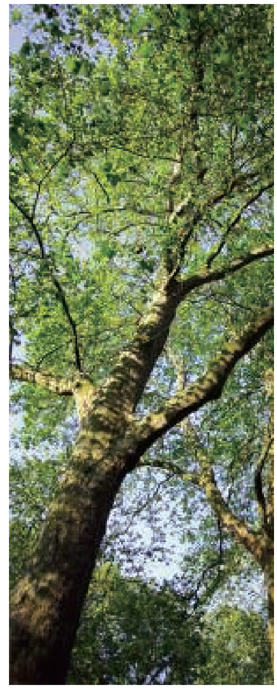

Technical Assessment Report

December 2011
Huadian Fuxin Energy Co., Ltd

Mott MacDonald

ISSUE AND REVISION RECORD

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EXECUTIVE SUMMARY

Introduction

Mott MacDonald Limited (herein and after MM) has been appointed by Huadian Fuxin Energy Corporation Limited (herein and after Huadian Fuxin) to act as Technical Consultant on the Company's global initial public offering (herein and after IPO) project.

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

- Huadian Fuxin Energy Corporation Limited;
- the asset portfolio that was subject to the technical assessment; or
- the outcome of the Global Offering.

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

MM is a wholly independent international company, with headquarters in the UK, annual turnover in excess of 1 billion pounds, over 14,000 staff and global experience spanning over 140 countries. Strong technical excellence, multi-disciplinary professional advantage, wide service range and world wide resources made MM to be one of the top consultant corporations around world, which provided solutions of management, engineering and development to lots of government department and private client. MM has started business in Beijing, Hong Kong and Shanghai over 50 years, completed hundreds of consultant projects, service covers many aspects such as transport, energy, building, water, environment, health, education, industry and communications etc. For the third consecutive year, MM has made the top 10 list in the UK's Sunday Times annual '25 Best Big Companies to Work For' employee survey, and ranking eighth in 2010.

MM has undertaken over seventy-four power projects in China totally over 35 GW including wind, hydro, biomass, waste-to-energy, gas-fired and coal-fired power plants, and power transmission and distribution.

MM carried out an independent technical assessment of Huadian Fuxin assets of wind farms, hydro power stations and coal-fired power plants. This review of wind farms includes wind resource assessment, power generation, availability, operation and maintenance arrangements, wind turbine technologies, grid connection arrangements and compliance with grid codes. The review of hydro power stations includes the design scheme, mechanical & electrical equipments, hydrology structure, hydrology, geography, availability, power generation, grid connection and environmental impact. The review of coal-fired power plants includes coal supply, power generation, availability, operation and maintenance, super-critical boiler and steam turbine technologies, life-limiting issues and major problems, and environmental limitations.

The majority of the information from which the report was compiled comprises of documents provided by Huadian Fuxin, and discussions and meetings with relevant Huadian Fuxin staffs. MM's professional judgement was exercised with regard to the rationality and validity of all information submitted from external sources. MM's knowledge of the Chinese power sector has been utilised throughout the independent technical assessment process.

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

Paul Jenkins, has been appointed to be Managing Director of China and Taiwan to look after business in this region since 2011. He has over 30 years' experience in the management, design and construction of major civil engineering, rail and metro projects in UK and overseas, including over 25 years of successfully managing projects from engineering studies through to major build, operate and transfer (BOT) rail schemes, with the past 10 years managing projects with capital values in excess of US$30,000 million. He has senior management experience leading large international multi-discipline teams on rail and metro transportation projects in UK and Asia Pacific Region.

Bauer Wu, MEng of Tsinghua University, BSc of Wuhan University, is the project manager for this project with over 8 years experience in China power sector, acting as the designer and technical consultant in over 15 power plant construction projects, covering coal-fired power plants, oil-fired power plants and wind farms. He also has experience for several hydro power plants technical assessment projects for assets acquisitions and some IPO technical due diligence projects such as Longyuan. The projects are both domestic and overseas.

Steven Cao, BSc in Power System and Automation and MSc in Power Engineering, has in depth understanding in energy system analysis, renewable energy and the development strategy of electric enterprise with over 15-year solid industrial, commercial and research experience in energy sector in and abroad. He has been involved in various energy projects as project engineer, for instance, primary electrical system design, sustainable development of power network, economic operation of transmission line, smart grid and distribution network reconstruction, due diligence for power projects and electricity business investment analysis, etc.

Adrian Kwek, has more than 20 years' experience in project management, business management and construction management which involves in structural steel construction and wind farm construction. He specialises in quality assurance, quality control system and engineering management progress. In the other hand, he is also very familiar with the environmental protection and site service engineering.

Ouyang Xun, Mechanical Engineer who has B.E. of Huazhong University of Science and Technology, MSc of University of Keele, Ph.D of the University of Derby. He has more than 10 years' experience in energy sector, and specialises in boiler system design for coal-fired power plant, Facilities installation, generator installation and commissioning, CCS, etc.

Recently he has offered technical consultation for six thermal power projects. He has also undertaken a number of projects, including construction of 300 MW to 800 MW sub-critical and super-critical coal-fired generation units, construction of 140 MW gas-fired combined cycle power generation, CCS, etc which located in China, UK, USA, Italy, Turkey, Pakistan, Iran, Kuwait and other countries.

Jeff Kerr, BEng, MBA. Over 22 years' experience in the design of civil engineering structures and excavation works, power houses and tunnel design, for hydroelectric power projects. He specialises in assessment of hydropower project viability and feasibility studies and the provision of lender's and owner's engineering services.

Jens Kahler, Ph.D, Hydroinformatics, a Chartered Engineer as well as being an ordinary member of the Institute of Engineering and Technology (IET) and The Association of German Engineers (VDI). Jens has extensive experience in mechanical and electrical design of hydropower plants as well as performing transient analysis and power and energy calculations. His experience in hydropower encompasses technical reviews and feasibility studies of hydropower plants, mechanical and electrical plant design in many countries all over the world.

Yuan Jingwei, BSc and MSc, engaged in large funded Integrated Water Resources Management project and several technical appraisal projects in water sector, including hydropower plant appraisal project to review the technical suitability and operation performance, and identify risks for the potential purchasers and investors.

Karryn Chen, MSc in Environmental Engineering, MSc in Energy Research of the University of Melbourne who has in depth understanding in renewable energy and concentrates on system design and review for solar power. She was responsible for ELI (Efficient Lighting Institute) certification services and involved in CNOOC Mass Energy Storage Station and Application Solution since joining MM. Meanwhile, she has accumulated rich experience in project investigation and report writing.

Project Participants

Huadian Fuxin Energy Co. Ltd. was formed in August 19, 2011 under Company Law of the People's Republic of China. It is converted from Huadian Fujian, the wholly-owned subsidiary of China Huadian Corporation. Its business focused on hydropower business, thermal power business and nuclear power business. At present, the company extends its business to the investment, construction and operation of all the clean energy projects and integrates the development and utilisation of hydropower, wind energy, thermal power, biomass power, distributed energy, solar PV power and other clean energy.

To date December 31, 2010, the hydro, wind, thermal power and other clean energy projects contributed approximately 26.1%, 24.6%, 29.1% and 20.2% of the total power installed capacity, respectively. As of December 31, 2011, Huadian Fuxin owned 36 operating wind power projects which had total installed capacity 2,171.3 MW. Meanwhile, there are 36 hydropower projects based in Fujian province that are in operation, which had installed capacity 2,223.4 MW in total. Huadian Fuxin also had 4 operating thermal power plants of which the total installed capacity is 2,050 MW. All the projects are managed by the subsidiaries of Huadian Fuxin in China.

Furthermore, Huadian Fuxin is a shareholder of a 2,000 MW nuclear power plant under construction and two 78 MW distributed energy projects which have been put into operation. Meanwhile, there are three solar power projects in operation with total installed capacity of 21.4 MW. Huadian Fuxin also owns two operating biomass power plants with total installed capacity of 25.3 MW.

Based on the review to representative projects, we consider that Huadian Fuxin is capable of acting as the owner and operator of the wind farms, hydro and coal-fired power plants.

Most of the WTG suppliers chosen by Huadian Fuxin to supply and maintain the WTGs on its wind farms are well known in wind industry. CSIC (Chongqing) Haizhuang Windpower Equipment Co., Ltd. (herein and after Haizhuang) did not have the long track record of the other chosen WTG suppliers. However it has undergone rapid development and its parent company CSIC has strong equipment manufacturing capability. We therefore considered Haizhuang is acceptable as a WTG supplier. We consider that these WTG manufacturers are capable of delivering their role in the reviewed projects.

Wind Farms Technical Assessment

Of the seven representative wind farms we reviewed, Guazhou wind farm and Lianyungang Guanyun wind farm power generation data is less than a year, as they are relatively new and so did not have enough operational data (at lease 12 months normal operational data), thus we could not assess whether their power generation of these two wind farms was in line with the forecasted value in the feasibility studies. For the rest of the five wind farms, the actual annual power generation of Kulun, Xiaocaohu and Muling are less than their feasibility studies forecasted value; Yilan Jiguanshan's annual power generation is in line with feasibility study's expectation; and Burqin has better annual power generation than feasibility study.

The seven representative wind farms are located in areas with excellent wind regimes of which six wind farms performance could be better if there were no grid curtailments for one reason or another. We would expect this curtailments problem to be mitigated by future upgrading of gird and load demand continuous increasing, and the strict imposition of LVRT and voltage control requirements on the wind farms by the grid operators.

For reactive power compensation devices in seven representative wind farms, Kulun wind farm has better capacity to feasibility study after reconstruction, which satisfies the requirements of reactive power compensation capacity. Xiaocaohu wind farm, Burqin wind farm, and Muling wind farm do not have sufficient reactive capacity to meet the reactive power demand required in the grid code and had submitted their reactive power compensation reconstruction plan to Huadian Fuxin headquarters and is pending approval. Yilan Jiguanshan wind farm will complete the construction of Static Var Generator (SVG) by the end of 2011. Comparing with feasibility study forecasted value, Guazhou wind farm has higher reactive power compensation capacity, which means the wind farm has sufficient reactive capacity to meet the reactive power demand required in the grid code. Lianyungang Guanyun wind farm is currently doing fine tuning of Static Var Generator (SVG), which capacity is sufficient for the technical requirements in grid code.

We were informed that both SGCC and Inner Mongolia grid company required all WTGs must have LVRT capability. Kulun, Xiaocaohu wind farm, Muling, and Yilan Jiguanshan wind farm do not have LVRT capability. They have submitted their LVRT reconstruction plan to Huadian Fuxin headquarters and were approved. As WTGs manufacturer of Kulun wind farm, Sinovel has developed LVRT reconstruction plan and promise implementing appropriately. Xiaocaohu wind farm will employ wind farm integrated LVRT technology for 54 Goldwind WTGs' reconstruction, and 6 WTGs from Sinovel LVRT reconstruction has been completed in December 2011. Since Muling has long operation time and less installation capacity, currently the wind farm is coordinating with local gird for necessity of LVRT reconstruction. Yilan Jiguanshan will complete LVRT reconstruction by the end of 2012. Goldwind promises that their WTGs installed at Muling wind farm have LVRT capability, and will be responsible for reconstruction if WTGs cannot be approved by inspection and certification. Sinovel WTGs installed at Guazhou wind farm have completed LVRT reconstruction by WTG manufacture in November 2011. The WTGs installed in Lianyungang Guanyun wind farm were inspected and certificated with LVRT capability.

There is a common problem for seven representative wind farms. The Group did not have regular testing and calibration on all torque wrenches, which are used to test whether the tower connecting bolts torque can meet manufacturer's requirements. It is a potential risk for WTGs safe operation. Huadian Fuxin should ensure that all torque wrenches are to be test and calibrated regularly.

Earth settlement monitor method and progress should improve immediately to meet earth settlement monitoring requirements in industrial regulation 'WTGs foundations design regulation FD003-2007'.

Kulun wind farm is running well. We hold the opinion that the actual power generation would be better if there is no grid curtailments. This wind farm is developing a pilot project to overcome grid curtailments by investing in electric boiler factor to provide regional winter heating. It is really important to reduce grid curtailments.

The actual power generation of Xiaocaohu wind farm is slightly lower than feasibility study forecasted value and is running in a good condition. Comparing lower capacity factor with feasibility study, we believed its annual power generation data is at a normal level.

The actual annual power generation of Burqin wind farm is higher than feasibility study forecasted value, which resulted from higher annual average wind speed and better capacity factor.

There were three large-scale off-grid incidents in Gansu area in 2011, thus Guazhou wind farm was affected by grid curtailments to date 7% of wind farm output.

Muling and Yilan Jiguanshan wind farm have long operation history. Comparing actual annual power generation data from 2009 to 2010 with feasibility study forecast, we concluded that the lower power generation of Muling wind farm in 2011 results from lower capacity factor. Base on historical data, we believed Muling wind farm is running well. Referring to Yilan Jiguanshan wind farm, its actual annual power generation fluctuated with feasibility study forecasted value in 2009-2010, and in 2010-2011. We understand Yilan Jiguanshan wind farm is running well.

Muling and Yilan Jiguanshan Wind Farm were built on areas with heavy vegetation and could be a potential fire hazard during the dry autumn and winter months. Special care and attention need to be taken into consideration during this period and Huadian Fuxin staffs need to stay vigilant during this season.

There is experimental Solar PV equipment at Yilan Jiguanshan Wind Farm to tap full resources into their wind farm, thus increase their revenue.

Liangyungang Guanyun Wind Farm showed lower performance than expected. We understand from the available information that missing operation data in 3 high wind speed months was the main reason for the low production. Earth settlement has to be monitored regularly at the major equipment components and rectifications works need to be done immediately where possible.

It is worthy to note that the wind farms located at Lianyungang in Jiangsu province do not have any such grid curtailment concerns.

Overall, the equipment and facilities of our visited representative seven wind farms are well-maintained and of good standard. The design, construction and installation are in line with our expectations.

Hydro Power Plants Technical Assessment

From reviewing the documents available and site inspection, all of the seven selected plants there well established and appropriate to current design. It appears to be no seismic activity at the powerhouse location and no major flood events or landslides have occurred that could have affected the dam and powerhouse and can be confirmed low risks.

Baisha hydropower station has been in operation for approximately four and half years since 2007. Analysis of operational records has shown that the plant has generated on average up to 88% of its design generation. It can be confirmed that the plant operates well as expected.

Mianhuatan hydropower has been in operation for approximately ten years and operated as expected based on the operation records.

Ansha hydropower station has been in operation for approximately 36 years. Some of the technology employed in the scheme (batteries) is considered old and may require replacement, even though it is not affecting the station capability. Overall the station equipment is appropriate for operation and considered to be low risk.

Fenghai hydropower station is a small-scale run-of-river power station and has been in operation for just over five years. The technology employed in the scheme (unit type, switchgear, batteries) is well established and appropriate to current design standards and considered to be low risk.

Gutianxi second cascade hydropower station has been in operation for more than 40 years. The dam has been reinforced during 2003-2005 and appropriate to current design standards. Most of the M&E equipments have been replaced since 2003 and in good condition.

Qinshan plant has almost been outage due to the construction of Zhouning hydropower plant in the downstream. Excluding 2004, the average annual power generation during 2000-2010 was 132.88 GWh, which has generated on average up to 91% of its design generation. It can be confirmed that the plant operates well as expected.

Chitan Hydropower station has been in operation over 30 years. Generally, the dam is in normal condition. Parts of equipments have been replaced since 2001. 1# generator and 2# turbine and generator are ageing. It is reported that the plant is preparing technical upgrading strategy and is planning to replace the ageing equipments gradually.

Thermal Power Plants Technical Assessment

We comment on the key conclusions relating to Unit 1 and Unit 2 in Kemen power station as below:

- We consider the power station design and equipment are based on mature and proven technology;
- We consider the output and power generation are in line with our expectation;
- Plant availability in some years had an outstanding performance and in general consistent with our expectations;
- Power station coal consumption reduction effect is higher than the national average and meet our expectations;
- The plant Capacity Factor is at high level among the similar power stations in China, though slightly lower than similar Western power stations. This is because annual power generation amount is decided by the production plan issued by government authority at beginning of every year;
- Because of high temperature premature failure and safety reason, the actual heat efficiency is slightly lower than design;

- We are slightly concerned about the 20% redundancy for circulating cooling water pumps. We consider the redundancy for other major equipment is adequate;

- Boiler high temperature superheater premature failure was due to design flaw and will be fixed by 2012;

- We reviewed the LTSA and the power cable maintenance agreement. We consider these agreements cost effective and provide some quality assurance;

- We reviewed the FSA, Grid Connection Agreement, and PPA and consider these agreements have provided some assurance to power generation, sales, and on-grid generation;

- We reviewed current Emission Permit and consider the emission meets current emission code. We would expect the NO_x emission meet the new emission regulation when fitted with SCR system;

- We reviewed the plant spare parts inventory and consider the stock and range are adequate for maintenance and planned outage.

1. INTRODUCTION

1.1 Overview

Mott MacDonald Limited (herein and after MM) has been appointed by Huadian Fuxin Energy Corporation Limited (herein and after Huadian Fuxin) to act as Technical Consultant on the Company's global initial public offering (herein and after IPO) project.

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1.2 Assets Overview

1.2.1 Introduction

To date December 31, 2010, the hydro, wind, thermal power and other clean energy projects contributed approximately 26.1%, 24.6%, 29.1% and 20.2% of the total power installed capacity, respectively. As of December 31, 2011, Huadian Fuxin owned 36 operating wind power projects which had total installed capacity 2,171.3 MW. Meanwhile, there are 36 hydropower projects based in Fujian province that are in operation, which had installed capacity 2,223.4 MW in total. Huadian Fuxin also had 4 operating thermal power plants of which the total installed capacity is 2,050 MW. All the projects are managed by the subsidiaries of Huadian Fuxin in China.

Wind turbine technologies adopted in the wind power projects of Huadian Fuxin are from renowned WTG manufacturers such as Goldwind, Sinovel, Haizhuang, Dongfang Electric Corporation (herein and after DEC) and international suppliers such as Nordex. The size of the turbines varies from 750 kW to 2 MW.

Hydro turbine technologies adopted in the hydro power projects of Huadian Fuxin are from well-known Chinese Hydro Turbine Generator manufacturers such as Harbin Electric Corporation (herein and after HEC), DEC, Hangzhou Hangfa Electrical Equipment Co., Ltd, etc.

Large-scale coal-fired power generation units adopted in the thermal power projects of Huadian Fuxin are from Shanghai Boiler Works Co., Ltd, Shanghai Turbine Works Co., Ltd and Shanghai Electric Power Generation Equipment Co., Ltd, which are the three subsidiaries of China Shanghai Electric Group Co., Ltd.

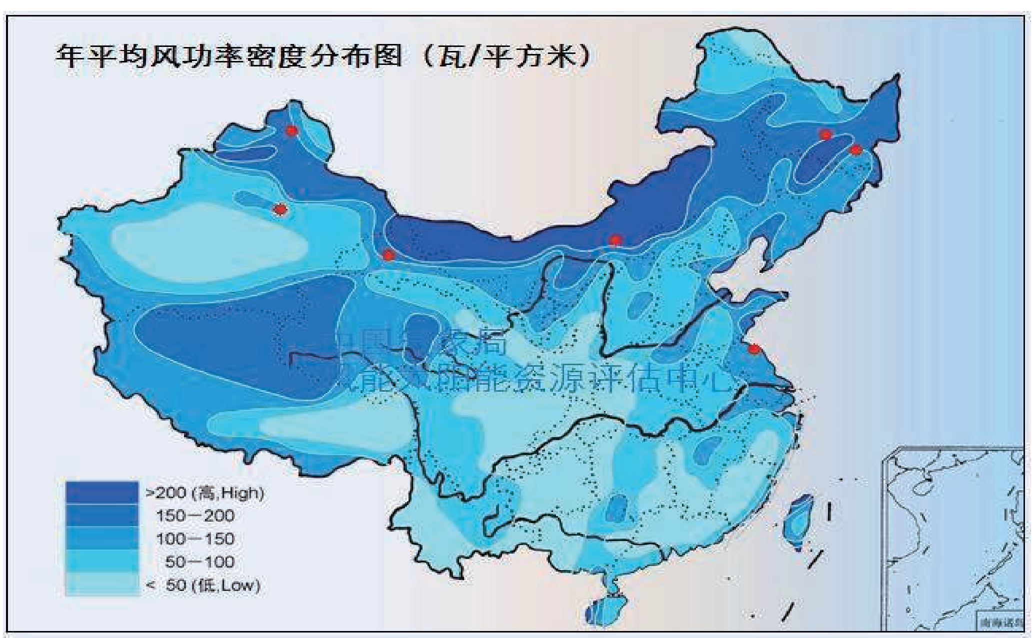
1.2.2 Selection of Representative Power Plants

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

Wind turbine types – Turbines selected in representative wind farms are produced by both domestic and international manufacturers as detailed in Section 2.2.1 of this report.

Wind resources and geographic coverage – Representative wind farms selected are located in areas with abundant wind resources including Inner Mongolia, Xinjiang, Gansu, Heilongjiang and Jiangsu, as indicated by the red marks in Figure shown in Figure 1.1 China has very sufficient wind resources, with the Global Wind Energy Council (GWEC) report "Global Wind 2009 Report," the estimated exploitable onshore wind resources at approximately 2,380 GW. According to a survey undertaken by the Chinese Renewable Energy Industries Association (CREIA) and the Business Council for Sustainable Energy (BCSE), wind resources are distributed as shown in Figure 1.1. Higher resources are located in the Northern parts of China such as Inner Mongolia, Xinjiang, Gansu Hexi Corridor, some areas of Qinghai-Tibetan Plateau, Northeast China, Hebei, and along the East China coast region from Shandong to Fujian provinces. The colour tone in Figure 1.1 represents wind density.

Figure 1.1: Wind power density of representative wind farms



Source: Provided by CMA Wind and Solar Energy Resources Assessment Center

- Operational time of wind farms – The operation date of the wind farms are various, however, the operational periods are mostly more than one year as shown in Table 1.1.

Table 1.1: Operation time of representative wind farms

Item	Project	Installed capacity (MW)	Operation date
1	Kulun Wind Farm Phase I	201 MW	Aug 2009
2	Xiaocaohu Wind Farm 1 Phase I	49.5 MW	Oct 2007
3	Burqin Wind Farm Phase I	49.5 MW	Mar 2010
4	Guazhou Wind Farm Phase I	201 MW	Mar 2011
5	Muling Wind Farm Phase I	31.2 MW	Sep 2006
6	Yilan Jiguanshan Wind Farm Phase I	49.5 MW	Sep 2009
7	Lianyungang Guanyun Wind Farm Phase I	100 MW	Apr 2011

Source: Provided by Huadian Xinfu

- Basin perimeter of hydro power plants – the representative hydro power plants are located in Jiulong river, Ting river, Minjiang Shaxi river system, Minjiang Futunxi River system, Minjiang downstream river system, Jiaoxi river system and etc as indicated by the green marks in Figure 1.2. The hydro power plants widely distributed on major water system in Fujian province, which fully reflect the generation ability of hydro power plants and are very representative.

Figure 1.2: Representative hydro power plants distribution in Fujian water system

Source: Fujian Agriculture Regional Planning Institute, Dec 2006

- Coal-fired power plants – the installed capacity of Kemen power plant contributes the major component of the thermal power as seen in Table 1.2.

Table 1.2 Operational thermal power projects

Item	Project	Installed capacity (MW)	Practical operation date
1	Fujian Huadian Kemen power plant	The two 600 MW units of Phase I, the two 600 MW units of Phase II	The two units of phase I started in Aug and Dec 2006

Source: Provided by Huadian Fuxin

The progress of the technical assessment was accomplished in China, of which the key procedures include but not limited to: site inspection, data collection, discussion, analysis and report writing.

1.3 Report Structure

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

- Project Participants;
- Wind Farms Assessment;
- Hydro Power Plants Assessment;
- Thermal Power Plants Assessment;
- Appendices;
- Glossary

1.4 Status of this Document

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

2. PROJECT PARTICIPANTS

2.1 Introduction

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

The predecessor, Huadian Fujian, was established on November 30, 2004. Huadian Fujian was a limited liability company wholly-owned by Huadian Group, primarily focusing on the operation of hydropower business, thermal power business and nuclear power business. On October 20, 2010, Huadian Fujian changed its name to Huadian Fuxin Energy Co. Ltd. upon SAIC's approval. On October 29, 2010, Huadian Group, Huadian Energy, Wujiang Hydropower, Huadian International and Huadian Engineering, which were all subsidiaries of Huadian Group (collectively "Five Shareholders"), transferred their respective equity interest in Huadian New Energy (Huadian New Energy was subsidiary controlled by Huadian Group, primarily focusing on the operation of clean energy business such as wind power business, distributed energy business and solar power business) to Huadian Fuxin Energy Co. Ltd.. After the transfer of equity interest, Huadian New Energy became a wholly-owned subsidiary of Huadian Fuxin Energy Co. Ltd.. Huadian Fuxin Energy Co. Ltd. was converted into a joint stock limited company under the Company Law on August 19, 2011.

To date December 31, 2010, the hydro, wind, thermal power and other clean energy projects contributed approximately 26.1%, 24.6%, 29.1% and 20.2% of the total power installed capacity, respectively. As of December 31, 2011, Huadian Fuxin owned 36 operating wind power projects which had total installed capacity 2,171.3 MW. Meanwhile, there are 36 hydropower projects based in Fujian province that are in operation, which had installed capacity 2,223.4 MW in total. Huadian Fuxin also had 4 operating thermal power plants of which the total installed capacity is 2,050 MW. All the projects are managed by the subsidiaries of Huadian Fuxin in China.

Furthermore, Huadian Fuxin is a shareholder of a 2,000 MW nuclear power plant under construction and two 78 MW distributed energy projects which have been put into operation. Meanwhile, there are three solar power projects in operation with total installed capacity of 21.4 MW. Huadian Fuxin also owns two operating biomass power plants with total installed capacity of 25.3 MW.

Based on the representative projects review, we consider that Huadian Fuxin is capable of acting as the owner and operator of the wind farms, hydro and coal-fired power plants.

2.2 Main Equipment Suppliers

2.2.1 WTG Manufacturers

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

2.2.1.1 Sinovel Wind Group Co., Ltd.

Sinovel Wind Group Co., Ltd. (herein and after Sinovel) is one of China's major wind turbine manufacturers, with its headquarters in Beijing, and branches or manufacture bases spread across Tianjin, Dalian of Liaoning province, Baotou, Xing'anmeng and

Bayannaoer of Inner Mongolia, Dongying of Shandong province, Yancheng of Jiangsu province and Jiuquan of Gansu province. It is actively engaged in development, design, manufacture, marketing, sales and operation & maintenance of both onshore and offshore WTGs. The Sinovel wind turbines are mostly gear-driven, with sizes including 1.5 MW, 3 MW, 5 MW and 6 MW.

On February 27, 2010, all 34 selected Sinovel 3 MW offshore generation units for the Shanghai Donghai Bridge 100 MW offshore wind power demonstration project are successfully installed and connected to grid on June 8.

According to 'Statistics of Installed Capacity of China Wind Power in 2010' launched by Chinese Wind Energy Association in March 2011, as of date December 31, 2011, Sinovel has contributed 4,386 MW new installed and 10,038 MW cumulative installed capacity. According to the ranking, Sinovel is the first place both in new installed and cumulative installed capacity among the all domestic and international wind turbine manufacturers.

2.2.1.2 Xinjiang Goldwind Science & Technology Co., Ltd.

The history of Xinjiang Goldwind Science & Technology Co., Ltd. (herein and after Goldwind) can be tracked back to 1998. It is one of the leading wind turbine manufacturers and whole technical solutions providers in China. Its core business includes research, development, manufacture and sales of WTGs.. Goldwind is also involved in design and construction, wind farm planning and consultancy services for wind farms.

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

Goldwind established a number of spare part warehouses in China and set Beijing branch as the centre. Of different periods, 11 other spare part centres are set up which are located in Xinjiang, Inner Mongolia, Liaoning, Guangdong, Ningxia, Jiangsu and other districts. These spare part centres formed an integrated nationwide service and spare part supply network, strengthened the response mechanism of the after sale service,and effectively guaranteed the next 20 years' continuous operation of the generation units.

On December 20, 2010, Goldwind wholly owned the Shady Oaks Wind farm located in Illinois, USA and there were more than 70 Goldwind megawatt PMSG units adopted in this wind farm. Meanwhile, Goldwind reached a power supply agreement with the local power operator. In addition, on November 23, 2010, Goldwind subscribed an agreement about the introduction of core module technology with Infineon Technologies AG.

PMSG wind turbine produced by Goldwind is currently the most representative megawatt wind turbine model in Chinese market.

According to 'Statistics of Installed Capacity of China Wind Power in 2010' launched by Chinese Wind Energy Association on March 2011, to date December 31, 2010, Goldwind contributed 9,078.85 MW cumulative installed capacity and 3,735 MW new. According to the ranking, Goldwind is the second place in terms of both new installed and cumulative installed capacity among the all domestic and international wind turbine manufacturers.

2.2.1.3 Dongfang Electric Corporation

Dongfang Electric Corporation (herein and after DEC) is converted from Dongfang Electric Machinery Co., Ltd which was formed in 1958. Through 50 years development, it has become the key member of the Chinese enterprises which produce large-scale generation equipment. DEC specialises in design, production and sales of water turbines, special motors and related control equipment, auxiliary equipment. Its subsidiaries spread in eight provinces and one city which are Sichuan, Guangdong, Zhejiang, Henan, Hubei, Jiangsu, Gansu, Inner Mongolia and Tianjin, furthermore, the headquarter is in Deyang of Sichuan Province. The DEC wind turbines are mostly gear-driven, with sizes from 1 MW to 2.5 MW.

According to 'Statistics of Installed Capacity of China Wind Power in 2010' launched by Chinese Wind Energy Association on March 2011, to date December 31, 2010, DEC contributed 2,623.5 MW new installed capacity and 5,952 MW cumulative in China. According to the ranking, DEC is the third place in terms of both new installed and cumulative installed capacity among all domestic and international wind turbine manufacturers.

2.2.1.4 Chongqing Haihuang Wind Power Co., Ltd

CSIC (Chongqing) Haizhuang Windpower Equipment Co., Ltd. (herein and after Haizhuang) was established in 2004, is the manufacturer who produces large-scale wind turbines and the related important parts. It was funded by the subsidiary and research institute of China Shipbuilding Industry Corporation (herein and after CSIC), which took advantages in system integration, gearboxes, generators, computer control, steel structure, hydraulic system, etc. Currently, there are 3 factories of Haizhuang which are respectively located in Chongqing, Shandong and Inner Mongolia.

According to 'Statistics of Installed Capacity of China Wind Power in 2010' launched by Chinese Wind Energy Association on March 2011, to date December 31, 2011, Haizhuang contributed 383.15 MW new installed capacity and 479.25 MW cumulative in China. According to the ranking, Haizhuang is the 11th place in terms of new installed capacity and 15th in cumulative installed capacity among the all domestic and international wind turbine manufacturers.

2.2.1.5 Nordex

Since established in 1985, Nordex has been committed itself to develop the high-powered and economical wind turbine. In 1995, the first Nordex megawatt wind turbine N54/1000 was produced, and N80/2500 series, the highest capacity wind turbine in the world, were manufactured in 2000.

At present, Nordex has installed over 4,600 wind turbines in 34 countries worldwide, and the total installed capacity reached to 7,111.45 MW. The branches of Nordex were set up in 18 countries, and its business in China commenced from 1995. As one of the international manufacturers who entered china earliest, Nordex established a joint venture specialising in wind turbine assembling and installation in Xi'an in 1998. So far, Nordex has installed over 550 wind turbines in China. There is a nacelle assembly line set up in Yinchuan at the end of 2006, and a blade manufactory established in Dongying in January 2007 producing 1.5 MW wind turbine blades.

According to 'Statistics of Installed Capacity of China Wind Power in 2010' launched by Chinese Wind Energy Association on March 2011, to date December 31, 2010, Nordex has contributed 524.7 MW cumulative installed capacity in China.It ranked 14th in terms of cumulative installed capacity among all domestic and international wind turbine manufacturers.

2.2.2 Hydro Turbine Manufacturers

2.2.2.1 Dongfang Electric Corporation

Dongfang Electric Corporation is converted from Dongfang Electric Machinery Co., Ltd which was formed in 1958. Through 50 years' development, it has become the key member of the Chinese enterprises which produce large-scale generation equipment. The main business of DEC includes design, production and sales of hydro turbine, special motors and relevant control equipment, auxiliary equipment. Its subsidiaries spread in Sichuan, Guangdong, Zhejiang, Henan, Hubei, Jiangsu, Gansu, Inner Mongolia and Tianjin, furthermore, the headquarters is in Deyang of Sichuan province.

At present, Dongfang Electric Corporation can produce 400 MW, 550 MW and 800 MW hydro turbine generation units. In recent 50 years, it has supplied plenty of power generation facilities for approximate 300 large and medium-sized power stations all over 31 provinces, cities and autonomous regions in China. By the end of 2007, Dongfang Electric Corporation has supplied generation equipment with 164,250.3 MW cumulative, which commands nearly 1/5 of the nationwide total installed capacity, of which there are 505 sets/33,130.5 MW of hydro turbines and 644 sets/131,109.2 MW of steam turbines.

2.2.2.2 Harbin Electric Corporation

Harbin Electric Corporation (herein and after HEC) was formed in 1951. At present, the hydro power generation of HEC reached to 4,000 MW, and its products has 50% domestic market share. HEC is the main Chinese hydro equipment manufacture base in China, whose hydro products contribute half of the domestic total installed capacity. A number of generation units have been manufactured for plenty of national key projects, for instance, cross-flow generation units with maximum capacity 800 MW, 300 MW pumped-storage aggregates, Kaplan generation units with maximum capacity 200 MW, and tubular generation units with maximum capacity of 45 MW. HEC has provided over 300 generation units for nearly over 200 domestic power stations, and nearly about 80 hydro power generation units for 26 overseas power stations.

2.2.2.3 Hangzhou Hangfa Electrical Equipment Co., Ltd

Hangzhou Hangfa Electrical Equipment Co., Ltd (herein and after HEEW) was formed in 1956, of which the leading products are hydro turbine generation units, steam turbine generators, motors, etc. HEEW has already had the ability of producing steam turbines with different specifications from 0.75 MW to 60 MW and hydro turbines from 0.32 MW to 50 MW. Among all the hydro power equipment series, the HEEW's mature manufacturing technique of high water head Francis and high-speed generation units maintain the leading position. Since 1970's, the products of HEEW have been applied in more than 30 countries and regions.

2.2.3 Boiler and Steam Turbine Suppliers

Shanghai Electric Group Co., Ltd

Shanghai Electric Group Co., Ltd (herein and after Shanghai Electric) is one of the biggest enterprise groups among Chinese equipment manufacturers. From 1990's, the sales revenue of Shanghai Electric always ranks 1st in China equipment manufacturing industry. Its core business is high efficient clean energy and new energy equipment, the latter contributed approximately 70% of the sales income.The leading products are 1,000 MW ultra-super critical thermal power generation units, 1,000 MW nuclear power generation units,heavy equipment, transmission and distribution, elevators, printing machinery and etc.

Shanghai Electric successfully produced the first Chinese 600 MW super-critical thermal power generation units in 2000. In addition, the first Chinese 1,000 MW ultra-super-critical generation units are manufactured in 2006. In 2009, Shanghai Electric contracted to build two 1,000 MW ultra-super-critical generation units for Waigaoqiao third power station.

Shanghai Electric actively developed the Integrated Gasification Combined Cycle (IGCC) technology, and then becomes the main equipment supplier of the first Chinese IGCC project – Huaneng IGCC power station.

