CLEAN DEVELOPMENT MECHANISM
PROJECT DESIGN DOCUMENT FORM (CDM-PDD)
Version 03 - in effect as of: 28 July 2006

CONTENTS

Annexes

SECTION A. General description of project activity

A.1. Title of the project activity:

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Energy efficiency improvements of Pucheng Power Plant through retrofitting turbines in China
Version 02.8
15 August 2011

A.2. Description of the project activity:

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This project activity improves the efficiency of electricity generation by retrofitting 2 × 330MW steam turbines used in a coal-fired power plant owned by Shaanxi Huadian Pucheng Power Generation Co., Ltd. (hereafter referred to as Pucheng Power Plant), located in Sunzhen, Pucheng County, Weinan City, Shaanxi Province, China. The plant is a subsidiary of China Huadian Corporation, which is one of the five biggest power companies in China.

Pucheng Power Plant operates six units of coal fired power plants in Pucheng County. Phase 1 construction (2 x 330MW units) started in 1983 and commenced operation in 1998. Phase 2 construction (2 x 330MW units) started in 2000 and commenced operation in 2003. Phase 3 construction (2 x 660MW units) started in 2005 and commenced operation in 2008. The CDM project focuses on Phase 1 only (No.1 and No.2 Units). The plant sells their electricity through Shaanxi Electric Power Corporation connected to North-West Power Grid (NWPG).

AM0062 was developed for this project activity.

Existing scenario and the baseline scenario

The turbines were made in Romania using technology developed in the 1960s and started operation on 3 September 1996 and 27 April 1998 respectively. The low-energy efficiencies of these two turbines are responsible for a decrease in the generation efficiency of the power plant. However, without this project activity, the power plant will be kept running without retrofitting the turbines because the return rate on the investment in turbine retrofit projects is low while the power demand is high.

Project scenario

The project activity aims to increase the efficiency rate of the turbines by approximately 10% (relative to the baseline). The energy efficiency of a power plant is subject to the thermal efficiencies of its boilers and turbines; i.e., efficiency improvements to either or both boiler and turbine lead to efficiency improvements of the power plant. In the case of Pucheng Power Plant, from several performance tests, it has been determined that the efficiency of the turbines is relatively low.

The main target of this retrofit project activity is optimization of the design of steam flow paths. The project activity involves replacement of the rotors and rotating blades of high-, medium-, and low-pressure turbines, while it utilizes the existing base and casing. Modifying the design of the blades, whose performances and designs greatly affect turbine efficiencies, will bring about a reduction in steam flow leakage and internal loss, thus improving the internal efficiency of turbines.

As a result of the project activity, Pucheng Power Plant will achieve lower coal consumption rates, and CO_2 emissions from the power plant will be reduced by 270,205 tonnes of CO_2/year.

Contribution to sustainable development

The project activity will contribute to China's sustainable development by leading the way for retrofits of 200-300MW-class turbines. Retrofitting to improve the energy efficiencies of turbines will decrease coal consumption. That is, it will contribute to saving coal, the primary energy resource in China. As the input energy (coal consumption) per electricity generation is reduced, not only CO_2 but also SO_2 and NO_x emissions and coal ash production are reduced. Moreover, it is expected that this project will trigger the spread of production of high-efficient turbine rotating blades made in China, which can bring positive economic effects and further technology development.

A.3. Project participants:

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Name of Party involved ((host) indicates a host Party)	Private and/or public entity(ies) project participants(*) (as applicable)	Kindly indicate if the Party involved wishes to be considered as project participant (Yes/No)
People's Republic of China (host)	Shaanxi Huadian Pucheng Power Generation Co., Ltd.	No
Japan	Kyushu Electric Power Co., Inc.	No

A.4. Technical description of the project activity:

A.4.1. Location of the project activity:

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A.4.1.1. Host Party(ies):

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People's Republic of China

A.4.1.2. Region/State/Province etc.:

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Shaanxi Province

A.4.1.3. City/Town/Community etc.:

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Sunzhen, Pucheng County, Weinan City

A.4.1.4. Details of physical location, including information allowing the unique identification of this project activity (maximum one page):

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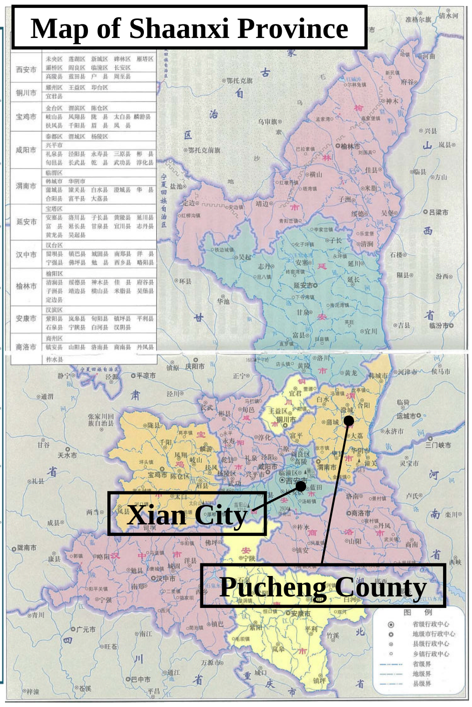
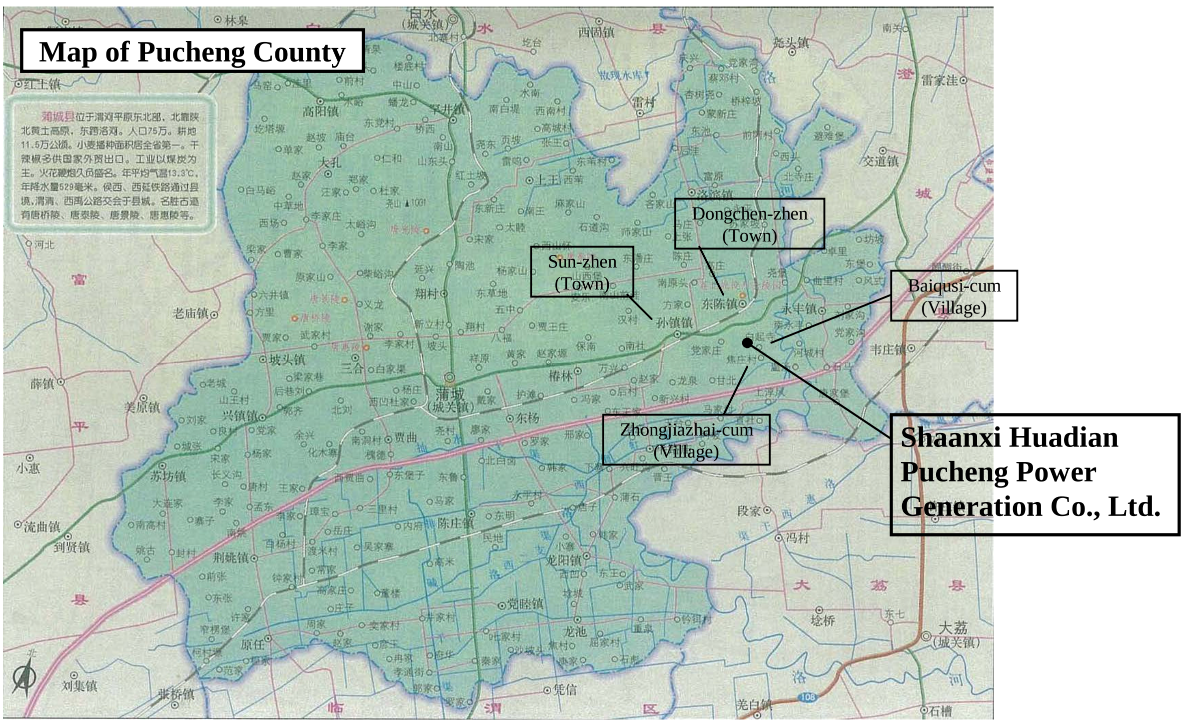
Pucheng Power Plant is located in the south-eastern part of Sunzhen, Pucheng County, Weinan City, Shaanxi Province, 120 km northeast of Xian City, 4.5 km west of the Luo River on the huge Ocher Plateau. It lies at latitude 34°58’ 45”north and longitude 109°47’24” east.





A.4.2. Category(ies) of project activity:

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Sectoral scope 1: Energy industries (renewable - / non-renewable sources)

A.4.3. Technology to be employed by the project activity:

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This project activity improves the efficiency of electricity generation by retrofitting 2 × 330MW steam turbines at Pucheng Power Plant.

The project activity aims to increase the efficiency rate of the turbines by approximately 10% (relative to the baseline). The energy efficiency of a power plant is subject to the thermal efficiencies of its boilers and turbines; i.e., efficiency improvements to either or both boiler and turbine lead to efficiency improvements of the power plant. In the case of Pucheng Power Plant, from several performance tests and operational data, it has been determined that the efficiency of the turbines is relatively low.

The main target of this retrofit project activity is optimization of the design of flow paths. The project activity involves replacement of the rotors and rotating blades of high-, medium-, and low-pressure turbines, while it utilizes the existing base and casing. Modifying the design of the blades, whose performances and designs greatly affect turbine efficiencies, will bring about a reduction in steam flow leakage and internal loss, thus improving the internal efficiency of turbines.

Technology prior to the project activity
These two turbines were made in Romania with technology developed by Alstom in the 1960s and the turbines started operation on 3 September 1996 and 27 April 1998 respectively. Since the start of operation, these turbines have not reached the rated capacity. Besides, the heat rates (design value 8229.9kJ/kWh) have increased over the years due to aging degradation. Recent performance tests have revealed that the low-energy efficiencies of the turbines are responsible for the low generation efficiencies of Pucheng Power Plant.

The principal specifications of the steam turbines are shown below:

Table 1 Comparison of technical specifications of the steam turbines before and after retrofitting

		Unit	Before retrofitting	After retrofitting
Manufacturer			General Turbine, Inc. (Bucharest, Romania)	Dongfang Turbine Co., Ltd. (China)
Type			4-cylinder 4-exhaust condensing turbine	4-cylinder 4-exhaust condensing turbine
Capacity (name plate output)		MW	330	360
Speed		r/min	3000	3000
Main Steam (HP turbine inlet)	Pressure	MPa	18.24	18.24
	Temperature	°C	535	535
Reheated Steam (IP turbine inlet)	Temperature	°C	535	535
Exhaust Pressure		kPa	5.4	5.4

According to performance test reports, the heat rates before retrofitting are 8,706.07kJ/kWh (41.35%) for No.2 turbine (January 2009) and 8,812.48kJ/kW (40.85%) for No.1 turbine (August 2009) respectively at the load factor 330 MW. In contract with Dongfang Turbine Co., Ltd., the heat rate after retrofitting is guaranteed to reach at 7913 kJ/kWh. This is approximately a 10% rise in comparison to the baseline.

The baseline scenario is that Pucheng Power Plant continues the operation without retrofitting turbines. Although retrofitting the turbines will increase the energy efficiencies of the power plant, the return rate on the investment in turbine retrofit projects is low while the power demand is high (Table 2).

Table 2 Load factor and average utilization hours

Year	Load factor (%)		Average utilization hours (hours)	
	No.1	No.2	No.1	No.2
2006	68.05	68.76	4435.25	5541.08
2007	70.30	70.34	4594.30	5480.14
2008	72.30	70.95	5181.05	5888.35

Note: Load factor = (electricity generated / operating hours) / rated capacity. A utilization factor used to compare units with different capacities.
Average utilization hours = electricity generated / rated capacity. Utilization hours as converted at full capacity.
Source: Operation log of Pucheng Power Plant

Procedure for estimating remaining lifetime of the power generation equipments
According to the Standard for the Specification for Stationary Utility Condensing Steam Turbine (SD269-88) established by the Ministry of Water Resources and Electric Power, P. R. China (Published 11 April 1988, effective 1 July 1988), the technical lifetime of a domestically-produced stationary utility condensing steam turbine with a capacity of more than 12MW should be at least 30 years. Since the project turbines started operation in 3 September 1996 and 27 April 1998 respectively, the remaining life at the start of the project activity (2 April 2007) is at least 19 years, far more than 10 years.

Project technology
The main target of retrofitting is the steam flow passages of high-, medium-, and low-pressure of turbines whose performances and designs greatly affect turbine efficiency, while the outer casing and base will be utilized without modification.

The latest technology of Dongfang Turbine Co., Ltd will be employed. Dongfang Turbine Co., Ltd. is one of the three biggest turbine manufacturers in China and has cooperated technologically with Hitachi Co., Ltd. in Japan. In particular, the shape of the rotating blades, which effectively convert steam energy to kinetic energy, have a strong impact on turbine efficiency. It is planned to use a "3-D compound lean blade", which requires advanced design, production, and inspection expertise. The advanced technologies of Dongfang Turbine Co., Ltd. employed by the project activity include:

- 3D viscous aero-dynamic design system
- Steam path with contoured sidewalls
- Advanced control stage
- After-loading vane profile with high efficiency

- Bowed blade with shroud
- Compound lean blade
- Splitter cascade
- Optimized controlled-vortex design
- Balanced compound-lean blade
- Blade with shroud
- Packing seal with multi-teeth
- Enthalpy optimization

Whilst maintaining the kinetic energy of the rotating blades, steam flow leakage to the downstream should be minimized. Steam flow leaks from spaces between the tips of rotating blades and inner casing, due to high steam pressure. All thermal energy is not transferred to rotors; a portion of the energy goes downstream as energy loss. As minimizing stream leakage should help to improve the energy efficiency of turbines, the seal mechanism is also modified with a special design.

By retrofitting the turbines, the rated capacity increases from 330MW to 360MW. On the other hand, the main steam temperature and pressure before stop valve, reheat steam temperature and pressure, exhaust steam conditions and condenser vacuum will remain the same.

Monitoring

See B.7 for the parameters, equipment, and location of monitoring.

A.4.4. Estimated amount of emission reductions over the chosen crediting period:

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The crediting period chosen is a fixed baseline of 10 years and the estimated amounts of emission reductions over the crediting period are shown in the table below. The crediting period will be from 01/07/2011 to 30/06/2021:

Years	Annual estimation of emission reductions in tonnes of CO_2e
2011 (Jul-Dec)	135,102
2012	270,205
2013	270,205
2014	270,205
2015	270,205
2016	270,205
2017	270,205
2018	270,205
2019	270,205
2020	270,205
2021 (Jan-Jun)	135,102
Total estimated reductions (tonnes of CO_2e)	**2,702,050**
Total number of crediting years	**10 years**
Annual average over the crediting period of estimated reductions (tonnes of CO_2e)	**270,205**

A.4.5. Public funding of the project activity:

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No public funding is involved.

SECTION B. Application of a baseline and monitoring methodology

B.1. Title and reference of the approved baseline and monitoring methodology applied to the project activity:

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The approved methodology that is used:

- AM0062 Energy efficiency improvements of a power plant through retrofitting turbines (Version 1.1)

Methodologies and tools which AM0062 draws upon:

- Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion (Version 02)
- Combined tool to identify the baseline scenario and demonstrate additionality (Version 02.2)
- Tool to calculate the emission factor for an electricity system (Version 02)

AM0062 was developed for this project activity.

B.2. Justification of the choice of the methodology and why it is applicable to the project activity:

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The methodology AM0062 is applicable to project activities where steam turbines and gas turbines are retrofitted with component(s) of improved design for energy efficiency improvements in an existing fossil fuel power plant.

The methodology is only applicable if all the following conditions are met:

1. The electricity is generated using fossil fuels; no biomass or waste heat is used;
   ------> The project power plant is coal-fired and not co-combustion.

2. The power plant where the project activity is applied supplies electricity to a grid only;
   ------> The project power plant supplies all the generating electricity to a grid.

3. In case of steam turbines, the steam supply and electricity generation should be separately measureable for each turbine retrofitted under the project activity;
   ------> The steam supply and electricity generation can be separately measureable for each turbine of Nos. 1 & 2.

4. Activities covered under the following two categories are not eligible as CDM activity under this methodology:
   (a) All the recommended regular or preventive maintenance activities (including replacements and overhauling) as provided by the manufacturer of turbine;
   (b) A superior practice of preventive maintenance e.g. sophisticated cleaning systems, resulting into an improved efficiency compared to historical efficiency after maintenance;

------> The project activity does not fall under either category above.

5. Project activities are only eligible when:
   (a) The operational parameters of turbines, that affect the energy efficiency of turbine, remain the same (subject to a variation of +/-5%) in the baseline and the project scenario (e.g. steam pressure and temperature, quality of steam in the case of a saturated steam turbine; condenser vacuum, and combustion temperature for gas turbine);
   ------> The project activity does not include any boiler retrofitting or does not change the operational parameters of the turbines (main steam temperature and pressure, reheat steam temperature). See Table 1.
   (b) The project activity does not increase the lifetime of the existing turbine during the crediting period (i.e. this methodology is applicable up to the end of the lifetime of the existing turbine, if shorter than crediting period);
   ------> The existing turbines started operation in 3 September 1996 and 27 April 1998 respectively and have a lifetime of 30 years, which means the remaining lifetime is much longer than the crediting period.

