Republic of Kosovo
Ministry of Environment
and Spatial Planning

Republic of Kosovo
Expert for Air Pollution Control
Final Report

May 2016

**Japan International Cooperation Agency
(JICA)**

JFE Techno-Research Corporation

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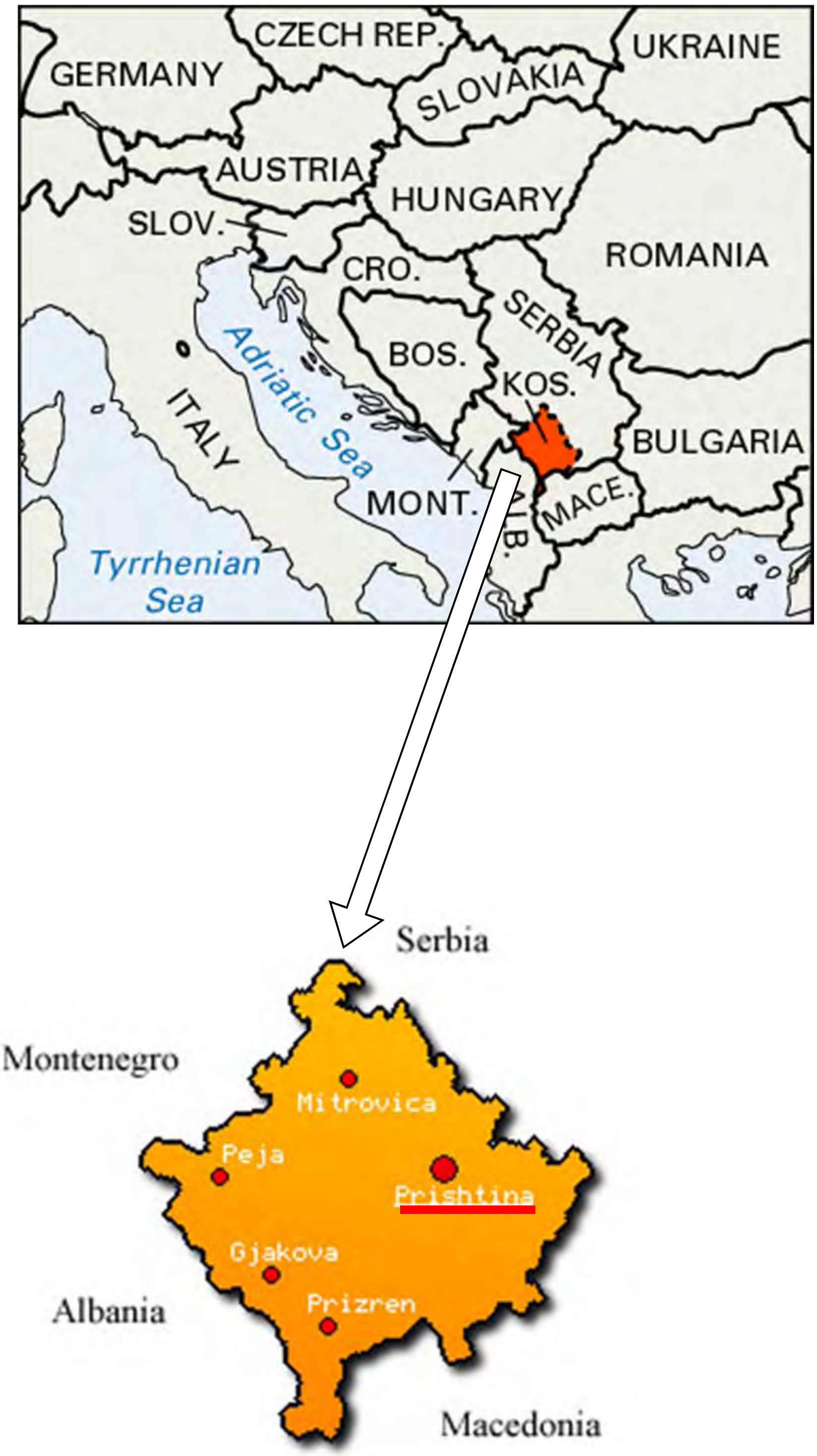
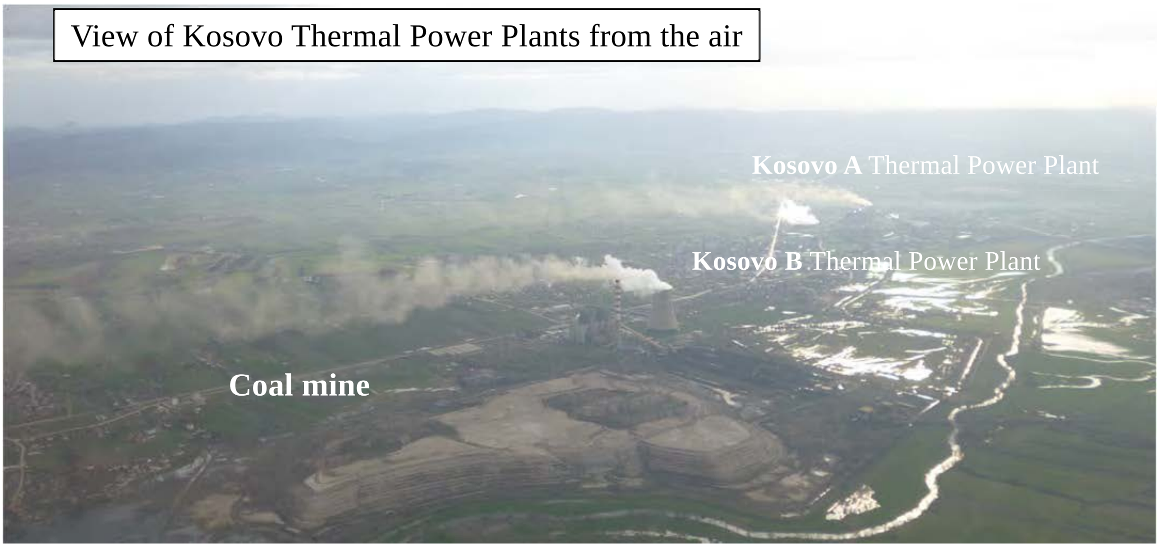


