Mongolia

Ex-Post Evaluation of Japanese ODA Loan Project

"The Rehabilitation Project for the 4thThermal Power Plant in Ulaanbaatar (I) (II)"

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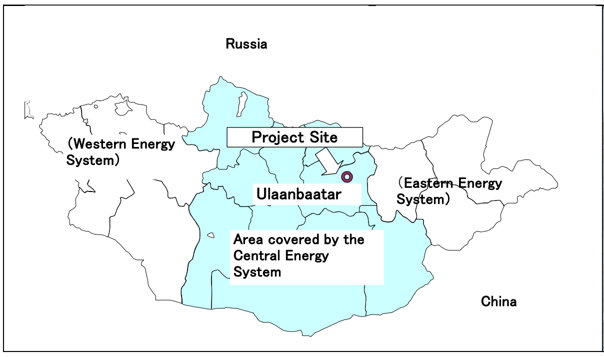
0. Summary

The project was implemented as a part of the continued assistance to the 4th thermal power plant (hereafter, TPP4) that was in critical condition after the withdrawal of human resource support from the former Soviet Union in the early 90's. Given TPP4's considerable significance as the largest source of electricity and heat supply in Mongolia, the project was highly relevant. The effectiveness of the project is high since the operation rate of the boilers increased (thanks to a radical drop in number of forced outages), and since a significant reduction in coal consumption and CO_2 emission per unit of electricity generated was obtained. Also, the stabilisation of and the substantial increase in the country's energy supply helped improve the credibility of the Central Energy System (hereafter, CES) as a whole. Although the energy sector policy of the country is now in transition and the external environment is uncertain, sustainability of the project itself is evaluated as high.
In light of the above, the project is evaluated to be highly satisfactory.

1. Project Description



(Project Location)

(The 4th Thermal Power Plant)

1.1 Background

Mongolia has a total land size of 1.56 million km² (four times that of Japan). Its population is around 2.75 million, out of which 1.24 million people, or 45%, live in the capital city of Ulaanbaatar (2010). Electricity is provided by CES, Western Energy System, and Eastern Energy System, with CES providing over 90% of the country's electricity.

In CES, TPP4 provides 73％ of the area’s electricity and 62% of the area’s heat (2010). It was built with assistance from the former Soviet Union and commenced operation in 1983. However, after Russian funding ended and Russian engineers were pulled out in 1991, the boiler’s auto-control system stopped functioning which constrained power generation. Moreover the indirect firing system being used at TPP4 was causing frequent mechanical trouble and posed a high risk of explosion: all of which were destabilizing factors for electricity supply[1]. Furthermore, due to a low combustion efficiency, TPP4 consumed large amount of coal thereby emitting high levels of air pollutants.

Although CES was importing electricity from Russia to offset the shortages, outages and drops in temperature for central heating were frequent which seriously affected industrial production and people’s daily life, especially in winter. To improve this situation, the rehabilitation of the automatic control system of the boilers and conversion to a direct firing system had become important at TPP4.

1.2 Project Outline

The objective of this project is to increase the reliability and combustion efficiency of TPP4’s existing facilities and to reduce air-pollutant emissions (by rehabilitating an automatic control system and switching to a direct firing system) and thereby contributing to the improvement of people’s daily life and the industrial development of Ulaanbaatar through a more stable supply of electricity and heat.

Loan Approved Amount/ Disbursed Amount	I: 4,493 million yen/4,493 million yen II: 6,139 million yen /6,072 million yen
Exchange of Notes Date/ Loan Agreement Signing Date	I: October 1995/ October 1995 II: February 2001/March 2001
Terms and Conditions	Interest Rate: I: 2.3％ II:0.75% Repayment Period: I:30 years II:40 years (Grace Period: 10 years) Conditions for Procurement: I: general untied II: general untied (bilateral tied for consultants)
Borrower / Executing Agency(ies)	Ministry of Mineral Resources and Energy [2] (implementor:TPP4)/Guarantor: Government of Mongolia
Final Disbursement Date	I: April 2002, II: July 2008
Main Contractor (Over 1 billion yen)	I:Austrian Environment Sgpiwaagner-biro (Austria）・Nissho Iwai（JV） II: ITOCHU
Main Consultant (Over 100 million yen)	Electric Power Development Co., Ltd.
Feasibility Studies, etc.	Feasibility Study on the Rehabilitation Project for the 4th Thermal Power Plant in Ulaanbaatar: Japan Consulting Institute, 1991

[1] In an indirect combustion system, pulverized coal is stored temporarily and poured into boilers as needed. In a direct burning system, coal is poured into the boiler for burning right after pulverization.
[2] Currently, Energy Authority under the Ministry of Mineral Resources and Energy (see 3.5.1.).

	SAPROF: August 1995
Related Projects	<Technical Cooperation> ・Dispatch of experts (1996~01, operation and maintenance) ・JICA Development Study Supporting the Rehabilitation Project of the 4th Thermal Power Plant in Ulaanbaatar Mongolia (2001~ 2002) ・Senior Volunteer（20, Electricity field, 2002~ 2011） <Grant> ・Emergency equipment provision（1991, 4 mil. yen） ・Rehabilitation Project for Improvement of the 4th Thermal Power Station in Ulaanbaatar (1992~1994, 2.415 bil. yen), Phase II (1.173 bil. yen, 1996), Follow-up (50 mil. yen, 2007)

2. Outline of the Evaluation Study

2.1 External Evaluator

Nobuko Fujita, Foundation for Advanced Studies on International Development

2.2 Duration of Evaluation Study

Duration of the Study: November, 2010 –December, 2011

Duration of the Field Study: January 17 – January 28, June 13ー June 17, 2011

2.3 Constraints during the Evaluation Study (if any)

None.

