ampere (power)
kg/m^3	kilogram per cubic metre (density)
kJ	kilojoule (energy)
kV	kilo voltage (electric)
kVA	kilo Volt Ampere (apparent power)
m	metre (length)
m^2	square metre (area)
m/s	metre per second (velocity)
mg/Nm^3	milligrams per normal cubic meter (particular emission density)
MJ	Megajoule (energy)
MPa	Mega Pascal (pressure)
MW	Mega Watt (electric)
MVA	Mega Volt Ampere (apparent power)
MVar	Mega Volt-ampere reactance (reactive power)
V	Voltage (electric)
W/m^2	Watt per square metre (power density)
%	percent
°C	Degree Centigrade (temperature)

Executive Summary

Introduction

Mott MacDonald Limited (MM) has been appointed by China Longyuan Power Group Corporation Limited (Longyuan) to act as Technical Consultant on Longyuan.

Mott MacDonald has carried out an independent technical appraisal of Longyuan's assets. The review of wind farms includes wind resource assessment, power generation, availability, and operational and maintenance arrangements, wind turbine technologies, and grid connection arrangements as well as compliance with grid codes. The review of a coal power plant focuses on generation and load factor, efficiency, availability, operating regime, investment requirement, and equipment and environmental limitations. The assessment is only for the representative power plants.

The main base of information from which the report was compiled comprises documents provided by Longyuan, and discussions and meetings with relevant staff of the Company and main wind turbine manufacturers. MM's professional judgement 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 utilised throughout the assessment process.

A large number of power plants are involved in the asset portfolio spread across a wide area in China. These plants were designed by various local design institutes based on the same Chinese standard and the turbines were supplied by a small number of domestic and international manufacturers. For these reasons it was agreed that the report would be compiled with specific reference to representative power plants. These plants were selected to best encapsulate and represent the diversity of all power plants controlled by Longyuan. 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 the wind abundant areas of Southeast China coast, Northeast China, Inner Mongolia, Gansu and Xinjiang.
- **Turbine types** — Representative wind farms selected include turbines produced by both domestic and foreign manufacturers.
- **Installed capacity and company share** — Representative wind farms selected are those in which Longyuan is the majority share-holder. The consolidated installed generation of the projects selected represents approximately 50% of the consolidated installed capacity of Longyuan at the end of December 2008.

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

Wind resource assessments for each of the representative power plants were reviewed and the Chinese standards of methodology, reporting, and data collection were compared to equivalent international standards. It was concluded that there was a consistent approach to the assessments largely adhering to standard international practice; however the Chinese standards lacked some on the detail found in their international counterparts. In particular Chinese assessments omitted uncertainty analysis; however conservative estimation of project efficiency were deemed to compensate for this omission.

Turbine Technologies

Longyuan uses many different models of wind turbine, supplied by both well-established international and domestic manufacturers. The wind turbine selection process is crucial for maximisation of electricity generation; hence an assessment of each of the key wind turbine manufacturers with installations on the representative sites was completed. The assessments detailed the market share, utilisation of specific technologies, and historic track records of each manufacturer, in addition to focusing on the anti-corrosion features of the turbines and their suitability to harsh environmental conditions. All manufacturers assessed were found to present adequate operational experience and operate in compliance with international industrial standards, a summary of each of the manufacturers is provided below:

- **GE Energy (GE)** — GE is one of the world's largest wind turbine suppliers and is well established in the Chinese market. The wind turbines installed on the representative site employ a technology that provides exceptional durability. Since initial production, GE has provided significant investment into improving the reliability and performance of the wind turbine. The product has an impressive track record and there are no concerns over quality.
- **Vestas** — Vestas is the world's leading supplier of wind turbines and leading foreign supplier in China. The Vestas V80 turbines used in Pingtan are based on proven technology. There are more than 5000 2MW Vestas turbines installed worldwide. Hence we consider Vestas to be a high quality and low risk supplier.
- **Gamesa** — Gamesa was ranked the world's third largest wind turbine supplier in terms of sales in 2008 and total installation at the end of 2008 and has a good share of the Chinese market. The specific turbine used on the representative sites is based on an early technology; however it has undergone constant redevelopment. The turbine is considered to be both a mature and proven technology.
- **Acciona WindPower** — Acciona uses in-house technology to assemble wind turbines. The specific turbine used on the representative sites employs a system allowing for prompt maintenance and reduced downtime. No specific issues have been reported during operation of the turbine, it is regarded to be a reliable product and the Acciona technology is regarded to be in line with industrial standards.
- **Goldwind** — Goldwind is the oldest, largest, and most experienced manufacturer in China. The wind turbines installed on the representative sites employ a direct drive system providing higher reliability and lower maintenance times, compared with doubly fed induction generators.
- **Sinovel** — Sinovel is one of the world's top ten suppliers of wind turbines and has specific experience in manufacturing built-to-resist wind turbines. Sinovel is regarded as having a good track record in China, and the design and manufacturing process is considered to be in keeping with general industry trends.

Energy Yield, Wind Farm Operation and Maintenance

Individual wind farms were assessed on their generation and availability, and their internal connection and substations. Each assessment contains information regarding the condition of both the geographical terrain and the equipment, also identified are site specific data discrepancies, and any general concerns that the reviewing teams raised. One important point raised following the completion of all assessments was that the meteorological mast heights in several feasibility studies were reported to be shorter than the wind turbine hub heights, indicating a degree of non-compliance with the Chinese standards. All sites were regarded as having adequate operation and maintenance arrangements in place. It should be noted that the majority of the wind farms assessed were found to have higher staffing levels than the international norm. A summary of the findings for each site visited by Mott MacDonald is included below:

Phase II of Jiangsu Rudong Wind Concession Projects, 150MW

Situated in a rural landscape on the coast. Facilities and buildings on the three sites are well maintained and of a high standard. Availability is above the guaranteed value as per the data presented by Jiangsu Longyuan Wind Power Generation Co., Ltd, however there is a concern that the actual availability figures of the wind farms could be slightly lower due to outages of other components. Incidents and outages experienced during the operation of the wind farm are considered to be in line with expectation. All electrical equipment is of a high quality and is housed in appropriate buildings with no signs of environmental corrosion. All switchgear and transformers are appropriately rated and maintained.

Fujian Pingtan World Bank Wind Power Project, 100MW

Availability is above the guaranteed value. Few major repairs to the yaw system were highlighted and generic issues experienced during the early stage of operation of the turbines is regarded to be a part of the routine lifecycle and in line with current industry norms. Staff are regarded as being trained and familiar with monitoring activities. The switchgear and transformers are regarded to be appropriately rated for the site and are kept in excellent condition.

Jilin Tongyu Wind Concession Projects, 200.6MW

Situated on flat scrub/desert with no adverse wind conditions, however sand storms are common and the climate is very cold which could result in blade contamination and icing. Buildings and facilities are of a high standard and appear well maintained. Technical issues have been identified on site, however these do not present concerns regarding the long term integrity of the fleet. Low availability was experienced during the early part of 2008 due to slip-ring replacement. Availability was up after the problem being fixed. The switchgear and transformers are regarded to be appropriately rated for the site.

Liaoning Faku Baijiagou Wind Power Project, 49.5MW

Situated on farmland with no concerns regarding adverse weather conditions, crop cycles will influence the wind conditions on the site but is not thought to affect wind farm operation. The buildings and facilities are of a high standard and appear well maintained. Shenyang Longyuan are regarded as having a good understanding and experience of wind farm operation, and targets seem realistic when compared to general industry expectations. The wind farm has only recently been commissioned and therefore insufficient data was available to give valuable comment on wind farm performance. The switchgear and transformers are regarded to be appropriately rated for the site.

Xinjiang Dabancheng No. 3 Wind Power Projects, (Phase II, III and IV) 129 MW

Situated in a half-desert environment with no agricultural activity. Availability is above the guaranteed value with the turbines producing more power than was expected. None of the wind farms have an on-site substation and at present the capacity of the transformers in the local substations is sufficient to deliver the available power to the grid, an additional transformer is planned for further expansion.

Gansu Yumen Wind Power Projects, (Yumen II and III, and Diwopu I) 107.1MW

Situated on flat terrain with low levels of extreme wind speed. Dust storms common on the site could cause turbine outages. In addition, extreme low temperature may cause further turbine outages. Power generation in the early part of 2008 was lower than expected; this was attributed to poor weather. Phase II & III feature a 10 kV secondary side which typically results in higher than average transmission line losses. The switchgear and transformers are regarded to be appropriately rated for the site.

Hebei Shangyi Shiren Wind Power Project, 49.5MW

Situated on high ground with a particularly low average temperature which can be expected to affect blade operation. The site appears well equipped and maintained. Availability is in line with the guaranteed value. Following the completion of the expansion project, installed equipment will be appropriately rated.

Inner Mongolia Bayin National Wind Concession Project, 201MW

Still under commission at time of site visit, however, with regard to the turbines already commissioned availability figures were high and the equipment was in good condition. It was noted that no Accident Record book was kept on site; it was recommended that this should be rectified in the future. The electrical layout of the substation is thought to provide an advantageous degree of flexibility and all switchgear and transformers are appropriately rated for the site.

Inner Mongolia Chifeng Wind Power Projects (Sunjiaying I and II, Wudaogou I), 150MW

Due to poor weather and icy road conditions at the time, a site visit was not carried out. Availability figures are high, all exceeding the guaranteed value. The rating of transformers indicates that future expansion is likely.

Grid Connection

A grid connection assessment was completed for each wind farm based on network topologies supplied to Mott MacDonald by Longyuan and its subsidiaries. It should be noted that Mott MacDonald did not undertake any independent simulation or calculation to validate the results of the studies conducted by Chinese Design Institutes. Each wind farm was assessed to grid connection point and voltage level, main transformer capacity, conductor size, power system studies and reactive power compliance were reviewed.

All step-up transformers and overhead lines associated with each of the wind farms, with the exception of Huangang transformer, are appropriately sized and have sufficient capacity to export maximum power under normal operation scenarios. The Huangang exception has been resolved through an expansion.

All grid connection substations have sufficient transformer capacity to accommodate power generated from the wind farms under normal system operation with two exceptions being that the transmission lines at both Pingtan and Dabancheng could be overloaded. In both cases this is anticipated to be resolved by future network enhancement.

All wind farms were able to maintain the power factors required by the current Chinese grid code at the grid connection points. This was achieved through a combination of reactive power compensation equipment installed on site and by installation of wind turbines with controllable power factors.

It is understood that the voltage profile at Faku Baijiagou wind farm will be improved through the installation of capacitive equipment. All wind farms have appropriate switchgear installed to withstand fault current at both step-up and grid connection substations.

Most local networks have the sufficient capability to accommodate the wind power generated by Longyuan. The exceptions encountered were at Yumen Phase II and Dabancheng wind farms. At these sites, wind farm generation is limited due to network transmission restrictions. This situation will be resolved in the long term by future network reinforcement.

Coal Power Plant

A single thermal plant was assessed alongside the wind farms; a detailed description of the operation of the plant is included. It is concluded that the majority of significant equipment at the station is comparable with that installed in the US, and that the equipment appears to be well maintained. Station personnel had a good understanding of the operation and maintenance procedures and documentation was found to be complete. Solid waste is sold and utilised. It was noted that both SCRs and a cooling system could represent a major future expenditure. The power station appears to have been designed with significant margin and high reliability; this is present in the fuel handling, storage, and preparation systems, in addition to individual margins on each of the major components. These margins allow each unit to operate above half load should it be required upon failure of other equipment. The operational and emissions data indicates that the station is performing satisfactorily.

Conclusions and Recommendations

All wind farms we visited had the equipment supplied by well-known international or domestic manufacturers who employ proven technologies and have track records in the market. Mott MacDonald holds the view that the turbine technologies are in line with current industrial standards, some of the sites were built to a high standard, exceeding our expectations.

We are able to confirm that the availability of the wind farms reviewed was higher than the manufacturers' guarantee of 95% and the actual electricity generation was also in line with the forecast made in feasibility studies. All plants are well operated and maintained.

Most of the wind farms we reviewed had their own dedicated substations with adequate electrical equipment installed to export electricity via overhead circuits to the power grids. The substation equipment is appropriately sized to withstand system faults and reactive compensation is installed in many wind farms to meet technical requirements of the power grid.

The coal power plant was well operated and maintained. The majority of key equipment was comparable to those in the US. The operational and emissions data of all plants is also satisfactory. Solid waste is sold and utilised.

We found during our site visits that most of the wind farms employed more staff than we have seen in the Europe and the US. We believe this is an area which the Company could make further improvements by reducing the number of staff on site, although Longyuan said more staff was also for future expansion.

Longyuan has a very ambitious expansion plan to develop more wind power projects in China. We believe that the Company, with its strong technical capability, has sufficient capacity to develop, operate, maintain and manage wind farms in China and overseas.

1 Introduction

1.1 Independence of Mott MacDonald

This independent technical assessment report has been prepared by qualified staff in Mott Macdonald Limited (MM), the Technical Consultant appointed by China Longyuan Power Group Corporation Limited (Longyuan, the Company) to provide technical assistance in connection with the Company.

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:

- the Company; or
- the asset portfolio that was subject to the technical assessment.

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.

1.2 Mott MacDonald Limited Qualification and Track Records

Mott MacDonald Limited is a world leading multi-disciplinary consultancy engaged in development, touching many aspects of everyday life from energy, transport, water and the environment to building, industry, communications health and education.

We are a wholly independent international company, headquartered in the UK, with turnover in excess of $1.4 billion, over 14,500 staff and global experience spanning 120 countries. Our success in winning the Queen's Award for Export Achievement three times in 1996 and 1998, 2004 reflects the scale of our international business, which accounts for two thirds of our total earnings.

Mott MacDonald operates from offices in centres throughout the UK and in countries across Europe, Asia and the Pacific, the Middle East, Africa and the America. This wide geographical network means we can bring our skills and resources closer to our clients wherever they or their projects are based.

Mott MacDonald is committed to Quality Assurance and is accredited to ISO 9001 and ISO 14001.

Our experience in the energy sector is second to none amongst the world's major engineering consultants. We have played a leading role in the electricity sector restructuring in Hong Kong, Ukraine, Malaysia, Indonesia, Thailand, Philippines, Pakistan, Northern Ireland, Ireland, Singapore, Iran and Qatar where we advised the respective governments on the financial/technical options best suited to the country in question, as well as regulatory, efficiency and contractual issues. We have been involved in regulatory reviews of electricity utilities, which have been corporatised or privatised and have advised various major investors on prospective power plant and distribution company acquisitions. Additionally we are involved with the development of privately funded power projects throughout the world as independent advisers to both owners and lenders.

Mott MacDonald is experienced in all types of power generation and transmission technologies and works in partnership with its clients, ensuring through total commitment that MM adds maximum value to every project. We have engineered over 200 GW of power plants world-wide. Our strength lies in a rich diversity of expertise which covers the complete spectrum of disciplines and skills. We have extensive experience with the technical and power network aspects of wind power (both onshore and offshore). Roles have included providing consultancy services to financiers, potential investors, project developers, owners and contractors as well as governments, local authorities and regulatory bodies. We have undertaken a wide range of roles in project development, appraisal and implementation and are able to bring the full range of resources to our assignments in both the onshore and offshore sectors.

We have undertaken over seventy projects in China totalling over 32 GW including wind, hydro, biomass, waste-to-energy, gas and coal power plants. Selected projects are provided below.

- Baicheng Wind farm, HSBC — Acting as the Lender's technical adviser, we undertook a comprehensive review on renewable market and policies in China, energy yield, turbine technology, civil, grid connection, carbon credits, financial model and environmental issues.
- Portfolio of Wind farms, Dragon Power/Citi Bank — Technical adviser to assess a portfolio of wind farms totalling 357 MW in PRC for potential acquisition.
- Dafengba Wind farm, Hong Kong Electric International — Acted as technical adviser to conduct a due diligence for this 47.6 MW wind farm located in Yunnan Province.
- Rudong Wind farm, Rabobank International — Technical adviser to conduct a due diligence for procurement of certified emission reductions (CERs) under clean development mechanism (CDM) from 100 MW Rudong wind farm.
- Inner Mongolia Wind farms, Honiton Energy — Owner's engineer on geological investigation, transportation, grid connection, turbine, electrical equipment procurement and site supervision for wind farms in Bailingmiao and Xiwu.
- Project Taishan IPO, JP Morgan/Dragon Power — Acted as the technical consultant to undertake a due diligence on the National Bio Engineering biomass power plants. Work includes fuel market review, straw burning technology assessment and benchmarking of construction and operation.
- Suhrak Due Diligence, KEPCO — Asset Appraisal, — Acted as the technical adviser undertaking asset appraisal, electricity market review and contract review. The Suhrak asset portfolio includes eleven operational, three under-construction and nine planned power plants as well as nine coal mines in a Chinese Province

1.3 Core Team Members

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

Dr. Aijuan Wang: Team Leader

Dr Wang holds BSc, MSc and PhD qualifications and is a Chartered Engineer with over twenty years of technical and commercial experience in the energy sector. Aijuan has extensive work experience in China in the areas of project development, commercial contract negotiation, generation and transmission asset expansion and strategy. Aijuan Wang worked in Ministry of Energy of PRC and China Longyuan in the 1990s.

Since joining Mott MacDonald in 1998, Aijuan has undertaken, managed and directed a number of due diligence assignments for banks and investors/developers and is familiar with the business environment and regulations in China. In addition, Aijuan has extensive experience in working with financial institutions and merchant banks to provide technical and commercial advice on transactions of M&A, project finance and IPO.

Other experience includes power sector restructuring and privatisation, implementation of competitive electricity market, project business case justification and market study, corporate development strategies, and technical performance audit for utilities, regulators and governmental organisations. Aijuan is of Chinese origin and speaks Mandarin Chinese.

Senior Consultants:

In conducting this independent technical assessment, Mott Macdonald assembled a team of qualified consultants and engineers who have been involved in providing advisory services for transactions of this type and have experience gained in Chinese projects and elsewhere in the world. These core team members are presented below:

Table 1.1: Core Team Members

Roles and Responsibility	Staff Name
Senior Mechanical Engineer	Valentine Madden
Electrical Engineer	Adam Hart
Wind Energy Yield	David Mudie
Grid Connection Specialist	Roddy Wilson
Wind Turbine Design	Fulvio Mariani
Wind Farm Operation	Cyril Pacot
Wind Power Project Development	Robert Speht
Power System Analysis	Dr Xuecheng Zhang
Network Planning	Jingwei Lu
Power System Operation	Zoran Nesovanovic
Project Coordination	Jinyu Yang

2 Methodologies

2.1 Objectives of Technical Appraisal

Established in January 1993, China Longyuan Power Group Corporation Limited is a dedicated power generation developer engaged in renewable energy. With wind power as its core business, the Company is focused on investment, construction, operation and management of wind farms and other forms of renewable energy such as biomass, tidal, geo-thermal and solar plants. Besides renewable energy projects, the Company also has technical expertise and advantage from the inherited conventional coal power stations.

MM's role is to assess the asset conditions and confirm adequacy of the technologies used, plant performance and comment on capacity of the power transmission and distribution systems.

— Hence, our review has been focussed on the following aspects:

- Wind power plants
- Wind resource assessment
- Generation, availability and maintenance
- Wind turbine technology
- Grid connection and grid code compliance

— Coal power plants

- Generation and load factor
- Heat rate and plant efficiency
- Availability
- Operating regime
- Planned investment requirements
- Issues that could potentially limit equipment life
- Environmental limitations

This report has been compiled based upon:

- Documents provided by Longyuan, discussions and meetings with relevant staff of the Company and manufacturers.
- Site visits to the selected representative power plants
- Relevant data and information from the public domain, together with our knowledge in this field and the Chinese power sector

During the course of producing this report, we have predominantly relied on the information made available to us, including the response to our questionnaire, though we have used our professional judgement in analysing the data. Our analysis and report production were undertaken in our UK and the US offices.

In the following sections of this report, we will address the key issues identified above, present our findings obtained during this technical due diligence exercise, and make our recommendations and conclusions.

2.2 Asset Overview

At the end of December 2008, Longyuan had in total 67 wind power projects operated by its subsidiaries mainly located in six geographical areas across China. The consolidated wind power installation reached 2,502.8 MW. Two coal power plants with a total consolidated installed capacity of 1875 MW in Jiangsu Province are also included in the asset portfolio.

We have summarised the wind capacity in Table 2.1, projects listed include those that the Company solely owns, or holds controllable. Table 2.1 shows Longyuan's wind power projects are mainly distributed in Xinjiang Autonomous Region, Gansu Province, Inner Mongolia Autonomous Region, Hebei Province, three Northeast provinces and Southeast coastal provinces which are regarded as the wind resources abundant regions as per the official survey produced by Chinese Academy of Meteorological Science (CAMS).

Wind turbine technologies adopted in the portfolio are from recognised international suppliers; for example GE, Vestas, Gamesa and Acciona and Chinese turbine manufacturers such as Goldwind and Sinovel. Size of single machine varies from several hundred kW to 2 MW.

Subsequent to the issue of the draft report, we were informed by the Company that the total wind consolidated installed capacity had increased to 2,886.0 MW.

Table 2.1: Summary of Consolidated Wind Power in Longyuan

	At the End of December 2008	
	No. of projects	Consolidated Installed Capacity (MW)
Xinjiang	11	223.8
Gansu	8	208.8
Inner Mongolia	13	760.9
Hebei	1	49.5
Three Northeast Provinces	18	774.5
Southeast Coastal Provinces	16	485.3
Total	67	2,502.8

2.3 Selection of the Representative Power Plants

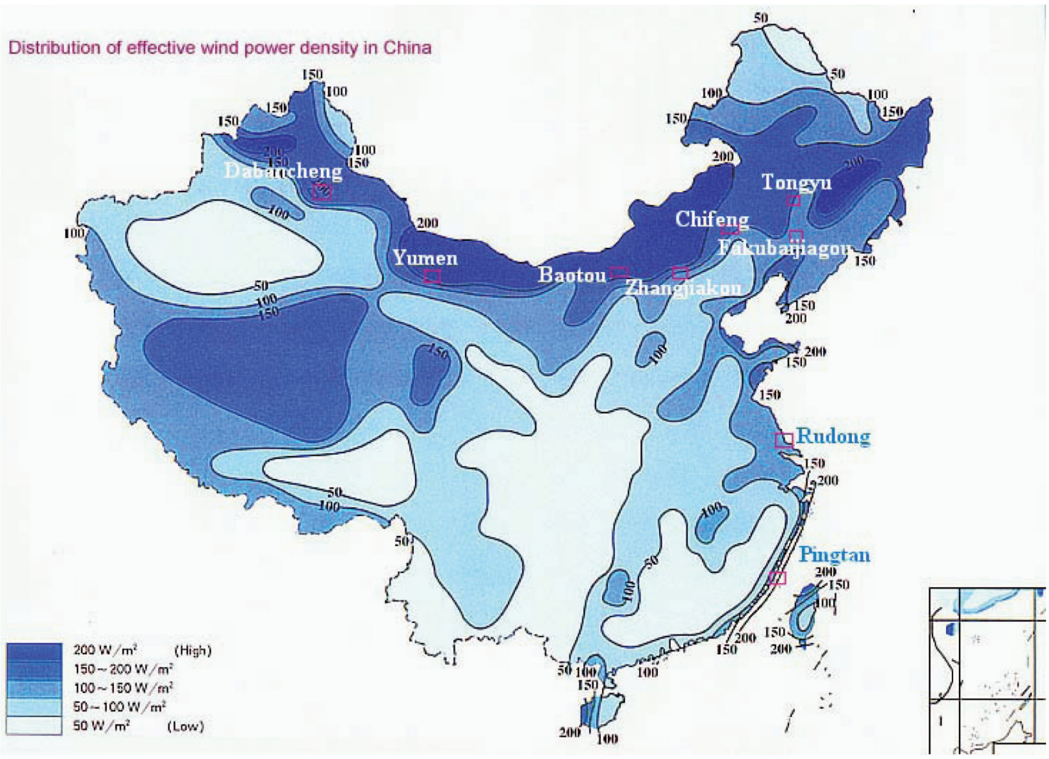
Due to the large number of projects involved in the asset portfolio and relatively short time-scale of the technical due diligence, it was not possible to visit and review all power plants owned by Longyuan. Hence, the MM team agreed with the Company to select representative power plants.