2.3 Grid Operators

2.3.1 Grid Operators of Representative Projects

Table 2.1: Grid operators of representative power stations

Item	Energy type	Project	Installed capacity (MW)	Local grid operator	Provincial grid operator	Regional grid operator	National grid operator	Connected Point Voltage
1	Wind	Kulun Wind Farm Phase I	201	Ulanqab Power Supply	Inner Mongolia Power Company	Inner Mongolia Power Company	Inner Mongolia Power Company	220 kV
2	Wind	Xiaocaohu Wind Farm 1 Phase I	49.5	Tulufan Power Supply	Xinjiang Power Company	Northwest China Grid Company Limited	SGCC	110 kV
3	Wind	Burqin Wind Farm Phase I	49.5	Aletai Power Supply	Xinjiang Power Company	Northwest China Grid Company Limited	SGCC	110 kV
4	Wind	Guazhou Wind Farm Phase I	201	Jiuquan Power Supply	Gansu Power Company	Northwest China Grid Company Limited	SGCC	330 kV
5	Wind	Muling Wind Farm Phase I	31.2	Mudanjiang Power Supply	Heilongjiang Power Company	Northeast China Grid Company Limited	SGCC	66 kV
6	Wind	Yilan Jiguanshan Wind Farm Phase I	49.5	Jiamusi Power Supply	Heilongjiang Power Company	Northeast China Grid Company Limited	SGCC	110 kV
7	Wind	Lianyungang Guanyun Wind Farm	100	Lianyungang Power Supply	Jiangsu Power Company	East China Grid Company Limited	SGCC	110 kV
8	Hydro	Baisha Hydro power station	70	Longyan Power Supply	Fujian Power Company	East China Grid Company Limited	SGCC	110 kV
9	Hydro	Mianhuatan Hydro power station	600	Longyan Power Supply	Fujian Power Company	East China Grid Company Limited	SGCC	220 kV

Item	Energy type	Project	Installed capacity (MW)	Local grid operator	Provincial grid operator	Regional grid operator	National grid operator	Connected Point Voltage
10	Hydro	Ansha Hydro power station	115	Sanming Power Supply	Fujian Power Company	East China Grid Company Limited	SGCC	110 kV
11	Hydro	Fenghai Hydro power station	30	Sanming Power Supply	Fujian Power Company	East China Grid Company Limited	SGCC	110 kV
12	Hydro	Qinshan Hydro power station	70	Ningde Power Supply	Fujian Power Company	East China Grid Company Limited	SGCC	220 kV
13	Hydro	Gutianxi second cascade Hydro power station	130	Ningde Power Supply	Fujian Power Company	East China Grid Company Limited	SGCC	220 kV 110 kV
14	Hydro	Chitan Hydro power station	100	Sanming Power Supply	Fujian Power Company	East China Grid Company Limited	SGCC	220 kV
15	Thermal	Kemen power station Phase I	1,200	Fuzhou Power Supply	Fujian Power Company	East China Grid Company Limited	SGCC	500 kV

Source: Provided by Huadian Fuxin

2.3.2 State Grid Corporation of China

Founded on December 29, 2002 by the State Council, State Grid Corporation of China (herein and after SGCC) is responsible for construction and operation of power grids, and providing secure economic clean and sustainable power supply for economic and society development. SGCC supplies electricity to 88% of the national area, in twenty-six provinces. Its service area represents 88% of the national territory. It also provides power services to one billion customers. By the end of 2010, it owned and managed five regional electric power grid companies, twenty-six provincial-level electric power grid companies, and operated Philippines national grid and seven Brazil transmission concession companies. SGCC was ranked the 8th in the Fortune Global 500 in 2010 and becomes the largest utility in the world. The owned transmission line at 110 kV and above was 618,837 km. In 2010, SGCC sold 2,689.1 TWh of electricity and had annual revenue of RMB1,542.7 billion. Therefore, we consider that SGCC is capable of acting as the grid operator.

2.3.3 Inner Mongolia Power Company

As the only independent provincial grid corporation, the Inner Mongolia Power Company is responsible for construction, operation, management and rural power work of the transmission and distribution networks of 10 cities in western Inner Mongolia except Chifeng and Tongliao. It is the only large-sized state-owned gird operating enterprise owned by the Inner Mongolia Autonomous Region government.The eastern power grid is operated by Northeast China Power Grid Company in SGCC. By the end of 2010, it owned transmission line at 110 kV and above was more than 20,000 km. In 2010, the Inner Mongolia Grid Company sold 110 TWh of electricity and had annual revenue of RMB32 billion. Therefore, we have no concerns with regards to the capabilities and experience of Inner Mongolia Grid Company.

2.4 Conclusions

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

Most hydro turbine generator and thermal power generation units suppliers (HEC, Dongfang Electric, Shanghai Electric) chosen by Huadian Fuxin in the hydro and thermal power projects are well known to the worldwide power industry. According to the substantial track records, we consider the technology used as mature and the models as reliable if operated properly and adequately maintained.

The transmission and distribution grid of the power stations owned by Huadian Fuxin is constructed, owned and maintained by large-scale state-owned grid corporations (SGCC and the Inner Mongolia Power Company) which have become world leading grid investors and operators with long history and tremendous strength. Therefore, we have no concerns with regards to the capabilities and experience of China transmission and distribution companies acting as grid operators.

3. WIND FARMS TECHNICAL ASSESSMENT

3.1 Introduction

3.1.1 Wind Resources Assessment

We conducted technical assessment for Huadian Fuxin's seven wind farms located at Inner Mongolia, Xinjiang, Gansu, Heilongjiang, and Jiangsu. The objective is to assist buyer to identify potential risks and issues through current documents and on-site visit.

MM reviewed the documents and conducted on-site visit for the follow 7 wind farms:

- Kulun Wind Farm Phase I (201 MW)
- Xiaocaohu Wind Farm 1 Phase I (49.5 MW)
- Burqin Wind Farm Phase I (49.5 MW)
- Guazhou Wind Farm Phase I (201 MW)
- Muling Wind Farm Phase I (31.2 MW)
- Yilan Jiguanshan Wind Farm Phase I (49.5 MW)
- Lianyungang Guanyun Wind Farm (100 MW)

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

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

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

3.1.1.1 Chinese Standards for Wind Resources Assessment

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

GB/T 18709-2002 – Methodology of Wind Resource Measurement for Wind Farm; and

GB/T 18710-2002 – Methodology of Wind Resource Assessment for Wind Farm.

The former standard covers data collection and reporting, while the latter outlines the procedures for long-term correction, data screening, data processing and reporting. The wind resource assessments for the wind farms in this review were developed by different Chinese design institutes. However, the methodology and reporting of results are common to all studies and are based on the Chinese standards listed above.

3.1.1.2 Methodology of GB/T 18709-2002

The Chinese Standard GB/T 18709-2002 'Methodology of Wind Resource Measurement for Wind Farm' has requirements about location & installation of met masts, selection & configuration of measuring equipment, arrangement & layout of sensors, and collecting & processing of measuring data. We have observed in previous projects that fewer masts were used in the Chinese measurement campaigns compared to our preferred practice. It can be found from our site visits for this portfolio, the measurement campaigns were often with more than one met mast considered in feasibility studies. Therefore we believe the forecast and analysis for wind resources and WTG model selection in feasibility study have reliable reference.

3.1.1.3 Methodology of GB/T 18710-2002

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

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

The culmination of GB/T 18710-2002, in terms of energy yield, is reporting of the average annual windspeed, the wind direction, power density (W/m^2) and diurnal and seasonal profiling. In order to calculate the energy yield from a wind farm, it is necessary to calculate the wind speed distributions at each wind turbine location and to integrate these over the power curve for the chosen wind turbine. The wake turbulence 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.

3.1.1.4 Feasibility Study for the Representative Wind Farms

Between September 22 and October 15, 2011 we conducted site visit for a selection of seven wind farms within the portfolio. During or after these visits Huadian Fuxin provided us with the original feasibility study for each wind farm. We also requested the production and availability figures, evidence of power curve performance, and details on the operational performance of each wind farm including significant outage, major component failure, grid curtailments etc.

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

3.1.1.5 Wind Resources

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

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

In each case of feasibility study, the wind speed distributions were modelled by WasP, which is a software package developed by Riso, the National Laboratory and is considered to be an industry standard tool for modelling the variation in wind flow considering details on topographic and ground cover variation in non-complex environments.

The difference of wind turbines types, number of units, and layouts between actual approval result and feasibility study is because the wind turbines suppliers for wind farms are not the recommended supplier in feasibility study, which is a common situation. However, the difference in the wind turbines types, number of units and layouts of the wind farms to their feasibility studies had not and will not effect the operation of the wind farms.

3.1.1.6 Energy Yield

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

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

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

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

However, we noted that there was no consideration of losses due to grid curtailments for those wind farms in Inner Mongolia, Xinjiang, Heilongjiang and Gansu. We understood that it was mainly because there was no grid curtailment when these feasibility study reports were prepared. The wind energy industry has grown rapidly since 2007 in China and grid curtailments became serious in western Inner Mongolia and partly North China in the winter of 2009. Along with the large-scale upgrade of relative regional grid from 2010, we expect that the bottleneck of curtailment will gradually ease in future. This is an area of concern in our opinion the local grid curtailments should be fully considered for production forecasts in the feasibility studies. Where possible, we would prefer to base the production forecasts on actual production data from at least 1 year of operating history. Typically in the feasibility studies, assumed losses are around 28% of the gross energy production, which we consider to be generous in our opinion. Nevertheless, where there were grid curtailments in place, more credence should be given to the actual production figures of each wind farm.

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

3.1.1.7 Conclusion

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

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

3.1.2 Grid Connection Assessment

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

- Power transferring capacity limitation of wind farm including all equipment, i.e. substation main transformer's nominal capacity, and export cable/overhead line nominal capacity etc. Analyse and assess if these have been rated appropriately to export full generation from the wind farm;

- Grid Codes and essential requirements for wind farms, including whether there are sufficient reactive power compensation capability available from the wind farm, so that the wind farm is capable of maintaining the required power factor at the grid connection point for the given voltage ranges and real power output, voltage control capacity, Low Voltage Ride Through (herein and after LVRT) and power quality indices of the wind farms connected to SGCC; and

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

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

- documents provided by Huadian Fuxin;

- meetings and discussions with relevant staffs of Huadian Fuxin;

- sites visit to the seven representative wind farms; and

- relevant data and information from the public domain, together with our general knowledge in this field and specifically of the Chinese power sector.

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

- feasibility study reports;

- grid connection system reports;

- main primary electrical single line diagrams of wind farms;

- single line diagrams of inter array collection lines of wind farms;

- grid connection agreement;

- grid codes and essential requirements for wind farms connect to grid;

- renewable energy policy of the Chinese Government;

- feedback to our questionnaire from Huadian Fuxin; and

- site visit records.

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

3.1.2.1 Key Issues Addressed in Grid Connection

Through our data review and analysis, we noted that the seven representative wind farms are properly connected to 330 kV, 220 kV, and 110 kV etc. transmission and distribution grid.

We summarised several key issues addressed in grid connection as following:

3.1.2.2 Equipment Capacity of the Wind Farm Step-up Substation

- Capacity of main transformer

Selection of a step-up main transformer's capacity 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.

The capacity of main transformers in the substation at the wind farms sites, except Kulun wind farm, are consistent with feasibility study report. Transformers are equipped with on-load tap changers which are able to provide flexible voltage adjustment and maintain stable voltage level of bus bar at the wind farm substation.

- Nominal capacity of the wind farm export overhead lines

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

It appears that all single lines connecting the visited 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, it is not compliant with the 'N-1' security contingency like western wind farms, it is noted that in western wind farms, the connection lines belonged to the wind farms, who applied 'N-1' principle based on its own choice, also there is no compelling regulation requirements. While, in China, the connection lines are owned by the grid company, and almost every wind farm connects to the grid by single circuits. Also, in the updated version of Chinese Grid Code (Revision) of wind farm grid connection published in December 2009, there is no requirement for the wind farm to meet the 'N-1' security criteria for the transmission network between the wind farm substation and the grid connection point.

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

- Other Equipment Capacity

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

3.1.2.3 Reactive Power Compensation and Voltage Control of Wind Farms

Wind farm reactive power compliance is an important technical requirement for the wind farm to be connected to the power grid. Maintaining the required power factor needs sufficient reactive power compensation of each wind farm. The purpose of the reactive power compliance analysis is to examine whether there are sufficient reactive power compensation capability 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 results reveal any insufficiency, reactive power compensation schemes should be considered when designing the grid connection scheme. Even though detailed reactive power studies are not performed for most Chinese wind farms as they are elsewhere in the world, Chinese grid connection system design usually provide requirements of reactive compensation schemes under typical operating modes.

Connection of numerous WTGs in a wind farm may cause voltage deviation, voltage fluctuation, flicker, and harmonics issues which have impact on the power supply quality of local power grid. The Chinese Grid Code of 'Wind farm grid connection technologies requirements (reversion)' in 2009 required technical indicators of the power quality and LVRT capability. State Electricity Regulatory Commission (SERC) issued a notice in October 2011, which required wind farms to conduct grid connection safety assessment by following "Safety conditions and assessment regulations for wind farms grid connection." This notice contained detail requirements and processing advices for WTGs LVRT. We are aware that part of Huadian Fuxin wind farms required to be technically upgraded so that they can perform LVRT to meet relevant requirement in the latest Chinese Grid Code issued by National Grid. Huadian Fuxin promised that these wind farms will implement the upgrade accordingly.

3.1.2.4 Local Power Grid Operation

The feasibility study reports have shown that the power system security analysis software package including the 'N-1' security criteria has been carried out for the local transmission grid in each wind farm in order to analyze the steady and dynamic performance of the local power gird.

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

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

In winter, especially during the night, the combined heat & power plants to provide heat to the local district heating systems, the power generation from wind farms may have to be curtailed to some extent due to insufficient capability to adjust active power. On the other hand, the voltage stability of power system has become the major issue in grid of wind power concentrated regions for a large scaled expansion of wind power. We understand that the local grid should have sufficient capability to accommodate Huadian Fuxin's wind farms and we would expect that this problem could be solved by future reinforcement of the power grid. It is reported that one option is strengthening the construction of interconnection lines between Inner Mongolia Grid and North China Grid, i.e. the proposed joint venture to establish two high voltage grid lines between Inner Mongolia grid and north China grid. We believe that the loss of power generation results from grid curtailments will gradually ease in two to three years.

3.1.3 Operation & Maintenance Execution of Wind Farms

For the operation and maintenance (herein and after O&M) of its wind farms, Huadian Fuxin has a general strategy to rely on WTGs manufacturers during the warranty period, while Huadian Fuxin O&M staffs also involve in daily work, hand it over to their O&M team on sites (Kulun wind farm, Xiaocaohu wind farm, and Burqin wind farm), or consider to extend warranty period with WTG manufactures after expiry (Yilan Jiguanshang wind farm), or sign sub-contract with professional O&M company (Guazhou wind farm, Muling wind farm, and Lianyungang Guanyun wind farm) under the premise of economic rationality.

The warranty period for seven wind farms visited, provided by the WTGs manufacturers, is two years. This is in line with our experience of other wind farms and current industry standards. We hold the opinion that two years warranty period is acceptable for proven WTG technologies.

Before starting O&M work, technicians are trained by the manufacturer in their training centre or other operating wind farms, daily training is continuous and based on the regulations issued by Huadian Fuxin headquarters. In our view, the safety and performance targets of operation should be achieved based upon adequate experience of technicians and compliance with proper procedures laid out by WTG manufacturers.

Each wind farm is responsible for the road access maintenance with an appropriated amount of expense by itself. It is normally sub-contracts to professional road maintenance team.

As required by the industry regulations, the export lines connected to the grid are maintained by the local grid company.

3.1.3.1 Operation & Maintenance Organization

We believe the staffing levels are adequate for each site. The number of employees at each wind farm site is set by Huadian Fuxin's Headquarter based on internal principles (refer to table 3.1) which also included human resource for further development and construction. Staff are recruited and trained by the Huadian Fuxin's headquarters, which ensures control of the qualification and competency of the employees on site. Wind farm project companies propose an organizational structure which is then to be approved by Huadian Fuxin's Headquarters. They assign the general manager and other senior managers, other O&M employees are hired by each project company.

Table 3.1: Human Resources Configuration for Wind Farms

Wind Farms Types		Small-scale (<50 MW)	Medium-scale (40*1.5 MW)	Large-scale (100*1.5 MW)	Note
1.	Production Personnel	22	24	31	Included 10% staff on standby
1.1	Units Operation	11	11	11	
1.2	Units Maintenance	10	12	19	
1.3	Others	1	1	1	
1.3.1	Warehouse	1	1	1	
1.3.2	Required Personnel				Approved by Group
2.	Management Personnel	10	12	15	Included management staff for Admin, Production, Operation, Party, and Logistics

Source: Provided by Huadian Fuxin

Three divisions are usually set for production, maintenance and execution. The O&M team usually has two or three shifts. Daily requirements are therefore satisfied, i.e. replacement of consumable parts. This organization set-up minimises reaction time for small maintenance tasks on the WTGs and manufacturer support is given during major overhauls. It also improves the availability of the turbines and power generation, which is good for the revenues. Most wind farms including Kulun, Xiaocaohu, Burqin, Guazhou, Yilan Jiguanshan, and Lianyungang Guanyun we visited are still covered by the warranty, which means all O&M services provided by WTGs manufacturers are covered by warranty fee.

3.1.3.2 Operation & Maintenance Arrangement

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

Huadian Fuxin has established its first regional control centre in Hohhot, which integrates wind farms' background control system of WTGs control platform and remote control system of substation to management company headquarters through information copy to control platform. This strategy achieved the objectives of central control for each wind farm WTGs and supervision for substation. By using remote control software, Huadian Fuxin headquarters can achieve the target that one host computer operates multiple computers within different regions, which means the control centre can be easily implement remote control by network. When the host computer operates multiple computers, the remote control software like a LAN administrator and the remote control terminal is an extension of wind farms' control platform. This special network approach made the network more secure and reliable to access, and the network manager can easily manage various online equipment. Control centre platform is the same as each wind farm's control platform, and video & voice communication system are also applied into this control strategy. Huadian Fuxin will establish similar regional control centre in other areas.

Training programs arranged by the manufacturers included in all O&M arrangement documents were reviewed. These are comprehensive, and include two to four weeks training in factories and on site, covering most topics and problems that may occur on site. The training covers using the maintenance manual, keeping records of faults, operation and control of WTGs, erection method for replacement parts, maintenance procedures, failure diagnosis, and spare part management. We understand that Huadian Fuxin staff also assists the manufacturer's team during scheduled and unscheduled maintenance and learns their experience and skill. We are satisfied that experience can be gained by the team through this arrangement.

Huadian Fuxin headquarters issue and publish the O&M regulations applied to each wind farm, and were ranked according to maintenance requirements. Maintenance method is divided into regular maintenance, condition-based maintenance, improvement maintenance, and troubleshooting maintenance. Maintenance Grade principle is base on power generation equipment maintenance and downtime, which was divided into Grade A, B, C, and D, major overhaul, and temporary maintenance. Grade A to D mean five years periodic inspection, three years periodic inspection, one year periodic inspection, and half year periodic inspection of wind turbines respectively. The downtime (days) of each grade maintenance were presented on table 3.2. The key sections of these regulations are written on boards and hung on the wall of relevant facilities at each site, which we were happy to find since this makes it easier for O&M staffs to find and follow them. All the main operational aspects are covered, e.g. the WTGs, public systems, production buildings, and accommodation facilities etc, which are drafted based on relevant national and industry standards, Huadian Fuxin wind power management experiences, and WTGs manufacturers O&M requirements. O&M regulations are important foundation of site daily O&M, we are satisfied with the regulations applied by Huadian Fuxin to the projects sites.

Table 3.2: Downtime for Different Wind Turbines Maintenance

Wind Turbines Generator Types	Maintenance Grade			
	Grade D	Grade C	Grade B	Grade A
1.5 MW Double-fed induction wind turbine	1	1.5	2	2
1.5 MW Direct-drive synchronous wind turbine	0.75	1	1.5	1.5
850 kW Double-fed induction wind turbine	0.5	0.5	1.5	1.5
750 kW Fixed Pitch Wind Turbine	0.5	0.5	1.5	1.5

Note: Maintenance downtime (days) includes the time of loading test.

Source: Provided by Huadian Fuxin

As previously discussed, most of the wind farms we visited continue to be maintained by the manufacturers, having started commercial operation during the past two years, they are still in their warranty period. According to the maintenance records we saw on sites, and interviews with the manufacturers' on-site staffs, the scheduled maintenance has been carried out in accordance with clauses in the agreements. We note that the WTGs Maintenance form elaborates on inspection and items which are to be checked by the manufacturer maintenance staffs regularly. The form is comprehensive and includes all the main items. After expiry of the warranty period, site staffs from Huadian Fuxin, WTGs manufacturer or specialised company will undertake the regular maintenance of WTGs. Most of the WTG suppliers have a regional service centre nearby the wind farms, so manufacturer servicing will still be accessible. We expect the manufacturer to respond rapidly to service requests as Huadian Fuxin is one of the major wind power producers in China. Huadian Fuxin plans to establish regional specialised O&M teams responsible for large-scale and difficult or requiring a large number of human resources and materials maintenance works of wind farms within the region.

In our view, plant maintenance by an external specialised company allows for more confidence in the quality of the service and is in line with industry practice at Western wind farms. If Huadian Fuxin could consider and compare the quality, cost and efficiency of maintenance to be provided by the sub-contractor and themselves in the future when the qualified sub-contractor are available, it will be more adaptable to international practice.

In order to make it cost-effective, Huadian Fuxin is considering managing maintenance service in some wind farms, extending warranty period with WTGs manufacturers, and sub-contracting maintenance service to specialised companies at other wind farms. This may contribute to its ambitious plans for future growth and could help consolidate the rapid expansion of its wind portfolio that has taken place in recent years. However, careful thought should be put into this balance. Currently, the O&M procedure and tasks of Huadian Fuxin wind farms are following industrial O&M standards such as 'DL/T 838-2003 Code on Maintenance of Power Plant' and 'DL/T 19001-2008 Code on Quality Management System' which were issued by the national authority.

At visited wind farms, the storage of spare parts is well-registered, well-managed and well-recorded. The consumable parts like sensors, tools, brake pieces, and sealing are purchased by the site company regularly. According to Huadian Fuxin headquarters' plan, spare parts procurement is a key part of its annual budget for O&M. The normal spare parts procurement, according to the regulation called 'Huadian Fuxin WTGs O&M Management Regulation (Version A)', each wind farm submits next annual O&M plan (include spare part procurement) bases on its 'Maintenance Grade Combined Plan', 'Five Year Regular Rotation Maintenance Plan' and actual conditions to Huadian Fuxin headquarters. Huadian Fuxin reviews each wind farm's maintenance plan, confirms procurement method of spare parts, and purchases materials in accordance with 'Materials Biding Management Regulation' by headquarters or by wind farms.

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

During our sites visit, we noted that no major impact has been recorded on the environment after construction period or during operation. For Quality, Health & Safety and Environmental (QHSE) manuals and relevant system files, 'China Huadian Group Renewable Energy Development Limited – Safety Power Generation' and 'China Huadian Group Renewable Energy Development Limited – WTGs Maintenance Management Regulation (Trial)' illustrated the requirements of safety, health, and quality.

3.1.3.3 Conclusion

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

The control centre in Hohhot is the first regional supervision centre for Huadian Fuxin, which centralized wind farms' background control system of WTGs control platform and remote control system of substation to management headquarters to achieve the objectives of central control for each wind farm WTGs and supervision for substation. In future Huadian Fuxin will establish similar regional control centre in other areas.

Huadian Fuxin has specific internal rules and regulations, which specified O&M arrangement and spare parts procurement. All in all, the structural organization and arrangement of O&M, the procurement and storage of spare parts and the QHSE requirements of Huadian Fuxin wind farms are generally excellent, however, its environmental pollution control regulations needs to be improve.

It is a good mature strategy for wind farms WTGs manufacturers to provide maintenance services after warranty period expire. Since these manufacturers are most familiar with their WTGs, which can increase the reliability of WTG and cost-effective.

3.2 Kulun Wind Farm Phase I

Kulun Wind Farm Phase I is located in Wulanchabu in Inner Mongolia. It consists of one hundred and thirty-four Sinovel SL1500/70 1.5 MW WTGs, with a total capacity of 201 MW, and start commissioning in August 2009.

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

3.2.1 WTGs

In 2010, Sinovel's new installed capacity was 4,386 MW and was mainly based on the wind turbines of the SL1500 WTG series and SL3000 WTG series in China. Sinovel introduced 1.5 MW WTG technology from the established German manufacturer Fuhrländer, and developed the 3 MW and 5 MW WTG technology with proprietary intellectual property rights. The SL1500 is a three blades, horizontal shaft WTGs with a double-fed generator, active pitch, and active yaw system with variable speed operation. The WTGs is available in a normal and a low temperature version.

Overall, we consider the design of Sinovel SL1500 to be in line with the industry standards. The main technical parameters are summarized in Table 3.3.

Table 3.3: Technical Summary of Sinovel SL1500

	SL1500
Hub Height	70 m
Rotor Diameter	77 m
Nominal Power	1,500 kW
IEC Classification	IEC III
Certification	Lloyd's Register
Cut-in Wind Speed	3 m/s
Nominal Wind Speed	11 m/s
Cut-out Wind Speed	20 m/s
Generator	Double-fed asynchronous generator
Gearbox	Two stage planetary gear + one stage spur gear
Gearbox Ratio	1:104
Power Compensation and Control	Pitching Blade Control
Operation Ambient Temperature	-30°C~+45°C
Standby Ambient Temperature	-45°C~+45°C

Source: Provided by Huadian Fuxin

3.2.2 Grid Connection Assessment

3.2.2.1 Equipment Capacity

Kulun Wind Farm Phase I has one hundred thirty-four Sinovel SL1500 – 1.5 MW WTGs installed with a total capacity of 201 MW. Each turbine is connected to a WTG step-up transformer via underground cables. These cables are rated appropriately in order to carry maximum output from each individual turbine. Then these turbines transformers are connected to their own sixteen 35 kV overhead inter array collection lines, through bus bar linked to two main transformers in 220 kV switch station and are rated appropriately to carry the maximum output from the wind turbines.

A step-up substation has been constructed with 2 x 100 MVA – 220/35 kV transformers with an on-load tap changer. The actual capacity of main transformer is different with feasibility study's result but almost meet the requirements of main transformer's capacity in industrial standard 'Wind Farms Design Technical Regulation DL/T 2383-2007'.

Kulun Wind Farm Phase I is connected to the 220 kV Hanhaidian substation via one 84 km 220 kV overhead line with appropriately rated thermal rating. We consider that the circuit is sufficient Inner Mongolia Power Grid requirements to export all power generated by the wind farm to the grid.

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

3.2.2.2 Reactive Power Compensation and Voltage Control

The total capacity of the Static Var Capacitor (herein and after SVC) installed at the site is 35 MVar inductive + 25 MVar capacitive, which is better than feasibility study's design. In addition, the step-up transformer is equipped with an on-load tap changer which is able to control voltage between 90% and 110% at the HV winding. We would consider the wind farm has sufficient reactive capacity and voltage control capacity to meet the reactive power demand and voltage regulation as required in the grid code.

For LVRT reconstruction, North China Electricity Regulation Bureau of State Electricity Regulatory Commission has issued a notice 'Wind Farms LVRT reconstruction schedule to access Western Inner Mongolia Grid', which required Huadian Fuxin Kulun Wind Farm should complete LVRT reconstruction by the end of December of 2012, and finish testing and certification in six months after completion. We were informed by Huadian Fuxin that Sinovel has provided a reconstruction proposal for LVRT reconstruction, and promised implementation reconstruction schedule appropriately.

3.2.2.3 Local Power Grid Operation

Kulun Wind Farm Phase I is located in Wulanchabu and is connected to local power grid via 220 kV transmission line, and hence it is dispatched by Inner Mongolia Power Company.

Like most windfarms in Inner Mongolia, where it connects to the western Inner Mongolia grid, curtailment during winter is inevitable as many combined heat and power plants have to be kept in operation in order to supply both electricity and heating. As a result, the power output from Kulun Wind Farm Phase I may have to be curtailed to some extent due to local power grid's insufficient capability to adjust active power. On the other hand, the voltage stability of power system has become the major issue in local power grid for a large scaled expansion of wind power. We understand that the local grid should have sufficient capability to accommodate from Huadian Fuxin wind farm and would expect that this problem could be eliminated in the medium term by future reinforcement.

It would be interesting to note that Huadian Fuxin Kulun wind farm is experimenting with a pilot project to overcome this curtailment by constructing a factory to provide heating to a town via electrical boilers in winter. Arrangement was made with Inner Mongolia Power Company to provide electricity to this factory to keep the boilers running and reduce the curtailment in this windfarm. It was reported that this project will reduce grid curtailments to some extent.

3.2.3 Performance of Wind Farm

3.2.3.1 Site Environment

Kulun Wind Farm Phase I is located on very flat and simple terrain and scrub/desert land with the site varying in altitude 1,430 m above sea level (herein and after ASL). From our appreciation of the terrain during our site visit, we do not have any concerns regarding shading, channeling or excessive gradient which could lead to adverse wind conditions such as severe wind shear, inflow angles or turbulence.

The site is subjected to very low temperature in winter. The operating ambient temperature of Sinovel SL1500 WTG is from -30°C to +45°C and the standby ambient temperature is from -45°C to +45°C which are similar to other wind turbine models as low temperature version.

3.2.3.2 Site Facilities and Maintenance

There is a compound area at the site which contains the substation, control room, spare parts warehouse, offices and other site facilities. The wind farm company which is the subsidiary of Huadian Fuxin employs one wind farm manager and has 5 operators and 22 maintenance engineers/technicians on two rotating shifts. The wind farm compound has very good facilities which are suitable for housing the stuffs and are well maintained.

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

Sinovel is a leading Chinese wind turbine manufacturers with a good track record and a significant number of units installed in China. We were informed during the site visit that they do experienced problems on the power generators to some WTG units before they took over and they were replaced without costs to Huadian Fuxin as it was still under warranty. The repairs were carried out by the manufacturers and according to Huadian Fuxin, it resulted in short downtime in each case as spare parts were readily available at the manufacturers' central warehouse nearby.

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

During our site visit, we had checked on the power curve and find the WTGs performance is properly and in accordance with manufacturer's promised requirement of power curve. Huadian Fuxin informed us that they will claim against the manufacturer if any of their WTG unit is under performing.

During our site visit, we noticed there were foundation apron slab constructed around the WTG foundation for water drainage.

Considering WTG foundation settlement inspection, we did not see any foundation settlement inspection regime and records being instituted, although we were informed that the windfarm does random WTG foundation settlement inspections. Huadian Fuxin has provided us with 'Quality and Safety Inspection reports' issued by third party, which show that the wind farms has been certified. Although currently there is no problem with WTGs foundations, for WTGs structure safety and long term operation of the wind farm, we suggested to check these foundations (unstable stratum with settlement risk) settlement on a regular basis.

There were three met masts in the wind farm collecting weather data for their operations and also in preparations for providing weather to the Load Data forecast transfer to the regional despatch centres.

At the time of our visit, the WTGs of Kulun Wind Farm Phase I were covered by a manufacturer's warranty with a two year period. We understand that scheduled maintenance and grid downtime are excluded from this figure. They only reflect the turbine availability for the whole wind farm and only as per the definition of availability in the turbine supply contract. During our site visit, Huadian Fuxin provided us the power curves from their SCADA (supervisory control and data acquisition) system and they appeared to be broadly consistent with the standard power curves from the manufacturer.

3.2.3.3 Performance of Power Generation

Wind speed data was collected by anemometer at the rear of nacelle, thus the measured data always lower than actual speed. In 2010, the average annual wind speed at the hub height of the WTGs has been calculated to be 6.81 m/s, which is lower than feasibility study result, and the net capacity factor is 0.25, which is typical for an onshore wind farm. The wind speed, availability and production data provided by Huadian Fuxin shows that the average turbine availability in 2010 was 97.29% (as shown in Table 3.4 below), higher than the warranted availability 95%.

Table 3.4: Kulun Wind Farm Phase I Operation Data

Date	Average WTGs Availability	Total Power Generation	On-Grid Power Generation	Equivalent Full-Load Hours	Capacity Factor	Average Wind Speed
	(%)	(MWh)	(MWh)	(h)		(m/s)
2010-12	98.06	44,079.38	43,130.35	215	0.29	10.2
2010-11	96.95	48,259.93	47,221.07	235	0.33	7.5
2010-10	98.34	40,633.98	39,759.25	198	0.27	5.8
2010-09	97.82	20,590.01	20,146.79	100	0.14	5.0
2010-08	95.69	21,210.03	20,753.48	103	0.14	5.3
2010-07	96.21	21,128.52	20,673.58	103	0.14	4.6
2010-06	97.23	19,731.25	19,306.59	96	0.13	4.5
2010-05	98.07	56,158.17	54,954.26	273	0.37	7.7
2010-04	97.28	60,837.60	59,554.84	296	0.41	7.3
2010-03	98.43	47,851.90	46,913.64	233	0.31	8.5
2010-02	98.26	17,738.85	17,390.69	87	0.13	6.8
2010-01	95.17	46,235.35	45,240.07	225	0.30	8.5
Total/Average	97.29	444,454.97	435,044.61	2,164	0.25	6.81

Source: Provided by Huadian Fuxin

We were informed by Huadian Fuxin that it is very common for wind farms in Inner Mongolia to be subjected to grid curtailments. The curtailments usually occur at night in the winter months when demand for heat generation in the region is at a peak, and the electrical generation from wind farms is sacrificed for combined heat & power plants which guarantee the heating supply. We have been provided with documents which outlines the details of curtailments imposed by the grid company in Inner Mongolia Grid Company issued on October 20, 2009 and March 15, 2010 separately. According to them, grid curtailment time was from 11 pm to 7 am of the next day. Grid curtailments depend on current power demand.

The most significant impact of the grid curtailments imposed by the grid company occur in the winter months, when part of the estimated potential output of the wind farm was lost. Its grid curtailments were lower than 8.6% in 2009 and 2010. The biggest loss happened in February 2010 when there was Chinese New Year and power load was lower than normal because most factories were closed for the holiday.

Wind farm estimated annual power generation in feasibility study is 496,530 MWh, while the actual annual power generation of 2010 was 444,454.97 MWh, which is lower than feasibility study's result. If there is no significant grid curtailments in winter, we believed the power generation of wind farm should be better.

It would be interesting to note that Huadian Fuxin Kulun wind farm is experimenting with a pilot project to overcome this curtailment by investing in a station to provide winter heating to a town via electrical boilers. Arrangement was made to provide electricity to this station to keep the boiler running and reduce the curtailment in this windfarm. It was reported that this project will reduce grid curtailments to some extent.

3.2.4 Conclusion

Wind turbines in Kulu Wind Farm Phase I were supplied by a well-recognised Chinese wind turbine manufacturer that employs proven technologies. The O&M arrangements are well-managed with very good facilities at the site. For safety and long-term usage of the wind farm, we still suggest to check these wind turbines foundations settlement on a regular basis.

We are of the opinion that the wind farm was built to a good standard. The wind farm capacity factor in 2010 has been about 0.25 which is typical for an onshore wind farm, the average WTGs availability has been 97.29% which was higher than warranty availability 95%, and the average wind speed at hub height has been 6.81 m/s which is lower than feasibility study estimated value, but still showed a better wind resources here. Although the most significant impact of the grid curtailments imposed by the grid company occurred in the winter months which is very common in Inner Mongolia, we would expect that this problem could be resolved by future reinforcements of the grid and the success of their pilot project promotion. We believed the power generation of wind farm should be better if there is no grid curtailment.

The capacity of main transformer differs with feasibility study estimated value, and almost meets the requirements in industrial regulation 'Wind Farm Design Technical Regulation DL/T 2383-2007', which should be sufficient to export all power generated by the wind farm to the grid in a certain period.

By reconstruction, the capacity of SVC is 35 MVar inductive + 25 MVar capacitive, better than feasibility study's result. We would consider the wind farm has sufficient reactive capacity to meet the reactive power demand and voltage regulation as required in the grid code.

Sinovel has developed wind farm LVRT reconstruction plan and promised to implement according to plan and schedule. Huadian Fuxin headquarters had approved the reconstruction plan.

The application of regional heating by electrical boiler will help wind farm to reduce their grid curtailments to some extent.

3.3 Xiaocaohu Wind Farm 1 Phase I

Xiaocaohu Wind Farm Phase I is located in Xiaocaohu in Xinjiang. It consists of Fifty-four Goldwind S48/750 750 kW WTGs, totalling 40.5 MW, and Six Sinovel FL1500/70 1.5 MW WTGs, totalling 9 MW. It was started operation from December 2007.

Under our scope of work, we have reviewed Xiaocaohu Wind Farm 1 Phase I.

3.3.1 WTGs

It first licensed Repower Electric 48 kW to 750 kW turbine technology issued to Goldwind in 2002. Goldwind 750 kW wind turbine is a horizontal shaft, and three blades WTG with fixed pitch stall regulation, and asynchronous generators. It is one of mature technologies in the world, with simple structure and reliable design, and all performance indicators were designed in accordance with IEC I and certified by Lloyd's Register.

Sinovel FL1500 is three blades WTG with an active pitch, active yaw system, and active variable speed operation. Its nominal power output is 1.5 MW. Through variable speed operation, it ensures low load, efficiency optimization, output side peak load adjustment, and achieve effective operation and long working life.