6. Where applicability conditions of the latest version of Board approved "Tool to calculate the emission factor for an electricity system" apply.
   ------> The tool is referred to in order to estimate the OM, BM and/or CM for the purpose of calculating baseline emissions for a project activity substitutes electricity from the grid, i.e. where a project activity supplies electricity to a grid or a project activity that results in savings of electricity that would have been provided by the grid (e.g. demand-side energy efficiency projects). The project activity meets the applicability condition of the tool.

The methodology is not applicable:

To project activities that involve fuel switch;
------> The project activity does not involve any fuel switch.

To combined cycle power plants, cogeneration plants, or the power plant that is part of an industry and a portion of the electricity is used to meet the internal demand of the industry.
------> The project power plant does not fall under any of the above types of plants.

Finally, this methodology is only applicable if the application of the procedure to identify the baseline scenario provides the results that the continuation of the current practice is the most plausible baseline scenario.
------> See B.4.

B.3. Description of the sources and gases included in the project boundary:
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The spatial extent of the project boundary includes the turbine directly connected to the electric generator (turbo-generator), boiler and condenser in the power plant and the electricity grid to which the CDM project power plant is physically connected.

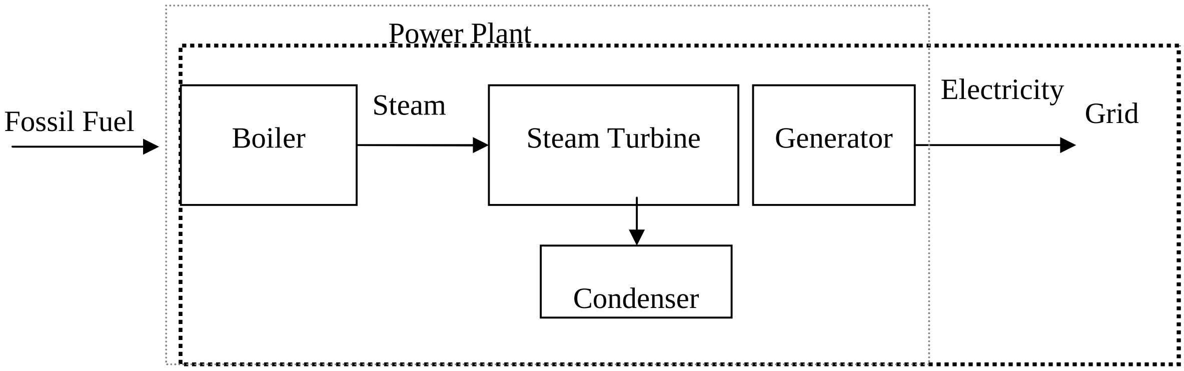

Figure 1: Conceptual diagram of the project boundary for steam turbine

The greenhouse gases included in or excluded from the project boundary are shown in Table 3.

Table 3 Emissions sources included in or excluded from the project boundary

	Source	Gas	Included?	Justification / Explanation
Baseline	Grid electricity generation	CO_2	Yes	Main emission source.
		CH_4	No	Excluded for simplification. This is conservative.
		N_2O	No	Excluded for simplification. This is conservative.
	On-site fossil fuel consumption to operate the power plant.	CO_2	Yes	An important emission source.
		CH_4	No	Excluded for simplification. This emission source is assumed to be very small.
		N_2O	No	Excluded for simplification. This emission source is assumed to be very small.
Project Activity	On-site fossil fuel consumption to operate the power plant.	CO_2	Yes	An important emission source.
		CH_4	No	Excluded for simplification. This emission source is assumed to be very small.
		N_2O	No	Excluded for simplification. This emission source is assumed to be very small.

B.4. Description of how the baseline scenario is identified and description of the identified baseline scenario:

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The baseline scenario is identified through the “Combined tool to identify the baseline scenario and to demonstrate additionality”.

Step 1: Identification of alternative scenarios

Sub-step 1a: Define alternative scenarios to the proposed CDM project activity

According to the methodology, the following scenarios should be considered as alternatives.

- Continuation of the current practice – the turbine continues to be operated without retrofitting;
- Turbine retrofit project activity is implemented without CDM;
- Part of turbine retrofit project activity is implemented without CDM;
- Turbine retrofit project activity (or part thereof) is implemented without CDM at a later point in time when technology is more common practice or other barriers are removed;
- A new turbine (either steam turbine, open cycle or combined cycle turbine) with a higher efficiency is installed to replace the existing turbine;
- Other retrofit activities that could result in increase in electricity generation.

There are 57 units (23 in Shaanxi, 14 in Ningsia, 18 in Gansu, 2 in Qinghai) of 300MW-class units in the North-West Power Grid (NWPG)[1].

The realities of the alternatives above have been examined.

Scenario 1 Continuation of the current practice – the turbine continues to be operated without retrofitting

------> Since the start of operation neither No.1 nor No.2 turbine has been retrofitted. The remaining lives of the turbines are long enough and operation safety and stability are assured without retrofitting. No additional cost is required. A realistic option.

Scenario 2 Turbine retrofit project activity is implemented without CDM

------> A cost-effective and realistic option. Credibility is to be decided in Section B.5.

Scenario 3 Part of turbine retrofit project activity is implemented without CDM

------> It is not a realistic option because part replacement of the turbines has limited energy-saving effect while it requires shutdown of the power plant.

Scenario 4 Turbine retrofit project activity (or part thereof) is implemented without CDM at a later point in time when technology is more common practice or other barriers are removed

------> Since the turbines were made in Romania and there is no original documentation of the design, a custom-design is required. Therefore, it is not expected to come down in price over time. Moreover, as the remaining life of a turbine becomes shorter, the IRR becomes lower.

Scenario 5 A new turbine (either steam turbine, open cycle or combined cycle turbine) with a higher efficiency is installed to replace the existing turbine

------> Replacing the existing turbine with a new highly-efficient turbine requires a large investment. Such a large investment would be avoided since the target equipment has been only used for one third of its expected actual service life. Considering the plant capacity and the average actual service life of a power plant in China, it is an unlikely option.

Scenario 6 Other retrofit activities that could result in increase in electricity generation

[1] Investigated by Northwest Electric Power Research Institute.

------> According to the performance tests carried out at Pucheng Power Plant, other retrofit activities including a more expensive boiler retrofit have less energy-saving effects than a turbine retrofit.

Therefore, only scenario 1 and 2 are considered realistic alternatives.

Sub-step 1b: Consistency with mandatory applicable laws and regulations:

Both scenario 1 and 2 are in compliance with all legal and regulatory requirements. There are a few laws and regulations relating to energy saving. The 'Energy Saving Law' was revised on 28 October 2007 and enacted on 1 April 2008. The 'Circulation-type Economy Promotion Law' was issued on 29 August 2008. Shaanxi Province promulgated the 'Energy Saving Act' on 1 December 2006. However, all of these are for promoting energy saving and are not mandatory. In addition, although the Chinese government has been promoting its policy of shutting down inefficient small-scale power plants, 300MW-class power plants are not a target of the policy thus far.

From the above assessment, it is clear that the following scenarios are plausible and credible as possible candidates for the baseline scenario:

- Scenario 1– Continuation of the current practice – the turbine continues to be operated without retrofitting
- Scenario 2– Turbine retrofit project activity is implemented without CDM

It will be demonstrated under the additionality assessment in Section B.5 that Scenario 2 faces barriers to be implemented without CDM leaving only Scenario 1 as the baseline scenario.

B.5. Description of how the anthropogenic emissions of GHG by sources are reduced below those that would have occurred in the absence of the registered CDM project activity (assessment and demonstration of additionality):

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The additionality is assessed and demonstrated through an investment analysis of the "Combined tool to identify the baseline scenario and to demonstrate additionality".

Step 2: Barrier analysis

Sub-step 2a: Identify barriers that would prevent the implementation of alternative scenarios

No barrier has been identified for Scenario 1.

Scenario 2 may face technological barriers because the turbines were made in Romania and there is no original documentation of the design. The scenario also may face prevailing practice barriers because the project is the "first of its kind" in the grid.

Sub-step 2b: Eliminate alternative scenarios which are prevented by the identified barriers

The identified barriers for Scenario 2 have been lessened by the efforts of the Chinese manufacturers and/or the technological cooperation with Japan and other developed countries. Hence, these barriers are not analyzed in detail and the two alternative scenarios are remaining to proceed to Step 3.

Step 3: Investment analysis

The identified alternative scenarios are as follows:

Scenario 1 Continuation of the current practice – the turbine continues to be operated without retrofitting

Scenario 2 Turbine retrofit project activity is implemented without CDM

IRR was adopted as the most suitable financial indicator in the decision making process. The suitable benchmark value is described as 8% in the *Interim Rules on Economic Assessment of Electrical Engineering Retrofit Projects (China Electric Power Press, 2003)*[2], which is commonly used for power project investments in China. This 8% benchmark figure is employed in the IRR of total investment. The table below represents the main data used in the IRR calculation for the Scenario 2. All the assumptions are listed below in order to maintain a transparent approach. The values for the initial investment and the income are the total of No.1 and No.2 turbines as the decision has been made together for the both units. The resulting IRR was 5.5%.

Table 4: Data used in the calculation of IRR for the Scenario 2

	Values	Sources
Financial Details		
Initial investment for turbines (including installation, retrofitting of generator and auxiliaries)	295,000,000 CNY	295,000,000 CNY was integrated by Shaanxi Huadian Pucheng Power Generation Co., Ltd. from estimation of suppliers at May 2006 when the decision was made to invest in retrofitting the turbines. The initial investment for turbines was finally reached at 350,847,500CNY.
Income	26,662,000 CNY/year	Calculated by multiplying the expected decreasing amount of coal consumption by the average purchase price of coal (without VAT). See the data assumptions below.
Project life (the remaining lifetime of the baseline turbines)	18 years	Calculated assuming the starting date of operation is October 2008.
Expenses		
Average O&M costs	0	Judged by the current status of the power station. Retrofitting turbines will not affect the O&M method or cost.
IRR without CER revenue	**5.5 %**	
IRR with CER revenue	**11.7 %**	

[2] http://cdm.unfccc.int/UserManagement/FileStorage/JL694VF0I1STX3G7M3RL8W0TMHVOAR

Data assumptions:

- The IRR was calculated at the point in time when Shaanxi Huadian Pucheng Power Generation Co., Ltd, decided to invest in retrofitting the turbines in May 2006. In the calculation, the completion date of retrofitting both turbines, No.1 Unit and No.2 Unit, was set to be September 2008 and the starting date of operation was assumed to be October 2008. Although Pucheng Power Plant had expected that the construction would be completed by June 2008 for No.2 Unit and by September 2008 for No.1 Unit, delays in delivery of turbines were not uncommon at that time.
- O&M costs including maintenance cost and labor cost were not considered as costs in the IRR calculation because they would remain unchanged with the project.
- Thus, in the calculation of IRR, the initial investment is the turbine retrofit cost and the income is the annual coal cost saving by energy efficiency improvement. As energy efficiency is improved by retrofitting turbines, the amount of coal consumption per production of electricity decreases.
- Pucheng Power Plant had set the future coal price of 207.1 CNY/t for the IRR analysis, which was the actual coal price at year 2005; the coal price had been stable as of May 2006 when the decision was made.
- Since the amount of electricity to supply to the grid will remain unchanged before and after retrofitting, the revenue from electric power sales will not change. In that case, the change in the sales need not be taken into account in the calculation of IRR.
- 2% of CER revenues after deducting EB-SOP-Admin should be paid to the Chinese Government and 15% or 33% income tax is imposed on the remaining amount. 15% income tax adopted as a means of executing China Western Development is applied up to 2010 and 33% is applied thereafter. The expected CER price is set to be a market price of 8EUR/t-CO_2
- 20% of the cost of retrofitting turbines is self-financed and 80% is borrowed with 6.26% interest rate on a 15-year payment plan. The interests were included when calculating income tax and added back when calculating annual revenue.
- Depreciation is calculated using the general approach in China for a power plant, that is, the straight-line method with 20 years for the depreciation period and 3% as residual value. The depreciation is not used for IRR calculation to avoid a double calculation between the initial investment and the depreciation. However, the depreciation is used for estimating income tax.
- Residual value was added as fair value of the project activity at 18 years after retrofitting.
- The IRR calculation period was set to be 18 years, equivalent to the length of the project life or the remaining lifetime of the baseline turbines. Since the No.1 Unit had started operation in September 1996 and the lifetime of the turbine was expected to be 30 years, the equipment life would end in 2026. The remaining life was determined from the starting reference point of October 2008, the expected starting date of operation of the retrofitted turbines. Although the No.2 Unit had started operation at the later date, a conservative approach was adopted.
- The exchange rate in April 2006 was 10.13 Chinese Yuan to the Euro and 8.01 Chinese Yuan to the dollar.

The IRR is compared to the benchmark to examine the financial attractiveness of retrofitting the turbine. The project IRR is estimated to be 5.5%, which is lower than the benchmark of 8%. Low IRR, compared to the hurdle rate, indicates that this project is not financially attractive without CDM assistance. The project IRR with CER revenue is estimated to be 11.7% exceeding the hurdle rate of 8%, which indicates that this project is financially attractive with CDM assistance.

The initial investment of 295,000,000 CNY in the calculation was the price quoted by the manufacture as of May 2006 when the decision was made. Subsequently, the contract was made in 2009 at 350,847,500 CNY. The retrofit cost was increased because the plant construction boom had brought about a tight supply of turbines. The initial investment includes the cost of retrofitting generators and auxiliaries other than the cost of turbines themselves. The generators and some auxiliaries need to be retrofitted to cope with the increase of the turbine capacity.

Sensitivity Analysis

The following assumptions are established to examine whether the conclusion regarding the financial attractiveness of the project is robust:

As the price of coal rises, the savings in the cost of coal increases; increase in apparent income results in higher IRR. Also, decrease in the cost of retrofitting turbines results in higher IRR. Therefore, sensitivity analysis has been conducted on the price of coal and the cost of retrofitting turbines.

The IRR is equivalent to the benchmark 8% when the cost of retrofitting turbines decreases to 80.5 % compared to the expected cost (See Figure 2) or when the price of coal rises to 127.5 % compared to the expected price (See Figure 3). It seems very unlikely that the cost of retrofitting turbines would decrease to 80.5% of the expected cost and/or that the price of coal would rise to 127.5% in a situation where the coal price had been stable around 2006 when the decision was made for retrofitting turbines; hence Scenario 2 may not be economically attractive.

Among the alternative scenarios, Scenario 1 (continuation of the current practices) is the sole scenario deemed most plausible as the baseline scenario.

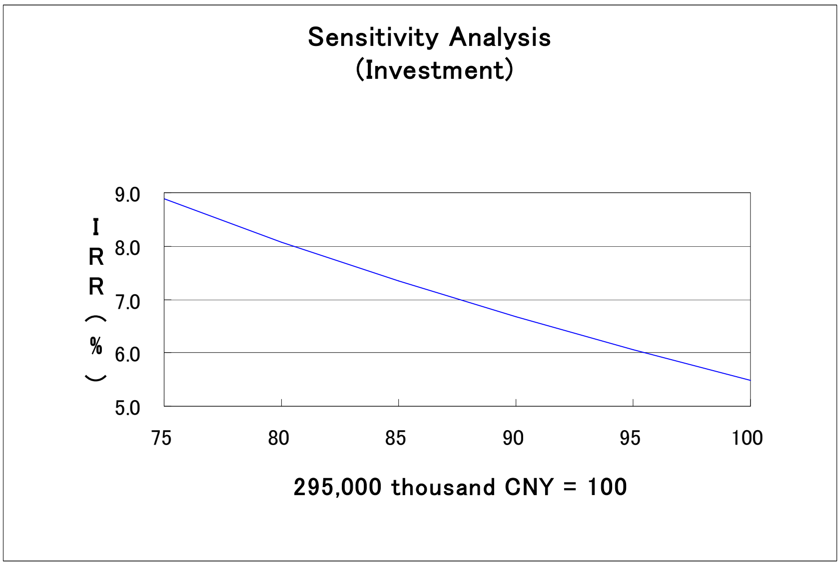

Figure 2: Sensitivity analysis for investment

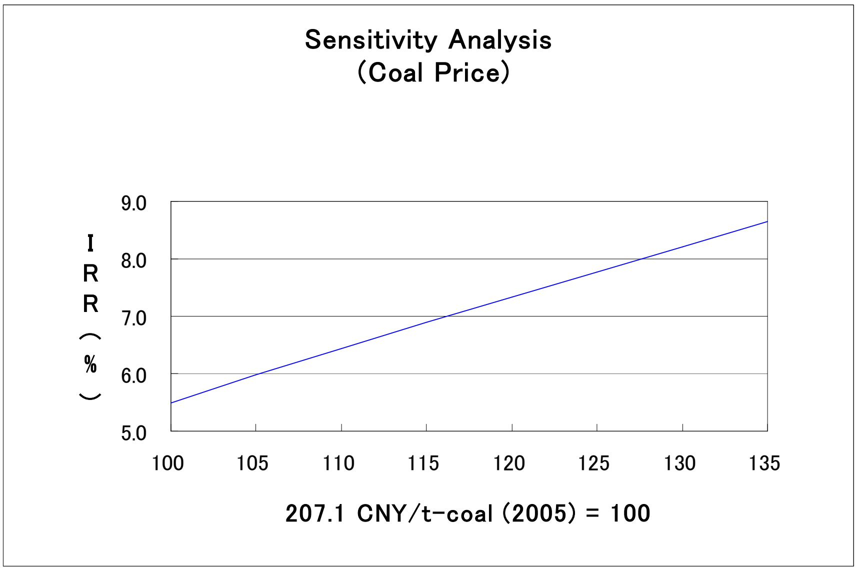

Figure 3: Sensitivity analysis for coal price

Step 4: Common practice analysis

As stated in step 1, none of the turbines of the 57 units in the NWPG has been retrofitted. Additionally, few retrofitting turbine project activities for 300MW-class power plants have been conducted by the five biggest power companies in China. This CDM project activity is expected to pioneer the way for other power plants.