3. Results of the Evaluation (Overall Rating: A[3])

3.1 Relevance (Rating: ③[4])

3.1.1 Relevance with the Development Plan of Mongolia

The Millennium Development Goals-based Comprehensive National Development Strategy of Mongolia (2008-2021) points out Mongolia’s limited and unreliable power supply as one of the country’s weaknesses and aims for self- sufficiency in energy in light of the growing energy needs of the Gobi region. The Mongolian Integrated Power System Program (enacted in 2002 and amended in 2007) lays out Mongolia’s vision for the energy sector and targets the integration of its power systems (by laying out power generation facilities nationwide), providing a stable supply of electricity to local regions and exporting electricity.

The Energy Sector Master Plan (2000–2020), approved in 2002, indicates that TPP4 will maintain its crucial role in electricity and heat supply even after 2020, considering that

3 A: Highly satisfactory, B: Satisfactory, C: Partially satisfactory, D: Unsatisfactory

4 ①: High, ② Fair, ③ Low

some of the aging power plants are expected to close down by 2020[5]. The Master Plan will be revised by November 2011, but even in the revised version, TPP4 is given a core role in CES[6].

3.1.2 Relevance with the Development Needs of Mongolia

Mongolia's imports of electricity to compensate for supply deficiencies amounted to 15.3% of its total electricity demand in 1995. Despite such imports there were frequent outages which caused shutdowns in factory production lines, and drops in heat temperature during severe winters. This was a serious problem since heat could not be imported.

Currently, prospects for a growth in mining and manufacturing are high and annual increases of between 3.2～7.7% are expected[7]. By 2015, the demand for heat is also expected to increase by 29.0% (compared to 2010)[8] due to a government policy to make the Ger area into apartments[9].

3.1.3 Relevance with Japan's ODA Policy

The basic framework of cooperation with Mongolia (1994, Ministry of Foreign Affairs of Japan) states that Japan places emphasis on strengthening economic infrastructure and diversification of industry. Also, at the 4th conference of Consultative Group on Mongolia, Japan indicated its support for the rehabilitation of TPP4 in light of the necessity to support the energy sector.

This project has been highly relevant with the country's development plan, development needs, as well as Japan's ODA policy; therefore its relevance is high.

3.2 Efficiency (Rating: ②)

3.2.1 Project Outputs

This project consisted of two phases, Phase I and II. Phase I was consisted of the

5 Among five thermal power plants of CES, 2nd thermal power plant is said to be shutdown in near future as its lifetime expired in 2009. Service life of 3rd thermal power plant will expire in 2011 and therefore will be shutdown in phases. Although 5th thermal power plant is expected to be built by 2020, TPP4 will keep playing an important role till then. As of the boilers of TPP 4, 20～28 years elapsed since their operationalization, and the Russian standard machine life is 25 years. However, the Energy Authority believes this project can extend the service life by 20 years. With proper maintenance and repair, they plan to make TPP4 play a core role in electricity supply of CES.（Source: Master Plan and the Energy Authority. (January 20, 2011)).

6 Hearing from Energy Authority. This revision has received support from the Japan Fund for Poverty Reduction.

7 Document supplied by the Energy Regulatory Authority

8 Document supplied by the National Dispatching Center

9 Area with Gers (Mobile residence of Mongolian nomads) and wooden houses surrounding the center of the city where nomads and others who migrated in Ulaanbaatar live.

installation and renewal of machinery for the recovery of the self-control system for four out of eight boilers, and conversion of the firing system method of the mills from indirect to direct (Table 1). In Phase II, the four remaining boilers underwent similar installations and renewals, and the exciter systems for the generators were also rehabilitated.
In both phases, outputs were produced as planned, except for the consulting service for Phase II which was extended by 1.36 MM[10].

Table 1 Major Output

Phase	Plan	Achievement	Differentiation
I	(1) Rehabilitation of automatic control system Boiler No. 1 ~4） (2) Conversion from indirect to direct firing system (ditto) (3) Rehabilitation and installation of associated machineries (ditto) (4) Consulting service 94MM	(1) Renewal of boiler control system, installation of chemicals injector, blow control system, data processing system, operation simulator, etc. (2) Installation of vertical mill motor,coal weighing machine, pulverized coal feeding tubes, ventilators, etc. (3) Renewal of boiler tubes, etc. (4) 94MM	(1)~(4) as planned
II	(1) Rehabilitation of automatic control system (Boiler No.5~8） (2) Conversion from indirect to direct firing system (ditto) (3) Rehabilitation and installation of associated machineries (ditto) (4) Stabilizing operation (5) Consulting service 108MM	(1) Same as Phase I (2) Same as Phase I (3) Same as Phase I (4) Renewal of the exciter system (5) 109.36MM	(1)~(4) as planned (5) increase by 1.36MM

3.2.2 Project Inputs

3.2.2.1 Project Cost

The total cost for Phase I and II amounted to 11,873 mil. yen opposed to 12,343 mil. yen as planned (96% of planned amount). In Phase I, the local cost exceeded the planned cost by 20%, however it decreased by 17% in yen terms due to currency depreciation. Although the consulting service in Phase II was extended as mentioned above, it was financed by contingency funds and TPP4’s own funds, which kept the total costs within the budget.

