Romania

FY2018 Ex-Post Evaluation of Japanese ODA Loan Project
"Turceni Thermal Power Plant Pollution Abatement Project"
External Evaluator: Koichiro Ishimori, Value Frontier Co., Ltd.

0. Summary

The objective of the project was to operate Turceni Thermal Power Plant (TTPP), Romania's largest coal-fired thermal power plant, in compliance with the sulphur dioxide (SO_2) emission standards of the European Union (EU) by installing Flue Gas Desulfurization (FGD) at its four units, and thereby contributing to environmental improvement and economic activities of the country. This project has been highly relevant to Romania's development plans and needs, as well as Japan's Official Development Assistance (ODA) policy. Therefore, its relevance is high. Whereas the project cost was within the plan, the project period exceeded the planned one by 169% because of changes in the detailed design, additional construction work of connections in FGD, etc. Therefore, efficiency of the project is fair. As a result of installing FGD within the project, the operation of TTPP complies with the SO_2 emission standards of the EU, and contributes to the country's environmental improvement and economical activities. Therefore, effectiveness and impact of the project are high. While there is slight anxiety over the current status of operation and maintenance, there have been no problems with the institutional/organizational, technical, and financial aspects. Therefore, sustainability of the project effect is high.

In light of the above, this project is evaluated to be highly satisfactory.

1. Project Description

Project location

FGD including four absorber towers in the front

1.1 Background

Units 1-7 of TTPP were established by the World Bank funds in the late 1970s. TTPP is the country's largest coal-fired thermal power plant, and has been indispensable to Romania's economic activities while it was too old and any environmental measures were

not implemented. Considering the prospect of Romania joining the EU, there was a need for environmental measures in compliance with the SO_2 emission standards of the EU. With this background, the executing agency operating TTPP, Complexul Energetic Turceni S.A. (CET)[1], planned first to implement a large-scale rehabilitation for Units 3-6 that had been assumed to operate continuously in the future, and second, to install FGD at them with a Japanese ODA loan. Last, it planned to operate TTPP which was efficient in generating electricity and in compliance with the SO_2 emission standards of the EU.

1.2 Project Outline

The objective of the project was to operate TTPP, Romania's largest coal-fired thermal power plant, which complies with the SO_2 emission standards of the EU by installing FGD at its units 3-6, and thereby contributing to environmental improvement and economic activities of the country.

Loan Approved Amount/ Disbursed Amount	28,746 million yen / 28,494 million yen	
Exchange of Notes Date/ Loan Agreement Signing Date	March 2005 / March 2005	
Terms and Conditions	Interest Rate Repayment Period (Grace Period Conditions for Procurement	0.75% 40 years 10 years) General Untied
Borrower/ Executing Agency	Ministry of Public Finance/ Complexul Energetic Oltenia S.A. (CEO)	
Project Completion	July 2016	
Target Area	Turceni City, Gorj Prefecture	
Main Contractors (Over 1 billion yen)	Civil engineering: AE&E Austria GmbH & Co KG (Austria) Supply and installation of plant equipment: S.C. Techno Montaj S.R.L (Romania)/ S.C. Romelectro S.A (Romania)/ S.C. Energomontaj S.A (Romania)	
Main Consultant (Over 100 million yen)	Tokyo Electric Power Services Co. Ltd. (Japan)	
Related Study (Feasibility Studies, etc.)	"Special Assistance for Project Formulation (SAPROF) of Turceni Thermal Power Plant Environmental Abatement Project"	
Related Projects	World Bank Turceni Thermal Power Project (I) (July 1974-Dec. 1983) *Installation of Unit 1-4 Turceni Thermal Power Project (II) (Jan. 1979-Unknown) *Installation of Unit 5-7 (The project finished without installation of planned Unit 8.)	

[1] Complexul Energetic Turceni S.A. (CET) was changed to Complexul Energetic Oltenia (CEO) in May 2012. (See Sustainability for the details.)

2. Outline of the Evaluation Study

2.1 External Evaluator

Koichiro Ishimori, Value Frontier Co., Ltd.

2.2 Duration of Evaluation Study

This ex-post evaluation study was conducted with the following schedule.
Duration of the Study: November 2018 - October 2019
Duration of the Field Study: March 1-18, 2019 and May 10-17, 2019

3. Results of the Evaluation Study (Overall Rating: A[2])

3.1 Relevance (Rating: ③[3])

3.1.1 Consistency with the Development Plan of Romania

The National Development Plan (2002-2005), the plan at the time of appraisal, promoted infrastructure development as one of the seven prioritized sectors. In this sector, replacement of facilities and environmental measures of the existing thermal power plants were highlighted. *The Industrial Policy of Romania 2005-2008 (2005)*, which shaped the industrial policies in all sectors, considered the energy sector's infrastructure as the base of economic activities. In addition, considering the prospect of Romania joining the EU, it emphasized the importance of complying with the EU standards. Moreover, *the Road Map for Energy Sector of Romania 2003-2015 (2003)* stated the necessity for environmental investment by installing FGD at the existing thermal power plants that were expected to contribute to generating electricity.