Evidence of the Project's being considered for CDM development and major events

Since CDM revenues play an important role in the investment decision of the Project, Shaanxi Huadian Pucheng Power Generation Co., Ltd. and China Huadian Corporation have given serious consideration to the CDM as described in Table 5. The approved methodology AM0062, which was developed to apply for this project, is inter alia the credible evidence that real actions were taken to secure CDM status for the project in parallel with its implementation.

Table 5: Timeline of the proposed CDM project activity

February 2005	Completion of the FSR
7 December 2005	China Huadian Corporation, the parent company of Shaanxi Huadian Pucheng Power Generation Co., Ltd, consulted with Mitsubishi Research Institute, Inc. about a turbine retrofit project at Pucheng Power Plant using CDM.
27 March 2006	The turbine retrofit project at Pucheng Power Plant was approved by China Huadian Corporation.
12 May 2006	Board meeting in which the decision of implementation of the project activity was made.

15 May 2006	Report on the implementation of a CDM project activity was submitted to Shaanxi Development and Reform Commission by Pucheng Power Plant
31 May 2006	The application for environmental impact assessment was accepted by Shaanxi province officials.
5 October 2006	A new CDM methodology for a turbine retrofit project activity was submitted to UNFCCC as NM0203 with the PDD of this project activity.
2 April 2007	Pucheng Power Plant placed an order for turbines with Dongfang Turbine Co., Ltd.
30 November 2007	The new CDM methodology for a turbine retrofit project activity was approved as AM0062 by CDM Executive Board.
12 May 2008	Sichuan Earthquake damaged factories of Dongfang Turbine Co., Ltd. significantly and caused delivery delay.
23 September 2008	Shaanxi Huadian Pucheng Power Generation Co., Ltd. signed an ERPA with Kyushu Electric Power Co., Inc.
10 April 2009	Kyushu Electric Power Co., Inc. signed a contract with Japan Quality Assurance Organization (DOE) for CDM validation.
13 -15 January 2009	Performance test of No.2 turbine before retrofitting.
18 February 2009 - 15 July 2009	Retrofitting of No.2 turbine.
20 July 2009	No.2 turbine was reconnected to the grid.
13 - 20 August 2009	168 hour-test of No.2 turbine.
15 - 17 August 2009	Performance test of No.1 turbine before retrofitting.
20 August 2009	Starting full operation of No.2 turbine.
15 September 2009 - 10 January 2010	Retrofitting of No.1 turbine.
7 - 10 November 2009	Performance test of No.2 turbine after retrofitting.
20 January 2010	No.1 turbine was reconnected to the grid.
28 January 2010 - 4 February 2010	168 hour-test of No.1 turbine.
4 February 2010	Starting full operation of No.1 turbine.
28 February 2010 - 10 March 2010	Performance test of No.1 turbine after retrofitting.

The project activity does not cause any amendment to the Power Purchase Agreement with the grid company, Shaanxi Electric Power Corporation.

B.6. Emission reductions:

B.6.1. Explanation of methodological choices:

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The proposed project activity fully meets all the applicability requirements of the approved methodology AM0062 “Energy efficiency improvements of a power plant through retrofitting turbines”, and the project emissions, baseline emissions, leakage emissions, and emissions reductions are calculated in accordance with the methodology.

The emission reduction (ER_y) by the project activity during year y is the difference between the baseline emissions (BE_y), project emissions (PE_y) and emissions due to leakage (LE_y), and can be expressed as follows:

$$ER_y = BE_y - PE_y - LE_y$$

Equation 1

Where:

ER_y = Emission reductions in year y (t CO_2/yr)
BE_y = Baseline emissions in year y (t CO_2/yr)
PE_y = Project emissions in year y (t CO_2/yr)
LE_y = Leakage emissions in year y (t CO_2/yr)

Baseline emissions (BE_y)

The baseline emissions for year y (BE_y) are calculated as follows:

Step 1: Determine Baseline Emissions for different scenarios of project electricity generation
Since the project activity turbine provides electricity to the grid, the following cases are differentiated and the methodological choice for case a) to c) is determined based on actual electricity generation:

Case a) The quantity of electricity generated in the project activity turbine ($EG_{PJ,y}$) exceeds the maximum annual quantity of electricity that the turbine could have produced prior to the implementation of the project activity (EG_{MAX}). Baseline emissions are calculated as:

$$BE_y = EG_{AVR} \cdot EF_{BL,y} + \left(EG_{MAX} - EG_{AVR}\right) \cdot \min\left(EF_{BL,y}; EF_{grid,y}\right) + \left(EG_{PJ,y} - EG_{MAX}\right) \cdot EF_{grid,y}$$

Equation 2

Case b) The quantity of electricity generated in the project activity turbine ($EG_{PJ,y}$) exceeds the historic average annual generation level (EG_{AVR}) but is lower than the maximum annual quantity of electricity that the turbine could have produced prior to the implementation of the project activity (EG_{MAX}). Baseline emissions are calculated as:

$$BE_y = EG_{AVR} \cdot EF_{BL,y} + \left(EG_{PJ,y} - EG_{AVR}\right) \cdot \min\left(EF_{BL,y}; EF_{grid,y}\right)$$

Equation 3

Case c) The quantity of electricity generated in the project activity turbine ($EG_{PJ,y}$) is lower or the same as the historic average annual generation level (EG_{AVR}). Baseline emissions are calculated as:

$$BE_y = EG_{PJ,y} \cdot EF_{BL,y}$$

Equation 4

Where:

BE_y	=	Baseline emissions in year '*y*' (tCO_2/yr)
$EG_{PJ,y}$	=	Quantity of electricity supplied by the project activity turbine to the grid in year '*y*' (MWh/yr), adjusted for changes in efficiency.
EG_{AVR}	=	Average annual quantity of electricity supplied by the project activity turbine to the grid during the three most recent historical years prior to the implementation of the project activity (MWh/yr)
EG_{MAX}	=	Maximum annual quantity of electricity that could have been supplied to the electricity grid by the project activity turbine prior to the implementation of the project activity (MWh/yr)
$EF_{BL,y}$	=	Baseline emission factor of the project activity turbine in year *y*, (tCO_2/MWh)
$EF_{grid,y}$	=	Emission factor of the electricity grid to which the project activity turbine is connected (tCO_2/MWh), estimated using "Tool to calculate emission factor for an electricity systems".

Note for above equations: When the project efficiency of turbine $\eta_{PJ,y}$ is above maximum efficiency of turbine $\eta_{PJ,\max}$ (as defined in section B.6.2), the adjusted generation of electricity ($EG_{PJ,y,adjusted}$) needs to be used in place of electricity generation ($EG_{PJ,y}$). For the procedure to estimate $EG_{PJ,y,adjusted}$ please refer Step-3 in this section.

Calculation of EG_{MAX}

The maximum annual amount of electricity that could have been supplied to the electricity grid by the PAT prior to the implementation of the project activity is calculated as:

$$EG_{MAX} = CAP_{max} \cdot T_{max}$$

Equation 5

Where:

EG_{MAX}	=	Maximum annual quantity of electricity that could have been supplied to the electricity grid by the project activity turbine prior to the implementation of the project activity (MWh/yr)
CAP_{max}	=	Maximum power generation capacity of the project activity turbine prior to the implementation of the project activity (MW)
T_{max}	=	Maximum amount of time in which the project activity turbine could have operated at full load prior to the implementation of the project activity (hours)

Calculation of T_{max}

$$T_{\max} = 8{,}760 - \frac{\sum_{x=1}^{3} HMR_x}{3}$$

Equation 6

Where:

T_{max} = Maximum amount of time during a year in which the project activity power plant could have operated prior to the implementation of the project activity (hours).

HMR_x = Average number of hours in a year during which the plant did not operate due to maintenance or repair, based on data for the three most recent years *x* prior to the implementation of the project activity (hours).

<u>*Calculation of EG_{AVR}*</u>

The average annual amount of electricity supplied to the electricity grid by the PAT prior to the implementation of the project activity is calculated as follows:

$$EG_{AVR} = \frac{\sum_{x=1}^{3} EG_{Tur,x}}{3}$$

Equation 7

Where:

EG_{AVR} = Average annual quantity of electricity supplied by the project activity turbine to the grid during the three most recent historical years prior to the implementation of the project activity (MWh/yr)

$EG_{Tur,x}$ = Quantity of electricity supplied by the project activity turbine (Project Activity Turbine) to the electricity grid in year *x* prior to implementation of project activity (MWh/yr)

x = Three most recent historical years prior to the implementation of the project activity

Step 2: Determine Baseline Emission Factor

The emissions factor for the baseline generation in tCO_2/MWh is calculated as follows. Case 1 is applied to the project activity because the project activity turbines are steam turbines:

Case 1: Emission factor for steam turbine, where fuel is fired in a boiler

$$EF_{BL,y} = \frac{3.6}{1000} \times \frac{EF_{FF,BL} \times HI_{PJ,y}}{\eta_{BL,y} \times FC_{PJ,y} \times NCV_{FF,PJ}}$$

Equation 8

Case 2: Emission factor for a gas turbine, where fuel is combusted in the turbine itself

$$\mathrm{EF_{BL,y}} = \frac{3.6}{1000} \times \frac{\mathrm{EF_{FF,BL}}}{\eta_{\mathrm{BL,y}}}$$

Equation 9

Where:

$EF_{BL,y}$	=	Baseline emission factor of the project activity turbine in year '*y*', (tCO_2/MWh)
$EF_{FF,BL}$	=	CO_2 emission factor of the fossil fuel used in the project activity turbine prior to the implementation of the project activity (tCO_2/TJ)
$NCV_{FF, PJ}$	=	Net Calorific Value (NCV) of fossil fuel used in the project activity turbine during year *y* (TJ/tonne of fuel)
$\eta_{BL,y}$	=	Energy efficiency of the turbine without retrofitting estimated using options A, B or C, as described below
$FC_{PJ,y}$	=	Actual fuel consumption by project in year '*y*' (tonne of fuel)
$HI_{PJ\,y}$	=	Heat input to the steam turbine in year '*y*' (TJ). In case of multi-cylinder steam turbines, this is the sum of the heat input at the inlet of first stage and the heat inputs in re-heaters of steam between various cylinders (e.g. high-pressure, medium pressure and low-pressure cylinders).

The baseline turbine efficiency ($\eta_{BL,y}$) is calculated using one of the following options:

Option A: Use the turbine baseline load-efficiency function

$$\eta_{BL,y} = \frac{\sum_t EG_{PJ,t}}{\sum_t (EG_{PJ,t} / \eta_{BL,t})}$$

Equation 10

Where:

$\eta_{BL,y}$	=	Energy efficiency of the turbine without retrofitting in year '*y*'
$EG_{PJ,t}$	=	Actual electricity generated in discrete time interval t, by project activity turbine in year '*y*' (MWh)
$\eta_{BL,t}$	=	Energy efficiency of the turbine without retrofitting, at discrete time interval 't', (Use following equation)
t	=	Discrete time interval of 1 hour (if the higher interval value is chosen by project proponents, the selection needs to be justified to DOE.)

Option A1: Establish an efficiency-load-function of the turbine, without retrofit.

$$\eta_{BL,t} = f(\mathrm{EG}_{\mathrm{PJ,t}}) + 1.96 \times \mathrm{SE(f(EG}_{\mathrm{PJ,t}}))$$

Equation 11

Where:

$EG_{PJ,t}$	=	Load of the turbine in discrete time interval '*t*' in year '*y*'
$f(\mathrm{EG}_{\mathrm{PJ,t}})$	=	Efficiency load function of the turbine, determined through the regression analysis, as described in Annex 1.
$\mathrm{SE(f(EG}_{\mathrm{PJ,t}}))$	=	Standard error of the result of the efficiency-load-function $f(\mathrm{EG}_{\mathrm{PJ,t}})$
t	=	Discrete time interval of duration *T hrs* for which the test is conducted

Option A2: Use manufacturer's load-efficiency function for the turbine without retrofit
The load-efficiency function (curve) should clearly show the efficiency of the turbine at various electrical loads. In case, the turbine is retrofitted (before the project activity occurs) in order to enhance the efficiency, the curve supplied by the turbine manufacturer may not match. Therefore a validation of the curve of the previously retrofitted turbine is necessary to show that the actual efficiency of the curve at few selected load points is either equal to or lower than the manufacturer's efficiency. Otherwise, for such retrofitted turbines, option-A1 should be followed.

Option B: Assume a constant efficiency for the baseline turbine and determine the efficiency, as a conservative approach, for optimal operation conditions. Efficiencies shall be determined through measurements based on performance tests as prescribed by international standards, norms and guidelines (ASME PTC 6-1996 or IEC 60953-3 (2001)) or an equivalent international and national standard).

Option C: Use manufacturer's specification of efficiency at optimum load.

$\eta_{BL,y}$ for the project activity will be calculated with Option B. This is a conservative approach since the Option B assumes the highest efficiency measured under the best conditions:

- The test should be carried out under ambient conditions when the cooling tower supplying water to condenser provides the coolest water. This is because; the vacuum generated under such conditions will be highest and therefore will provide optimal baseline efficiency. These conditions will pertain to best combination of ambient dry bulb and wet bulb temperatures. Generally the best conditions for operation of a cooling tower are achieved on the coldest days of the winter season.
- Best practices for operation of turbines should be followed.
- The measurement should be supervised by a competent independent third party testing institution. The measurement should be conducted immediately after scheduled preventive maintenance has been undertaken and under good operation conditions.

<u>Treatment of different fuels being used in the baseline scenario</u>
Note that the most plausible baseline scenario may be that several fuel types would be used in the baseline power plant. As a conservative approach for estimating baseline emission factor where the use of several fuel types is the most plausible baseline scenario, project participants should, select the emission factor of the fuel type with the lowest CO_2 emission factor from the fuels used in the power plant during the most recent three years prior to the implementation of the project activity.

Step 3: Determine the EG_{adjusted}

$$EG_{PJ,y,adjusted} = EG_{PJ,y} \times \eta_{PJ,min} / \eta_{PJ,y} \quad \text{If} \quad \eta_{PJ,y} \rangle \eta_{PJ,max}$$

Equation 12

Where:

$$\eta_{PJ,min} = \min(\eta_{PJ,y-1},.......\eta_{PJ,1})$$

Equation 13

$EG_{PJ,y}$	=	Quantity of electricity supplied by the project activity turbine to the grid in year '*y*' (MWh)
$EG_{PJ,adjusted,y}$	=	Adjusted electricity generation in project year for estimation of baseline emissions, if the efficiency of turbine in project year y is above the maximum efficiency
$\eta_{PJ,max}$	=	Maximum project energy efficiency of the turbine at the average load of year y based on load v/s efficiency curve drawn for the project turbine immediately after retrofit, as per the test immediately after the implementation of the project activity.
$\eta_{PJ,min}$	=	Minimum project energy efficiency of the turbine observed as per measurement requirements during the previous years (1 to 'y-1') after the implementation of the project activity
$\eta_{PJ,y-1}$	=	Project energy efficiency of the turbine during the year 'y-1'

Determination of efficiency of project activity turbine $\eta_{PJ,y}$

The efficiency of project activity turbine can be estimated either by using the following equations or in accordance with the recognized standards for the measurement of the turbine efficiency, such as ASME PTC 6 (1996) or IEC 60953-3 (2001). Please refer to the note on efficiency of the project activity turbine in section III.