3.2.2.2 Project Period

The project period was 121 months which was longer than planned (136%). Completion of the project was delayed by 16 months in both phases[11]. Causes for delay in Phase I included; the delay in procurement, taking time for removal of underground concrete to install equipment, as well as deliberate commissioning. In Phase II, the first package out

10 Because continuous advice regarding management and adjustment of boilers was necessary.

11 The project period is defined as starting the month of loan agreement signing to the completion of commissioning.TPP4 uses the same definition. And since there was 17 months blank between Phase I and II, project period was defined extracting this period.

of seven needed 15 months from public notice of pre-qualification to contract signing which slowed down other packages[12]. Moreover, installation works were extended by 2-3 months, and commissioning took longer than expected due to a drop in the temperature of the boilers. All of these contributed to the project period's overrun.

Although the project cost was within the plan, the project period needed to be extended, therefore efficiency of the project is fair.

3.3 Effectiveness[13] (Rating: ③)

3.3.1 Quantitative Effects

The boiler operation rate, which was an indicator set during the appraisal, was mostly achieved. The auxiliary rate and the frequency of boiler suspension (which indicate the combustion efficiency and the facility's reliability) also improved considerably. In addition, the consumption of coal and heavy oil were reduced which contributed to energy conservation.

3.3.1.1 Results from Operation and Effect Indicators

（1） Improvement of efficiency and facility reliability of TPP4

① Operation rate of boilers

As for operation rate of the boilers, the target was mostly reached (Table 2). The maximum output of TPP4 in 2010 increased by 50% compared to that of 1995 (By January 2011, it increased by 80%, reaching 576MW)[14]. Power production (sending end) increased by 92.7% in the same period, which indicates an obvious effect of this project （Figure 1）.

Table 2 Operation and Outcome Indicators

indicators	baseline（1995）	target (1999)	actual（2010）	actual/baseline (%)
Boiler operation rate（%）*1	41.3	60.0	59.5	144.1
Maximum Output（MW）	320		481	150.3
Power Production (sending end)（MWh/y）	1,314,906		2,533,470	192.7
Net Thermal Efficiency（%）*2	50.6		56.4	111.5
Auxiliary Power Rate（%）	20.5		13.8	67.3
Rate of boiler failure due to mechanical problems（%）*3	47.7		13.1	27.7

*1：Annual operating hours (8 boilers total)（24h x 365 days x 8 boilers）

*2：Annual power production（sending end）x 860/annual fuel consumption x heat valuex100. It indicates thermal efficiency.

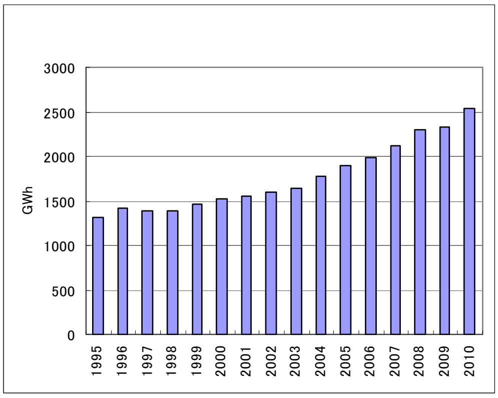
[12] It took a long time to examine the tender document in terms of technical aspects such as how performance could be adjusted depending on different kinds of coal.

[13] Effectiveness is scored also in the light of factors regarding Impact.

[14] As for turbines, the maximum output of No5 (2007) and No.6 (2010) was raised from 80MW to 100MW by TPP4's own fund, bringing the total maximum output to 580MW.

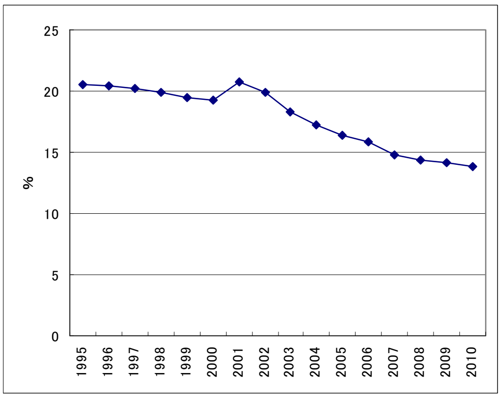
*3: Among total operating hours x 8, total hours in which boilers were suspended

(Source: TPP4)



(Source : TPP4)

Figure1 : Power Production of TPP4 (sending end)



(Source : TPP4)

Figure2 : Auxiliary Power Rate of TPP4

② Auxiliary Power Rate

The Auxiliary Power Rate (the rate of consuming produced electricity within the power plant) decreased to 13.8% in 2000 from 20.5% in 1995 (Figure2). It is lower than any of the other four coal firing power plants[15] in CES (ranging from16.0%～22.1% in 2010) indicating that TPP 4 has the most efficient power production in CES.