The National Sustainable Development Strategy of Romania 2013-2020-2030 (2008), the national development plan at the time of ex-post evaluation, highlights the importance of mitigating the negative effects of the energy sector on the environment, in particular, by reducing emissions of air pollutants as *Objectives for 2013, 2020, 2030 and actions to be taken in accordance with the strategic guidelines of the European Union*. Additionally, *the Industrial Policy of Romania 2018-2020 (2018)* highlights the importance of preventing environmental degradation and implementing investment stimulus plans for the energy sector. Moreover, the EU, which Romania joined in 2007, states the policy of increasing the share of renewable energy in its electricity market in *Energy 2020: A strategy for competitive, sustainable, and secure energy (2010)* and *A clean Planet for all: A European strategic long-term vision for a prosperous, modern, competitive, and climate neutral economy (2018)*. However, *the Energy Sector of Romania 2018-2030 (2019)* incorporates the energy sector into part of the country's development plans and aims to build new thermal power plants, and continuously modernize the existing power

[2] A: Highly satisfactory, B: Satisfactory, C: Partially satisfactory, D: Unsatisfactory
[3] ③: High, ②: Fair, ①: Low

facilities, including the thermal power ones.

Since the project aims to operate TTPP, Romania's largest coal-fired thermal power plant, complying with the SO_2 emission standards of the EU by installing FGD at its units 3-6, one can say that it has been consistent with the development plans of Romania both at the time of appraisal and ex-post evaluation.

3.1.2 Consistency with the Development Needs of Romania

The composition of power supply in Romania at the time of appraisal was thermal (61%), hydro (35%), and nuclear (4%) based on the installed capacity. The installed capacity of thermal power was 10,598 MW, of which TTPP, the largest thermal power plant in the country, represented 1,980 MW (330 MW x 6 units[4]) accounting for approximately 19% of the total. However, the six units that had been installed after the late 1970s were too old to be equipped with environmental measures. As a result, SO_2 emissions ranged as high as 3,230 mg/Nm^3 to 4,764 mg/Nm^3. Meanwhile, the Romanian government considering the prospect of joining the EU decided in its cabinet decision 541/2003 to suspend operations of existing thermal power plants not in compliance with the SO_2 emission standards of the EU (400 mg/Nm^3) by the end of 2011. Considering the magnitude of TTPP in power supply, it was inevitable to reduce SO_2 emissions from TTPP.

The composition of power supply at the time of ex-post evaluation was thermal (39%), hydro (30%), renewable (24%), and nuclear (7%) based on the installed capacity. The installed capacity of thermal power has decreased to 7,765 MW due to suspension of deteriorating units. However, thermal power is still the base load energy source[5] occupying the largest share. TTPP represents 1,320 MW (330 MW x 4 units[6]) and accounts for approximately 17% of the total, which is almost the same as at the time of appraisal. It is also still the largest thermal power plant in the country, along with Rovinari Thermal Power Plant. As Romania joined the EU in 2007, it is still important[7] that TTPP complies with its SO_2 emission standards[8].

Therefore, one can say that the project has been consistent with the development needs of Romania both at the time of appraisal and ex-post evaluation.

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[4] Units 1, 3-6, and 7. Unit 2 was taken out of service in 1999 as planned before the start of the project.

[5] At the time of ex-post evaluation, one could observe that the anti-coal movement was growing in EU regions after the Paris Agreement in 2015. However, as is the case with Germany and Poland where thermal power generates more electricity than any other sources, Romania still considers thermal power as its base load energy source. (*Energy Sector of Romania 2018-2030 (2019)*)

[6] Units 3-5 and 7. It was planned for unit 6 to be continuously operated. Currently, however, unit 7 was used because unit 6 did not undergo a large-scale rehabilitation as planned and was significantly deteriorated, as described in footnote 9. Unit 1 that was functioning at the time of appraisal was suspended in 2016 as planned.

[7] Maximum power demand in Romania has been increasing: 9,099 MW (2008), 9,166 MW (2013), and 9,758 MW (2018). It is also expected to increase in the future.

[8] The SO_2 emission standard of the EU was tightened from 400 mg/Nm^3 to 200 mg/Nm^3 in 2010 during the project period.

3.1.3 Consistency with Japan's ODA Policy

Japan's ODA Charter (2003) at the time of appraisal stated that "Japan would address through ODA global issues such as the environment and energy and play an active role in establishing international standards" as one of its priorities, "Addressing global issues." *The Medium Term Policy on Official Development Assistance (2005)* adopted "measures against environmental pollution including air pollution, as one of its priorities", "Addressing global issues." It also stated that "Japan would provide developing countries with scientific and technological supports for environmental issues". *The ODA Databook by Country (2004)* stated that "pollution control in the energy and mining sectors is one of the most critical issues that should be solved for Romania". Additionally, *the Development Policy of Romania (2005)* by JBIC (now JICA) put "industrial development and trade promotion and environmental conservation contributing to the transition to market economy as two prioritized areas, since the most important agenda for Romania was joining the EU in 2007". It also stated that "JBIC had a meaning to support Romania with its ODA loan in that environmental projects in the energy sector, including electricity, would make significant contributions through Japan's knowledge and technologies".

Therefore, one can say that the project was consistent with Japan's ODA policy at the time of appraisal.

In sum, this project has been highly relevant to the Romania's development plans and development needs, as well as Japan's ODA policy. Therefore, its relevance is high.