Republic of Kosovo



View of Kosovo Thermal Power Plants from the air


Kosovo A Thermal Power Plant


Kosovo B Thermal Power Plant


Surface mining of lignite


Electrostatic precipitator at Kosovo A


Electrostatic precipitator at Kosovo B

Table of abbreviations

	Original
CEMs	Continuous Emission Monitoring system
CFB	Circulating Fluidized Bed combustion boiler
CO	Carbon monoxide
C/P	Counterpart
EC	Energy Community
ECT	Energy Community Treaty
EEA	European Environment Agency
ELVs	Emission Limit Values
ESP	Electrostatic Precipitator
EU	European Union
KHMI	Kosovo Environmental Protection Agency
IC	Ion Chromatograph
ISO	International Organization for Standardization
JET	JICA Expert Team
JICA	JICA International Cooperation Agency
JIS	Japanese Industrial Standards
KEK	Kosovo Energy Corporation
KEPA	Kosovo Environmental Protection Agency
KHMI	Kosovo Hydro-Meteorological Institute
KOSTT	Kosovo Operator Sistemi, Transmisioni dhe Treu SH.A
LCP	Large Combustion Plant
Lignite	Lignite (brown coal), lowest rank of coal
MOU	Minutes of Understanding
MED	Ministry of Economics, Department of Energy
MESP	Ministry of Environment and Spatial Planning
NERP	National Emission Reduction Plan
NO_2	Nitrogen dioxide
NO_X	Nitrogen oxides
O&M	Operation and Maintenance
OJT	On-the-Job Training
O_2	Oxygen
PM2.5	Particulate Matter with diameter of 2.5 micrometers or less
SO_2	Sulphur dioxides
SO_X	Sulphur oxides
SOP	Standard Operating Procedure
TPP	Thermal Power Plant