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

- wind resources and geographic coverage

China has enormous wind resources, with exploitable onshore wind resources being estimated at approximate 253 GW by CAMS. According to a survey undertaken by CAMS as shown in Figure 2.1 , the wind resources are distributed 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 Jiangsu to Fujian Provinces. The colour tone in Figure 2.1 represents wind density.

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



Source: Chinese Academy of Meteorological Sciences

As indicated in the pink square in Figure 2.1, we have selected representative projects located in the wind abundant areas of Rudong, Pingtan, Tongyu, Faku, Zhangjiakou, Chifeng, Baotou, Yumen and Dabancheng. Table 2.2 gives more detailed information on the representative wind farms.

Table 2.2: Representative Wind Farms

Ref	Area	Project Company	Project Name	Consolidated Installed Capacity (MW)	Manufacturer of WTG	Rated Power (MW)	WTG No.
1	Southeast Coastline Provinces	Jiangsu Longyuan Wind Power Generation Co., Ltd.	Phase II of Jiangsu Rudong Wind Concession Project - Huangang	58.5	GE	1.5	39
2	Southeast Coastline Provinces	Jiangsu Longyuan Wind Power Generation Co., Ltd.	Phase II of Jiangsu Rudong Wind Concession Project - Dongling	42	GE	1.5	28
3	Southeast Coastline Provinces	Jiangsu Longyuan Wind Power Generation Co., Ltd.	The Expansion Project of Phase II of Jiangsu Rudong Wind Concession Project - Lingyang	49.5	GE	1.5	33
4	Three Northeast Provinces	Longyuan (Pingtan) Wind Power Generation Co., Ltd.	Fujian Pingtan World Bank Project	100	Vestas	2	50
5	Three Northeast Provinces	Jilin Longyuan Wind Power Generation Co., Ltd.	Phase I Jilin Tongyu Wind Concession Project	100.3	Gamesa	0.85	118
6	Three Northeast Provinces	Jilin Longyuan Wind Power Generation Co., Ltd.	Phase II Jilin Tongyu Wind Farm Concession Project	100.3	Gamesa	0.85	118
7	Three Northeast Provinces	Shenyang Longyuan Wind Power Generation Co., Ltd.	Liaoning Faku Baijiagou Wind Power Project	49.5	Sinovel	1.5	33
8	Xinjiang	Xinjiang Tianfeng Power Generation Joint Stock Company	Phase II of Dabancheng No. 3 Wind Power Project	30	Goldwind	0.75 1.5	30 5
9	Xinjiang	Xinjiang Tianfeng Power Generation Joint Stock Company	Phase III of Dabancheng No. 3 Wind Power Project	49.5	Goldwind	1.5	33
10	Xinjiang	Xinjiang Tianfeng Power Generation Joint Stock Company	Phase IV of Dabancheng No. 3 Wind Power Project	49.5	Goldwind	1.5	33

Ref	Area	Project Company	Project Name	Consolidated Installed Capacity (MW)	Manufacturer of WTG	Rated Power (MW)	WTG No.
11	Gansu	Gansu Jieyuan Wind Power Generation Co., Ltd.	Phase II of Gansu Yumen Wind Power Project	11.9	Gamesa	0.85	14
12	Gansu	Gansu Jieyuan Wind Power Generation Co., Ltd.	Phase III of Gansu Yumen Wind Power Project	45.9	Gamesa	0.85	54
13	Gansu	Gansu Jieyuan Wind Power Generation Co., Ltd.	Phase I of Gansu Diwopu Provincial Concession Project	49.3	Gamesa	0.85	58
14	Hebei	Longyuan (Zhangjiakou) Wind Power Generation Co., Ltd.	Phase I of Hebei Shangyi Shiren Wind Power Project	49.5	Acciona	1.5	33
15	Inner Mongolia	Longyuan (Baotou) Wind Power Generation Co. Ltd.	Inner Mongolia Bayin National Wind Concession Project	124.5	Goldwind	1.5	83
				31.5		1.5	21
				45		1.5	30
16	Inner Mongolia	Chifeng Xinsheng Wind Power Generation Co., Ltd.	Phase I of Inner Mongolia Wengniute Wudaogou Wind Power Project	50.25	Goldwind	0.75	67
17	Inner Mongolia	Chifeng Xinsheng Wind Power Generation Co., Ltd.	Phase I of Chifeng Wengniute Sunjiaying Wind Power Project	50.25	Goldwind	0.75	67
18	Inner Mongolia	Chifeng Xinsheng Wind Power Generation Co., Ltd.	Phase II of Chifeng Wengniute Sunjiaying Wind Power Project	49.5	Goldwind	0.75	66
		Total		**1,136.7**			

Table 2.3: Representative Coal Power Plant

Project Company	Project Name	Location	Capacity (MW)	COD	Manufacturer	Size of Generator (MW)	No. of generator
Jiangyin Sulong Power Generation Go., Ltd.	Jiangyin Xiagang Power Plant Project	Jiangyin, Jiangsu	275	Jun-95	Shanghai Boiler Company	137.5	2
			280	Feb-03		140.0	2
			660	Dec-04		330.0	2
Total		**1,215**					

- Turbine types

  The second key factor considered in selecting projects was the turbine types in the asset portfolio. As mentioned earlier in this report, the Company has installed several types of turbines both from international brands and from domestically manufacturers. We consider the turbine models in the projects indicated in Figure 2.1 to be representative of the predominant technologies adopted by the Company. The turbine manufacturers and ratings are detailed in Table 2.2.

- Installed capacity and the Company share

  The third key factor in the selection was the project size, both as a whole and also the size of Longyuan's share in the project. In other words, our focus is on the both the comparatively large wind farms, and in which that the Company owns a majority of shares. As shown in Table 2.2, the consolidated installed generation capacity of the eighteen representative projects makes up approximately 50% of the total consolidated installed capacity of Longyuan's wind asset portfolio at the end of 2008.

Table 2.2 and Table 2.3 summarises the eighteen representative wind farms and one coal power plant that were reviewed in this report.

2.4 Process of the Technical Due Diligence

Following selection of the eighteen representative wind farms and one thermal plant, our appraisal started with issuing the Company and its relevant subsidiaries with a detailed questionnaire addressing all issues relating to the scope of the technical assessment. Issues addressed included wind energy yield, wind turbine type, operational records, maintenance arrangements, turbine supply agreement and grid connection.

During March 2009 engineers from the UK and US offices conducted a document review in China. Three days were spent in a data room set up in the Company's headquarter in Beijing to initially review feasibility studies and grid connection study reports in addition to discussing technical details with Production and Engineering Divisions of the Company and the main wind turbine manufacturers.

Site visits were carried out in March and April 2009. Geographically the representative wind farms were widely spread across China, consequently our engineers, consisting of wind resource, turbine and power network specialists, were divided into four groups. These groups were then sent to Northwest, Northeast, Inner Mongolia and Hebei, and Southeast coastline. An additional team was assembled for visiting the coal power plant in Jiangsu Province. Each group was accompanied on the site visits by a representative of Longyuan. The site visits allowed MM to witness the assets and to meet with the site operational and maintenance staff to discuss technical issues in more detail.

We undertook an analysis of the data collected and information obtained. Where gaps were identified upon return from site visits our engineers had further communication with Longyuan. Our report was produced in our UK and US offices.

The key process of the technical due diligence is summarised below.

Table 2.4: Process of Technical Appraisal

Procedure	Location
Questionnaires preparation	UK, US
Data room review	China
Site visit, data collection and discussions	China
Analysis of data	UK, US
Report production	UK, US

3 Technical Appraisal of Wind Farms

3.1 *Wind Resource Assessment*

This section contains the findings from our review of the wind resource and energy yield assessments contained within the feasibility studies for each project. Our review focuses on the adopted methodology and assumptions and does not include remodelling or recalculation of the energy yields. In addition we have reviewed the applicable Chinese standards, which set out recommended practice in order to comment on the approach compared to wider international practice.

The wind resource assessments form a key component of the feasibility reports produced during the development stage of the wind farms, and can provide a useful insight in to the expected generation from the wind farms, particularly where limited production data is available.

Although the wind resource assessments in the representative wind farms have been carried out by a number of different Chinese design institutes, the methodology and reporting of results is common to all studies and is based on the Chinese standards, GB/T 18709-2002; entitled 'Methodology of Wind Energy Resource Measurement for Wind Farm' and GB/T 18710-2002; entitled 'Methodology of Wind Resource Assessment for Wind Farm'. The former standard covers data collection and reporting, while the latter outlines the procedures for long-term correction, data screening, data processing and reporting.

With regard to data collection, GB/T 18709-2002 is largely consistent with international convention and includes guidance on measurement parameters, calibration and mast specification and set-up. Although the standard covers key principles, it lacks some of the detail that can be found in other international equivalents such as IEC 61400-12-1. For example, the Chinese standard provides guidance on met mast configuration and sensor placement; however it does not specify details on sensor alignment and mitigating influence from tower shading.

There is limited information on the mast set up within the reviewed feasibility studies and no installation reports have been made available in order to check that the data used in the wind resource assessments has been collected in compliance with the Chinese standards. It is noted that in several of the feasibility studies, the mast height is reported to be shorter than the wind turbine hub heights. This deviates from GB/T 18709-2002, which states that the mast height should be no lower than the proposed hub height. This does not present us with concern as this is commonplace throughout the industry and is acceptable in simple terrain environments; however it demonstrates a degree of non-compliance with standards. It should also be noted that in some of the projects it is known that the anemometry masts were installed by the project commissioners (local government etc) and not by Longyuan, and data was supplied to prospective contractors during the bidding process.

GB/T 18710-2002 is the Chinese standard for wind resource assessment and outlines the methodology for processing the wind data and reporting results. The standard covers reference data requirements and long-term correction as well as data screening, formulae for extracting relevant parameters (wind shear, turbulence intensity) and reporting of results. GB/T 18710-2002 references a number of documents including NREL/SR-440-22223; 'Wind Resource Assessment Handbook'. This is an American publication by the 'National Renewable Energy Laboratory' of the U.S. Department of Energy and provides a good overview of the well established measurement based wind resource assessment method or MCP (Measure Correlate Predict). Much of the Chinese standard is derived directly from this document and hence the approach to wind resource assessment in China is largely consistent with international practice.

The MCP method requires that at least twelve months of quality wind speed and direction data is collected from the proposed site. This is then correlated with data from a nearby reference meteorological station with a reliable historical record. A relationship between the site and reference data is then established and the long term wind conditions at the site can then be calculated by extrapolating over the historical record. GB/T 18710-2002 provides some good advice on implementing this method, including how to select and assess the integrity of reference meteorological data, however lacks detail on methods of correlation. It is often unclear in the feasibility studies whether the correlations are based on hourly, daily or weekly averages which affect the interpretation of the results. In several of the feasibility studies reviewed, where doubts in the integrity of the reference data was encountered and the MCP process resulted in an increase in long term wind speed, then the MCP process was abandoned and the 12 months site data was used as the basis for the energy calculations. This shows evidence of diligence and conservatism in approach.

The culmination of GB/T 18710-2002, in terms of energy yield, is the reporting of average annual wind speed, wind direction and power density (W/m^2), and diurnal and seasonal profiling. In order to calculate the energy yield from a proposed 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 modelled, and other losses, such as electrical efficiency and availability, must be considered in order to arrive at a Net Energy Yield.

In the feasibility studies reviewed, the wind speed distributions at each wind turbine have been modelled by WAsP, which is a software developed by Danish wind institution RISO. WAsP is an industry standard tool for evaluating variation in wind flow from topographic and ground cover variation in non-complex environments. From our review of the sites visited, this method is appropriate. It is common for some modifications to the wind farm layout to be required between the production of the wind resource assessment and construction. We are able to confirm, with the exception of Pingtan and Chifeng, that the as-built layouts are consistent with the layouts in the feasibility studies except for some minor repositioning. The turbines used in Pingtan, Chifeng Sunjiaying I and Wudaogou I wind farms were changed after the feasibility studies, see later sections for detail.

The power curves used in the feasibility studies are often not listed numerically and the origins are not stated. To appreciate the accuracy of a wind resource assessment it is necessary 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 the feasibility studies have been reduced by 5% to account for any shortfall from the power curve, which provides some comfort and compensation for the lack of clarity on origin of the power curves. Adjustments have also been made to compensate for site air density relative to standard test conditions, in line with expected practice.

Wake modelling has been carried out using WAsP software, which is an acceptable method. The wake model parameters have not been provided in the feasibility studies, however the results appear in line with our expectations. In many of the sites visited, the wind farms have been developed in stages, or have wind farms constructed adjacent to the site. It is understood that the influence of neighbouring wind farms and subsequent phases have not always been captured in the feasibility study wind resource assessments.

Estimated losses have been factored to account for electrical efficiency, availability, and grid downtime etc. The feasibility studies provide little in the way of substantiation for the chosen figures, and they appear to be based largely on assumption. The losses applied to each project vary significantly, this can be attributed to regional climate variations, in addition to the nature of the studies; each study was conducted by a different institute. The losses evaluations are generous, resulting in project efficiencies (excluding wake effect) of 73% in average (in Europe a figure of 90% is typical). This suggests a good deal of conservatism in the energy yield prediction and this is backed up by the limited performance data.

The Chinese standards do not prescribe any evaluation of uncertainty in the measurement of wind speed and direction. Consequently, no uncertainty analyses are provided in the feasibility studies and only central estimates are presented. Uncertainty analyses are important for making commercial decisions about wind farm performance as they describe the confidence, and hence degree of risk associated with a prediction. Adherence to published industry standards does not alleviate an energy yield assessment from uncertainty as sources of error are endemic in the process and are not from consistent site to site. The lack of requirement for uncertainty analysis is, in our opinion, an omission in the Chinese approach. Likewise inter-annual variability has not been considered in the feasibility studies. Inter-annual variability accounts for the fact that wind speed varies year on year, however the variation reduces as the averaging period increases. It is therefore easier to predict the annual production, averaged over 10 years than it is to predict the production during a particular year. We are able to confirm a long term prediction was carried out in the feasibility studies, although some of the wind farms were lack of long-term correlated or reliable reference data or the on-site mast data were measured in low wind speed years, in which cases conservative estimations were made in the long term prediction.

From the pool of studies reviewed we can conclude that there is a consistent approach to wind resource assessment and the adopted methodology is largely consistent with standard international practice. The Chinese standards have been derived from well known Western publications; however they do not contain the same level of detail as other international equivalents. The most notable omission from the Chinese approach is the lack of uncertainty analysis. This said there is evidence of conservatism in the process and assumptions. In particular the losses applied to calculate the net yields are, in general, extremely generous compared to those typically included in other areas of the world. This results in conservative estimations of project efficiency, and it is expected that this conservatism compensates for the lack of uncertainty analysis and other more minor ambiguities such as wake effects from subsequent phases.

A summary of the key findings of the wind resource assessments reviewed is presented in Table 3.1.

Table 3.1: Energy Yield Summary

Wind farm	Long term average wind speed	Wake loss factor	Other loss factor	Net Yield (GWh)	Capacity Factor	Comments
Phase II of Jiangsu Rudong Wind Concession Project (100.5 MW)	6.96 m/s at 70m	94.27%	79.7%	228.44	26.0%	Energy yield calculated using 12 months of data from 70m mast on site, installed in 2003. Long term record considered unreliable and 2003, found to be representative year, compared to 1997-2003.
The Expansion Project of Phase II of Jiangsu Rudong Wind Concession Project (49.5 MW)	6.70 m/s at 80m	91.30%	85.0%	106.7	24.6%	Energy yield calculated using 12 months of data from 40m mast from 1999 only. 80m wind speeds extrapolated from 30m anemometer as 40m considered poor. No MCP conducted as long term data record unreliable and 1999 found to be representative based on 1995-2004. Result is expected to be conservative as predicted long term average wind speed is lower than that calculated for Phase 1, which is considered more reliable. Note also that this study was conducted after 70m data was available, however this was not used in the prediction.

Wind farm	Long term average wind speed	Wake loss factor	Other loss factor	Net Yield (GWh)	Capacity Factor	Comments
Fujian Pingtan World Bank Project (100 MW)	8.21m/s at 70m	89.55%	82.1%	259.58	29.5%	Both site and reference wind data show unusually high wind speed variation and the reported 2002 correlation between the 70m mast and reference station seems unfeasibly high for hourly resolution data. The MCP results in an 18% increase in average wind speed which is very high. The reported year-on-year wind speed variation is much higher than observed in other regions and without further substantiation to verify that this is a natural phenomena, as opposed to a data issue, we advise that the reported wind speed is viewed cautiously.
Phase I Jilin Tongyu Wind Concession Project (100.3 MW)	7.43 m/s at 65m	89.23%	81%	231.59	26.4%	Wind speed is derived from 40m mast installed by local government for tendering process. The results agree reasonably well with those reported from Phase II, which is based on better quality data, providing confidence in the results. Applied losses are high and it is known that wake losses from neighbouring wind farm and subsequent phases have not been included. On balance the predicted yield seems reliable and perhaps conservative, as evidenced by production data for 2008.
Phase II Jilin Tongyu Wind Concession (100.3 MW)	7.23 m/s at 65m	93.7%	66.2%	227.2	25.9%	Energy yield calculated using 12 months data at 70m from 2005 as poor correlation was achieved with reference station. Long term local records indicate that 2005 was a low wind speed year, therefore result is expected to be conservative. Loss allowances are very high. Actual project efficiency is expected to be higher.
Liaoning Faku Baijiagou Wind Power Project (49.5 MW)	6.81m/s at 65m	93.2%	79.7%	108.5	25.0%	Wind resource assessment is of good quality. There are some omissions from the report nevertheless there is evidence of a prudent approach, conservatism and good practice.

Wind farm	Long term average wind speed	Wake loss factor	Other loss factor	Net Yield (GWh)	Capacity Factor	Comments
Phase II of Dabancheng No. 3 Wind Power Project (30 MW)	8.79 m/s at 50m	95%	74.4%	79.8	30.4%	Energy yield calculated using 2004/2005 data of 1# met mast at 50 m, wind data from operational wind farm (Plant 2) and reference station used to correct site data to long term. Correlation is mixed, most likely because of wind farm influence on Plant 2 data. Plant 3 prediction benefits from 13 years of production data from Plant 2, therefore assessment is expected to be reliable.
Phase III of Dabancheng No. 3 Wind Power Project (49.5 MW)	8.58m/s at 50m	94.60%	78.30%	136.61	31.5%	Wind speeds are high, reflecting high altitude of site. Extreme wind speed is reported to be very close to IEC class 1 design limit. Wind data from operational wind farm (Plant 2) and reference station used to correct site data to long term resulting in 5% increase in average wind speed. Correlation is mixed, most likely because of wind farm influence on Plant 2 data Therefore assessment is expected to be reliable.
Phase IV of Dabancheng No.3 Wind Power Project (49.5 MW)	9.63 m/s at 65m	91%	76.5%	142.7	32.9%	High wind speed, production calculated using 2005 meteorological mast data, correlated by relevant reference station data. . Long term local records indicate that 2005 was a low wind speed year, therefore result is expected to be conservative.
Phase III of Gansu Yumen Wind Power Project (45.9 MW)	7.19 m/s at 50m	90%	73.9%	94.7	26.5%	Wind data recorded from seven different masts over two years. No MCP was carried out as reference stations were corrupted by thick shelterbelts. Energy yield calculations are based solely on data from 2003/2004, which medium term records indicate to be representative of average conditions.
Phase I of Gansu Diwopu Provincial Concession Project (49.3MW)	7.61 m/s at 60m	—	67%	107.9	25%	Energy yield calculated by data from a met mast. Wind speed reported is IEC class III. Long term data from reference station is hired for correlation. Loss figure is high. Actual production is expected to be higher.

Wind farm	Long term average wind speed	Wake loss factor	Other loss factor	Net Yield (GWh)	Capacity Factor	Comments
Phase I of Hebei Shangyi Shiren Wind Power Project (49.5 MW)	7.42 m/s at 40m	96.15%	66%	113.91	26.3%	Wind resource analysis seems reasonable, although at 40m the meteorological mast is shorter than preferred. Generous loss assumptions suggest that prediction may be conservative.
Inner Mongolia Bayin National Wind Concession Project (201 MW)	7.87 m/s at 70m	93.46%	78.3%	465.92	26.5%	Production calculation is based on 2004/2005 data from two nearby met masts, correlated by long term reference station data.
Phase I of Chifeng Wengniute Wudaogou Wind Power Project (50.25 MW)	8.6m/s at 50m	95.90%	62.8%	124.66	28.8%	High wind speed site, reflecting high altitude. Poor correlation achieved with reference data, however the long term correction results in reduction of wind speed, which reduces concern. High loss assumptions applied. Air density correction is high due to effects of altitude. Predicted capacity factor is low given the predicted wind speed, therefore results seem conservative.
Phase I of Chifeng Wengniute Sunjiaying Wind Power Project (50.25 MW)	8.56m/s at 65m	97.4%	57.2%	120.9	27.9%	Energy yield calculation based on 2004/2005 data of a met mast 10 km away, however, long term reference data is hired to correlation, which reduces concern. Due to very high loss assumptions, predicted production seems conservative.
Phase II of Chifeng Wengniute Sunjiaying Wind Power Project (49.5 MW)	8.6m/s at 70m	94.10%	61.64%	118.93	27.5%	High wind speeds predicted. No long term correction carried out and energy calculations based on measured wind speeds from 2005/2006.

3.2 *Key Wind Turbines Involved*

Longyuan uses many different wind turbine models supplied by international and domestic manufacturers in its wind farms. The wind turbine selection process is crucial for maximisation of the electricity generation considering a number of factors such as suitability to site conditions, energy yield, market availability, price, and technology. We were informed that the Company manages all the procurement and engineering activities centrally, from its Headquarters in Beijing, providing ready-to-be-built projects to its regional subsidiaries.