3.2 Efficiency (Rating: ②)

3.2.1 Project Outputs

The table below summarizes the original and actual project scope.

Table 1: Original and Actual Scope of the Project

Output	Original	Actual
(1) FGD and related facilities	Installation of FGD with a desulphurization rate of 95% at units 3-6	1) The SO_2 emission standard of the EU was tightened from 400 mg/Nm^3 to 200 mg/Nm^3 in 2010 during the project period. Because of this change, the desulphurization rate of FGD's specifications increased from 95% to 96.4%, followed by the rehabilitation work. It was an appropriate course of action trying to meet the new standard. 2) FGD was installed at units 3-5 as well as unit 7 instead of unit 6, since the realization of CEO's plan of a large-scale rehabilitation of the unit 6's boiler by its own fund was uncertain[9] and unit 6 was too deteriorated to be

[9] At the appraisal, CEO had ideas to implement a large-scale rehabilitation for units 3 and 6 with its own budget, but it had no definite plan. Meanwhile, CEO had an agreement with the European Bank for Reconstruction and Development (EBRD) in 2008 that it would provide a EUR 300 Million loan for a large-scale rehabilitation for units 3 and 6. However, because of the Lehman Shock in September 2008, it informed CEO in January 2009 that it would provide half of the amount, EUR 150 Million, for only unit 6 that was too deteriorated. Afterwards, CEO signed the loan agreement with the EBRD in July 2009. However, CEO ended up canceling the rehabilitation work for unit 6 and renouncing the loan agreement in May 2015 after long processes of hiring

		continuously operated. It was a necessary change due to the CEO's financial situation.
	Installation of related facilities (e.g., limestone supply facility, gypsum storage)	Same as planned.
(2) Related civil engineering	Foundation work (e.g., stakeout, concrete placement)	Same as planned.
(3) O&M Equipment (for five years after operation)	Supply of spare parts (e.g., pump, motor)	Same as planned.
(4) Expansion of the existing ash ponds including their water blocking	Expansion of the three existing ash ponds.	Expansion of the three existing ash ponds became unnecessary. In June 2005, soon after the project started, the National Environmental Protection Agency (NEPA) issued an order prohibiting the use of the three existing ash ponds by the end of 2012 for fear of water pollution. Therefore, CEO followed it and constructed new ash ponds by its own fund. Consequently, expansion of the existing ash ponds became unnecessary. It was a necessary change to comply with the law.
(5) Consulting services	260 man-months (International: 164 man-months, National: 96 man-months)	215 man-months (International: 118 man-months, National: 97 man-months) Reduction of man-months in international consultants was due to effective input.

Source: Materials provided by JICA and the executing agency

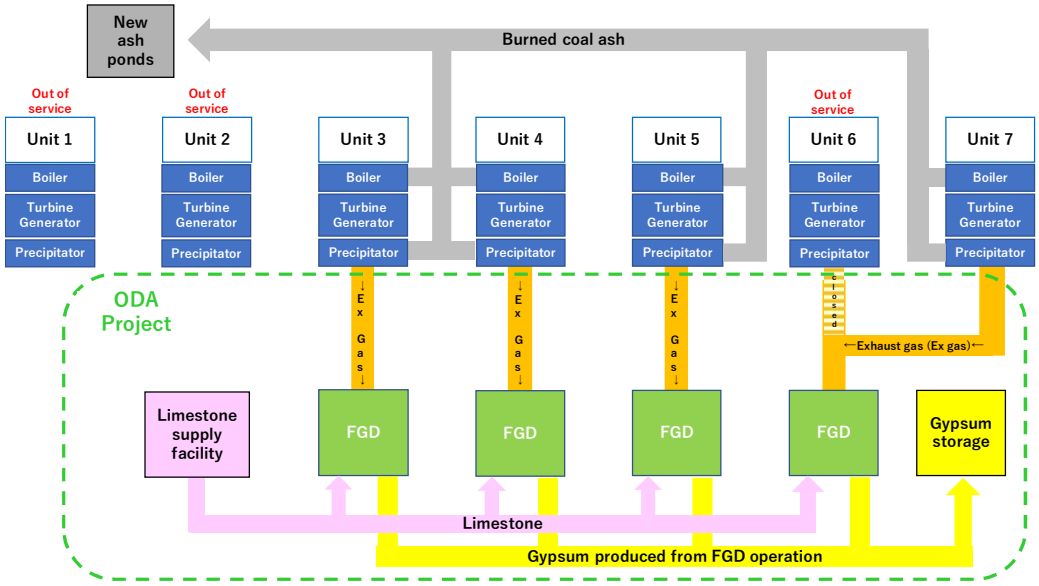

Figure 1: Whole chart of TTPP at the time of ex-post evaluation

Source: made by the evaluator

consultants, making tender documents, etc., since it was not possible for CEO to find a general contractor for the rehabilitation of boilers in the technical conditions imposed by the tender documents in line with the EBRD rules. After all, CEO could not allocate its own budget for implementing a large-scale rehabilitation for units 3 and 6.