Case: $\eta_{PJ,y}$ for steam turbines

$$\eta_{PJ,y} = \frac{EG_{PJ,y} * (3.6/1000)}{HI_{PJ,y}}$$

Equation 14

Case: $\eta_{PJ,y}$ for gas turbines

$$\eta_{PJ,y} = \frac{EG_{PJ,y} * (3.6/1000)}{FC_{PJ,y} \times NCV_{FF,PJ}}$$

Equation 15

Where:

$\eta_{PJ,y}$	=	Energy efficiency of the turbine in year '*y*'
$EG_{PJ,y}$	=	Actual electricity generated by project in year '*y*' (MWh)
$HI_{PJ,y}$	=	Heat input to the steam turbine in year '*y*' (TJ). In case of multi-cylinder steam turbines, this is the sum of the heat input at the inlet of first stage and the heat inputs in re-heaters of steam between various cylinders (e.g. high-pressure, medium pressure and low-pressure cylinders).
$FC_{PJ,y}$	=	Actual fuel consumption by project in year '*y*' (tonne of fuel)
$NCV_{FF,PJ}$		Net Calorific Value (NCV) of fossil fuel used in the project activity turbine during year *y* (TJ/tonne of fuel)

Note: In case of a steam turbine where steam generated by boiler(s) is distributed to various users (e.g. turbines) in the plant, follow the guidance provided in section of project emissions.

Step 4: Determine $EF_{GRID,y}$

The calculation can be conducted according to "Tool to calculate the emission factor for an electricity system (Version 02)". It also refers to 'Bulletin on Baseline Emission Factor of China Region Grid' as published by the Office of National Coordination Committee on Climate Change (i.e. the national DNA)[3], which calculates the Operating Margin (OM) Emission Factor and the Build Margin (BM) Emission Factor for the Chinese regional power grids.

The full process of the calculation of the emission factors and all underlying data are presented in Annex 3 to this PDD.

Step 4-1. Identify the relevant electricity systems

The information of the Project electricity system and connected electricity system as defined by the Host Country DNA has been used to define the relevant electric power system. The power generated by the project activity will be transferred to the North-West Power Grid (NWPG), comprising the provincial electric systems of Shaanxi, Gansu and Qinghai provinces, and Ningxia Hui and Xinjiang Weiwuer Autonomous regions. Therefore the NWPG is identified as the Project electric power system.

Step 4-2. Choose whether to include off-grid power plants in the project electricity system (optional)

Project participants may choose between the following two options to calculate the operating margin and build margin emission factor:

Option I: Only grid power plants are included in the calculation.
Option II: Both grid power plants and off-grid power plants are included in the calculation.

Option I was chosen.

Step 4-3. Select a method to determine the operating margin (OM)

According to the "Tool to calculate the emission factor for an electricity system (Version 02)", one of the following options can be applied for the EFOM calculation:

(a) Simple OM;
(b) Simple adjusted OM;
(c) Dispatch data analysis OM;
(d) Average OM.

The simple OM method is used for this Project. The selected method is applicable to this Project because low cost/must run resources constitute less than 50% of the total grid generation in average of the five most recent years. Data from the China Electric Power Yearbook 2003-2007 indicate that the share of low cost/must run resources of the total NWPG generation accounted for 22.83% in 2002, 19.93% in

[3] http://cdm.ccchina.gov.cn/english/index.asp

2003, 21.21% in 2004, 27.45% in 2005 and 24.71% in 2006 (See Table 6): the average is clearly lower than 50%.

Table 6: Annual electricity generation of NWPG during 2002-2006

Year	Electricity generation (10^8kWh)[4]					Percentage of Low cost/must run
	Total generation	Thermal	Hydro	Nuclear	Others	
2002[5]	1209.81	933.56	274.27	-	1.98	22.83%
2003[6]	1412.34	1130.93	278.99	-	2.42	19.93%
2004[7]	1674.57	1319.39	348.13	-	7.05	21.21%
2005[8]	1845.63	1339.09	428.01	-	78.52	27.45%
2006[9]	1984.91	1494.38	478.17	-	12.37	24.71%

Ex-ante option is selected to calculate the simple OM emission factor. Therefore, the OM Emission Factor is calculated as 2004-2006 NWPG generation-weighted average, where 2004, 2005 and 2006 are the latest years for which data are available.

Step 4-4. Calculate the operating margin emission factor according to the selected method

According to the "Tool to calculate the emission factor for an electricity system (Version 02)" the Simple OM emission factor is calculated as the generation-weighted average CO_2 emissions per unit net electricity generation (tCO_2/MWh) of all generating power plants serving the system, not including low-cost / must-run power plants / units. It may be calculated:

Option A. Based on the net electricity generation and a CO_2 emission factor of each power unit; or
Option B. Based on the total net electricity generation of all power plants serving the system and the fuel types and total fuel consumption of the project electricity system.

The Project selected Option B for the following 2 reasons:

1. Options A is not applicable as fuel consumption data for each power plant are commercially confidential and not available to the public in China;
2. Nuclear and renewable power generations are considered low-cost / must-run power plants / units within the NWPG, and the quantity of electricity supplied to the NWPG is known.

According to Option B, the calculation follows the following formula:

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[4] According to ACM0002 (Version 10), the typical low cost/must run resources include hydro power, terrestrial heat, wind power, low cost biomass, nuclear energy and solar power.

[5] China Electric Power Yearbook 2003, Page 585

[6] China Electric Power Yearbook 2004, Page 709

[7] China Electric Power Yearbook 2005, Page 474

[8] China Electric Power Yearbook 2006, Page 568

[9] China Electric Power Yearbook 2007, Page 638

$$EF_{grid,OMsimple,y} = \frac{\sum_i FC_{i,y} * NCV_{i,y} * EF_{CO2,i,y}}{EG_y}$$

Equation 16

Where:

$EF_{grid,OMsimple,y}$	=	Simple operating margin CO_2 emission factor in year y (tCO_2/MWh)
$FC_{i,y}$	=	Amount of fossil fuel type i consumed in the project electricity system in year y (mass or volume unit)
$NCV_{i,y}$	=	Net calorific value (energy content) of fossil fuel type i in year y (GJ / mass or volume unit)
$EF_{CO2,i,y}$	=	CO_2 emission factor of fossil fuel type i in year y (tCO_2/GJ), using 2006 IPCC values
EG_y	=	Net electricity generated and delivered to the grid by all power sources serving the system, not including low-cost / must-run power plants / units, in year y (MWh)
i	=	All fossil fuel types combusted in power sources in the project electricity system in year y
y	=	The relevant year as per the data vintage chosen in Step 4-3.

Table 7 Operating Margin Emission Factor of NWPG during 2004-2006

	2004	2005	2006	**Weighted Average**
Electricity delivered to the grid (MWh)	122,605,242	125,496,682	156,142,241	-
Operation margin(OM) (tCO_2e/MWh)	1.131315	1.174740	1.073594	**1.1225**

In accordance with the “Tool to calculate the emission factor for an electricity system (Version 02)”, the Ex-ante option is selected to calculate the OM emission factor, Therefore, the equation above is applied to the three latest years for which data are available, and a 3-year generation-weighted average value is taken for the OM Emission Factor.

The bulletin calculates the emission factor directly from published aggregated data on fuel consumption net calorific values, power supply to the grid and IPCC default values for the CO_2 emission factor and the oxidation rate. Aggregated generation and fuel consumption data have been used for the calculation of the emission factors, since more disaggregated data are not publicly available in China.

On the basis of these data, the Operating Margin emission factors for 2004, 2005 and 2006 are calculated. The three-year average is calculated as a full-generation-weighted average of the emission factors. Detailed explanations and demonstration of the calculation of the OM emission factor are provided in Annex 3. The Operation Margin Emission Factor is calculated as 1.1225tCO_2/MWh.

The operating margin emission factor of the baseline is calculated ex-ante and will not be updated in the crediting period of the project activity.

Step 4-5. Identify the group of power units to be included in the build margin

To the purpose of this Project, the sample group of power units m used to calculate the build margin is the set of the power capacity additions in the electricity system that comprise 20% of the system generation (in MWh) and that have been built most recently.

In terms of the vintage data, the "Tool to calculate the emission factor for an electricity system (Version 02)" indicates two options for the calculation of $EF_{BM,y}$. The Project selected Option 1: In the first crediting period, calculate the build margin emission factor $EF_{BM,y}$ ex-ante based on the most recent information available on plants already built for sample group m at the time of CDM-PDD submission to the DOE for validation. For the second crediting period, the build margin emission factor should be updated based on the most recent information available on units already built at the time of submission of the request for renewal of the crediting period to the DOE. For the third crediting period, the build margin emission factor calculated for the second crediting period should be used. This option does not require monitoring of the emission factor during the crediting period.

Step 4-6. Calculate the build margin emission factor(s) (EF_{BM})

The Build Margin Emission Factor is calculated as the generation-weighted average emission factor (tCO_2e/MWh) of all power units m during the most recent year y for which power generation data is available, calculated as follows;

$$EF_{grid,BM,y} = \frac{\sum EG_{m,y} \times EF_{EL,m,y}}{\sum_m EG_{m,y}}$$

Equation 17

Where:

$EF_{grid,BM,y}$	=	Build margin CO_2 emission factor in year y (tCO_2/MWh)
$EG_{m,y}$	=	Net quantity of electricity generated and delivered to the grid by power unit m in year y (MWh)
$EF_{EL,m,y}$	=	CO_2 emission factor of power unit m in year y (tCO_2/MWh)
M	=	Power units included in the build margin
Y		Most recent historical year for which power generation data is available.

However, a direct application of this approach is difficult in China, as data on either the five power plants that have been built most recently or the power plants capacity additions in the electricity system that comprise 20% of the system generation are classified as business confidential and are not publicly available. As the data required cannot be obtained in China, the EB has provided guidance and allowed for deviation[10]. The following deviation has been indicated by the EB:

[10] "Request for guidance: Application of AM0005 and AMS-I.D in China", a letter from DNV to the Executive Board, dated 07/10/2005, http://cdm.unfccc.int/UserManagement/FileStorage/6POIAMGYOEDOTKW25TA20EHEKPR4DM.

a. Use of capacity addition from one year to another as basis for determining the build margin, i.e. the capacity addition over five years, whichever results in a capacity addition that is closest to 20% of total installed capacity.
b. Use proportional weights that correlate to the distribution of installed capacity in place during the selected period above instead of power generation, using plant efficiencies and emission factors of commercially available best practice technology.

The Executive Board (EB) also suggests using the efficiency level of the best technology commercially available in the provincial/regional or national grid of China, as a conservative proxy, for each fuel type in estimating the fuel consumption to estimate the build margin.

The calculations of build margin emission factor are derived from the "Bulletin on the Baseline Emission Factor of the China's Regional Grids", which is renewed and published by the DNA (Office of National Coordination Committee on Climate Change) in China, on December 30, 2008.

First we calculated the newly added installed capacity and the share of each power generation technology in the total capacity.

Second, the weights of newly-added installed capacity for each power generation technology have been calculated. Since the exact data are aggregated and is not possible to distinguish among the different thermal power generation technology capacities (e.g. coal, oil, gas, etc), the calculation applied the following method: calculation of shares of CO_2 emissions from solid fuel, liquid fuel and gas fuel in total emissions respectively by using the latest energy balance data available; the calculated shares are the weights. Shares of CO_2 emissions from solid fuel, liquid fuel and gas fuel in total emissions are calculated using the below formulas:

$$\lambda_{Coal,y} = \frac{\sum_{i \in COAL,j} F_{i,j,y} \times NCV_{i,y} \times EF_{CO2,i,j,y}}{\sum_{i,j} F_{i,j,y} \times NCV_{i,j} \times EF_{CO2,i,j,y}}$$

Equation 18

$$\lambda_{Oil,y} = \frac{\sum_{i \in OIL,j} F_{i,j,y} \times NCV_{i,y} \times EF_{CO2,i,j,y}}{\sum_{i,j} F_{i,j,y} \times NCV_{i,j} \times EF_{CO2,i,j,y}}$$

Equation 19

$$\lambda_{Gas,y} = \frac{\sum_{i \in GAS,j} F_{i,j,y} \times NCV_{i,y} \times EF_{CO2,i,j,y}}{\sum_{i,j} F_{i,j,y} \times NCV_{i,j} \times EF_{CO2,i,j,y}}$$

Equation 20

Where:

$F_{i,j,y}$	=	The amount of fuel i (in a mass or volume unit) consumed by power sources j in year(s) y
$NCV_{i,y}$	=	Net calorific value of fossil fuel type i in year y (GJ / t or volume unit GJ / m3)
$EF_{CO2i,j,y}$	=	Emission factor of fuel i (tCO_2e/GJ) in year(s) y
Coal, Oil and Gas	=	Solid, liquid and gas fuels respectively

The weights of newly-added installed capacity for each power generation technology are $\lambda_{Coal,y}$ =98.49%, $\lambda_{Oil,y}$ =0.11%, $\lambda_{Gas,y}$ =1.41% respectively.

Third, the Emission Factor for thermal power generation is calculated multiplying the emission factor for advanced efficient technology by the weights calculated above.

$$EF_{Thermal,y} = \lambda_{Coal,y} \times EF_{Coal,Adv,y} + \lambda_{Oil,y} \times EF_{Oil,Adv,y} + \lambda_{Grid,y} \times EF_{Gas,Adv,y}$$

Equation 21

Where:

$EF_{Coal,Adv,y}$, $EF_{Coal,Adv,y}$, $EF_{Gas,Adv,y}$	=	Emission factors for coal-fired, oil-fired and gas-fired generation technology according to commercially available best practice technology in terms of efficiency.

A coal-fired power plant with a total installed capacity of 600 MW is assumed to be the commercially available best practice technology in terms of efficiency, the estimated coal consumption of such a National Sub-critical Power Station with a capacity of 600 MW is 329.94gce/kWh, which corresponds to an efficiency of 37.28% for electricity generation.

For gas and oil power plants a 200 MW combined cycle power plant with a specific fuel consumption of 252gce/kWh, which corresponds to an efficiency of 48.81% for electricity generation, is selected as commercially available best practice technology in terms of efficiency[11] in 2006.

The Emission Factor for thermal power generation is $EF_{Thermal,y}$ = 0.9062 tCO_2/MWh.

Fourth, the BM emission factor of the power grid was calculated by multiplying the emission factor of the thermal power with the share of the thermal power in 20% of the newly-added capacity of the power grid.

$$EF_{BM,y} = \frac{CAP_{Thermal}}{CAP_{Total}} \times EF_{Thermal}$$

Equation 22

[11] http://cdm.ccchina.gov.cn/web/index.asp

Where:
CAP_{Total} = Total capacity addition, and $CAP_{Thermal}$, is the total thermal power capacity addition.

The calculation result of the Building Margin emission factor is $EF_{BM,y}$ = 0.6199 tCO_2e/MWh, which is published by the bulletin from DNA, and the details can be found in the bulletin.

The build margin emission factor of the baseline is calculated ex-ante and will not be updated in the crediting period of the project activity.

Step 4-7. Calculate the combined margin emissions factor (EFy)

The combined margin emission factor is calculated as weighted average of the operating margin and build margin.

$$EF_{grid,CM,y} = EF_{grid,OMSimple,y} \times w_{OM} + EF_{grid,BM,y} \times w_{BM}$$

Equation 23

Where:
$EF_{grid,BM,y}$: Build margin CO_2 emission factor in year y (tCO_2/MWh)
$EF_{grid,OM,y}$: Operating margin CO_2 emission factor in year y (tCO_2/MWh)
w_{OM} : Weighting of operating margin emissions factor (%)
w_{BM} : Weighting of build margin emissions factor (%)

According to steps above and the Bulletin on Baseline Emission Factor of China Region Grid published by the Office of National Coordination Committee on Climate Change, the build margin emission factor of the NWPG is $EF_{gird,BM,y}$=0.6199 tCO_2/MWh. The value of the defaults weights of the operating margin (w_{OM}) and building margin (w_{BM}) as specified in the "Tool to calculate the emission factor of an electricity system" are w_{OM}= 0.5 and w_{BM} = 0.5.

The calculations of $EF_{gird,CM,y}$ are below:

Table 8 Emission Factor of Northwest Power Grid

Emission Factor	Value (tCO_2/MWh)	Default Weights
OM Emission Factor	1.1225	0.5
BM Emission Factor	0.6199	0.5
Combined Emission Factor (EF_y)	0.8712	

The combined emission factor of the baseline is calculated ex-ante and will not be updated in the crediting period of the project activity.

Project emissions
The CO_2 emissions from fossil fuel consumption in the project activity (PEy) should be calculated using the latest approved version of the *"Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"*, where the process *j* in the tool corresponds to the combustion of fossil fuels in the project activity for electricity generation in the project power plants.

$$PE_{FC,j,y} = \sum_i FC_{i,j,y} \times COEF_{i,y}$$

Equation 24

Where:

$PE_{FC,j,y}$	=	CO_2 emissions from fossil fuel combustion in process j during the year *y* (tCO_2 / yr)
$FC_{i,j,y}$	=	quantity of fuel type i combusted in process j during the year *y* (mass or volume unit / yr)
$COEF_{i,y}$	=	CO_2 emission coefficient of fuel type i in year *y* (tCO_2 / mass or volume unit)
i	=	fuel types combusted in process j during the year *y*.

Calculation of $FC_{i,j,y}$

In case of steam turbine, where steam generated by boiler(s) is distributed to various users (e.g. turbines) in the plant, following guidance should be used to determine the proportion of fuel combusted in the boiler for the purpose of supplying steam to the project activity turbine.