Chapter 1 Outline of Project

1-1 Background of project

The Republic of Kosovo (hereinafter referred to as “Kosovo”)[1] is located almost in the center of the Balkan Peninsula. Kosovo is a young country which declared its independence in 2008. At present, the population is approximately 1.8 million and the land area is approximately 10,000 km^2, which is approximately the same as that of Gifu Prefecture in Japan. Kosovo is the least developed country of the former Yugoslavia. It does not yet have an autonomous economic structure because it depended on the former Yugoslavia and Republic of Serbia before gaining its independence. The present Kosovo has many problems, which include a chronic trade deficit, an unestablished tax collection system, shortages of electric power and a high unemployment rate, mainly among members of the young generation, among others. Most people depend on remittances from emigrants living or working abroad and foreign aid.

Under these circumstances, air pollution in urban areas, which is mainly caused by obsolete large thermal power plants, exhaust gas from vehicles, etc., has become a serious environmental problem, and its effect on human health is a concern. Since Kosovo’s declaration of independence, improvement of social infrastructure has been the first priority, and as a result, environmental preservation measures have been delayed. Implementation of environmental measures to satisfy the environmental emission standard, especially for Large Combustion Plants (hereinafter referred to as “LCP”) is an urgent issue in order to participate in Energy Community[2] (hereinafter referred to as “EC”), which mainly consists of members of the European Union (hereinafter referred to as “EU”).

The Ministry of Environmental and Spatial Planning (hereinafter referred to as “MESP”) is tackling the legislation and enactment of related provisions necessary to establish an environmental air monitoring system. In 2011, MESP drew up “Strategy and Action Plan on Air Quality.” At present, a National Emission Reduction Plan (hereinafter referred to as “NERP”) is required as a precondition for participation in EC, and it is necessary to address environmental problems based on national resources and support from other donors. The fundamental requirement for a NERP is to satisfy the emission values of dust content, SO_2, and NO_X for LCP of the Emission Limit Values (hereinafter referred to as “ELVs”) regulated by EC directive[3].

In the situation outlined above, MESP requested technical cooperation (Experts Mission) to support capacity development for the Department of Environmental Protection (hereinafter referred to as “DEP”) in MESP. Based on the request from Kosovo, JICA invited 2 members to the task training course “Capacity building for atmospheric

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[1] Website of Ministry of Foreign Affairs: http://www.mofa.go.jp/mofaj/area/kosovo/

[2] Website of Energy Community: https://www.energy-community.org/portal/page/portal/ENC_HOME

[3] Directive on LCPs: 2001/80/EC of the European Parliament and of the Council, and Chapter 3 (Article 28 to Article 41) of Directive 2010/75/EC of the European Parliament and of the Council.

environmental management.” The invited members were one person from MESP and another from the Kosovo Hydro-Meteorological Institute (hereinafter referred to as “KHMI”), which is an implementing agency of MESP. These persons drew up a roadmap as an action plan for developing a NERP for Kosovo. In April 2015, the Japan International Cooperation Agency (hereinafter referred to as “JICA”) sent a contact mission to Kosovo, and on April 23, 2015, MESP and JICA signed Minutes of Understanding[4] (hereinafter referred to as “MOU”) regarding the cooperation framework.

Based on the MOU, this project supports the establishment of on-site gas measurement technology, establishment of evaluation of measurement results and measurement data collection and monitoring technologies in the roadmap planned by the Counterparts (hereinafter referred to as “C/P”) to develop NERP.