3.2.2 Project Inputs

3.2.2.1 Project Cost

The planned total cost for the project was 38,329 million yen, of which the ODA loan was 28,746 million. The actual total cost was 34,748 million yen, of which the ODA loan was 28,494 million. Therefore, it was within the planned cost. The main reasons that the total cost fell within the planned cost, despite additional work such as the improvement in FGD and connection of unit 7, were as follows: 1) the reduction in civil engineering costs because expansion of the existing ash ponds became unnecessary; 2) the reduction in consulting service fees due to the efficient input of international consultants; and 3) the reduction in costs resulting from minimum expenditures in price escalation, contingencies, etc.

3.2.2.2 Project Period

The planned total period of the project was 81 months, from March 2005 (L/A signing) to November 2011 (starting of service), whereas the actual total period was 137 months, from March 2005 (L/A signing) to July 2016 (starting of service), thus becoming 169% of the planned period, which was significantly longer than planned. The main reasons for this extension were as follows: 1) the belated approval of L/A by the Romanian congress (approximately 6 months); 2) the delay in contract due to changes in the bidding procedures for the civil engineering contractor (approximately 5 months), and 3) the delay in civil engineering work due to changes in the detailed design resulting from changes in steels, internal and external coordination for a large-scale rehabilitation of units 3 and 6, and additional construction work of connections in FGD, etc. (approximately 45 months).

3.2.3 Results of Calculations for Internal Rates of Return (Reference only)

At the time of Appraisal, considering the nature of the project, environmental improvement, a quantitative analysis of the internal rate of return was regarded as inappropriate and the financial rate of return (FIRR) and the economic internal rate of return (EIRR) were not calculated. Due to the same reason, both FIRR and EIRR were not calculated at the time of ex-post evaluation as well.

Although the project cost was within the plan, the project period exceeded the plan. Therefore, efficiency of the project is fair.

3.3 Effectiveness and Impacts[10] (Rating: ③)

3.3.1 Effectiveness

3.3.1.1 Quantitative Effects (Operation and Effect Indicators)

[10] Sub-rating for Effectiveness is to be put with consideration of Impacts.

Operation Indicator (1) Annual Operating Ratio of FGD*

Table 2: Annual Operating Ratio of FGD

(Unit: %)

	Benchmark	Target	Actual		
	2004	2014	2016	2017	2018
	-	3rd year after completion	1st year after completion	2nd year after completion	3rd year after completion
Unit 3	-	100	96.9	96.5	98.1
Unit 4	-		99.0	98.6	97.9
Unit 5	-		99.1	98.9	98.9
Unit 7**	-		97.2	97.5	97.1

Source: Materials provided by the executing agency

* Annual Operating Ratio of FGD = (Annual hours of operating FGD/Annual hours of generating electricity) x 100%

** It was planned to be installed at unit 6, but it was instead installed at unit 7 for the aforementioned reason. Therefore, it is not "unit 6." It will be applied to all the following tables for convenience.

Following recommendations from the boilermaker, CEO does not operate FGD during startup and shutdown periods, since exhausted gas from the boilers during the periods will damage FGD. Thus, the operating ratio of FGD has not achieved the target of 100%. However, the aforementioned operation is rather suitable for prolonging the life of FGD. Besides, the annual operating ratios of 2018 (targeted year), the 3rd year after completion, were high enough, ranging from 97.1% to 98.9%. Therefore, it is judged that the target has been achieved.

Operational indicator (2) Annual Frequency and Duration of Power Outages by Causes

Table 3: Annual Frequency and Duration of Power Outages by Causes

(Unit: time (T), hours (H))

	Cause	Benchmark	Target		Actual					
		2004	2014		2016		2017		2018	
		-	3rd year after completion		1st year after completion		2nd year after completion		3rd year after completion	
			T	H	T	H	T	H	T	H
Unit 3	HE	-	0	0	0	0	0	0	1	2
	TF	-	6	500	18	2,273	11	1,841	16	2,722
	PPO	-	1	950	1	696	1	3,920	0	0
Unit 4	HE	-	0	0	0	0	0	0	1	6
	TF	-	6	500	13	1,263	24	1,003	19	2,912
	PPO	-	1	950	0	0	0	0	0	0
Unit 5	HE	-	0	0	1	1	0	0	1	0
	TF	-	6	500	11	908	16	856	16	1,643
	PPO	-	1	950	1	2,578	0	0	1	695
Unit 7	HE	-	0	0	1	1	0	0	0	0
	TF	-	6	500	21	2,882	14	2,030	11	3,270
	PPO	-	1	950	1	72	1	2,315	1	3,288

Source: Materials provided by the executing agency

HE: Human Errors, TP: Technical Failures, PPO: Planned Power Outage

The annual frequency and duration of power outages by causes vary in each unit and year. The actual annual frequency and duration of power outages due to human errors (HE), technical failures (TF), and planned power outages (PPO) in the targeted year of 2018, third year after completion, were as follows;

HE: While the planned frequency and duration of power outages due to HE were both 0, the actual frequency and duration were 0-1 times and 0-6 hours in all units. This was almost as planned.

TF[11]: While the planned frequency and duration of power outages due to TF were 6 times and 500 hours, the actual frequency and duration were 11-19 times and 1,643-3,270 hours in all units. Considering the fact that all units have been operating for over 30 years and deteriorating, it is judged to be unavoidable.