The proportion of fuel combusted in the boiler(s) for the purpose of supplying steam to the project activity turbine should be estimated on the basis of the ratio of heat input of steam supplied to the project activity turbine to the enthalpy of total steam generated in the boiler(s). Both the steam quantities should be measurable to arrive at a clear estimate of the ratio.

$$FC_{PJ,y} = FC_{Tot,y} \times f_{tur}$$

Equation 25

$$f_{tur} = \frac{HI_{PJ,y}}{HI_{Tot,y}}$$

Equation 26

Where:

$FC_{PJ,y}$	=	Actual fuel consumption in boiler(s) towards steam generation for project activity turbine in year '*y*' (mass or volume unit)
$HI_{PJ,y}$	=	Heat input to the project activity steam turbine in year '*y*' (TJ). In case of multicylinder steam turbines, this includes the heat input at the inlet of first stage and the heat inputs in re-heaters of steam between various cylinders (e.g. high-pressure, medium pressure and low-pressure cylinders).
$FC_{Tot,y}$	=	Total fuel consumption in boiler(s) in year '*y*' (tonne of fuel)
$HI_{Tot,y}$	=	Enthalpy of total steam generated by boiler(s) in year '*y*' (TJ)
f_{tur}	=	Proportion of heat input of steam to turbine to the enthalpy of total steam generated by boiler in year '*y*'.

The above guidance requires that:

- Where multiple boilers supply steam into common steam headers, all the boilers have to provide the same quality of steam.
- The calculation should be based on the energy supplied to the steam turbine. The enthalpy and the steam flow rate must be monitored for each boiler to determine the energy content of the steam. The calculation implicitly assumes that the properties of steam (temperature and pressure) generated from different sources are the same. The enthalpy of steam will be determined at measured temperature and pressure and the enthalpy difference will be multiplied with quantity measured by a steam flow meter.

Calculation of $COEF_{i,y}$
According to "*Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion*", the CO_2 emission coefficient $COEF_{i,y}$ can be calculated using one of the following two Options, depending on the availability of data on the fossil fuel type i, as follows:

Option A: The CO_2 emission coefficient COEFi,y is calculated based on the chemical composition of the fossil fuel type i, using the following approach:

If $FC_{i,j,y}$ is measured in a mass unit:

$$COEF_{i,y} = w_{c,i,y} \times \frac{44}{12}$$

Equation 27

If $FC_{i,j,y}$ is measured in a volume unit:

$$COEF_{i,y} = w_{c,i,y} \times \rho_{i,y} \times \frac{44}{12}$$

Equation 28

Where:

COEFi,y	=	CO_2 emission coefficient of fuel type i (tCO_2/mass or volume unit)
wC,i,y	=	weighted average mass fraction of carbon in fuel type i in year y (tC/mass unit of the fuel)
ρ *i,y*	=	weighted average density of fuel type i in year y (mass unit/volume unit of the fuel)
i	=	fuel types combusted in process j during the year y

Option B: The CO_2 emission coefficient COEFi,y is calculated based on net calorific value and CO_2 emission factor of the fuel type i, as follows:

$$COEF_{i,y} = NCV_{i,y} \times EF_{CO2,i,y}$$

Equation 29

Where:

$COEF_{i,y}$	=	CO_2 emission coefficient of fuel type i in year *y* (tCO_2 / mass or volume unit)
$NCV_{i,y}$	=	weighted average net calorific value of the fuel type i in year *y* (GJ/mass or volume unit)
$EF_{CO2,i,y}$	=	weighted average CO_2 emission factor of fuel type i in year *y* (tCO_2/GJ)
i	=	fuel types combusted in process j during the year *y*

Option A should be the preferred approach, if the necessary data is available.

Leakage

No leakage is identified under this methodology.

B.6.2. Data and parameters that are available at validation:

Data / Parameter:	$\mathbf{EF_{FF, BL}}$
Data unit:	tCO_2/TJ of fuel
Description:	CO_2 emission factor of the fossil fuel used in the project activity turbine prior to the implementation of the project activity
Source of data used:	Historical records for coal (2006-2008)
Value applied:	101.32
Justification of the choice of data or description of measurement methods and procedures actually applied :	$EF_{FF, BL}$ is the weighted average emission factor calculated from carbon content (%) and NCV of the coal. The carbon content and the NCV are based on ultimate analysis and calorific value measurement of the coal in an authorised laboratory (Electric Power Industry Northwest Power Plants Coal Quality Supervision & Test Center, Xian).
Any comment:	-

Data / Parameter:	$\mathbf{CAP_{max}}$
Data unit:	MW
Description:	Maximum power generation capacity of the project activity turbine prior to the implementation of the project activity
Source of data used:	Generation license
Value applied:	330
Justification of the choice of data or description of measurement methods and procedures actually applied :	This is based on commissioning certificate of the power plant, as issued by the power plant implementing entity.
Any comment:	-

Data / Parameter:	$\mathbf{HMR_x}$
Data unit:	h
Description:	Average hours in which the plant cannot operate due to maintenance or repair in the three most recent years *x* prior to the implementation of the project

	activity.
Source of data used:	Historical records for maintenance and repair intervals (2006-2008).
Value applied:	No 1: 734.00 (2006); 1,436.80 (2007); 402.25 (2008) No 2: 390.17 (2006); 807.21 (2007); 334.00 (2008)
Justification of the choice of data or description of measurement methods and procedures actually applied :	-
Any comment:	-

Data / Parameter:	**$EG_{Tur,x}$**
Data unit:	MWh/yr
Description:	Quantity of electricity generated by the project activity turbine (Project Activity Turbine) to the electricity grid in year *x* prior to implementation of project activity.
Source of data used:	Historical records for power generation (2006-2008)
Value applied:	No 1: 1,360,024 (2006); 1,414,918 (2007); 1,595,788 (2008) No 2: 1,710,194 (2006); 1,685,454 (2007); 1,814,276 (2008)
Justification of the choice of data or description of measurement methods and procedures actually applied :	The quantity of electricity generated by each unit had been measured by each electricity meter continuously. Also, the quantity of electricity consumed by auxiliaries had been measured for each unit. Thus, the quantity of electricity supplied by each unit was calculated by subtracting the quantity of electricity consumed by auxiliaries from the quantity of electricity generated by each unit.
Any comment:	-

Data / Parameter:	**$\eta_{BL,y}$**
Data unit:	%
Description:	Energy efficiency of the turbine without retrofitting in year 'y'
Source of data used:	Performance tests
Value applied:	No 1: 40.85 No 2: 41.35
Justification of the choice of data or description of measurement methods and procedures actually applied :	Energy efficiencies were determined through measurements based on performance tests as prescribed by ASME PTC6-1996 and GB8117-87 (Chinese national standards based on ASME). The tests were conducted by Shaanxi Electric Power Research Institute 13-15 January 2009 for the No.2 turbine and 15-17 August 2009 for the No. 1 turbine. The efficiency at full load was estimated on the extended straight line of the two largest loads among the test loads since performance tests at the full load had not been permitted by the grid company. However, this is a conservative approach because a slope of a load-efficiency curve should lie below a straight line. See Annex 3 for more details.
Any comment:	See Annex 3 for the main results of the performance test.

Data / Parameter:	$\eta_{PJ,max}$
Data unit:	%
Description:	Load v/s Energy efficiency curve of the turbine immediately after retrofitting
Source of data used:	Performance tests for range of loads at commissioning.
Value applied:	No 1: 45.46 No 2: 45.45
Justification of the choice of data or description of measurement methods and procedures actually applied :	The performance tests were conducted by Hangzhou Huadian Electric Power Experimentation Research Institute on 7-10 November 2009 for the No.2 turbine and by Huadian Electric Power Research Institute from 28 February to 10 March 2010 for the No.1 turbine following the procedure of ASME PTC6-1996. The efficiency at full load was assumed the same as the average of the two maximum tested loads since performance tests at the full load had not been permitted by the grid company. However, this is a conservative approach because efficiency at full load should be larger than efficiency at maximum test load. See Annex 3 for more details.
Any comment:	The performance test was completed three months after retrofitting of No.2 turbine since the power plant had been waiting for permission from the power network company. See Annex 3 for the main results of the performance test.

Data / Parameter:	$EF_{GRID,y}$
Data unit:	tCO_2/MWh
Description:	Emission factor of the electricity grid to which the project activity turbine is connected (tCO_2/MWh)
Source of data used:	Power suppliers, government monitoring agency, technical audit data
Value applied:	0.8712
Justification of the choice of data or description of measurement methods and procedures actually applied :	$EF_{GRID,y}$ is estimated as combined margin emission factor using the latest approved version of the “Tool to calculate the emission factor for an electricity system” ex-ante.
Any comment:	See Annex 3 for collected data.

B.6.3. Ex-ante calculation of emission reductions:

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The emission reduction (ER_y) by the project activity during year *y* is the difference between the baseline emissions (BE_y), project emissions (PE_y) and emissions due to leakage (LE_y), and can be expressed as follows:

$$ER_y = BE_y - PE_y - LE_y \quad \text{(Equation 1)}$$

Where:

ER_y = Emission reductions in year *y* ($t\ CO_2/yr$)
BE_y = Baseline emissions in year *y* ($t\ CO_2/yr$)
PE_y = Project emissions in year *y* ($t\ CO_2/yr$)

LE_y = Leakage emissions in year *y* (t CO_2/yr)

Baseline emissions (BE_y)

The baseline scenario is the following: continuation of the current practice – the turbine continues to be operated without retrofitting. The baseline emissions for year y (BE_y) (with assumption made regarding the baseline situation) are calculated as follows:

Step 1: Determine Baseline Emissions for different scenarios of project electricity generation

Since the quantity of electricity generated in the project activity turbine ($EG_{PJ,y}$) is expected to be the same as the historic average annual generation level (EG_{AVR}), the baseline emissions are calculated as case c. The annual quantity of electricity supplied to the grid is determined by a contract between an electric transmission company and a power generation plant in China. The Power Purchase Agreements for 2006-2010 indicate that the quantity of electricity supplied to the grid remains unchanged before and after retrofitting the turbines and the actual results for 2006-2011 has confirmed that. Thus, the case c is used for the ex-ante calculation[12].

$$BE_y = EG_{PJ,y} \cdot EF_{BL,y} \qquad \text{(Equation 4)}$$

Where:

BE_y	=	Baseline emissions in year '*y*' (tCO_2/yr)
$EG_{PJ,y}$	=	Quantity of electricity supplied by the project activity turbine to the grid in year '*y*'(MWh/yr), adjusted for changes in efficiency.
$EF_{BL,y}$	=	Baseline emission factor of the project activity turbine in year *y*, (tCO_2/MWh)

		No.1	No.2
$EG_{PJ,y}$	MWh	1,456,910	1,736,641

Step 2: Determine Baseline Emission Factor

The emissions factor for the baseline generation in tCO_2/MWh is calculated as follows:

Emission factor for steam turbine, where fuel is fired in a boiler

$$EF_{BL,y} = \frac{3.6}{1000} \times \frac{EF_{FF,BL} \times HI_{PJ,y}}{\eta_{BL,y} \times FC_{PJ,y} \times NCV_{FF,PJ}} \qquad \text{(Equation 8)}$$

Where:

$EF_{BL,y}$	=	Baseline emission factor of the project activity turbine in year '*y*', (tCO_2/MWh)
$EF_{FF,BL}$	=	CO_2 emission factor of the fossil fuel used in the project activity turbine prior to the implementation of the project activity (tCO_2/TJ)
$NCV_{FF,PJ}$	=	Net Calorific Value (NCV) of fossil fuel used in the project activity turbine during year *y* (TJ/tonne of fuel)
$\eta_{BL,y}$	=	Energy efficiency of the turbine without retrofitting estimated using options A, B

[12] The methodological choice for case a) to c) is determined based on actual electricity generation in the ex-post calculation.

		or C, as described below
$FC_{PJ,y}$	=	Actual fuel consumption by project in year '*y*' (tonne of fuel)
$HI_{PJ\,y}$		Heat input to the steam turbine in year '*y*' (TJ). In case of multi-cylinder steam turbines, this is the sum of the heat input at the inlet of first stage and the heat inputs in re-heaters8 of steam between various cylinders (e.g. high-pressure, medium pressure and low-pressure cylinders)

The baseline turbine efficiency ($\eta_{BL,y}$) will be calculated using Option B:

Option B: Assume a constant efficiency for the baseline turbine and determine the efficiency, as a conservative approach, for optimal operation conditions. Efficiencies shall be determined through measurements based on performance tests as prescribed by international standards, norms and guidelines (ASME PTC 6-1996 or IEC 60953-3 (2001)) or an equivalent international and national standard).

		No.1	No.2
$EF_{FF,BL}$	tCO_2/TJ	101.32	101.32
$NCV_{FF,\,PJ}$	TJ/tonne of coal	0.0207	0.0207
$\eta_{BL,y}$	%	40.85	41.35
$FC_{PJ,y}$	tonne of coal	557,032	664,089
$HI_{PJ\,y}$	TJ	11,537	13,754
$EF_{BL,y}$	tCO_2/MWh	0.893	0.882

Step 3: Determine the $EG_{adjusted}$

The efficiency ($\eta_{PJ,y}$) of turbine in crediting period should be calculated once in a year as per Equation 14. If the project efficiency of turbine $\eta_{PJ,y}$ is above maximum efficiency of turbine $\eta_{PJ,max}$ (as defined in section B.6.2), the adjusted generation of electricity ($EG_{PJ,y,adjusted}$) needs to be used in place of electricity generation ($EG_{PJ,y}$) by the following equations. That is, if efficiency gains due to further retrofits or replacement or superior preventive maintenance activities exceed maximum efficiency ($\eta_{PJ,max}$) for a particular year, the emission reductions for that year can be claimed only based on the minimum project efficiency of the turbine after implementation of project activity, as per the procedure described in the following equations.

$$EG_{PJ,y,adjusted} = EG_{PJ,y} \times \eta_{PJ,min} / \eta_{PJ,y} \quad \text{If } \eta_{PJ,y} \rangle \eta_{PJ,max} \qquad \text{(Equation 12)}$$

Where:

$$\eta_{PJ,min} = \min(\eta_{PJ,y-1}, ...\eta_{PJ,1}) \qquad \text{(Equation 13)}$$

$EG_{PJ,y}$	=	Quantity of electricity supplied by the project activity turbine to the grid in year '*y*' (MWh)
$EG_{PJ,adjusted,\,y}$	=	Adjusted electricity generation in project year for estimation of baseline emissions, if the efficiency of turbine in project year y is above the maximum efficiency,
$\eta_{PJ,max}$	=	Maximum project energy efficiency of the turbine at the average load of year y

		based on load v/s efficiency curve drawn for the project turbine immediately after retrofit, as per the test immediately after the implementation of the project activity.
$\eta_{PJ,min}$	=	Minimum project energy efficiency of the turbine observed as per measurement requirements during the previous years (1 to 'y-1') after the implementation of the project activity
$\eta_{PJ,y-1}$	=	Project energy efficiency of the turbine during the year 'y-1'

$\eta_{PJ,y}$ for steam turbines

$$\eta_{PJ,y} = \frac{EG_{PJ,y} * (3.6/1000)}{HI_{PJ,y}}$$ (Equation 14)

Where:

$\eta_{PJ,y}$	=	Energy efficiency of the turbine in year '*y*'
$EG_{PJ,y}$	=	Actual electricity generated by project in year '*y*' (MWh)
$HI_{PJ,y}$	=	Heat input to the steam turbine in year '*y*' (TJ). In case of multi-cylinder steam turbines, this is the sum of the heat input at the inlet of first stage and the heat inputs in re-heaters of steam between various cylinders (e.g. high-pressure, medium pressure and low-pressure cylinders).

Project emissions (PE_y)

Project emissions in year y (PE_y) include emissions from use of fossil fuel to operate the retrofit turbine during the year and calculated using the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion". The process *j* in the tool corresponds to the combustion of fossil fuels in the project activity for electricity generation in the project power plants.

$$PE_{FC,j,y} = \sum_i FC_{i,j,y} \times COEF_{i,y}$$ (Equation 24)

Where:

$PE_{FC,j,y}$	=	CO_2 emissions from fossil fuel combustion in process j during the year *y* (tCO_2 / yr)
$FC_{i,j,y}$	=	Quantity of fuel type i combusted in process j during the year *y* (mass or volume unit / yr)
$COEF_{i,y}$	=	CO_2 emission coefficient of fuel type i in year *y* (tCO_2 / mass or volume unit)
i	=	Fuel types combusted in process j during the year *y*.