③ Shutdown of boilers

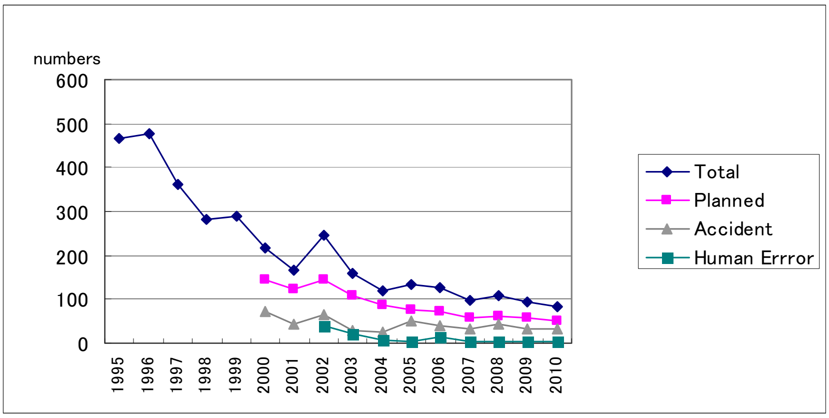
In 2010, the hours of boiler shutdown was one fourth that of 1995 (table 3). The number of boiler shutdown has decreased substantially across the board including; planned shutdowns, accidental shutdowns, and shutdowns due to human error (Figure3).

Table3 Hours of boiler shutdown

	1995	2000	2010
Hours of boiler shutdown (8 boilers total, h/year)	33,459	29,411	9,212

(Source : TPP4)

15 Four other power plants are TPP2, TPP3 in Ulaanbaatar, Darhan and Erdenet Thermal Power Plants.



(Source：TPP4)

Figure3 Frequency of boiler shut down

（2）Environmental improvement effect

Although consumption of coal increased due to the increase in power production, the amount per unit power generation in 2010 decreased by 11.5% compared to year 2000, reaching the target (11.3%). Likewise, CO_2 emission increased in absolute terms but decreased in terms of unit power production by 16.4% compared to year 2000 surpassing the goal of 11.5 % (Table 4).

As for heavy oil consumption, the amount in 2010 is less than one third that of year 2000, due to a decrease in the number of boiler shutdowns (less re-starting operation).

As for SO_2 and NOx, it is hard to compare current data with that of 1995 because the detailed measurement conditions in 1995 are unknown; however, unit production wise, SO_2 was halved, and NOx is unchanged. Since neither desulphurization equipment nor NOx removal system is installed, the decrease in SO_2 is most likely due to the change in combustion and the electrostatic precipitator.

Table4 Environmental improvement effect

	1995 (reference)	2000 (baseline)	2008 (target)	2010 (actual)
Electricity generation (generation end)（MWh/y）	1,654,000	1,910,000		2,940,600
Total consumption of coal（t/y）	1,968,502	2,190,369		2,985 ,000
Coal consumption per unit production of electricity（t/MWh）	1.190	1.147		1.015
Rate of change per unit production of electricity (compared to 2000) （%）			－11.3%	－11.5%
CO_2 emission（t/y）	2,755,895	3,007,508		3,868,560
CO_2 emission per unit production of electricity（t/MWh）	1.6662	1.5746		1.3158
Rate of change per unit production of electricity (compared to 2000)（%）			－11.5%	-16.4%
Heavy oil consumption（t/y）	20,085	4,793		1,366
SO_2 emission（t/y）	9,236.2			7,402.2
SO_2 emission per unit production of electricity（t/MWh）	5,580			2,520
Rate of change per unit production of electricity (compared to 2000) (%)			－45%	－54.8%
NOx emission（t/y）	5,232.5			9,280.6
NOx emission per unit production of electricity（t/MWh）	3,163			3,157
Rate of change per unit production of electricity (compared to 2000) (%)			－22%	-0.2%

（Source: target: Appraisal report. CO_2emission is calculated considering the proportion of different kind of coals, others are from data provided by TPP4. Since there was no accurate measurement of SO_2 and NOx for the period 1999~2008, 1995 data was used as a baseline.）

SO_2 concentration in exhaust falls below Mongolian National Standards (2008) in 2010 although NOx exceeds the Standard by 40~70% for the boilers using Shive-Ovoo coal (Table 5). TPP4 pays attentions to air pollutants and conducts monitoring of exhaust twice a month and the installation of a smoke stack monitor is being planned to constantly measure pollutants[16].

Table 5 Air pollutants in the exhaust of TPP4 boilers compared to National Standards

Boiler No.	coal	SO_2	NOx
No.3,4	Baganuur	0.11～0.33times	1.03～1.06times
No.5,6,7	Shivee-Ovoo	0.1～0.3times	1.42～1.76times

（Note: Mongolian National Standards are set according to the size of power plants. The above comparison was made using TPP4 size standards. Source: Air Quality Agency of the Capital City）

3.3.1.2 Results of Calculations of Internal Rates of Return (IRR)

Combining Phase I and II, the IRR for the period 1996~2020 was re-calculated as follows.

Table 6 Recalculated IRR as of ex-post evaluation

	FIRR (%)		EIRR (%)	
	appraisal	ex-post evaluation	appraisal	ex-post evaluation
Phase I	8.8	6.2	10.5	26.2
Phase II	17.4		18.8	

[16] Environmental monitoring is conducted every four years by private consultant companies, although its recommendations are not binding and follow-up reporting is not necessary. Starting 2010, Air Quality Agency of the Capital City is in charge of monitoring and its enhancement is expected.