In conclusion, we believe that the design of Goldwind S48 WTG and Sinovel FL1500/70 met industrial standards. Main technical indicators were represented in Table 3.5.

Table 3.5: Technical Summary of Goldwind S48 & Sinovel FL1500/70

	S48/750	FL1500/70
Hub Height	50 m	65 m
Rotor Diameter	49 m	77.4 m
Nominal Power	750 kW	1,500 kW
IEC Classification	IEC I	IEC IIIc
Certification	Lloyd's Register	Lloyd's Register
Cut-in Wind Speed	4 m/s	3 m/s
Nominal Wind Speed	14-15 m/s	12 m/s
Cut-out Wind Speed	25 m/s	25 m/s
Generator	Double-winding asynchronous generator	Doubly-fed induction generator
Gearbox	Three spiral planetary spur	One horizontal shaft + two helical gear stages
Gearbox Ratio	1:67.4	1:90
Power Regulation and Control	fixed pitch stall regulation	Pitching Control
Operation Ambient Temperature	-30°C~+55°C	-30°C~+50°C
Standby Ambient Temperature	-45°C~+55°C	-45°C~+60°C

Source: Provided by Huadian Fuxin

3.3.2 Grid Connection Assessment

3.3.2.1 Equipment Capacity

Xiaocaohu Wind Farm Phase I has fifty-four Goldwind S48/750 750 kW WTGs and six Sinovel FL1500/70 1.5 MW WTGs installed with a total capacity of 49.5 MW. Each turbine is connected to a WTG step-up transformer via underground cables. These cables are rated appropriately in order to carry maximum output from each individual turbine. Then these turbines are connected to their own 10 kV substation main transformer low-voltage side through eight 10 kV inter array collection lines which consist of underground line and are rated appropriately to carry the maximum output from the wind turbines.

A substation has been constructed with one 50 MVA – 110/10 kV transformer with an on-load tap changer. The capacity of main transformer is corresponding to feasibility study, and met the requirements of main transformer's capacity in industry standard 'Wind Farms Design Technical Regulation DL/T 2383-2007'.

Xiaocaohu Wind Farm Phase I is connected to the 110 kV Xiaocaohu substation via an 18 km 110 kV overhead line and the thermal rating is appropriately rated. We consider that these lines are sufficient to export all power generated by the wind farm to the grid.

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

3.3.2.2 Reactive Power Compensation and Voltage Control

The reactive power compensation device in this wind farm is capacitors. Its installed capacity is 8 MVar. In addition, the main transformer is equipped with an on-load tap changer which is able to control voltage between 90% and 110% at the HV winding. Therefore, we would consider the wind farm has partly sufficient reactive capacity and voltage control capacity but cannot meet the reactive power demand as required in the grid code. Wind farm has submitted a reconstruction plan to Huadian Fuxin headquarters and is pending approval.

Considering LVRT reconstruction, we were informed that wind farm had submitted their reconstruction plan to Huadian Fuxin headquarters. Huadian Fuxin informed us that Xiaocaohu wind farm will employ wind farm integrated LVRT technology for the reconstruction of 54 Goldwind WTGs. and 6 Sinovel WTGs' LVRT reconstruction has been completed in December 2011.

3.3.2.3 Local Power Grid Operation

Xiaocaohu Wind Farm 1 Phase I is located at south of Wulumuqi and it is connected to Tulufan power grid via 110 kV transmission line, and hence it is dispatched by XinJiang Power Company.

Xiaocaohu has abundant wind resources and electricity from the wind farm is exported to the transmission grid via Tuokexun Substation. We do not expect curtailments from local grid company to happen on Xiaocaohu Wind Farm 1 Phase I under normal circumstances.

3.3.3 Performance of Wind Farm

3.3.3.1 Site Environment

Xiaocaohu Wind Farm 1 Phase I is located on very flat and simple terrain and scrub/desert land with little vegetation. The site varies in altitude of about 400 m ASL. From our appreciation of the terrain during our site visit, we do not have any concerns regarding shading, channeling or excessive gradient which could lead to adverse wind conditions such as severe wind shear, inflow angles or turbulence.

The site is subjected to very low temperature in winter. All WTGs are of low temperature version. Indicated by Huadian Fuxin, there was no downtime from extreme low temperature up to date.

3.3.3.2 Site Facilities and Maintenance

There is a compound area at the site which contains the substation, control room, spare parts warehouse, offices and other site facilities. The wind farm company which is the subsidiary of Huadian Fuxin employs 38 staffs on site, 3 for safety production, 3 for O&M management, and 32 for O&M. 12 of O&M staffs are new employees and 10 of them have more than one year experience. O&M team works on two rotating shifts with 10 days per shift. The wind farm compound has very good facilities which are suitable for housing the staffs and is well maintained.

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

Sinovel and Goldwind are leading Chinese wind turbine manufacturers with a good track record and a significant number of units in China. We were informed that they do experienced problems to some WTG units before they took over and they were replaced without costs to Huadian Fuxin as it was still under warranty. The repairs was carried out by the manufacturers and according to Huadian Fuxin, it resulted to some downtime in each case but not significant, as parts were readily available at the manufacturers' central warehouses nearby.

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

During our site visit, we noticed some clear signs of oil/lubrication spill on some of the towers of the WTGs. Upon raising this with Huadian Fuxin, we were told that the spill was due to maintenance engineers accidentally spilled a bucket of oil in the nacelle and they had already requested the manufacturer to clean as soon as possible. As the high temperature differences between winter and summer is rampant here, there is a higher requirement for wind turbine's oil system components to fail. During the site visit we found that a number of wind farms in this region show this phenomenon. We suggested wind farm to enhance oil system's monitoring, maintenance and repairing, and coordinate with WTGs manufacturers for rectification if necessary to ensure safe operation of WTGs.

We also noticed there were signs of rust outside the WTG towers. This were all facing windward and was below 4 m height. Huadian Fuxin informed us that this was caused by sand carried by the wind and is blasting at the steel towers causing the protective coating to be blasted. It may affect the structural strength of WTGs towers in long-term without any treatment. We suggested to them that it should be re-coated as soon as possible during their regular maintenance.

Met mast used for considering the wind resources analysis of the site was removed after the feasibility study had been completed. Weather data were now collected from the WTG sensors and is used for wind farm operations.

At the time of our visit, the WTGs were covered by manufacturers' two year warranty guaranteeing a 95% availability level, although we understand that scheduled maintenance and grid downtime are excluded from this figure. Huadian Fuxin provided us with a selected power curve for one of the WTGs from the SCADA system and it appeared to be broadly consistent with the standard power curves from the manufacturer.

3.3.3.3 Performance of Power Generation

From March 2010 to February 2011, average annual wind speed at the hub height of the WTGs has been calculated to be 9.87 m/s and the net capacity factor to be 0.23, which is very good for an onshore wind farm. The wind speed, availability and production data provided by Huadian Fuxin shows that the average WTG availability since operational was 98.51% (as shown in Table 3.6 below), higher than the warranted availability 95%.

Table 3.6: Xiaocaohu Wind Farm 1 Phase I Operation Data

Date	Average WTGs Availability	Total Power Generation	On-Grid Power Generation	Equivalent Full-Load Hours	Capacity Factor	Average Wind Speed
	(%)	(MWh)	(MWh)	(h)		(m/s)
2011-02	98.83	5,584.89	5,381.586	109	0.16	8.8
2011-01	97.96	2,713.75	2,649.9	54	0.07	3.79
2010-12	97.88	822.777	782.1	16	0.02	3.03
2010-11	97.97	2,268.003	2,182.29	44	0.06	4.23
2010-10	98.79	4,798.457	4,815.03	97	0.13	7.48
2010-09	99.14	10,198.62	9,875.91	200	0.28	11.33
2010-08	99.03	13,944.16	13,529.67	273	0.37	14.07
2010-07	99.22	15,748.36	15,246	308	0.41	14.75
2010-06	98.64	14,308.43	13,883.1	280	0.39	15.47
2010-05	99.54	14,026.67	13,533.3	273	0.37	13.42
2010-04	98.2	10,930.56	10,645.8	215	0.30	10.95
2010-03	96.88	7,064.711	6,860.7	139	0.19	11.11
Total/Average	98.51	102,409.39	99,385.39	2,008	0.23	9.87

Source: Provided by Huadian Fuxin

In response to our request for information on grid curtailments, we were informed by Huadian Fuxin other than regular service and maintenance of the power transmission line and substations, there were less grid curtailment and the average grid curtailments from 2009 is lower than 4%.

Wind farm estimated annual power generation in feasibility study was 116,225 MWh, while the actual annual power generation from March of 2010 to February of 2011 was 102,409.39 MWh, which is lower than feasibility study's result. Consider to its lower capacity factor, we believe it is the normal power generation of wind farm.

3.3.4 Conclusion

The WTG installed in Xiaocaohu Wind Farm Phase I were supplied by well recognised Chinese wind turbine manufacturer Goldwind and Sinovel that employs proven technologies. Our opinion is that the WTG technology is in accordance with international standards and the site facilities and O&M setup are of a high standard. Assessment of the production data supplied to us by Huadian Fuxin suggests that the performance of the wind farm to date has been normal.

We are of the opinion that the wind farm was built to a good standard. From March 2010 to February 2011 the wind farm capacity factor has been 0.23, the average availability has been 98.51% which was higher than warranty availability 96% and the average wind speed at hub height has been 9.87 m/s, lower than feasibility study estimation. Since its similar capacity factor with feasibility study value, we hold the opinion that the wind farm power generation has been normal.

During our site visit, we noticed some clear signs of oil/lubrication leakage on some of the WTG nacelles, which result to potential risk for WTGs safe operation, and we recommend immediate cleaning up and enhance monitoring, maintenance, and repairing of WTGs oil system. We noticed other wind farms in this region also have this issue due to local strict climatic conditions and huge environmental temperature difference, which lead to higher components failure of WTGs oil system. We found rusts on the steel towers and suggested to have this rectified immediately to avoid decrease of tower structural strength.

Wind farm reactive power compensation capacity cannot meet the reactive power demand as required in the grid code. Huadian Fuxin informed us that Xiaocaohu wind farm will employ wind farm integrated LVRT technology for the reconstruction of 54 Goldwind WTGs. and 6 Sinovel WTGs' LVRT reconstruction has been completed in December 2011.

Consider to wind farm had submitted their LVRT reconstruction plan to Huadian Fuxin headquarters and was approved. Xiaocaohu wind farm phase I will upgrade WTG separately.

3.4 Burqin Wind Farm Phase I

Burqin Wind Farm Phase I was located at Altay in Xinjiang. It consists of thirty-three Goldwind GW82/1500 1.5 MW, with totalling 49.5 MW, and started commissioning from March of 2010.

Under our scope of work, we assessed the performance of Burqin Wind Farm Phase I.

3.4.1 WTGs

Goldwind GW82 1,500 kW wind turbine is a horizontal shaft, and three blades WTG with variable speed pitching control, direct drive, external rotor permanent magnet synchronous generator. Its generator operating at low speed, full power converter, power flexible control and multiple strategies to suppress harmonics, and owns LVRT capacity.

In conclusion, we believe that the design of Goldwind GW82-1500 WTG meets industrial standards. Main technical indicators were represented in Table 3.7.

Table 3.7: Technical Summary of Goldwind GW82-1500

	GW82-1500
Hub Height	70 m
Rotor Diameter	82 m
Nominal Power	1,500 kW
IEC Classification	ICE III A
Certification	Lloyd's Register
Cut-in Wind Speed	3 m/s
Nominal Wind Speed	10.3 m/s
Cut-out Wind Speed	22 m/s
Generator	Direct-drive permanent magnet synchronous generator
Power Regulation and Control	Variable speed and pitching
Operation Ambient Temperature	-30°C~+40°C
Standby Ambient Temperature	-40°C~+50°C

Source: Provided by Huadian Fuxin

3.4.2 Grid Connection Assessment

3.4.2.1 Equipment Capacity

With thirty-three Goldwind GW82/1500 1.5 MW WTGs installed, Burqin Wind Farm Phase I have a total installed capacity of 49.5 MW. Each wind turbine is connected to a WTG step-up transformer via underground cables. These cables are rated appropriately in order to carry maximum output from each individual turbine. Then these turbines are connected to their own three 35 kV overhead inter array collection lines through bus bar linked to 110 kV substation main transformer low voltage side 35 kV bus bar, and are rated appropriately to carry the maximum output from the wind turbines.

One step-up substation has been constructed at the site with a 50 MVA – 110/35 kV transformers equipped with one on-load tap changer. The capacity of the main transformer is correspond with feasibility study estimated value, and meet the requirements of main transformer's capacity in industrial standard 'Wind Farms Design Technical Regulation DL/T 2383-2007', and appropriately to export the full power from the wind farm to the grid.

The step-up substation is connected to two 110 kV substation at Burqin substation and Irtysh substation via 7 km and 85 km 110 kV overhead line respectively and the thermal rating is appropriately rated to export the full power from the wind farm to the grid.

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

3.4.2.2 Reactive Power Compensation and Voltage Control

The reactive power compensation device in wind farm is capacitors with 10 MVar. In addition, the transformer is equipped with an on-load tap changer which is able to control voltage between 90% and 110% at the HV winding. Therefore, we would consider the wind farm has certain reactive capacity and voltage control capacity and cannot meet the reactive power demand and voltage regulation as required in the grid code. Wind farm has submitted a reconstruction plan to Huadian Fuxin headquarters and is pending approval.

Considering to LVRT reconstruction, There is a clear request for LVRT in WTG procurement contract. We believe wind farm have LVRT capability and manufacturer also confirmed if the wind turbines cannot be approved by inspection and certification, Goldwind will provide upgrade services.

3.4.2.3 Local Power Grid Operation

Burqin Wind Farm Phase I is located in Burqin, the north of Xinjiang. It is connected to Altay power grid via 110 kV transmission line, and hence it is dispatched by Xinjiang Power Company.

Burqin has abundant wind resources. At present electricity from the wind farm is exported to the main transmission grid for provincial or national use via Burqin and Irtysh substation.We think there are expecting more curtailments from local grid company to happen on Burqin Wind Farm Phase I as more wind farms are expected to connect to grid in this region and congest the main transmission grid. As a result, the power output from Burqin Wind Farm may be further curtailed to some extent due to local power grid's insufficient capability to adjust active power. On the other hand, the voltage stability of power system has become the major issue in local power grid for a large scaled expansion of wind power.

3.4.3 Performance of Wind Farm

3.4.3.1 Site Environment

Burqin Wind Farm Phase I was built on the desertification steppe with an altitude of approximately 580 m ASL. The terrain does not present any concerns regarding shading, channelling or excessive gradient which could cause adverse wind conditions, such as severe wind shear, inflow angles, or turbulence.

Due to the cold high pressure in Xinjiang, the climate is very cold, resulting in long periods of below zero temperatures. We were told by Huadian Fuxin that all WTGs are low temperature versions and there was no outage due to extreme cold weather to date.

3.4.3.2 Site Facilities and Maintenance

A control building is located near the step-up substation of the wind farm. This building includes the control centre, offices, spare parts store, switchgear housing, and other site facilities. Burqin wind farm employs 26 staff on this site, they are responsible for operation and maintenance and work on two rotating shifts (7 persons per shift) and all staff has 10 days break for 30 days worked. The building and facilities are of a high standard and appeared to be well-maintained.

Site roads are in good condition. We were also informed that diggers have to be used to clear the access and site roads of snowing period. When we visited the site at September of 2011, we were able to visit the control building, site facilities and wind turbines.

There is a met mast operating in the wind farm and is collecting weather data for their operations and Load Data Forecast transfer to the regional grid company.

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

3.4.3.3 Performance of Power Generation

In response for information on grid curtailments, we were informed by Huadian Fuxin that curtailment in this wind farm is expected to increase about 6% to 7% this year as three wind farms are connected to local grid and the grid cannot accept increased power output from new wind farms. It is imperative that the local grid increases the power transmission line capacity so that this wind farm can optimise its operations.

Currently the WTGs are covered by the manufacturer's warranty which guarantees the WTG availability at 95%. The warranty period is two years. From June 2010 to August 2011, the average wind speed at hub height has been calculated to be 7.22 m/s, and the net capacity factor is calculated to be 0.34, which is excellent for an onshore wind farm. According to the power generation, wind speed, and availability data provided by Huadian Fuxin from their SCADA system and listed in Table 3.8, Burqin Wind Farm Phase I has shown an average availability of 97.63%. All monthly availabilities are above the 95% guaranteed value.

Table 3.8: Burqin Wind Farm Phase I Operation Data

Date	Average WTGs Availability	Total Power Generation	On-Grid Power Generation	Equivalent Full-Load Hours	Capacity Factor	Average Wind Speed
	(%)	(MWh)	(MWh)	(h)		(m/s)
2011-08	/	11,040	10,860	219	0.29	/
2011-07	98.1	13,140.9	12,940.62	261	0.35	7.66
2011-06	97	10,945.013	10,765.03	217	0.30	6.5
2011-05	97.5	14,364	14,156	286	0.38	6.85
2011-04	97.1	7,422.819	7,291.34	147	0.20	5.79
2011-03	97.8	13,725.4	13,559	274	0.37	7.8
2011-02	91.4	7,639.1	7,535.9	152	0.23	5.78
2011-01	96.8	13,785.8	13,588.7	275	0.37	6.98
2010-12	99.2	14,251.1	14,062.6	284	0.38	7.53
2010-11	98.8	12,499.6	12,346.9	249	0.35	7.42
2010-10	98.4	11,912.3	11,789.2	238	0.32	7.01
2010-09	98.5	12,192.5	12,021.2	243	0.34	8.19
2010-08	98.8	15,264.9	15,036.4	304	0.41	8.31
2010-07	98.4	12,828.7	12,632.1	255	0.34	7.12
2010-06	97.8	17,271.2	17,051.7	344	0.48	8.98
Total/Average	97.63	188,283.33	185,636.69	3,750	0.34	7.22

Source: Provided by Huadian Fuxin

As a typical onshore wind farm, Burqin Wind Farm last year annual power generation was 161,836.07 MWh, which is higher than feasibility study estimation of 120,469 MWh, which means excellent power generation capacity. Its average grid curtailments between January and September in 2011 were 3%.

3.4.4 Conclusion

Equipment at Burqin Wind Farm Phase I was supplied by manufacturers well-known by the industry; WTGs design and manufacture are mature technologies that have credible track records within the market. We are of the view that the wind turbine technologies are in accordance with current industry standards, and the sites were built to a high standard. O&M arrangement is well-managed. It should be noted that the grid capacity will limit the wind farm normal operation.

We are of the opinion that the wind farm was built to a good standard. From June 2010 to August 2011, the wind farm capacity factor has been 0.34, which is exceptional for an onshore wind farm, and the average availability has been 97.63% which was higher than warranty availability 95% and the average wind speed at hub height has been 7.22 m/s, which shows a good wind condition. As a onshore wind farm, its power generation has been excellent.

Wind farm reactive power compensation has insufficient reactive capacity to meet the reactive power demand as required in the grid code. Wind farm had submitted their reconstruction plan to Huadian Fuxin headquarters is pending approval.

According to WTGs procurement contract, Goldwind promised their WTGs have the capability of LVRT, and manufacturer will be responsible for upgrade if their WTGs cannot be approved by inspection and certification.

3.5 Guazhou Wind Farm Phase I

Guazhou Wind Farm is located in Guazhou, Gansu. It consists of one hundred and thirty-four Sinovel SL1500/82 1.5 MW WTGs, with totalling 201 MW and start operation from December 2010.

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

3.5.1 WTGs

Sinovel SL1500 is a three blades, horizontal shaft WTG with a double-fed generator, active pitching, and yaw system. The WTG is available in a normal and a low temperature version.

Overall, we consider the design of the SL1500 to be in line with the industry standards. The main technical parameters are summarized in Table 3.9.

Table 3.9: Technical Summary of Sinovel SL1500/82

	SL1500/82
Hub Height	70 m
Rotor Diameter	82.9 m
Nominal Power	1,500 kW
IEC Classification	IEC III
Certification	Lloyd's Register
Cut-in Wind Speed	3 m/s
Nominal Wind Speed	10.5 m/s
Cut-out Wind Speed	20 m/s
Generator	Double-fed asynchronous generator
Gearbox	Two stages planetary gear + one stage spur gear
Gearbox Ratio	1:104
Power Regulation and Control	Pitching control
Operation Ambient Temperature	-30°C~+45°C
Standby Ambient Temperature	-45°C~+45°C

Source: Provided by Huadian Fuxin

3.5.2 Grid Connection Assessment

3.5.2.1 Equipment Capacity

Guazhou Wind Farm Phase I has one hundred and thirty-four Sinovel SL1500/82 1.5 MW WTGs installed with a total capacity of 201 MW. Each turbine is connected to a WTG step-up transformer via underground cables. These cables are rated appropriately in order to carry maximum output from each individual turbine. Then these turbines are connected to their own twelve 35 kV inter array collection lines links to 35 kV bus bar of 330 kV substation, and are rated appropriately to carry the maximum output from the wind turbines.

All WTGs via inter array collection lines link to a 240 MVA – 330/35 kV transformer with an on-load tap changer, which is located in the Ganhekouxi 330 kV substation with other two wind farms' four similar transformers where outside the wind farm. Jiayuguan Jiuquan Power Grid Company Maintenance Center is responsible for daily O&M tasks. The substation transmission is via 330 kV circuit to 750 kV Anxi Substation and connected to northwestern grid. The capacity of main transformer is corresponding with feasibility study estimated value, and meets the requirements of main transformer's capacity in industry standard 'Wind Farms Design Technical Regulation DL/T 2383-2007'.

Wind farm monitor center was constructed near the 330 kV Ganhekouxi Substation. Monitor center power supplying comes from 35 kV bus bar of substation.

Power meter was installed at high voltage side of main transformer in substation, therefore no power loss of cable transmission would be considered.

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

3.5.2.2 Reactive Power Compensation and Voltage Control

The total capacity of the reactive power compensation device installed at the site is 35 MVar. In addition, the transformer is equipped with an on-load tap changer which is able to control voltage between 90% and 110% at the HV winding. Therefore, we would consider the wind farm has sufficient reactive capacity and voltage control capacity to meet the reactive power demand and voltage regulation as required in the grid code.

Considering LVRT capability, Sinovel WTGs installed at Guazhou wind farm have completed LVRT reconstruction by WTG manufacture in November 2011.

3.5.2.3 Local Power Grid Operation

Guazhou Wind Farm Phase I is located in Guazhou city in Gansu Province. It is connected to Jiuquan Power Grid via 330 kV transmission line, and hence it is dispatched by Gangsu Power Company.

Guazhou has abundant wind resources. The electricity from the wind farm is exported to the main transmission grid for regional use via a 330 kV overhead transmission line linked to Ganhekouxi substation. Curtailments still exist, as in 2011 there were three large-scale WTGs off-grid incidents at Gansu Qiaoxi No.1 Wind Farm, Gansu Qiaodong No.2 Wind Farm, and Gansu Ganxi No.2 Wind Farm. These incidents all resulted from wind farm cable connectors failures, WTGs without LVRT capability to stabilize grid voltage, and reactive power compensation devices cannot auto-adjust reactive power as required. Therefore Grid Company requires local wind farms must have LVRT capability in order to avoid similar grid incidents and stabilize the voltage of local grid.

3.5.3 Performance of Wind Farm

3.5.3.1 Site Environment

Guazhou Wind Farm Phase I was constructed on flat desert grassland with an altitude of approximately 1,200 m ASL. The terrain does not present any concerns regarding shading, channelling or excessing gradient which could cause adverse wind conditions, such as severe wind shear, inflow angles or turbulence.

The site is subjected to low temperature in winter and we were informed by Huadian Fuxin that all WTG's are of low temperature versions. According to Huadian Fuxin, there was no outage caused by extreme cold weather up to date.

3.5.3.2 Site Facilities and Maintenance

There is a compound area at the site which contains the control room, spare parts warehouses, dormitory, offices and other site facilities are well maintained with good living facilities. The wind farm company which is the subsidiary of Huadian Fuxin employs 27 staffs on site for wind farm O&M, 10 for operations and others for maintenance. The Operation team adopt two rotating shifts, 5 persons a shift, and 6 WTGs maintenance teams of 2-3 persons per team. Lanzhou regional office manages their operation staffs, while their maintenance staffs are managed by Jiayuguan Maintenance Company.

It was noted that this windfarm 330 kV transformer and export units operations is being contracted to outside operators who centrally manage other two 330 kV main transformers for other two wind farms. We could envisage this be the direction that most wind farm operators would take in future to reduce their costs and overheads.

The access roads into the wind farm are well maintained and we were able to visit WTGs, substation, and all the areas we required during our site visit. We have confirmed with Huadian Fuxin that there are no problems for a crane to access in the wind farm and conduct a lift.

Sinovel is a leading Chinese wind turbine manufacturer with a good track record and a significant number of WTGs installed. In response to our enquiries during the site visit, Huadian Fuxin informed that they had replaced a WTG's generator during their warranty period.

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

Guazhou Wind Farm has one operating met mast in the wind farm belonging to the Meteorological Bureau and data is being collected and used in this wind farm.

During our visit, the WTGs of Guazhou Wind Farm Phase I were covered by manufacturer's two years warranty period. Sinovel guarantees a 95% average availability, although we understand that scheduled maintenance and grid downtime are excluded from this figure. We had reviewed the power curve from the wind farm SCADA system and it appeared to be broadly consistent with the standard power curves from the manufacturer.

3.5.3.3 Performance of Power Generation

Wind speed data was collected by anemometer at the rear of nacelle, thus the measured speed always lower than actual speed. Between January and August 2011, the average wind speed at the hub height of the WTGs has been 5.57 m/s, the net capacity factor is 0.22, which was normal for an onshore wind farm. The wind speed, availability and production data provided by Huadian Fuxin shows that the average availability since operational was 97.11% (as shown in Table 3.10 below). Guazhou Wind Farm started operations in January 2011 we do not have sufficient data to review the full year operations since it only started operations this year.

Since the actual constructed model and numbers and layout of WTG units are the same compared with the feasibility study, the production forecast in the feasibility study report can be compared with the actual production. From January to August 2011, the actual on-grid power production was 252,262.56 MWh.

Table 3.10: Guazhou Wind Farm Phase I Operation Data

Date	Average WTGs Availability	Total Power Generation	On-Grid Power Generation	Equivalent Full-Load Hours	Capacity Factor	Average Wind Speed
	(%)	(MWh)	(MWh)	(h)		(m/s)
2011-08	97.41	40,566.008	40,001.28	199	0.27	6.7
2011-07	99.2	20,374.367	20,151.12	100	0.13	4.98
2011-06	98.56	20,341.915	20,111.52	100	0.14	4.9
2011-05	99.2	22,692.724	22,302.72	111	0.15	5.09
2011-04	98.87	57,150.768	56,403.6	281	0.39	6.65
2011-03	98.96	38,887.665	37,942.08	189	0.25	5.01
2011-02	92.53	37,535.237	36,611.52	182	0.27	6.2
2011-01	92.13	19,228.86	18,738.72	93	0.13	5
Total/Average	97.11	256,777.54	252,262.56	1,255	0.22	5.57

Source: Provided by Huadian Fuxin

For information on grid curtailments, we were informed by Huadian Fuxin that curtailment still exists, up to date they had been curtailed about 7% of their power generation especially when there were 3 large-scale WTGs off-grid incidents in 2011, which caused by insufficient power capacity of system load shifting and voltage instability.

3.5.4 Conclusion

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

We are of the opinion that the wind farm was built to a good standard. Since operations started in January 2011, the wind farm capacity factor has been 0.22 which was typical for an onshore wind farm. The average availability has been 97.11% which was higher than the warranty availability of 95%. The average wind speed at hub height has been 5.57 m/s, less than feasibility study results. We do not have sufficient data to review the full year operations since it only started operations this year. Although the most significant impact of the grid curtailments imposed by the grid company occurred due to the 3 large-scale off-grid incidents in 2011. We would expect that this problem could be solved by future reinforcement of the network and with the strict imposing of LVRT on all wind farm WTGs.

The capacity of wind farm reactive power compensation is higher than feasibility study estimated value, and there is sufficient reactive capacity to meet the reactive power demand as required in the grid code.

Sinovel WTGs installed at Guazhou wind farm have completed LVRT reconstruction by WTG manufacture in November 2011.

3.6 Muling Wind Farm Phase I

Muling Wind Farm Phase I is located in Mudanjiang in Heilongjiang province. It comprises of 24 Nordex 1.3 MW WTGs, totalling 31.2 MW, and started full commercial operation in January 2006.

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

3.6.1 WTGs

Nordex N60/1300 wind turbine is a three blades, and main shaft transmission (double main shafts) WTG with three phase asynchronous generator, active yaw system, fixed pitch stall regulation system, air brakes and ABS mechanical brakes.

Table 3.11: Technical Summary of Nordex N60/1300

	N60/1300
Hub Height	60 m
Rotor Diameter	60 m
Nominal Power	1,300 kW
IEC Classification	IEC I
Certification	Lloyd's Register
Cut-in Wind Speed	2.5 m/s
Nominal Wind Speed	13.5 m/s
Cut-out Wind Speed	25 m/s
Generator	Three phases asynchronous generator
Gearbox	One stage planetary gear/two stages helical
Gearbox Ratio	1:78.896
Power Regulation and Control	Fixed Pitch Stall regulation
Operation Ambient Temperature	-35°C~+40°C
Standby Ambient Temperature	-45°C~+50°C

Source: Provided by Huadian Fuxin

3.6.2 Grid Connection Assessment

3.6.2.1 Equipment Capacity

Muling Wind Farm has twenty-four Nordex 1.3 MW WTGs installed with a total capacity of 31.2 MW. Each turbine is connected to a WTG step-up transformer via underground cables. These cables are rated appropriately in order to carry maximum output from each individual turbine. Then these turbines are connected to their own five 10 kV collection inter array lines, which consist of underground line connection and are rated appropriately to carry the maximum output from the wind turbines. The 10 kV collection lines are connected to 10 kV bus bar at the substation and then stepped up to 66 kV via the main transformers.

A 66 kV step-up substation has been constructed with one 31.5 MVA – 66/10 kV transformers with an on-load tap changer. Transformer's capacity is corresponding to feasibility study estimation to carry the maximum output from wind farm.

Muling Wind Farm is connected to the 220 kV Lishu substation via one 51.36 km 66 kV overhead line and the thermal rating is rated appropriately. We consider that the circuit is sufficient to export all power generated by the wind farm to the grid.

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

3.6.2.2 Reactive Power Compensation and Voltage Control

Wind farm reactive power compensation device is capacitor type, with 6 MVar. In addition, the transformer is equipped with an on-load tap changer which is able to control voltage between 90% and 110% at the HV winding. Therefore, we would consider the wind farm has certain reactive capacity and voltage control capacity but cannot meet the reactive power demand and voltage regulation as required in the grid code. Wind farm has submitted their SVC reconstruction plan to Huadian Fuxin headquarters and was pending approval.

We understand that SGCC required WTGs in their respective wind farms should have LVRT capability. Since Muling wind farm has long operation time and less installation capacity, at present wind farm is coordinating with local power gird company for necessity of LVRT reconstruction, and WTG manufacturer has done technical research for providing reconstruction service.

3.6.2.3 Local Grid Operation

Muling has abundant wind resources. At present, the electricity production exceeds local demand and surplus electricity from the wind farm will be exported to the main transmission grid for provincial or national use. We do not expect curtailments from local grid company to happen on Muling Wind Farm under normal circumstances. However, during winter months when the electrical generation from wind farms is sacrificed for CHP plants operation, providing heating. As a result, the power output from Muling wind farm may have to be curtailed to some extent due to local power grid's insufficient capability to adjust active power. On the other hand, the voltage stability of power system has become the major issue in local power grid for a large scaled expansion of wind power. We understand that the local grid should have sufficient capability to accommodate Huadian Fuxin wind farm power generation and would expect that this problem could be eliminated in the near future by reinforcement of the network.

3.6.3 Performance of Wind Farm

3.6.3.1 Site Environment

Muling Wind Farm is located on hilly and heavy forested area with the altitude about 1,050 m ASL. From our appreciation of the terrain during our site visit, we do have concerns with potential forest fire hazards especially during the dry autumn & winter period. However, it is comforting to see that there are fire wardens stations at various look-outs and check points to report any potential forest fire.

The site is subjected to very low temperature in winter. The operating ambient temperature of Nordex WTGs is from -35°c to +40°c and the standby ambient temperature is from -45°c to +50°c which is similar to other wind turbines. According to Huadian Fuxin, there was no downtime because of the extreme cold weather up to date.

3.6.3.2 Site Facilities and Maintenance

There is a compound area at the site which contains the substation, control room, spare parts warehouse, offices and other site facilities. The wind farm company which is the subsidiary of Huadian Fuxin employs 20 O&M staffs on 10 days rotating shift. The wind farm compound has very good facilities which are suitable for housing the teams and is well maintained.

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

Nordex is a leading wind turbine manufacturer with a good track record and a significant number of installed units in the world. In response to our enquiries during the site visit, Huadian Fuxin informed us that they had changed a gear box of one WTG and is operating normally now. We would normally expect to review monthly reports either from the WTG manufacturer or compiled by the wind farm company itself, which include details of any significant downtime or component failures and any remedial work carried out that month. Huadian Fuxin had provided us their monthly production figures to us.

Two met masts were considered for the wind resources analysis of the site and had been decommissioned. Currently, they had installed another 2 new met masts to meet Heilongjiang power company requirements of load data forecast transfer and also to keep track of the wind farm weather data.

During our visit, the WTGs warranty had expired. Nordex had guaranteed a 95% availability level. Huadian Fuxin provided us the power curve for Nordex 1300 from SCADA system and it appeared to be broadly consistent with the standard power curves from the manufacturer.

3.6.3.3 Performance of Power Generation

The wind speed, availability and production data provided by Huadian Fuxin show that the average availability for 2011 first 9 months is 96.59% (as shown in Table 3.12 below). Average wind speed at the hub height of the WTGs has been calculated to be 5.3 m/s. Wind speed data was collected by anemometer at the rear of nacelle, thus the measured speed always lower than actual speed, in addition the missing operation data for strong wind period (from October to December) also affect speed result. The net capacity factor is 0.14 for months starting from January to September 2011 which was a lower value for an onshore wind farm. After reviewing the historical records, the average capacity factor for 2009 and 2010 was 0.19 and 0.18 respectively, which is acceptable for an onshore windfarm.

Table 3.12: Muling Wind Farm Phase I Operation Data

Date	Average WTGs Availability	Total Power Generation	On-Grid Power Generation	Equivalent Full-Load Hours	Capacity Factor	Average Wind Speed
	(%)	(MWh)	(MWh)	(h)		(m/s)
2011-09	96.32	2,862.1	2,740	88	0.12	4.8
2011-08	98.4	1,957.3	1,851.4	59	0.08	4.7
2011-07	97	1,532.9	1,480	47	0.06	3.8
2011-06	93.21	2487	2,440	78	0.11	4.6
2011-05	96.57	2,950.56	2,801.1	90	0.12	4.7
2011-04	96.44	4,152.9	4,034.6	129	0.18	6.1
2011-03	94.81	4,390	4,210	135	0.18	6.2
2011-02	97.27	3,880	3,580	115	0.17	5.9
2011-01	99.29	5,690	5,320	171	0.23	7.2
Total/Average	96.59	29,902.76	28,457.1	912	0.14	5.3

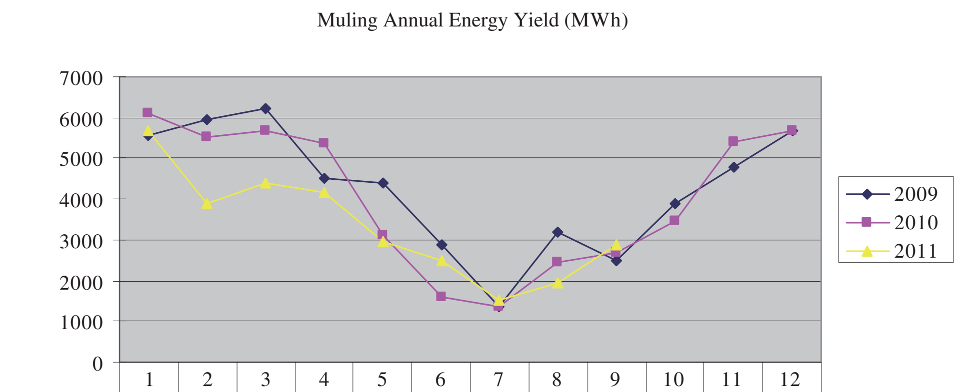
Source: Provided by Huadian Fuxin

In response to our request for information on grid curtailments, we were informed by Huadian Fuxin that it is very common for their wind farm to be subjected to grid curtailments. We understand that the curtailments usually occur during winter months when demand for heat generation in the region is at a peak, the electrical generation from wind farms is sacrificed for CHP plants operation providing heating to the local districts.