		No.1	No.2
$FC_{coal,j,y}$ ($FC_{PJ,y}$)	t-coal	557,032	664,089

Calculation of $COEF_{i,y}$

The CO_2 emission coefficient $COEF_{i,y}$ can be calculated as follows, if Option A is chosen:

$$COEF_{i,y} = w_{c,i,y} \times \frac{44}{12} \qquad \text{(Equation 27)}$$

Where:

$COEF_{i,y}$	=	CO_2 emission coefficient of fuel type i (tCO_2/mass or volume unit)
$w_{C,i,y}$	=	weighted average mass fraction of carbon in fuel type i in year y (tC/mass unit of the fuel)
i	=	fuel types combusted in process j during the year y

		No.1	No.2
$w_{C,i,y}$	tC/t-coal	0.57	0.57
$COEF_{i,y}$	tCO_2/ t-coal	2.099	2.099

Leakage

No leakage is identified under this methodology.

Estimation of emissions reductions (ER_y)

		No.1	No.2	Total
BE_y	tCO_2/yr	1,300,871	1,531,918	2,832,789
PE_y	tCO_2/yr	1,168,959	1,393,624	2,562,584
Ly	tCO_2/yr	0	0	0
ER_y	**tCO_2/yr**	**131,911**	**138,294**	**270,205**

B.6.4 Summary of the ex-ante estimation of emission reductions:

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Year	Estimation of project activity emissions (tonnes of CO_2e)	Estimation of baseline emissions (tonnes of CO_2e)	Estimation of leakage (tonnes of CO_2e)	Estimation of overall emission reductions (tonnes of CO_2e)
2011	1,281,292	1,416,394	0	135,102
2012	2,562,584	2,832,789	0	270,205
2013	2,562,584	2,832,789	0	270,205
2014	2,562,584	2,832,789	0	270,205
2015	2,562,584	2,832,789	0	270,205
2016	2,562,584	2,832,789	0	270,205
2017	2,562,584	2,832,789	0	270,205
2018	2,562,584	2,832,789	0	270,205
2019	2,562,584	2,832,789	0	270,205
2020	2,562,584	2,832,789	0	270,205
2021	1,281,292	1,416,394	0	135,102
Total (tonnes of CO_2e)	**25,625,837**	**28,327,887**	**0**	**2,702,050**

B.7. Application of the monitoring methodology and description of the monitoring plan:

B.7.1 Data and parameters monitored:

Data / Parameter:	**$EG_{PJ,y}$**
Data unit:	MWh
Description:	Quantity of electricity supplied by the project activity turbine to the grid in year '*y*'
Source of data to be used:	Measurements and calculations by project participants
Value of data applied for the purpose of calculating expected emission reductions in section B.5	No.1: 1,456,910 No.2: 1,736,641
Description of measurement methods and procedures to be applied:	The quantity of electricity generated by each unit is measured by each electricity meter continuously. Also, the quantity of electricity consumed by auxiliaries is measured for each unit. Thus, the quantity of electricity supplied by each unit is calculated by subtracting the quantity of electricity consumed by auxiliaries from the quantity of electricity generated by each unit.
QA/QC procedures to be applied:	Both the meters of electricity generated and supplied are calibrated by Weinan Power Supply Bureau every five years. The electricity meters to measure auxiliary electricity consumption are calibrated by Xi'an Electric Power Research Institute every five years. All electricity meters are calibrated and verified following Chinese national standard of Verification Regulation of Electrical Energy Meters with Electronics (JJG596-1999) every five year. The accuracy of the meter is 0.5s. In addition, the metered net electricity generation is cross-checked with receipts from sales.
Any comment:	Ensure that $EG_{PJ,y}$ is the net electricity generation (the gross generation by the project plant minus all auxiliary electricity consumption of the plant)

Data / Parameter:	**$FC_{PJ,y}$**
Data unit:	t
Description:	Actual fuel consumption towards electricity generation in project activity turbine in year 'y' Following point should be noted in this regard; - For a gas turbine, fuel is directly consumed in turbine - For a steam turbine, fuel is consumed in boiler(s)
Source of data to be used:	Calculated.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	No.1: 557,032 No.2: 664,089

Description of measurement methods and procedures to be applied:	$FC_{PJ,y} = FC_{Tot} * f_{tur}$
QA/QC procedures to be applied:	-
Any comment:	-

Data / Parameter:	**$FC_{Tot,y}$**
Data unit:	t
Description:	Total fuel consumption in boiler in year 'y'
Source of data to be used:	Fuel meters.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	No.1: 763,785 No.2: 922,411
Description of measurement methods and procedures to be applied:	Direct measurements. Continuously.
QA/QC procedures to be applied:	The fuel meters are calibrated by engineers at Pucheng Power Plant three times per month with the standard meter of Shaanxi Institute of Metrology Science and by the institute once a year, following Chinese national standard of "Digital Indicating Weighing Instrument" (JJG539-1997). The consistency of monitored fuel consumption quantities is crosschecked by applying an annual energy balance that is based on purchased quantities and stock changes.
Any comment:	The quantity of fossil fuel combusted should be collected separately for all types of fossil fuels used in the project power plant.

Data / Parameter:	**f_{tur}**
Data unit:	-
Description:	Proportion of heat input of steam to turbine to the enthalpy of total steam generated by boiler in year 'y'.
Source of data to be used:	Calculated.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	No.1: 0.729 No.2: 0.720
Description of measurement methods and procedures to be applied:	$f_{tur} = \frac{HI_{PJ,y}}{HI_{Tot,y}}$

QA/QC procedures to be applied:	-
Any comment:	-

Data / Parameter:	**$NCV_{FF, PJ}$**
Data unit:	TJ/t of fuel
Description:	Net Calorific Value (NCV) of fossil fuel used in the project activity turbine during year y
Source of data to be used:	Choose the Net Calorific Value (NCV) corresponding to the applicable fuel type. Use preferably the tested value in the authorized test laboratory or well documented and reliable regional or national average values. If such data is not available, IPCC default values may be used.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0.0207
Description of measurement methods and procedures to be applied:	The tested values based on calorific value measurement of the coal in an authorised laboratory will be used.
QA/QC procedures to be applied:	Use the standard operating procedure and calibrated equipment for testing of fuel, such as GB/T213-2008 “Determination of calorific value of coal”.
Any comment:	Check the note on “Treatment of different fuels, being used in the baseline scenario” in the baseline emissions section.

Data / Parameter:	**$HI_{PJ\ y}$**
Data unit:	TJ
Description:	Heat input to the steam turbine in year ‘y’. In case of multi-cylinder steam turbines, this includes the heat input at the inlet of first stage and the heat inputs in re-heaters of steam between various cylinders (e.g. high-pressure, medium pressure and low-pressure cylinders).
Source of data to be used:	Plant records for flow and properties of steam, steam tables for enthalpy of steam.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	No.1: 11,537 No.2: 13,754
Description of measurement methods and procedures to be applied:	The following parameters need to be measured directly to calculate $HI_{PJ,y}$: • Turbine inlet steam flow, pressure, temperature • Feed water flow, pressure, temperature • Reheater inlet/outlet flow, pressure, temperature • Reheater spray flow, pressure, temperature Of the above parameters, reheater inlet temperature is assumed as the design value and reheater outlet flow is calculated combining inlet flow and reheater

	spray flow. The parameters are measured continuously and aggregated periodically. The enthalpy of steam is determined using steam tables.
QA/QC procedures to be applied:	The flow, pressure, and temperature meters are calibrated by engineers at Pucheng Power Plant once a year with the standard meters of Shaanxi Institute of Metrology Science, following Chinese national standard of "Rule for the Examination of Measurement Standard" (JJF1033-2008). All the standard meters are calibrated by Shaanxi Institute of Metrology Science once a year, following Chinese national standards of "Digital Pressure Gauges" (JJG875-2005) for flow and pressure meters and "Standard Platinum Resistance Thermometer" (JJG160-2007).
Any comment:	See B.7.2 for the monitoring locations.

Data / Parameter:	$\mathbf{HI_{Tot\ y}}$
Data unit:	TJ
Description:	Heat input of total steam generated by boiler(s) in year 'y'
Source of data to be used:	Plant records for flow and properties of steam, steam tables for enthalpy of steam.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	No.1: 15,819 No.2: 19,105
Description of measurement methods and procedures to be applied:	The following parameters need to be measured directly to calculate $HI_{Tot,y}$: • Coal consumption at boiler • Boiler inlet steam flow • Boiler outlet steam flow, pressure, temperature • Feed water flow, pressure, temperature • Reheater inlet/outlet flow, pressure, temperature • Reheater spray flow, pressure, temperature Of the above parameters, reheater inlet temperature is assumed as the design value and reheater outlet flow is calculated combining inlet flow and reheater spray flow. The parameters are measured continuously and aggregated periodically. The enthalpy of steam is determined using steam tables.
QA/QC procedures to be applied:	The flow, pressure, and temperature meters are calibrated by engineers at Pucheng Power Plant once a year with the standard meters of Shaanxi Institute of Metrology Science, following Chinese national standard of "Rule for the Examination of Measurement Standard" (JJF1033-2008). All the standard meters are calibrated by Shaanxi Institute of Metrology Science once a year, following Chinese national standards of "Digital Pressure Gauges" (JJG875-2005) for flow and pressure meters and "Standard Platinum Resistance Thermometer" (JJG160-2007).
Any comment:	See B.7.2 for the monitoring locations.

Data / Parameter:	$\mathbf{w_{C,i,y}}$
Data unit:	tC/mass unit of the fuel

Description:	Weighted average mass fraction of carbon in fuel type *i* in year *y*
Source of data to be used:	The following data sources may be used if the relevant conditions apply: **Data source** — **Conditions for using the data source** a) Values provided by the fuel supplier in invoices — This is the preferred source b) Measurements by the project participants — If a) is not available
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0.57
Description of measurement methods and procedures to be applied:	Measurements should be undertaken in line with national or international fuel standards. The mass fraction of carbon should be obtained for each fuel delivery, from which weighted average annual values should be calculated
QA/QC procedures to be applied:	Verify if the values under a) and b) are within the uncertainty range of the IPCC default values as provided in Table 1.2, Vol. 2 of the 2006 IPCC Guidelines. If the values fall below this range collect additional information from the testing laboratory to justify the outcome or conduct additional measurements. The laboratories in b) should have ISO17025 accreditation or justify that they can comply with similar quality standards.
Any comment:	Applicable where Option A is used

B.7.2. Description of the monitoring plan:

>>

Operational and management structure of the project activity

Pucheng Power Plant has established a set of management system within the power company through ISO 9001, ISO 14001 and OHSM 18001 certification. The monitoring procedures for the CDM project activity including operation and maintenance, data collection, and calibration, will be augmented by the use of the established management system within the power plant.

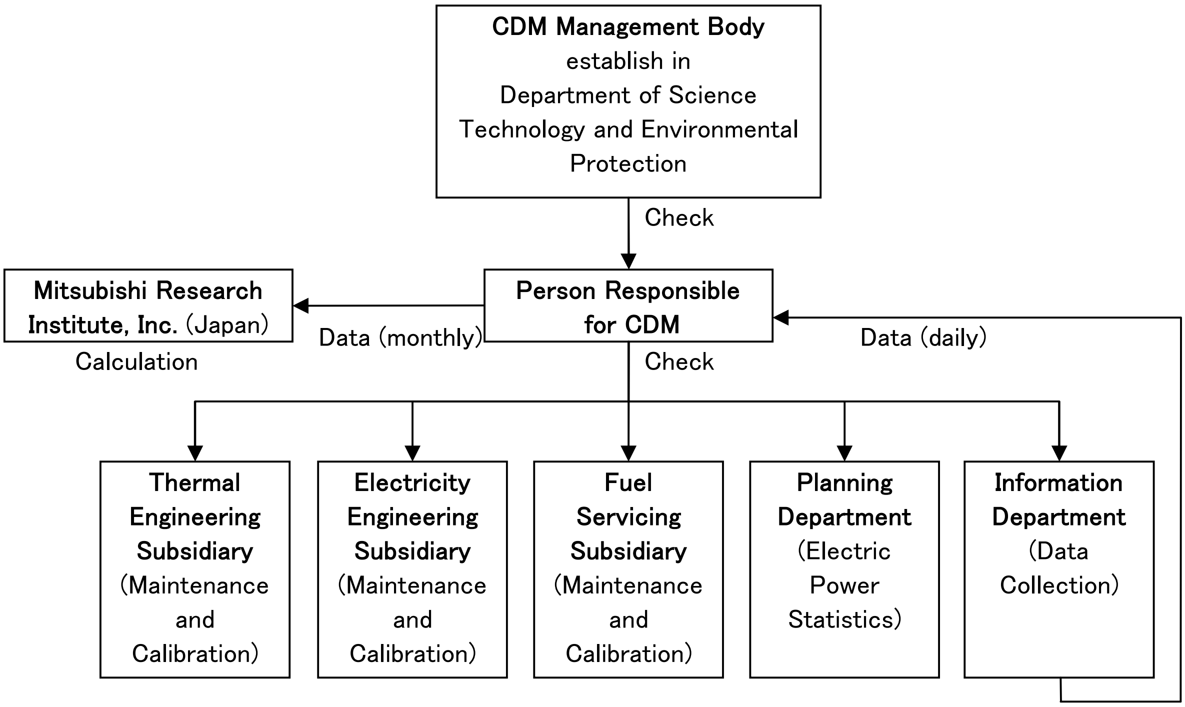


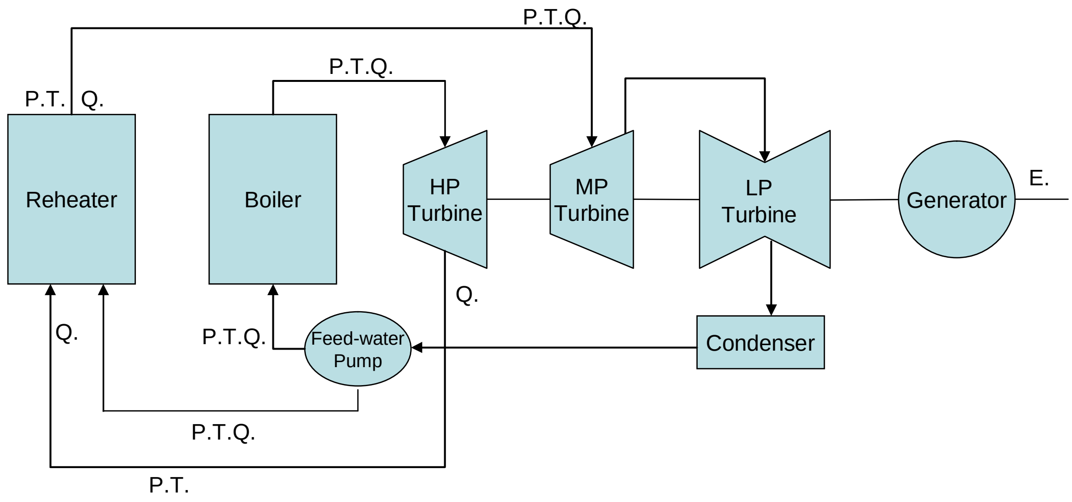
Figure 4: Operational and management structure of the project activity in Pucheng Power Plant

Data Collection

Pucheng Power Plant has responsibility for data collection and instrument calibration with support from Mitsubishi Research Institute, Inc. The data monitored will be recorded and archived electronically or on paper. Operational data relevant for emission accounting will be logged by the operator on a daily basis using a pre-prepared log-sheet form, as part of the data logging system. The log book will be signed and checked by an operational manager who will compile the report on a monthly basis prior to submitting it to Mitsubishi Research Institute, Inc. for calculation of heat inputs and emission reductions. The operational manager is also responsible for cross-checking the amount of net electricity generation and coal consumption against receipts and/or invoices. The data is to be compiled in a monitoring report for verification by the DOE.

Maintenance and Calibration

The Instrument will be calibrated on a regular basis during the annual maintenance. Calibration status for all CDM-related instruments will be recorded and provided in a monitoring report. For details of calibration, see B.7.1.



Q: Flow rate of steam
P: Pressure of steam
T: Temperature of steam

Figure 5 Monitoring locations for $HI_{PJ,y}$ and $HI_{Tot,y}$

B.8. Date of completion of the application of the baseline study and monitoring methodology and the name of the responsible person(s)/entity(ies):

>>
The baseline study and monitoring methodology was completed on 15/08/2011 by:

Kuniyuki Nishimura (Mr.)

Mitsubishi Research Institute, Inc.
Tokyo, Japan

E-mail: kuni@mri.co.jp
Tel: +81-3-6705-5439
Fax: +81-3-5157-2146

SECTION C. Duration of the project activity / crediting period

C.1. Duration of the project activity:

C.1.1. Starting date of the project activity:

>>
02/04/2007 (the date Pucheng Power Plant placed an order for turbines with Dongfang Turbine Co., Ltd. is set as the starting date of the project activity).

C.1.2. Expected operational lifetime of the project activity:

>>
19 years 5 months (the most conservative remaining lifetime of the existing turbines at the starting date of the project activity).

C.2. Choice of the crediting period and related information:

C.2.1. Renewable crediting period:

C.2.1.1. Starting date of the first crediting period:

>>
Not applicable.

C.2.1.2. Length of the first crediting period:

>>
Not applicable.