As for FIRR, a before and after comparison is not appropriate since the decrease of electricity imported from Russia, which is not in TPP4's account, was calculated as a benefit at the time of the appraisal. The relatively low 6.2% FIRR is influenced by tariff controls.

EIRR was calculated under the same conditions as the appraisal. This project contributed to electricity import savings, and given that the expected import price was twice as high in 2010, the benefit (import savings) pushed EIRR as high as 26.2%.

3.3.2 Qualitative Effects

(1) Number of explosive accidents in the plant

By introducing a direct firing system, fire caused by storage of pulverized coal, which happened 16 times in 1996, was prevented and there have been no further explosions since 2000[17].

(2) Reduction of operation and maintenance cost

By efficient firing, the project saved 388,080t of coal or 4,424 mil. Tug (around 290 mil. yen) a year in 2010 compared to 2000[18]. Restarting a boiler takes 25~26t of heavy oil which amounts to 15 mil. Tug (around 1 mil. yen) each time. Efficient firing and reduction in the number of boiler halts contributed to reduce operation and maintenance costs.

This project has largely achieved its objectives; therefore its effectiveness is high.

		
Control Room	Mill	Boiler Tubes

3.4 Impact

3.4.1 Intended Impacts

(1) Stabilization of power supply

In a survey targeting large scale users of electricity in CES and residents of Ulaanbaatar

[17] TPP4 hearing.
[18] 1yen=15.22Tg（2010 Average）.

and Darhan city[19], 75.6% responded that power supply improved (in terms of fewer outages and stable voltage) compared to the 1990s. Large scale users reported smoother business operation and increase in production due to a stable power supply, and reduction of machinery failures due to stabilization of voltage. Residents of both cities mentioned less problem for preparing meals (since there is no town gas supplied in Mongolia, electricity is used for cooking in apartments).

In the 1990s, even though electricity was supplied to Ulaanbaatar by sacrificing some local areas, planned outages still occurred in Ulaanbaatar, neither of which is seen today[20].

Although outages have decreased in comparison to the 1990s, they started to increase again since 2007 (Table 7). Beneficiary survey also shows that there are 3~26 hours of outages depending on where they live (Table 8).

Causes of outages in 2009 relate to problems of distribution facilities (41%), planned outages (34%), natural disasters (6.4%), and generation and transmission-related problems (1.3%)[21]. The recent increase in outages is caused by a tightening of supply due to increasing demand as well as distribution-related problems.

According to the distribution company, causes of distribution problems are cable accidents (48%), natural disasters (8.3%), and others (33.8%), and aging distributional facilities is a serious concern[22]. The transmission company states that transmission facilities are also aging since they were installed by the former Soviet Union in the 1980s and only 10-20 percent has been rehabilitated[23].

Table 7　Number of outages（CES）

	1995	2000	2005	2006	2007	2008	2009	2010
Number of outage in CES	184	12	11	6	27	99	159	238*

（*estimate, source：Energy Statistics 2010）

[19] Beneficiary survey was conducted in January and February 2011 targeting 30 large users, 30 households in Ulaanbaatar, and 30 households in Darhan city, who have been doing business or living in Darhan since 1990s. As for Ulaanbaatar, 12 households living in apartment with electricity and heat supplied, 10 households living in Ger and 8 households living in wooden houses with electricity (proportion reflects actual proportion of housing situation in Ulaanbaatar). Also, since location determines frequencies of outages, sample numbers were distributed according to proportion of the population in the 3 central districts, 3 suburban districts, and 3 remote districts.) In Darhan city, 18 households living in apartments and 12 households living in Ger were selected, which were also broken down to 12 central and 18 suburban households. All were asked about their satisfaction with the energy supply, comparisons to 1990s, and their conception about TPP4.

[20] Interview at Ministry of Mineral Resources and Energy

[21] Energy Regulatory Authority Annual Report 2009

[22] Interview at Ulaanbaatar Electricity Distribution Network State Owned Joint Stock Company

[23] Transmission facilities with 25 year life spans have already been used for 45 years. Interview at Central Regions Electricity Transmission Grid State Owned Joint Stock Company

Table 8　Frequency and hours of outage (2011)（beneficiary survey）

	Frequency/year	Average hours/time
large scale users in CES	4.6	2hours36’
Ulaanbaatar residents	13.1	1 hour57’
Darhan residents	2.2	1hour16’

(Source：Beneficiary Survey. Frequency and hour differs depending on location in a city.)

（2）Increase in heat supply

In comparison to 1995, heat supply in 2010 shows a 41.4% increase. According to the beneficiary survey, 68.4% responded that heat supply improved compared to the 1990s. (Heat supply stabilized and there were fewer disruptions in heating.) Heat and hot water supply is crucial in winter when temperature falls below 30 Celsius.