The representative wind farms include wind turbines produced both by domestic and foreign well-established manufacturers. All the wind turbine models reviewed have a modern design in line with current technology standards with a rated power range of 750 to 2000 kW. All installed wind turbine models have been selected according to the specific site conditions; designed to sustain extreme wind speed and temperature which could be very low in the northern regions of China and hot and humid in the south-east. Therefore, extra care has been taken in the analysis of low temperature and anticorrosion features for the wind turbines located in harsh environments such as shore areas or cold steep regions.

In our high level review we have analysed the various wind turbine models in order to identify potential technology risks which could prevent the wind turbines from operating in accordance with the developer's expectations. Whilst operational experience reduces the possibility of failure, independent analysis and certification of the design can give additional confidence. However the key safeguard is the manufacturers' warranty with liquidated damages for under performance.

The Chinese wind turbine supply chain is in constant growth, producing an output that meets 90% of the demand for 600 kW and 750 kW turbines and about 70% for bigger wind turbines[1]. However the domestic market for high precision and high technology components such as gearboxes, bearings, and control systems is still not independent and relies on foreign imports.

We consider that in assessing wind turbine generator (WTG) technologies, it is essential to review a type certification for the mitigation of design-related risks. The type certificate is issued to the wind turbine manufacturer following a thorough design review with respect to the relevant codes and standards. The testing of the prototype wind turbine and the evaluation of the implementation of design-related requirements in Implementation in Production and Erection (IPE) forms an integral part of the certification process, which is carried out through inspections at the manufacturer or respective sub-supplier.

The quality of wind turbine technology is a key element for the performance of a wind farm, for the maximisation of the electricity production, and for other aspects such as the electrical system and equipment, and the Operational and Maintenance (O&M) arrangements in place. Power generation and maintenance plans are also reviewed in this report. We are generally satisfied with the selection of the wind turbines and the contractual arrangements in place for O&M, warranty and liquidated damages which are in line with the current market.

Table 3.2: Wind Turbines installed in Representative Wind Farms

Ref	Wind farm	Capacity (MW)	COD	Manufacturer	WTG Model	Rated Power (kW)	WTG No.
1	Phase II of Jiangsu Rudong Concession Project - Huangang	58.5	May-07	GE	GE77	1,500	39
2	Phase II of Jiangsu Rudong Concession Project - Dongling	42	Dec-07	GE	GE77	1,500	28
3	Phase II of Jiangsu Rudong Concession Project - Lingyang	49.5	Jan-08	GE	GE77	1,500	33
4	Fujian Pingtan World Bank Project	100	Nov-07	Vestas	V80	2,000	50
5	Phase I Jilin Tongyu Wind Concession Project	100.3	Oct-07	Gamesa	G58	850	118
6	Phase II Jilin Tongyu Wind Farm Concession Project	100.3	Oct-08	Gamesa	G58	850	118
7	Liaoning Faku Baijiagou Wind Power Project	49.5	Dec-08	Sinovel	SL 1500/77	1,500	33
8	Phase II of Dabancheng No. 3 Wind Power Project	30	May-07	Goldwind	S48	750	30
			Sep-08	Goldwind	GW77	1,500	5
9	Phase III of Dabancheng No. 3 Wind Power Project	49.5	Feb-08	Goldwind	GW77	1,500	33
10	Phase IV of Dabancheng No. 3 Wind Power Project	49.5	Nov-08	Goldwind	GW77	1,500	33
11	Phase II of Gansu Yumen Wind Power Project	11.9	Nov-06	Gamesa	G58	850	14

[1] BTM Consult ApS - March 2008

Ref	Wind farm	Capacity (MW)	COD	Manufacturer	WTG Model	Rated Power (kW)	WTG No.
12	Phase III of Gansu Yumen Wind Power Project	45.9	Dec-06	Gamesa	G58	850	54
13	Phase I of Gansu Diwopu Provincial Concession Project	49.3	May-08	Gamesa	G58	850	58
14	Phase I of Hebei Shangyi Shiren Wind Power Project	49.5	Jun-08	Acciona	IT1500CII	1,500	33
15	Inner Mongolia Bayin National Wind Concession Project	201	Apr-09	Goldwind	GW77	1,500	134
16	Phae I of Inner Mongolia Wengniute Wudaogou Wind Power Project	50.25	Dec-06	Goldwind	S48	750	67
17	Phase I of Chifeng Wengniute Sunjiaying Wind Power Project	50.25	Dec-06	Goldwind	S48	750	67
18	Phase II of Chifeng Wengniute Sunjiaying Wind Power Project	49.5	Nov-07	Goldwind	S48	750	66

3.2.1 *GE*

GE Energy (GE) is part of General Electric group; the world's biggest power equipment manufacturer[2]. GE is one of the world's largest wind turbine suppliers with over 10,000 worldwide wind turbine installations comprising more than 15,000 MW of power capacity, their knowledge and expertise spanning more than two decades. GE is well-established in the Chinese market, having manufacturing and assembly facilities located in Shenyang, a research centre in Shanghai, and several O&M centres spread across the country. GE's 1.5 MW wind turbine has an impressive track record with over 8,500 units in operation worldwide.

The GE77 wind turbines installed in the Rudong wind farms have an active yaw and pitch regulated with power/torque control capability and an asynchronous generator. They use a bedplate drive train design where all nacelle components are joined on a common structure, providing exceptional durability. The generator and gearbox are supported by elastomeric elements to minimize noise emissions and the slip coupling is designed to reduce gearbox load.

Since starting production of 1.5 MW wind turbines in 2002, GE has invested $750 million in improving reliability and performance of this wind turbine, and we have no concerns over the quality of this product.

Table 3.3: Technical Summary of GE77

Hub Height	70 m
Rotor Diameter	77 m
Rated Power	1,500 kW
IEC Classification	IA/IIA
Certification	Germanischer Lloyd IIa /DIBt II

2 BTM Consult ApS - March 2009

3 BTM Consult ApS - March 2009

Cut-in Wind Speed	3 m/s
Nominal Wind Speed	14 m/s
Cut-out Wind Speed	25 m/s
Generator	asynchronous, doubly fed induction
Gearbox	combined spur / planetary gear
Gearbox Ratio	1:78
Power regulation and control	variable via microprocessor, active blade pitch control

3.2.2 *Vestas*

With a 20 per cent market share, Vestas is currently the world's leading supplier of wind turbines[3] and has 38,000 wind turbines installed worldwide. Vestas entered into the Chinese market twenty years ago and has supplied more than 1500 turbines in 13 Provinces in China for a total power capacity of over 1350 MW. Vestas, currently the leading foreign supplier in China, now has a head office in Beijing, a procurement office in Shanghai, and factories in Tianjin, Xuzhou and Hohhot with more than 80% of components produced in China.

The Vestas V80 wind turbines installed in the Pingtan Wind Farm are pitch regulated, three-bladed, horizontal axis, variable speed upwind turbine for medium and high winds utilising Vestas' OptiSpeed control system. There are over 2700 V80 turbines installed worldwide and more than 5000 Vestas 2 MW wind turbines both onshore and offshore. The impressive operational experience and the excellent track record give confidence in the quality of the technology.

The OptiSpeed system employed in this wind turbine is a variable speed technology that allows the rotor speed to vary within a range of approximately 60 per cent in relation to nominal rpm, which allows the rotor speed to vary by as much as 30 per cent above and below synchronous speed, hence increasing productivity. The V80 is based on the same platform and principles as the V66 1.75 MW turbine which is the first Vestas machine to employ a nacelle mounted transformer.

Each turbine has a service crane that can lift up to 800 kg, used for lifting equipment and material needed to service the turbine. Additional sub-components can be lifted and fitted to the crane and support structures enabling the lifting capacity of the crane to increase to 6400 kg. This additional lifting capacity allows components up to the weight of a generator to be removed without having to employ an external crane.

Vestas encountered some problems with the V80 at the 160 MW Horns Rev offshore wind farm in the North Sea, 14 km west of Denmark in 2007. It was reported the problems were with regards to transformers, generators, and gearboxes and were linked to manufacturing quality rather than a design flaw or the marine environment. The turbine nacelles had to be removed and transported back to shore for repairs at an estimated cost to Vestas of € 12 to 13 million. Vestas also encountered problems with the generator and gearbox at Scroby Sands 60MW wind farm. However in both cases the manufacturer has overcome the problems and we believe that this shall not be considered as a risk for the Longyuan projects.

Overall, we consider Vestas to be a high quality, low risk supplier with which the market is now comfortable and the certification provided for the projects gives us considerable confidence in the quality of the Chinese supply chain.

Table 3.4: Technical Summary of Vestas V80

Hub Height	85 m
Rotor Diameter	80 m
Rated Power	2,000 kW
IEC Classification	IA/IIA
Certification	Germanischer Lloyd IIa /DIBt II
Cut-in Wind Speed	4 m/s
Nominal Wind Speed	15 m/s
Cut-out Wind Speed	25 m/s
Generator	Asynchronous with OptiSpeed
Gearbox	Planet/parallel axles
Gearbox Ratio	1:100
Power regulation and control	variable via microprocessor, active blade pitch control

3.2.3 *Gamesa*

Gamesa is a wind turbine manufacturer leader in Spain, as well as one of the key international suppliers. In 2008 it was ranked third largest wind turbine supplier in the world with more than 13,000 MW installed and a market share of more than 15.4%[4]. Gamesa has installed thousands of wind turbines in China to date with a total capacity of 1,600 MW and gained a good market share.

Gamesa has extensive capabilities in design of wind turbines, as well as the largest integral production capacity in China, comprising the manufacturing of blades, root joints, blade moulds, gearboxes, generators, converters, and towers, in addition to assembling the wind turbines. Gamesa's domestically manufacturing facilities are located in Tianjin. Chinese made components for G58 amount to more than 80%

The G58 wind turbine used in Yumen and Tongyu wind farms is a standard Gamesa product. Currently over 5,800 Gamesa G5X-850 kW wind turbines have been installed worldwide. We consider the G58 850kW as a well established and mature wind turbine developed based on a Vestas' licensed design. The design of the G58 is very similar to the Vestas V52 which is recognised as a robust product. This also reflects the common ties of the two companies. Gamesa's G58 technology incorporates features including a doubly fed induction asynchronous generator and variable speed generator as summarised in Table 3.5.

Table 3.5: Technical Summary of G58

Hub Height	55 m
Rotor Diameter	58 m
Rated Power	850 kW
IEC Classification	IIA
Certification	TÜV Nord IIIb
Cut-in Wind Speed	3 m/s

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Nominal Wind Speed	13 m/s
Cut-out Wind Speed	21 m/s
Generator	Doubly fed asynchronous, water cooling
Gearbox	1 planetary stage / 2 helical stages
Gearbox Ratio	1:61
Power regulation and control	Pitch and variable speed technology

The hydraulic pitch control system employed in the G58 wind turbine is collective and does not allow independent pitching of the blades. Although the G58 is based on an early technology it has been constantly updated benefiting from various developments Gamesa experienced in wind turbine manufacturing.

This wind turbine model is classified IEC IIIB and it has been certified by TÜV Nord. We have no concern on the quality of this wind turbine as it is a mature and proven technology.

3.2.4 *Acciona WindPower*

Acciona WindPower is a Spanish wind turbine manufacturer belonging to the Acciona Energy group, which works in the entire range of renewable energies sources where it has considerable assets.

Acciona WindPower uses an in-house technology and only assembles wind turbines as it is not vertically integrated. In 2008 it assembled 858 wind turbines (1,290 MW), which represented an annual increase of 47%[5] . Since the company started manufacturing wind turbines in 2004, it has assembled more than 2,000 units with a total capacity of 3027 MW. The domestically manufacturing facilities are located in Nantong with an annual production capacity of 400 units (600 MW). The product range of Acciona includes 1.5 MW wind turbines and the new AW-3000 with a rated power of 3 MW.

The AW77-1500 wind turbine installed in Shiren Phase I wind farm is a 1500 kW power-rated horizontal shaft wind turbine, with three blades, variable speed, 12 kV rated voltage, and is certified by Germanischer Lloyd (GL) for IEC class IIa sites. The AW77-1500 features hydraulic blade pitch regulation and a three phased doubly fed induction generator with wound rotor and excitation by collector rings, which generate power at medium voltage of 12 kV. We consider this system to be advantageous as it reduces losses and negates the need for a transformer. The wind turbine employs a condition monitoring system that helps to perform a predictive maintenance system through sensors installed in the gearbox and on the drive train that detect any malfunctioning and allow prompt maintenance and reducing downtime.

We are not aware of any specific issue experienced during operation with this wind turbine model.

Table 3.6: Technical Summary of AW77-1500

Hub Height	60 m
Rotor Diameter	77 m
Rated Power	1,500 kW
IEC Classification	IIA
Certification	Germanischer Lloyd IIa

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Cut-in Wind Speed	3,5 m/s
Nominal Wind Speed	11m/s
Cut-out Wind Speed	25 m/s
Generator	6 poles doubly fed, 12 kW
Gearbox	3 stages planetary/helical
Gearbox Ratio	1:65
Power regulation and control	Full span blade pitch

We consider the Acciona technology to be in line with the industry standards and the AW77-1500 wind turbine to be a reliable product.

3.2.5 *Goldwind*

Goldwind is the oldest, largest, and most experienced manufacturer in China. Founded in 1998, Goldwind started its business by procuring the know-how from German wind turbine manufacturers. It first licensed REpower's 48-kW to 750-kW turbine technology in 2002 and then acquired a license in 2003 from Vensys Energiesysteme GmbH for its Vensys 62-1.2-MW turbine, and subsequently for the low wind speed version 64m- 1.5 MW.

Goldwind has been enjoying an annual market share growth of 100% between 2000 and 2007, and it was reported that in 2008 they installed a total capacity of 1,132 MW[6]. It has become the second largest WTG supplier in China with a market share of 18% by the end of 2008 [7]. Goldwind currently offers WTG products ranging from 600 kW to 1500 kW. Further to the acquisition of 70% of the stakes of Vensys, Goldwind started to develop 2.5 MW and 3 MW turbines. The manufacturer has built three factories in Hebei, Zhejiang, and Guangdong and two production bases in Beijing and Baotou, establishing a large production capacity.

GW77 has been developed on Vensys' 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 gear box, 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.

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Table 3.7: Technical Summary of S48 and GW77

	S48	GW77
Hub Height	50 m	65 m
Rotor Diameter	48 m	77.4 m
Rated Power	750 kW	1,500 kW
IEC Classification	Ia	IIa
Certification	Germanischer Lloyd Ia	China General Certification Centre IIa
Cut-in Wind Speed	4 m/s	3 m/s
Nominal Wind Speed	14 m/s	11.8 m/s
Cut-out Wind Speed	25 m/s	22 m/s
Generator	Asynchronous generator	Permanent Magnet Synchronous Generator
Gearbox	3 stages with 1 planetary gear and 2 cylindrical gears	Gearless direct drive
Gearbox Ratio	4:67	n/a
Power regulation and control	Stall regulation system, no speed control	Electromechanical blade pitch

Compared with doubly fed induction generators, direct drive systems are generally, theoretically more reliable and need less maintenance. The permanent magnet generator reduces rotating losses as excitation is not required. The use of wear-free toothed belts in the pitch system leads to further savings, as lubrication and seals become unnecessary. The airflow that powers the turbine rotor is guided directly over hot generator parts such as the stator with the aid of specially shaped cooling ducts. The direct-drive generator system has some disadvantages such as large size and heavy mass, which result in high cost when compared to the geared generator system. Some additional disadvantages attributed to permanent magnet generators are the loss of the field current strength control variable, a more complex assembly and disassembly process, and the high cost of the (NdFeB) magnetic material. Vensys' wind turbine technology looks very promising. We were not provided relevant information about the track records of WTGs used in other wind farms.

The early Goldwind model S48 is based on REpower's standards doubly fed induction generator system. Licensed by the German manufacturer, this technology has been gradually replaced by bigger, MW-sized wind turbines in the European market. Although the technology is relatively old, as stall blades do not allow the speed control and thus power control, we consider that the technology is mature and proven and this model to be reliable.

3.2.6 *Sinovel*

Sinovel is a major Chinese wind turbine manufacturer and one of the world's top ten suppliers, with an installed wind turbine capacity of 1,403 MW in 2008[8]. It has become the largest WTG supplier in China with a market share of 22% by the end of 2008[9]. Sinovel has currently a factory in Dalian and is establishing its manufacturing facilities in Baotou (Inner Mongolia), Yancheng (Jiangsu Province) and Jiuquan (Gansu Province) which are believed to reach their full production ability in the first half of 2009.

Sinovel SL1500/77 installed in the Faku Baojiagou wind farm in Northeast China is a turbine product developed jointly with German manufacturer Führlander which owns independent intellectual property rights.

[8] BTM Consult ApS - March 2009

[9] Global and China Wind Power Industry Report, 2008-2009

Table 3.8: Technical Summary of SL1500/77

Hub Height	60 m
Rotor Diameter	77.4 m
Rated Power	1,500 kW
IEC Classification	IIA
Certification	Germanischer Lloyd IIa
Cut-in Wind Speed	3 m/s
Nominal Wind Speed	11 m/s
Cut-out Wind Speed	20 m/s
Generator	Doubly fed asynchronous, water cooling
Gearbox	Two planetary stages + One spur gear stage
Gearbox Ratio	1:104
Power regulation and control	Electromechanical blade pitch

The SL1500/77 is a three blade, horizontal shaft wind turbine with a doubly fed generator, active pitch, and active yaw system with variable speed. The applicable low temperature version of SL1500 has an operating temperature ranging from -30°C to +45°C and survival temperature is from -45°C to +45°C. Structural components, rotating equipment, electric components and control system, and heating and sealing parts are all designed to sustain in cold climate conditions. Due to the harsh environment of China's windiest regions Sinovel has gained experience in manufacturing built-to-resist wind turbines.

Sinovel manufacturing process and quality control has obtained GL, CGC, ISO 9001 and ISO 14000 certifications and has some independent quality inspections of the quality system.

It was reported that Sinovel experienced some problems in 2006 which brought to the replacement of 40 generators. These were not in Longyuan's wind farms. The detail of the problem has not been disclosed to us. Sinovel has achieved a fast growth in recent years in terms of wind turbine production in China.

As discussed above, Sinovel developed its turbine technology jointly the German manufacturer. We therefore expect the technology risk is limited. During our site visit, Shenyang Long Yuan informed us Sinovel was a well established wind turbine supplier with a good track record in China and showed confidence in the performance of the wind turbines. This gave us additional comfort. We consider the design and manufacturing process is in keeping with general industry trends.

3.3 *Plant Performance — Availability and Generation*

With the exception of Chifeng wind farms, Mott MacDonald has visited all representative wind farms and had discussions with the technical staff in the local Longyuan subsidiaries in order to inspect the assets, gain a better understanding of the operational practice used and the management organisation in place, as well as to collect operational data of the plants.

In this sub-section, we summarise our findings in relation to the performance of the wind farms such as the availability of the wind turbines and actual electricity generated arrangements. Our assessment and findings are presented below on an individual wind farm basis.

3.3.1 *Jiangsu Rudong Wind Concession Projects*

Phase II of Jiangsu Rudong Wind Power Project is a concession project which consists of three wind farms located along the Huanghai coast in Jiangsu Province, about 40 km northeast of Nantong City. The project was developed by Jiangsu Longyuan Wind Power Generation Co., Ltd.(JSLY), a subsidiary of Longyuan and has a consolidated installed capacity of 150 MW. Commissioned during May 2007 to January 2008, the three wind farms are now fully operational. The three wind farms of Lingyang, Huangang, and Dongling comprise 33, 39, and 28 GE 1.5 MW wind turbines.

(i) Generation and availability

The three sites are very similar as they are all located on the same coastal area. The landscape is rural and the wind farms are surrounded by fish cultivating pools. JSLY has a control building with permanent staff for the monitoring activities for each wind farm. The site facilities include WTGs (wind turbine generators), connector cables, substation equipment, an office building with a control room and meeting rooms and O&M contractor's office, and workers' accommodation.

In MM's view the facilities and building on the sites appear well maintained and are of a high standard, even above the standard compared with similar wind farms we have seen in Europe. To a certain extent, the overall facilities and the staff may be excessive for the actual need of the wind farms.

JSLY has installed a mast for each site to continue monitoring the wind resources at the sites during operational phase. We have been provided the wind resources data measured from the masts.

According to the data provided by JSLY, the wind farms show good average availabilities of 98.6%, 98.8%, and 98.9% for Dongling, Lingyang, and Huangang respectively since commissioning, all above the 95% guaranteed value. It is worth noting that the calculation of availability, as presented by JSLY, includes a few caveats such as wind turbines are considered as available when they are actually down due to scheduled maintenance, extreme weather conditions, or grid problems. This is in line with the practice used in European countries. Therefore, we consider the actual availability of the wind farms to be potentially lower than the above figures.

The electricity generation figures provided to us are net of the internal losses and measured at the substation. The average yearly generation of three wind farms in 2008 is presented in Table 3.9 Comparing the actual generation with the forecast made in the feasibility studies as presented earlier in this report, we are able to confirm that all three wind farms generate the electricity as expected.

Table 3.9: Rudong Wind Farms Annual Generation

	2008 Generation (GWh/annum)
Lingyang	104.12
Huangang	142.05
Dongling	95.37
Total	341.54

Limited information on the incidents and outages collected at the sites indicates that the wind farms did not experience major problems. JSLY provided us with a list of generic issues experienced during the operation of the wind turbines. We are of the view that these problems are part of the routine lifecycle of wind turbines in line with our expectation and international norm.

The O&M arrangements in place for the project look adequate at present given that all WTGs are still covered by manufacturer's warranty. GE has a service centre in the region and the local presence of the wind turbine manufacturer give additional comfort on the promptness of response in case of repair. We acknowledge that JSLY's staff currently assist the turbine supplier in the maintenance activities as part of the training to ensure a smooth handover of O&M activities to JSLY at the end of warranty period. It appears that the local staff we met are familiar with the operational and monitoring activities on the sites. We were also informed that the wind farm SCADA systems also send the operational data to the JSLY in Nantong and Longyuan's headquarter in Beijing.

(ii) Internal connection and substations

The three wind farms were designed by the same Chinese institute, following the same standard and procedure. All the electrical equipment is of high quality and housed in appropriate buildings. Although the coastal environment may be extremely aggressive there are no signs of corrosive damage or vermin infestations found.

The design criteria used to size the inter-array cables in the three wind farms is appropriate for the amount of power they need to carry. The evacuation system is closed delta. The evacuation system cables are three-core without concentric neutral or accompanying ground cable. A ground fault detection circuit is present on the collector bus. This is markedly different from American and most European designs, where the design would contain a grounding transformer. This design has more in common with Russian practice than American or Western European. The benefit of this design is two fold: cost effectiveness, and in the event of a ground fault, power is still able to be exported. The only drawback of this design is that it lends itself to stray ground currents.