1-2 Outline of project activity

JICA provides the implementation policy to achieve the following outcomes through this Expert Mission on the basis of the above-mentioned MOU. The framework of this Expert Mission is shown in Table 1-1.

Table 1-1 Framework of Expert Mission (JET)

Title	Expert for Air Pollution Control
Object Facilities	Kosovo A TPP, Kosovo B TPP
Implementation Period	October 2015 to May 2016
Main Counterpart	Ministry of Environmental and Spatial Planning (MESP)
Related Authorities	Ministry of Economics, Department of Energy (MED)
Counterparts (C/P)	MESP, related organizations of MESP <Department of Environmental Protection (MED) in MESP, Inspectorate, Kosovo Hydro-Meteorological Institute (KHMI)>, Ministry of Economics Department of Energy (MED), related organization of MED <Kosovo Energy Corporation (KEK)>
Targets of Implementation	a) JICA Expert Team (hereinafter referred to as “JET”) will transfer on-site stack gas measurement technology, which will help C/P to improve its understanding of on-site stack gas measurement and to acquire better measurement technology. b) JET will provide enlightenment as to how to utilize on-site stack gas data in order to achieve ELVs in Thermal Power Plants, and will enforce the knowledge of related organizations (MESP,

4 “Minutes of Understanding between Japan International Cooperation Agency and Ministry of Environment and Spatial Planning of Republic of Kosovo for the Contact Mission for “Expert for Air Pollution Control JFY 2015” (4th April, 2015)

	KHMI, KEK, TPP). c) Through the activities of on-site stack gas measurement and utilization of these data, JET will reinforce the ability of MESP to grasp conventional conditions of LCP toward formulating emission inventories, and to study and implement countermeasures to achieve ELVs in LCP. d) JET will hold workshops to promote the understanding of this project by related organizations, and to enhance the presence of this project.

The list of C/P is provided in the attached documents.

1-3 Activities for achieving targets of implementation

The outline of the activities for achieving the targets of implementation is shown below.

1-3-1 Technology transfer of on-site stack gas measurement

The aim of this technology transfer is that JET demonstrates how to conduct on-site gas stack measurement for the Kosovo A Thermal Power Plant (hereinafter referred to as "TPP") and Kosovo B TPP, which are the only two main TPPs in Kosovo, and that JET transfers the on-site gas stack measurement technology to Kosovo.

The specific contents are:

a) To specify and procure all the necessary measurement equipment to enable on-site stack gas measurement (dust content, SO_X[5] and NO_X) from sampling to analysis.
b) To hold workshops to enhance knowledge of on-site stack gas measurement in Kosovo.
c) To demonstrate on-site stack gas measurement (from sampling to analysis, also including data calculation) with the measurement equipment. The measurement targets all of the inlets and outlets of electrostatic precipitators (hereinafter referred to as "ESP") at Kosovo A TPP and Kosovo B TPP as far as conditions permit.
d) To conduct On-the-Job Training (hereinafter referred to as "OJT") about on-site stack gas measurement for persons of C/P in charge of on-site stack gas measurement.

Dust measurement follows JISZ8808 (Japanese Industrial Standard; hereinafter referred to as "JIS"). In SO_2 and NO_X measurements, an automated gas analyzer is used. However, it was not possible to prepare the automated gas analyzer in time for the 1st mission because of a lack of time for its procurement. Therefore, JET conducted SO_X and NO_X measurements by using detection tube instead, and performed these measurements with an automated gas analyzer in the 2nd mission.

[5] The EC Directive[3] regulates SO_2. The automated gas analyzer used in this project measures SO_2. There are several other methods to measure SO_2 or SO_X (SO_2+SO_3). From this point forward, this paper generally describes SO_X other than the case related to the EC Directive and the automated analyzer.