C.2.2. Fixed crediting period:

C.2.2.1. Starting date:

>>
01/07/2011 or date of registration, whichever the later.

C.2.2.2. Length:

>>
10 years and 0 months.

SECTION D. Environmental impacts

>>

D.1. Documentation on the analysis of the environmental impacts, including transboundary impacts:

>>
Under the 'Environmental Impact Assessment Law' the project activity is classified as a third class activity, in which the environmental impacts are very low or positive, not negative. Under the law, the project activity was requested to prepare the environmental impact registration table. The table was submitted to Shaanxi Environmental Protection Bureau (SEPB) on 31 May 2006 and approved on the same day because the table for third class activities does not necessitate deliberation by the technical committee in SEPB.

The table includes the environmental impacts of the project activity and actions to be taken. Certain amount of solid waste and waste water will be generated during retrofitting. Pucheng Power Plant should properly classify such materials and dispose of them in accordance with the relevant waste-related regulations.

On the other hand, SO_2 and NO_x emissions will be reduced as a direct result of the project activity. Therefore, the environmental impacts are not very significant but rather positive.

D.2. If environmental impacts are considered significant by the project participants or the host Party, please provide conclusions and all references to support documentation of an environmental impact assessment undertaken in accordance with the procedures as required by the host Party:

>>

No significant impacts on the environment are expected.

SECTION E. Stakeholders' comments

>>

E.1. Brief description how comments by local stakeholders have been invited and compiled:

>>

First of all, the public participation or the stakeholder consultation process is not required for a project activity classified as third class under the EIA Law. Therefore, the process was voluntarily conducted by the Project Participants without the direction of SEPB.

Information to residents

On 1-4 November 2008, information explaining the contents and effects of the proposed CDM project activity was provided to residents living in the vicinity of Pucheng Power Plant, including farmers in Baiqisi Village, the nearest town to the power plant. Five comments were received, three of which were from the leaders of the village and two from the workers at the power plant.

Note: Pucheng Power Plant is located on the border between Suzhen and Donchenzhen. Baiqusi Village is one of the eight villages, belonging to Donchenzhen and the nearest village to the project site.

Stakeholders' meeting

A stakeholder consultation meeting was held on 26 February 2009 in a conference room at Pucheng Power Plant. Key personnel from local government and the local community were contacted by telephone during the week prior to the meeting and invited to attend. Including workers at the power plant, a total of approximately 20 persons participated in the meeting. 7 people external to the power plant took part in the meeting, including the top official of the Environmental Protection Agency of Pucheng County, the top official of the government of Dongchen Town (Pucheng County) and residents of Baiqisi Village (Dongchen Town, Pucheng County).

The person responsible for CDM at Pucheng Power Plant explained the contents and effects of the proposed CDM project activity, summarized as follows:

- Pucheng Power Plant is planning to retrofit 2 x 330MW turbines of Phase 1 units (No.1 and No.2 Units) as a CDM project activity.
- The target turbines were made in Romania utilizing 1960s technology and their energy efficiencies have been historically low.
- The project activity will optimize the design of steam flow paths employing the latest technology at Dongfang Turbine Co., Ltd and will increase the efficiency rate of the turbines by approximately 10% (relative to the baseline).

- The project activity will bring social benefits by reducing coal consumption per electricity generation. Not only CO_2 but also SO_2 and NO_x emissions and coal ash production will be reduced.

Subsequently, an exchange of opinions between participants in the meeting took place, after which questionnaires were distributed and completed by particpants. Questions included the following:

- Are you for or against the project activity?
- Do you think the project activity is consistent with the energy-saving and low-emission policies?
- Does the project activity influence your life and/or job?
- Any comments and suggestions?

E.2. Summary of the comments received:

>>

All comments received have indicated a welcoming for and expectation of early implementation of the project.

E.3. Report on how due account was taken of any comments received:

>>

Since all comments were positive, additional measures are not required.

Annex 1

CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

Organization:	Shaanxi Huadian Pucheng Power Generation Co., Ltd.
Street/P.O.Box:	Sunzhen, Pucheng County
Building:	-
City:	Weinan City
State/Region:	Shaanxi Province
Postcode/ZIP:	715501
Country:	People's Republic of China
Telephone:	86-913-766-2473
FAX:	86-913-766-2195
E-Mail:	Rqj3132@126.com
URL:	http://www.sxpd.cn
Represented by:	Wang Weidong
Title:	-
Salutation:	Mr.
Last Name:	Wang
Middle Name:	-
First Name:	Weidong
Department:	Department of Science Technology and Environmental Protection
Mobile:	86-13892375881
Direct FAX:	
Direct tel:	
Personal E-Mail:	wwd3027@sohu.com

Organization:	Kyushu Electric Power Co., Inc.
Street/P.O.Box:	1-82, Watanabe-dori 2-Chome
Building:	-
City:	Chuo-ku
State/Region:	Fukuoka
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Country:	Japan
Telephone:	+81-92-726-1533
FAX:	81-92-761-7368
E-Mail:	Ayumu_Itou@kyuden.co.jp
URL:	http://www.kyuden.co.jp
Represented by:	Ayumu Itou
Title:	Group Manager, Global Environment Group
Salutation:	Mr.
Last Name:	Itou
Middle Name:	-
First Name:	Ayumu
Department:	Environmental Affairs Department

Mobile:	-
Direct FAX:	81-92-761-7368
Direct tel:	81-92-726-1533
Personal E-Mail:	Ayumu_Itou@kyuden.co.jp

Annex 2

INFORMATION REGARDING PUBLIC FUNDING

This project will not receive any public funds.

Annex 3

BASELINE INFORMATION

Estimation methods of the turbine efficiencies at full load

Since performance tests at the full loads had not been permitted by the grid company, they were extrapolated by the primary expressions and/or by quadratic expressions as described below. Full-load efficiencies are the theoretical maximum efficiencies. Therefore, the efficiencies at full loads would have been higher than the ones at the highest-measured loads.

The *lower* baseline efficiencies result in the larger emission reductions. Thus, the baseline efficiencies for both No.1 and No.2 turbines have been estimated by the primary expressions.

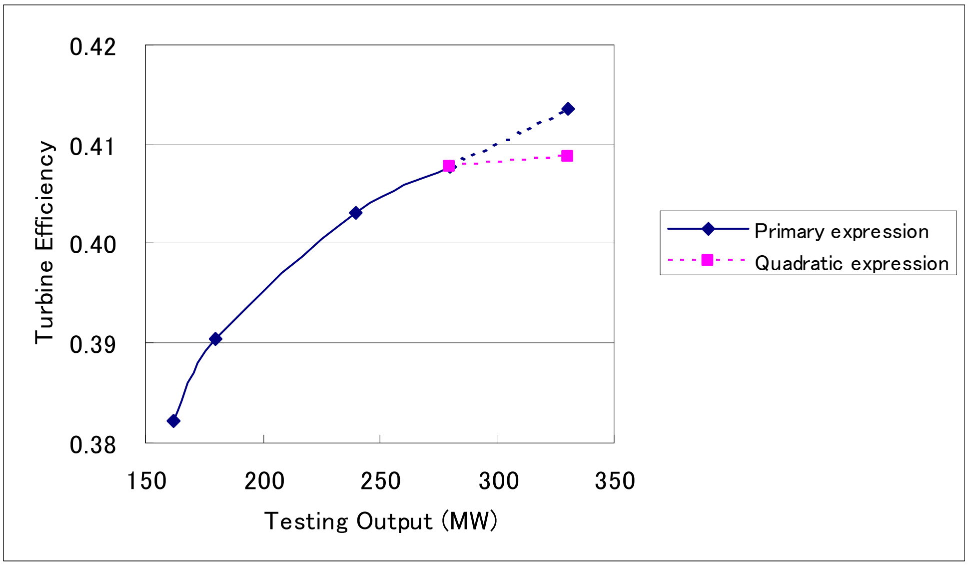

Figure 6 Estimation method of the baseline efficiency at full load

On the other hand, the *higher* project efficiencies result in the larger emission reductions. Thus, the project efficiencies for both No.1 and No.2 turbines may be estimated by the quadratic expressions. Once again, the efficiencies at full loads would have been higher than ones at *any* other loads, even ones at the highest-measured loads. In this project, “THA (Turbine Heat Acceptance)”, which means thermal performance testing at full power, is the highest-measured load. The project efficiencies have been assumed to be equal to the efficiencies at THA; this estimation is even more conservative than estimation by quadratic expression.

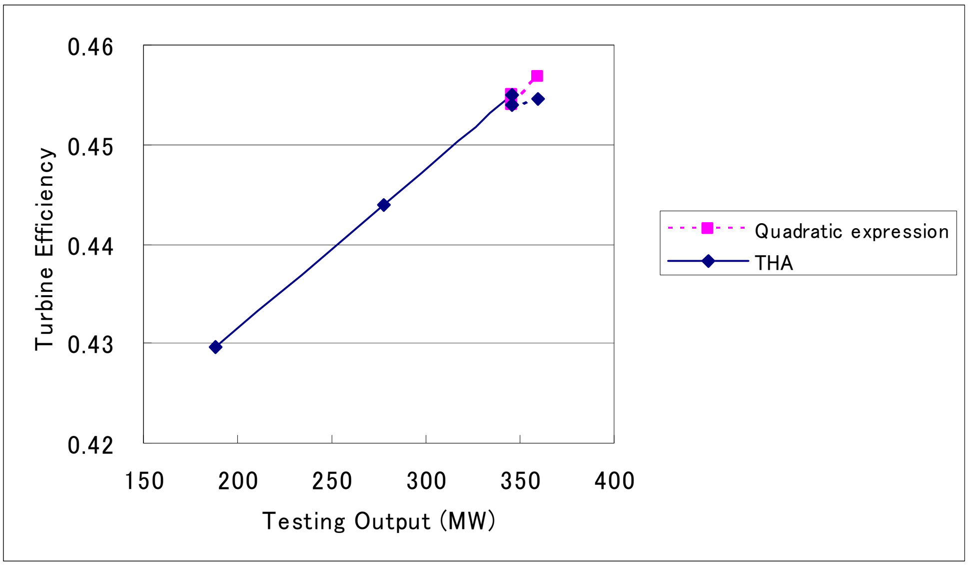

Figure 7 Extrapolation method of the project efficiency at full load

Main results of the performance tests

The performance tests were conducted by the institutes authorised by the Chinese government following the procedure of the Performance Test Code for the Steam Turbines of American Society of Mechanical Engineers (ASME PTC6-1996). The Code provides procedures for the accurate testing of steam turbines.

No.2 turbine prior to retrofitting (13-15 January 2009)

Table 9 Main results of performance test of No.2 turbine prior to retrofitting

Measurement item	Unit		Steam pump operation			
		330MW est.	280MW	240MW	180MW	162MW
Testing output	kW	-	285398.36	242078.69	184326.67	162151.22
Testing heat rate	kJ/(kW·h)	-	9055.43	8995.91	9123.03	9288.64
Corrected heat rate	kJ/(kW·h)	8706.07	8830.13	8929.36	9219.46	9420.20
Corrected thermal efficiency	%	41.35	40.77	40.32	39.05	38.22

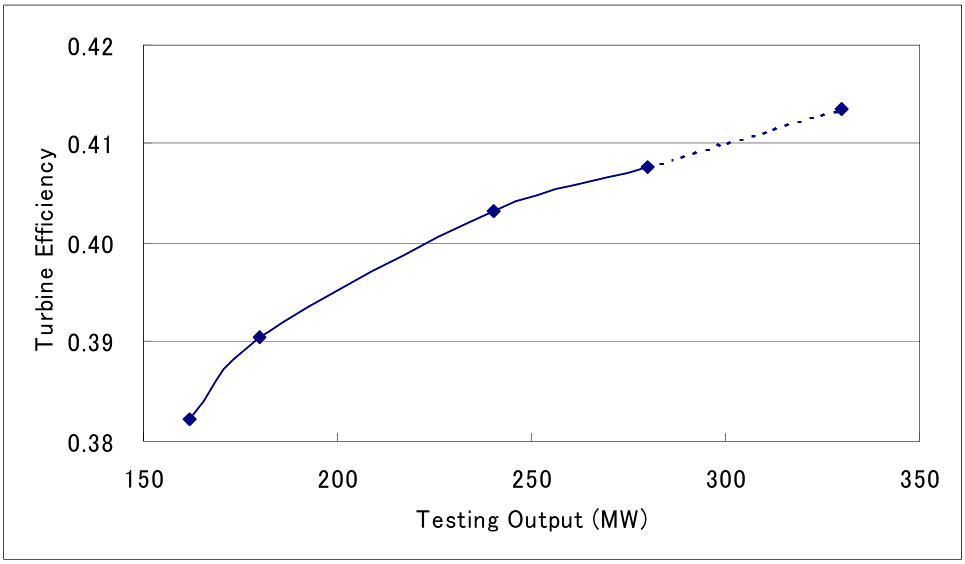

Figure 8 Corrected Load-efficiency curve of No.2 turbine prior to retrofitting

No.1 turbine <u>prior to</u> retrofitting (15-17 August 2009)

Table 10 Main results of performance test of No.1 turbine prior to retrofitting

Measurement item	Unit		Steam pump operation		
		330MW est.	250MW	180MW	160MW
Testing output	kW	-	252192.3	187138.5	161776.9
Testing heat rate	kJ/(kW·h)	-	10078.0	10369.6	10507.2
Corrected heat rate	kJ/(kW·h)	8812.48	9266.2	9663.4	9728.1
Corrected thermal efficiency	%	40.85	38.85	37.25	37.01

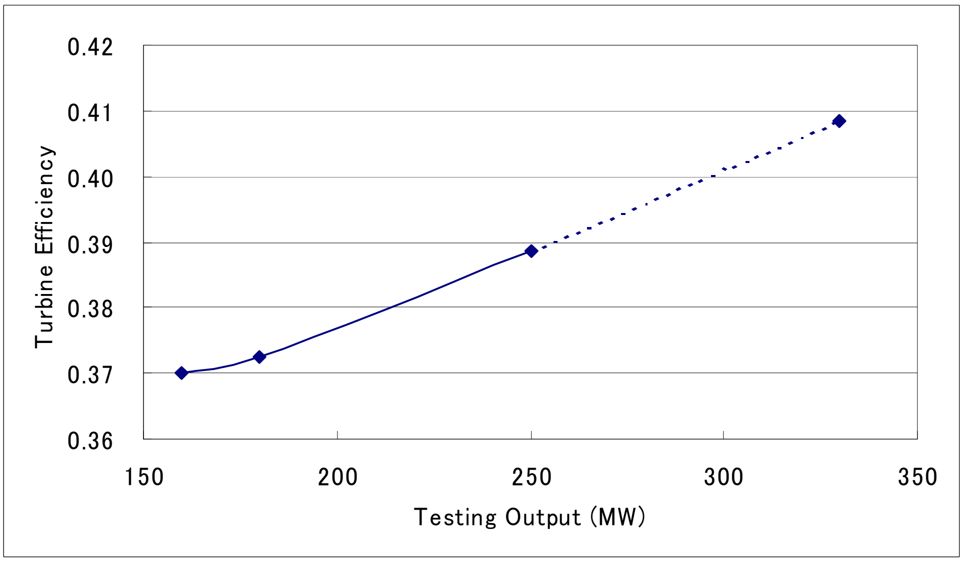

Figure 9 Corrected Load-efficiency curve of No.1 turbine prior to retrofitting

No.2 turbine <u>after</u> retrofitting (7-10 November 2009)

Table 11 Main results of performance test of No.2 turbine after retrofitting

Measurement item	Unit	360MW est.	THA1	THA2	75%THA	50%THA
Testing output	kW	-	345.731	345.983	277.631	188.057
Testing heat rate	kJ/kW·h	-	7951.58	8043.20	8113.08	8323.15
Corrected heat rate	kJ/kW·h	7920.13	7928.53	7911.73	8108.5429	8377.3107
Corrected thermal efficiency	%	45.45	45.41	45.50	44.40	42.97

THA: Turbine Heat Acceptance. Thermal performance testing at full power.
The full-load (360MW) efficiency is estimated as the average of THA1 and THA2.