PPO: While the planned frequency and duration of power outages due to planned power outages were 1 time and 950 hours, the actual frequency and duration were 0-1 times and 0-3,288 hours. Units 3 and 4 had 0 time and 0 hour of PPO. Since CEO could not secure enough budget for regular maintenance, it could not have annual planned power outages and inspection. As stated above, all units have been deteriorating; thus, to prolong the life of FGD, maintenance checks should be carried out, including not only an annual checkup as planned, but also a large-scale inspection once in several years.

Effective indicator (1) Annual Average of SO_2 Emission Concentration

Table 4: Annual Average of SO_2 Emission Concentration

(Unit: mg/Nm^3)

	Benchmark	Target	Actual		
	2004	2014	2016	2017	2018
	-	3rd year after completion	1st year after completion	2nd year after completion	3rd year after completion
Unit 3	3,230 -4,764	200 (changed from 400*)	184	185	183
Unit 4			184	182	185
Unit 5			186	192	185
Unit 7			182	194	170

Source: Materials provided by the executing agency

* Since the SO_2 emission standard of the EU was restricted to 200 mg/Nm^3 in 2010, the target in the project also changed to 200 mg/Nm^3. The objective of the project was to meet the SO_2 emission standards of the EU, and therefore 200 mg/Nm^3 was adopted as the new target for the indicator.

The project achieved the target of 200 mg/Nm^3, not only in 2018, the planned 3rd year after completion, but in all years.

[11] Technical failures indicate failures with boilers, turbines, generators, and electrostatic precipitators of units 3-5 and 7, not with FGD installed by the project.

Effective indicator (2) Annual Average of the Reduction Rate of SO_2 Emissions*

Table 5: Annual Average of the Reduction Rate of SO_2 Emissions

(Unit: %)

	Benchmark	Target	Actual		
	2004	2014	2016	2017	2018
	-	3rd year after completion	1st year after completion	2nd year after completion	3rd year after completion
Unit 3	-	96.4 (changed from 95**)	96.8	96.8	96.8
Unit 4			97.2	97.0	96.9
Unit 5			96.7	96.8	96.9
Unit 7			96.6	96.7	97.1

Source: Materials provided by the executing agency

* The reduction rate of SO_2 emissions = (1 - SO_2 emission per electricity generated after installing FGD/SO_2 emission per electricity generated before installing FGD) x 100

** Since the SO^2 emission standard of the EU was restricted to 200 mg/Nm^3 in 2010, the target in the project also changed to 96.4%. The objective of the project was to meet the SO_2 emission standards of the EU, and therefore 96.4% was adopted as the new target for the indicator.

The project achieved the target of 96.4%, not only in 2018, the planned 3rd year after completion, but in all years.

3.3.1.2 Qualitative Effects (Other Effects)

There were no expected qualitative effects (other effects) at the time of appraisal and ex-post evaluation of this project. Therefore, no analysis was conducted.

3.3.2 Impacts

3.3.2.1 Intended Impacts

Since the appraisal had not set any quantitative and qualitative effect indicator for the impact, ex-post evaluation set the following indicators, (1) 1) – 4) and (2).

(1) Quantitative effect

1) Improvement in the Ambient Environment

Table 6: SO_2 Concentration in the Air

(Unit: μg/m^3, times)

	Before operating FGD*			After operating FGD		
	Actual			Actual		
	2009	2010	2011	2016	2017	2018
Daily average	16.09	16.34	24.49	Unavailable	22.45	17.73
Frequency of excess	4	8	12	Unavailable	1	2

Source: Data from the monitoring point of NEPA in Turceni

* Since NEPA started monitoring SO_2 concentration in the air from 2009, there were no available data before the start of the project. Therefore, while data from 2009 to 2011 are used as benchmarks representing the situation before installation of FGD, data after 2016, when FGD started operating, are used as figures representing the situation after installation of FGD.

The daily average of SO_2 concentration in the air of Turceni has been meeting the daily average standard of 125 μg/m^3, both before and after the installation of FGD. Since there are

no available scientific data, it is not certain why it has been remaining more or less the same before and after installation of FGD despite the fact that the annual average of SO_2 emission concentration from TTPP substantially decreased after the installation of FGD. Meanwhile, the frequency of exceeding the hourly limit standard of SO_2 concentration, 350 μg/m^3, decreased from 8 times a year on average before the installation of FGD to 1.5 times a year after. Since TTPP is the single largest source of SO_2 emissions in Turceni, this decrease can be verified by the operation of FGD at TTPP and is considered an impact of the project.

2) Improvement in the Natural Environment

Table 7: pH in Precipitation

(Unit: NA)

	Benchmark	Target	Actual		
	2004	2014	2016	2017	2018
		3rd year after completion	1st year after completion	2nd year after completion	3rd year after completion
pH in precipitation	Unavailable	Unavailable	Unavailable	Unavailable	Unavailable

Due to lack of data, no qualitative analysis was conducted. Meanwhile, the daily average of SO_2 concentration in the air of Turceni has been meeting the daily average standard since 2009 and quite low. Therefore, it is unlikely that SO_2 concentration in the air decreases pH in precipitation and causes acid rain, on which Director of NEPA in Targu Jiu agreed during an interview at the time of ex-post evaluation.