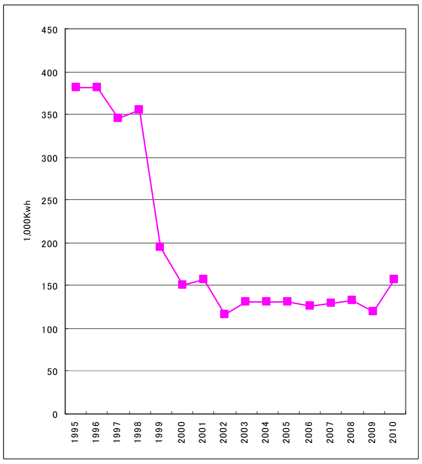
Table 9　Heat supply

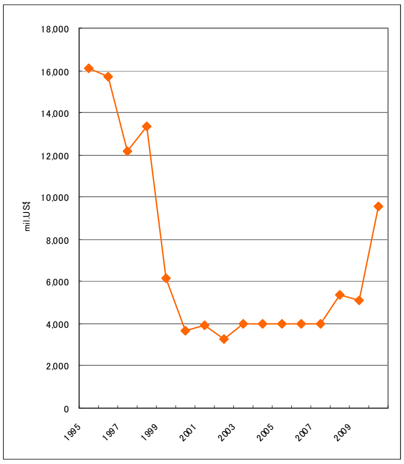
	1995	2000	2010
heat supply（1,000 GCal）	2,148	2,608	3,038

(Source: TPP4)

（3）Decrease of electricity imports from Russia

Electricity imports have dropped substantially and are only one third of that in 1995, representing 4.9% of total demand in 2009. Imports, however, started increasing in 2010 when the economy, especially the mining sector, started recovering from the Lehman shock (Figure 4). In monetary terms, imports have decreased from 1995, although they are on the rise again since the unit cost has been on the rise since 2008 (Figure 5).





（Source：Energy Statistics2010）

Figure 4 Electricity Imported (kWh)　Figure 5 Electricity Imported (US$)

3.4.2 Other Impacts

(1) Impacts on the natural environment

As stated before, this project contributed to the reduction of CO_2 and SO_2 per unit of power production by reducing coal consumption. On the other hand, in absolute terms, TPP4 remains one of Ulaanbaatar's contributors to air pollutants.

Air pollution in the capital city is serious. According to fixed ambient air monitoring stations, NO_2 concentration is 0.8~3.6 times the national standard (depending on annual average from monitoring spots), SO_2 concentration is 2.6~5.7 times, SPM (PM10) is 0.7~4.5 times. In winter, all pollutants exceed national standards at every monitoring spot[24].

Such pollution is caused by; three coal fired power plants, boilers and stoves for houses and Gers that are not connected to the central heating system, and exhaust gas from the rapidly increasing use of vehicles. Pollution is exacerbated in that dust in a dry climate can more easily be carried up by wind, at the same time the upper atmosphere is stable and pollutants are not easily diffused[25].

The beneficiary survey shows that 60% of large scale users and 73.3 % of Ulaanbaatar residents think TPP4 has a negative environmental impact. Although, since there are other power plants close-by, the respondent might not necessarily be able to identify the source of pollution. Among the negative environmental impacts associated with TPP4, 53.3% pointed out exhaust gas and 8.3% pointed out flying coal dust and ash.

・Dust in exhaust gas

An electrostatic precipitator (ESP) was installed at the time of installation and the removal rate has been improving (up to 97.98% in 2010). However, due to the aging of the ESP, the frequency of mechanical problems has been increasing and TPP4 is considering using their own funds to renew the ESP.

・Coal dust

In downwind regions of TPP4, flying coal dust is a problem. Coal is carried into TPP4 by open wagon and stored open air (about 260,000t regularly). In April and May when the wind is strong, coal dust is blown downwind and windows are covered by dust and ash as mentioned below. TPP4 tries to prevent such blow-off by sprinkling water.

・Ash

After combustion, coal ash is carried to an ash pond 3km away from TPP4 as slurry. When the ash pond becomes full, it is covered by soil. In 2000 and 2008 part of ash pond retaining wall collapsed and ash flowed off into the surrounding area (into Tora River in

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24 Data provided by the National Agency of Meteorology Hydrology and Environment Monitoring

25 According to simulations conducted by S. Guttikunda of the rate of contribution to pollution by each pollutant, No2, 3, and 4 power plants total contributes 34% of PMS in Ulaanbaatar, 59% of SO2, and 56％of NOx (Urban Air Pollution Analysis for Ulaanbaatar, 2007). Contribution by each power plant is simulated by JICA Technical Cooperation Project "Capacity Development Project for Air Pollution Control in Ulaanbaatar City."

2000). The ash pond has been re-enforced since then[26] and it is usually under water or snow; however, during the dry season, strong wind can blow ash away and although TPP4 takes preventative measures by pouring water in the ash pond to adjust the water content of the ash, they are sometimes unsuccessful.

（TPP4,View from the Ash Pond）

（2） Land acquisition and resettlement

Land acquisition and resettlement did not occur for this project.

（3） Other positive/negative impact

Thanks to a more stable supply of electricity and heat, the TPP4 project has improved the reliability of CES itself[27].

In light of the above, this project made a stable supply of heat and electricity possible, contributed to the reduction of outages in CES and saved foreign currency by reducing electricity imports.