The actual constructed model and numbers and layout of WTG units are corresponding with the feasibility study, however since the feasibility study did not account for any losses due to grid curtailments, we suggest that the future production forecast is based on actual production figures.

In their monthly operational report compiled by Huadian Fuxin, figures have been provided to represent the lost production due to grid curtailments occurring that month. This is shown in Table 3.12. We enquired as to the methodology applied by Huadian Fuxin in calculating the lost production and broadly used. Fig 3.1 shows Muling Wind Farm actual power generation between January 2009 and September 2011. Actual annual power generation in 2009 and 2010 were 50,880 MWh and 48,420 MWh respectively, they were lower than feasibility study estimated value (55,767 MWh).

Figure 3.1: Muling Wind Farm Annual Power Generation



	1	2	3	4	5	6	7	8	9	10	11	12
2009	5570	5940	6210	4520	4390	2880	1370	3190	2480	3870	4780	5680
2010	6120	5540	5680	5360	3120	1580	1380	2460	2670	3450	5390	5670
2011	5690	3880	4390	4153	2951	2487	1533	1957	2862			

Source: Provided by Huadian Fuxin

3.6.4 Conclusion

The wind turbines installed for Muling Wind Farm were supplied by a well recognised wind turbine manufacturer that employs proven technologies. The O&M arrangements are well managed with very good facilities at the site. We had concerns with potential forest fire hazards especially during the dry autumn and winter period. It is comforting to see that there are fire wardens stations at various look-outs and check points to report any potential forest fire. Apart from this issue, we are of the opinion that the wind farm was built to a good standard.

Assessment of the production data supplied to us by Huadian Fuxin suggests that the performance of the wind farm to date has been normal, affected mainly due to grid curtailments which is very common in this part area of Heilongjiang in winter and we would expect that this problem could be solved by future reinforcement of the network.

We are of the opinion that the wind farm was built to a good standard. According to 2011 annual operation data, the average availability is 96.59%, average annual wind speed at the hub height of the WTGs has been calculated to be 5.3 m/s, lower than feasibility study estimated value, and capacity factor has been 0.14 for first nine months which was lower for an onshore wind farm. However from 2009 and 2010 historical records the capacity factor was 0.19 and 0.18 respectively, which is acceptable for an onshore wind farm. With grid curtailments in parts of Heilongjiang province, and lower summer wind speed in this region, Muling Wind Farm actual power generation is slightly less than feasibility study estimated value.

Wind farm reactive power compensation device cannot meet the reactive power demand and voltage regulation as required in the grid code. Wind farm has submitted their reconstruction plan to Huadian Fuxin headquarters is pending approval.

Considering LVRT capability, Since Muling wind farm has long operation time and less installation capacity, at present wind farm is coordinating with local power gird company for necessity of LVRT reconstruction.

3.7 Yilan Jiguanshan Wind Farm Phase I

Yilan Jiguanshan Wind Farm Phase I is located at Jiamusi in Heilongjiang province. It comprises 33 DEC FD70 1.5 MW WTGs totalling 49.5 MW, and started operation in September 2009.

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

3.7.1 WTGs

DEC FD70 WTG was imported from Repower MD70 1.5 MW WTG. Its design principle based on 600-750 kW WTG successful experience and the special requirements of megawatt WTGs. FD70 WTG established the new standard of second-generation megawatt WTGs, whose economy and reliability is typical of this Grade.

Overall, we consider the design of the DEC FD70 WTG to be in line with the industry standards. The main technical parameters are summarized in Table 3.13.

Table 3.13: Technical Summary of DEC FD70-1500

	FD-70
Hub Height	65 m
Rotor Diameter	70 m
Nominal Power	1,500 kW
IEC Classification	IEC IA
Certification	Lloyd’s Register
Cut-in Wind Speed	3.5 m/s
Nominal Wind Speed	13.0 m/s
Cut-out Wind Speed	25.0 m/s
Generator	Double-fed asynchronous generator
Gearbox	One stage planetary/two stages spur gear
Gearbox Ratio	1:95
Power Regulation and Control	Pitching control
Operation Ambient Temperature	-35°C~+40°C
Standby Ambient Temperature	-45°C~+55°C

Source: Provided by Huadian Fuxin

3.7.2 Grid Connection Assessment

3.7.2.1 Equipment Capacity

Yilan Jiguanshan Wind Farm deployed thirty-three DEC FD70 1500 WTGs with a total capacity of 49.5 MW. Each wind turbine is connected to a WTG step-up transformer via underground cables. These cables are rated appropriately in order to carry maximum output from each individual turbine. Then these turbines are connected to their own four 35 kV inter array collection lines, which consist of underground cables connection, link to their 110 kV substation and are rated appropriately to carry the maximum output from the wind turbines.

A 110 kV step-up substation has been constructed with one 63 MVA – 110/35 kV transformer with an on-load tap changer for Phase I. The capacity of the main transformer is corresponding with feasibility study. Therefore, we consider that the transformer is sufficiently rated to export the full power from the wind farm to the grid.

Wind farm is connected to 220 kV Dalianhe Substation via one 35.6 km 110 kV line and the thermal rating is appropriately rated. We consider that the circuit is sufficient to export all power generated by the wind farm to the grid. According to the current version of Chinese Grid Code, the transmission network between the wind farm substation and the grid connection point is not required to meet the 'N-1' security criteria.

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

3.7.2.2 Reactive Power Compensation and Voltage Control

The reactive power compensation device installed at the site is capacitor with totalling 5 MVar. Wind farm is installing Static Var Generator (herein and after SVG) with totalling ±8 MVar and will complete by the end of 2011 for wind farm phase I and phase II. In addition, the transformer is equipped with an on-load tap changer which is able to control voltage between 90% and 110% at the HV winding. Therefore, we would consider the wind farm has certain reactive capacity, in future after construction will have sufficient reactive capacity and voltage control capacity to meet the reactive power demand and voltage regulation as required in the grid code.

We understand that under Chinese Grid Code all the WTG's must have LVRT capability. We were informed from wind farm site staff that Yilan Jiguanshan wind farm had submitted their reconstruction plan to Huadian Fuxin headquarters and is approved. They would complete their LVRT reconstruction by end 2012 to meet the relevant requirements.

3.7.2.3 Local Grid Operation

Yilan Jiguanshan Wind Farm is located near Jiamusi, north-east of Heilongjiang province. It is connected to Heilongjiang power grid via 110 kV overhead line, and hence it is dispatched by Heilongjiang Power Company.

At present, the electricity production exceeds the consumption and surplus electricity from the wind farm is exported to the main transmission grid of Heilongjiang power grid for other area. We do not expect curtailments from local power company despatcher to happen on Yilan Jiguanshan Wind Farm under normal circumstances. However, during winter months when demand for heating generation in the region is at a peak demand, the electrical generation from wind farms is sacrificed for CHP plants operation. As a result, the power output from Yilan Jiguanshan wind farm may have to be curtailed to some extent due to local power grid's insufficient capability to adjust active power and the requirement of supplying heat by thermal power plants. On the other hand, the voltage stability of power system has become the major issue in local power grid for a large scaled expansion of wind power. We understand that the local grid should have sufficient capability to accommodate Huadian Fuxin wind farm and would expect that this problem could be eliminated in near future by reinforcement of the network.

3.7.3 Performance of Wind Farm

3.7.3.1 Site Environment

Yilan Jiquangshan Wind Farm is built on hilly areas with neighbouring farm land at an altitude of approximately 300 m ASL. From our appreciation of the terrain, it does not present any concerns regarding shading, channelling or excessive gradient which could cause adverse wind conditions, such as severe wind shear, inflow angles, or turbulence.

Yilan Jiguanshan Wind Farm is located at Heilongjiang and there are abundant wind resources in this area. The site is subjected to very low temperature in winter. We were informed from Huadian Fuxin that all WTGs are low temperature version and there was no downtime because of the extremely cold weather to date.

3.7.3.2 Site Facilities and Maintenance

The compound building includes the control centre, offices, spare parts warehouse, switchgear housing, and other site facilities. Huadian Fuxin employs 15 operational and maintenance staffs, deployed in 2 teams of 4 people on a 7 days rotating shift. There are another 12 staffs for administrative support. The building and facilities are of high standard and appear to be well-maintained.

The access roads on site are rough and may need remedial work in places to ensure access, especially in winter months when visibility of the site road parameters may be obscured by snow and diggers have to be used to clear the access and site roads. However, when we visited the site in October 2011, we were able to visit the control building, site facilities and wind turbines without any problems.

Wind resources data at the sites were recorded from one met masts installed on site and these weather data were used for their operations and also to meet the Load Data Forecast Transfer to the provincial grid company.

For information on grid curtailments, we were informed by Huadian Fuxin that it is very common for their wind farm to be subjected to grid curtailments. We understand that the curtailments usually occur during winter months when demand for heat generation in the region is at a peak. At these times of peak demand, the electrical generation from wind farms is sacrificed for CHP plants operation and providing heating. We further understand the curtailment is also caused by local grid not being able to sent out electricity. The grid curtailments in 2010 and 2011 are 6.58% and 7.53% respectively.

Huadian Fuxin had provided us with power curves from the SCADA system. It appeared to be broadly consistent with the standard power curves from the manufacturer. Currently the TWGs are covered by warranty which is two years, and WTG manufacturer guaranteed availability is 95%.

3.7.3.3 Performance of Power Generation

Wind speed data was collected by anemometer at the rear of nacelle, thus the measured data always lower than actual speed, in addition the missing operation data for strong wind period (from October to December) also affect speed result. Since 2011, the average wind speed at hub height has been calculated to be 6.9 m/s and the net capacity factor is calculated to be 0.25, which is reasonable for an onshore wind farm. According to the power generation, wind speed and availability provided by Huadian Fuxin from their SCADA system (shows in Table 3.14), Yilan Jiquangshan Wind Farm has shown an average availability of 91.28% due to low availability in January and February 2011. Most monthly availabilities are above the 95% guaranteed value.

Table 3.14: Yilan Jiguanshan Wind Farm Phase I Operation Data

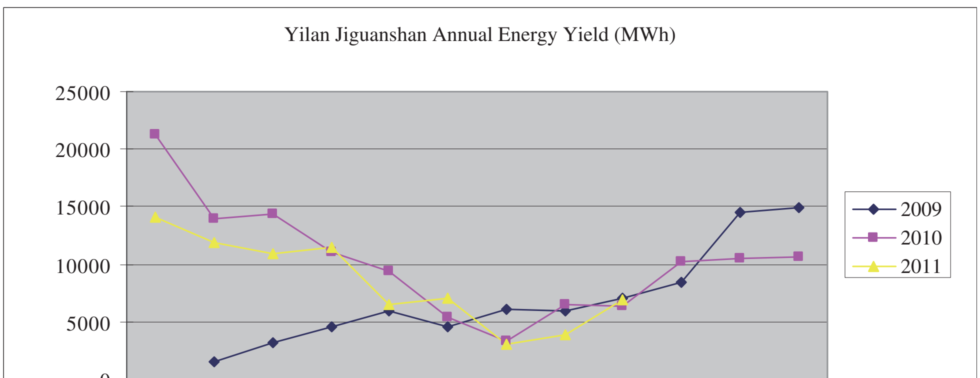
Date	Average WTGs Availability	Total Power Generation	On-Grid Power Generation	Equivalent Full-Load Hours	Capacity Factor	Average Wind Speed
	(%)	(MWh)	(MWh)	(h)		(m/s)
2011-09	94	6,841.2	6,817.4	138	0.19	5.9
2011-08	98	3,904.9	3,884.8	78	0.11	4.8
2011-07	93	3,061.8	3,037.6	61	0.08	4.7
2011-06	93.5	7,007	6,997	141	0.20	5.9
2011-05	98	11,500	11,450	231	0.31	5.8
2011-04	98	11,500	11,450	231	0.32	7.7
2011-03	97	10,890	10,830	219	0.29	7.7
2011-02	75	11,803	11,750	237	0.35	9.2
2011-01	75	14,160	14,070	284	0.38	10.2
Total/Average	91.28	80,667.9	80,286.8	1,622	0.25	6.9

Source: Provided by Huadian Fuxin

The actual constructed model and numbers and layout of WTG units are the same compared with the feasibility study, however since the feasibility study did not account for any losses due to grid curtailments, we suggest that the future production forecast is based on actual production figures.

Comparing the feasibility study estimated annual power generation 111,870 MWh with actual annual power generation, the actual power generation data between February 2009 and September 2011 illustrated in Fig 3.2 below. It was 129,680 MWh between October 2009 and September 2010, higher than estimated value; and 107,010 MWh between October 2010 and September 2011, lower than estimated value. It meets the forecast of feasibility study.

Figure 3.2: Yilan Jiguanshan Wind Farm Phase I Annual Power Generation



	1	2	3	4	5	6	7	8	9	10	11	12
2009		1510	3120	4510	5920	4570	6090	5970	7090	8480	14540	14890
2010	21300	13960	14430	11083	9420	5360	3270	6550	6400	10280	10430	10640
2011	14150	11820	10890	11490	6500	7010	3060	3900	6840			

Source: Provided by Huadian Fuxin

3.7.4 Conclusion

Wind turbines installed at Yilan Jiguanshan Wind Farm Phase I was supplied by manufacturers with proven technologies or has credible track records within the market. We are of the view that the turbine technologies are in accordance with current industrial standards, and the sites were built to a high standard. O&M arrangement are well-managed with good facilities on site. We are concern with potential fire especially when neighbouring farmers burn their straws during the dry season, which Huadian Fuxin site staffs need to pay special attention. Apart from this, we are of the opinion that the wind farm was built to a good standard.

It can be found from 2011 operation data that the average WTGs availability is 91.28%, the average wind speed at hub height is 6.9 m/s, lower than feasibility study forecast, and the net capacity factor is 0.25, which is reasonable for an onshore wind farm. Due to recent wind speed is lower than forecast long-term average wind speed and regional grid curtailments in Heilongjiang, Yilan Jiguanshan wind farm last year actual power generation is lower than the estimated annual value in feasibility study. Wind farm annual power generation meets the forecast of feasibility study.

Assessment of the operation data supplied to us by Huadian Fuxin suggests that the performance of the wind farm to date has been normal and reasonable, affected mainly due to grid curtailments about 7% of the potential output of the wind farm. It is very common in this part of Heilongjiang in winter and we would expect that this problem could be solved by future reinforcement of the network.

Wind farm plans to upgrade their reactive power compensation devices to SVG with totalling ±8 MVar. Reconstruction plan has been submitted to Huadian Fuxin headquarters and is approved. Reconstruction will be completed by the end of 2011.

For LVRT reconstruction, wind farm has submitted their reconstruction plan to Huadian Fuxin headquarters and is approved. It will be completed by the end of 2012.

It was noted that there is a pilot solar PV facilities that generate power for substation usage and a possibility of complementing WTG power generation into the local grid.

3.8 Lianyungang Guanyun Wind Farm Phase I

Lianyungang Guanyun Wind Farm is located along the coast line of Lianyungang, north of Jiangsu province and consist of fifty Haizhuang 2 MW WTGs totalling 100 MW, which was fully commissioned in December 2010.

3.8.1 WTGs

Haizhuang 2.0 MW double-fed WTG was jointly developed by Haizhuang and German Aerodyn Company based on Chinese market demand and support capacity. It is a three blades, horizontal shaft, electrical pitching, and variable-speed constant-frequency WTG with active facing wind, and two-points supporting transmission chain. H93-2000 WTG was design and manufactured in accordance with standardization, serialization, and universal. It has power control & prediction, LVRT Capability, and grid friendly requirements, and could adapt to snowing, freezing, dust, and low concentrations salt fog and other harsh environment.

Overall, we consider the design of the Haizhuang H93-2000 WTG to be in line with the industry standards. The main technical parameters are summarized in Table 3.15.

Table 3.15: Technical Summary of Haizhuang H93-2000

	H93-2000
Heb Height	80 m
Rotor Diameter	93 m
Nominal Power	2 MW
IEC Classification	IEC IIIc
Certification	Lloyd's Register
Cut-in Wind Speed	3 m/s
Nominal Wind Speed	10.8 m/s
Cut-out Wind Speed	25 m/s
Generator	Asynchronous Double-fed Generation
Gearbox	One stage planetary gear/ two stages spur gear system
Gearbox Ratio	1:118
Power Regulation and Control	Pitching Control
Operation Ambient Temperature	-10°C~+40°C
Standby Ambient Temperature	-20°C~+50°C

Source: Provided by Huadian Fuxin

3.8.2 Grid Connection Assessment

3.8.2.1 Equipment Capacity

Wind farm has fifty Haizhuang WTGs installed with a total capacity of 100 MW. Each wind turbine is connected to a WTG step-up transformer via underground cables. These cables are rated appropriately in order to carry maximum output from each individual turbine. Then these turbines are connected to their own four 35 kV inter array collection lines linked to 110 kV substation of wind farm. These lines are rated appropriately to carry the maximum output from the wind turbines.

The 110 kV step-up substation has been constructed with two 50 MVA – 110/35 kV transformers with an on-load tap changer. Unlike the other representative wind farms we visited, wind farm circuit breakers are indoors GIS system.

Wind farm is connected to 110 kV Guanhe substation via one 18 km 110 kV overhead line belonging to the local grid and the thermal rating is appropriately rated. We consider that the circuit is sufficient to export all power generated by the wind farm to the grid.

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

3.8.2.2 Reactive Power Compensation and Voltage Control

The total capacity of SVG installed at the site is 17.4 MVar and they are doing fine tuning when we visited the site. In addition, the transformer is equipped with an on-load tap changer which is able to control voltage between 90% and 110% at the HV winding. Therefore, we would consider the wind farm has sufficient reactive capacity and voltage control capacity to meet the reactive power demand and voltage regulation as required in the grid code.

We understand that under Chinese grid code all WTGs must have capability for LVRT. We were informed that all WTGs in Lianyungang Guanyun wind farm have LVRT capability and certificated by professional inspection.

3.8.2.3 Local Grid Operation

Wind farm is located along the coastline on the north of Jiangsu province. It is connected to Jiangsu power grid via 110 kV overhead line, and hence it is dispatched by Jiangsu Power Company.

Wind farm is located at an area which has abundant wind resources and the absorptive capability for wind power of local grid is quite strong. There was no grid curtailment from regional or local power company dispatcher on wind farm under normal circumstances.

3.8.3 Performance of Wind Farm

3.8.3.1 Site Environment

WTGs were deployed on flat terrain along the coastline. From our appreciation of the terrain during our site visit, we do not have any concerns regarding shading, channeling or excessive gradient which could lead to adverse wind conditions such as severe wind shear, inflow angles or turbulence. As this wind farm is close to the coast, we queried about the typhoon possibility and was advised by their site stuff that under the feasibility study, it had a very low occurrence, besides, this wind farm construction did take typhoon landing there into consideration.

Unlike other sites we visited, they were not subjected to very low temperature in winter and so would not be required low temperature versions of the WTGs. However, since the wind farm located at coastline, there may occur salt fog corrosion. Wind farm should improve anti-corrosion measures during daily O&M.

3.8.3.2 Site Facilities and Maintenance

There is a compound area at the site which contains the substation, control room, spare parts warehouse, offices and other site facilities. The wind farm company, which is the subsidiary of Huadian Fuxin, employs 30 staffs for their O&M tasks. Operations team is 2 rotating shifts of 7-8 staffs, 7 days a shift rotation and the maintenance team includes 15 staffs. The wind farm compound has very good facilities which are suitable for housing the teams and are well maintained.

During our visit we were able to visit WTGs without any issue. However, we did notice that earth settlement is quite rampant in areas around the compound buildings foundations. Huadian Fuxin had responded that the water level of this land is quite high and soil is very soft, whilst we did notice some rectifications works going on at the affected areas, we suggested that the wind farm should take measures to control earth settlement immediately, and since this wind farm is located at the coastal area, it is recommended that the long-term earth settlement observations should be implemented strictly to wind turbines foundations and inner-site transmission cables foundations in order to ensure safe operation of wind farm.

Haizhuang is a Chinese wind turbine manufacturer with a good track record and a significant number of installed units in China. According to the operational report for wind farm, the annual average WTG availability for the first 9 months of 2011 was 95.4%. We were informed that the WTGs had 3 generators and 2 shafts changed in 2011 and all costs were under the manufacturer as it was not handled over to them yet. To date there were no further problems with the generators or shafts. We also noted that this windfarm had slightly reduced the rotor rpm to give the blades pitch control more reactive time. We were informed that they did this as blades pitch control system is not so sensitive, thus had taken this safety measures.

There are three 80 m met masts in operation as we visited the site, and weather data were used for their operations and also for Load Data Forecast Transfer as required by Jiangsu power company.

At the time of our visit, WTGs of wind farm has not started their warranty period, thus all service and maintenance of WTGs are still under the manufacturer's care and wind farm operations team does keep a close tap on all WTGs event during this period. Huadian Fuxin provided us a power curve for Haizhuang 2 MW from their records and appeared to be broadly consistent with the standard power curves from the manufacturer.

3.8.3.3 Performance of Power Generation

Haizhuang guarantee a 95% availability level and they are achieving the average of about 95.4% (shows in Table 3.16). We understand that scheduled maintenance and grid outage are excluded from this figure. Between November 2010 and September 2011, the average annual wind speed at the hub height of the WTGs has been calculated to be 5.80 m/s, lower than feasibility study estimated value, and the capacity factor is 0.19, which is a typical value of onshore wind farm.

Table 3.16: Lianyungang Guanyun Wind Farm Phase I Operation Data

Date	Average WTGs Availability	Total Power Generation	On-Grid Power Generation	Equivalent Full-Load Hours	Capacity Factor	Average Wind Speed
	(%)	(MWh)	(MWh)	(h)		(m/s)
2011-09	95.09	15,150.8	14,837.5	148	0.21	6.0
2011-08	94.82	9,056	9,340	93	0.13	5.05
2011-07	94.56	7,320	7,150	72	0.10	4.63
2011-06	92.70	11,880	11,630	116	0.16	5.67
2011-05	97.23	16,430	16,100	161	0.22	6.4
2011-04	95.73	19,317	18,915.8	189	0.26	6.33
2011-03	95.23	18,549.5	18,162.6	182	0.24	6.23
2011-02	94.35	16,610	16,250	163	0.24	5.33
2011-01	97.36	13,160	13,000	130	0.17	4.78
2010-12	97.36	17,786.5	17,662	177	0.24	4.78
2010-11	96.17	6,188.7	6,140.6	61	0.09	7.01
Total/Average	95.40	151,448.5	149,188.5	1,492	0.19	5.80

Source: Provided by Huadian Fuxin

Since the power transmission line belongs to the local grid and its billing meter is within the substation, thus apart from wind farm electrical power losses, there were no need to account for further losses in the power transmission line to the grid. From November 2010 to September 2011, the net capacity factor based on on-grid power generation is about 0.19, which maybe caused by missing three high wind speed months operation data (October, November, and December). Since the wind farm start commissioning within this year, we cannot compare actual power generation with feasibility study estimation.

For information on grid curtailments, we were informed by Huadian Fuxin that there are no active curtailments being imposed on this wind farm.

3.8.4 Conclusion

The wind turbines installed for Lianyungang Guanyun wind farm were supplied by a well recognised Chinese wind turbine manufacturer that employs proven technologies. The O&M arrangements are well managed with very good facilities at the site. The power meter is based in wind farm substation, thus power losses to grid transmission lines were covered by local grid and there is no active curtailment.

The substation is sitting on soft ground along the coastline and earth settlement is a major issue. However, it is comforting to note that Huadian Fuxin had also identified the affected areas and is taking corrective measures. Assessment of the production data supplied to use by Huadian Fuxin suggests that the performance of the windfarm to date has been reasonable.

According to wind farm operation data from November 2011 to September 2011, it can be found that the average availability is 95.4%, the average annual wind speed at the hub height of the WTGs is 5.8 m/s, less than feasibility study forecast, and the capacity factor is 0.19, which is a typical value of onshore wind farm. Since the wind farm start commissioning within this year, we cannot collect enough operation data and compare actual power generation with feasibility study estimation.

Wind farm are doing fine tuning of SVG when we visited the site. To compare with SVC, SVG has better technical performance, and sufficient reactive power compensation technical requirements.

All WTGs installed in Lianyungang Guanyun wind farm have LVRT capability and certificated by professional inspection.

3.9 Conclusion of Wind Farms Technical Assessment

Of the seven representative wind farms we reviewed, Guazhou wind farm and Lianyungang Guanyun wind farm power generation data is less than a year, as they are relatively new and so did not have enough operational data (at lease 12 months normal operational data), thus we could not assess whether their power generation of these two wind farms was in line with the forecasted value in the feasibility studies. For the rest of the five wind farms, the actual annual power generation of Kulun, Xiaocaohu and Muling are less than their feasibility studies forecasted value; Yilan Jiguanshan's annual power generation is in line with feasibility study's expectation; and Burqin has better annual power generation than feasibility study.

The seven representative wind farms are located in areas with excellent wind regimes of which six wind farms performance could be better if there were no grid curtailments for one reason or another. We would expect this curtailments problem to be mitigated by future upgrading of gird and load demand continuous increasing, and the strict imposition of LVRT and voltage control requirements on the wind farms by the grid operators.

For reactive power compensation devices in seven representative wind farms, Kulun wind farm has higher capacity than feasibility study after upgrading, which satisfies the requirements of reactive power compensation capacity. Xiaocaohu wind farm, Burqin wind farm, and Muling wind farm do not have sufficient reactive capacity to meet the reactive power demand required in the grid code and had submitted their reactive power compensation reconstruction plan to Huadian Fuxin headquarters and is pending approval. Yilan Jiguanshan wind farm will complete the upgrading of Static Var Generator (SVG) by the end of 2011. Comparing with feasibility study forecasted value, Guazhou wind farm has higher reactive power compensation capacity, which means the wind farm has sufficient reactive capacity to meet the reactive power demand required in the grid code. Lianyungang Guanyun wind farm is currently doing fine tuning of Static Var Generator (SVG), which capacity is sufficient for the technical requirements in grid code.

We were informed that both SGCC and Inner Mongolia grid company required all WTGs must have LVRT capability. Kulun, Xiaocaohu wind farm, Muling, and Yilan Jiguanshan wind farm do not have LVRT capability. They have submitted their LVRT reconstruction plan to

Huadian Fuxin headquarters and were approved. As WTGs manufacturer of Kulun wind farm, Sinovel has developed LVRT reconstruction plan and promise implementing appropriately. Xiaocaohu wind farm will employ wind farm integrated LVRT technology for 54 Goldwind WTGs' reconstruction, and 6 WTGs from Sinovel LVRT reconstruction has been completed in December 2011. Since Muling has long operation time and less installation capacity, currently the wind farm is coordinating with local gird for necessity of LVRT reconstruction. Yilan Jiguanshan will complete LVRT reconstruction by the end of 2012. Goldwind promises that their WTGs installed at Muling wind farm have LVRT capability, and will be responsible for reconstruction if WTGs cannot be approved by inspection and certification. Sinovel WTGs installed at Guazhou wind farm have completed LVRT reconstruction by WTG manufacture in November 2011. The WTGs installed in Lianyungang Guanyun wind farm were inspected and certificated with LVRT capability.

There is a common problem for seven representative wind farms that if the torque wrenches used to test the tower connecting bolts torque meets manufacturer's requirements, did not have regular testing and calibration. It is a potential risk for WTGs safe operation. Huadian Fuxin should ensure that all torque wrenches are to be test and calibrated regularly.

Monitor method and progress of earth settlement should improve immediately to meet earth settlement monitoring requirements in industrial regulation 'WTGs foundations design regulation FD003-2007'.

Kulun wind farm is running well. We hold the opinion that the actual power generation would be better if there is no grid curtailment. This wind farm is developing a pilot project to overcome grid curtailments by investing in electric boiler factor to provide regional winter heating. It is really important to reduce grid curtailments.

The actual power generation of Xiaocaohu Wind Farm 1 Phase I is slightly lower than feasibility study forecasted value and is running in a good condition. Comparing lower capacity factor with feasibility study, we believed its annual power generation data is at a normal level.

The actual annual power generation of Burqin Wind Farm Phase I is higher than feasibility study forecasted value, which resulted from higher annual average wind speed and better capacity factor.

There were three large-scale off-grid incidents in Gansu area in 2011, thus Guazhou Wind Farm Phase I was affected by grid curtailments to date 7% of wind farm output.

Muling and Yilan Jiguanshan wind farm have long operation history. Comparing actual annual power generation data from 2009 to 2010 with feasibility study forecast, we concluded that the lower power generation of Muling Wind Farm Phase I in 2011 results from lower capacity factor. Base on historical data, we believed Muling Wind Farm Phase I is running well. Referring to Yilan Jiguanshan Wind Farm Phase I, its actual annual power generation fluctuated with feasibility study forecasted value in 2009-2010, and in 2010-2011. We understand Yilan Jiguanshan Wind Farm Phase I is running well.

Muling and Yilan Jiguanshan wind farms were built on areas with heavy vegetation and could be a potential fire hazard during the dry autumn and winter months. Special care and attention need to be taken into consideration during this period and Huadian Fuxin staffs need to stay vigilant during this season.

There is an experimental Solar PV equipment at Yilan Jiguanshan Wind Farm to tap full resources into their wind farm.

Lianyungang Guanyun Wind Farm Phase I showed lower performance than expected. We understand from the available information that missing operation data in 3 high wind speed months was the main reason for the low production. There is no internal control breakdown in the Group with regard to missing operation data in the three high wind speed months. As Lianyungang Guanyun wind farm was in commissioning during the three months, the generation data can not be recorded exactly by control system. Earth settlement has to be monitored regularly at the major equipment components and rectifications works need to be done immediately where possible.

It is worthy to note that the Lianyungang Guanyun wind farm located at Lianyungang in Jiangsu province does not have any such grid curtailment concerns.

Overall, the equipment and facilities of our visited representative seven wind farms are well-maintained and of good standard. The design, construction and installation are in line with our expectations.

4. TECHNICAL ASSESSMENT OF HYDROPOWER STATION

4.1 Introduction

4.1.1 General

The following is a technical review of 7 hydropower schemes owned by China Huadian Fuxin Energy Corporation Limited, and located in Fujian province, China. The purpose of this study is to review the available documentation as well as the knowledge gained from the site visit and to identifying potential risks and issues for the purchaser.

The documentation for the following plants has been reviewed and the sites were inspected during the visit:

- Baisha (Installed Capacity of 70.0 MW)
- Mianhuatan (Installed Capacity of 600.0 MW)
- Ansha (Installed Capacity of 115.0 MW)
- Fenghai (Installed Capacity of 30.0 MW)
- Qinshan (Installed Capacity of 70.0 MW)
- Gutianxi Second Cascade (Installed Capacity of 130.0 MW)
- Chitan (Installed Capacity of 100.0 MW)

Documentation reviewed includes monthly operation records, equipment specifications, condition of the plant, dam and intake structure as well construction drawings and reports.

4.1.2 Regular Dam Safety Inspection

In order to ensure safe and reliable operation of hydropower dams, the Large Dam Safety Supervision Center under State Electricity Regulatory Commission will organize regular dam safety inspection according to 'Regulations on Safety Operation for Dams of Hydropower Station' and 'Methods on Regular Safety Inspection of Dams for Hydropower'. The main tasks include:

- Review on engineering design and construction quality;
- Safety evaluation of flood control;
- On-site inspection;
- Summarize the operation performance since the latest regular inspection (or safety assessment);
- Evaluate the repairment or reinforcement works completed since latest regular inspection (or safety assessment);
- Inspect and evaluate the dam safety monitoring systems;
- Analyze the dam safety monitoring;
- Dam risk assessment;
- Dam aging test and assessment;
- Define the safety level and identify the defects and risks and issues should be focused during operation.

Generally, dams are differentiated into normal dam, defective dam and dangerous dam in China according to the results of safety assessment.

- Normal dams-refers to the dams that operated well and satisfied with the current regulatory requirements;
- Defective dams-with certain defects that reinforcement and treatment are needed;
- Dangerous dams-shall be reinforced or change the operation modes to ensure their safety.

Inspections are required for dams of hydropower plants every five years.

4.1.3 M&E Maintenance Schedule

The China Huadian Fuxin Group operates their plants in accordance with the Chinese Standard DL/T838-2003 (Guide of maintenance for power plant equipments) which provides details about the maintenance works and intervals for turbines.

According to maintenance scale and outage time, four types of maintenance works are differentiated in this guide, namely:

- Class A maintenance understood to be a complete strip-down of the whole power generation unit to maintain, recover or improve performance;

- Class B maintenance understood to be partial strip-down of unit and overhaul of parts to fix certain problems;

- Class C maintenance understood to involve corresponding check, evaluation, repairs and cleaning works according to the aging and tearing law;

- Class D maintenance understood to eliminate defects for auxiliary system and equipments of major equipments.

A full description of the different units maintenance procedures was not available at the time of this review, but the classification of maintenance into four categories is a standard approach to unit maintenance works.

The maintenance intervals according to DL/T 838-2003 are given in Table 4.1 for reference.

Table 4.1: Turbine generation units maintenance intervals

Type/Equipment	Class A	Class B	Class C
Sediment-laden turbine	4-6 years	1 between 2 A class maintenances	1 per year
Non sediment-laden turbine	8-10 years	Same as for sediment laden	Same as for sediment laden
Step-up transformers	10 years (depends on operation and testing results)		1 per year

Source: Guide of maintenance for power plant equipments (DL/T 838-2003)

The Guideline also advises outage times for the different maintenance classes depending on the size of the runner as shown in Table 4.2.

Table 4.2: Estimated outage times for maintenance works for Francis-type turbines

Runner Size (m)	Class A (days)	Class B (days)	Class C (days)
<1.2	30-40	20-25	3-5
1.2-2.5	35-45	25-30	3-5
2.5-3.3	40-50	30-35	5-7
3.3-4.1	45-55	35-40	7-9
4.1-5.5	50-60	40-45	7-9
5.5-6.0	55-65	45-50	8-10
6.0-8.0	60-70	50-55	10-12
8.0-10.0	65-75	55-60	10-12
>10.0	75-85	60-65	12-14

Source: Guide of maintenance for power plant equipments (DL/T 838-2003)

4.2 Baisha Hydropower Plant

4.2.1 General

Baisha hydropower plant, the second hydro power plant of the cascade development for Wan'an River, is located in Longyan County, Fujian province and is approximately 45 kilometres from Longyan down town. Baisha dam is located approximately 2 km upstream of the powerhouse location, upstream of a river bend.

The hydropower plant began commercial operation in November 2006 and is designed as a peaking power station with a installed capacity of 70 MW based on a design discharge of 142.2 m^3/s at a rated head of 55 m.

The annual design energy production is given as 186.5 GWh, based on a plant load factor of 30.4% (or 2,664 hours per year).

4.2.2 Project Technical Program Review

4.2.2.1 Hydrology

Wan'an River First cascade hydropower plant has been developed in the upstream of Baisha dam in August 1994 with drainage area of 667 km^2, accounting for 51% of drainage area of Baisha Hydropower Plant.

The main hydrological characteristics of Baisha hydropower plant are shown in the table below. Although the raw hydrological data has not been reviewed, in general the assumptions and methodology employed appear reasonable.

Table 4.3: Basic Hydrological characteristic – Baisha

No.	Item	Unit	Features	Remarks
1	catchment			
	whole catchment	km^2	1,470	
	catchment in the upstream of the dam		1,307	
2	Hydrological data series		41 years	1957-1997
3	Average annual runoff	10^8 km^3	13.72	
4	Average annual flow	m^3/s	43.8	
	Dam design flood and flow	m^3/s	3,470	P=1%
	Dam check flood and flow	m^3/s	4,550	P=0.1%
	Power house check flood and standard flow	m^3/s	4,260	P=0.2%
5	Flood volume			
	Dam design flood volume	10^8 m^3	1.569	P=1%
	Dam check flood volume	10^8 m^3	2.223	P=0.1%
	Power house check flood volume	10^8 m^3	2.026	P=0.2%
6	Sediments			
	Multi-year average amount of suspended sediment discharge	’0000 tons	9.95	
	Multi-year average sediment concentration	kg/m^3	0.142	
	Multi-year average bedload sediment discharge	’0000 tons	2.74	

4.2.2.2 Geology

No in-depth study has been undertaken on the geology of the project area and it is not considered to be seismically active according to feasibility study and a visual review of the structures do not indicate that they have suffered from any adverse movements. The size and nature of the structures involved in hydroelectric projects tend to mean that any adverse ground movements result in cracking of the windows and brickwork of the structures none of this was evident during the site visit.