Kosovo has only the dust content data collected by the plant makers, and, furthermore this data was presumed to be measured by a Continuous Emission Monitoring System (hereinafter referred to as “CEMs”), which is not the official data measurement method. At the same time, Kosovo must prepare data for submitting actual emission values to the Energy Community (EC) as part of NERP development. Therefore, priority was placed on acquiring the actual measurement data, together with demonstrating the dust measurement.

Regarding the education of persons responsible for on-site gas stack measurement, JET provided the Standard Operating Procedure (hereinafter referred to as “SOP”) as support for measurement activities. However, the priority of acquiring the actual data did not allow enough time to give training on the on-site gas stack measurement technology. It was hard for the C/P members to learn the technology due to the lack of time.

Although use of an ion chromatograph was planned as the analysis method for SO_X and NO_X for on-site stack gas measurement, JET and C/P abandoned the idea of using the ion chromatograph. The final purpose of the existing ion chromatograph is to measure trace harmful substances in air. Furthemore, in order to use this technology, additional activities such as instrument adjustment by an engineer from the instrument maker, etc. are required. JET and C/P decided not to use the ion chromatograph because of the difficulty of preparation and implementation.

1-3-2 Enforcement of knowledge of application of on-site stack gas data to ELVs

The aim of this target is that JET ensures that C/P can recognize the present emission values of TPPs, and that JET gives instrctions to C/P on effective methods for using the measurement results.

For this purpose, JET implements the following items and offers related proposals.

a) To confirm the specifications of the TPP facilities, properties of the coal used, current operating condition, operation data, trouble records, operation and maintenance history, actual management condition (power generation and efficiency management, environmental protection management, etc.), maintenance condition (contents of periodical maintenance, procurement of spare parts at outbreak of trouble, etc.), emission control measures, etc.
b) To sample the coal, fly ash and bottom ash, and to analyze (proximate analysis and ultimate analysis, etc.) the composition of these materials in Japan. This is useful in the study of the operational condition of the TPP.
c) To explain the necessity of combustion control for reducing emissions which are the basic operational schemes, and to ensure an understanding of the relationships between the boiler fuel/combustion method and the generation of dust, SO_X, and NO_X.
d) To study the current problems of each TPP based on the data collected and analysis results of coal, etc., and to present concrete proposals to improve the boiler and to lessen the environmental effects of the facilities.

Based on the study of the conventional boiler facility and operational condition, JET reported on-site stack measurement results, and explained the relationship between the present emission values of Kosovo A TPP and Kosovo B TPP and the ELVs.

Dust measurement was conducted at both the inlet and the outlet of ESP with measurement of the velocity distribution inside the duct and the dust content distribution, and JET proposed improvements. In the case of SO_2, it may be possible to satisfy the ELVs because in-furnace desulfurization may occur in the boiler due to the special features of the coal; JET explained the content of this item. For NO_X reduction, JET explained operational improvements such as exhaust O_2 reduction and appropriate hardware improvements such ad low NO_X burner.

1-3-3 Enforcement of ability to evaluate and implement improvements toward formulation of emission inventories

The aim here is that C/P recognizes the present emission condition by using measured data, and JET supports C/P in converting the results into numerical values for Kosovo A TPP and Kosovo B TPP as emission inventories, and in drawing up improvement plans.

JET implements the following items and offers related proposals.

a) To obtain basic air pollution-related information such as policies, strategies, action plans, standard emission data, etc. through interviews with the related authorities and organizations.
b) To provide information based on the current problems of TPPs for establishing emission inventories by MESP.
c) To extract problems to achieve ELVs for TPPs and to develop a NERP.
d) To propose measures to achieve ELVs for TPPs and to arrange problems for developing a NERP. This will lead to the future energy strategy.
e) To introduce similar projects for air pollution control.

JET studied basic information and the conventional condition of the TPPs, together with the information from the interviews with related authorities and organizations, and extracted problems and proposed future plans for the NERP.