3.5 Sustainability (Rating: ③)

3.5.1 Structural Aspects of Operation and Maintenance

Organisational structure for operation and maintenance is in place and staffs are properly assigned. Due to organizational reforms, the executing agency has been changed from the Ministry of Energy, Geology, and Mining to: the Ministry of Infrastructure and the Ministry of Fuel and Energy. At the time of the ex-post evaluation, TPP4 is administered by the Energy Authority which is under the Ministry of Mineral Resources and Energy.
Actual implementing organisation of the project, TPP4, is a 100% state owned joint stock company (41% owned by the Ministry of Mineral Resources and Energy, 39% by the National Property Committee, and 20% by the Ministry of Finance). Privatization is not foreseen in the next 15 years[28].
Operation and maintenance is carried out by the Operation Department, and the Repair

[26] Current ash pond is made by building a wall after banking first and second ash pond, and is said to be available for another 5 years. After that, the third and fourth ash ponds currently being land filled will be banked and used as the next ash pond.
[27] Interviews at Energy Authority, Energy Regulatory Agency, National Dispatching Center, Central Regions Electricity Transmission Grid State Owned Joint Stock Company, Ulaanbaatar Electricity Distribution Network State Owned Joint Stock Company, Ulaanbaatar district heating company.
[28] Interview at Energy Authority

Department is in charge of maintenance. As of January 1st, 2011, the total staff count is 1,456. Staff count is broken down as follows; 1,063 are in the Operation Department (including 293 in Boiler Section), 161 in Research and Development Department (including 106 in the maintenance shop, in charge of repair and fabrication of parts), 98 in Management Department (finance and procurement), and 128 in Administration Department (canteen, transport, clinic, etc.).

3.5.2 Technical Aspects of Operation and Maintenance

Operation's training is conducted at the operation simulation room which was provided by the project and which comes equipped with control panels just like actual control rooms and are suitable for the improvement of operational techniques. The skill and knowledge of the staff are improved by training courses and on-the-job training. A major training course is conducted once a month for all the energy-related organisations in CES[29] and other overseas training includes training by JICA.

Operation and maintenance manuals are still in use. All the spare parts are imported from China, Russia, and Japan, however no particular problem was reported regarding procurement.

Along with the project's two JICA Experts, twenty Senior Volunteers (SV) have been dispatched on an ongoing basis between 1996 and today. Their fields cover not only energy supply, but management, maintenance, personnel administration, environmental management, procurement and others. Their long standing advice contributed to the improvement of operations and management. Especially when a group of SVs were dispatched from a private Japanese firm, management and personnel administration improved in addition to technical aspects.

3.5.3 Financial Aspects of Operation and Maintenance

In Mongolia, power plants became joint-stock companies in 2001 in order to introduce the principle of market mechanism into the energy sector and each company is required to maintain financial independence. However, the amount of power production by each plant is instructed by the National Dispatch Center and tariffs are set at a relatively low level compared to international standards (tariffs are set by the Energy Regulatory Authority with the consent of the Parliament)[30]. All the power companies have difficulties making profit independently with the tariffs set so low.

TPP4 is facing loan repayments in addition to the need to secure funds for repair and new

[29] Participants' performance is evaluated in the crisis management course and re-training is required for unsuccessful participants. He/she cannot go back to work without a passing grade, and ultimate failing of the course causes demotion or job displacement (interview at TPP4).

[30] Power tariff in Mongolia is 25~63% of that of Sri Lanka, Philippines, and Indonesia whose GDPs are about the same level as Mongolia (2008, Japan Electric Power Information Center）.

investment[31]. TPP4's net profit was negative for the period from 2007 to 2009, due to factors including an increase in the price of coal (2008 prices were 1.5 times 2006 prices) and currency losses（Mongolia's currency depreciated 56% between 2007 and 2009）. However, net profit turned positive in 2010 because the electricity tariff was raised 17.35% in February, 2010. Heat production costs exceeds the sales costs at TPP4 (production costs were, 1.7 times the sales cost in 2010[32]) which reflects the national cross subsidy energy policy which subsidizes losses in heat supply by electricity sales. A major heating price increase is not easy in a country with long and harsh winters.

TPP4's financial situation will stabilise if the electricity and heat tariff is raised to the breakeven point. The Government of Mongolia has been making efforts to improve the situation by promoting market mechanisms and encouraging the entry of private businesses. The Parliament approved Resolution #72 in December 2010 with regard to subsidizing losses in the energy sector for three years as well as promoting the liberalisation of the energy sector. Therefore, TPP4 received a 3.487 bil. Tg subsidy from the government in 2010. Whether or not energy prices will be raised to the level at which TPP4 can make ends meet without subsidies depends on the implementation of Resolution #72.

Although there are concerns regarding TPP4's future financial situation, even if energy prices do not rise to a self-sustaining level for TPP4, considering the importance of TPP4, the Government will most likely support an extension of the resolution. Therefore, it is unlikely to jeopardize the sustainability of the outcome of the project.

Table 10　Financial condition of TPP4（in mil. Tg）

	Total sales profit	Sales and other cost	Operational profit	Non-operational profit	Net profit
2006	2377	1,399	978	-722	256
2007	2619	1,440	1,178	-1,412	-234
2008	1741	1,295	446	-10,811	-10,365
2009	-2,704	1,695	-4,400	-17,623	-22,023
2010	-207	1,313	-1,520	15,114	13,594

（Source：Energy Statistics for 2006, TPP4 for 2009.2007~2010）

3.5.4　Current Status of Operation and Maintenance

Operation and maintenance is generally good and over-halls are done regularly (every four years for boilers and every five years for turbines). Mill roller plates are repaired every 5,000 hours which is equivalent to about once a year.