Due to the size of the reservoir, it was not possible to inspect the reservoir slopes for landslides; however, the areas visible from the dam and powerhouse showed no signs of being subjected to sliding.

4.2.2.3 Design Standards

According to GB50201-94 "Flood Control Standards" and DL5180-2003 – "Hydropower Project Classification and Safety Design Standards," the project is classified as Grade II based on the reservoir capacity and installed capacity. The design flood frequency for the dam is 100 year return (P=1%) and the check flood frequency is 1,000 year return (P=0.1%); the design flood frequency for power house is 100 year return (P=1%) and check flood frequency is 200 year return (P=0.5%).

According to DL5073-2000 – "Specifications for Seismic Design of Hydraulic Structures", the scheme was designed in line with VI degree of seismic fortification intensity of VI degree.

It can be confirmed that the original design is in line with standards and current relevant specifications.

4.2.2.4 Scheme Layout and Main Structures

Baisha consists of a roller concreted dam, spillway, intake arrangement, powerhouse and step-up switchyard. The intake system is on the right abutment of the dam and water is taken via an infall, pressure tunnel and penstock to the powerhouse. The step-up switchyard is arranged at the downstream of the powerhouse.

Baisha dam is used to enable peaking generation at Baisha hydropower plant as well as flood protection and the salient features of the dam are summarised in Table 4.4.

Table 4.4: Baisha Dam Salient Features

	Reservoir
Dam Type	Rolling Compacted Concrete Dam
Dam Height (m)	75
Crest Length (m)	171.8
Crest Width (m)	6
Live Volume (m^3)	100
Total Volume (m^3)	199.26
Total Volume (km^2)	1,307
Impounds	Wan'an River

Source: Feasibility Study of Baisha Hydro Power Plant

4.2.2.5 M&E System

The powerhouse contains the generating units, step-up transformer, air-insulated switchgear (SF_6) and all balance of plant components.

The station consists of two vertical Francis-type turbines with a rated capacity of 36 MW each; however, generating output is limited to 35 MW due to the generator capacity. Hence, the total installed capacity is 70 MW. The unit centreline is at 200.8 m, and according to the design layout drawings and neither of the two units is fully submerged as the tailwater level is 200.8 m under rated operating conditions.

The salient features of the turbines are given in Table 4.5.

Table 4.5: Baisha Turbines Salient Features

	Turbine 1	Turbine 2
Type	Vertical Francis	Vertical Francis
Manufacturer	HLX75E-LJ-285	HLX75E-LJ-285
Rated Output (MW)	36	36
Rated Head (m)	55	55
Rated Discharge (m^3/s)	71.1	71.1
Rated Speed (rpm)	214.3	214.3
min. operating head (m)	47.99	47.99
max. operating head (m)	65.58	65.58
Runner Setting (m)	0	0
Turbine Centreline (m asl)	200.8	200.8
Installation Date	Dec 2006	Dec 2006

Source: Baisha Site Visit – Turbine Rating Plate

Each vertical Francis-type is coupled to a synchronous vertical axis salient-pole generator, located on the generator floor level. The generating voltage at Baisha is set to 10.5 kV and the salient features are provided in Table 4.6.

Table 4.6: Baisha Generators Salient Features

	Generator 1 & 2
Manufacturer	Dongfang Electric SF35-28/5500
Rated Capacity (MVA)	40
Rated Voltage (kV)	10.5
Rated Current (A)	2,199.4
Power Factor (-)	0.875
Rated Power (MW)	35.0
Rated Speed (rpm)	214.3
Frequency (Hz)	50
No. of Pole Pairs	14
Manufacturing Date	Aug 2006

Source: Baisha Site Visit – Generator Rating Plate

Each generator is then connected to a 10.5 kV generator bus bar and each generator step-up transformer steps up the voltage to the transmission grid voltage of 110 kV. Transformers and high voltage air-insulated switchgear are located in an annexure building to the powerhouse. The salient features of the transformers are provided in Table 4.7.

Table 4.7: Baisha Step-Up Transformers – Salient Features

	Step-up Transformer 1&2
Model	Shan Dong Luneng Electric Equipment SF10-40000/110
Rated Capacity (MVA)	40.0
Rated Voltage (kV)	121 ± 2 x 2.5%/10.5
Cooling	ONAF/ONAN
Connection	YNd11
Manufacturing Date	March 2006

Source: Baisha Site Visit – Transformer Rating Plate

4.2.2.6 *Other Facilities*

A separate staff building is located within the compound of the hydropower plant.

4.2.3 Plant Maintenance and Operation

4.2.3.1 *O&M of Main Hydraulic Structures*

Baisha dam has registered in Dam Safety Center in 2009 and ranked its safety level as Grade A by the Large Dam Safety Supervision Center.

From "Construction Acceptance Inspection Report for Baisha Hydropower Plant," Baisha plant experienced a five years return flood in June 15, 2010 with a maximum inflow of 1,380 m^3/s and maximum flood drainage of 670 m^3/s and the highest water level reached 265.04 m, the tail water level reached 204.04 m. The observations show that the dam displacement, leakage, osmotic pressure and stress-strain were within the normal range. The slopes near the dam seem stable from the records and the the dam is under safe operation.

4.2.3.2 *Operation and Maintenance of M&E System*

From the site visit and local inspection of the generation unit and balance of plant, it can be confirmed that that the general condition of the generating equipment is good.

The scheme is operated from a control room located on the ground floor of the powerhouse adjacent to the relay room. The ground floor also houses modern leak-free batteries and associated chargers for the DC supply of the power plant instead of outdated and hazardous lead-acid batteries.

Several additional administration buildings are located in the actual powerhouse compound, but no workshop is located on site and any necessary repair work needs to be carried out off-site in the nearby towns.

The operating floor of the powerhouse is spacious and clean and the loading/assembly bay includes a rotor poling pit for shaft machining and general rotor repair works. The operating floor also houses the oil storage tank and pump for the unit HPU (high-pressure unit).

The two step-up transformers are located on the ground floor in an adjacent building to the powerhouse, with the air-insulated switchgear located on the first floor of the same building.

It should be noted that there was no automatic fire fighting system, such as a water spray system, installed for the main step-up transformers, and in the unlikely event of transformer fire/explosion, manual fire fighting with fire extinguishers would be required. Furthermore, there were no means provided for removal of the transformers, such as a roller shutter gate, and replacement of the transformer would require removing at least one of the concrete walls enclosing the transformer.

Similarly, the air-insulated switchyard was fully enclosed, even though there was no obvious reason to do so.

While there is a risk of transformer explosion/fire and subsequent damage the adjacent building or switchgear, the design is not fatally flawed and is also used in other power stations in China.

The power station has only been in operation for a short time, and it was confirmed during the site visit that the hydraulic structures and major mechanical and electrical equipment were generally in good condition.

Complete records of maintenance were provided for both units from 2006 onwards. During the site inspection both units were operational, however, only one unit was generating due to low demand.

Maintenance at Baisha follows the guidelines for unit overhaul stated in Table 4.8 with A class maintenance every 4 to 6 years. The overall condition of the inspected machines and plant seems to indicate that both machines are overhauled and maintained in regular intervals.

Table 4.8: Scheduled and unscheduled Maintenance Record for Baisha

Year	Unit 1	Unit 2
2006		
2007		A (62 days)
2008	A (46 days)	
2009	B (55 days, stator)	
2010		B (40 days, rotor)
2011	B (45 days, electric braking)	
2012 (scheduled)	A (50 days)	
2013 (scheduled)		A

Additional smaller maintenance (C and D class maintenance) was also carried in each year to remedy small defects. The intervals and outage time of such small maintenance are as expected for stations of this size.

According to the maintenance schedule provided Unit 1 will come up for class A maintenance in 2012, with the next A class maintenance for Unit 2 scheduled for 2013.

Overall the maintenance records provided are satisfactory and there have been no major problems since operation.

4.2.3.3 Power Output

Generation records are shown in Table 4.9 for the period from January 2007 to September 2011 as the plant commissioning was completed in December 2006.

Table 4.9: Summary of Annual Energy Generation – Baisha

Year	Annual Generation	Load Factor	Proportion of Design Generation
	(GWh)		
2007	186.6	30%	100%
2008	155.4	25%	83%
2009	109.4	18%	59%
2010	223.9	37%	120%
2011[(1)]	87.6	n/a	n/a
Average (2007 – 2010)	168.8	28%	88%

Note 1: Generation data for January to September 2011 available only and hence no load factor or proportion of design has been calculated.

It can be seen from the table above that the load factor (proportion of design generation) for the scheme has been generally in the region of 20% to 40%, which is expected for this kind of peaking plant. The records also show that apart from 2009 the plant has mostly met its design generation.

Energy generation in 2009 was considerably lower compared to the other three full years of operation, and this is most likely linked to the low available water in the river and Fujian province in general as low generation outputs for those years has also been noticed for other plants in the province.

Table 4.10: Monthly Average Energy Generation at Baisha

Month	Average Generation (GWh)	Load Factor	Remarks
January	8.9	17%	Low generation
February	13.8	29%	
March	10.8	21%	
April	18.3	36%	
May	13.7	26%	
June	25.5	51%	Peak generation period
July	25.4	49%	Peak generation period
August	16.1	31%	
September	15.8	31%	
October	6.4	12%	Low generation
November	7.1	14%	Low generation
December	7.0	13%	Low generation
Total	168.8	28%	Low generation

For its short period of operation, the plant has managed to generate on average 88% of its design generation, which is a satisfactory generation value for this kind of plant.

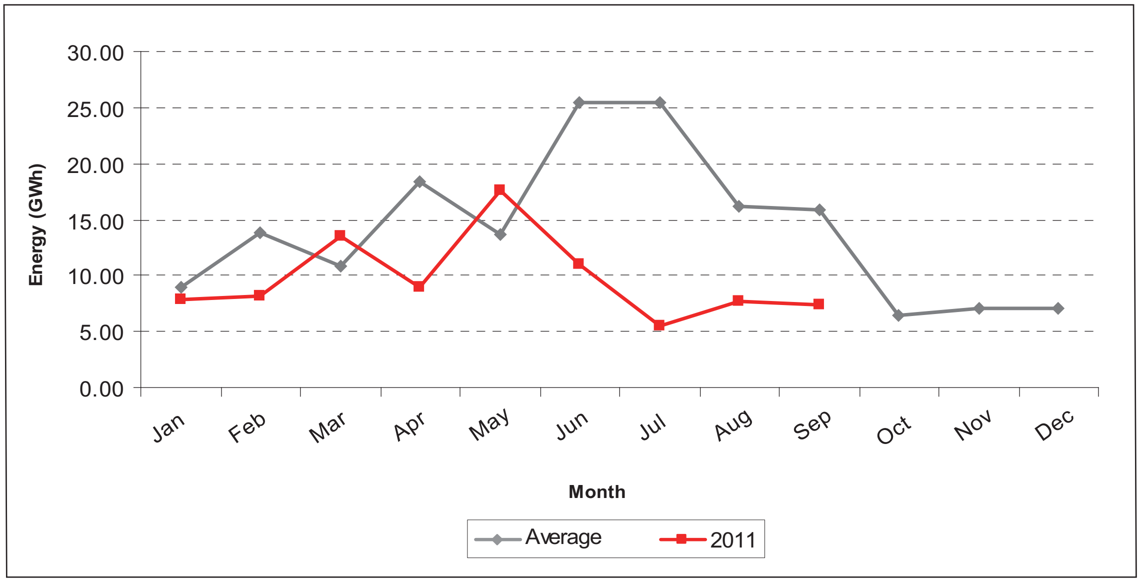
Table 4.10 shows the monthly average energy generation, indicating that peaking generation for the Baisha power plant is generally in June and July, with October to January being the low demand periods.

Based on the monthly average energy generation it is possible to estimate the total energy output of 2011 for Baisha Hydropower Plant. For this purpose, Table 4.11 shows the monthly output from January to September and this is then compared with the average monthly energy in Figure 4.1 below.

Table 4.11: Summary of Generation in 2011 (January to September)

Month	Average Generation (GWh)	Load Factor	Remarks
January	7.8	15%	
February	8.1	17%	
March	13.5	26%	
April	9.0	18%	
May	17.6	34%	
June	11.0	22%	
July	5.5	10%	
August	7.7	15%	
September	7.4	15%	
Total (Jan-Sep)	95		

Figure 4.1: Average Monthly Energy Generation and 2011



Source: Baisha Site Visit – Generating Output

From this figure, it can be seen that for the first five months of the year, Baisha was generating on average the same amount of energy as the previous years, albeit seemingly delayed by one month. However, for the high generation periods of June and July, Baisha was generating significantly less than the monthly averages for those two months and if generating output does not increase for the remainder of the year, it is likely that Baisha will not meet its design generation and an overall annual energy generation similar to 2009.

During our site visit, it was confirmed that the current period of low generation output is probably partly due to less inflow and low power demand in 2011.

4.2.4 Organization and Staff

According to the staffing program provided by China Huadian Fuxin, 31 staffs are permanently employed, 6 are management, 12 maintenance and 10 operational staffs. 3 staffs are assigned for health and safety inspection as well as logistics. Operational staff duties are organized in 2 shifts per day, which is a normal practise. No information was provided if temporary staff was employed during unit overhaul or maintenance periods.

4.2.5 Quality and Condition

The vegetation around the dam and powerhouse is well covered. No special issues are identified during site inspection. The plant shall ensure minimum drainage flow of 16.3 m^3/s to meet the demand for the downstream environmental and human use as required by the environmental administration.

4.2.6 Consent

The process water demand of power plant has been approved by the local authority. Baisha HEP obtained the approval of water abstraction permit as required (Number: Shui (Min) [2007] No. 000002), valid until December 31, 2012.

4.2.7 Grid Connection Agreement

We reviewed the grid connection agreement signed between Fujian Power Limited Company, Fujian Longyan Power Bureau and Fujian Mianhuatan Hydropower Development Limited Company in November 2006 (validity period: 2006/11/10-2008/12/31). All of the three parties agreed no further amendment three months before the expiration of the agreement so this agreement automatically extended for another three years, i.e. expired on December 31, 2011.

4.2.8 Conclusion

Baisha hydropower station is a peaking power station and has been in operation for approximately four and half years. The technology employed in the scheme (unit type, switchgear, batteries etc) is well established and appropriate to current design and considered to be low risk.

We have also reviewed general layout drawings and arrangement drawings of power house in addition to our site visit and no concerns have been found.

There is no seismic activity at the powerhouse location and no major flood events or landslides have occurred that could have affected the dam and powerhouse. Both the powerhouse and the dam are well maintained and in good condition.

Analysis of operational records has shown that the plant has generated on average up to 88% of its design generation, with only 2009 significantly lower than the design generation and it can be confirmed that so far the plant is operating and providing energy as anticipated. However, it is likely that in 2011 the power plant may miss its design generation partly due to a low inflow and power demand during the usual high generation period. But generally this scheme is well designed and operating according to expectations. Additionally, operating and maintenance staff appears well trained and competent.

It is recommended that these factors are taken into consideration in any commercial analysis of the scheme.

4.3 Mianhuatan Hydropower Plant

4.3.1 General

Mianhuatan hydropower plant is located in Yongding County, Fujian province and is approximately 25 km from Yongding county town. Mianhuatan hydropower plant also can play multi functions, including generation and flood control.

The hydropower plant began commercial operation in April 2001 and is designed as a peaking power station with a total installed capacity of 600 MW (4 units) based on a design discharge of 774.7 m^3/s (196.3 m^3/s for each turbine) at a rated head of 87.6 m.

The annual design energy production of the plant is 1,532 GWh, based on a plant load factor of 29.1% (or 2,533 operational hours per year).

4.3.2 Project Technical Program Review

4.3.2.1 Geology

"Expert Opinion on Seismic Intensity for Mianhuatan Hydropower Plant in Yongding County" (issued by Fujian Provincial Seismological Bureau, Minzhengyezi [035] (97)) stated that it is unlikely to have earthquake greater than 6 degree in this region within 100 years . As reference to the "China seismic intensity zoning map (1990)," (issued by State Seismological Bureau and the Ministry of Construction and approved by State Council of PRC in 1992), Mianhuatan is located in the 6 degree zone.

No in-depth study has been undertaken on the geology of the project area during site visit. A visual review of the structures does not indicate that they have suffered from any adverse movements. The size and nature of the structures involved in hydroelectric projects tend to mean that any adverse ground movements result in cracking of the windows and brickwork of the structures. None of this was evident during the site visit.

Due to the size of the reservoir, it was not possible to inspect the reservoir slopes for landslides; however, the areas visible from the dam and powerhouse showed no signs of being subjected to sliding.

4.3.2.2 Hydrology

The drainage area of the dam is 7,907 km^2. Reliable hydrological data series from 1951 are available. References to the design documents, the main hydrological characteristics are show in Table 4.12.

Table 4.12: Basic Hydrological Characteristics – Mianhuatan

No.	Item	Unit	Features	Remarks
1	Catchments area			
	The whole catchments	km^2	11,802	
	Drainage area	km^2	7,907	
2	Data series		1951-1978	28 years
3	Average annual runoff	10^8 m^3	73.2	
4	Average annual rainfall	mm	1,657.1	
5	Representative flood flow			
	20 years return	m^3/s	6,950	P=5%
	100 years return	m^3/s	9,440	P=1%
	Design flood flow	m^3/s	12,000	P=0.2%
	Check flood flow	m^3/s	15,500	P=0.02%
6	Flood volume			
	Design flood volume (3 days, P=0.2%)	m^3/s	19.8	
	Check flood volume (3 days, P=0.02%)	m^3/s	26	

Source: Mianhuatan Hydropower Plant Feasibility Study

4.3.2.3 Design Standards

The total storage capacity of Mianhuatan reservoir is 2.035 billion m^3. Mianhuatan HEP is designed as a Grade 1 multi-purpose project. The dam is Class 1 structures, based on 500 years return flood and checked with 5,000 years return flood.

Water conveyance structures are defined as Class 2 structures, based on 50 years return flood and checked with 500 years return flood. The water retaining structure of the intake is designed at the same standard with the dam.

The basic seismic intensity of the site is 6 degree and the design seismic intensity is also 6 degree. But for safety consideration, the dam is checked with 7 degree and the seismic fortification intensity of main water conveyance structures is degree 7.

4.3.2.4 Scheme Layout and Main Structures

Mianhuatan main structures are comprised of a 111 m high roller compacted concrete (RCC) dam, underground powerhouse, intake arrangement, spillway gates, flushing gate and hoisting equipment. The intake arrangement is located on the left side of the abutment. The normal water level is at 173 m ASL and the bottom water level is given as 146 m ASL, allowing for a total drawdown of 27 m and providing a useable live storage of 1,122 million m^3.

Apart from generation peaking energy dam is also used for flood control purpose, i.e. the dam is also used to regulate the downstream water supply and the salient features of the dam are provided in Table 4.13.

Table 4.13: Mianhuatan Dam – Salient Features

	Dam & Reservoir
Dam Type	Roller compacted concrete dam
Dam Height (m)	111
Crest Length (m)	308.5
Crest Width (m)	7
Live Volume (million m^3)	1,122
Total Volume (million m^3)	1,698
Catchments Area (km^2)	7,907
Impounds	Tingjiang River

Source: Mianhuatan Hydropower Plant Feasibility Study

The intake arrangement is located on the left side of the abutment.

The underground plant system is located in the left bank, including intake, diversion tunnel, penstock, underground power house, main transformer room, tail water regulation chamber, bus bar tunnel, access tunnel, ventilation hole, GIS distribution room and other underground structures.

4.3.2.5 M&E System

The underground powerhouse contains the generating units, step-up transformer, gas (SF_6) insulated switchgear and all balance of plant components.

Energy is generated by four vertical Francis-type turbines, each with a rated capacity of 150 MW, resulting in a station output capacity of 600 MW. To avoid unit cavitations and low pressures during load rejection, each unit is submerged by 6.5 m compared to the rated tail water level of approximately 85 m ASL. The salient features of each turbine are also summarised in Table 4.14.

Table 4.14: Mianhuatan Turbines – Salient Features

	1-4# Turbines
Model	Voith – HLD41-LJ-440
Rated Output (MW)	153
Rated Head (m)	87.6
Rated Discharge (m^3/s)	193.6
Rated Speed (rpm)	166.7
min. operating head (m)	68.0
max. operating head (m)	104.0
max. power output (MW)	175.0
Runner Setting (m)	-6.5
Inlet Diameter (m)	4.4
Year of Installation	2001

Source: Mianhuatan Site Visit – Turbine Rating Plate

Each Francis-type is coupled to a synchronous vertical axis salient-pole generator, located above the turbines on the generator floor, with a generating voltage of 15.75 kV. The salient features for each generator are provided in Table 4.15.

Table 4.15: Mianhuatan Generators – Salient Features

	Unit 1-4 Generators
Model	Dongfang Generator
Rated Capacity (MVA)	171.43
Rated Voltage (kV)	15.75
Rated Current (A)	6,248
Rated Power (MW)	150
Rated Speed (rpm)	166.7
Frequency (Hz)	50
No. of Pole Pairs	18
Moment of Inertia (tm^2)	1,600

Source: Mianhuatan Site Visit – Generator Rating Plate

For voltage step-up and power evacuation two generators are connected onto a common generator bus and generator step-up transformer, which is located on the operating floor of the powerhouse. Power is stepped up to the transmission grid voltage of 220 kV and the transformer is connected to a 220 kV gas (SF_6) insulated switchgear. Salient features of transformer and gas (SF_6) insulated switchgear are provided in Table 4.16 and Table 4.17.

Table 4.16: Mianhuatan Step-Up Transformers – Salient Features

	Transformer 1 to 2
Model	Baoding Tianwei Electrics – SSP-360000/220
Rated Capacity (MVA)	360
Rated Voltage (kV)	242 ± 2x2.5%/15.75
Cooling	ODAF
Connection	YNd11

Source: Mianhuatan Site Visit – Step-up Transformer Rating Plate

Table 4.17: Mianhuatan Gas (SF_6) Insulated Switchgear – Salient Features

	220 kV GIS
GIS Type	ZF9-252
Insulating Gas	SF_6
Rated Voltage (kV)	252
Rated Frequency (Hz)	50
Rated Current (A)	2,000

Source: Mianhuatan Site Visit – GIS Rating Plate

Power can be evacuated via a total of four 220 kV transmission lines which are connected to the GIS via SF_6 gas to air bushings outside of the powerhouse.

The powerhouse also houses the cast-resin dry type transformers for step-down to 400 V for station AC supplies, unit motor control centre and auxiliary services as well as all required balance of plant, i.e. cooling water systems, drainage systems, hydraulic pressure units for turbine control, etc.

4.3.2.6 *Other Facilities*

Facilities above ground include an administration building housing the control room, vent-regulated lead-acid batteries and chargers for station d.c. supplies as well as control and metering equipment. The hydropower station also includes site colony for resident staff.

4.3.3 Plant Operation and Maintenance

4.3.3.1 *Operation and Maintenance of Hydraulic Structures*

Mianhuatan dam has registered in the Dam Safety Centre as Grade A and passed the regular safety inspection organized by Large Dam Safety Supervision Center under State Electricity Regulatory Commission in 2009 identified as "normal" dam and it can be confirmed the operation of the dam is in line with the current specifications.

4.3.3.2 *Operation and Maintenance of M&E System*

From the site visit and local inspection of the generating unit and balance of plant, it can be confirmed that that the general condition of the generating equipment is good and only minimal signs of wear and tear were visible.

The complete operational records and schedules of Mianhuatan hydropower plant were available for review. The power station has been in operation for 10 years, and the site inspection showed that the major mechanical and electrical equipment are generally in good condition.

According to the provided maintenance plan each unit is scheduled to undergo A class maintenance every 4-5 years, actual maintenance carried out since 2011 is given in table 4.18 below.

Table 4.18: Maintenance Samples for Unit 1 to 4

Year	Unit 1	Unit 2	Unit 3	Unit 4
2001	–	–	–	C (5)
2002	B (27)	B (30)	B (23)	–
2003	B (21)	B (14)	–	B (13)
2004	B (15)	A (60)	B (21)	B (11)
2005	A (82)	B (15)	B (19)	B (14)
2006	B (18)	B (16)	B (21)	A (79)

Year	Unit 1	Unit 2	Unit 3	Unit 4
2007	B (19)	A (94)	B (18)	B (19)
2008	B (14)	B (17)	A (96)	B (20)
2009	A (83)	B (23)	B (15)	B (20)
2010	B (25)	B (19)	B (25)	B (30)
2011	B (20)	B (20)	B (20)	A (120)

Source: Maintenance records of Mianhuatan HEP

According to the provided maintenance records, apart from scheduled A Class maintenance, B class maintenance was carried each year after flood season to check if there is any damage to the units.

The given maintenance records show that Mianhuatan station is kept in good order and the site visit confirmed that all plant was in very good working condition.

As far as it was possible to tell, health and safety precautions were taken by the owners and operator and observed by operating and maintenance personnel (hard hats, ear protection, footwear, warning and hazard signs as well as garbage separation and recycling).

At the time of the site visit Unit 4 was currently out of service for class A maintenance. The general work and assembly areas were clean and well lit and working conditions were appropriate.

All other 3 generation units also appeared to be in very good operating condition and the operator confirmed that Mianhuatan did not have any major problems.

Machine hall, generator and turbine floor as well as all other underground floor level (access ways and transformer hall) as well as the above ground GIS arrangement were clean and in good working condition.

A water spray system for automatic fire fighting for the transformers was visible on inspection and is deemed sufficient for this purpose.

The scheme is operated from a control room located in an above ground administration building, overlooking dam and transmission lines.

Access to the SF_6 cable to air bushing and other related 220 kV gas-insulated switchgear equipment (CCVT, CT) was restricted by fencing and warning signs.

4.3.3.3 Power Output

Generation records are shown in Table 4.19 for the period of January 2002 to September 2011.

Table 4.19: Summary of Annual Energy Generation Mianhuatan

Year	Annual Generation	Load Factor	Proportion of Design Generation
	(GWh)		
2002	1,124.4	21%	73%
2003	1,314.7	25%	86%
2004	654.0	12%	43%
2005	1,651.0	31%	108%
2006	1,897.4	36%	124%
2007	1,581.5	30%	103%
2008	1,601.1	30%	105%
2009	1,027.3	20%	67%
2010	1,933.8	37%	126%
2011(1)	499.4	n/a	n/a
Average (2002-2010)	1,420.6	27%	93%

Note 1: Generation data for January to September 2011 available only and hence no load factor or proportion of design has been calculated.

It can be seen from the table above that the load factor for the scheme (percentage of actual generation out of maximum possible generation) has generally been in the region of 20% to 40%, which is expected for this kind of high capacity peaking plant. The records also show that for the period from 2005 onwards the plant has exceeded its design generation every year apart from 2009.

In 2004 and 2009 energy generation was considerably lower compared to the other 8 years available, and this may be linked to the low available water in the Tingjiang River and in Fujian province in general, as low generation outputs for those years have also been noticed for other plants in the region.

On average, the plant has managed to meet its design generation, generating 93% (2002-2010) of its design energy, indicating that the plant is operating as planned.

Table 4.20 shows the average monthly energy generation and Table 4.21 provides the monthly energy figures for a dry and wet year. These tables clearly show that the peak generation period for Mianhuatan HEP is between April and August, with the plant reaching load factors in excess of 30%, i.e. at least 2 out of 4 units operating.

Table 4.20: Average Monthly Energy Generation (2002-2010)

Year	Monthly Generation	Load Factor	Remarks
	(GWh)		
January	57.1	13%	
February	74.8	18%	
March	96.5	22%	
April	157.3	36%	High Generation Period
May	162.3	36%	High Generation Period
June	247.6	57%	High Generation Period
July	172.4	39%	High Generation Period
August	136.3	31%	High Generation Period
September	104.4	24%	
October	60.3	14%	
November	60.4	14%	
December	85.8	19%	
Total	1,415.2	27%	

Table 4.21: Monthly Energy for low generation (2004) and high generation (2006) year Mianhuatan

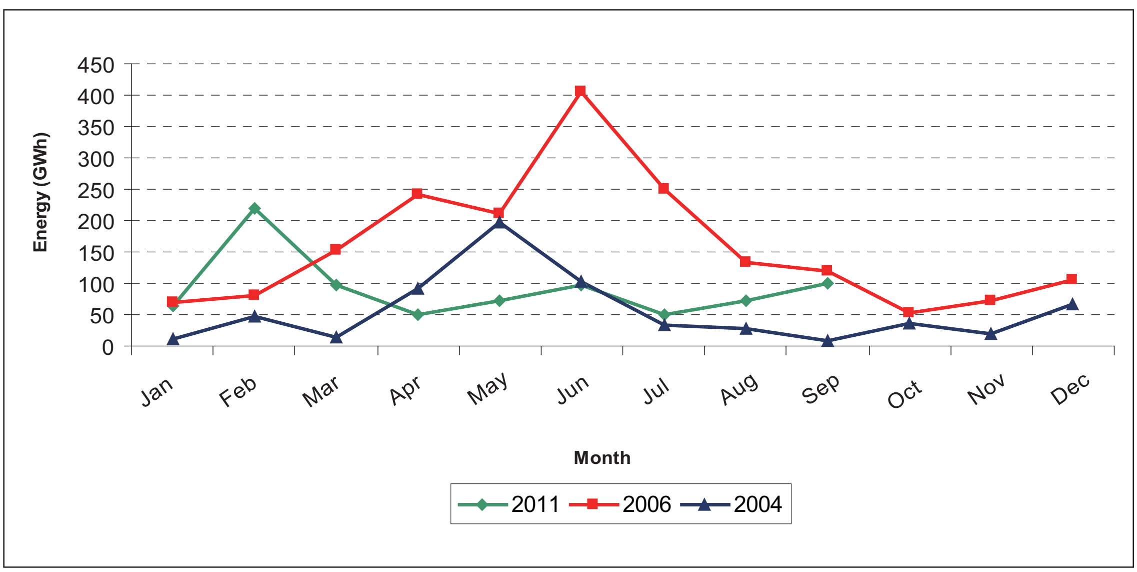
	2004		2006	
Month	Actual Generation	Load Factor	Actual Generation	Load Factor
	(GWh)		(GWh)	
January	9.91	2%	70.6	16%
February	46.8	12%	81.2	20%
March	13.4	3%	152.0	34%
April	91.7	21%	241.7	56%
May	196.3	44%	211.9	47%
June	103.9	24%	406.5	94%
July	34.5	8%	249.7	56%
August	28.7	6%	134.5	30%
September	7.2	2%	120.4	28%
October	34.9	8%	53.2	12%
November	20.5	5%	70.9	16%
December	66.2	15%	104.8	23%
Total	654.0	12%	1,897.4	36%

Table 4.20 and Table 4.21 can also be used to estimate the overall generating output of 2011 based on the given energy generation between January and September 2011. The average output for the first nine months of the year is shown in Table 4.22 and is then also compared graphically with the average, dry and wet year in Figure 4.2 below.

Table 4.22: Summary of Generation in 2011 (January to September) – Mianhuatan

Month	Actual Generation (GWh)	Load Factor	Remarks
January	62.8	14%	
February	219.5	54%	
March	96.6	22%	
April	48.7	11%	
May	71.9	16%	
June	96.6	22%	
July	48.67	11%	
August	71.89	16%	
September	99.87	23%	
Total (from Jan to Sep)	816.53	21%	

Figure 4.2 Monthly Energy Generation (Dry, Average & Wet Year) and 2011



Source: Mianhuatan Site Visit-Energy Generation

From this figure it can be seen that for January to March 2011 Mianhuatan was generating as or above an average year, however, since April generating output has been lower than the energy output of the previously driest year, i.e. 2004. As generating output did not increase during the high generation period, it is likely that Mianhuatan will not meet its design generation.

During our site visit it was confirmed that the current period of low generation output is partly due to a reduced available water and low power demand.

4.3.4 Organization and Staff

According to the staffing program provided by China Huadian Fuxin, a total 49 permanent staffs are employed; this includes 5 management staffs, 19 maintenance staffs and 21 operations staffs and working schedules are arranged in 2 shifts per day for operational staff. No information was provided if temporary staff was employed during unit overhaul or maintenance periods.

4.3.5 Environment

According to the reply on "Fujian Mianhuatan hydropower plant environmental impact report (revised) approval" issued by National Environmental Protection Agency (Huanjian [1995] No. 436), Mianhuatan hydropower project is the fourth cascade hydropower plant in Tingjiang River (five cascade hydropower plants along Tingjiang River basin in total). There is no major environmental constraint for Mianhuatan project and the potential adverse impacts can be mitigated with appropriate measures.

4.3.6 Consents

We reviewed the Power Business Licence issued by State Electricity Regulatory Commission issued to Mianhuatan Hydropower Development Limited Company (1341907-00203) effective from 2007/02/06-2027/02/05.

Mianhuatan Hydropower Plant has obtained hold the approval of water abstraction permit (Number: Shui (Min) [2007] No. 000027)as required, valid until December 31, 2012.

4.3.7 Grid Connection Agreement

MM reviewed the grid connection agreement signed between Fujian Power Limited Company and Fujian Mianhuatan Hydropower Development Limited Company in 2009 (validity period: 2009/06/01-2015/12/31).

4.3.8 Conclusions

Mianhuatan hydropower station is a large-scale peaking power station and has been in operation for approximately ten years. The technology employed in the scheme (unit type, switchgear, batteries etc) is well established and appropriate to current design and considered to be low risk.

We have reviewed general layout drawings and arrangement drawings of powerhouse in addition to our site visit and no concerns have been found.

The project area is not in a seismically active area and it appears no major flood events or landslides have occurred that could have affected the dam and powerhouse. Overall the plant is well maintained and in very good condition.

Analysis of operational records have shown that the plant has missed its annual design generation only once since 2005 and has on average generated 93% of its design generation, which shows that the plant is operating and providing energy as anticipated. It is likely that in 2011 the power plant will miss its design generation partly due to less water available and low power demand.

Generally this scheme is well designed and operating according to expectations and staff appear well trained and competent.

It is recommended that these factors are taken into consideration in any commercial analysis of the scheme.

4.4 Ansha Hydropower Plant

4.4.1 General

The Ansha hydropower plant is located in Sanming, Fujian province and is approximately 50 km from Yong'An town.

Ansha began construction in December 1970 and the reservoir started to store water in September 1975. The first unit came into commercial operation since October in 1975 and the plant was designed to provide continuous power output for the local and regional grid. The plant has a rated output capacity of 115 MW based on a design discharge of 221.2 m^3/s and a rated head of 60 m and has been designed to provide an annual energy of 546.8 GWh based on a 51.3% plant load factor (or 4,500 hours per year).

4.4.2 Project Technical Program Review

4.4.2.1 Geology

According to the preliminarily design of Ansha scheme, the basic rock for hydraulic structures are quartzes conglomerate and sandstone. The seismic intensity is designed as degree 6.

No in-depth study has been undertaken on the geology of the project area. This area is not considered to be seismically active and visual reviews of the structures do not indicate that they have suffered from any adverse movements. The size and nature of the structures involved in hydroelectric projects tend to mean that any adverse ground movements result in cracking of the windows and brickwork of the structures none of this was evident during the site visit. As this station has been in operation since 1975, any ground movements would be noticeable well before now.

Due to the size of the reservoir it was not possible to inspect the reservoir slopes for landslides, however the areas visible from the dam and powerhouse showed no signed of being subjected to sliding.

4.4.2.2 Hydrology

The catchments area for Ansha reservoir is 5,184 km^2, with multi-year average flow of 160 m^3/s and annual runoff of 5.04 billion m^3. The minimum observed flow is 20.7 m^3/s and the largest flood in history is 7,300 m^3/s. The average annual sediment delivery is 0.655 million tons.

4.4.2.3 Design Standards

The RCC dam is defined as Class 2 structure and the design is based on 100 year return flood and checked with 1,000 years return flood.

4.4.2.4 Scheme Layout and Main Structures

The scheme is composed by the dam and sluice way, penstock, surge shaft, powerhouse, switchgear, log transportation facilities, irrigation drawing canal and other permanent structures. Water is provided to the generating units from Ansha Reservoir, which is impounded by a RCC dam. There are 3 spillway gates (clear width 56.0 m for each) and controlled by 4 radial steel gates (13.5 m*14.0 m). The outlet entrance and irrigation flow release gate are arranged in the dam section. There is a small hydropower plant at the bottom of the dam. However, this plant was not part of this review.