The size of the main transformer in Lingyang is 63 MVA, which is appropriate, as the wind farm will produce 55 MVA assuming typical power factor of 0.90. In addition, the transformer is equipped with a 16 position Load tap changing device, which has the capability to raise or lower the voltage in ± 8 taps by 1.25% per tap. The result of the tap changer is that the transformer has MVA ranges of 108.9 kV through 133.1 kV. The unit's primary side is at 121 kV, to connect to the 110 kV grid. Similar techniques have been utilized in the United States to mitigate the voltage drop of the plant before it connects to the grid.

The switchgear is Hyundai Gas Insulated Switchgear (GIS) which is housed at the project site. The equipment is in excellent condition and is housed in an appropriate building. The station service transformer is a dry type 100 kVA, which is acceptable.

The size of the main transformer in Huangang is 50 MVA, which is smaller in capacity than the full output of the wind farm of 58 MW. This means the transformer has to operate under an over-load condition when the wind farm produces the full output. The Production Director of Jiangsu Longyuan showed us an expansion plan that will increase the output to 100 MW. We observed both the erection of new turbines, and an additional 50 MVA transformer being installed and waiting to be connected. When we issued the draft report, we were informed that the construction has been finished on July 2009.With two 50 MVA transformers sharing a common bus, the plant is then able to support its full rated output.

Equipped with a 16 position load tap changing device, the transformer has the capability to regulate voltage in the range of 108.9 kV through 133.1 kV. The unit's primary side is at 121 kV, to connect to the 110 kV grid. This technique is commonly used to mitigate the voltage drop of the plant before it connects to the grid.

Similar to Lingyang, the switchgear in Huangang is Hyundai GIS which is housed and maintained in excellent condition. The station service transformer is a dry type 200 kVA, which is acceptable.

The size of the main transformer is 50 MVA, which is adequate to send the full output of 42 MW in Dongling. Similar to the other two wind farms, the transformer is equipped with a 16 position load tap changing device, which can regulate the voltage ranges of 108.9 kV through 133.1 kV.

The in-housed Hyundai Gas Insulated Switchgear at the Dongling site is kept in excellent condition.

3.3.2 *Fujian Pingtan World Bank Wind Power Project*

Located in the southeast of Fujian Province, Pingtan is the fourth largest island in China. The wind farm, on the northeast coast of the island, was commissioned during September 2007 to January 2008 and is now fully operational. Developed by the local subsidiary Longyuan Pingtan Wind Power Generation Co.(LYP), the Pingtan Changjiang'ao Phase II project consists of fifty V80 WTGs supplied by Vestas with a consolidated installed capacity of 100 MW. The wind farm is the second phase of a smaller project sponsored by the World Bank with an installed capacity of 10 MW.

Pingtan wind farm employs the largest single size wind turbine in the Longyuan asset portfolio which were visited by Mott MacDonald.

(i) Generation and availability

We note that selection of the turbines in the Pingtan wind farm changed after the feasibility study. It was originally envisaged to build 67×1.5MW WTGs and an energy yield calculation was undertaken on this basis in the feasibility study. The discussion we had with the site staff indicates the reason for the change was to install larger size wind turbines and maximise the electricity production. No energy yield study has been undertaken using the turbine model V80. Although MM has no concerns over the suitability of the Vestas V80 wind turbines and its marinisation, as V80 is a model which could also be installed in offshore environment, it is international best practice to undertake a detailed study including micro-siting when a decision was made to change to 50 × 2 MW turbines.

A summary of monthly operational figures supplied by the LYP such as availability and actual power generation shows a consistency with the numbers in the feasibility study. The actual availability is greater than 97.5%, above the guaranteed value of 95%. Similar to other wind farms, the availability calculation, as presented by LYP, includes a few caveats such as regarding the wind turbines to be available when they are actually down due to scheduled maintenance, weather conditions, or grid problems. Therefore we would suggest using a comprehensive availability, a smaller number in the financial models. This is in line with the practice used in European countries.

The plant also achieved good power generation of 280 GWh and capacity factor of 32% in 2008. The electricity generation is measured at the substation, net of the internal losses. We note that the actual generation is higher than the projected number in the energy yield in the feasibility study. This is largely due to the change of the turbine model from 1.5 MW to 2 MW.

During the site visit, MM met the Vestas team in charge of the maintenance activities for the wind farm and discussed the maintenance and repair records. A few major repairs to the yaw system were highlighted. According to the information provided by Vestas these problems have been promptly fixed to minimise downtime and the wind turbines are now fully operational. LYP also provided us with a list of generic issues experienced during the early operation stage of the wind turbines; in MM's view these problems are part of the routine lifecycle of wind turbines and in line with current industry norm.

The O&M system in place for the project looks adequate as WTGs are still covered by manufacturer's warranty. Vestas has currently employed six people working in the Pingtan wind farm and we consider the presence of the WTG team provide additional confidence to O&M activities. As per Longyuan, O&M strategy used in all wind farms, LYP will takeover the O&M and use its own staff to operate and maintain the wind farm after the warranty period.

We consider the local staff to be trained and familiar with monitoring activities through the experience gained in Phase I. We were informed that the SCADA system could send operational data to the LYP office in Pingtan and Longyuan's head office in Beijing.

(ii) Internal connection and substations

The design criteria used to size the inter-array cables is appropriate for the amount of power they need to carry. This windfarm uses small sections of underground cable, most less than 75 meters, to take power from the turbine, at which point is brought to a riser structure where it is linked to a 35 kV "trunk" line. The trunk line consists of ASCR cable. The evacuation cables are closed Delta. The evacuation system does not have either concentric neutral or accompanying neutral, however, each bus is equipped with a correctly sized grounding transformer, providing path to ground in case of fault or to monitor circulating ground current. This design is indicative of typical American and Western European installations.

The substation bus work is split into two 25 turbine collector busses. The busses have identical main auto-transformers, sized at 63 MVA. The size of these transformers will support the full output of the units, as each bus of 25 turbines will output at 55.6 MVA assuming a 0.9 power factor. Equipped with a 5 position tap, the auto-transformer has the capability to raise or lower the voltage in the range of 103.5 kV through 126.5 kV.

S & G Gas Insulated Switchgear is installed in the Pingtan wind farm and is kept in an excellent condition. The station service transformer is a dry type 100 kVA, which is acceptable.

3.3.3 *Jilin Tongyu Wind Concession Projects*

Tongyu wind farm is located in Jilin Provence in Northeast China, close to the town of Tongyu. The wind farm consists of two phases owned and operated by Jilin Longyuan Wind Power Generation Co. Ltd (JLLY) and a 49.3 MW wind farm owned by another operator. Of the phases owned by JLLY, phase I and II are each 100.3 MW and each comprise 118 Gamesa G58, 850 kW wind turbines. Phase I was commissioned in October 2007 and Phase II was commissioned in December 2008. Phase III is 49.3MW and consists of 58 Gamesa G58-850 kW wind turbines. In our scope of works, it has been agreed that we consider Phases I and II.

(i) Generation and Availability

The wind farm is constructed on relatively flat scrub/desert land which varies in altitude from 170 m to 200 m ASL. The terrain is simple and does not present any concerns regarding shading, channelling or excessive gradient which could cause adverse wind conditions. Sand storms are common in the area and the climate is very cold, resulting in long periods of subzero temperatures. These factors can be expected to influence performance in terms of blade contamination and icing. From consideration of wind farm operation, the site presents us with no concerns.

A control building is located in the centre of the wind farm; the substation is located 10 km from the site. The control building includes the control centre, offices, spare parts store, and other site facilities. JLLY employs 23 operations personnel, deployed in two teams on a rota basis. The building and facilities are of a high standard and appear well maintained.

Site roads are rough and could present access problems for heavy plant in snow and ice. JLLY inform us that this is common in China and are confident that heavy plant access can be achieved.

Gamesa is a Spanish wind turbine manufacturer previously partly-owned by Vestas, with manufacturing facilities in China. The G58 850kW wind turbine is a well established and mature wind turbine. The design of the G58 is very similar to the Vestas V52, reflecting the common ties of the two companies, and is recognised as a robust product.

Presently 236 G58s are being commissioned at Tongyu across both phases. Some technical maintenance issues were reported during our site visit: It is known that 60 wind turbines required the generator slip-rings to be replaced, resulting in reduced availability in the early part of 2008 across Phase I. The same problem was experienced in Phase II; however this was addressed prior to commissioning. During our site visit it was noticed that some turbines showed evidence of significant oil leakage from the nacelles. This was reported by JLLY to have been caused by a failure of an oil pipe at the radiator for the gearbox cooling system. The problem has occurred in eight wind turbines so far at approximately two months after the commissioning date. The problem has reportedly been rectified by Gamesa. The G58 design is well established, therefore it is likely that these problems are caused by lower quality components sourced by Gamesa from domestically manufacturers, and while further occurrences are likely, this does not present us with major concerns regarding the long term integrity of the fleet.

The wind farm is currently under a service and maintenance agreement with Gamesa, who has a permanent presence onsite. This agreement will last for two years from commissioning and includes an availability warranty of 95% (excluding scheduled maintenance and outage out with manufacturers control e.g. grid downtime) with liquidated damages payable for shortfall (calculated at end of two year duration). The liquidated damages are reported to be equivalent to the loss in revenue. After two years, servicing and maintenance will be carried out by Longyuan as described in Section 3.4. Training of JLLY personnel is included in the service agreement with Gamesa. Post service agreement maintenance work will be carried out by Longyuan's own maintenance division which was set up at the end of 2007, and currently has 30 personnel and serves two wind farms, including Tongyu (still under service agreement). Likewise, spare parts provision will be managed by Longyuan's central spare parts division. On our inspection of the spare parts only consumables and minor components, no major components, were present. Like Baijiagou wind farm, Tongyu will be set a target availability, which is anticipated to be above 95%.

Operational data including monthly production, availability, and downtime has been supplied for Phase I and II by JLLY for 2007 and 2008. This includes 14 months of post commissioning data for Phase I. We have therefore been able to compare actual production with predicted production. Since Phase II was only commissioned in December 2008, there is insufficient data available to give valuable comment on wind farm performance and our performance appraisal is primarily based on a review of the preconstruction feasibility study.

We have carried out a review of the wind resource assessments contained in the Tongyu feasibility studies for Phase I and II which follow procedures set out in Chinese recommended guidance for good practice; GB/T 18709-2002. For Phase I the study is based on 24 months data from 1996/1997 from two 40 m masts that were installed near the site by the local government and supplied to all parties bidding for construction of the wind farm. JLLY installed a 70 m mast on site during 2004 and used this as the basis for assessing the site conditions relevant to site classification and for the production estimate for Phase II. It is noted that the losses applied to calculate the project efficiency and net yield in each study are high and do not agree.

The average wind speed at hub height (65 m) calculated in the feasibility studies is 7.43 m/s at the location of the 40 m mast, at 206 m ASL (Phase I study), and 7.23 m/s at the location of the 70 m mast, 190 m ASL (Phase II study), which indicates a good wind resource. The good agreement between the studies provides confidence in the wind resource as they are based on independent data sets. The net capacity factor for Phase I is calculated to be 26.3% and the capacity factor for Phase II is 25.8%.which is slightly lower than expected given the reported wind speed, reflecting the high losses predicted in the feasibility studies.

We have analysed the Phase I monthly production records for 2008 and compared them to the preconstruction prediction. As mentioned previously, the wind farm experienced low availability during the early part of 2008 due to the slip-ring replacement, resulting in a total availability of 89.7% and a production of 217.9 GWh. If the production is adjusted to the guaranteed availability level of 95% then the production becomes 230.7 GWh, which is 0.4% below the predicted level of 231.6 GWh.

We have been issued with a summary of the wind data recorded at 65 m during 2008 which recorded an average wind speed of 6.47 m/s during 2008. It should be noted that the wind data will be influenced by the wake effects of the surrounding wind turbines and we are seeking some clarity on the source of this data; however if verified, this may indicate that the wind speeds experienced during 2008 were below the expected average and that production can be expected to be higher during an average year.

(ii) Internal connection and substation

Designed by the same Chinese institute group, the designs of the two wind farms are quite similar in methodology. Tongyu wind farms owned by Longyuan share a main substation with another holding company. Each Phase has its own 35 kV bus. The Phase I bus is its own separate entity, while the Phase II bus is connected via a normally-open tie breaker to another 35 kV bus owned by another holding company. The power of the two wind farms is combined at the 220 kV level, where it is synchronized and connected to the grid.

The evacuation system of each wind farm is a combination of underground and overhead construction. The underground cable is three-core, ungrounded, and direct buried. Each turbine has a short underground length, before being lashed to a riser structure, where it is joined via compression tap to the main overhead trunk line. This design is both a common, and economical, method of construction. All of the evacuation cables are sized correctly and will support the full load of all turbines. The evacuation system does not have either concentric neutral or accompanying neutral. Fibre-optic cable is buried in the same trench at a suitable distance from the power cable when underground, and when overhead is lashed to a messenger cable slung below the power cable.

Each phase has its own collector bus. Phase I's collector bus, with seven collector circuits connecting to it. After the seven circuits are collected on the 35 kV bus, they are stepped up to transmission and ultimately interconnection voltage. Phase II's collector bus is connected via a normally-open tie breaker with a collector bus from another holding company. Phase II's bus has seven collector circuits, identical in configuration to Phase I. After the seven circuits are collected on the 35 kV bus, they are stepped up to transmission and ultimately interconnection voltage.

The Phase I wind farm contains both capacitor banks and reactor banks. The total capacitive support is 10 MVar as is reactive support. Phase II wind farm also contains both capacitor banks and reactor banks. The total capacitive support for Phase II is 12 MVar, and the reactive support is 0.5 MVar. If the normally-open tie breaker is closed in, then Phase II has an additional 8 MVar of capacitance available.

There is one main transformer for Phase I. It is sized at 100 MVA. The size of this transformer supports the full output of its 118 units, as it was designed assuming a utilization factor of 90 percent. Our experience indicates that this utilization factor is appropriate. The transformer is equipped with a 16 position on-load tap changer, which has the capability to raise or lower the voltage in ± 8 taps by 1.25% per tap. As a result of the tap changer, the transformer has voltage ranges of 103.5 kV through 126.5 kV. The unit's primary side is at 115 kV, to connect to the 110 kV grid.

The main transformer at Phase II is identical to that at Phase I. Similarly, it is sized appropriately. We were told a 50 MVA transformer is for Phase III expansion.

3.3.4 *Liaoning Faku Baijiagou Wind Power Project*

Baijiagou wind farm is located in northeast China, approximately 85 km north of the city of Shenyang. The wind farm totals 49.5 MW, comprising 33 Sinovel 1,500 kW wind turbines and was commissioned in December 2008.

(i) Generation and Availability

The wind farm is constructed on undulating farmland which varies in altitude from 120 m to 240 m ASL (Above Sea Level). The terrain is relatively simple and does not present any concerns regarding shading, channelling or excessive gradient which could cause adverse wind conditions such as severe wind shears, inflow angles, or turbulence. Corn is grown on the wind farm and surroundings by the locals and the ground cover varies with the crop cycle from dense vegetation up to 3 m high, to open farmland. This will influence the wind conditions at the site; however, this cycle was present during the preconstruction measurement campaign, and therefore its influence will be captured in the energy prediction. With regards to wind farm operation, the site presents us with no concerns.

A control building and substation is located in the centre of the wind farm. This building includes the control centre, offices, spare parts store, switchgear housing, and other site facilities. Shenyang Longyuan Wind Power Generation Co., Ltd. (SLY) employ 12 operations personnel, deployed in two teams of six on a rota basis. The building and facilities are of a high standard and appear well maintained.

Site roads are rough and could present access problems for heavy plant in snow and ice. SLY inform us that this is the norm in China and are confident that heavy plant access can be achieved no problem.

Sinovel is a Chinese wind turbine manufacturer and are reported by SLY to be well established with a good track record in China. SLY have reported no significant technical issues since the wind farm was commissioned in December 2008.

The wind farm is currently under a service and maintenance agreement with Sinovel. This agreement will last for two years and includes an availability warranty of 95% (excluding scheduled maintenance and outage out with manufacturers control e.g. grid downtime) with liquidated damages payable for shortfall (calculated at end of two year duration). The liquidated damages are reported to be equivalent to the loss in revenue. After two years, servicing and maintenance will be carried out by Longyuan. It is also reported that the defects liability period for the wind turbines also expires after two years. Training of SLY personnel is included in the service agreement with Sinovel. Furthermore all operation and maintenance staff undergo a two year training program with Longyuan. Post service agreement maintenance work will be carried out by Baijiagou's own maintenance division based on site. SLY are confident of their personnel's ability to carry out major maintenance activities, stating that Longyuan personnel have already carried out major component overhauls on wind farms elsewhere in the portfolio. Spare parts provision will be managed by Longyuan's central spare parts division. On our inspection of the spare parts store only small components and consumables were present and no major components. After two years, Baijiagou wind farm will be set a target availability, which is anticipated to be above 95%. This target will be set by Longyuan based on the experience gained while under the agreement with Sinovel. Presently there are no wind farms in SLY's portfolio that are being operated and maintained out with a service agreement with the turbine manufacturer. Information gained during the site visits and subsequent discussions gives an overview of Longyuan's high level approach, however information of detailed specifics including, call-out times, staffing levels, and details of spare parts holdings and policy are unclear. Responses to questions posed by Mott MacDonald showed that SLY management have a good understanding and experience of wind farm operation and the indicated targets seem realistic when considered against general industry expectations.

Since the wind farm was only commissioned in December 2008, there was insufficient data available to give valuable comment on wind farm performance and our performance appraisal is primarily based on a review of the preconstruction feasibility study. SLY has supplied us with production, wind, and availability data for January and February for 2009 which shows a slight increase in targeted production.

The average wind speed at hub height (65 m) has been calculated to be 6.81 m/s and the net capacity factor for Phase II is calculated to be 25.0% which is typical for an onshore wind farm. Our overall impression is that the wind resource assessment is of good quality. Although there are some omissions from the report and no uncertainty analysis has been undertaken, there is evidence of a prudent approach, conservatism and good practice in the feasibility study and we have so far not encountered anything which causes alarm. Initial production figures are in line with the prediction and we have conducted some high level independent checking of the results using NCAR (National Centre for Atmospheric Research) wind data, which show good agreement with the results presented by Longyuan.

(ii) Internal Connection and substations

The Faku Baijiagou Wind Farm is comprised of 33 Sinovel 1.5 MW turbines. The evacuation system operates at 35 kV, where it is then raised to 66 kV for transmission purposes. After a 24 km transmission line, it is raised again to 220 kV where it is connected to the grid.

The evacuation system is a combination of underground and overhead construction. The underground cables are three-core, ungrounded, and direct buried. Each turbine has a short underground length, before being lashed to a riser structure, where it is joined via compression tap to the main overhead trunk line. This design is both a common, and economical, method of construction. All of the evacuation cables are sized correctly and will support the full load of all turbines. The evacuation system does not have either concentric neutral or accompanying neutral. Fibre-optic cable is buried in the same trench at a suitable distance from the power cable when underground, and when overhead is lashed to a messenger cable slung below the power cable.

The substation bus work contains four evacuation circuits. Bus and circuit breakers are sized correctly for the available short circuit current. After the circuits are collected on the common bus, they are stepped up to transmission voltage and the power is transmitted to the Wenhua substation.

The wind farm has capacitive support in the amount of 7 MVar.

The main transformer is sized at 63 MVA. The size of this transformer will support the full output of the units, which is 49.5 MW or 55 MVA. In addition, the transformer is equipped with an on-load tap changer. Specifications of this tap changer are not available.

3.3.5 *Xinjiang Dabancheng No. 3 Wind Power Projects*

Dabancheng No. 3 wind power projects are located approximately 45 km away from Urumqi City, Xinjiang Uygur Autonomous Region in Northwest China. Dabancheng area is known as one of the good wind energy exploring sites in China. As such, many developers have built wind farms in Dabancheng. The No. 3 project consists of five phases owned and operated by the Longyuan's local subsidiary Xingjiang Tianfeng Power Generation Joint Stock Company (XJTF).

The MM Northwest sub-team visited three representative projects in Dabancheng Plant 3: ie., Phase II including 30×Goldwind S48-750 and 5×GW77-1500 WTGs with a total capacity of 30MW; Phase III containing 33×GW77-1500 WTGs with a total capacity of 49.5MW; and Phase IV consisting of 33×GW77-1500 WTGs with a total installation of 49.5 MW as summarised in Table 3.10. The three Phases were commissioned during December 2006 to February 2009. All turbines are fully operational.

Table 3.10: WTG Control Systems in Dabancheng Plant 3

Project	Installed (MW)	WTG Type	Number of WTGs	WTG Control Type
Phase II	30	S48-750kW	30	Stall, fixed Speed, Induction
		GW77-1500kW	5	Pitch, Variable Speed, Direct Drive Synchronous
Phase III	49.5	GW77-1500kW	33	Pitch, Variable Speed, Direct Drive Synchronous
Phase IV	49.5	GW77-1500kW	33	Pitch, Variable Speed, Direct Drive Synchronous
Total	129		101	

(i) Generation and Availability

Dabancheng is well known for its typical 'valley between two mountains' terrain. The two mountains, Bogeda Mountain and Qiersi Mountain, form the Valley, which is 80 km long and 15-30 km wide. The main wind direction is northwest and southeast, which is parallel to the Tianshan Mountains. There is a regular source of wind in the area. We observed that the land is in a half desert environment where there is no agriculture activity. We have no concerns regarding the wind resources.

There are two masts built in Dabancheng Plant 3. Both of them are 50 m high. The Feasibility Studies of Phases II, III, IV were based on the data of #1 mast. We have been provided the wind resources data measured from the mast.

According to the operational data provided by XJTF, the wind farms show a good average availability of Phase II 98.6%, Phase III 96.8% and Phase IV 97.9% since commissioning, all above the guaranteed value of 95%.

Table 3.11: Power Generation at Dabancheng Plant 3 Phase II

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
2007												
Wind speed (m/s)	8.69	7.11	7.27	7.99	8.42	7.61	7.49	6.73	6.64	6.71	7.43	6.26
Generation (MWh)	5,770	4,370	5,350	5,710	6,570	5,400	5,210	4,610	5,020	5,700	7,140	5,210
2008												
Wind speed (m/s)	6.42	8.26	7.58	8.35	9	7.27	7.25	6.79	6.86	6.98	7.13	8.19
Generation (MWh)	4,460	8,410	7,730	7,650	6,490	4,900	4,610	5,300	5,570	5,610	6,320	6,990
2009												
Wind speed (m/s)	8.72	7.32	6.56									
Generation (MWh)	9,360	6,590	6,020									

Table 3.11 above gives the wind speed measured at the site and the actual power generation from January 2007 to March 2009 of Phase II. From the site staff, we understand that the thirty 750 kW Goldwind turbines were commissioned in December 2006, and were fully operational by March 2007. From the generation figures as shown in Table 3.11, we calculated the equivalent load factor of 29% to 34% between January and April 2007. This indicates that the turbines produced more power than expected.