1-3-4 Promotion of understanding of this project by related organizations through workshops

JET holds several workshops on dust measurement methods and lectures on boilers, including a reporting session for the measurements results. JET intends that the workshops and reporting sessions should enable C/P to gain a fuller understanding of this project through question & answer sessions and discussions of the project.

Table 1-2 shows the workshops and the reporting session held in Kosovo.

Table 1-2 Workshops and reporting session

1st mission (October 19th, 2015 to November 12th ,2015)		
Date	Agenda	Content
21st Oct.	Exhaust Gas Measurement and Analysis in Japan (Air environment)	・ History of air pollution countermeasures in Japan ・ lecture on dust measurement
2nd Nov.	Exhaust Gas Measurement (Dust Measurement) Interim Report	・ Reporting of dust measurements results of Kosovo A TPP
10th Nov.	Exhaust Gas Measurement (Dust Measurement) Report Air Pollution and Boiler	・ Reporting of dust measurements results of Kosovo B TPP ・ Lectures on countermeasures to improve boiler emissions
2nd mission (March 7th, 2016 to March 31st, 2016)		
22nd Mar.	Exhaust Gas Measurement (SO_2, NO_X, dust measurement) Report On-site stack gas measurement	・ Reporting of dust, SO_2, NO_X measurement results of Kosovo A & B TPP ・ Regulations, rule, etc., about on-site stack gas measurement
25th Mar.	Pollution Control of Boiler Lignite & ash analysis result Introduction of Similar project for air pollution control	・ Measures for environmental protection for coal fired boiler ・ Results of analysis of lignite etc. in Japan ・ Introduction of Mongolian Project
29th Mar.	Wrap-up workshop	・ Discussion and confirmation of outcomes and future problems

1-4 Members and schedule

The 1st mission of "Expert for Air Pollution Control" visited the city of Pristina on October 18th, 2015, started its activity on October 19th, and was completed on November 12th, 2015. The 2nd mission started its activity on 6th March and was completed on 31st March. The list of members, the schedule and outline of the activities of the mission are shown in Table 1-3, Figure 1-1, and Table 1-4 respectively.

Table 1-3 Mission members

Masuto Shimizu	Project Manager, on-site stack gas measurement	JFE Techno-Research Corporation
Tadayoshi Usui	On-site stack, gas measurement	JFE Techno-Research Corporation

Yasufumi Nakajima	Supervision of LCP emissions Utilization of emission data	Thermal Power Engineering Institute

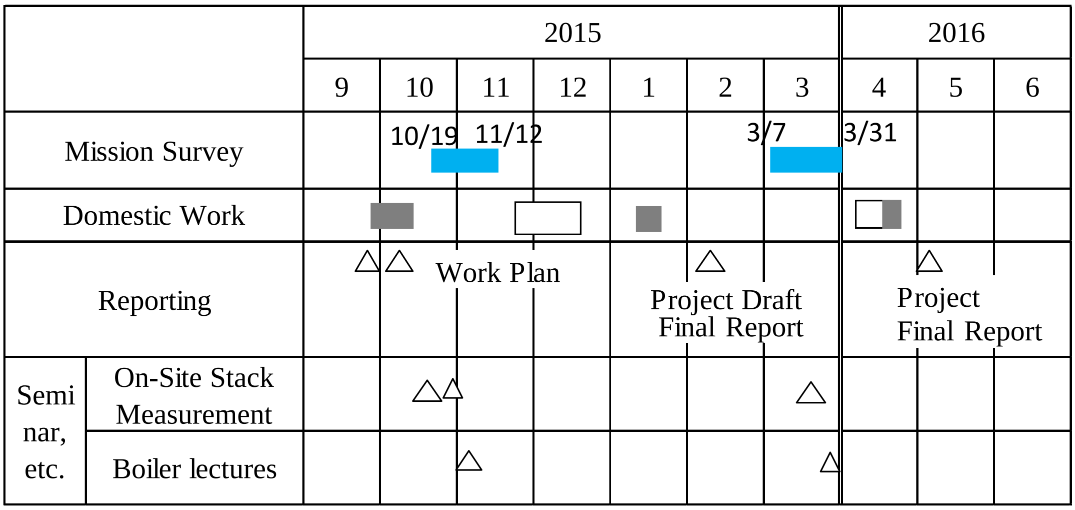

Fig. 1-1 Planned schedule

Table 1-4 Outlines of activities in each week

1st mission activities (October 19th, 2015 to November 12th, 2015)