The intake arrangement is located on the left abutment with a total length of 300 m. The above ground powerhouse is arranged at the left side of the dam downstream, around 130 m away from the dam. In addition to energy generation, the dam also serves as a flood control mechanism and does regulate the downstream water supply; its salient features are provided in Table 4.23.

Table 4.23: Ansha Dam – Salient Features

	Dam & Reservoir
Dam Type	RCC
Dam Height (m)	92
Crest Length (m)	170
Live Volume (million m^3)	527
Total Volume (million m^3)	740
Catchments Area (km^2)	5,184
Impounds	Sha River

The normal operating water level is at 265 m asl and the bottom water level is given as 244 m asl, allowing for a total drawdown of 21 m.

4.4.2.5 M&E System

The powerhouse contains the generating units, all balance of plant components, lead acid batteries for DC supply, dry-type transformers for step-down for AC station supply as well as relay room, and control and metering equipment.

Power is generated by 3 differently rated vertical Francis-type turbines. All three units have a different rated capacity, with Unit 2 being the smallest with a rated capacity of 20.8 MW. Unit 1 has a rated capacity of 23.0 MW and Unit 3 is the largest unit with a rated capacity of 77.3 MW, resulting in a total rated capacity of 121.5 MW. The centreline of all three units is set to at least 2 m below rated tail water level to avoid unit cavitations and low pressures during load rejection. The salient features of each turbine are summarised in Table 4.24.

Due to its age Unit 1 has been replaced and upgraded in 2007 and we understand that Unit 3 is lined up for replacement in 2012. No fixed date was given for the replacement of Unit 2.

Table 4.24: Ansha Turbines – Salient Features

	1# Turbine	2# Turbine	3# Turbine
Model	HLA835a-LJ-203.4	HL220-LJ-200	HL702-LJ-410
Rated Output (MW)	23.4	20.8	77.3
Rated Head (m)	68.0	64.5	60
Rated Discharge (m^3/s)	38.2	37.0	146
Rated Speed (rpm)	300	300	136.4
Min. operating head (m)	49.3	49.3	49.3
Max. operating head (m)	73.3	73.3	73.3
Runner Setting (m)	-2.4	-2.0	-2.2
Turbine Centreline (m)	188.8	188.8	189
Year of Installation	2007	1975	1975

Source: Ansha site visit – turbine rating plate

Each Francis-type turbine is coupled to a synchronous vertical axis salient-pole generator, located on the generator floor above the turbine. Unit 1 and Unit 2 are generating at the same voltage of 10.5 kV and are connected to common medium voltage busbar. Due to the higher output capacity of unit 3, the generator rated voltage is 13.8 kV and the generator is connected to a separate medium voltage busbar. The salient features of Unit 1 to 3 are given in Table 4.25.

Table 4.25: Ansha Generators – Salient Features

	1# Generator	2# Generator	3# Generator
Model	SF23.3-20/4250	SF425/120-20TH	TS-854/190-44
Rated Capacity (MVA)	26.94	23.13	88.24
Rated Voltage (kV)	10.5	10.5	13.8
Rated Current (A)	1,482	1,270	3,690
Power Factor (-)	0.865	0.865	0.85
Rated Power (MW)	23.3	20.0	75.0
Rated Speed (rpm)	300	300	136.4
Frequency (Hz)	50	50	50
No. of Pole Pairs	10	10	22
Manufacturing Date	Jan 2006	Mar 1978	Dec 1972

Source: Ansha Site Visit – Generator Rating Plate

Voltage step up to the transmission grid voltage of 110 kV is achieved by two separate oil-filled transformers, located above ground level in an outside location next to the powerhouse. The 10.5 kV generator busbar is connected to a 63 MVA transformer while the 13.8 kV busbar is connected to a 120 MVA transformer. The salient features of both transformers are provided in Table 4.26.

Table 4.26: Ansha Step-Up Transformers – Salient Features

	1# Transformer	2# Transformer
Model	SFPS10-J-63000/110	SFPQ10-120000/110
Rated Capacity (MVA)	63	120
Rated Voltage (kV)	121 ± 2x2.5%/10.5	121 ± 2x2.5%/10.5
Cooling	ODAF	ODAF
Connection	YNd11	YNd11

Source: Ansha site Visit-Transformer Rating Plate

4.4.2.6 *Other Facilities*

The two step-up transformers as well as the 110 kV ring busbar for power evacuation are located above ground, separate to the powerhouse. A total of 3 circuits of transmission lines are available for power export from Ansha hydropower station.

An oil storage shed and workshop are also located above ground in near vicinity of the transformers.

The hydropower station includes a site colony for resident staff as well as number of workshop facilities.

4.4.3 *Plant Operation and Maintenance*

4.4.3.1 *Operation and Maintenance of Main Hydraulic Structures*

It is found from the third regular safety inspection report that there was certain water erosion at the apron for tail water of Unit 3. The site staff reported that it has been repaired in December 2009 and closely joint with the bed rock. Ansha dam was developed in 1975, although with certain defects, generally such defects are not likely to threaten the safety of the dam. Ansha dam is ranked as “normal dam” at the third round inspection and satisfied with the current specification.

4.4.3.2 Operation and Maintenance of M&E System

The operational records since beginning of operation in 1975 of Ansha hydropower plant were available for review, however, maintenance records were only provided for the last 4 years of operation and these are given in Table 4.27.

Table 4.27: Scheduled and unscheduled Maintenance Record for Ansha

Year	Unit 1	Unit 2	Unit 3	Unscheduled
2008	–	A	–	
2009	–	–	A	Outage
2010	B	–	–	
2011	–	B	–	

As Unit 1 has been completely replaced in 2007 only one class B maintenance was carried out for this unit. Unit 2 and 3 have both undergone at least one class A maintenance in accordance with Table 4.1 and considering that Unit 3 is planned to be replaced in 2012, it is most likely that the next class A maintenance will not occur before 2013; most likely for Unit 1 (in its 6th year since installation) unless approval is being given to replace Unit 2.

During the undertaken site visit Unit 2 was out of service for class B maintenance. The general work and assembly areas were clean and well lit and working conditions were appropriate. As Unit 2 was over 35 years in service, signs of wear and tear were visible on shaft, turbine cover and other unit parts; this, however, was to be expected. There were no signs of severe damage to runner or guide vane apparatus due to heavy sedimentation, oil spillage from HPU or oil mist on exposed generator parts.

Machine hall, generator and turbine floor were clean and in good working condition considering the age of the station and the fact that maintenance was underway.

Due to the age of the station, lead-acid batteries are used for DC services supply and these are located in a separate ventilated room in the powerhouse. Due to the nature of the batteries, the chargers had to be located in a neighbouring room, but are on the same floor level.

Both oil-filled step-up transformers are located above ground between powerhouse and air-insulated switchyard and are separated by concrete blast walls. A water spray system for automatic fire fighting was visible.

Three decommissioned transformers (two of transformers that were originally commissioned in 1975, as well as one transformer, which had been replaced in 2001 due to underperformance) are stored on the pathway towards the switchyard. It is not clear, why these transformers have not been transported off-site or if they have been drained, however, no visible oil spillage was noted around the decommissioned transformers.

An oil storage room and warehouse are located at the back of the 2nd transformer, but were not inspected.

Access to 110 kV air-insulated switchgear (CCVT, CT) is not restricted by fencing and no warning signs were visible indicating a high-voltage area, but equipment seemed to be in good working out (visual inspection).

Apart from the decommissioned transformers as well as the missing access restrictions to the switchyard, necessary health and safety precautions have been taken by the owner and were observed by operating personnel (hard hats, ear protection, footwear, warning and hazard signs as well as garbage separation and recycling).

4.4.3.3 Power Output

Generation records are shown in Table 4.28 for the period of October 1975 to August 2011. Commercial operation started in October 1975, however, ongoing commissioning for other units may have affected the energy generation during last the 3 months.

Table 4.28: Summary of Annual Energy Generation – Ansha

Year	Annual Generation	Load Factor	Proportion of Design Generation	Year	Annual Generation	Load Factor	Proportion of Design Generation
	(GWh)				(GWh)		
1975[(1)]	15.23	n/a	n/a	1993	551.8	52%	101%
1976	412.6	39%	75%	1994	599.7	56%	110%
1977	466.7	44%	85%	1995	715.0	67%	131%
1978	516.7	49%	94%	1996	562.4	53%	103%
1979	522.5	49%	96%	1997	778.5	73%	142%
1980	525.9	49%	96%	1998	681.8	64%	125%
1981	555.8	52%	102%	1999	586.6	55%	107%
1982	626.8	59%	115%	2000	563.3	53%	103%
1983	609.8	57%	112%	2001	618.6	58%	113%
1984	540.6	51%	99%	2002	560.4	53%	102%
1985	669.5	63%	122%	2003	422.4	40%	77%
1986	549.8	52%	101%	2004	243.5	23%	45%
1987	540.8	51%	99%	2005	505.7	48%	92%
1988	608.3	57%	111%	2006	565.7	53%	103%
1989	467.2	44%	85%	2007	534.0	50%	98%
1990	656.1	62%	120%	2008	486.4	46%	89%
1991	402.9	38%	74%	2009	357.3	34%	65%
1992	693.1	65%	127%	2010	640.2	60%	117%
				2011[(2)]	21.2	n/a	n/a
Average (1976-2010)	552.5	51.9%	101%				

Note 1: Commissioning works in 1975 may have affected generation.

Note 2: Generation data for January to September 2011 available only and hence no load factor or proportion of design energy has been calculated.

It can be seen from the Table 4.28 that the load factor for the scheme has been generally in the region of 40% to 60%, which is expected for this kind of power plant. The records show that since 2000 the plant failed only three times (2003, 2004 and 2009) to provide at least 90% of its design generation.

Especially in year 2004 and 2009 energy generation was considerably lower than for the other 8 years of the decade, and this most likely is linked to the low available water in Shaxi River Basin and Fujian province in general, as low generation outputs for those years have also been noticed for other plants in the region.

On average the plant has managed to exceed its design generation by 1% for the 35 year period from 1976 to 2010, with an average annual energy of 552.5 GWh compared to the design energy of 546.8 GWh. This indicates that the plant is operating as planned.

Table 4.29 shows the average monthly energy generation and Table 4.30 provide the monthly energy figures for a dry and wet year, which shows that the peak generation period for the Ansha power plant is between April and August, with load factors in excess of 50%, i.e. the plants output capacity during those periods is in excess of 60 MW. As the total capacity of unit 1 and 2 is only 43 MW, it is obvious that an outage/overhaul of Unit 3 will have a negative impact on the generation output and revenue at Ansha plant. If Unit 3 is being replaced in dry season of 2012 as scheduled the impact will not be significant.

Table 4.29: Average Monthly Energy Generation (1976-2010)-Ansha

Month	Average Generation (GWh)	Load Factor	Remark
January	23.4	26%	
February	27.9	34%	
March	44.7	49%	
April	66.3	76%	High generation period
May	73.4	81%	High generation period
June	74.5	85%	High generation period
July	66.9	74%	High generation period
August	52.7	58%	High generation period
September	41.5	47%	
October	30.1	33%	
November	27.1	31%	
December	24.1	27%	
Total	552.5	52%	

Table 4.30: Monthly Energy in low Generation (2004) and high Generation (2006) year Ansha

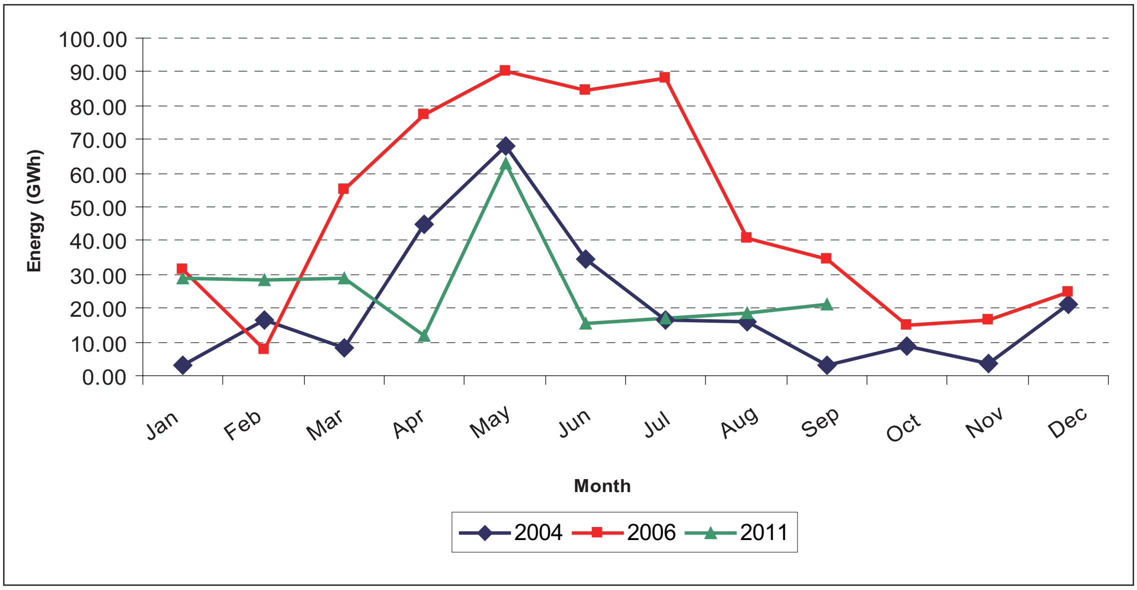
	2004		2006	
Month	Actual Generation	Load Factor	Actual Generation	Load Factor
	(GWh)		(GWh)	
January	3.1	3%	31.2	35%
February	16.4	20%	7.9	10%
March	8.1	9%	55.2	61%
April	44.7	51%	77.2	88%
May	68.0	75%	90.2	100%
June	34.3	39%	84.6	97%
July	16.4	18%	88.1	97%
August	15.9	18%	40.6	45%
September	3.3	4%	34.5	39%
October	8.9	10%	14.9	16%
November	3.4	4%	16.3	19%
December	21.1	23%	25.0	28%

The monthly generating output of Ansha in Table 4.29 and Table 4.30 can be used to estimate the annual generating output for 2011. The monthly output for the first nine months (January to September) is given in Figure 4.3 and is also compared graphically in Table 4.31 below with the monthly output of a dry, wet and average year.

Table 4.31: Summary of Monthly Generation in 2011 (January to September)

Month	Actual Generation	Load Factor	Remarks
	(GWh)		
January	28.8	32%	
February	28.6	35%	
March	28.9	32%	
April	11.7	13%	
May	63.0	70%	
June	15.4	18%	
July	17.2	19%	
August	18.4	20%	
September	21.03	23%	
October	233.03	29%	
November			
December			

Figure 4.3 Monthly Energy Generation (Dry, Average & Wet Year) and 2011



Source: Ansha Site Visit – Generating Output

This figure shows that the generation output of Ansha hydropower plant is in line with the lowest generation on record in 2004 and as such it is expected that 2011 will be another low generation year on a similar level as 2004. Hence, it is most likely that Ansha hydropower plant will not meet its design generation in 2011 due to significantly less inflow than annual average level.

4.4.3.4 Future Works

At Ansha hydropower plant the following works are planned to be carried out over the next years:

- Replacement of Unit 3 – planned for 2012 with an increase in capacity to 85 MW;
- Replacement of Unit 2 – the station has applied for replacement of this unit, but as of the site visit, the approval for this maintenance work was still outstanding;
- Raising of Dam – a feasibility study is currently carried out to investigate the benefits of raising Ansha dam by 10 m-15 m to a dam height of approximately 102 m to 107 m.

The increased net head will result in a higher installed capacity, but this would likely result in upgrading the existing units and generators to adjust the unit rated head.

4.4.4 Organization and Staff

According to the information received from Huadian Fuxin, 22 people are employed at Ansha for reservoir regulation, a total of 80 maintenance personnels, 24 operational staffs and 4 health and safety staffs. Operational staffs are organized in 2 shifts per day. No information was provided if temporary staff was employed during unit overhaul or maintenance periods.

4.4.5 Environment

As Ansha plant was constructed in 1970s, the central government did not have Environmental Impact Assessment (EIA) and EIA acceptance regulations at that moment. There are no special environmental issues, which need further attention during site inspection.

4.4.6 Consents

Ansha HydroPower Plant has applied the water abstraction permit as required. The permit number is Shui (Min) [2007] 000012, valid until December 31, 2012.

4.4.7 Grid Connection Agreement

MM reviewed the grid connection agreement signed between Fujian Power Limited Company, Sanming Power Bureau under Fujian Power Limited Company and Ansha Hydropower Plant in June 30, 2011 (validity period: 2011/07/01-2016/04/30).

4.4.8 Conclusions

Ansha hydropower station is a large season-regulation power station, which is rare in Fujian province and has been in operation for approximately 36 years. Some of the technology employed in the scheme (batteries) is considered old and may require replacement, even though it is not affecting the station capability. Most other equipment either has been replaced or is still up to current design standards (transformers, switchgear). Overall the station equipment is appropriate for operation and considered to be low risk.

We have also briefly reviewed general layout drawings and arrangement drawings of the powerhouse in addition to our site visit and no concerns have been found.

Analysis of operational records has shown that the plant has only missed its annual design generation target three times since 2000 and over the whole operating period of 36 years it has exceeded its design generation by 1%, which shows that the plant is operating and providing energy as anticipated. It is projected that Ansha will miss its design generation in 2011 due to significant less inflow, which also been noted for other plants in the region.

Additionally, the plant is depending mainly on one unit (Unit 3), which provides over 60% of the station capacity. Time-consuming scheduled or unscheduled outages of this unit could have a significant impact on the energy generation potential of the station.

Generally this scheme is operating well and is good working condition considering its age. Operating and maintenance staff appear well trained and competent.

It is recommended that these factors are taken into consideration in any commercial analysis of the scheme.

4.5 Fenghai Hydropower Plant

4.5.1 General

The Fenghai hydropower plant is located in Samning county, Fujian province and is approximately 30 km from Yong'An town.

Fenghai hydropower plant began commercial operation in June 2005 and is a low water head run-of-river type power plant with an installed capacity of 30 MW based on a total of 273.9 m^3/s at a rated head of 9.9 m. The powerhouse is located next to the weir and intake structure. Fenghai hydropower plant is approximately 15 km downstream of Ansha hydropower plant.

The annual design energy production of the plant is given as 135.8 GWh, based on a plant load factor of 51.7% (or 4,525 hours per year).

4.5.2 Project Technical Program Review

4.5.2.1 Geology

According to the early investigation results, the regional structure in the site is simple and stable. In addition, considering the dam size and storage capacity, the possibility to induce earthquake due to the presence of reservoir is very low.

No in-depth study has been undertaken on the geology of the project area. This area is not considered to be seismically active and a visual review of the structures does not indicate that they have suffered from any adverse movements. The size and nature of the structures involved in hydroelectric projects tend to mean that any adverse ground movements result in cracking of the windows and brickwork of the structures none of this was evident during the site visit.

4.5.2.2 Hydrology

The catchment of Fenghai HEP is 5,518 km^2. The average annual runoff is 5.39 billion m^3 and the multi-year average flow is 171 m^3/s.

4.5.2.3 Design Standards

According to GB50201-94 "Flood Control Standards" and DL5180-2003-"Hydropower Project Classification and Safety Design Standards," the project is classified as Grade III based on the size of Fenghai Hydropower Plant. Main structures are designed as Class 3 structures based on 50 years return design flood, checking with 500 years return flood; the water retaining structures at the downstream of power house and access road is designed based on 100 years return flood and checked with 200 years return flood.

It can be confirmed that the original design is in line with standards and current specifications.

4.5.2.4 Scheme Layout and Main Structures

The structures at Fenghai are composed by the weir, spillway gates, intake arrangement, trashrack grappling machine powerhouse and outdoor switchgear yard. The powerhouse is arranged at the left side of the river and the outside switchgear is located at the downstream of the powerhouse. The main drivers for developing the Fenghai hydropower project were to generate continuous electricity for the local grid and industry without playing flood control and water supply functions.

4.5.2.5 M&E System

The powerhouse houses two horizontal bulb-type turbines with an installed capacity of 15 MW each. The centreline of each turbine is set at 166.5 m, approximately 7.5 m below the tail water level. The salient features of each unit are summarised in Table 4.32.

Table 4.32: Fenghai Turbines Salient Features

	Turbines 1 & 2
Turbine Type	Bulb
Model	GZA684-WP-440
Rated Output (MW)	15.0
Rated Head (m)	9.9
Rated Discharge (m^3/s)	136.95
Rated Speed (rpm)	136.4
min. operating head (m)	3.23
max. operating head (m)	14.3
Runner Setting (m)	-7.5
Turbine Centreline (m asl)	166.5
Runner Diameter	4.4 m
Installation Date	2005

Source: Fenghai Site Visit – Generator Rating Plate

Each bulb-type turbine is coupled to a synchronous salient-pole generator, located in the bulb of the turbine enclosure, with a generating voltage is 6.3 kV. The salient features of the generator are given below in Table 4.33.

Table 4.33: Fenghai Generators Salient Features

	Generators 1 & 2
Model	SFG15-44/4590
Rated Capacity (MVA)	16.7
Rated Voltage (kV)	6.3
Rated Current (A)	1,527.4
Power Factor (-)	0.9 (lagging)
Rated Power (MW)	15.0
Rated Speed (rpm)	136.4
Frequency (Hz)	50
No. of Pole Pairs	22
Rated Efficiency (%)	97.3

Source: Fenghai Site Visit – Generator Rating Plate

Both generators are connected a common generator bus and a single three-winding oil-insulated generator step-up transformer located above ground and outside the powerhouse. The transformer steps up the voltage to the transmission grid voltage of 110 kV for power evacuation via a single transmission line. The transformer also has a tertiary winding to 38 kV for direct export to the local grid and consumers. The salient features of the three-winding transformer are provided in Table 4.34.

Table 4.34: Fenghai Step-Up Transformers Salient Features

	Step-Up Transformer
Model	SS9-40000/110
Rated Capacity (MVA)	40.0
Rated Voltage (kV)	121±2x2.5%38.5//6.3
Cooling	ONAN
Connection	YNyn0d11
Manufacturing date	Oct 2004

Source: Fenghai Site Visit – Transformer Rating Plate

4.5.2.6 *Other Facilities*

High voltage switchgear equipment is located outside the main powerhouse in an air insulated switchyard. Additional administrative buildings are also located within the power plant complex.

4.5.3 Plant Operation and Maintenance

4.5.3.1 *Operation and Maintenance of Main Hydraulic Structures*

From the site visit and local inspection of the generating unit and balance of plant, it can be confirmed that the general condition of hydraulic structures are in good condition. The intake is a traditional arrangement to prevent major debris entering the penstock and a trashrack cleaning system is installed to clean the trashrack from any debris caught.

From operation records, Fenghai hydropower plant has experienced two flood seasons from scheme operated to 2008. From site visit and local inspection, the dam, water retaining walls, powerhouse and other hydraulic structures were in good condition. The intake gate, tail water gate, overflow weir, maintenance gate and hoisting equipments seemed operated properly. The spillways consist of 3 radial gates and stop logs. The radial gates were in good condition.

4.5.3.2 *Operation and Maintenance of M&E System*

The operational records since beginning of operation of Fenghai hydropower plant were available for review. The power station has only been in operation for a short time, and upon inspection during the site visit it was confirmed that major mechanical and electrical equipment are generally in good condition.

According to the available operational records and maintenance procedures, provided in Table 4.41, no unscheduled incidents have been reported. In 2010, Unit 1 has undergone a planned class A maintenance outage, which lasted for 95 days. Comparing with Table 4.2, such major plant outages for comparable Francis-type turbines should only last approximately 60 days.

An extended outage period for the first ever major maintenance of a new unit is expected and future outage times are expected to be shorter than 95 days. Additionally minor repairs were carried out on both units in 2011.

Unit 2 was undergoing maintenance during site visit. It was reported that the maintenance would only last for one day to eliminate certain defects. The latest Class A maintenance for Unit 1 and Unit 2 was in 2010 and 2008 respectively.

Table 4.35: Scheduled and unscheduled Maintenance Record for Fenghai

Year	Unit 1	Unit 2
2006	A	–
2007	–	–
2008	–	A
2009	–	–
2010	A (95 days)	–
2011*	–	–

Source: Maintenance plan – Fenghai

The scheme is operated from a control room located in an adjacent ground administration building on the ground floor. Next to the control room is the relay room and motor control centre. The ground floor also houses the VRLA batteries and associated chargers for the DC supply of the power plant.

The operating floor of the powerhouse is spacious and clean and the loading/assembly bay includes a rotor poling station and a generator holding slot for extensive shaft machining and generator repair works.

Access to the bulb turbine floor level is via several stair cases and access to the unit is provided via a small manhole. The operating area around the turbine itself houses the guide vane mechanism and the HPU, both looked in good working order.

The generator step-up transformer was located outside the building, surrounded by a simple fence with sand pits.

As with all other inspected hydropower plants health and safety precautions were been taken by the operator and were observed by operating personnel (hard hats, ear protection, footwear, warning and hazard signs) and storage areas were clean and tidy.

4.5.3.3 Power Output

Generation records are shown in Table 4.36 for the period of June 2005 to September 2011. Even though commercial operation of Unit 1 began in June 2005 so that the generation was lower than other years, and Unit 2 in November 2005. Generation data for January to September 2011 available only and hence no load factor or proportion of design has been calculated.

Table 4.36: Summary of Annual Energy Generation Fenghai

Year	Annual Generation	Load Factor	Proportion of Design Generation
	(GWh)		
2005[1]	23.1	9%	17%
2006	111.4	42%	82%
2007	140.6	53%	104%
2008	130.1	50%	96%
2009	101.4	39%	75%
2010	146.4	56%	108%
2011	67.66	n/a	n/a
Average (2006-2010)	126.0	48%	93%

Note 1: Commissioning works in late 2005 may have affected generation.

It can be seen from the table above that the load factor for the scheme has been generally been above 40% (apart from the year of commissioning), which is expected for this kind of run-of-river plant. The records also show that for the full 5 year period since commissioning (2006 -2010) the plant has achieved on average 93% of its design generation, which shows that plant is generating as expected.

The lowest energy output so far has been recorded in 2009, which has been a dry hydrology year and this has also been noted for the other three plants visited.

Table 4.37 gives the average monthly energy generation, showing that Fenghai power plant has a load factor of at least 50% for two thirds of the year, i.e. more than one unit is operating during this period. Hence, any outage (planned or unplanned) of at least one unit during this period will result in lost energy and revenue.

Table 4.37: Average Monthly Energy Generation Fenghai

Month	Average Generation	Load Factor	Remarks
	(GWh)		
January	7.1	32%	
February	10.4	51%	More than 1 unit in operation
March	9.9	44%	
April	15.0	70%	More than 1 unit in operation
May	11.1	50%	More than 1 unit in operation
June	16.5	76%	More than 1 unit in operation
July	17.2	77%	More than 1 unit in operation
August	14.2	64%	More than 1 unit in operation
September	10.6	49%	
October	5.9	26%	Low generation period, only 1 unit operating
November	6.7	31%	Low generation period, only 1 unit operating
December	5.1	23%	Low generation period, only 1 unit operating
Total	129.6	52%	Low generation period, only 1 unit operating

Source: Generation records – Fenghai site visit

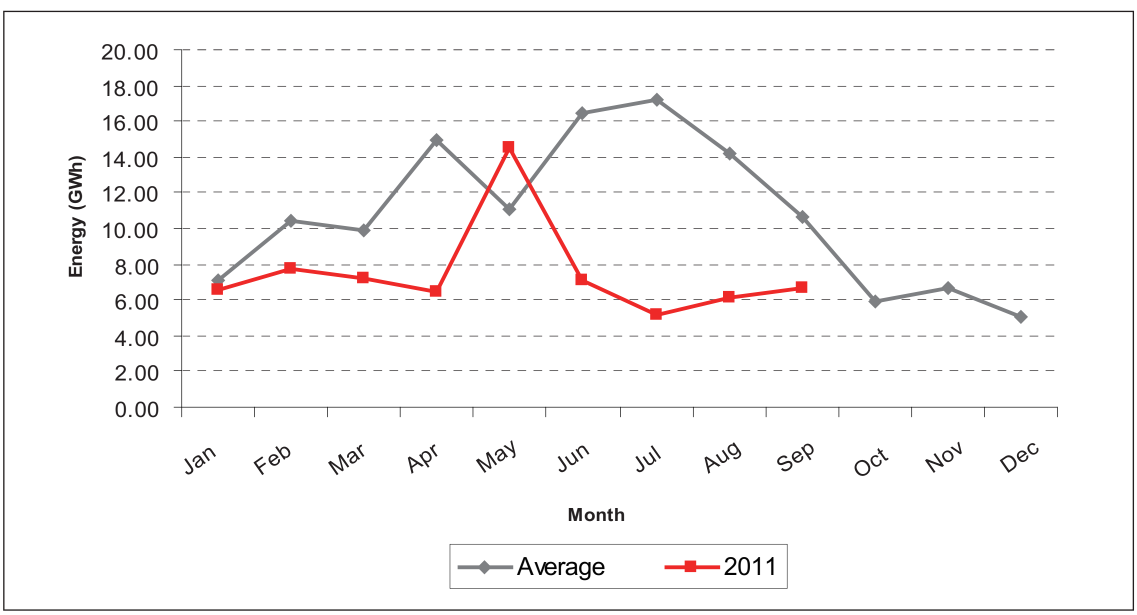
The average generating capacity of Fenghai over the last 5 years can also be used to estimate the overall generating output of 2011, which is given in Table 4.38. Figure 4.4 compares the generation of 2011 with an average generating year at Fenghai Hydropower Plant.

Table 4.38: Summary of Generation in 2011 (January to September) – Fenghai

Month	Actual Generation (GWh)	Load Factor	Remarks
January	6.6	30%	
February	7.7	38%	
March	7.2	32%	
April	6.5	30%	
May	14.5	65%	
June	7.1	33%	
July	5.2	23%	
August	6.15	27%	
September	6.71	30%	
Total (from Jan to Sep)	67.66	34%	

Source: Generation records – Fenghai site visit

Figure 4.4: Monthly Average Generation and 2011



Source: Generation records – Fenghai site visit

Table 4.38 and Figure 4.4 shows clearly that apart from May 2011 energy generation was continuously less than for an average year, with June and July significantly lower, leading to estimate that total energy for 2011 will be on level or less than the lowest annual energy generation so far as only around 50% inflow comparing with the average condition. Furthermore, it should be noted that the average year is only based on 5 full years worth of data, so the statistical value of this average energy figure is limited.

4.5.4 Organization and Staff

According to the staffing program provided by Huadian Fuxin, a total of 40 people are employed at Fenghai hydropower plant, and these include 6 administrative managerial staffs, 8 permanent maintenance staffs and approximately 25 operational staffs. We have been told that operational staff is working in 5 shifts per day, which results in shorts shifts of approximately 4.5 hours. No information was provided if temporary staff was employed during unit overhaul or maintenance periods.

4.5.5 Environment

The upstream is well covered by vegetation. No signs of soil erosion have been found during site visit.

4.5.6 Consents

The permit of process water demand of power plant has not been obtained yet. It was told that the plant is applying for water abstraction permit.

4.5.7 Grid Connection Agreement

Yongan Fenghai Hydropower Plant has signed a long term grid connection agreement with Fujian Sanning Power Bureau on March 1, 2005 and purchase agreement with Yonga Power Supply Bureau on April 30, 2011. The agreement will be indefinitely extended if no objection.

4.5.8 Conclusions

Fenghai hydropower station is a small-scale run-of-river power station and has been in operation for just over five years. The technology employed in the scheme (unit type, switchgear, batteries, etc) is well established and appropriate to current design standards and considered to be low risk.

We have reviewed general layout drawings and arrangement drawings of power house in addition to our site visit and no concerns have been found.

There appears to be no seismic activity at the powerhouse location and no major flood events or landslides have occurred that could have affected the dam and powerhouse. Both the dam and powerhouse are well maintained and in good condition.

Analysis of operational records has shown that the plant is operating very close to its design generation, which shows that the plant is providing energy as anticipated. It is, however, likely that in 2011 the energy output of the power plant will be significantly lower than its design generation possibly as only around 50% inflow comparing with the average condition.

Generally, this scheme is well designed and operating according to expectations. Operating and maintenance staff appears well trained and competent.

It is recommended that these factors are taken into consideration in any commercial analysis of the scheme.

4.6 Qinshan Hydropower Plant

4.6.1 General

Qinshan hydropower plant is located in the Muyang River, which is a tributary of Jiao River, Zhouning, Fujian province, it is the first cascade hydropower plant of Muyang river cascade development, where is approximately 32 km from Zhouning.

Qianshan plant is a hybrid type power station; the catchments area above dam site is 453 km^2. The main structures of Qinshan plant is consisted of a dam, spillway gates, intake arrangement, above ground powerhouse and switch yard etc. The crest height of the concrete faced rock filled dam is 120 m with crest length of 259.8 m; the normal water level is 755 m with a total storage volume of 265 million m^3; it is a multi-year regulation reservoir. The design energy generation of the plant is 145 GWh based on the rated capacity of the plant is 70 MW.

Qinshan hydropower plant started construction in May 1997 and the first unit entered into commercial generation in December 1999. All of the construction were completed in March 2000, mainly plays the function of grid peak regulation and reservation in Fujian province.

According to Muyang River hydropower planning, there are three cascade developments in Muyang River, i.e. Qinshan, Zhouning and Hedong cascade hydropower stations. Qinshan reservoir can serve several purposes simultaneously, including energy generation and flood control.

The normal operating water level of reservoir is 755 m asl and the bottom water level is given as 707 m asl. The multi-years regulating reservoir has a live capacity of 195 million m^3. Plant headrace tunnel is 857.5 m long; the penstock length is 317 m. The plant installed two Francis-type turbines with the rated capacity of 35 MW for each set based on the rated water head of 95 m and maximum rated discharge flow of 82.4 m^3/s. The firm capacity is 17 MW, and the design average generation is 145 GWh based on operation hours of 2,071 h per year with design load factor of 25%.

4.6.2 Project Technical Program Review

4.6.2.1 Hydrology

Hydrological design of the plant is mainly based on data series of Qibu Hydrological Station from 1959-1988. The catchment area is 453 km^2 and the average annual flow is deduced to be 18 m^3/s. The dam is designed based on 100-year return flood peak flow of 3,310 m^3/s (design condition) and 2,000-year return flood peak flow of 5,330 m^3/s (check condition) according to the calculations on flood at dam toe.

It can be confirmed that the methods of calculating hydrologic analysis and calculation results used in Qinshan power plant are generally reasonable.

4.6.2.2 Geology

No in-depth study has been undertaken on the geology of the project area. From the results of feasibility, no regional faults are known in this area, geotechtronic activities in this area are weak; non-destructive earthquake has been recorded in history within the range of 200 km. According to "Seismic Ground Motion Parameter Zoning Map of China," the basic seismic intensity of the project area is VI degree. Dam foundation rocks are mainly rhyolitic crystal tuff, hard rocks, and it is complete with high bearing capacity and low permeability coefficient, dam abutment is stable, engineering geology and hydro-geological conditions are good without significant problem of dam foundation leakage or seepage around dam. Hydraulic design and treatment process are relatively easy. Generally, the design can meet with relevant requirements.

From the literature review, it was told that the main engineering geological problems have been identified through geological investigation at early stage. The geological conditions are good and the engineering program is reasonable and feasible.

4.6.2.3 Design Standards

The installed capacity of Qinshan power plant is 70 MW, the total storage capacity of reservoir is 265 million m^3. According to national power industry standard DL5180-2003 "Hydropower Project Classification and Design Safety Standards," the scheme is classified as Grade 2 project based on the storage capacity of the reservoir. The dam is concrete faced rock filled type and higher than 90 m, therefore the water-retaining dam is designed as Class 1 structures and the spillway is designed as Class 2 structure. The powerhouse is Class 3 structure.

The dam and spillway of the plant are designed based on 100-year return flood, and checked by 2,000-year return flood standard. Powerhouse is designed as 50-year return flood standard, checked with 200-year return flood standard. According to "Seismic Ground Motion Parameter Zonation Map of China," the basic seismic intensity of the project area is VI degree. As the dam is defined as Class 1 structure, the intensity of the earthquake resistance of the main structures are degree 7 as required by the relevant specifications.

It can be confirmed that the design standards of the plant are in line with the requirement of the relevant specifications for hydropower projects.

4.6.2.4 Scheme Layout and Main Structures

The main structures are comprised of a concrete faced rock filled dam, left shore spillway, intake arrangement, above ground powerhouse and switchgear yard etc.

The crest height of the concrete faced rock filled dam is 120.00 m with the crest length of 259.80 m, and the crest width of 9.00 m.