As the five 1.5 MW units were commissioned from May 2007 to September 2008, we are unable to analyse the capacity factor of the whole wind farm without knowing how many units were in operation each month during this period. Assuming the thirty-three units were all in operation October 2007, the generation data during this period suggests the equivalent capacity factor is from 25% to 42%, average of 31%. Thus generation performance is as expected from the feasibility study.

Commissioning of Phase III, consisting of 33 units of GW77/1.5 MW, started in February / March and finished in November 2008. The plant passed the commissioning tests and was fully operational from December 2008. The average load factor between November 2007 and March 2009 is around 33% which is higher than the projection of 31.5% produced in the feasibility study. We consider this to be due to the operational data used, this was taken during the strong wind period, whereas the forecast is an annual average.

Phase IV has the same wind turbines as in Phase III. We were told by the site staff Phase IV has been fully operational since February 2009. The operational data from the first three months in 2009 indicates good power production from 13.96 GWh to 15.87 GWh, giving an equivalent power factor of 37% to 43%. We attribute this to the strong wind period in the winter.

On the Dabancheng site there is a control building with operational staff for monitoring activities for each wind farm.

The three wind farms are currently under a two-year service and maintenance agreement with Goldwind. The onsite operational staff were satisfied with the services provided by the manufacturer. Furthermore, as Goldwind's factory is located in Urumqi, it could respond to emergencies and offers spare parts promptly.

We were told that there are fifty-seven permanent staff on the site responsible for O&M activities and working together with the manufacturer's service team. This staffing level appears high compared to the staff number of similar wind farms we have seen elsewhere in the world. Given that labour costs are generally low in China, it is understandable that XJTF has manned a relatively large number of staff in order to ensure they are in a position to be responsible for the maintenance after the guarantee period.

(ii) Internal Connection and Substations

As mentioned earlier, the Phases II, III and IV wind farms in the Plant 3 feature Goldwind turbines. The three wind farms were also designed by the same Design Institute group and, as such, are similar in methodology.

We note that none of the wind farms has an on-site substation, instead each directly connects to the Dafeng grid substation via 35 kV connection systems. The grid substation is invested by Longyuan and operated by the local grid company.

The evacuation systems for all three phases are a combination of underground and overhead construction. The underground cables are three-core, ungrounded, and direct buried. Each turbine has a short underground length, before being lashed to a riser structure, where it is joined via compression tap to the main overhead trunk line. This design is both a common, and economical, method of construction. All of the evacuation cables are sized correctly and will support the full load of all turbines. The evacuation system does not have either concentric neutral or accompanying neutral. Fibre-optic cable is buried in the same trench at a suitable distance from the power cable when underground, and when overhead is lashed to a messenger cable slung below the power cable.

There are two main transformers in the Dafeng substation with the capacity of 120 MVA and 150 MVA respectively. The Phases II & III and Phase IV are connected to the No.1 and No.2 transformers respectively. We understand that Phase IV shares Transformer No.2 with a wind farm owned by another developer. At present, the transformers' capacity is sufficient to deliver the power to the grid. We were informed Transformer No.3 has been planned for Phase V expansion.

3.3.6 *Gansu Yumen Wind Power Projects*

The Yumen site is located approximately 12 km east of Yumen City, Gansu Province. The three wind farms were developed by Gansu Jieyuan Wind Power Generation Company Limited (GSJY), a subsidiary of Longyuan. MM team visited the three representative projects, ie, Yumen II with 14 wind turbines installed, totalling 11.9 MW; Yumen III with 54 WTGs, totalling 45.9 MW; and Diwopu I with 58 WTGs, totalling 49.3 MW. The three projects use the same turbine model of Gamesa G58 850 kW which adopts the variable speed and doubly fed induction generator.

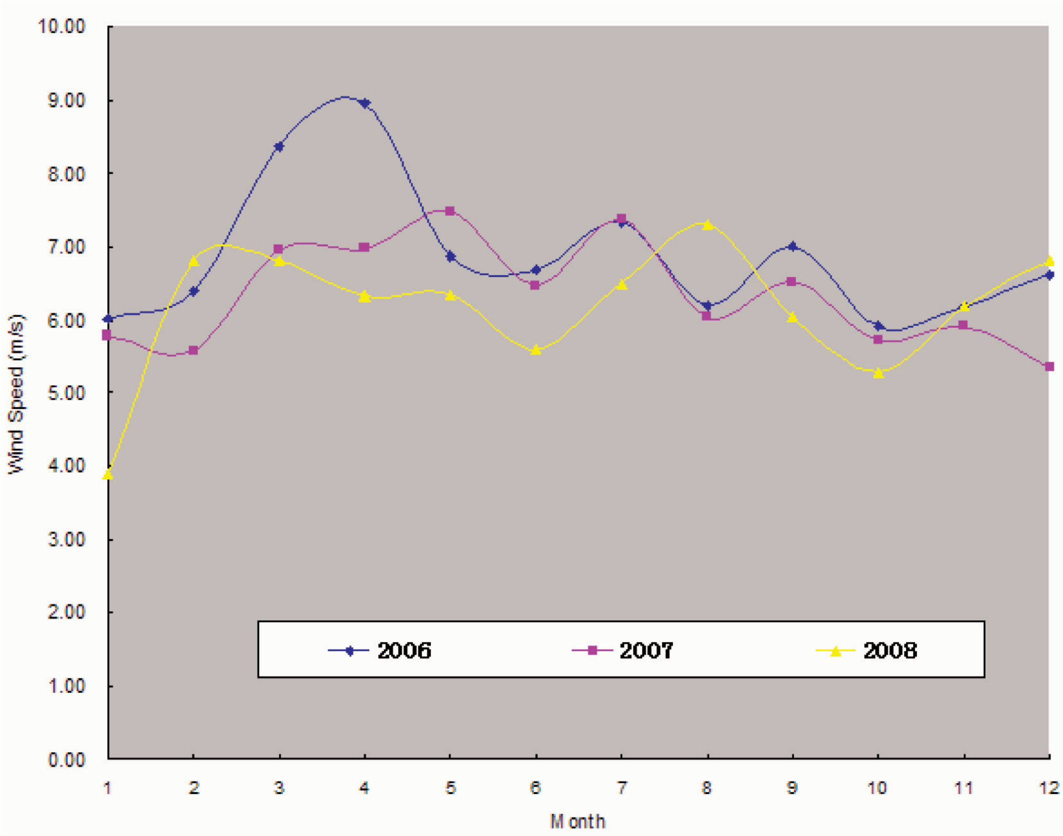
Yumen Phases II & III have been fully operational since December 2006 and April 2007 respectively, while Diwopu I was in the commissioning period when we visited the site. We were informed the commissioning of Phase IV is expected to be finished in July 2009.

Yumen is located in the well-known Hexi Corridor in Gansu Province. Situated between North Mountain and Qilian Mountain, the terrain of the wind farm site is flat. According to the on-site mast data, wind speed is stable and distributed in a reasonable range. Extreme wind speed (above wind turbine cut-out speed) is seldom found in the record. Wind direction is mainly West and East as stated in the feasibility study. This is beneficial to wind turbine operation. We also noted from the SCADA data that the actual turbulence between turbines are bigger than envisaged in the feasibility study. We consider these differences may be caused by the turbine layout.

In spring and autumn dust storms occasionally pass through the site which could bring dust and dirt to the blades. Extra care should be taken to prevent turbine outages. In addition, extreme low temperature weather occurring in winter may cause low-temperature warnings and outage of wind turbines.

According to the data supplied by the site staff, the measured annual average wind speed on site is 6.2m/s (2007), and 6.3 m/s (2008). Figure 3.1 is an example of wind speed variation of a meteorological mast installed in phase II from 2006 to 2008. The equivalent operating hours per annum is around 2100-2200 hours in average according to on-site statistics, slight lower than the forecast of 2321 hours in the Feasibility Study.

Figure 3.1: Wind Speed Curve in Yumen (2006-2008)



(i) Availability and Generation

Table 3.12: Operational Availability of Yumen Phases II, III and Diwopu I

	Phase II		Phase III		Diwopu I	
Year	**2007**	**2008**	**2007**	**2008**	**2007**	**2008**
January	99.04	99.38		97.28		
February	99.18	93.73		94.15		
March	98.20	98.11		97.22		
April	98.94	99.40	97.92	98.45		
May	99.49	98.54	98.34	96.87		
June	99.25	98.54	98.98	98.20		97.80
July	98.13	97.50	98.62	98.59		97.71
August	98.75	98.68	99.41	98.63		98.57
September	99.26	99.08	99.01	99.09		98.64
October	99.05	99.33	98.92	98.41		98.52
November	98.68	98.85	99.30	98.58		99.15
December	97.12	95.89	96.87	98.68		97.47
Annual	98.76	98.09	98.06	97.85		98.27

Similar to other manufacturers, the definition used by Gamesa to calculate WTG availability only considers events that have occurred inside the turbine generators. It does not consider the outages of any other components in the wind farm, a wind speed beyond the operating range, extreme weather condition such as icing, lighting or any Force Majeure events.

Table 3.12 presents the operational availability supplied by the site staff. The data shows that the monthly availability of Phases II and III is lower in February 2008 than the other months. This was caused by an unusually low temperature of -27°C. We note the turbines installed on this site are designed to operate in the temperature range between -20°C and 40°C. Most turbines on the site gave low temperature warnings and stopped generation. The bad weather lasted for a week.

The operational generation record supplied to us by the site staff indicates the power outputs in the winter, spring and autumn for all Phases were relatively higher than the summer season. This is in line with the wind speed pattern as discussed earlier and air density at this location.

We note that the power generation in the early part of 2008 was lower than expected. The site staff told us this was caused by poor weather conditions.

Yumen Phase III and Diwopu Phase I are currently under a service and maintenance agreement with Gamesa, which has allocated their services staff on the site. This agreement lasts for two years from commissioning and includes an availability warranty of 95% (excluding scheduled maintenance and outage out with manufacturers control e.g. grid downtime) with liquidated damages payable for shortfall (calculated at end of two year duration). A WTG of Yumen Phase III was recalled to the manufacturer in 2008 due to a fatal defect. The on-site operating record indicates that the fault was caused by a winding destroying the insulation in the generator.

The two-year maintenance period for Yumen Phase II has expired and the onsite staff of GSJY are therefore responsible for the maintenance work under the guidance of Point Inspection Mechanism, which is the maintenance practice established by headquarters and applies to all wind farms in Longyuan. Although the same type of WTG, Gamesa G58, is installed in the three wind farms, there were some technical modifications in different batches of orders. For example, we were told the WTG control system in G58 is renewed in later phases. We expect the newer technology would enhance operation of the wind farms.

(ii) Internal Connection and Substations

The three wind farms were designed by the same Design Institute group and, as such, are similar in methodology. As mentioned earlier, all three projects use Gamesa G58 turbines, with output at 850 kW. Phases II and III share a common bus while Phase IV has its own.

Phases II and III share a common bus and between them have ten evacuation circuits. Diwopu I uses 8 evacuation circuits on its own bus. We note that these wind farms feature a 10 kV secondary side, whereas the other wind farms in the portfolio were at or above 33 kV. It is not possible to calculate an exact line loss without a cable schedule, but typically a voltage this low results in higher then normal line loss.

The 35 kV bus is split into two sections, connected by a normally open bus tie breaker. The ratings of associated switchgear, instrumentation, and bus are appropriate for the load. Protection schemes in place indicate typical bus differential and evacuation circuit over current, which are appropriate.

The main step-up transformers are two identical 50 MVA units connected on a common 110 kV bus. This configuration could enhance reliability when one of the main transformers experiences an outage. A single 50 MVA unit will not be able to carry the output of all of the turbines, but it will be able to bear the burden of additional units so that an increased percentage of revenue can still be maintained despite one transformer outage. A 0.9 utilization factor was used in sizing these units. This is appropriate considering the quantity of turbines, cable in the ground, and secondary side voltage of 10 kV. The primary side of these units is rated at 121 kV. In addition, the transformers are equipped with a 16 position Load tap changing devices, which have the capability to raise or lower the voltage in ± 8 taps by 1.25% per tap. As a result of the tap changer, the transformer has MVA ranges of 108.9 kV through 133.1 kV. The unit's primary side is at 121 kV, to connect to the 110 kV grid.

3.3.7 *Hebei Shangyi Shiren Wind Power Project*

Longyuan Zhangjiakou Wind Power Generation Co., Ltd (LYZ), a subsidiary of Longyuan, owns Shangyi Shiren Phase I located in Shangyi County, approximately 116 km away from Zhangjiakou City, Hebei Province. The project consists of 33 Acciona AW-77/1500 1.5 MW wind turbines and has a consolidated installed capacity of 49.5 MW. It was commissioned during July to October 2008 and has been fully operational since then.

(i) Generation and Availability

The wind farm is constructed on highland which ranges in altitude from 1700 m to 1880 m ASL. The terrain is smooth and flat and does not present any concerns regarding shading, channelling, or excessive gradient which could cause adverse wind. The climate is very cold and windy, and the average yearly temperature is 0.87 ^{o}C. This factor can be expected to influence performance in terms of blade icing.

The site facilities include WTGs, connector cables, substation equipment, a control building, and workers' accommodation. The control building for the monitoring activities is located in the centre of the wind farm. The site appears well equipped and maintained, and the Acciona SCADA system was made available for our inspection, which was also of good quality and fully functional. Approximately 20 staff are employed permanently in the operation of the wind farm, which is higher than we have seen elsewhere. Site roads are rough and could present access problems for heavy plant in snow and ice.

The feasibility study is based on 12 months data from 2004/2005 from a 40 m mast that was installed near the site by LYZ and Shangyi Meteorological Station. It was reported in the feasibility study that the average wind speed at height 65 m was 8.2 m/s, the estimated annual production with 33 units of 1.5 MW WTGs was 114 GWh, and average utilisation hours were 2300 hour per unit. Our overall impression is that the wind resource assessment is of good quality. LYZ installed a 70 m mast on site in 2007 and used this as the basis for assessing the site conditions and production estimate.

Since Shiren Phase I was only commissioned in November 2008 our performance appraisal is primarily based on a review of the feasibility study. In addition, the proposed hub height in the feasibility study was 65 m which is different from the actual hub height in 60 m.

LYZ has supplied us with the production and wind speed data from July 2008 to March 2009 which shows the initial production figures are in line with the prediction and we have conducted some high level independent checking of the results using NCAR wind data, which agree with the results presented by LYZ.

The wind farm is currently under a service and maintenance agreement with Acciona. This agreement will last for two years and includes an availability warranty of 95% with liquidated damages payable for shortfall (calculated at end of two year duration). The availability data supplied by LYZ shows that the average availability from September to December 2008 is 95.4%, slightly higher than the warranty level. According to the agreement, the production losses caused by liquated damages will be paid and calculated based on the average production of WTGs. The defects liability period for the WTGs also expires after two years. LYZ has provided us monthly O&M reports, three month maintenance records, and 6 month maintenance reports which demonstrated an adequate maintenance management in place. We have also discussed O&M with the Acciona personnel on the site. We were informed that the wind farm adopted the every six month maintenance plan in accordance with the manufacturer's recommendation. Training of LYZ personnel (six people 14 days) is included in the agreement with Acciona. Post service agreement maintenance work will be carried out by LYZ's own maintenance division.

(ii) Internal Connection and Substations

The thirty-three Acciona turbines are divided into three groups, each with 11 WTGs connected by the seven evacuation circuits to a single 35 kV bus. Documentation indicates that the turbines have a short (<70 meters) underground run to the main overhead trunk line.

LGJ -150 overhead line circuits are used in the 35 kV energy collection system with the rated capacity of around 27 MVA which is greater than the maximum generation output of 16.5 MW from 11 WTG units. Thus, the size of the overhead line is sufficient for power collection from WTGs and exportation to the 35 kV bus-bar.

From the 35 kV bus, the voltage is stepped to 110 kV transformer equipped with an on-load tap changer. We were told the site has plans to expand to another 33 turbines. Current equipment installed is rated to handle a closed bus tie containing another 33 turbines. Upon completion of the expansion project, installed equipment will still be rated correctly.

The substation bus work is one 35 kV collector bus supporting seven evacuation circuits. Bus, switchgear, and instrumentation are rated correctly.

The main transformer is sized at 50 MVA. The size of this transformer supports the full output of the units. In addition, the transformer is equipped with a 16 position load tap changer, which has the capability to raise or lower the voltage in ± 8 taps by 1.25% per tap. As a result of the tap changer, the transformer has MVA ranges of 108.9 kV through 133.1 kV. The unit's primary side is at 121 kV, to connect to the 110 kV grid.

3.3.8 *Inner Mongolia Bayin National Wind Concession Project*

Baotou Bayin wind farm is a concession project located in Damao County, Northeast of Baotou City in Inner Mongolia Province. The project was developed by Longyuan Baotou Wind Power Generation Co., Ltd. (LYB), a subsidiary of Longyuan. It comprises 134 Goldwind GW77-1500 wind turbines and has a consolidated installed capacity of 201MW. At the date of inspection, 106 wind turbines had been commissioned, a process that began from the end of August 2008 and would be completed by the end of April 2009.

(i) Generation and Availability

Operational data was made available, however the wind farm is still in its commissioning Phase and the data is, at this time, of limited use. Production since commissioning is shown in Table 3.13 . It is noted that the commissioning period will take approximately eight months, which is longer than we would expect in other places. It appears the long commissioning period was not due to the extreme weather conditions as the fastest commissioning rate seems to have been during December and January when temperatures are as low as -35°C. Indeed, February appears to have been the slowest month, and the reason given was the Chinese Spring holidays when most workers took a month off.

Table 3.13: Bayin Monthly Production since Commissioning

Date	Turbines of Commissioned (Unit)	Generation (GWh)
Sep 2008	14	0.91
Oct 2008	24	5.31
Nov 2008	28	8.06
Dec 2008	83	15.34
Jan 2009	99	20.92
Feb 2009	99	22.30
18th Mar 2009	106	22.57
Total		95.41

For the wind turbines that are commissioned, availability figures are high and the wind farm is in good physical condition. The wind farm control centre is well equipped and the SCADA system made available for inspection is also of good quality and fully functional. It was noted that no Accident Record book is kept on the wind farm site, and the wind farm manager said that no accidents had occurred during the installation of 134 wind turbines. We would suggest an Accident Record should have been set up as a good practice especially on the sites in remote locations with extreme weather conditions. Meteorological data for the site was readily provided.

The wind farm is currently under a service and maintenance agreement with Goldwind. This agreement will last for two years and includes an availability warranty of 95% with liquidated damages payable for shortfall (calculated at end of two year duration). Goldwind personnel were also questioned about the O&M. We were informed that the first scheduled maintenance taking place 500 hours after the commercial operation and thereafter one maintenance every six months.

(ii) Internal Connection and Substations

The 134 Goldwind 1.5 MW turbines, are divided into ten groups, each having 13~14 WTG units connected to the 35 kV cable circuit, feeding into a 35 kV bus-bar in the wind farm substation. 150mm^2 XLPE cable circuits are installed in the 35 kV energy collection system with rated capacity of around 22 MVA which is just above the maximum output of 13 or 14 WTG units. We consider the cable is appropriately sized to send the power to the on-site substation.

The windfarm contains both capacitor banks and reactor banks. Each section of 35 kV bus has identical capacitive and reactive support. The total capacitive support for each bus is 19.2 MVar, while the reactive support is 2.4 MVar.

The substation bus work is split into two 35 kV turbine collector busses. Each section of bus supports five evacuation circuits, one reactor, two capacitor banks, and appropriate switchgear. A normally open bus-tie breaker connects the two sections. The two 35 kV bus sections go to each of their respective transformers, at which point they are stepped up to 220 kV. The primary side shares a common 220 kV bus. Bus, switchgear, and instrumentation transformers are all rated appropriately.

The main transformers are two identical units. Each of them is 100 MVA, to support sixty-seven 1.5 MW turbines. These units appear to be autotransformers and as such do not have an on-load tap changer. This is to be expected as the transformer ties directly into the substation 220 kV side and no transmission line is present. Each section is then stepped up from 35 kV to 220 kV at the Wanghai substation.

We consider the electrical layout in the substation provides certain degree of flexibility. In the event that any of the two main transformers is out of service, or an associated circuit breaker in maintenance, the arrangement allows part of power produced to be sent through the other 220/35 kV transformer by closing the 35 kV bus-bar coupler.

3.3.9 *Chifeng Wind Power Projects*

Three wind farms make up the Chifeng Xinsheng Wind Power Generation Co. Ltd's (CFXS) portfolio — Sunjiaying Phase I with 67 Goldwind S48-750 wind turbines, totalling 50.25MW; Sunjiaying Phase II with 66 Goldwind S48-750 wind turbines, totalling 49.5MW; and Wudaogou Phase I with 67 Goldwind S48-750 wind turbines, totalling 50.25 MW.

Sunjiaying Phase I and Wudaogou Phase I were fully operational from December 2006 and Sunjiaying Phase II was fully operational from November 2007. The wind farms are co-located about 110 km away from Chifeng City, Inner Mongolia, China. Due to the poor weather conditions and icy road when the site visit was taking place, we were not able to visit the wind farm sites or the control centre, despite concerted effort. However, the CFXS's office in Chifeng City was fully accessible to the MM team.

(i) Generation and Availability

We note that selection of the WTGs in Sungjiaying Phase I and Wudaogou Phase I has been changed since the feasibility study. It was originally envisaged to import 33$\times$1.5 MW WTGs and an energy yield calculation was undertaken on this basis in the feasibility study. A consent adjusting feasibility study about the selection of the WTGs for Sunjiaying Phase I and Wudaogou Phase I issued by Xingjiang Wind Power Design Institute indicates the reason for the change was to meet the requirement of using more than 70%

Chinese made equipment and support Chinese wind turbine industry. No energy yield study has been undertaken using the turbine model of S48-750. Although MM has no concerns over the suitability of the Goldwind S48-750 wind turbines, it is advisable, as per the international best practice, to undertake a detailed study including micro-siting when a decision was made to change to 67×750 kW turbines.

Operational data was tabulated and could be verified through visual inspection of the online SCADA system. The availability figures of Sunjiaying Phase I as shown in Table 3.14 are high, averaging around 96%, although it is noted that the O&M contract specifies a contractual availability for the first two years of 97% (provided by the manufacturers Goldwind). The deputy company manager stated the compensation would be resolved by the Headquarter after the end of the two year warranty period (agreed end of commissioning for contractual purpose is the end of April 2007). The other two wind farms show a good average availability of Sunjiaying Phase II 97.9% and Wudaogou Phase I 97.75% since commissioning, all above the 97% guaranteed value. The average yearly generation of three wind farms is presented in Table 3.14. Comparing the actual generation with the forecast made in the feasibility studies as presented earlier in this report, we are able to confirm that all three wind farms generate the electricity as expected.