3) Improvement in the Living Environment

Table 8: Number of Patients with Respiratory Diseases Such As Asthma and Chronic Obstructive Pulmonary Disease

(Unit: people)

	Benchmark	Target	Actual		
	2004	2014	2016	2017	2018
		3rd year after completion	1st year after completion	2nd year after completion	3rd year after completion
Number of patients	Unavailable	NA	8	16	8

Source: Data from Turceni City Hospital

Turceni City Hospital started keeping detailed medical records after 2016, when FGD started operating. Therefore, it is impossible to compare the number of patients before and after operating FDG. Meanwhile, the daily average of SO_2 concentration in the air of Turceni has been meeting the daily average standard since 2009 and quite low. Thus, it is unlikely that SO_2 concentration in the air causes respiratory diseases, on which the doctor of internal medicine agreed during an interview at the time of ex-post evaluation.

4) Stable Electricity Supply

Table 9: Percentage of Electricity Generated by TTPP*

(Unit: %)

	Benchmark	Target	Actual		
	2003**	2014	2016	2017	2018
		3rd year after completion	1st year after completion	2nd year after completion	3rd year after completion
Percentage of electricity	12.1	NA	7.3	8.4	7.8

Source: Materials provided by the executing agency

* Percentage of electricity generated by TTPP = electricity generated by TPP/total electricity generated in Romania x 100

** Data of 2003 data were used because there were no data for 2004.

The percentage of electricity generated by TTPP out of the total generation has decreased in 2016-2018 when compared to before the project. However, it still generates approximately 8%, which is the largest percentage by a single power plant, and supports economic activities in Romania.

② Qualitative effect

1) Being part of the EU

Romania has been a member of the EU since 2007.

3.3.2.2 Other Positive and Negative Impacts

（1） Impacts on the Natural Environment

1) The Environment of the Ash Ponds

Most of the gypsum produced from FGD operation is sold to plasterboard companies, etc. Only burned ashes mixed with water are discharged into new ash ponds. CEO monitors the environment of ash ponds on a daily basis and submits environmental monitoring reports to the NEPA Office in Targu Jiu on a quarterly basis. Neither the latest environmental monitoring report nor the director of NEPA Office in Targu Jiu points out any environmental problem.

2) Others (Ash Spill Accident)

In December 2013, burned ash mixed with water leaked through cracks of the existing ash ponds to lower levels of lands including 15 hectare (ha) of agricultural lands, affecting 10 households. CEO took the responsibility to either pay for the decontamination of the agricultural lands or decontaminate them on behalf of farmers, according to their preference. This problem has been solved by the time of ex-post evaluation.

（2） Resettlement and Land Acquisition

There was no resettlement or land acquisition.

(3) Unintended Positive/Negative Impacts

None.

Operational indicator (1), Annual Operating Ratio of FGD, has reached its target, whereas operational indicator (2), Annual Frequency and Duration of Power Outages by Causes has not. Both of effect indicator (1), Annual Average of SO_2 Emission Concentration and indicator (2), Annual Average of the Reduction Rate of SO_2 Emissions, have reached the target. Considering that the objective of the project was to comply with the SO_2 emission standards of the EU, the weight of judgement for effectiveness should be on effect indicators rather than operational ones. Therefore, it is judged that effectiveness is high, though operational indicator (2) has not reached the target.

Simultaneously, quantitative effect indicator (1) of the impact, i.e., 1) Improvement in the Ambient Environment and 4) Stable Electricity Supply, showed impact of the project, so did qualitative effect indicator (2) (i.e., Being part of the EU).

In sum, this project has achieved its objectives. Therefore, effectiveness and impacts of the project are high.

	Contributing to Goals 7 and 11 of the Sustainable Development Goals (SDGs) !
	Goal 7. Ensure access to affordable, reliable, sustainable and modern energy for all Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable
In goal 7.a of SDGs, it is stated, "By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology." And in goal 11.6, it is stated "By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management." This project contributes to goal 7.a because it installed FGD at TTPP with bilateral cooperation between Japan and Romania. It also contributes to goal 11.6, since FGD installed by this project impacted the ambient environment.	

3.4 Sustainability (Rating: ③)

3.4.1 Institutional/Organizational Aspects of Operation and Maintenance

As part of governmental restructuring, CET was merged with other three energy related public companies and turned into CEO in May 2012, with 77.15% of CEO's shares being transferred from the Ministry of Economy, Commerce, and Business Environment to the

Ministry of Energy. Since the Ministry of Energy still holds the same percentage of shares, the status of CEO as a public company remains the same, even at the time of ex-post evaluation (the remaining 21.56% and 1.29% of the shares are held by a private fund and related public companies, respectively). There is no definite plan for privatizing CEO at the time of ex-post evaluation. Currently, there are 13,053 employees in CEO, of which 1,341 work at TTPP.

Romanian government still considers thermal power plants as the base load energy source, and there remain 40 years of coal reserves from ten mines that CEO owns and operates (*Energy Sector of Romania 2018-2030 (2019)*). Although the EU decided to abolish subsidies for coal-fired thermal power plants by member countries in December 2018, CEO sees no particular problem because it has been operating TTPP with no subsidy from the Romanian government. Therefore, CEO is planning to operate units 3-5 and 7 of TTPP using lignite form the ten mines.