Spillway is arranged on the bank and locate in the left bank and is comprise of diversion canal section, chamber section, chute section and ogee section of spillway, total length is 350 m with max discharge capacity of 3,315 m^3/s. The spillway crest height is 742.00 m ASL with two 12 m*13 m (height*width) radial steel gates.

Intake arrangement include intake structure, diversion tunnel, surge chamber and penstock. The full length is 1,192.90 m. The shaft-type intake structure is at left bank and 220 m away from upstream of the dam axis. Diversion tunnel is 782.792 m long, diameter is 6.5 m; surge shaft is impedance with a internal diameter of 11 m; the penstock length is 315.407 m.

The powerhouse (size: 46.2 m×16.4 m×36.76 m) is arranged above ground, two generation units (HL-LJ-224.5) are installed in the powerhouse with the capacity of 35 MW each.

4.6.2.5 M&E System

M&E equipments are mainly consisted of turbine, governor, main valves, generators, excitation, the main step-up transformer, relay protection, communication and control equipments. The equipments installed are reasonable, and the equipments are good, safe and secure.

(1) Turbine

The vertical shaft Francis turbine (HL-LJ-224.5) was manufactured by Hangfa Power Equipment Limited Company, the salient features are given in table 4.39.

Table 4.39: Qinshan turbine-Salient features

	Hydro turbine
turbine type	HL-LJ-224.5
rated power (kW)	36,100
max/design/min water head (m)	121.5/95/70
rated discharge (m^3/s)	41.2
rated speed (rpm)	333.3
runaway speed (rpm)	650
runner setting (m)	-2.6
runner diameter (mm)	2245

(2) Generator

The SF-J35-18/4840 generator was supplied by Hangfa Power Equipment Limited Company. Salient features are given in table 4.40.

Table 4.40: Qinshan Generator – Salient features

	Generator
model	SF-J35-18/4840
output (kW)	35,000
stator voltage (kV)	10.5
stator current (A)	2,264
excitation voltage (V)	250
excitation current (A)	670
power factor	0.85
rated speed (rpm)	333.3
stator connection	Y
insulation grade	F/F

(3) Main Transformer

The model is SFP10-90000/220, the capacity is 90,000 KVA, made by Baoding Tianwei Ground Co., Ltd, its salient features are given in table 4.41. The 220 kV outdoor switchyard lies on the left side of the access road. The capacity of unit 1&2 is 35 MW respectively, connecting to 10.5 kV busbar. The voltage steps up to 220 kV and the high voltage side of the main transformer is connected to Zhouning substation, then to Fujian grid via ZhouGan line.

Table 4.41: Qinshan step-up transformer – Salient features

Item	
model	SFP10-90000/220
capacity	90,000 KVA
rated voltage (kV)	242±2×2.5%/121/10.5
frequency	50 Hz
join group	Ynd11
cooling	Forced-oil circulating wind cooling (ODAF)
manufacturer	Baoding Tianwei Limited Company
grounding	Direct grounding

4.6.3 Operation and Maintenance

4.6.3.1 Operation and Maintenance for Main Hydraulic Structures

Based on the inspection reports and site visits of plant operation, maintenance records, and safety assessment, regular inspection of hydraulic structures in recent years, the dam level and design flood can satisfy the standard requirements. Spillway capacity and structural stability can meet the design requirements; the slope of dam and reservoir near dam is stable; the dam foundation seepage is stable, impervious affection is good; downstream river bed of dam scour slightly; spillway gates and hoist operate normally; dam deformation and seepage observation results are normal overall; operation and maintenance conditions of hydraulic structures are summarized below:

(1) Reservoir

Vegetation cover of Qinshan reservoir basin is good, there are no major towns upstream, reservoir sediment and dirt are less, soil erosion is small; there have no large collapse and landslides since it has been built.

The highest water level of reservoir is 755.28 m (2005 June), the lowest water level is 707.44 m (2000 April), the water level drawdowns in the range of 9.46 m to 46.42 m over years. The multi-year average water level is 735.19 m asl. Reservoir has experienced a large flood since operation, which nearly three days flood volume of 100-year return flood.

From the site survey, the bank near to the intake and the gate is in good condition despite the water level variation.

(2) Dam and Spillway

Qinshan dam is operating well since storage, no big defects that will affect the safe of major buildings have been found. Spillway slope is in stable condition from the visual inspection during site visit. All of diversion canal, chamber, chute and energy dissipater operate well. No unfavorable flow pattern was found during largest flood flow of 500 m^3/s in 2005 and 2006. The slope is stable, no collapse and landslide occurred in downstream scouring hole and the banks around the river. All of the water retaining structures, discharge structures, water diversion structures include the front tunnel, head, bifurcated pipe, powerhouse and watertail buildings were defined as class A facilities.

(3) Metal Structure

Since plant has put into operation, gates hoist equipments in good condition; seal effection of gate is good; electrical, control and protection devices operate normally and can ensure the safety operation of the project in general.

4.6.3.2 Operation and Maintenance of Main Equipments

The plant has been in operation for more than 10 years. The M&E configuration is appropriate and in good condition. Parts of electrical equipments have been upgraded due to the aging of electronic components, mainly including excitation systems of unit 1 and 2. The original LTW6200 excitation regulator, demagnetizer, power cabinet 1 and 2 were replaced by NARI's NES5100 type excitation panel respectively in October and April of 2009. Currently the computer monitoring system is ready to be upgraded and scheduled in December 2011-January 2012.

(1) Maintenance

Table 4.42 below shows the maintenance records from 2000 to 2011, since it put into operation in December 1999. The records indicates that the equipments operate as scheduled to ensure the equipments are all in safe and good working conditions.

Table 4.42: Maintenance and Technical Upgrade Record for Qinshan

Year	Unit 1	Unit 2
2000	C (2000.8.4~8.8)	C (2000.8.6~8.11)
2001	C (2001.3.5~3.10)	C (2001.2.26~3.3)
	A (2001.10.9~11.24)	
2002	N/A	A (2002.2.28~4.27)
2003	A (2003.2.19~4.21)	C (2003.12.26~12.28)
	C (2003.12.20~12.24)	
2004	C (2004.5.17~ 5.21)	C (2004.5.23-2004.5.27)
2005	C (2005.3.22~3.26)	C (2005.3.27-2005.3.31)
2006	C (2006.3.22~3.26)	C (2006.3.28-3.31)
2007	C (2007.3.12~2007.3.19)	A (2007.10.12~2007.12.01)
2008	C (2008.3.28~2008.4.2)	C (2008.9.23~2008.9.28)
	A (2008.10.6~2008.12.4)	
2009	C (2009.10.14~10.25)	C (2009.4.10~4.15)
2010	C (2010.10.23-2010.10.29)	C (2010.3.14~3.20)
2011	N/A	C (2011.3.7~2011.3.13)

The inspection of the operation of the equipments, maintenance records and safety inspection reports in recent years and the on-site survey show that major equipments and the balances operated well and have been in safety production to 4,117 days by September 30, 2011.

4.6.3.3 Annual Power Output

Both of two units are all into operation in January 2000. The power output records since it commercial operation is given below:

Table 4.43: Qinshan power generation

Year	Annual power output ('0000 kWh)
2000	11,259
2001	12,782
2002	12,200
2003	8,671
2004	4,704
2005	20,008
2006	17,111
2007	11,262
2008	12,090
2009	11,524
2010	15,970
Annual average	12,507.42(1)
	13,287.7(2)

Note 1: Power generation in 2004 was included in the calculation;

Note 2: Power generation in 2004 was excluded in the calculation.

It can been seen from the table above that the average power output in the recent 10 years is 125.07 GWh, which is 19.93 GWh less than design generation with a difference of 13.7%. Power generation in 2004 was significantly lower than average level since Zhouning hydropower Plant at downstream with installed capacity of 250 MW was under construction during that time so that Qinshan plant almost has been outage to store water in 2004. Energy generation in 2003 was also lower than average level. It was told that 2003 was dry year when the average inflow was only 8.2 m^3/s. However, we considered that it cannot fully explain the reason. Excluding 2004, the average annual power generation during 2000-2010 was 132.88 GWh, which has generated 91% of its design average generation, indicating that the plant operates well as expected.

4.6.4 Organization and Staff

The operation and maintenance department is in charge of production, including 36 employees, who are divided into two operating teams and a maintenance team. It is managed by a director, two deputy directors and one technical staff. There are also a safety inspector and hydraulic maintenance department. Temporary staffs are employed to guard the dam.

4.6.5 Environment

On-site observations indicated that vegetation of project area covered well and do no have significant adverse environmental concerns that will effect the project area environment.

During the site visit, it was found that there was an around 1.5 km long river section with little water in the downstream of the river. According to requirements from environmental protection departments, it should discharge certain ecological flows, generally 10% of average annual flow to ensure ecological water use. It is suggested that the operators of the plant pay attention to this issue and propose appropriate measures.

4.6.6 Consents

According to current state regulations, hydropower companies should apply for water abstraction permits. Qinshan power plant water abstraction permit number is (Min) [2007] 000024, valid until December 31, 2012 and is required to renewal every four years.

4.6.7 Grid Connection Agreement

Qinshan power plant in Fujian Power Company also signed a “grid connection agreement” (valid until December 31, 2025) and “power purchase agreement” (valid until December 31, 2014).

4.6.8 Conclusions

Through the site survey and desktop review, we propose following conclusions:

The technical arrangements employed by the scheme are well established.

It is confirmed that the dam engineering level and flood control design were well designed. Both of the spillway capacity and structural stability comply with the current design requirement. The slope near the dam and powerhouse is stable; the dam foundation seepage is stable with good impervious effection. There is slight scour in the river bed in the downstream of the dam; spillway gates and hoist operate well; dam deformation and seepage observation results show good condition overall.

The inspection of the operation of the M&E equipments, maintenance records, and the safety assessment reports and the on-site check show they operate as planned and executed accordingly. Two units are put into commercial operation in March 2000, running just over 10 years, the main equipments are in good working condition, have not been upgraded. The main and auxiliary equipments operate well and has accumulated safety production to 4,117 days by September 30, 2011.

Qinshan plant has almost been outage due to the construction of Zhouning hydropower plant in the downstream. Excluding 2004, the average annual power generation during 2000-2010 was 132.88 GWh, which has generated on average up to 91% of its design generation. It can be confirmed that the plant operates well as expected.

No significant environmental issues were identified during site visit. It is suggested that the plant shall pay attention to the drying section in the downstream of the river, and take appropriate measures as the environmental protection requirements.

4.7 Gutianxi Second Cascade Hydropower Plant

4.7.1 General

Gutianxi is the second hydropower plant in a cascade of four plants in total located along the Gutian River in Longting Town, Gutian County in Fujian province. The Gutian River is a tributary of the Minjiang River. Gutian Hydropower Plant is a hybrid type power plant with installed capacity of 130 MW (2 units) based on a max discharge flow 150 m^3/s, firm output 46.3 MW at rated head of 115 m as peaking power station.

The annual design energy production of the plant is 478 GWh, based on 3,680 operation hours per year.

The normal water level is at 254 m asl and the minimum operating level is given as 245 m asl, allowing for a total drawdown of 9 m and providing a useable live storage of 7.5 million m^3 with daily regulation function.

The construction started in July 1958 and wholly completed in 1973.

4.7.2 Project Technical Program Review

4.7.2.1 Hydrology

The design of the project is based on the hydrological series from 1936 to 1957. The catchments are 1,520 km^2 with average annual flow of 56.3 m^3/s. Gutianxi First Cascade could control more than 85% of catchments of the project. The original hydrological results were checked with the data series from 1950 to 2009 (average annual flow is 44.3 m^3/s) and data from Gutianxi First Cascade plant and found that the average annual flow is about 50.8 m^3/s, 10% less than the original design flow, which shows that the original design flow is obviously larger than actual situation. It is probably because of the upstream dam, regulating the flow along the cascade and limited data availability for the original design.

Considering the original design inflow was larger than actual situation and the regulating function of the first cascade reservoir, the plant has checked the original design annual production. According to "Energy checking report for Gutianxi second cascade HEP," the checked annual energy generation is 353 GWh which is similar with the actual annual generation (345.8 GWh, from 1970-2010).

The reservoir of first cascade power plant can regulate the water availability for the plants in the downstream. With first cascade power plant regulating the flood, the 100-year return flood for the dam of second cascade power plant is 3,317 m^3/s (design condition) and 1,000-year return flood is 4,385 m^3/s (check condition). Our results showed that the design for food control is reasonable.

4.7.2.2 Regional Geology

No in-depth study has been undertaken on the geology of the project area during site visit. From the feasibility report and regular inspection report, it was told that the scheme is located in the north section of Pingnan-Meilin faulting belt, where is a relatively stable area. The seismic intensity is VI degree. The regional Lithological character is simple with low permeability and the reservoir is far away from the adjacent watershed so leakage at the bottom and seepage around the dam is unlikely.

It can be told that the major geological issues have been identified during the early geological investigation before construction. The geological condition is suitable for this project and appropriate engineering measures have been taken during construction. The plant has been operating almost 40 years and no evidence showed that the scheme has suffered adverse movement. Major structures are in good condition.

4.7.2.3 Design Standards

According to the national power industry standard DL5180-2003 – "Hydropower Project Classification and Safety Design Standards," the project is classified as grade 3 based on its size. The major structures, dam and powerhouse is designed as class 3 structures and others are designed as class 4 structures. The flood control frequency for the dam is 100 years return and verified with 1000 years return. The powerhouse is designed in accordance with 50 years return flood and verified with 200 years return flood. Reference to "China Earthquake Zoning Map," the main structures of the scheme is designed in line with 6 degree.

It can be confirmed that the original design is in line with standards and current relevant specifications.

4.7.2.4 Scheme Layout and Main Structures

The second cascade plant is a run of the river type power station. Main hydraulic structures include RC flat dam, intake, pressure tunnel, surge shaft, powerhouse above ground and step up transformer and switchyard.

The dam is consisted with two sections of flat slab buttress dam section (24 segments with 7.5 length for each) and gravity section (2 segments). The overflow spillway is arranged at the middle of dam with a maximum discharge capacity of 3,300 m^3/s. Salient features of the dam are provided in Table 4.44.

Table 4.44: Gutianxi Second cascade Dam – Salient Features

	Reservoir
Dam Type	Reinforced concrete flat-slab buttress dam
Dam Height (m)	43.5
Crest Length (m)	208.5
Crest Width (m)	2
Live Volume (million m^3)	13.45
Total Volume (million m^3)	18.85
Catchment Area (km^2)	1551

Source: Site visit

4.7.2.5 M&E System

The powerhouse contains turbines, governors, valves, generators, excitation, step-up transformers, protection system, communication system, control system and all the balance of the plant. Most of the original facilities have been replaced since 2003 and the current facilities are in good condition.

Turbine

The vertical shaft Francis turbine (HLA398-LJ-320) is provided by Haerbin Electrical Limited Company. The salient features of the turbine are summarized in the table below.

Table 4.45: Gutian Turbines – Salient Features

	Hydro turbine
Turbine Type	HLA398-LJ-320
Rated power (kW)	68,000
Rated Head (m)	115
Rated Discharge (m^3/s)	75
Rated Speed (rpm)	214
Runaway Speed (rpm)	410
Number of vanes	17
Runner Setting (m)	+0.5
Runner Diameter (mm)	3200
Guide Vane Height (mm)	740

Source: operation procedure

Generator

The generator (SF65-28/6400) is made by Harbin Electrical Limited Company. The salient features of the turbine are summarized in the table below.

Table 4.46: Gutianxi Generators – Salient Features

	Generator
Manufacturer	SF65-28/6400
Output (kW)	65,000
Stator Voltage (kV)	10.5
Stator Current (A)	3971
Excitation Voltage (V)	166
Excitation Current (A)	1245
Power Factor	0.9
Stator connection	2Y
Insulation Grade	F/F

Source: Operation procedure

Governor

The governor is stepping oil free programmable microcomputer type (BWT-PLC-100) and managed by programmable controller. The salient features of the governor are provided in the Table 4.47.

Table 4.47: Gutianxi Generators – Salient Features

	Governor
Manufacturer	BWT-PLC-100
Frequency measurement	Residual voltage frequency measure
Piston Diameter of Main Distribution Valve (mm)	100
Max Oil Pressure (MPa)	2.5
Emergency stop time (s)	1#: 13.4 2#: 13.1

Source: Operation procedure

Step-up Transformer

1# step up transformer (ODFS10-150000/220) with capacity of 150 MVA operated since August 2004, which was supplied by Zhongshan ABB; 2# step up transformer (SFPS10-X-180000/220) with capacity of 180,000 kVA operated since January 25, 2003, supplied by Changzhou Transformer Plant. The salient features of step transformers are summarized in the table below.

The medium voltage 110 kV side of 1# and 2# main transformers are connected to bus bar I and II, the energy is transmitted to Chengguan substation via Tiancheng line. The high voltage 220 kV side is connected to bus bar I and II, energy is transmitted to Beijiao substation and Yangzhen substation via Gubei line and Guyang line. In addition, all of the energy generated by generators of the First, Third and Fourth cascade hydropower stations is transmitted to the 110 kV bus bar I and II of transformers of Second cascade hydropower station via 110 kV Lianyi line, Lianer line and Liansan line. Then energy can be transmitted via two 220 kV transmission lines after step up by 1# and 2# main transformers or one 110 kV transmission line.

Table 4.48: Gutianxi second cascade Step-up Transformers – Salient Features

Item	1# Transformer	2# Transformer
Type	OSPS1O-150000/220 (150,000 KVA)	OSFPS10-X-180000/220 (180,000 KVA)
Rated Capacity MVA	150	180
Rated Voltage kV	242±2×2.5%/121/10.5	(242±2×2.5%)/121/10.5
Rated Current A	357.9/715.7/4123.8	429.4/858.9/4949
Connection	YN,a0,d11	YN,a0,d11
Cooling	ONAN/ONAF	ODAF
Phases	3	3
Frequency	50	50
Operation Date	Aug 2004	Jan 2003
Manufacturer	Zhongshan ABB Transformer Limited Company	Changzhou Transformer Plant
Remarks		Combined by three single-phase three-winding transformers

Source: Operation procedure

4.7.3 Plant Operation and Maintenance

4.7.3.1 Operation and Maintenance of Hydraulic Structures

MM has reviewed the relevant operation and maintenance records, safety assessment and regular safety inspection report. The dam has been largely reinforced during 2003 to 2005 and its design is consistent with current requirements. The dam foundation is in good condition. The dam is in line with existing norms in terms of stability and structural safety. The dam safety monitoring results show that the overall performance of the dam is good; adjacent area, bank and slope are stable. Gutianxi second cascade dam is evaluated as Normal dam.

Operation Performance

Except for some special maintenance of dam that need to drainage below dead water level, the dam has been operated as design for many years and did not have any abnormal conditions. From the site visit and local inspection, it can be confirmed that the general condition of the dam is good.

Dam Safety Monitoring

Vertical displacement, horizontal displacement, uplift pressure and seepage are monitored. It can be told from the monitoring records that the dam is mainly affected by temperature, hydraulic pressure and service time. No significant issues on uplift pressure and seepage have been found and the Gutianxi Second cascade dam is under normal state from the monitoring records.

Dam Reinforcement

Considering the shock strength of stiff grider is not very good and local anti-cracking performance of the slab and aging problem, the dam was reinforced in April 2005 and the reinforcement works received completion acceptance in October 2005.

It was told that the engineering measures were taken to reinforce. After reinforcement, the dam should meet with the existing specification.

4.7.3.2 *Operation and Maintenance of M&E System*

It was told that most of the M&E equipments were replaced since 2003, including generation units, step-up transformers, protection system, monitoring system etc. From site inspection, the equipments are operated well. The machine hall, generator and turbine floor were clean and in good working condition. No signs of oil leakage were found during site visit.

Unit Maintenance

The table below indicated the maintenance records since 2003. From the records, the maintenance works have been conducted as schedule to ensure the facilities in good condition.

Table 4.49: M&E maintenance and upgrading records

Year	Unit 1	Unit 2
2003	A (2003.12.8~2004.9.25) Technical upgrading 2004.7.14~2004.8.22,1# step up transformer replacement (including the protection system)	2003.1.3~2003.1.25,2# step up transformer replacement
2004		A (2004.9.28~2005.9.20) Unit replacement
2005		
2006	C (2006.1.12~2006.1.21)	C (2006.4.6~2006.4.13)
2007	B (2007.3.8~2007.4.30)	C (2007.1.24~2007.2.1)
2008	C (2008.1.8~2008.1.19)	B (2008.3.1~2008.4.23)
2009	C (2009.1.9~2009.1.18)	C (2009.2.14~2009.2.23) C (2009.9.16~2009.9.25)
2010	C (2010.1.5~2010.1.13)	C (2010.1.23~2010.1.31)
2011	A (2011.2.25~2011.5.14) Class A maintenance and monitoring system upgrading and 621 switchgear maintenance	A (2010.11.23~2011.2.22) Class A maintenance, guide vane require, 622 switchgear upgrading; monitoring system monitoring; install SF_6 warning system

Safety Review

In order to ensure safety operation, the plant carried out safety evaluation each year. Mott Macdonald reviewed the Safety Report in 2011 prepared by the project company, containing safety management, turbine, primary electric, secondary electric, computer monitoring and automation system, hydraulic and labor safety. In general, the equipments are in good condition. Maintenance and testing were conducted periodically and managed well.

Technical Upgrading for Units

Gutianxi second cascade power plant has been operated since March 1969 and the generation units were aging with times. Therefore, the plant has repaired the turbine ring, scroll, tail water pipes to ensure the runner settings consistent with the original units and most of other parts were replaced and upgraded, including the runners (replaced by HL A398-LJ-320), renovation of tail water pipes; main valve and expansion joints etc. The generators were also upgraded, including stator, rotor, upper and lower racks, brake system and jacking rotor; the new WT-S-100 microcomputer based governor is used.

From operation records that turbine efficiency has been greatly improved and problems of cavitations and vibration have been eliminated so that the units operation is more stable and reliable.

4.7.3.3 Power Output

Generation records are shown in Table 4.50 for the period of 1974 to 2010.

Table 4.50: Power generation from 1974-2010

Year	Annual Generation	Year	Annual Generation
	('0000 kWh)		('0000 kWh)
1974	40,592.8	1993	34,068.0
1975	44,768.8	1994	26,661.0
1976	33,822.6	1996	30,410.0
1977	35,772.9	1997	38,600.0
1978	39,340.1	1998	49,970.0
1979	32,452.9	1999	37,547.0
1980	26,086.7	1995	39,675.5
1981	32,455.5	2000	39,484.0
1982	27,063.7	2001	37,327.0
1983	33,289.9	2002	34,851.0
1984	29,479.0	2003	32,201.0
1985	30,926.1	2004	20,721.0
1986	28,206.1	2005	44,554.0
1987	24,240.9	2006	49,844.8
1988	36,824.8	2007	36,347.4
1989	30,834.0	2008	36,592.4
1990	29,032.1	2009	29,508.5
1991	28,625.9	2010	52,390.4
1992	38,362.9		
Average annual generation	34,944		

It can be seen from annual generation data in the last 37 years (see Table 4.50) that the actual average annual generation is 350 Gwh, which is lower than expected 478 Gwh of design. MM reviewed the inflow data and found that the average inflow is 48.8 m^3/s (from 1986-2010) which shows the inflow in recent 25 years is less than average level. It is an important factor affecting the actual generation. In addition, it is reported from Huadian Fuxin that the capacity of penstock is lower than designed and the reservoir storage also became smaller due to sediments over years, which also result in the actual generation can't meet the original expectation.

4.7.4 Environment

As Gutianxi second cascade plant started construction in 1958, the central government did not have EIA and EIA acceptance regulations at that moment. From site inspection, the vegetation is well covered and there are no adverse factors related to the scheme.

The plant is run-of-river type and there is a 6 km long dry river reach in the downstream. The plant shall release certain environmental flow, generally 10% of average annual flow, as required by the Environment agency. It is recommended that the plant shall take relevant measures and pay attention to the environmental flow issue.

4.7.5 Organization and Staff

Gutianxi second cascade power plant (all of the four cascade plants) employed 10 operations staffs, 15 maintenance staffs for the second cascade plant and 2 safety inspection staffs for the safety of four cascades plants. 1 operation director, 1 deputy director and 1 director assistant are arranged to manage the operation of there four cascade plants.

4.7.6 Consents

Hydropower plant shall apply the water abstraction license according to the relevant regulations. Gutianxi Second cascade power plant has obtained the abstraction license (Min [2007] 000030, expired on December 31, 2012). It is required to renewal the license every four years.

4.7.7 Grid Connection Agreement

Gutianxi plant has signed grid connection agreement with Fujian Power Limited Company (expired on December 31, 2015) and power purchase agreement (expired on December 31, 2014).

4.7.8 Conclusions

Gutianxi Second cascade plant has been in operation for more than 40 years. Overall, the technology employed in the scheme is appropriate to the current design.

The dam has been largely reinforced during 2003 to 2005 and its design is consistent with current requirements. The dam foundation is in good condition. The dam is in line with existing norms in terms of stability and structural safety. The dam safety monitoring results show that the overall performance of the dam is good; adjacent area, bank and slope are stable. Gutianxi second cascade dam is evaluated as Normal dam.

Most of the mechanical and electrical equipments were replaced since 2003 (except for some buried parts), including generation units, step-up transformers, protection system, monitoring system etc. From site inspection, the equipments are operated well.

The second cascade plant is synchronous run with the Gutianxi First cascade plant is the upstream and plays an important role to the power grid.

The actual generation is less than original design. Lower natural inflow, the lower capacity of penstock and the smaller reservoir storage are major factors.

No serious environmental issue was identified during site inspection. However, the plant shall pay attention to the water reduced section and take appropriate measures to ensure environmental flow as required.

4.8 Chitan Hydropower Plant

4.8.1 General

Chitan Hydropower Plant is located in Taining County, Fujian province, 3 km upstream of Chitan Village. The Jinxi River is planned to develop nine cascade plants in total and Chitan is the first cascade Jinxi

The powerhouse is inside of the dam, installed with two 50 MW Francis turbine units based on discharge of 228 m^3/s at a rated head of 51 m. The plant is designed to provide guaranteed maximum continuous output of 36 MW. The annual design energy production of the plant is 500 GWh, based on 5,000 operational hours per year.

Chitan Hydropower plant was constructed in 1978 and started to provide generation on May 1980. The construction was completed on October 1980.

4.8.2 Project Technical Program Review

4.8.2.1 Hydrology

The design of the Chitan plant is based on the hydrological data series from 1954 to 1975. The catchments are 453 km^2 and the deducted average annual flow is 152 m^3/s. According to the hydrological calculation, the peak flow of 100 years return flood is 8,000 m^3/s (design condition) and the 1,000 years return flood peak flow is 12,100 m^3/s (check condition).

It can be confirmed that basically, the original calculation and design are appropriate. As the plant was design in early times, only 21-years observed data series were available at that time therefore there maybe little deviation for the calculation results.

4.8.2.2 Geology

The scheme is located in the north of Shaowu-Heyuan seismic section and no regional active fault across the sites. The neotectonic movements are faint in the region and no destructive earthquake records in history. According to the "China Earthquake Zoning Map," the seismic intensity is degree VI.

The engineering geology and hydro geological conditions are good without leakage and seepage problems as the permeability coefficient is small and the abutment is stable. Therefore, the design and treatment of the foundation is relatively simple.

The main engineering and geological problems have been identified through the early geological exploration and investigation. It can be confirmed that the engineering strategy employed during construction is appropriate and feasible.

4.8.2.3 Design Standards

According to the national power industry standard DL5180-2003 – "Hydropower Project Classification and Safety Design Standards," the project is classified as grade 2 based on its size.

The major structures, as class 2 structures and others are designed as class 3 structures. The flood control frequency for the dam is 100 years return and verified with 1,000 years return flood; the power house is designed in accordance with 100 years return flood and verified with 500 years return flood. According to "China Earthquake Zoning Map," the site is located in a VI area and the main structures of the scheme are designed in line with 6 degree.

It can be confirmed that the original design is in line with standards and current relevant specifications.

4.8.3 Scheme Layout and Main Structures

The powerhouse is inside the dam. The normal water level is at 275 m asl and the bottom water level is given as 251 m asl, allowing for a total drawdown of 24 m and providing a useable live storage of 665 million m^3. The flood control water level is 274 m.

The main hydraulic structures contain dam, powerhouse and log transportation access etc. The crest height of the RCC dam is 78 m and the crest length is 253 m, consisting of 13 sections; the spillway section is arranged in the middle of the riverbed with total width of 93.3 m and five orifice spillway, each is 13 m wide. A 4.5 m x 4.5 m bottom sluice is arranged at the 10# dam section; the overflow spillway type powerhouse is located at the downstream of the dam. The log transportation access has not been used.

The salient features of the dam are summarised in Table 4.51.

Table 4.51: Chitan Dam – Salient Features

	Reservoir
Dam Type	RCC gravity dam
Dam Height (m)	78
Crest Length (m)	253
Live Volume (million m^3)	630
Total Volume (million m^3)	870

Source: Site visit

4.8.3.1 M&E System

The powerhouse contains the turbines, generators, governors, excitation system, protection system, communication and control system and all balance of the plant components. The transformer is located in the switchyard on the bank.

Most of the equipments have been upgraded or replaced with good conditions. However, the turbine and generator of Unit 2 have been in operation for more than 30 years and have not been replaced yet. The aging unit is a potential safety threat to the plant. It is reported that the technical upgrading study for Unit 2 is undergoing and will be completed in early November 2011. Once upgrading for the generator of Unit 2 completed, Unit 1 will be upgraded then.

Hydro Turbine

Energy is generated by two vertical Francis-type turbines. The runners of 1# turbine (HLX220C-LJ-380) was replaced during A class maintenance during December 2006 to February 2007, which was manufactured by Xi'an Hengxin Hydro Technology Co., Ltd; 2# turbine (HL220-LJ-380) was provided by Dongfang Electrics; The salient features of 1# and 2# turbines are the same (see the table below) except for the number of runners.

Table 4.52: Chitan Turbines – Salient Features

	1# turbine	2# turbine
Turbine Type	HLX220C-LJ-380	HLX220C-LJ-380
Rated power (MW)	51.6	51.6
Max/Design/Min Water Head (m)	66.3/51/34	66.3/51/34
Rated Discharge (m^3/s)	114	114
Rated Speed (rpm)	136.4	136.4
Runaway Speed (rpm)	285	285
Number of vanes	13	14
Runner Setting (m)	-1.5	-1.5
Runner Diameter (mm)	3,817	3,817
Guide vanes Height (mm)	948	948

Source: Operation procedure

Generator

The generators (TS920/115-44) are supplied by Dongfang Electrics. The salient features of the generators are summarized in the table below.

Table 4.53: Chitan Generators – Salient Features

	Generator
Manufacturer	TS920/115-44
Output (MW)	50
Stator Voltage (kV)	10.5
Stator Current (A)	3,235
Excitation Voltage (V)	215.5
Excitation Current (A)	1,188
power factor	0.85
Rated Speed (rpm)	136.4
Runaway Speed (rpm)	285
Stator connection	2Y
Insulation Grade	F/F

Source: Operation procedure

Step-up Transformer

1# and 2# transformers were replaced in 2001, the salient features are provided in Table 4.54.

3# generator with capacity of 18 MW is also connected to 2# transformer. Huadian Fuxin purchased unit 3 from a private power plant and Unit 3 is not within the scope of this technical appraisal.

1# transformer with capacity of 180 MVA is connected to Unit 1. The medium voltage side is connected to 110 kV GIS bus bar. Power is evacuated to the grid with 220 kV transmission line. Unit 2 with capacity of 50 MW and Unit 3 are connected to 2# transformer (63 MVA) with 10 kV II bus bar. Power is evacuated to Chi-San line with common 220 kV transmission line. 2# almost operated under full load. The site staff reported that the plant is planning to connect Unit 3 to 1# transformer.

Table 4.54: Chitan Step-up Transformer – Salient Features

Item	1# transformer	2# transformer
Type	OSSPS10-180000/220	SSP9 63000/220
Rated Capacity (KVA)	180,000	63,000
Rated Voltage (kV)	242±2×2.5%/121/10.5	242±2×2.5%/121/10.5
Connecting	YN ao d11	Ynd11
Cooling	Forced-oil circulation water cooling	Forced oil circulation water cooling
Manufacturing Date	July 2001	January 2002
Manufacturer	Shenyang Special Transformer Plant	Changzhou Transformer Plant

Source: Operation procedure

4.8.4 Plant Operation and Maintenance

4.8.4.1 *Operation and Maintenance of Hydraulic Structures*

From the operation and maintenance records of hydraulic structures, safety inspection report and regular inspection report and site inspection, the condition of the structures are described below.

Reservoir and Dam

The reservoir has been in operation for 31 years. The storage capacity of the reservoir has been verified with RS in 2007 and the newly measuring result was almost the same with the original design curve. No landslide, collapse or leakage was found from the inspection.

The dam has experienced serious flood in June 2002. The maximum outflow reached 7,033 m^3/s. "Plunge pools" and river erosion were found in 70 m away from the downstream of the dam. However, it does not threat the safety of the dam considering its size and depth. The surface of the spillway has been treated with epoxy process to repair the tear and wear places.

From review of the documents available, defects appear to have been eliminated timely and the automatic monitoring system is stable and reliable. Dam deformation is in line with the general variation of the concrete gravity dam. The seepage of the dam was not significant and the change of uplift pressure is normal. Generally, the dam is in normal condition.

Intake arrangement, powerhouse and mental structures

The powerhouse, tailwater structures, dam abutment and vicinity areas are in good condition. However, the inspection and testing conducted in 2003 showed that radial gate and certain parts of penstock were serious corroded. It was told that Huadian has approved the 2012 maintenance plan to repair the corrosion.

4.8.4.2 Operation and Maintenance of M&E System

The plant has been in operation for more than 30 years. Many of the equipments have been upgraded or replaced since 2001 and it can be confirmed that overall the equipments are in good conditions. However, 2# turbine and both of 1# and 2# generators have not been upgraded yet. It was told from the site staff that the plant is undertaking the feasibility study on technical upgrade of Unit 2 followed by upgrading of 1# generator. The details for maintenance and operation are described in the sections below.

Maintenance Records

Both of Unit 1 and Unit 2 have been operated since May 1980 and both have experienced 43 times of C Class maintenance from 1981 to 2010. The maintenance history is summarized in Table 4.55.

Table 4.55: Maintenance records – Chitan

Year	Unit 1	Unit 2
1981		B
1982	B	
1984		B
1985	B	
1988		A
1989	A	
1992		B
1993	A	
1996	B	A
2000	B	
2002		A
2003	B	
2006	A	
2007		B

Equipments Maintenance and Operation

(1) Hydro Turbine

Runner of Unit 1 has been replaced in December 2006. No cracks and cavitations were found from the B Class maintenance records in 2008. The efficiency testing results showed that the efficiency of Unit 1 is almost the same with 2006 and the runner of Unit 1 was determined as class A equipment reference to the maintenance records.

Runner of Unit 2 has been in operation for more than 30 years. There were some cracks at the joint of blade and crown. After welding for several times, there are large deformation and water loss is greater, which means lower efficiency. Runner of Unit 2 was determined as class 3 equipment as stated in the maintenance records.

(2) Governor

The ZFL/D-100 governors were provided by NARI. The electric cabinet and machine cabinet of Unit 1 were renovated in September 2001 and December 2004 respectively. The electric cabinet and machine cabinet of Unit 2 were renovated in December 2002 and December 2007 respectively. The governor is determined as class 1 equipment with good condition.

(3) Generator

The generators of unit 1 and unit 2 have been completely maintenance respectively in 2007 and 2008. However, the coils were not replaced. After thirty years running and maintenance, insulation aging is serious and almost reaching its lifetime. In view of the status of the generators, it was told that Huadian Fuxin has developed strict measures to to strengthen monitoring and anti-accident measures developed for the generators and propose renovation in the near future. It is reported that Huadian Fuxin is studying the technical upgrading option for Unit 2.

(4) Step up Transformer

The and oil circulation-water cooling step up transformers were replaced by OSFPS10–180000/220 and SSP9–63000/220 in 2002 and provided by Shenyang Special Transformers Factory and Changzhou Transformer Factory respectively. All items of post testing after installation was qualified and the annual precautionary testing results were good. With minor maintenance each year as scheduled, the condition is good.

4.8.4.3 Power Output

Both of 2 units have been in operation since October 1980. Generation records are shown in Table 4.56.