Table 3.14: Chifeng Yearly Operational Data

	2007		2008	
	availability	production (GWh/annum)	availability	production (GWh/annum)
Sunjiaying I	96%	112.60	96.2%	133.35
Sunjiaying II	—	—	97.9%	134.19
Wudaogou I	97.7%	133.13	97.8%	160.90
Total		249.73		428.44

CFXS has installed two masts, one for Sunjiaying, and another for Wudaogou, to continue monitoring the wind resources at the sites during operational Phase. Meteorological data for the site was readily provided.

Although the MM team were unable to visually inspect the wind farm site, or interview the onsite personnel or Goldwind staff due to poor weather conditions and icy road, the real-time SCADA data sent to the CFXS office in Chifeng City suggested the wind farms were still in operation despite the weather. We were told that approximately 60 staff are permanently employed in the running of the three parts of the wind farm, which is considerably higher than we have seen elsewhere in the world.

(ii) Internal Connection and Substations

The Sunjiaying Phase I and the Sunjiaying Phase II windfarms were designed by the same Design Institute group, and as such they are similar in methodology. The Sunjiaying Phase I and Phase II windfarms utilize Goldwind units. Each Phase has its own section of bus. Each section is then stepped up from 35 kV to 220 kV at the substation. The size of the Phase II main transformer indicates that there will be future expansion, but details were not available at this time.

The evacuation system of each Phase is a combination of underground and overhead construction. The underground cables are three-core, ungrounded, and direct buried. Each turbine has a short underground length, before being lashed to a riser structure, where it is joined via compression tap to the main overhead trunk line. This design is both a common, and economical, method of construction. All of the evacuation cables are sized correctly and will support the full load of all turbines. The evacuation system does not have either concentric neutral or accompanying neutral. Fibre-optic cable is buried in the same trench at a suitable distance from the power cable when underground, and when overhead is lashed to a messenger cable slung below the power cable.

The substation bus work of each Phase consists of a single collector bus accepting two 35 kV overhead evacuation circuits. Bus, switchgear, and associated equipment are all rated correctly. The substation is not equipped with bus tie breakers. As such, outage of the main step up transformer will render that Phase inoperable. Typically a bus tie breaker is installed to mitigate the impacts of outage situations.

The size of the main transformer for Sunjiaying Phase I is 63 MVA, which is appropriate, as the windfarm will produce 55 MVA assuming typical power factor of 0.9. In addition, the transformer is equipped with a 16 position Load tap changing device, which has the capability to raise or lower the voltage in ± 8 taps by 1.25% per tap. As a result of the tap changer, the transformer has primary side voltage ranges of 198 kV through 242 kV.

The size of the main transformer for Sunjiaying Phase II is 120 MVA, which is significantly larger than needed considering the wind farm produces 55 MVA assuming typical power factor of 0.9. The size of this unit indicates that future expansion is likely. In addition, the transformer is equipped with a 16 position Load tap changing device, which has the capability to raise or lower the voltage in ± 8 taps by 1.25% per tap. The result of the tap changer being the transformer has primary side voltage ranges of 198 kV through 242 kV.

The substation bus work is split into two 35 kV turbine collector busses. The Wudaogou project exports through on of the bus sections, while the other is under construction for future use. Bus and switchgear are all rated correctly to support the future closing of a bus tie breaker.

The windfarm contains both capacitor banks in the form of two capacitor banks at each 35 kV bus section. The total capacitive power available is 12 MVar.

The main transformer is rated at 50 MVA to support the full output of the units. Information regarding either a tap changer or off-load taps is not available at this time. We noted that the transformer impedance is high, at 14 percent. Typical ratings for a transformer of this size should be around 8 percent. It is possible that this transformer is an older style unit, using pumped oil to cool its core. Specifications of this detail level are not available.

3.4 ***Operational and Maintenance Arrangements***

To adequately operate a wind farm, it is necessary to have an experienced team to constantly monitor the wind turbines, to ensure prompt resolution of any problem that may occur to wind turbines, and to avoid downtime which could lead to reduction electricity production. Following the site visits to representative wind farms MM acknowledges that the overall Longyuan strategy is to rely on wind turbine manufacturers during the warranty period of the wind turbines and to subsequently handover this responsibility to its own team.

The warranty provided by the manufacturers for the Longyuan wind farms is on average for a two year period, in line with current industry standards, and is similar to wind farms in other countries. MM considers this warranty duration generally acceptable for all wind turbine technologies which have proven track record and sound experience. However, for wind turbine manufacturers such as Goldwind and Sinovel, which did not provide a satisfactory track record, we consider that, in future contract negotiations, inclusion of a longer period warranty would provide additional comfort.

For a wind farm, high availability is vital in order to maximise revenue. A number of factors could affect the availability of which O&M arrangement is likely to have the greatest impact. There is a commercial balance between the O&M cost and availability and this needs to be considered carefully in contract negotiations. Liquidated damages are the key buffer against poor availability. Finally, care is needed during the contract negotiation of the O&M contract with respect to the definition of "availability;" turbine suppliers will endeavour to define within availability some events that Longyuan would expect to consider as non-availability. During site visits we raised these points and requested evidence of the relevant documentation. In MM's view these issues have been generally properly addressed by Longyuan in the negotiation of turbine supply agreements. We are satisfied with this arrangement.

All turbine supply agreements that MM has reviewed include training programs arranged by the manufacturers, these are usually comprehensive, and include four weeks training in factories and on site, covering most of the topics and problems that may occur on site. The service team is trained to use the maintenance manual, keeping records of faults, operation and control of turbines, erection method for replacement, maintenance procedures, trouble shooting, and spare part management. MM understood that in addition to the standard training, Longyuan staff also assist manufacturer's team during scheduled and unscheduled maintenance, MM appreciates the potential experience gained by the team through this arrangement.

As previously discussed, most of the wind farms we visited were recently commissioned, still in warranty period, and maintained by the manufactures. According to the maintenance records on site, and interview of manufacturers' onsite staff, the scheduled maintenance has been carried out in accordance with the defined in the turbine supply agreement. We are provided a Goldwind 750 kW Wind Turbine Maintenance form which elaborates the inspection items to be checked by the manufacturer's maintenance staff every half-year. The form is comprehensive and includes the following sixteen aspects: preparation, environmental parameters, blade, hub, main shaft, gearbox, shaft coupling, generator, pitch control system, hydraulic system, mechanical brake system, sensor, main control board, top control board, tower, and nacelle.

A Longyuan maintenance team employed for each project company is trained by the WTG suppliers and in position to assist during the warranty period, and will be responsible for performance maintenance activities on wind turbines at a later date.

In addition, Longyuan informed MM it issued a Maintenance Manual in compliance with Chinese wind power industry practice to each project company to standarise the maintenance activities. A Point Inspection (PI) Scheme is a regularly checking practice defined in the manual to maintenance wind turbines and their auxiliary equipment in order to find potential problems before a fault happens. PI includes following five aspects:

- Routine visual inspection by operators;
- Regularly inspection by Point Inspection staff;
- Technical inspection by professional engineers;
- Technical diagnosis and trend analysis by WTG experts;
- Equipment accuracy test by engineers

A PI practice for tower part, shown in Table 3.15, defines the inspection items, appropriate standards, schedule, inspection method, and frequency. Potential hazards could be reported through PI and be dealt with in time.

Table 3.15: PI Scheme (Tower Part)

Item	Standard	Schedule	Method	Status
Tower inside and outside surface	No oil leakage, corrosion, fade, or cracks; Grounding well	W	Visual	○
Vibration	No exceptional vibration	M	Listening & Touching	○
Tower gate lock	No corrosion, or damage	M	visual	○
Tower gate	Closing tight, No corrosion	M	Visual & Testing	○
Base flange bolt M42×220-10.9 (124)	Right number, No break, 4500N.m	M	Testing	△
Tower flange	No damage	H	Testing	△
Tower flange bolt M42×220-10.9 (84)	Right number, No break, 4500N.m	H	Testing	△

Status: ○ — when the turbine is in scheduled maintenance; △ — when the turbine is in unscheduled maintenance

Schedule: D — Daily; W- Weekly; M — Monthly; H — once half a year; A — Annual

In MM's view, maintenance from an external specialised company gives more confidence in the quality of the service. However, we acknowledge that there are few companies with a significant track record in the market and Longyuan may consider it cost effective to manage this service internally. This could help consolidate the rapid expansion of its wind portfolio that has taken place in recent years and contribute to its ambitious plans for future growth. Some companies with big wind farm portfolios use the same strategy as Longyuan and have their own service team. MM considers it is necessary to have a corporate strategy for training and O&M that defines best practice principles during these activities in order to ensure the same quality of maintenance and to share experience.

3.5 ***Conclusions***

The wind resource assessments in the representative wind farms were carried out by a number of different Chinese design institutes. The methodology and reporting of results are common to all studies and are based on the Chinese standards. Most of the content of the Chinese standard is derived directly from a Western publication and provides a good overview of the well established measurement based wind resource assessment method or MCP. Hence the approach to wind resource assessment in China is largely consistent with international practice.

The meteorological mast heights in several feasibility studies are reported to be shorter than the wind turbine hub heights, which is a degree of non-compliance with standards. Due to lack of detail on methods of correlation for wind speed data, the energy calculation shows conservatism in approach. No uncertainty analyses are provided in the feasibility studies due to an omission in the Chinese approach. However, they are important for making commercial decisions about wind farm performance as they describe the confidence and hence degree of risk associated with a prediction.

From a pool of studies reviewed we can conclude that there is a consistent approach to wind resource assessment and the adopted methodology is largely consistent with standard international practice. According to above analysis for each wind farm, most generated electricity in line with our expectations and, some exceeded the prediction. Hence, the conservatism of the wind resource assessment approach in China is confirmed.

The wind turbines in the asset portfolio were supplied by both international and domestic manufacturers. All the wind turbines models reviewed with a rated power range of 750 kW to 2 MW have adopted modern designs in line with the current technology standards.

The international turbine suppliers including GE, Vestas, Gamesa and Acciona presented adequate operational experience and good track record on the global stage and we have no concerns over the quality of their products. Both models of Goldwind S48 and GW77 are based on mature technologies. Sinovel has track record in China and its design and manufacturing process gave us comfort as well.

The operational data indicates that most representative wind farms have been performing satisfactorily. Some electrical equipment is of high quality and housed in appropriate buildings such as Rudong wind farms. The design criteria used to size the inter-array cables is appropriate for the amount of power they need to carry. In Huangang wind farm, the size of main transformer in the step-up substation was smaller than the full outputs of the wind farms. We were informed this had been resolved by an expansion in July, 2009.

The warranty provided by the manufacturers for the Longyuan wind farms is on average a two year period, in line with current industry standards and similar to wind farms in other countries. Longyuan maintenance teams in the project companies are trained by the relevant turbine suppliers during the warranty period, and are responsible for performance maintenance activities on wind turbines after the warranty period. We consider the operation and maintenance arrangements in place to be adequate.

The staffing level in the wind farms we visited appeared higher than we have seen elsewhere in the world. Given the labour costs are relatively low in China, this may not have a significant impact on the financial performance. We therefore consider the current staffing level is adequate from a technical point of view.

4 Grid Connection Assessment

4.1 ***Introduction***

Our findings of the grid connection assessment presented in this section of the report are limited to the eighteen representative wind farms. The assessment has been undertaken largely based on the data provided by the Longyuan and their subsidiaries during the site visits and the following documents:

- 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
- Feedback to the Mott MacDonald's Questionnaire
- Site visit records

It should be noted that when assessing the impact of the wind farm connections on the local network and system operation, we have relied on the network topologies supplied to us in the above reports. Mott MacDonald has not undertaken any independent simulation or calculation to validate the inputs and results in the studies conducted by different Chinese Design Institutes. The Chinese Design Institutes refer to the following eight design institutes in the PRC, all of which are independent third parties to the Company.

(1) Jiangsu Electric Power Design Institute (江蘇省電力設計院), a subsidiary of Jiangsu Electric Power Company Limited, mainly provides engineering and consulting services in the PRC and Jiangsu for electric power industry, such as power systems design, survey and assessment on coal power projects.

(2) Fujian Electric Power Survey and Design Institute (福建電力勘測設計院), a subsidiary of Fujian Electric Power Company Limited, mainly provides power systems design, and survey and assessment on coal power projects as well as power transmission projects in the PRC and Fujian.

(3) Jilin Electric Power Survey and Design Institute (吉林省電力勘測設計院), a subsidiary of Jilin Electric Power Company Limited, mainly provides power systems design and consulting service to power projects in the PRC and Jilin.

(4) Liaoning Xinchuangda Electric Power Design Company Limited (遼寧新創達電力設計研究有限公司), mainly provides power systems design in the PRC and Liaoning.

(5) Xinjiang Electric Power Design Institute (新疆電力設計院), mainly provides comprehensive engineering and consulting service such as power systems design and survey, project assessment, construction, and environmental impact assessment in the PRC and Xinjiang.

(6) Gansu Electric Power Design Institute (甘肅電力設計院), a subsidiary of Gansu Electric Power Company Limited, mainly provides power transmission design and survey in the PRC and Gansu.

(7) North China Power Engineering (Beijing) Co., Ltd (北京國電華北電力工程有限公司), mainly provides design, survey and consulting services to electric power systems, as well as to various coal power and wind power projects.

(8) Inner Mongolia Electric Power Survey and Design Institute (內蒙古電力勘測設計院), a subsidiary of Inner Mongolia Electric Power Group Limited, mainly provides design, survey and consulting service to coal power and wind power projects, as well as to transmission projects.

The results of the studies by Chinese Design Institutes demonstrate whether or not the wind farms could be connected to the grids, what system enhancements are needed to accommodate the wind power and set requirements for key equipment such as main transformers, switchgears and circuits. The studies and results provide Mott MacDonald with evidence of adequacy of the grid connection schemes and confirm the grid capability to deliver the wind power to the systems.

We expect any changes of the network configurations in the local power grids after commissioning of the wind farms to reinforce the local network capability and to improve the system operation and performance, which will ultimately benefit the wind farm connections and operations.

To determine whether a wind farm could be connected to a power grid it is common practice to investigate the following:

- Capability of transmission circuits and transformers for power evacuation from the dedicated step-up substations at wind farm sites to the grid connection points
- Network configurations at the grid connection points and potential operational issues in the local power grids
- Reactive power capability of the wind farms to meet grid connection requirements
- Arrangements of internal energy collection systems
- Potential impact of system faults on wind farm operations
- Power quality issues of the wind farm connections to the grid.

It is crucial to examine the above technical issues in order to identify risks which may affect normal operation of the wind farms and subsequent impact on power export to the grids. Our assessment is therefore centred around these issues.

4.2 ***Key Issues Addressed in Grid Connection Studies***

In China, a feasibility study needs to be reviewed and approved by a panel expert appointed by a Provincial Development and Reform Commission (PDRC) before a grid connection study undertaken. Upon an approval of the feasibility study and project construction, a wind farm developer should engage a qualified electric power design or research institute to perform the grid connection study and design the connection from the project site to the grid. The practices and key issues investigated in the grid connection study in China in comparison with the international norm are summarized below.

(i) *Connection point and voltage level*

Identification of grid connection point and selection of a voltage level should ensure that the maximum power output from a wind farm can be effectively transmitted to the grid. In China, depending on the installed capacity, a wind farm is normally connected to the closest 110 kV or 220 kV substation in the vicinity of the project. This is subject to the possibility of expansion of the substation and sufficient transmission circuit and transformer capacity to export the electricity generated from the wind farm. In some cases, connection of a wind farm may require construction of a new substation.

If possible, at least two grid connection points (substations) should be considered and evaluated. A preferred one is then chosen by comparing flexibility of the connection, transmission line corridor from the wind farm to the connection point, investment requirement, and system operation performance for all options.

(ii) *Main transformer capacity*

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. It is evident that some Chinese institutes apply a principle to size the main transformer's apparent power capacity equal to the total installed wind turbine real power capacity. While this is acceptable, given the utilisation hours of a wind farm is usually low, it is recommended that the transformer should be sized slightly greater than the installed generation capacity to avoid overloading. Where several transformers are installed in the same wind farm, good size of transformers could ensure adequate reliability of power export while one of them is out of service.

(iii) *Conductor size*

Once the grid connection point is chosen, conductor type and size of the transmission circuit should be identified. The conductors of a circuit should be sized to have a thermal rating adequate to meet the requirement to export the maximum apparent power output from the wind farm, this should also take into account potential connection of other generation sources connected to the circuit.

(iv) *Power system studies*

Power system steady state and dynamic performance studies including load flow, contingency analysis, and even transient stability are carried out to assess the steady and dynamic performance of the power system under typical operational scenarios after the connection of the wind farm. Although it may not be required to meet the N-1 security criteria for the transmission network from the wind farm substation to the grid connection point, it is usually required the N-1 security criteria to be met for the transmission network at the grid connection point. The system studies are used to identify requirements for reinforcement or additions in order to meet the N-1 criteria.

Fault level calculation aims to choose appropriate switchgear ratings, so that the switchgear is capable of withstanding potential fault currents at the wind farm substation and has sufficient margins to withstand fault current increase over a longer period, for example, twenty years.

(v) *Reactive power compliance*

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. Although 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 under typical operating modes.

(vi) *Power quality check*

Design principles adopted in wind generators differ from conventional synchronous generators. Connection of many 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 specification of wind farm grid connection requires an assessment of the power quality to ensure quality indices within the given limits in accordance with relevant technical standards. At present, most Chinese wind power projects do not perform power quality studies whereas an assessment of power quality is usually undertaken in the UK and Europe.

Another important part in the grid connection studies is the design of electrical secondary system, such as protection, SCADA system, and communications' system.

4.3 ***Grid Connection of Each Wind Farm***

4.3.1 *Jiangsu Rudong Wind Concession Projects*

Three wind farms of Lingyang, Huangang and Dongling are constructed along the east coast in Rudong, Jiangsu Province. The former is connected to the Wuyi grid substation while the latter two are connected to the same substation at Yangkou.

(i) Lingyang

With thirty-three 1.5 MW WTGs installed, Lingyang has a total real power capacity of 49.5 MW. A step-up substation has been constructed at the site with one 110/35 kV 63 MVA transformer for power evacuation from the wind farm to the local grid.

Lingyang is connected to the 220 kV Wuyi grid substation via one 20 km LGJ-185 overhead line circuit with a thermal rating of 65.2 MVA which is sufficient for the power evacuation.

Power generated in the Lingyang wind farm is consumed by the local loads connected to the Wuyi substation and the remaining is transmitted to the Rudong local grid. One 220/110 kV 180 MVA transformer is installed at the Wuyi substation.

The grid connection report indicates all WTGs installed in the wind farm have an adjustable power factor between 0.95 lagging and 0.95 leading. When the power factors of all WTGs are maintained at 0.98 lagging, the reactive power generated by the WTGs can compensate the reactive power demand of transformers and circuits of the wind farm. Hence there is no specific reactive power compensation equipment required at Lingyang.

According to the grid connection report, the short circuit currents in the Wuyi substation are 12.73 kA and 12.51 kA at the 220 kV and the 110 kV sides respectively. The fault currents of circuit breakers in the substation are 40 kA and 31.5 kA at 220 kV and 110 kV sides respectively. Hence the circuit breakers should be able to withstand the fault currents.

The maximum voltage fluctuation at the 110 kV side of the Wuyi substation is 5.66 kV which is within the permitted range of ±10% as required by the Chinese grid code.

(ii) Huangang

Huangang has a total installed generation capacity of 58.5 MW comprising thirty-nine 1.5 MW WTGs. A step-up substation with one 110/35 kV 50 MVA transformer was constructed to send the power out to the local grid. As discussed in an earlier section of this report, the size of the step-up transformer was smaller than the installed capacity of the wind farm, which means the transformer had to operate under overload condition during the maximum output of all wind turbines. Subsequent to the issue of the draft report, we were informed that another thirty-one 1.5 MW WTGs had been installed on site with one 50 MVA transformer. The total installed capacity of WTGs has reached to 105 MW, and the total transformer capacity is 100 MVA. Considering the wind farm operates at 0.95 lagging power factor and 5% of the internal losses, the maximum output of the wind farm is approximate 99.75 MW, which is close to the total transformer capacity. We consider the transformers have sufficient capacity to export the maximum output of the wind farm.

The wind farm is connected to the 220 kV Yangkou substation via one 22 km LGJ-300 110 kV overhead line circuit with a thermal rating of 105.7 MVA. The circuit capacity is sufficient for power evacuation.

There are two 220/110 kV transformers installed at the 220 kV Yangkou grid substation, each with a capacity of 120 MVA. By the end of 2008, the minimum load at the Yangkou substation was 49 MW, while maximum generation connected to the substation was 165 MW, which means 116 MW of net power would be required to be transmitted via those two 120 MVA transformers to the local grid. This is slightly greater than the full capacity of a single transformer unit. If one transformer were subject to outage for maintenance, the remaining transfomer could feasibly become overloaded. We expect the risk of overload or capacity constraint could be mitigated by arranging maintenance during periods of light wind condition.

We have noted that most wind farms in China only have single circuit connection to local grids. A risk of occurrence of faults on the line could be mitigated through a combination of good maintenance and utilizing fast auto-reclosure devices to keep potential duration of loss of power generation to minimum.

The WTGs installed in the Huangang wind farm have controllable power factor between 0.95 leading to 0.95 lagging. The grid connection study suggests that in neither peak or in off-peak periods in there any requirement for additional reactive power compensation to satisfy the current Chinese grid code.

Selection of the circuit breakers satisfies the fault current in the short-circuit condition. We can also confirm that the voltage regulation capability in the 110 kV step-up substation complies with the grid code requirement of the permitted range of ±10%.

(iii) Dongling

Dongling has twenty-eight 1.5 MW WTGs installed with a total capacity of 42 MW. We were informed that a 50 MW expansion has been planned at the same site. A step-up substation has been constructed with one 110/35 kV 50 MVA transformer to send the power out to the grid.

Dongling wind farm is connected to the 220 kV Yangkou substation, (as is Huangang), via one 28 km 110 kV overhead line with a thermal rating of 105.74 MVA. The circuit is sufficient to export all power generated in the current phase plus the future expansion of 50 MW.

The grid connection report suggests there are two groups of shunt capacitors installed at the 35 kV bus-bar in the 220 kV Yangkou substation, with a capacity of 6 MVar each to maintain the power factor at 220 kV bus-bar at Yangkou above 0.96.

There is no information relating to reactive power compensation devices at Dongling wind farm in the grid connection report. It is mentioned, however, the the power factor at 35 kV bus-bar of the Dongling can be maintained at 0.98 lagging. We expect the turbine generators could provide sufficient reactive power compensation.

The calculation results presented in the grid connection report suggest that the equipment at the step-up substation meets fault current requirements and voltage regulation requirements.

4.3.2 *Fujian Pingtan World Bank Wind Power Project*

Located on Pingtan Island, in the southeast of Fujian Province, the wind farm has fifty 2.0 MW WTGs installed with a total power capacity of 100 MW.