As stated above, there is no problem with institutional/organizational aspect of operation and maintenance for the project.

3.4.2 Technical Aspects of Operation and Maintenance

Thirty-five staff members at the former CET have received training on operation and maintenance of FGD by the contractor during the project, and many of them still work for CEO. Although there has been no problem with FGD so far, the desulphurization workshop (27 members) would ask the boiler & auxiliary office (8 members) under the thermomechanical department to make a diagnosis, should any technical problem occur. Then, the manager of technical division overseeing the thermomechanical department decides on whether he will ask the maintenance department (250 members) to take care of it or entrust an external entity with fixing it, depending on its significance. The maintenance department still keeps the operation and maintenance manuals and refers to them, if necessary.

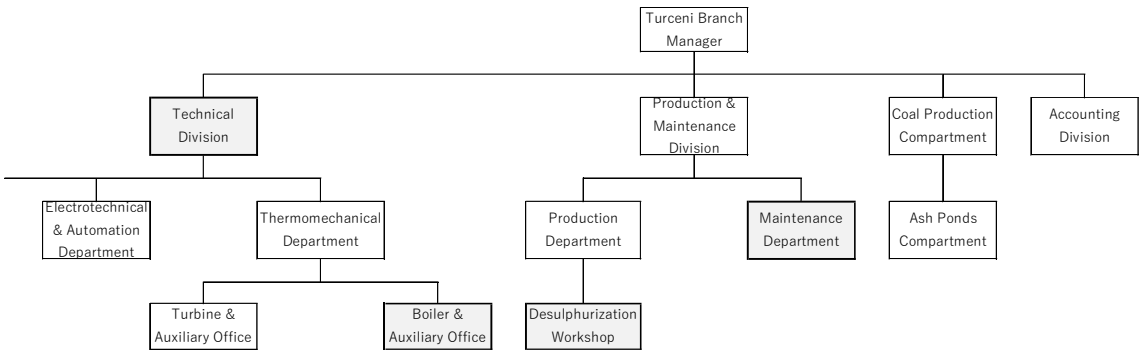

Figure 2: Organization Chart of TTPP

Source: Materials provided by the executing agency

As stated above, there is no problem with technical aspect of operation and maintenance for the project.

3.4.3 Financial Aspects of Operation and Maintenance

Table 10: Profit and Loss of CEO

(unit: Million lei)

Year	2016	2017
Total Income	3,678	4,368
Total Expenditure	3,818	4,092
Profit before tax	-	276
Income Tax	0	95
Net	-140	181

Source: Materials provided by the executing agency

CEO recorded net loss of LEI 140 million in 2016, but had net profit of LEI 181 million in 2017. The Return on Asset (ROA) increased from -1.9% in 2016 to 2.5% in 2017. Complexul Energetic Hunedoara S.A. (CEH), another public power company operating thermal plants in Romania, had ROA of - 49.3% in 2016 and - 46.2% in 2017. This verifies the superiority of CEO in efficiency and profitability of business (ten large-scale electric power companies in Japan[12] recorded ROA from - 0.03% to 2.56% (approximately 1.4% on average) in 2017, and therefore the CEO's ROA is equally good). CEO's equity ratio was 52.1% in 2016 and 54.4% in 2017, while the CEH's equity ratio was - 119.0% in 2016 and - 170.9% in 2017, both of which show signs of excessive debt. Thus, again, it verifies the superiority of CEO in safety management (ten large-scale electric power companies in Japan recorded equity ratio from 10.5% to 37.7% (approximately 21.4% on annual average) in 2017), and therefore the CEO's equity ratio is equally good).

As stated above, there is no problem with financial aspect of operation and maintenance for the project.

3.4.4 Status of Operation and Maintenance

All of FGD installed at units 3-5 and 7 are operated in a way that achieves the targets of effect indicator (1), Annual Average of SO_2 Emission Concentrations[13]. However, as stated in operational indicator (2), Annual Frequency and Duration of Power Outages by

[12] Hokkaido Electric Power Co., Inc., Tohoku Electric Power Co., Inc., Hokuriku Electric Power Co., Inc., Tokyo Electric Power Co., Inc., Chubu Electric Power Co., Inc., Kansai Electric Power Co., Inc., Chugoku Electric Power Co., Inc., Shikoku Electric Power Co., Inc., Kyusyu Electric Power Co., Inc., and Okinawa Electric Power Co., Inc.

[13] The new SO_2 emission standard of the EU in 2017 (Footnote (ii) of Table 4 in *Decision (EU 2017/1442 of 31 July 2017)*) was softened from 200 mg/Nm^3 to 320 mg/Nm^3 in the case of existing thermal power plants equipped with FGD. TTPP is likely to be operated in a way that meets the new standard in the future as well. Meanwhile, it was not certain for the evaluator why the standard was softened, so was the executing agency.

Causes, all of the units have been experiencing frequent mechanical failures. Although CEO carries out maintenance check on units that have mechanical failures, some units are operated without annual planned power outages and subsequent planned maintenance due to lack of budget. This leaves a minor anxiety over the use of FGD in the long term.

Institutional/organizational aspects of operation and maintenance of the project support the continuous use of TTPP that is equipped with FGD, so are the technical and financial aspects. Although the current status of operation and maintenance leaves a minor anxiety over the use of FGD in the long term because some units are operated without planned maintenance, sustainability of the project effects is high.