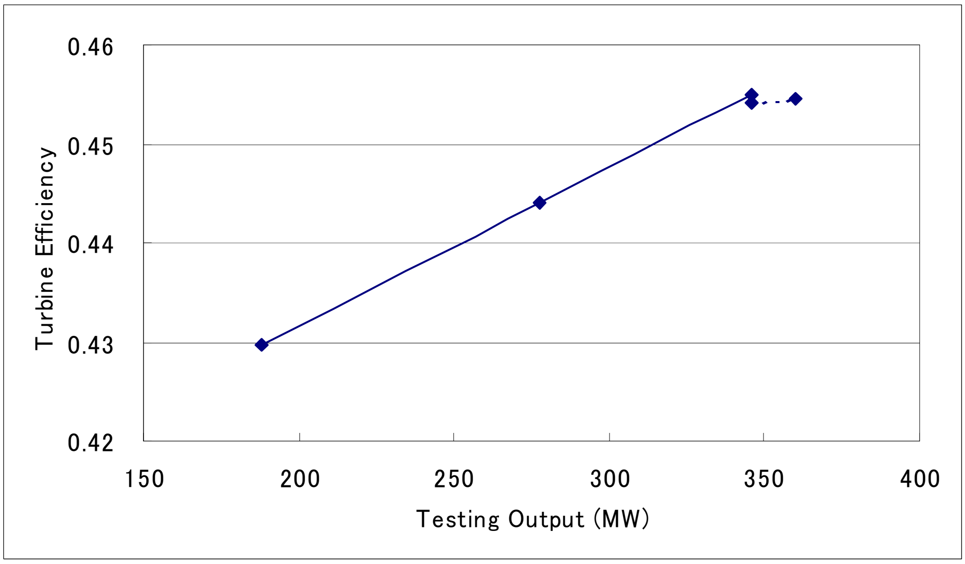

Figure 10 Corrected Load-efficiency curve of No.2 turbine after retrofitting

No.1 turbine <u>after</u> retrofitting (28 February - 10 March 2010)

Table 12 Main results of performance test of No.1 turbine after retrofitting

Measurement item	Unit	360MW est.	THA1	THA2	75%THA	50%THA
Testing output	kW	-	346.80	341.75	279.39	186.88
Testing heat rate	kJ/kW·h	-	8013.24	7961.58	8375.93	8567.27
Corrected heat rate	kJ/kW·h	7918.88	7915.54	7922.21	8082.12	8308.35
Corrected thermal efficiency	%	45.46	45.48	45.44	44.54	43.33

THA: Turbine Heat Acceptance. Thermal performance testing at full power.
The full-load (360MW) efficiency is estimated as the average of THA1 and THA2.

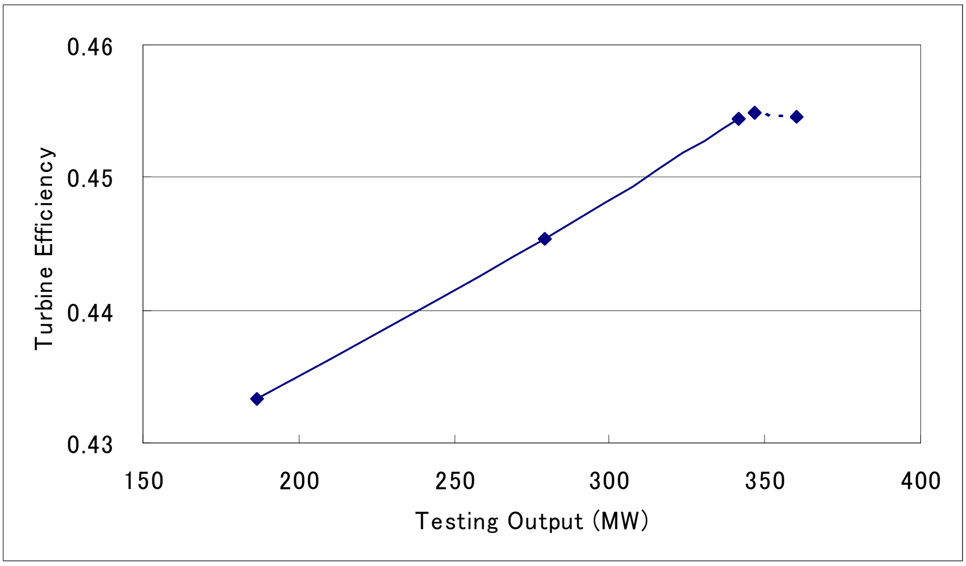

Figure 11 Corrected Load-efficiency curve of No.2 turbine after retrofitting

Calculation of Operating Margin (OM) Emission Factor

Table 13 CO_2 Emissions from Fuel-fired Power Plants of NWPG in 2004

Fuel types	Unit	Shaanxi	Gansu	Qinghai	Ningxia	Xinjiang	Subtotal	Emission factor	Oxidation factor	NCV	CO_2 emission (tCO_2e)
								tc/TJ	%	MJ/t,m³	*J=G*H*I*F*44/12 /10000 (Mass unit)*
		A	B	C	D	E	F=A+B+C+D+E	G	H	I	*J=G*H*I*F*44/12/ 1000 (Volume unit)*
Raw coal	10^4t	2428.7	1595.9	322.8	1270.1	1240.9	**6858.4**	25.8	100	20908	135652074
Cleaned coal	10^4t							25.8	100	26344	0
Other washed coal	10^4t				102.64	10.5	**113.14**	25.8	100	8363	895096
Coke	10^4t	0.78					**0.78**	29.2	100	28435	23747
Coke oven gas	10^8m^3		0.3				**0.3**	12.1	100	16726	22262
Other coal gas	10^8m^3	0.74	1.26				**2**	12.1	100	5227	46381
Crude oil	10^4t	0.01				0.06	**0.07**	20	100	41816	2147
Gasoline	10^4t	0.02					**0.02**	18.9	100	43070	597
Diesel	10^4t	2.16	0.36		0.05	0.41	**2.98**	20.2	100	42652	94141
Fuel oil	10^4t	0.01	0.69			0.3	**1**	21.1	100	41816	32352
LPG	10^4t						0	17.2	100	50179	0
Refinery gas	10^4t					3.26	**3.26**	15.7	100	46055	86430
Natural gas	10^8m^3	1.61	0.59			6.27	**8.47**	15.3	100	38931	1849873
Other oil products	10^4t						**0**	20	100	38369	0
Other coal chemicals	10^4t						**0**	25.8	100	0	0
Other energy	10^4tce		6.17			3.46	**9.63**	0	100	28435	0
										Total	**138,705,098**

Data sources: *China Energy Statistical Yearbook 2005*

Table 14 Fuel-fired Power Generation of NWPG 2004

Name of the province	Generation	Rate of electricity used by factory	Power supply
	MWh	%	MWh
Shaanxi	44,439,000	7.5	41,106,075
Gansu	33,242,000	6.21	31,177,672
Qinghai	6,208,000	7.96	5,713,843
Ningxia	25,298,000	5.45	23,919,259
Xinjiang	22,752,000	9.07	20,688,394
Total			122,605,243

Data sources: *China Electric Power Yearbook 2005*

Table 15 Calculation on Simple OM Emission Factor of NWPG in 2004

Total emission amount NWPG （tCO2）	138,705,098
Total power supply in NWPG （MWh）	122,605,243
Emission factor in NWPG （tCO2/MWh）	**1.13131**

Data sources: *China Electric Power Yearbook 2005*

Table 16 CO_2 Emissions from Fuel-fired Power Plants of NWPG in 2005

Fuel types	Unit	Shaanxi	Gansu	Qinghai	Ningxia	Xinjiang	Subtotal	Emission factor	Oxidation factor	NCV	CO_2 emission (tCO_2e)
								tc/TJ	%	MJ/t,m^3	*J=G*H*I*F*44/12 /10000 (Mass unit)*
		A	B	C	D	E	F=A+B+C +D+E	G	H	I	*J=G*H*I*F*44/12/ 1000 (Volume unit)*
Raw coal	10^4t	2461.28	1597	345.1	1467.7	1358.09	**7229.17**	25.8	100	20908	142985522
Cleaned coal	10^4t	16.22					**16.22**	25.8	100	26344	404225
Other washed coal	10^4t	35.56			101.95	10.2	**147.71**	25.8	100	8363	1168593
Coke	10^4t	3.23					**3.23**	29.2	100	28435	98335
Coke oven gas	10^8m^3						**0**	12.1	100	16726	0
Other coal gas	10^8m^3						**0**	12.1	100	5227	0
Crude oil	10^4t					0.18	**0.18**	20	100	41816	5520
Gasoline	10^4t	0.02				0.01	**0.03**	18.9	100	43070	895
Diesel	10^4t	2.24	0.46	0.06		0.5	**3.26**	20.2	100	42652	102986
Fuel oil	10^4t	0.01	0.57			0.25	**0.83**	21.1	100	41816	26852
LPG	10^4t						**0**	17.2	100	50179	0
Refinery gas	10^4t					7.71	**7.71**	15.7	100	46055	204410
Natural gas	10^8m^3	1.46	0.52	1.33		7.81	**11.12**	15.3	100	38931	2428640
Other oil products	10^4t						**0**	25.8	100	28435	0
Other coal chemicals	10^4t						**0**	25.8	100	28435	0
Other energy	10^4tce	8.24	1.3				**9.54**	0	100	0	0
										Total	**147425979**

Data sources: *China Energy Statistical Yearbook 2006*

Table 17 Fuel-fired Power Generation of NWPG 2005

Name of the province	Generation	Rate of electricity used by factory	Power supply
	MWh	%	MWh
Shaanxi	41,100,000	7.16	38,157,240
Gansu	33,106,000	4.23	31,705,616
Qinghai	5,500,000	2.69	5,352,050
Ningxia	27,643,000	5.73	26,059,056
Xinjiang	26,560,000	8.8	24,222,720
Total			**125,496,682**

Data sources: *China Electric Power Yearbook 2006*

Table 18 Calculation on Simple OM Emission Factor of NWPG in 2005

Total emission amount NWPG （tCO2）	147425979
Total power supply in NWPG （MWh）	125,496,682
Emission factor in NWPG （tCO2/MWh）	**1.17474**

Data sources: *China Electric Power Yearbook 2006*

Table 19 CO_2 Emissions from Fuel-fired Power Plants of NWPG in 2006

Fuel types	Unit	Shaanxi	Gansu	Qinghai	Ningxia	Xinjiang	Subtotal	Emission factor	Oxidation factor	NCV	CO_2 emission (tCO_2e)
								tc/TJ	%	MJ/t,m^3	*J=G*H*I*F*44/12 /10000 (Mass unit)*
		A	B	C	D	E	F=A+B+C +D+E	G	H	I	*J=G*H*I*F*44/12/ 1000 (Volume unit)*
Raw coal	10^4t	2834.44	1660.92	421.86	1833.72	1547.69	**8298.63**	25.8	100	20908	164138337
Cleaned coal	10^4t						**0**	25.8	100	26344	0
Other washed coal	10^4t				112.7	8.45	**121.15**	25.8	100	8363	958466
Coke	10^4t				0.01		**0.01**	29.2	100	28438	304
Coke oven gas	10^8m^3	0.2				0.08	**0.28**	12.1	100	16726	20778
Other coal gas	10^8m^3	0.1					**0.1**	12.1	100	5227	2319
Crude oil	10^4t					0.02	**0.02**	20	100	41816	613
Gasoline	10^4t	0.01					**0.01**	18.9	100	43070	298
Diesel	10^4t	1.14	0.24	0.61		1.25	**3.24**	20.2	100	42652	102355
Fuel oil	10^4t		0.6			0.11	**0.71**	21.1	100	41816	22970
LPG	10^4t						**0**	17.2	100	501	0
Refinery gas	10^4t						**0**	15.7	100	46055	0
Natural gas	10^8m^3	1.59	0.56	1.06		7.49	**10.70**	15.3	100	38931	2336911
Other oil products	10^4t						**0**	20	100	38369	0
Other coal chemicals	10^4t	1.86					**1.86**	25.8	100	28435	50033
Other energy	10^4tce	33.57	8.81			2.2	**44.58**	0	100	0	0
										Total	**167633385**

Data sources: *China Energy Statistical Yearbook 2007*

Table 20 Fuel-fired Power Generation of NWPG 2006

Name of the province	Generation	Rate of electricity used by factory	Power supply
	MWh	%	MWh
Shaanxi	54482000	6.97	50684605
Gansu	35738000	4.29	34204840
Qinghai	7204000	2.57	7018857
Ningxia	36731000		36731000
Xinjiang	9901000	8.02	27502940
Total			**156142241**

Data sources: *China Electric Power Yearbook 2007*

Table 21 Calculation on Simple OM Emission Factor of NWPG in 2006

Total emission amount NWPG （tCO2）	167633385
Total power supply in NWPG （MWh）	156142241
Emission factor in NWPG （tCO2/MWh）	**1.07359**

Data sources: *China Electric Power Yearbook 2007*

Calculation of Build Margin (BM) Emission Factor

Table 22 The Proportion of CO_2 Emissions of Different Fuel-fired Power Plants in the Total CO_2 Emissions

Fuel types	Unit	Shaanxi	Gansu	Qinghai	Ningxia	Xinjiang	Subtotal	NCV	Emission factor	Oxidation factor	CO_2 emission (tCO_2e)
		A	B	C	D	E	F=A+…+E	G	H	I	*J=F*G*H*I*44/12/100*
Raw coal	10^4t	2834.44	1660.92	421.86	1833.72	1547.69	**8298.63**	20908kJ/kg	25.8	1	164138337
Cleaned coal	10^4t	0	0	0	0	0	**0**	26344kJ/kg	25.8	1	0
Other washed coal	10^4t	0	0	0	112.7	8.45	**121.15**	8363kJ/kg	25.8	1	958466
	10^4t	0	0	0	0	0	**0**	20908kJ/kg	26.6	1	0
Coke	10^4t	0	0	0	0.01	0	**0.01**	28435kJ/kg	29.2	1	304
Total											***165,097,108***
Crude oil	10^4t	0	0	0	0	0.02	**0.02**	41816kJ/kg	20.0	1	613
Gasoline	10^4t	0.01	0	0	0	0	**0.01**	43070kJ/kg	18.9	1	298
Coal oil	10^4t	0	0	0	0	0	**0**	43070kJ/kg	19.6	1	0
Diesel	10^4t	1.14	0.24	0.61		1.25	**3.24**	42652 kJ/kg	20.2	1	102355
Fuel oil	10^4t		0.6			0.11	**0.71**	41816kJ/kg	21.1	1	22970
Other oil products	10^4t	0	0	0	0	0	**0**	38369kJ/kg	20.0	1	0
Other coke production	10^4t	1.86	0	0	0	0	**1.86**	28435 kJ/kg	25.8	1	50033
Total											***176.269***
Natural gas	10^7m^3	15.9	5.6	10.6		74.9	**107**	38391kJ/m3	15.3	1	2336911
Coke oven gas	10^7m^3	2				0.8	**2.8**	16726kJ/m^3	12.1	1	20778
Other coal gas	10^7m^3	1					**1**	5227kJ/m^3	12.1	1	2319
LPG	10^4t	0	0	0	0	0	**0**	50179 kJ/kg	17.2	1	0
Refinery gas	10^4t	0	0	0	0	0	**0**	46055 kJ/kg	15.7	1	0
Total	*10^4t*										***2,360,008***
Total											**167,633,385**

Data sources: *China Energy Statistical Yearbook 2007.*

Table 23 Installed Capacity of the NWPG 2006

Installed capacity	Unit	Shaanxi	Gansu	Qinghai	Ningxia	Xinjiang	Total
Fire power	MW	9723	6448	1517	6002	5937	29627
Hydro power	MW	2165	4291	5423	429	1766	14074
Nuclear power	MW	0	0	0	0	0	0
Wind power and other	MW	46	199	0	11	189	445
Total	MW	11934	10938	6940	6442	7892	44146

Data sources: *China Electric Power Yearbook 2007*

Table 24 Installed Capacity of the NWPG 2005

Installed capacity	Unit	Shaanxi	Gansu	Qinghai	Ningxia	Xinjiang	Total
Fire power	MW	9132.1	5715	886.8	4577	5051.7	25362.6
Hydro power	MW	1578	4036.2	4825	428.5	1352.1	12219.8
Nuclear power	MW	0	0	0	0	0	0
Wind power and other	MW	46	109.1	0	112.2	132.2	399.5
Total	MW	10756.1	9860.3	5711.8	5117.7	6536	37981.9

Data sources: *China Electric Power Yearbook 2006*

Table 25 Installed Capacity of the NWPG 2004

Installed capacity	Unit	Shaanxi	Gansu	Qinghai	Ningxia	Xinjiang	Total
Fire power	MW	7640.4	4975.6	889.8	3782	4959.7	22247.5
Hydro power	MW	1876.5	3566.1	4053.4	366.2	973	10835.2
Nuclear power	MW	0	0	0	0	0	0
Wind power and other	MW	0	138.2	0	42.5	95.3	276
Total	MW	9516.9	8679.9	4943.2	4190.7	6028	33358.7

Data sources: *China Electric Power Yearbook 2005*

Table 26 BM Calculation of the NWPG

	Installed capacity 2004	Installed capacity 2005	Installed capacity 2006	New added installed capacity 2004-2006	The fraction of newly added installed capacity
	A	B	C	D=C-A	
Fire power	22247.5	25362.6	29627	7379.5	68.41%
Hydro power	10835.2	12219.8	14074	3238.8	30.02%
Nuclear power	0	0	0	0	0
Wind power	276	399	445	169	1.57%
Total	**33358.7**	**37981.4**	**44146**	**10787.3**	**100%**
The fraction of installed capacity 2004	75.64%	86.13%	100%		

$EF_{BM,y}$= 0.9062 × 68.41% = 0.6199 tCO_2/MWh

Annex 4

MONITORING INFORMATION

Refer to B.7.

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