A 110 kV step-up substation has been constructed with two 110/35 kV 63 MVA transformers for power evacuation to the local grid. There are two bus-bar sections at the 35 kV side, which are connected by a normally-open bus section breaker in between. This substation is connected to the 110 kV Beicuo grid substation via one 15 km 110 kV overhead line circuit. The economical rating of 94.3 MVA and thermal rating of 133 MVA maximum suggest the circuit has sufficient capacity to send the power out to the grid.

The power generated in Pingtan is sent to the 110 kV Beicuo substation and further to the 110 kV Gaoshan substation via one 110 kV circuit. The power transmitted through this circuit under light-load condition could reach up to 80 MW when the wind farm is producing maximum output. This is very close to the thermal rating of the circuit. Hence, under the extreme condition, the power generation of Pingtan wind farm might need to be curtailed. However, according to the announcement of the local government, new lines would be built between Beicuo and Gaoshan substations. We therefore expect the potential constraint would be solved in the near future with the network enhancement.

Two groups of shunt capacitors have been installed at the wind farm step-up substation, with 6 MVar each. The WTGs in the wind farm have controllable power factors, between 0.95 leading and 0.95 lagging. Thus the total reactive power provision is approximately 44.87 MVar, which is about 35.6% of total transformer capacity at the wind farm step-up substation. We consider the wind farm has sufficient capacity to meet the reactive power demand and voltage regulation.

The circuit breakers are able to withstand the short circuit fault current.

4.3.3 *Jilin Tongyu Wind Concession Projects*

Tongyu Phase I has a total installed capacity of 100 MW, while Tongyu Phase II has 100.3 MW. Each is connected to a 220 kV substation via its own 35 kV bus-bar section. Two 220/35 kV 100 MVA transformers are installed in the substation for the two phases respectively.

The substation is connected to the 220 kV Chaonan grid substation via one 107 km 220 kV overhead line with a thermal rating of 644 MVA, which is sufficient to transmit the power generated by the wind farm.

It is possible that any voltage fluctuation at the Chaonan substation will affect the voltage control at the wind farm. It has been identified, according to the grid connection report, that during 'N-1' contingency of two interconnection lines between Chao-Bai grid, where the wind farm is connected, and the local grid of Baicheng area, the voltage profile at 220 kV bus-bars in Chao-Bai grid could be very low. This would result in the remaining interconnection becoming overloaded, and therefore the two interconnection lines would not meet the requirement of exporting all power generation to Baicheng grid following the connection of new wind farms to the system. Under the extreme condition, the power generation might need to be curtailed. We expect the potential problem would be solved in the near future with the network enhancement.

With two 100 MVA transformers installed, the capacity is not compliant with 'N-1' security requirements. Any transformer being out of service would cause constraints on power export.

In addition, the total capacity of two transformers installed in Tongyu 220 kV step-up substation is 200 MVA, while the total installed WTG capacity is 200.3 MW. Applying the internal loss factor of 0.5, the net electricity sent-out is 200.3 x 0.95 = 190.28 MW. Assuming the power factor at the grid entry point is 0.95, all power which needs to be exported from Tongyu wind farm is calculated to be 190.28/0.95 = 200.3. Furthermore, considering the utilisation factor of the wind farms is around 0.25, the chance of generation at full output is small. The length of time per year when the transformers are required to operate in an overloaded condition is relatively short. We consider the capacity of the transformers to be acceptable.

The WTGs installed in the Tongyu wind farm have the reactive power capability of +/- 0.95 power factor at the rated output. In addition, 20MVar shunt capacitors are also installed at 35 kV bus-bar at Tongyu wind farm substation. It is expected the wind farm should have sufficient reactive power capacity to maintain required power factor of +/- 0.98 at the grid entry point under normal condition. However, as stated above, during 'N-1' contingency of two interconnection lines between Chao-Bai grid and Baicheng grid, the 220 kV bus-bar at Tongyu wind farm substation may experience low voltage profile due to lack of reactive power support from the system, especially when the wind farm is generating maximum power.

4.3.4 *Liaoning Faku Baijiagou Wind Power Project*

With the total installed capacity of 49.5 MW, Faku Baijiagou Wind Farm is connected to a 66/35 kV step-up substation and then to a 66 kV bus-bar at the 220 kV Wenhua grid substation via one 66 kV circuit.

Baijiagou wind farm shares the same step-up substation with the Heping wind farm. Each of the wind farms has its own 35 kV bus section at the step-up substation, which is connected to the 66 kV bus bar via one 63 MVA transformer. The transformer is sized appropriately to export power generated. There is no bus section breaker between these two bus-bar sections. Thus one transformer trip from the system would lead to the corresponding wind farm being out of service.

A single 66 kV overhead line circuit provides the only power evacuation corridor from the wind farm to Wenhua substation. The total length of this circuit is 28.1 km, and the conductor type LGJ-240 with two conductors per phase. By the year 2010, the load estimation at the 220 kV Wenhua substation would be 130 MVA. Thus power generated by Baijiagou wind farm should be consumed by local load connected to Wenhua substation unless an expansion takes place.

According to Chinese equipment specification, the maximum transmission capacity of LGJ-240 at 35 kV is 26.9 MVA. Since there are six conductors in total (two per phase), the maximum transmission capacity of the power evacuation line is 161.4 MVA which is sufficient to export all power generated by both Baijiagou wind farm and Heping wind farm.

Regarding voltage stability, the meter at central control indicates the voltage level at the grid entry point of the wind farm is oscillating on a small scale which suggests there might not be enough reactive power at the wind farm to maintain a constant voltage level. According to the development plan it is expected that more reactive power compensation devices will be installed on the site to solve the voltage problem.

4.3.5 *Xinjiang Dabancheng No. 3 Wind Power Projects*

No on-site substation has been built at the Dabancheng Plant 3 site. Instead, the wind farm's Phases II, III and IV are connected to the grid 220 kV Dafeng substation, near Urumuqi.

(i) Phase II

Phase II is connected to the Urumqi grid at Dafeng, 1 km away, via two 35 kV overhead line circuits and with a total installed capacity of 30 MW. One of these two circuits connects twenty-four 750 kW WTGs and five 1500 kW WTGs, and the remaining six 750 kW WTGs are connected to the other 35 kV circuit. The conductor type of both circuits is LGJ-185 with a thermal rating of 33 MVA, which is sufficient to export the power produced by the WTGs connected to it.

The Dafeng 220 kV substation is connected to Urumqi grid via two 220 kV overhead line circuits, one of which is connected to Tuokexun 220 kV substation, and the other to Hongyanchi power plant 2. We consider the 220 kV overhead to lines have sufficient capacity to export all power to the grid.

It is unlikely that Dafeng 220 kV substation would suffer severe voltage fluctuation since it is located very close to Urumqi grid; the system impedance could be very small. However, since Dafeng 220 kV substation is also supplying local 110 kV load, there is a possibility that the voltage profile at the remote load connection points could be affected by the wind farm, especially under heavy load conditions and maximum generation from the wind farm, and when there is no sufficient reactive power support from adjacent substations or power plants. This possibility of this occurring in the Dabancheng district is currently low, though it needs to be taken into account for future load expansion.

The 750 kW WTGs have the reactive power capability of +/- 0.95 power factor at rated power output, and the 1500 kW WTGs have unity power factor. In addition, two 12 MVar shunt capacitors are installed at the 35 kV bus at the Dafeng 220 kV substation. As such, it is expected that the wind farm should have sufficient reactive power capacity to maintain the required power factor of +/- 0.98 at the 220 kV side of 220 kV Dafeng substation regardless the real power output.

(ii) Phase III

Phase III is connected to the 220 kV Dafeng substation, as with Phases II and IV, via two 35 kV overhead lines, and with a total power capacity of 49.5 MW. The 33 WTGs are divided into two groups; one of 16 and another of 17 turbines, separately connected to the 35 kV bus-bars. The conductor type of both circuits is LGJ-185 which has sufficient capability to export all power generation.

Compared with Phase II, the possibility that the 220 kV Dafeng substation would be affected by the grid has been increased. A potential risk regarding power evacuation from 220 kV Dafeng substation to Urumqi grid has been identified; due to the capacity increase in Dabancheng Wind Farm, the output circuits of 220 kV Dafeng substation are now carrying heavy burden of power generated by the wind farm. Particularly in light load condition, there would be power injection from Tulufan power plant which is connected to 220 kV Tuokexun substation into Urumuqi grid, which increases the loading of output circuits from the 220 kV Dafeng substation even further, since both circuits act as interconnection lines between Urumqi and Tulufan. Under certain scenarios, the power generation would have to be curtailed to maintain network security.

Further network enhancement has been suggested to increase the thermal rating of output circuits from the 220 kV Dafeng substation. To implement the enhancement, an existing line between Hongyanchi power plant one and the 220 kV Tuokexun substation has been divided into two sections. Section 1 goes from the power plant to the 220 kV Dafeng substation, and section 2 goes from the 220 kV Dafeng substation to the 220 kV Tuokexun substation. One 120 MVA transformer and one 150 MVA transformer supply the two sections respectively with a bus section break between the two sections. It is expected that these two new sections of lines can increase the transmission ability from the 220 kV Dafeng substation to the Urumqi grid. However, it has been stated in the grid connection report that the constraint still exists.

Low voltage profile issues can be considered negligible, since two groups of shunt capacitors have been installed in phase III, and all WTGs installed in phase III have unity power factor and do not absorb reactive power at nominal output. However it is still possible that the local load connected to 220 kV Dafeng substation could be affected due to lack of reactive power support as a result of the transmission constraints stated above, especially when the wind farm is generating maximum power. It is expected that this problem will be solved with new network development in the future.

The WTGs have unity power factor, which do not absorb reactive power at rated output. Two additional shunt capacitor groups have been installed at the 35 kV bus-bar at the wind farm step-up substation; each group has 12 MVar reactive power capacity. It is expected that the wind farm should have adequate reactive power capacity to maintain the required power factor of +/- 0.98 at the grid entry point under all operation scenarios.

The feasibility study report and the grid connection study report indicate that, by the year 2007, the three phases short circuit current at the 35 kV bus-bar at the 220 kV Dafeng substation was 15.7 kA, and would increase to 18.6 kA by the year 2015. This suggests that the switchgear is capable of withstanding the prospective fault current in the electrical network.

It is also indicated that under ‘N-1’ contingency of output circuits of the 220 kV Dafeng substation, one of the remaining lines, which goes from Hongyanchi power plant two to Tuokexun substation via Dafeng substation, will be overloaded. This is expected to be solved by future network development.

The grid connection report also indicates that harmonic levels are all within permitted range for each order of harmonic that exists in the system.

(iii) Phase IV

With a total capacity of 49.5 MW, Phase IV wind farm is connected to the 35 kV bus-bar at the 220 kV Dafeng substation, in the same manner as the previous two wind farms. Phase IV wind farm is connected to one 35 kV bus-bar section which is supplied by a 150 MVA transformer. The WTGs divided into two groups, 16 in group one and 17 in group two, are connected to the 35 kV bus-bar at Dafeng substation via two 35 kV overhead lines without interconnection. The conductor type of both lines is LGJ-240 with transmission capacity of 26.9 MVA, which is sufficient to export the power output.

The WTGs have unity power factor at the rated output and thus do not absorb reactive power from the grid. There are two 15 MVar shunt capacitor groups installed at the bus-bar section where the Phase IV project is connected. It is expected to be sufficient to maintain the required power factor of +/- 0.98 at the 220 kV side.

The switchgear is sized to be able to withstand faults in the network.

4.3.6 *Gansu Yumen Wind Power Projects*

(i) Phases II & III

Yumen Phase II wind farm has a total installed capacity of 11.9 MW, and Phase III project has a total capacity of 45.9 MW.

Both phases are connected to the same 110 kV step-up substation, which is connected to Jia-Jiu power grid at the 110 kV Yangguan substation via two 12 km LGJ-150 overhead lines. Two 50 MVA transformers are installed at the substation with a total capacity of 110 MW. Each overhead line has a thermal rating of 52.9 MVA which is sufficient under normal scenario if the wind farm loss factor is 0.05 and the power factor at Yangguan substation is 0.95. However, this may not comply with ‘N-1’ contingency requirements, i.e. one line could not carry the full power output when the other line is out of service.

The 110 kV Yangguan substation is located in the west part of the Jia-Jiu power grid, where major generation is connected, while the loads are mainly distributed in the east part. These two areas are interconnected via three 110 kV circuits to transfer the power to supply demand. It has been identified in the grid connection report that these three circuits are not compliant with ‘N-1’ contingency requirement, since any circuit outage will cause overload on the remaining circuits. It was indicated that under such a scenario, the power generation of the Yumen wind farm might be curtailed. Furthermore, it was identified that due to the huge amount of generation, the reactive power in the west Jia-Jiu grid was limited to prevent over-voltage, while at the same time the load centre in the east Jia-Jiu grid was not receiving enough reactive power support. This would require additional reactive power from other parts of the Gansu Provincial Grid, which might not be available all the time.

No information was given about the availability of reactive power compensation devices in the Yumen wind farm. But it is indicated that at the wind farm grid entry point, the power factor is maintained at unity, thus we expect there should be sufficient reactive power support.

According to the short circuit calculation in the grid connection report, the fault level is 1349 MVA at the 110 kV bus-bar at the wind farm, and is 1868 MVA at the 110 kV bus-bar at Yangguan substation; the maximum fault current is less than 10 kA. The circuit breakers are able to withstand the fault level at both locations.

(ii) Diwopu I

Diwopu I wind farm has a total installed capacity of 49.3 MW. A 110 kV step-up has been constructed with one 50 MVA transformer. The power output is sent to the Jia-Jiu grid via one 15 km LGJ-240 overhead line circuit.

Within the Jia-Jiu power network, the generation sources, including all phases of Yumen wind farms, are mainly located in the west part of the network, while the load centre is in the east part. This arrangement leads to requirement to send a huge quantity of power generated from the west part to the load centre in the east via three 110 kV overhead-line circuits. With the connection of Diwopu I project, the power being transmitted through the three circuits would be even greater, since there is no significant load increase in the west local network. At present, it has been identified that these three interconnection circuits between east and west parts of Jia-Jiu grid are not compliant with 'N-1' contingency requirement. In addition, the reactive power generation from all power plants in the west Jia-Jiu grid has to be limited to prevent overvoltage in the west part of the grid, while the east load centre demands more reactive power from the west part.

It was suggested in the grid connection report that this problem is expected to be solved by future network development. A new 330 kV substation, named Changma substation, has been constructed near the 110 kV Yangguan substation in the west part of Jia-Jiu grid. The Diwopu I wind farm will be connected to this newly-built substation via one 20 km LGJ-240 overhead line circuit. The new 330 kV Changma substation is then connected to the 330 kV Jiayuguan substation located in the east part of Jia-Jiu power grid. It was indicated that with the new network reinforcement, the interconnection circuits between the east and west will meet the 'N-1' contingency requirement, and there would be no limitation on the reactive power, since all power can be transmitted to the load center in the east. The expansion work was expected to be completed in June 2009.

All WTGs installed in the wind farm have controllable power factors, each between 0.95 leading and 0.95 lagging. The maximum reactive power can be produced by all WTGs is 16.20 MVar which is about 32.4% of transformer capacity of the wind farm step-up substation. It is considered the wind farm can produce sufficient reactive power to compensate its own reactive power demand in order to maintain the required power factor at the wind farm grid entry point.

4.3.7 *Hebei Shangyi Shiren Wind Power Project*

Zhangjiakou Shiren wind farm has a total generation capacity of 49.5 MW. An on-site 110/35 kV substation with a 50 MVA transformer was built to send power out to the grid.

The substation is connected to the Zhangbei 220/110 kV grid substation via a 38 km 110 kV overhead line transmission circuit. The 110kV circuit, with the conductor type LGJ-240, has a thermal rating of 116MVA, which is sufficient to send power to the grid. Additionally, the 110 kV circuit also has extra transmission capacity of evacuating the power from the wind farm in Phase II project to the grid.

A single 35 kV bus-bar was constructed at the 110/35 kV substation for energy collection of the Phase I project. Three 35 kV circuits were built in the wind farm for wind energy collection from WTG units and connected to the 35 kV bus-bar. Additionally, a 35 kV 8 MVar shunt capacitor is installed at the substation and connected to the 35 kV bus-bar.

The Zhangbei substation is connected to the Wanquan 500/220 kV substation via two 220 kV transmission circuits. Wanquan 500 kV substation is in the middle of power transfer corridors from the Inner Mongonia Grid to the North-China Power Grid. Several 500 kV circuits connecting the 500 kV substations constitute strong links with other neighbouring 500 kV networks. As a result, voltage profile at Zhangbei 220 kV substation can be easily regulated within the operating limits under any given operational scenario. Thus, it is anticipated that voltage regulation at the Shiren wind farm would not experience any difficulty provided sufficient reactive power capacity.

There are two 220 kV circuits from the grid connection to the backbone power grid, thus N-1 contingency on 220 kV power grid would not affect power evacuation from the wind farm.

The WTGs have the reactive power capability of maintaining +/- 0.95 capacitive/inductive power at the rated MW output. Additionally the 8 MVar shunt capacitor banks are also installed at 35 kV bus-bar. As such, it is expected that the wind farm should have sufficient reactive power capacity to maintain the required power factor of +/- 0.98 at the 110kV side of the wind farm substation at all levels of the real power output.

The ratings of 110 kV and 35 kV switchgears installed at Shiren110/35 kV substation to withstand fault currents are 31.5kA and 25 kA respectively. Fault results given in the grid connection report are less than 13 kA at the 110 kV side by 2020. We consider that the switchgear is capable of withstanding the faults in the electrical network.

4.3.8 *Inner Mongolia Bayin National Wind Concession Project*

Bayin wind farm has a total power capacity of 201 MW. A 220 kV substation was constructed with two 220/35 kV 100 MVA transformers installed for power evacuation and 4×12 MVar reactive power shunt capacitors. The energy collection system comprises two 35 kV bus-bar sections with a bus-bar coupler, ten 35 kV cable circuits.

Bayin is connected to the Baotou power grid at the Wanghai 220 kV substation via a 10 km 220 kV LGJ-400 overhead line transmission circuit which has the thermal rating of 305 MVA. Wanghai 220 kV substation is then connected to the Baotou Gaoxin 500/220 kV substation via a single 220 kV transmission circuit which passes two other 220 kV substations. We consider the 220 kV overhead line from Bayin wind farm to Wanghai 220 kV substation has sufficient transmission capacity to export the wind generation from the wind farm to the grid.

Bayin is at the end of the 220 kV circuit to Baotou Gaoxin 500/220 kV substation and the total length of the single 220 kV circuit from Bayin to Gaoxin is around 200 km. There is only one 500/220 kV substation in Baotou area, thus there is a possibility that any voltage fluctuation at the 500/220 kV substation may affect voltage control at 220 kV substations in the local grid. Voltage control at Baoyin wind farm may experience difficulty in some operational scenarios, especially when the system operates during heavy load periods with insufficient reactive power support. In order to improve this, reinforcement of the Baotou 500 kV network by constructing multiple links between Baotou Gaoxin 500/220 kV substation and other neighbouring 500 kV substations is necessary.

As there is only one 220 kV circuit connecting the wind farm to the Gaoxin 500/220 kV substation, which is the centre of the local grid, occurrence of any fault on the circuit will affect the power export of the wind farm.

The WTGs installed in the Bayin wind farm have reactive power capability of +/-0.95 power factor at the rated output. Additionally 4×12 MVar shunt capacitors are also installed at 35 kV energy collection system. As such, it is expected that the wind farm should have sufficient reactive power capacity to maintain the required power factor of +/- 0.98 at the 220/kV side of the wind farm substation.

The feasibility study and grid connection study show the fault levels calculated at the 220 kV bus-bars and 35 kV bus-bars at the wind farm are much less than the fault rating of switchgear installed at the substation. This suggests the switchgear is capable of withstanding the faults in the electrical network.

4.3.9 *Inner Mongolia Chifeng Wind Power Projects*

Wudaogou Phase I has a total installed capacity of 50.25 MW, while Sunjiaying Phases I and II have a total capacity of 50.25 MW and 49.5 MW respectively.

Two 35 kV bus-bars and six 35 kV circuits were installed for energy collection of the three wind farms, with bus-bar I and four 35 kV circuits for Wudaogou and Sunjiaying Phase I, and bus-bar II and two 35 kV circuits for Sunjiaying Phase II. Additionally 2×8 MVar and 1×8 MVar reactive power compensation equipment were installed at 35 kV bus-bar I and II respectively.

A 220/35 kV substation is constructed at the Sunjiaying site with a 220/35 kV 120 MVA transformer and a 220/35kV 63 MVA transformer installed for power evacuation from all three sites to the local power grid. This is connected to Yangshugoumen 220 kV substation via a 9 km 220 kV LGJ-400 overhead line transmission circuit, which is then connected to Xijiao 220 kV grid substation in the local Chifeng power grid. The thermal rating of the overhead line circuit of 305 MVA is sufficient to send the power to the grid.

At the grid connection point of the Xijiao 220 kV substation, two 220 kV circuits are connected to the 220 kV Chifeng and Wudan substations, which are regarded as the centre of Chifeng the local power grid. It is anticipated that the local network is able to maintain the N-1 security requirement, which means if one 220 kV circuit is out of service, the other 220 kV circuit is able to transfer the power from 220 kV Xijiao substation to the system. We consider the local network has capability to export the power from the wind farms owned by Longyuan.

As there is only one 220 kV circuit connecting the 220 kV Sunjiaying substation to Xijiao 220 kV substation via Yangshugoumen 220 kV substation, there is a possibility that circuit failure of this circuit will affect the power export of the wind farm. Additionally, the distance of the 220 kV circuit from Sunjiaying 220 kV substation to Xijiao 220 kV substation is over 100 km, voltage regulation at the Sunjiaying 220 kV substation may experience difficulty should there be insufficient reactive power compensation capacity installed at the two substations, especially when the system operates during the off-peak period when the wind output is small.

The switchgear installed at 220/35 kV Sunjiaying substation is capable of withstanding the faults in the electrical network.

4.4 ***Conclusions***

The transformers at most 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 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.

Most grid connection substations have sufficient transformer capacity to accommodate power generated from the wind farms under normal system operation. However, it has been noted that in the cases of the Pingtan and the Dabancheng, the transmission lines between the grid connection substations and other substations in the local networks might be overloaded.

All projects reviewed are able to maintain the power factors required by the current Chinese grid code at the grid connection points. Most wind farms have reactive power compensation equipment installed to provide reactive power support. All wind turbines have controllable power factors which allow WTGs to provide certain amount of reactive power output. We understand that capacitive equipment will be installed to improve the voltage profile in Faku Baijiagou wind farm.

Most local networks have sufficient capability to accommodate the Longyuan wind power. In Yumen Phase II, the power output may have to be curtailed due to local power system configuration and insufficient reactive power compensation in the local power network. In Dabancheng wind farm, power generation may be curtailed due to overloading of two interconnectors between the Dabancheng local network and adjacent regional power grid under N-1 contingency. The problems are expected to be solved by future network reinforcement.

All 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 violation regarding switchgear rating has been identified at any of the representative wind farms.