Table 4.56: Power generation from 1980

Year	Annual Generation ('0000 kWh)	Year	Annual Generation ('0000 kWh)
1981	43,319.1200	1996	45,078.0800
1982	54,949.7800	1997	64,078.4000
1983	61,095.9200	1998	62,025.6000
1984	48,601.8400	1999	58,649.0400
1985	40,159.2400	2000	52,395.2000
1986	47,393.4400	2001	66,703.8400
1987	40,015.7000	2002	59,615.4400
1988	62,844.6400	2003	44,363.6000
1989	47,630.3400	2004	25,307.5200
1990	53,460.8900	2005	50,229.2800
1991	41,135.4600	2006	57,101.8400
1992	62,041.9200	2007	44,010.1104
1993	46,394.8800	2008	48,033.8576
1994	58,157.6800	2009	30,359.8360
1995	65,426.1600	2010	54,773.6480
Average	50,883.5		

It can be seen from the table above that the actual average annual generation is 511.78 GWh, which is 11.78 GWh greater than the original design (about 2.3% larger), shows that the plant operated as expected.

We also reviewed the runoff data series from 1951-2010. The average annual runoff is 158.1 m^3/s for the recent 60 years. The average flow during 1981-2010 is 165.9 m^3/s, showing more water available in recent 30 years. The average annual flow in recent 40 years from 1971-2010 is 164.6 m^3/s, no significant difference with data series of 1981-2010, which means that the data series of recent 30 years is representative and can be used to check the annual generation.

The operation efficiency of the units has been greatly improved after renovation and replacement in recent years and the generation is likely to increase. The checked average annual generation is 530.7 GWh and the operation hours are 5,307 h per year in view of the considering factors.

The average operation hours are significantly higher comparing with the general level and the average load factor is also relatively higher. Chitan HEP is a peak power station and need to reserve certain spare capacity for the grid. The local load level has greatly increased during the recent 30 years so that more spare capacity is required. It is suggested that Chitan HEP take expanding installed capacity into account to lower the operation hours per year and load factor in order to reserve more back-up load for the grid and play full function as peak load plant. It was reported from the site staff that Chitan HEP is studying the feasibility of expanding installed capacity.

4.8.5 Organization and Staff

Chitan HEP arranged one Operation division (28 staffs), one Maintenance division (15 staffs), the Second Operation and Maintenance division (58 staffs) and Safety and Inspection division for the generation. Among of them, some employers are seconded to other plants under Huadian Fuxin.

4.8.6 Environment

As Chitan plant was constructed in 1970s, the central government did not have EIA and EIA acceptance regulations at that moment. There are no special environmental issues, which need further attention from site inspection.

4.8.7 Consents

Hydropower plant shall apply the water abstraction license according to the relevant regulations. Chitan power plant has obtained the abstraction license (Min [2007] 000029, expired on December 31, 2012). It is required to renewal the license every four years.

4.8.8 Grid Connection Agreement

Chitan plant has signed the grid connection agreement with Fujian Power Limited Company (expired on December 31, 2015) and power purchase agreement (expired on December 31, 2014).

4.8.9 Conclusions

Generally, this scheme is well designed and operating better than expectations.

The plant has been in operation for 31 years, the vegetation is well covered. No signs of landslide and leakage have been identified.

The automatic monitoring system of the dam is stable and reliable. Dam deformation is in line with the general variation of the concrete gravity dam. The seepage of the dam was not significant and the change of uplift pressure is normal. Generally, the dam is in normal condition with enough discharge capability for flood control.

The powerhouse, tail water structures, dam abutment and vicinity areas are in good condition. However, the inspection and testing conducted in 2003 showed that radial gate and certain parts of penstock were serious corroded. It was told that Huadian has approved the 2012 maintenance plan to further repair the corrosion.

The plant has been in operation over 30 years and has been maintenance and operated as schedule.

Part of the equipments have been upgraded or replaced since 2001, including 1# turbine, governor, excitation system, step-transformer, protection system, communication and control system etc. It can be confirmed that overall the new equipments are in good conditions.

2# turbine and both generators have not been replaced yet and the facilities are aging, which may threat the safety operation of the plant. Except for strengthening inspection and management, it is recommended to study the technical upgrading for such facilities in the near future.

As the operation hours are relatively larger, it was told that the plant is undertaking the feasibility study to enlarge installed capacity in the future.

4.9 Summary

From reviewing the documents available and site inspection, all of the seven selected plants there well established and appropriate to current design. It appears to be no seismic activity at the powerhouse location and no major flood events or landslides have occurred that could have affected the dam and powerhouse and can be confirmed low risks.

Baisha hydropower station has been in operation for approximately four and half years since 2007. Analysis of operational records has shown that the plant has generated on average up to 88% of its design generation. It can be confirmed that the plant operates well as expected.

Mianhuatan hydropower has been in operation for approximately ten years and operated as expected based on the operation records.

Ansha hydropower station has been in operation for approximately 36 years. Some of the technology employed in the scheme (batteries) is considered old and may require replacement, even though it is not affecting the station capability. Overall, the station equipment is appropriate for operation and considered to be low risk.

Fenghai hydropower station is a small-scale run-of-river power station and has been in operation for just over five years. The technology employed in the scheme (unit type, switchgear, batteries) is well established and appropriate to current design standards and considered to be low risk.

Gutianxi second cascade hydropower station has been in operation for more than 40 years. The dam has been reinforced during 2003-2005 and appropriate to current design standards. Most of the M&E equipments have been replaced since 2003 and in good condition.

Qinshan hydropower station has been in operation over 10 years and most of the equipments and facilities are in good condition. Qinshan plant has almost been outage due to the construction of Zhouning hydropower plant in the downstream. Excluding 2004, the average annual power generation during 2000-2010 was 132.88 GWh, which has generated on average up to 91% of its design generation. It can be confirmed that the plant operates well as expected. It is suggested that the plant shall pay attention to the potential drying river reach at the downstream of the dam.

Chitan Hydropower station has been in operation over 30 years. Generally, the dam is in normal condition. Parts of equipments have been replaced since 2001. 1# generator and 2# turbine and generator are ageing. It is reported that the plant is preparing technical upgrading strategy and is planning to replace the ageing equipments gradually.

5. THERMAL POWER STATION TECHNICAL ASSESSMENT

5.1 Introduction

Fujian Kemen Power Generation Co Ltd is located on the Huangqi peninsula, on the south bank of Luoyuan Bay in the East Fujian province. The power station site was selected within Kemen Economical Development Zone, which is about 85 km to Fuzhou City, 54 km to Ma'wei, and 39 km to Lianjiang. This power station was developed by China Huadian Corporation. A FEED study for phase I (Unit 1 and Unit 2) was conducted in 2003 and construction started in 2004. Unit 1 and Unit 2 achieved commercial operation Data (COD) in August and December of 2006 respectively. Phase I contains two coal-fired super-critical units with nameplate capacity of 600 MW each. The total investment of Phase I was CNY5 billion. Currently Luoyuan Bay has industrial docks with an annual throughput of 10,000,000 tonnes, which makes it convenient for coal and industrial heavy shipping.

The design coal for the power station is from Shenfu Dongsheng coal mine, and the check coal is northern Shanxi bituminous. Power station and Huadian Coal Co. Ltd have signed a long term Fuel Supply Agreement (FSA). All coal is shipped to the industrial dock of the power station.

The Power Purchase Agreement (PPA) is between the Procurer (Fujian Electric Power Co. Ltd) and the Kemen Power Generation Co Ltd. Phase I export electric power to Fuzhou Substation is via a 500 kV two-circuit power line. The usual PPA term is 3 years and automatically renewable 3 months prior to expiration till end of commercial operation unless significant power purchase changes are envisaged. The initial PPA terminated on December 31, 2008 and it has been renewed till January 2012.

The power station uses seawater as the main cooling media for the circulating cooling water system for the condenser and closed cooling water system for auxiliary equipment. All other water consumption including production water, potable water and fire-fighting water is fresh water, which is mainly sourced from Bantang reservoir. Mu'Pu reservoir is used as backup.

5.2 Major Supplier

5.2.1 Overall Design

Kemen Power Station overall design was undertaken by China Southwest Electric Power Design Institute (SWEPDI), a subordinate company under the Electric Power Project Consulting Group of China. SWEPDI possesses Grade A qualification in the areas of engineering design, electrical engineering and construction design, engineering survey, environmental impact assessment, pollution prevention and control engineering, EPC contracting, engineering consulting, project cost consulting, project supervision, pressure vessel design and etc. In 1995, SWEPDI became one of the first enterprises certificated by the Authorities of the State Electric Exploration-Survey and Design to have reached International Standard Organization 9001 (ISO9001) and certificated by the State Foreign Trade Ministry for the qualification for overseas businesses.

As of September 2010 (not including years before 1999) SWEPDI has designed more than 70 sets of 600 MW units in 13 countries, with a total capacity of 44,717 MW. Through these projects SWEPDI has accumulated extensive experience in super-critical and ultra-supercritical unit. As one of the main design institutes, we do not have major concern regarding SWEPDI's ability to design to this power station.

5.2.2 Major Equipment Supplier

Shanghai Electric Group (SEG) provided steam generators, steam turbines and generators for both units in Phase I. To date, SEG has already delivered 53 sets of 600 MW supercritical units and 20 sets of 1,000 MW ultra-supercritical units, and has 94 and 46 similar units under construction, respectively. SEG offers from 50 MW to 1,000 MW units covering circulating fluidized bed (CFB) units, ultra-supercritical units, and combined cycle units for all size power stations. We consider the main equipment from SEG are of mature technology and proven design and we do not have major concern with regards to their quality and service.

5.3 Power Station Construction and Configuration

5.3.1 Power Station Construction

This power project construction started in 2004. Both units overall design was undertaken by SWEPDI. Major equipment include steam generator, steam turbine and generator were manufactured by SEG and the project construction was undertaken by Guangdong Thermal Power Engineering Corporation. Unit 1 and Unit 2 started commercial operation in August and December 2006, respectively.

5.3.2 Power Station Configuration

Both units use 600 MW supercritical pulverised coal steam generators, they feature a modularised main steam system, reheated steam system and main water feeding system. The system uses 30% high pressure and low pressure steam bypass design, and each unit is equipped with 2 × 50% steam-driven feed water pumps and 1 × 30% electric feed water pump. The model number of the reheating and condensing steam turbines is N600/24.2 MPa/566°C/566°C. The steam turbine driven generator is QFSN-600~650-2 type featuring a water-hydrogen cooled design.

The balance of plant (BOP) includes closed cooling water, water treatment, compressed air, fire fighting, transformers and 500 kV GIS, and distributed control system (DCS).

The following sub-sections give an overview of plant major equipment and systems.

5.3.2.1 Steam Generator

The steam generators by Shanghai Boiler Works, a subordinate company of SEG, were based on the Alstom US technology and further developed as per clients' specific requirements and experience of burning coal from Shenfu Dongsheng (the design coal).

The supercritical steam generators feature sliding pressure, single furnace, single reheat, corner firing, balanced draft, two-pass open layout, dry bottom ash removal, full steel structure, 2-off tri-sector Ljungstrom gas-air heaters. Key data of the steam generator are listed in table 5.1:

Table 5.1: Boiler Key Data

Item	Unit	(BMCR)	(BRL)
Main Steam Flow	t/h	1913	1821
Main Steam Pressure	MPag	25.4	25.29
Main Steam Temperature	ºC	571	571
Hot Reheat Steam Flow	t/h	1581	1514.2
Cold Reheat Pressure	MPag	4.38	4.16
Cold Reheat Temperature	ºC	312	306
Hot Reheat Pressure	MPag	4.16	3.97
Hot Reheat Temperature	ºC	569	569
Feedwater Temperature	ºC	282	279

Source: Ke'men Power Station Steam Turbine Manual

Steam generators are equipped with medium-speed mills with primary air swept pulverising system. The furnace is designed for corner firing and incorporated a total of 24 burners arranged in six rows of four. Coal dust and air are introduced into the furnace at distinct elevations through windbox assemblies located in the corners. The windbox nozzles direct the coal and air streams at slight angles off the diagonals and tangent to a firing circle in the center of the furnace. The combination of the firing angles and momentum of the fuel and air streams create a rotating or cyclonic fireball that fills the plan area of the furnace. Overfire Air (OFA) equipment has been provided within the corner firing system to reduce NO_x. The auxiliary fuel is #0 light diesel oil.

Spray attemperation is used to control superheater steam temperature during operation. Stage I attemperators are located on the inlet header of platen superheater and Stage II attemperators are located on the inlet header of final superheater. There are two spray attemperators on the reheater inlet header to control cold reheat temperature in emergency. The spray attemperation is a mature and well proven method to control steam temperature.

All boiler pressure parts use mature design and well proven material. The power station has been operated at base-load condition which leads to limited thermal impact to pressure parts, so the remaining life of major equipment should be compatible with the remaining design life.

During the site visit we determined that T91 has been used as the material for final superheater piping. From the unplanned outage records we have learnt that all major unplanned outages for both units were caused by final superheater piping premature failure. The cause of this premature failure was inadequate safety factor during design phase and this has been addressed.

The integrity of the steam generator is one of the most factors in a reliable coal-fired power station. We have been advised that there are more than 200 units of this size and type in operation in China, of which 53 units were supplied by Shanghai Boiler Works and another 94 similar units are under manufacturing or construction as of September 2010. We are not aware of any major inherent design defects with this design. We believe the technology for this type of boiler is mature and proven.

5.3.2.2 Steam Turbine

The model number of the reheating and condensing steam turbines is N600/24.2 MPa/566°C/566°C, which was supplied by Shanghai Turbine Ltd of SEG. This steam turbine is capable of operating at both full load and sliding pressure conditions. This type of unit uses single reheat, single axle, three-cylinder four extraction design. Table 5.2 lists the main technical parameters of the turbine.

Table 5.2: Key Steam Turbine Parameter

Item	Unit	
Net Plant Output	MW	600
Main Steam Pressure	MPa(a)	24.2
Main Steam Temperature	°C	566
Reheat Temperature	°C	566
Revolutions per minute	r/min	3000
Rotation		Clockwise
Average Backpressure	KPa	5.4
Summer Average Backpressure	KPa	11.8
Rated Feedwater Temperature	°C	275.3
Feed Heating		3 X HP, 4 X LP, 1 X Deaerator
Feedwater Drive		Steam Pump
Rated Steam Flow Rate	t/h	1681.542
Net Heat Rate	kJ/kWh (kcal/kWh)	7597 (1814.5)
Average Backpressure of Steam Pump	kPa	6.78

Source: Steam Turbine Operation and Maintenance Manual

Shanghai Turbine Ltd has supplied 54 sets of such steam turbines within the Chinese market and possesses production capability of 12 units per year. As of this draft report stage we are not aware of this steam turbine having any inherent design defects. We consider this type of turbine used proven and mature technology. We do not have major concern with regards to the quality and reliability of the steam turbine.

5.3.2.3 Generator

The QFSN type water-hydrogen cooled generators used for unit 1 and 2 were supplied by Shanghai Turbine Generator Co Ltd, with rated capacity of 600 MW to 650 MW. As the draft report stage we are not aware of these generators having an inherent design defect.

5.3.2.4 Coal Unloading and Storage

Coal supply is shipped to the 10,000,000 tonnage industrial dock. The dock is equipped with 2 sets of gantry unloader with rated capacity of 1,200 ton/hour.

Kemen Power station has two hemi-sphere shaped coal storage yards with internal diameter of 120 m. Each storage yard has one coal conveyor. Total capacity of coal storage is 293,000 ton, which can provide power station with 26 days usage at full load. The storage yard is fully enclosed structure and weather proof, which would reduce environmental pollution.

There are three belt conveyors between the dock and the transfer yard, two in operation and one standby. There are two belt conveyors between the transfer yard and storage yard with one in operation and one standby. Unit 1 and 2 share one coal feed system which has two belt conveyors. The design margin of coal feed system is 1.8 and meet the output requirements.

5.3.2.5 Gas Air Heater

Each boiler unit has 2-off tri-sector Ljungstrom gas-air heaters (GAH), which feature separate primary and secondary air arrangement, primary air damper opening at 50°C, counterflow rotor. Each air heater has two retractable sootblowers. Water washing pipe and firefighting pipework is fitted on the flue gas side. GAH is also equipped with fire alarm system, and meet the safety requirement.

5.3.2.6 Fans

Shenyang Blower Works Group Co supplied the primary air fans and forced draft fans, and Howden Hua supplied the induced fans to Unit 1 and Unit 2 of the power station. The power station has signed a long term service agreement (LTSA) with Fujian Xiamen Si-Te-Lang Engineering Co Ltd and Anhui Power Construction Ltd respectively for Unit 1 and Unit 2 for equipment maintenance that covers all the fans. The power station has adequate spare parts for the fans.

5.3.2.7 Distributed Control System (DCS)

Unit 1 and 2 in the power station use distributed control system (DCS) by Emerson. This DCS system is well proven in modern thermal power station and we do not have any major concern to this system.

5.3.2.8 Transformers and 500 kV Substation

The generators are connected to corresponding feeder circuits to the 500 kV switchyard and connected to Fuzhou 500 kV substation via 2-circuit connection. 500 kV and 720 MVA outdoor type, three-phase double-winding copper wire surge-type low-loss non-excitation step-up transformers were adopted for both generators. We consider the transformers meet national standard (GB code) and the International Electrotechnical Commission (IEC) standard. Table 5.3 lists the main technical parameters of the transformers.

Table 5.3: Key Transformer Parameter

Item	Value
Rated capacity	720 MVA
Voltage and tapping range	500 kV ±2 X 2.5%
Cooling method	ODAF
Transformer loss at rated output	275 kW

Source: Primary Transformer Product Manual

5.3.2.9 *Electrical Static Precipitator (ESP)*

ESP systems for Unit 1 and Unit 2 were designed by Fujian Provincial Power Design Institute and supplied by Fujian Long-Jing Environmental Co. Ltd. The design employed dual chamber and four electric fields with rated flue gas rate of 1,634,140 m^3/h. Each ESP unit contains 16 hoppers. The ESP systems were designed to use 380 V, 3-phase 4 wire, 50 Hz AC. The maintenance of ESP systems for Unit 1 and Unit 2 fall into their own LTSA. According to plant O&M records we did not find any major issues for the ESP systems.

5.3.2.10 *Flue Gas Desulphurization System*

Both Unit 1 and Unit 2 use wet scrubber to control sulfur dioxide emission, each unit has one scrubber. The incoming flue gas from ESP is introduced to the FGD absorber tower after the heat exchanger where it is cooled by outcoming flue gas (after scrubbing). The flue gas enters the side of absorber tower and exits from the transition at the top after scrubbing and is then heated up by incoming flue gas and lead to the stack and discharged to atmosphere. The gypsum slurry can be reused after the dewatering process. The actual maximum SO_2 emission is less than 100 mg/m^3 and meets national emission code GB13223-2011, which is to be implemented in 2012.

5.3.2.11 *Cooling Water System*

Seawater is used as the cooling medium of circulating cooling water system. It is mainly used to cool down the condenser, closed cooling water heat exchangers, and supply to the Chlorine system. The circulating cooling water system uses the modular direct water supply mechanism and each boiler unit is equipped with 2 × 50% cooling water pumps. We were told that, cooling water pump combinations will be changed according to seasonal changes in temperature. Usually 3 pumps are used in winter and 4 in the summer with a 20% redundancy for cooling water flow rate. If 20% flow rate redundancy is the case then any pump failure in summer may affect the power station output. Because the use of seawater as a cooling medium, power station uses sodium hypochlorite electrolytic water treatment system to prevent marine life caused corrosion or clogging. The pump arrangement and the water chemistry in this power station are widely used and well accepted worldwide.

5.3.3 Summary

We consider the technology and equipment used in this power station are mature and well proven based on the information provided and meet our expectation. However we have some concerns about the final superheater piping premature failure, otherwise we consider Unit 1 and Unit 2 in Kemen power station fundamentally meet the design requirement and are in stable operation.

5.4 Operation History

5.4.1 Capacity and Availability

Fuzhou Kemen Power station Phase I construction started in 2004. Unit 1 and Unit 2 started commercial operation on August 3, 2006 and December 4, 2006, respectively. Both units have been in base load operation. With the information provided Table 5.4 lists both units' capacity factors and availabilities from 2008 to September 2011.

Table 5.4: Unit 1 and 2 Capacity Factors and Availabilities

	Year	2008	2009	2010	2011 (to Sept)
Unit 1#	Capacity Factor (%)	69.52	70.35	59.54	66.95
	Availability Factor (%)	87.68	90.06	91.18	81.6
	Net Generation (GWh)	3664.23	3697.71	3129.43	2631.84
Unit 2#	Capacity Factor (%)	54.85	67.04	61.05	56.88
	Availability Factor (%)	82.44	90.65	100	72.68
	Net Generation (GWh)	2890.81	3523.66	3208.62	2236.14

Source: Ke'men Power Station Reliability Record

As per the 5,000 equivalent operating hour proposed in the FEED study report we consider both units generate more power than predicted.

5.4.2 Outage

Provided with the operation record we list both units' outage statistics in Table 5.5.

Table 5.5: Units Outage

	Unit 1		Unit 2	
Year	Planned Outage	Unplanned Outage	Planned Outage	Unplanned Outage
	(hours)	(hours)	(hours)	(hours)
2008	903.07	179.38	1,267.57	274.55
2009	728.55	141.82	637.05	182.12
2010	772.98	0	0	0
2011	1,047.57	157.85	1,271.98	518

Source: Ke'men Power Station Reliability Record

From the statistics above we consider major outages were planned outages. Notably both units did not experience any unplanned outages in 2010 and Unit 2 did not have planned outage in that year, which lead to 100% availability. In 2008 both units have undertaken planned Grade A outages since commercial operation. All other annual outages and planned outages before key festivals were deemed as normal outage and have been recorded.

We have noted the following reasons from the unplanned outage record:

- Unit 1
  - In 2011 has experienced 157.85 hours unplanned outage because of premature failure on 4th tube in row 54 of final superheater;
  - In 2009 has experienced 141.82 hours unplanned outage because of premature failure on platen superheater;
  - In 2008 has experienced 179.38 hours unplanned outage with the reason the same as above.
- Unit 2
  - In 2011 has experienced 3 times with a total 518 hours unplanned outage because of premature failure on final superheater;
  - In 2009 has experienced 4 times with a total 182.12 hours unplanned outage largely due to the reason same as above;
  - In 2008 has experienced 3 times with a total 274.55 hours unplanned outage largely due to the reason same as above.

We believe T91 premature failure was the main cause of unplanned outages for both units and the record further confirmed our concern. The direct reason lead to this was largely due to lower design margin by the boiler supplier. This issue has been addressed and aimed to be repaired by 2012.

Affected by the outages both units' availabilities were less than 92% (100% for Unit 2 in 2010). We have noted that that the definition of plant availability in China is different from the western market, and also the regulations of availability of PPA and grid despatch apply different principles, so we consider the availabilities here for Kemen power station as a long term average and meet our expectation based on our experience of similar power station worldwide.

We consider the plant capacity factor is at high level among the similar power stations in China though slightly lower compared to western plants, that's because its annual power generation amount is pre-decided by the production plan by government authority for each year. In accordance with verbal information provided during our visit, under the PPA, plant income is based on exported energy volume only with no plant availability or capacity payment. The plant is therefore not compensated if Fujian Electrical Company limits the purchased energy volume in a period.

5.4.3 Plant Coal Consumption

In Kemen power station the coal consumption for power generation has been steadily decreasing since 2007 from 318.0 g/kWh to 304.1 g/kWh in 2011 (as reported in December 2011). Notably the national average standard coal (according to standard coal LHV of 29.3 MJ/kg) consumption for power generation is 333 g/kWh (2010 Annual Power Generation Briefing – SERC) for any coal fired power station greater than 6 MW capacity in 2010, when Kemen power station's figure was 305.3 g/kWh in that year. This means major large-scale power generation enterprises have higher level of technology, equipment and corporate management. Table 5.6 lists the power station's annual average coal consumption.

Table 5.6: Plant Average Coal Consumption

Year	Average Coal Consumption
	(g/kWh)
2007	318.0
2008	316.9
2009	307.8
2010	305.3
2011	304.1*

* *Figure based on report in December 2011*

Source: Ke'men Power Station Monthly Analysis Report

It is noted that there are big difference between Chinese large state-owned power stations and Western similar power stations in operation regime and PPA, which lead to big difference in calculating annual standard coal consumption.

5.4.4 Plant Efficiency

Generally the design conditions for supercritical units in the western countries is $P_{F/SHTR}$=30 MPa, $T_{F/SHTR}$=600°C, $P_{F/RHTR}$=6.5 MPa with overall efficiency greater than 46%. The design conditions for Kemen power station is $P_{F/SHTR}$=24.2 MPa, $T_{F/SHTR}$=571°C, $P_{F/RHTR}$=4.17 MPa with designed overall efficiency no less than 43%. During site visit the verbal information we have regarding overall efficiency was between 35% and 40%, which is lower than expected. Table 5.7 lists both units' actual annual operating conditions since 2008.

Table 5.7: Units Average Operating Condition

Year	Operating Condition	Unit 1	Unit 2
2008	Main Steam Temperature (°C)	557.62	551.35
	Main Steam Pressure (MPa)	22.57	21.92
	Hot Reheat Temperature (°C)	547.12	546.11
	Hot Reheat Pressure (MPa)	3.2	3.07
2009	Main Steam Temperature (°C)	556.74	555.17
	Main Steam Pressure (MPa)	22.87	22.20
	Hot Reheat Temperature (°C)	546.95	541.81
	Hot Reheat Pressure (MPa)	3.28	3.09
2010	Main Steam Temperature (°C)	557.42	556.16
	Main Steam Pressure (MPa)	21.58	20.61
	Hot Reheat Temperature (°C)	548.75	544.77
	Hot Reheat Pressure (MPa)	2.84	2.62
2011 (till October 2011)	Main Steam Temperature (°C)	557.55	552.67
	Main Steam Pressure (MPa)	23.64	21.96
	Hot Reheat Temperature (°C)	522.74	548.23
	Hot Reheat Pressure (MPa)	3.38	3.22

Source: Ke'men Power Station Monthly Analysis Report

We have noted in Table 5.7 that actual operating conditions for both units from 2008 were lower than design conditions. In some months after the high temperature superheater tube premature failure the units were operated under lower condition or subcritical condition for safety reason and this was the cause of the lower efficiency. Huadian Fuxin Energy Co., Ltd has been in consultation with the boiler supplier, Shanghai Boiler Works, who has acknowledged this and agree to retrofit. Currently Huadian Fuxin Energy Co., Ltd has approved the retrofit plan and aim to accomplish by 2012.

5.5 Operation and Maintenance

Kemen power station has almost 400 staff working on a total of 4 power generation units. The number includes 193 operating staff and 112 maintenance staff. Operating staff work in three shifts. We consider the staff number is higher compared to those similar power stations in Western countries, partly due to in-house maintenance for Unit 3 and Unit 4.

As introduced in previous sections, the mechanical maintenance for Unit 1 and Unit 2 has been outsourced to Fujian Xiamen Si-Te-Lang Engineering Co Ltd and Anhui Power Construction Ltd, respectively. The maintenance agreements are usually valid for 3 years and are renewable. The current agreement is valid till December 31, 2013. The agreements cover steam generators, steam turbines, shared facilities between unit 1 and unit 2, and boundary area between the two units. The maintenance of the 2-circuit power cable connected with Fuzhou Substation has been outsourced to Fujian Power Construction Ltd. This type of LTSA is a popular form of equipment maintenance and is widely accepted in the power stations in many countries. The advantage of these agreements is controllable cost within the maintenance cycle. Unit 3 and Unit 4 in the power station are currently maintained by its own staff and it is not clear whether they are using outsourced LTSA as Units 1 and 2 do.

As of September 30, 2011 Unit 1 has accumulated actual operating hours (AOH) of 21,872 and equivalent operating hour (EOH) of 26,573 and Unit 2 has AOH of 19,765 and EOH of 25,723. At the end of 2007 both units have undertaken planned Grade A outages since commercial operation and due for the next in the end of 2012 as planned. All other annual outages have been undertaken as scheduled.

5.6 Asset Condition

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

5.7 Spare Parts

We reviewed the plant spare parts inventory and consider spare parts stock for boiler, steam turbine, EC&I, and FGD to be adequate. Each discipline reviews the inventory and produce stock list for procurement monthly in accordance with the actual stock. There are a large number of similar units and BOP equipment in operation nationwide so we do not have any concern about key spare parts supply. We also consider the LTSA an assurance to spare part supply.

5.8 Environment, Health and Safety

The overall investment for Unit 1 and Unit 2 in the Phase I was CNY5 Billion which include CNY 568 Million environmental protection investment. The environmental protection facilities were put in operation along with unit COD.

Both Unit 1 and Unit 2 use low-NO_X combustion technology (low-NO_X burner, staged combustion and overfire air). Flue gas is discharged through the 210-metre stack after ESP and FGD. Continuous Emission Monitoring System (CEMS) and GGH are equipped to monitor emission and are connected to the local environmental authority. Coal handling system includes fully enclosed coal storage yards and conveyors. Mill, coal transfer field, and ash storage yard have precipitator. Seawater is the main cooling medium. All industrial waste water is treated and re-used. Noise control systems have been used at every noise sources.

Particulate, SO_2, NO_X emissions are 17.1 mg/m^3, 100 mg/m^3, and 170 mg/m^3 respectively. However, there is no mercury emission information as it is not required as per the current national regulation. As advised Unit 1 and Unit 2 will have SCR retrofit in two years and mercury emission will be monitored. No major issue or environmental incidents were noted during our review of operational records and relevant documents provided.

Under the new emission code GB 13223-2011, which is to be implemented in 2012, Kemen power station will have to meet the requirement of particulate, SO_X, NO_X and mercury emissions no more than 30 mg/m^3, 100 mg/m^3, 100 mg/m^3 and 0.03 mg/m^3 respectively. We are satisfied with the current emission level as per current regulation, but we would expect the NO_X emission will meet the new regulation after SCR retrofit.

5.9 General Conclusion

We comment on the key conclusions relating to Unit 1 and Unit 2 in Kemen power station as below:

- We consider the power station design and equipment are based on mature and proven technology;
- We consider the output and power generation are in line with our expectation;
- Plant availability in some years had an outstanding performance and in general consistent with our expectations;
- Power station coal consumption reduction effect is higher than the national average and meet our expectations;
- The plant Capacity Factor is at high level among the similar power stations in China, though slightly lower than similar Western power stations. This is because annual power generation amount is decided by the production plan issued by government authority at beginning of every year;
- Because of high temperature premature failure and safety reason, the actual heat efficiency is slightly lower than design;
- We are slightly concerned about the 20% redundancy for circulating cooling water pumps. We consider that there is no indication of idle capacity of the circulation pump, because the capacity shall be designed according to actual conditions. The pump configuration and 20% redundancy is reasonable and well proven. This type of pump is very reliable and durable, and what can be slightly concerned are the spare parts for the pump (i.e. motor, propeller, and casing), in case of motor failure, or impeller/casing damage due to foreign objects intaken from seawater. However as long as the pump intake screen/filter has reasonable mesh size, the spare parts of propeller and casing is not necessary. So, it means the 20% margin of this plant is adequate for the condition and meets the relevant margin requirement of national codes. We consider the redundancy for other major equipment is adequate;

- Boiler high temperature superheater premature failure was due to design flaw and will be fixed by 2012;

- We reviewed the LTSA and the power cable maintenance agreement. We consider these agreements cost effective and provide some quality assurance;

- We reviewed the FSA, Grid Connection Agreement, and PPA and consider these agreements have provided some assurance to power generation, sales, and on-grid generation;

- We reviewed current Emission Permit and consider the emission meets current emission code. We would expect the NO_X emission meet the new emission regulation when fitted with SCR system;

- We reviewed the plant spare parts inventory and consider the stock and range are adequate for maintenance and planned outage.

APPENDIX

APPENDIX A: DOCUMENTS REVIEWED

List of documents reviewed

No	Column
1	Kulun Wind Farm Phase I PPA Maintenance plan Grid connection agreement Construction contracts Environmental effect report and review Huiteng project document Equipments technical specification Operation performance monthly report Feasibility study report Wind power for regional heating proposal SVC design SVC technical agreement Single line diagram Notice of 220 kV transmission project Approval of 220 kV transmission project WTGs maintenance methods Maintenance tools register list Equipments purchase contracts
2	Xiaocaohu Wind Farm 1 Phase I PPA O&M agreement Feasibility study report Project approval from DRC design/installation/construction contract Equipments contract Phase II contracts Single line diagram Spare parts list Safety assessment Operation performance monthly report Quality inspection result Notice of environmental effect report

No	Column
3	Burjin Wind Farm Feasibility study report Notice from DRC Equipments contracts Design/installation/construction contract Environmental effect report Notice of environmental effect report Financial documents Grid connection and dispatch agreement Equipments technical specification Curtailment summary 2011 production plan Operation performance monthly report
4	Guazhou Wind Farm Phase I Feasibility study report Equipments contract Construction/supervision contract Project approval from DRC Environmental effect report Project implementation journal WTGs layout Single line diagram Main transformer test report WTGs manual Main equipments technical specification Operation performance monthly report 330 kV system assessment inspection Equipments fault list LVRT inspection report Wind power large-scale off-grid report Notice for wind farm off-grid

No	Column
5	Muling Wind Farm Phase I Legal investigation documents Warehouse materials sheet Feasibility study report WTGs contract Box transformer technical specification WTGs layout Single line diagram WTGs fault register Operation performance monthly report WTGs 240 hr report Spare part list Spare part procedure method Approval and inspection report Phase II documents
6	Yilan Jiguanshan Wind Farm Phase I Legal investigation documents Feasibility study report WTGs contract and technical specification Main transformer specification Box transformer specification' Supervision completion report Operation performance monthly report 35 kV cable diagram and capacitors Spare part list O&M budgeting method Spare part management method

No	Column
7	Lianyungang Guanyun Wind Farm Phase I Feasibility study Consent of land Approval of project from NDRC Notice of project approval Consent of EIA Grid connection agreement Grid despatch agreement PPA Operation performance monthly report Commissioning log of WTG 2011 Main components change record WTG layout WTG purchase contract Spare parts list Single line diagram Technical data table of equipments

Source: Huadian Fuxin

GLOSSARY

AOH	Actual Operating Hours
ASL	Above Sea Level
AGL	Above Ground Level
BCSE	Business Council for Sustainable Energy
BEC	Beijing Electricity Company
BOP	Balance Of Plant
CCGT	Combined Cycle Gas Turbine
CCHP	Combined Cooling Heating and Power
CHP	Combined Heat and Power
CI	Combustion Inspection
CW	Cooling Water
CWEA	China Wind Energy Association
CREIA	Chinese Renewable Energy Industries Association
CSG	China Southern Power Grid Co., Ltd.
Cut-in Wind Speed	Wind speed at which a wind turbine begins to generate electricity
Cut-out Wind Speed	Wind speed at which a wind turbine ceases to generate electricity
DCS	Distributed Control System
DFIG	Double-Fed Induction Generator
EIA	Environmental Impact Assessment
EOH	Equivalent Operating Hours

EPC	Engineer, Procure and Construct
GB/T	Guobiao/Tujian, Chinese National Standard, Recommended
GE	General Electric Company, Energy
Gearbox Ratio	Ratio of the speed of rotation of the powered gear to that of the final gear
GL	Germanischer Lloyd
GT	Gas Turbine
GWEC	Global Wind Energy Council
HGPI	Hot Gas Path Inspection
HP	High Pressure
HRSG	Heat Recovery Steam Generator
Hub Height	Distance from the ground to the center-line of the turbine rotor
IEC	International Electrotechnical Commission
IMPC	Inner Mongolia Power Company
IP	Intermediate Pressure
IPO	Initial Public Offering
ISO	International Organization for Standards
LP	Low Pressure
LTSA	Long Term Service Agreement
LVRT	Low Voltage Ride Through
MCP	Measure Correlate Predict
MHI	Mitsubishi Heavy Industries Limited

MM	Mott MacDonald Limited
NCEPRI	North China Electric Power Research Institute
NG	Natural Gas
NOx	Nitrogen Oxides
OEM	Original Equipment Manufacturer
O&M	Operation and Maintenance
PPA	Power Purchase Agreement
PRC	People's Republic of China
QHSE	Quality, Health & Safety and Environment
Rated Power	Maximum power that a WTG can produce at constant wind speed
RH	Relative Humidity
RMS	Gas Regulating and Metering Station
SCADA	System Control and Data Acquisition
SGCC	State Grid Corporation of China
ST	Steam Turbine
UK	United Kingdom
UPS	Uninterruptible Power Supply
WAsP	Wind Atlas Analysis and Application Program
WTG	Wind Turbine Generator

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