In sum, although the current status of operation and maintenance leaves a minor anxiety, no major problems have been observed in the institutional/organizational, technical, and financial aspects. Therefore, sustainability of the project effects is high.

4. Conclusion, Lessons Learned, and Recommendations

4.1 Conclusion

The objective of the project was to operate TTPP, Romania's largest coal-fired thermal power plant, in compliance with the SO_2 emission standards of the EU by installing FGD at its four units, and thereby contributing to environmental improvement and economic activities of the country. This project has been highly relevant to Romania's development plans and needs, as well as Japan's ODA policy. Therefore, its relevance is high. Whereas the project cost was within the plan, the project period exceeded the planned one by 169% because of changes in the detailed design, additional construction work of connections in FGD, etc. Therefore, efficiency of the project is fair. As a result of installing FGD within the project, the operation of TTPP complies with the SO_2 emission standards of the EU, and contributes to the country's environmental improvement and economical activities. Therefore, effectiveness and impact of the project are high. While there is slight anxiety over the current status of operation and maintenance, there have been no problems with the institutional/organizational, technical, and financial aspects. Therefore, sustainability of the project effect is high.

In light of the above, this project is evaluated to be highly satisfactory.

4.2 Recommendations

4.2.1 Recommendations to the Executing Agency

In general, maintenance requires a budget and reduces income, since the electricity generated by the power plants cannot be sold during the maintenance period. Therefore, power plants may have disincentive effects on maintenance. However, it is necessary for

CEO to carry out planned maintenance in order to use units 3-5 and 7 with FGD in the long term. Frequent maintenance can prevent severe damages in the future from happening and reduce maintenance costs in the long run. Additionally, it could help CEO to avoid the opportunity cost of not being able to sell electricity, if units had severe damages. Therefore, it is recommended that CEO should carry out appropriate maintenance, not only through planned power outages and subsequent maintenance of units 3-5, and 7 once a year, but also a large-scale maintenance once in several years.

4.2.2 Recommendations to JICA

None.

4.3 Lessons Learned

Obtaining commitment from the high levels in the executing agency and the borrower and requiring the fulfillment of the project preconditions

At the appraisal, CEO had ideas to implement a large-scale rehabilitation for units 3 and 6 with its own budget, but it had no definite plan. JICA imposed the signing of a contract for a large-scale rehabilitation for units 3 and 6 on CEO as a precondition for approving the bidding documents for the installation of FGD, since damages to these units would limit the usage of FGD to be installed. However, in 2006, the signing of the contract was likely to be postponed due to delays in preparation of the bidding documents regarding a large-scale rehabilitation of the two units. In November 2006, JICA, foreseeing that delay in the contract would cause a delay in the installation of FGD, decided to renounce the agreed precondition. Namely, JICA lost the means to guarantee implementation of the large-scale rehabilitation for units 3 and 6. Meanwhile, EBRD reached a conclusion of canceling the loan agreement with CEO because it found the implementation of a large-scale rehabilitation to be technically difficult, despite the signing of the loan agreement. Not implementing the large-scale rehabilitation for units 3 and 6 did not have any adverse effects on the project, apart from the changes in the project plan. After all, CEO finished the project without implementing a large-scale rehabilitation of the two units.

Therefore, when imposing a precondition regarding the project on the executing agency at the appraisal, it is important for JICA to obtain financial commitment to fulfilling it from the high levels in both the executing agency and the borrower. Simultaneously, it is also important to scrutinize technical issues. Finally, it is important to agree with the executing agency upon means to guarantee the fulfillment of the preconditions at the appraisal, and then to continuously request its fulfilment throughout the project period.

Comparison of the Original and Actual Scope of the Project

Item	Plan	Actual
1. Project Outputs		
FGD and related facilities	Installation of FGD with a desulphurization rate of 95% at units 3-6	1) Desulphurization rate was improved from 95% to 96.4% 2) FDG was installed at unit 3-5 as well as unit 7 instead of unit 6
	Installation of related facilities (e.g., limestone supply facility, gypsum storage)	Same as planned
Related civil engineering	Foundation work (e.g., stakeout, concrete placement)	Same as planned
O&M Equipment (for five years after operation)	Supply of spare parts (e.g., pump, motor)	Same as planned
Expansion of the existing ash ponds including their water blocking	Expansion of the three existing ash ponds	Not implemented
Consulting services	260 man-months (International: 164 man-months, National: 96 man-months)	215 man-months (International: 118 man-months, National: 97 man-months)
2. Project Period	March 2005 (L/A signing) - November 2011 (starting of service) (81 months)	March 2005 (L/A signing) - July 2016 (starting of service) (137 months)
3. Project Cost Amount Paid in Foreign Currency Amount Paid in Local Currency Total ODA Loan Portion Exchange Rate	 15,045 million yen 23,284 million yen (6,848,235 million lei) 38,329 million yen 28,746 million yen 1 lei = 0.0034 yen (as of June 2004)	 25,553 million yen 9,195 million yen (2,786,364 million lei) 34,748 million yen 28,494 million yen 1 lei = 0.0033 yen (Average between March 2005 and July 2016)
4. Final Disbursement	November 2016	

End