In general, we consider the grid connection of Longyuan wind power projects has been well planned, without major constraints found to prevent power export under normal system operation. Exception exists only when the local power system operates under specific scenarios, and such situation can be eliminated by future network reinforcement.

5 Coal Power Plant Appraisal

5.1 *Plant Description*

The Jiangyin Sulong Heat and Power Generating Station is located on the Yangtze River north of the city of Jiangyin. The station generates electricity, transmitted at 220 and 110 kV, and produces steam for district heating throughout the city of Jiangyin.

The station comprises six coal fired units built in phases. Table 5.1 gives the units' capacity and their commercial operation dates.

Table 5.1: Unit Capacities and CODs in Sulong

	Unit 1 & 2	Unit 3 & 4	Unit 5 &6
Capacity (MW)	2×137.5	2×140	2×330
COD	June 1995	February 2003	December 2004

Phases 1 and 2 (Units 1, 2, 3, 4) are served by a separate coal unloading, storage, and handling system from that of Units 5 & 6. The Phase 1 and 2 coal unloading system consists of three clam shell bucket type unloaders, a stack-out conveying system, a covered storage pile, and an outdoor storage pile. The coal unloading, storage, and handling system for Units 5 & 6 is similar to that for Phases 1&2 except that it has five storage silos in lieu of the covered pile for dry coal storage. Reclaim from both outdoor piles is achieved using bucket wheel type reclaimers. Units 1 to 4 (Phases 1&2) are served by a dual inclined conveyor which feeds a total of eight silos; two per unit, each feeding coal to a coal ball mill. The pulverized coal from the ball mills is discharged through a cyclone separator which directs the fine coal to a storage silo and redirects the oversized particle back to the ball mill for regrinding. The pulverized coal enters a distribution conveyor, which can direct it to any one of the eight pulverized coal storage silos throughout Units 1, 2, 3 and 4. From the pulverized coal storage silo, the coal is directed to the burner levels on the individual units using the primary air fans. Units 5 & 6 are served by their own dual inclined conveyor system which feed a total of six coal silos; three on each unit. The coal is fed from the silos through a gravimetric feeder to a pressurized ball mill, and then blown through coal pipes to the burner levels of the unit using the unit's primary air fans. There is no storage of pulverized coal on Units 5 & 6.

All six of the boilers are corner fired boilers manufactured by Shanghai Boiler Company. They are equipped with low NOx burners with two levels of overfire air. The Units 1 and 2 boilers are single reheat units producing 420 t/h of main steam at 540°C, 13.7 MPa, and 350 t/h of reheat steam at 540°C, 2.62 MPa. The Units 3 and 4 boilers are single reheat units producing 435 t/h of main steam at 540°C, 13.7 MPa and 356 t/h of reheat steam at 540°C, 2.62 MPa. The Unit 5 and 6 boilers are also single reheat units producing 1080 t/h of main steam at 541°C, 17.5 MPa and 854.2 t/h of reheat steam at 541°C, 3.72 MPA.

Flue gas exits the boiler and enters a lungstrom style air preheater, followed by an electrostatic precipitator and a flue-gas desulphurisation (FGD) system for SO2 removal. Units 1 and 2 share a common FGD system absorber, as do Units 3 & 4. Units 5 and 6 are equipped with separate absorbers. Each of the units has two forced draft (FD) fans and two induced draft (ID) fans and each FGD system is equipped with a booster fan, bypass duct, and damper. There are gas to gas heat exchangers downstream of each absorber which are used to reheat the flue gas entering the chimney to approximately 90°C. There are three chimneys; each serving two units. The FGD systems are served by a common limestone handling and preparation system located on the North side of the plant.

Fly ash is collected from the electrostatic precipitator hoppers and the economiser hoppers, and conveyed pneumatically to storage silos that discharge to either trucks or barges for transport to customers. There are two flyash systems; one for Units 1 to 4, and one for Units 5 & 6. Bottom ash is collected in wet bottom ash hoppers and conveyed hydraulically to dewatering silos. There are separate bottom ash systems for Units 1 to 4 and 5 & 6. Bottom ash is also sold for reuse. The FGD systems produce marketable gypsum using a forced oxidation system. The gypsum generated by FGD system after de-watering is sold to cement factories and gypsum wallboard factories. This complies with the Chinese government policy of "Resources' Comprehensive Utilisation."

The steam from each unit's boiler is directed to the unit's steam turbine. All six of the turbines were manufactured by Shanghai Steam Turbine Manufacture. They are single reheat units with extractions feeding two high pressure feedwater heaters; a deaerator and four low pressure feedwater heaters. The turbines exhaust to a surface condenser cooled by an open cooling water system withdrawing water from, and discharging water to, the Yangtze River. The river water temperature reaches 30°C in the summer. At this time there are no relevant national regulations to limit the temperature of the discharge water. Each of the turbines is furnished with supervisory instrumentation monitoring vibration and rotor position.

The station provides steam to the city of Jangyin for district heating and furnishes hot water to the local area in tanker trucks. None of the condensate is recovered and returned to the station, so the station has a significant make-up water requirement.

There are separate water treatment systems for Units 1 to 4 and Units 5 & 6. The water treatment systems consist of clarifiers followed by anion and cation ion exchange vessels, followed by mixed bed demineralizers. The Yangtse River is the source of make-up water.

Units 1 to 4 are equipped with Network 6000 distributed control systems (DCS), while Units 5 & 6 have Foxboro I/A systems. Each of the FGD systems has a separate control room with its own control system. These communicate with the main unit DCS. The water treatment systems have separate control rooms and control systems.

Each unit's generator output is transformed to 220 kV by its own individual step up transformer. The unit 2 step up transformer has an additional winding that allows it to feed the 110 kV transmission system. Each unit has a station service transformer that feed the 6 kV bus on each unit. Units 1 through 4 are cross connected at the 6 kV level by bus ties. The same is true of Units 5 & 6. Units 1 through 4's 6 kV bus is fed from the 220 kV transmission system through a step down transformer. The 6 kV bus for Units 5 & 6 is also fed from the 220 kV transmission system via a separate step down transformer.

5.2 *Condition of Equipment*

Based on our preliminary review of the facility and the documents provided, the station appears to be in good operating condition. No significant problems with the major equipment such as the boiler, steam turbine, fuel handling, or flue gas treatment systems have been reported. The Units 1 and 2 boiler economizers are being replaced to add more surface area. No other boiler sections have been replaced or have experienced excessive tube failures. Station personnel indicate that problems with corrosion of the lower furnace water wall tubes have not occurred. This is a common problem associated with the operation of Low NOx burners. The station monitors tube wall thickness during the scheduled outages.

A review of the materials used for the boiler components and major high pressure piping systems indicates that proper materials have been selected for the applications.

The materials used in the FGD system are conventional for China. The absorber modules are carbon steel lined with flake glass. The internal spray piping is Fibre-glass Reinforced Plastic (FRP) with silicon carbide spray nozzles. The external spray piping is rubber lined carbon steel, and the recycle pumps are rubber lined cast stainless steel. The gas to gas re-heater is made of ceramic. Flake glass lining of FGD absorber modules is not common in the US. It was common practice in the early days of FGD, but today most absorbers are made of solid alloy, alloy linings, or acid resistant tiles. Also, gas-gas heaters are no longer used in the US downstream of FGD systems. When they were first installed, they were high maintenance items prone to failure. Today, most stations that are equipped with FGD in the US operate with wet stacks, and are either relined or built with chimneys made of corrosion resistant materials, so the need for flue gas re-heaters downstream of FGD systems has been eliminated.

Selected outage reports and equipment operating and maintenance manuals were reviewed on a high level basis. The level of documentation and record keeping appears to be complete. Outage reports are created and filed for each outage. Separate reports are created for the turbines and boilers and their respective auxiliary equipment.

A walk down of the facility indicated that the plant is kept clean and in a safe condition. The boilers are located outdoors, while the steam turbines, feed water heaters, and boiler feed water pumps are housed in a building, keeping the presence of coal dust in the steam turbine area to a minimum.

As noted above, pulverized coal is stored in silos, prior to being blown into the furnace on Units 1 through 4. This is unusual and could be considered dangerous because pulverized coal can be explosive. Station personnel are aware of this and state that they take extra precautions with equipment and site cleaning routines and maintenance to minimize the build-up of coal dust. Coal preparation on Units 5 & 6 is more conventional in that the pulverized coal is not stored, but blown directly into the furnace once pulverized.

The station has significant level of margin and redundancy in the major equipment. There are two 100% coal mills on Units 1 to 4, and three 60% capacity coal mills on Units 5 & 6. Each unit has two 60% capacity FD fans and two 60% capacity ID fans. There are two 100% capacity condensate pumps on each unit, and two 100% capacity boiler feed pumps on Units 1 to 4. Units 5 & 6 are each equipped with two 50% capacity steam turbine driven boiler feed pumps and one 50 % capacity motor driven boiler feed pump.

Units 1 & 2 are served by a common FGD absorber with four 33% capacity recycle pumps (three operating, one standby at full load), as are Units 3 & 4. Units 5 & 6 each have their own absorber with four 33% capacity recycle pumps (three operating, one standby at full load). There is a bypass flue duct with a bypass damper between inlet and outlet of each absorber. During normal operations the damper is closed. The bypass is only used during emergencies. The station has a common limestone preparation system with two 100% capacity trains consisting of dry limestone ball mills, product silos and slurry storage tanks, and a common gypsum dewatering system.

A notable feature of the plant is that space and some structural steel has been designed into the existing facility to accommodate the future installation of Selective Catalytic Reduction systems on each unit should future NOx emissions regulation limits require this technology.

With the exception of some of the features of the FGD systems, the major equipment at the station is comparable to that installed in the US. The boilers, turbines, and their associated equipment all compare favourably. The electrostatic precipitators are equipped with rigid electrodes and are adequately sized. The equipment appears to be well maintained and in good condition. It should be noted that the station is relatively new, with the first two units being placed in commercial operation in 1995.

5.3 *Plant Operation and Efficiencies*

Monthly operating reports for the years 2006, 2007 and 2008 were reviewed. Since Units 1 to 4 are combined heat and power (CHP) generation, we investigated the plant production including electricity generation and stream extraction. As shown in Table 5.2, the production is satisfactory.

Table 5.2: Sulong Production and Utilisation Hours

		Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Total
capacity (MW)		137.5	137.5	140	140	330	330	1,215
2006	gross generation (TWh)	748	778	698	773	1,776	2,019	6,792
	utilisation hours (hours)	5,439	5,660	4,988	5,518	5,382	6,117	—
	plant use (TWh)	—	—	—	—	—	—	37.99
	net generation (TWh)	—	—	—	—	—	—	6,730
	steam extraction (TJ)	814	847	747	826	—	—	3,234
2007	gross generation (TWh)	824	795	733	676	2,284	2,101	7,414
	utilisation hours (hours)	5,993	5,785	5,234	4,838	6,919	6,367	—
	plant use (TWh)	—	—	—	—	—	—	41.90
	net generation (TWh)	—	—	—	—	—	—	6,948
	steam extraction (TJ)	987	985	926	823	—	—	3,720
2008	gross generation (TWh)	787	724	732	756	2,086	2,176	7,262
	utilisation hours (hours)	5,723	5,268	5,228	5,402	6,322	6,594	—
	plant use (TWh)	—	—	—	—	—	—	43.56
	net generation (TWh)	—	—	—	—	—	—	6,781
	steam extraction (TJ)	1,038	955	948	980	—	—	3,920

Station and Unit efficiencies are reported in terms of grams of coal consumed per kilowatt hour and kilograms of coal consumed per gigajoule steam produced. Average annual efficiencies, provided to us by Longyuan, in terms of heat rate and availability for the three years of operating data are presented in Table 5.3.

Table 5.3: Unit Heat Rate and Availability of Sulong

			Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6
2006	Heat Rate - electricity	g/kWh	327	327	326	326	326	326
		kJ/kWh	9,571	9,571	9,542	9542	9,542	9,542
	Heat Rate - Steam	kg/GJ	40.25	40.25	39.97	39.97	—	—
		MJ/GJ	1,178	1,178	1,170	1,170	—	—
	Availability	%	97.06	97.06	96.91	96.91	85.4	95.5
2007	Heat Rate - electricity	g/kWh	320	320	320	320	317	317
		kJ/kWh	9,367	9,367	9,367	9,367	9,279	9,279
	Heat Rate - Steam	kg/GJ	40.57	40.57	40.54	40.54	—	—
		MJ/GJ	1,188	1,188	1,187	1187	—	—
	Availability	%	96.92	92.22	97.2	96.93	96.67	86.25
2008	Heat Rate - electricity	g/kWh	316	316	317	317	316	316
		kJ/kWh	9,250	9,250	9,279	9,279	9,250	9,250
	Heat Rate - Steam	kg/GJ	40.18	40.18	40.21	40.21	—	—
		MJ/GJ	1,176	1,176	1,177	1,177	—	—
	Availability	%	93.89	100	93.31	97.11	95.29	96.12

Since Units 1 to 4 are CHP generation, the heat rate given in Table 4-2 allocated to electricity generation excluding the heat production are overall more efficient than similar size pure power generation units.

Unit downtime hours due to dispatch are reported for each month. It appears Units 5 & 6 are dispatched on more than 90% of the time that they are available, whereas Units 1 to 4 are off-line significantly more. Unit 3, in particular, was off-line due to dispatch more than 20% of the time that it was available during the years 2006, 2007 and 2008. Unit 4 also has a high number of downtime hours due to dispatch. It appears that the increase in capacity that resulted from the turbine upgrades performed on Units 1 and 2 have made these units preferable to Units 3 and 4 in the dispatch order.

The steam turbines on Units 1 and 2 were replaced to gain additional capacity. The Units were tested in October 2001, prior to the upgrades, and then retested after the upgrades. Unit 1 was tested in December 2001. The capacity of the unit was raised to 138 MW from 125 MW and the heat rate was improved. Unit 2 was tested in April 2002. Its capacity was raised to 138 MW as well and its heat rate improved.

Units 5 and 6 underwent testing after their initial two years of operation. The results of the testing showed that the major equipment and the auxiliaries were operating normally.

The station has produced their own Operating and Maintenance manuals for the boilers and turbines. Those for the boiler contain information on the coal mills, FD and ID fans, the Air Pre-heater, and the Electrostatic Precipitator. The manuals for the turbines cover the feed-water heaters, the condensers, boiler feed pumps, and auxiliary turbines.

5.4 ***Environmental Issues***

Emissions data was provided for the months from July 2007 to October 2008. Daily average Particulate, SO2, NOx, and flow data are listed in terms of mg/Nm^3 and total tons per day for each. Monthly averages, and maximum and minimum emissions concentrations are also listed. All six units meet the emissions limits as set by the regulatory agencies. The station is controlling NOx using Low NOx burners with overfire air. Lower NOx emissions limits are expected in China in the near future, and as stated earlier the station is in a good position to install Selective Catalytic Reduction (SCR). The FGD systems are operating above 90% removal efficiency. The particulate emissions on Units 1 & 2 are higher than those of 3, 4, 5 and 6 probably because the precipitators are three fields deep rather than four.

The emissions data for the period from July 2007 to October 2008 indicate that the gas-gas heater (GGH) operated satisfactorily, achieving stack gas temperatures above 90°C. It is reported that gas-gas heaters installed on other FGD systems in China have experienced problems with plugging and heat exchanger tube failures, so we would suggest that the operational staff should take extra-care of these heaters.

There is also an indication that the government may not allow the operation of the FGD bypass in the future. This would require that the FGD systems to be available to allow the units to operate. We consider the FGD systems have spare recycle pumps and sufficient margin to achieve high levels of availability.

The station markets all of it's solid waste. Fly ash and bottom ash are sold as cement substitute and asphalt base; the gypsum produced by the FGD system is sold to the cement industry or to wallboard manufacturers. This complies with the Chinese government policy of "Resources' Comprehensive Utilisation."

Most of the liquid waste streams are recycled in the station and used for dust suppression, lawn watering, etc. following treatment for solids removal and neutralization.

5.5 ***Conclusions***

The station appears to be a well run power station. The equipment is in good condition and the station personnel that were interviewed have a very good understanding of the operation and maintenance procedures of the station. The level of documentation in terms of outage reports, operating data, emissions data, and equipment manuals is complete. The only known major expenditure that the station could be faced with is the installation of SCRs but, as stated previously, space has been allocated for the reactors and ductwork, hence installation should be relatively simple.

The station may be faced with modifying its cooling system if the government adopts environmental regulations limiting the temperature of the cooling water discharge to the Yangtse River.

The power station appears to have been designed with significant margin, especially in the fuel handling, storage, and preparation systems. In addition each of the major components has some margin to allow each unit to operate above half load should a single component, such as an FD or ID fan, fail.

The operational and emissions data indicates that the station is performing satisfactorily. Solid waste is sold and utilised.

6 Conclusions and Recommendations

During the course of our technical appraisal, Mott MacDonald engineers visited eighteen wind farms and one coal power plant situated in eight different Provinces and Autonomous Regions in China, west from Xinjiang to the east in Jiangsu; north in Jilin to south in Fujian.

We were impressed by the enthusiasm and diligence of the site staff who provided responses to our technical questionnaire and attended meetings and discussions with us despite being very busy.

All wind farms we visited had the equipment supplied by well-known international or domestic manufacturers who employ proven technologies and have track records in the market. We are of the view that the turbine technologies are in accordance with current industrial standards, some of the sites were built to a high standard, exceeding our expectations. All plants are well operated and maintained.

Turbine availability and power generation were the two key operational performance indictors we used in our appraisal. We are able to confirm that the availability of the wind farms reviewed was higher than the manufacturer's guarantee of 95% and the actual electricity generation was also in line with the forecast made in feasibility studies.

Most of the wind farms we reviewed had their own dedicated substations with adequate electrical equipment installed to export electricity via overhead circuits to the power grids. The substation equipment is appropriately sized to withstand system faults and reactive compensation is installed in many wind farms to meet technical requirements of the power grid.

The coal power plant was well operated and maintained. The majority of key equipment was comparable to those in the US. The plant operational and emission data are also satisfactory. Solid waste is sold and utilised.

We found during our site visits that most of the wind farms employed more staff than we have seen in the Europe and the US. We believe this is an area which the Company could consider reviewing and make further improvements by reducing the number of staff on site when building new projects, although Longyuan said more staff was also for future expansion.

Longyuan has a very ambitious expansion plan to develop more wind power projects in China. We believe that the Company, with its strong technical capability, has sufficient capacity to develop, operate, maintain and manage wind farms in China and overseas.

Appendix A List of Key Documents Reviewed

Ref	Document Title
1	Phase II of Rudong Concession Project Feasibility Study Report
2	The Expansion Project of Phase II of Jiangsu Rudong Wind Concession Project Feasibility Study Report
3	Fujian Pingtan World Bank Project Feasibility Study Report
4	Phase I Jilin Tongyu Wind Concession Project Feasibility Study Report
5	Phase II Jilin Tongyu Wind Farm Concession Project Feasibility Study Report
6	Liaoning Faku Baijiagou Project Feasibility Study Report
7	Phase II of Dabancheng Plant 3 Project Feasibility Study Report
8	Phase III of Dabancheng Plant 3 Project Feasibility Study Report
9	Phase IV of Dabancheng Plant 3 Project Feasibility Study Report
10	Phase III of Yumen Project Feasibility Study Report
11	Yumen Sansilijingzi Project 49.5 MW Feasibility Study Report
12	Phase I of Hebei Shangyi Shiren Wind Power Project Feasibility Study Report
13	Inner Mongolia Bayin National Wind Concession Project Feasibility Study Report
14	Phase I of Inner Mongolia Wengniute Wudaogou Wind Power Project Feasibility Study Report
15	Phase I of Chifeng Wengniute Sunjiaying Wind Power Project Feasibility Study Report
16	Phase II of Chifeng Wengniute Sunjiaying Wind Power Project Feasibility Study Report
17	Huangang (100 MW) Grid Connection Study Report
18	Lingyang (50 MW) Grid Connection Study Report
19	Dongling Grid Connection Report
20	Pingtan Changjiangao Project Grid Connection Study Report
21	Phase II of Jilin Tongyu Project Grid Connection Study Report
22	Faku Baijiagou Project Grid Connection Study Report

Ref	Document Title
23	Phase II of Dabancheng Plant 3 Project Grid Connection Study Report
24	Phase III of Dabancheng Plant 3 Project Grid Connection Study Report
25	Phase IV of Dabancheng Plant 3 Project Grid Connection Study Report
26	Yumen Phase III Expansion Project Grid Connection Study Report
27	Sanshilijingzi Project Grid Connection Study Report
28	Phase I of Zhangjiakou Shangyi Shiren Project Grid Connection Study Report
29	Inner Mongolia Damao County Project Grid Connection Study Report
30	Sunjiaying (Wudaogou) Project Grid Connection Study Report
31	Phase II of Sunjiaying Project Grid Connection Study Report
32	Rudong Dongling Met Mast Data
33	Rudong Huangang Met Mast Data
34	Rudong Lingyang Met Mast Data
35	Pingtan Met Mast Data
36	Tongyu Phase I Met Mast Data
37	Tongyu Phase II Met Mast Data
38	Faku Baijiagou Project Met Mast Data
39	Shiren Phase I Project Met Mast Data
40	Bayin Project Met Mast Data
41	Wudaogou Phase I Project Met Mast Data
42	Sunjiaying Phase I Project Met Mast Data
43	Sunjiaying Phase II Project Met Mast Data
44	Rudong Dongling Operation and Maintenance Record
45	Rudong Huangang Operation and Maintenance Record
46	Rudong Lingyang Operation and Maintenance Record
47	Pingtan Project Operation and Maintenance Record
48	Tongyu Phase I Operation and Maintenance Record
49	Tongyu Phase II Operation and Maintenance Record
50	Faku Baijiagou Project Operation and Maintenance Record
51	Dabancheng Plant 3 Phase II Project Operation and Maintenance Record
52	Dabancheng Plant 3 Phase III Project Operation and Maintenance Record
53	Dabancheng Plant 3 Phase IV Project Operation and Maintenance Record
54	Yumen Phase II Operation and Maintenance Record
55	Yumen Phase III Project Operation and Maintenance Record
56	Diwopu I Project Operation and Maintenance Record
57	Shiren Phase I Project Operation and Maintenance Record
58	Bayin Project Operation and Maintenance Record
59	Wudaogou Phase I Project Operation and Maintenance Record
60	Sunjiaying Phase I Project Operation and Maintenance Record
61	Sunjiaying Phase II Project Operation and Maintenance Record
62	Goldwind GW77-1500 kW Technical Specification
63	Acciona IT1500CII Technical Specification
64	Gamesa G5X Doubly Fed Inductive Machine and LVRT Solutions
65	Gamesa Characteristics and General Operating of the Gamesa G5x-850 kW 50 HZ-60 HZ Wind Turbine Platform
66	Gamesa Characteristics and General Opertion of the Wind Turbine Platform Gamesa G8X-2MW
67	GE77 1.5sle Technical Specification
68	Sinovel FL1500 Technical Specification
69	Vestas V80 Technical Specification