[31] Repayment of loan to JICA is 5 mil US$/year (6.6 billion Tg), and the repayment to ADB and KfW is 320,000US$.Outstanding balance for JICA loan is 79 million US$, for ADB and KfW is 7 million US$ in the end of 2010.

[32] In case of electricity, production cost is 0.9 times sales cost.

The number of times boilers are shut off has been decreasing year by year, however eight shut offs occurred in January 2011 which caused concern. The reason why the boiler operation rate remains at 60% even though it improved compared to 1995 is that repair takes five to seven days once a boiler stops. The causes of shut off of boilers include the burst of air heater pipes, adhesion of ash and slug in the heaters and pre-heaters (especially the boilers using higher ash content Shivee-Ovoo coal), steam leaks from pipes and valves, etc. In order to prevent shutoffs, TPP4 is now considering: 1) periodical checkups and rehabilitation of air heater pipes and water wall, 2) installation of pre-air heater to prevent adhesion of ash and slag, and 3) installation of a boiler soot blower[33].
Other major TPP4 rehabilitations include, installing a washing device in the condenser tube of the turbine (KfW loan is under request), rehabilitation of aged generator breakers, installation of a hot water feeding pump, construction of a heat exchange station for expanding heat supply, replacement of an electrostatic precipitator, all by TPP4's own funding or government subsidies. Also, TPP4 has a plan to synchronize the automatic control of the turbine operation system with the automatic boiler controls. With all of the planned rehabilitations mentioned, TPP4 is trying to further stabilise energy supply.

Although there is some concern about TPP4's financial conditions, no major problems have been observed in the operation and maintenance system, therefore sustainability of the project effect is high.

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

The project was implemented as a part of the continued assistance to the 4th thermal power plant that was in critical condition after the withdrawal of human resource support from the former Soviet Union in the early 90's. Given the considerable significance of TPP4 which is the largest source of electricity and heat supply in Mongolia, the project was highly relevant. The effectiveness of the project is high since the operation rate of the boilers increased thanks to a radical drop in the number of forced outages, and a significant reduction has been identified in coal consumption and CO_2 emission per unit of electricity generated. Also, the substantial increase in and stabilisation of energy supply has contributed to the improvement in the credibility of the Central Energy System as a whole. Although the energy sector policy of the country is now in transition and the external environment is uncertain, sustainability of the project itself is evaluated as high.
In light of the above, the project is evaluated to be highly satisfactory.

[33] Interview of TPP4 and a Senior Volunteer.

4.2 Recommendations

4.2.1 Recommendations to the Executing Agency

In order to prevent boiler shutoffs: periodical inspection, repair, and renewal in addition to countermeasures to prevent adherence of ash and slag are necessary. Also, in the future, installation of desulfurization and NOx removal devices should be sought in order to cut down the emission of pollutants, and continuous attention should be paid to prevent dispersion of coal dust and ash.

4.2.2 Recommendations to JICA

None.

4.3 Lessons Learned

Many JICA experts and senior volunteers were dispatched to TPP4 continuously since 2002 in order to complement hardware assistance with technical support. In one particular case, a group of Senior Volunteers were sent from a private company (eight SVs in 2002~2006) and introduced Japanese-style work force management. The "5S" movement introduced then still remains operational today. As such, the effect of cooperation can be enhanced using a combination of hard and soft assistance.

Column 1: High visibility of the project

Beneficiary survey shows that 51.2% said they knew this project well or were somehow informed. Although it was a loan project, people are aware of the assistance from Japan in view of its significance in their lives.

Column 2: Bond shown in disaster

At the time of an earthquake and tsunami in 2011, all the employees of TPP4 donated one day's worth of salary to Japan.

Comparison of the Original and Actual Scope of the Project

Item	Original	Actual
1.Project Outputs	I:(1)Recovering function of automatic control system of the 4 boilers (2) Switching to a direct firing system of the 4 boilers (3) Repair of the boiler incidental facilities (4) Consulting service: 94MM II:(1) Switching to a direct firing system of the 4 boilers (2) Modernization of automatic control system of boilers (3) Boiler tube exchange (4) Exchange of the generator excitation equipment (5) Repair of boiler incidental facilities (6) Consulting Service :108MM	I: (1)~(4) As planned. II: (1)~(6) As planned (7) Consulting Service: 109.36MM
2.Project Period	I: October 1995 – May 1998 (33 months) II: March, 2001 – October 2005 (56 months)	I: October 1995 – October 1999 (49 months) II: March, 2001 –February 2007 (72 months)
3.Project Cost		
Amount paid in foreign currency	I: 4,493 mil. yen II: 6,139 mil. yen	I: 4,493 mil. yen II: 6,072 mil. yen
Amount paid in local currency	I: 798 mil. yen (3,522 mil.Tg.) II: 922 mil. yen (8,017 mil.Tg.)	I: 658 mil. yen (4,235 mil. Tg.) II: 650 mil. yen (6,632mil. Tg.)
Total	I: 5,282 mil. yen II: 7,061 mil. yen	I: 5,151 mil. yen II:6,722 mil.yen
Japanese ODA loan portion	I: 4,493 mil.yen II: 6,139 mil.yen	I: 4,493 mil. yen II: 6,072 mil. yen
Exchange rate	I: 1Tg=0.224yen（1995Average） II:1Tg=0.115 yen (2001 Average)	I: 1Tg=0.155yen (1996～2001 Average) II:1Tg=0.098yen(2002~2008Average)