1st week	Introduction of mission activities, study of Kosovo A TPP and Kosovo B TPP, interviews with related authorities and organizations, 1st workshop, preparation for dust measurement, etc.
2nd week	Measurement of Kosovo A TPP and data arrangement, visit to coal mine
3rd week	Reporting of measurement results of Kosovo A TPP, and measurement of Kosovo B TPP and data arrangement
4th week	Wrap-up of 1st mission activities, planning of 2nd mission activities, 2nd workshop

2nd mission activities (March 7th, 2016 to March 31st, 2016)

1st week	Measurement of Kosovo A boilers and arrangement of measurement results Support for answering questionnaire about draft NERP from EC Secretariat
2nd week	Measurement of Kosovo B boiler and arrangement of measurement results Support for answering questionnaire about draft NERP from EC Secretariat
3rd week	1st workshop (Reporting of measurement results of Kosovo A & B TPP) 2nd workshop (Environmental measures for coal fired boiler in Kosovo, results of analysis conducted in Japan, etc.) Procedure of measurement equipment transfer, meeting with each related organization
4th week	3rd workshop, wrap-up of activities

Chapter 2 Energy Situation and Environmental Regulation in Kosovo

Based on interviews with related organizations and the TPPs, this chapter summarizes the energy situation and condition of environmental regulation in Kosovo. This chapter explains the energy situation, outline of environmental regulation in Kosovo and the future direction for environmental countermeasures, which are related to "1-3-2 Enforcement of knowledge of application of on-site stack gas data to ELVs" and "1-3-3 Enforcement of ability to evaluate and implement improvements toward formulation of emission inventories".

2-1 Energy situation in Kosovo

The Ministry of Economic Development (MED) is the main ministry which controls energy delivery and plans future energy strategy in Kosovo. Under MED, Kosovo Operator Sistemi, Transmisioni dhe Treu SH.A (hereinafter referred to as "KOSTT") is responsible for power transmission and distribution, and Kosovo Energy Corporation (hereinafter referred to as "KEK") is responsible for power generation.

KOSTT was founded in 2006 in concert with the market opening policy for electrical power in the EU. It is a national enterprise under MED, and is in charge of future plans and power transmission for both domestic control and power trade with neighboring countries. Power delivery in Kosovo is privatized, and now KESCO, in which a Turkish enterprise has invested, is in charge of power delivery in Kosovo. The following summarizes the energy situation in Kosovo, and especially the situation of electric power, where most information is mainly supplied by KOSTT.

2-1-1 Main features of energy situation and power situation in Kosovo

a) Kosovo has abundant lignite resources. The country's reserves of lignite[6] are said to be the 4th or 5th largest in the world. Lignite is extracted by surface mining. Most reserves are located near the two main TPP in Obliq close to the city of Pristina[7]. Mining started in 1922, and 320 million tons of lignite has been mined to date. Annual production is 8.5 million tons/year, roughly corresponding to the consumption of Kosovo A TPP and Kosovo B TPP. A simple calculation shows that this can satisfy demand for more than 1,000 years. Fig. 2-1 shows the locations of the coal mine and lignite reserves.

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[6] The classification of coal is generally based on the content of volatiles (daf base). Low volatile coal is generally positioned as high rank. The volatile contents are 7~12% for anthracite, 15~45% for bituminous coal and 45% or higher for lignite.

[7] KOSTT presentation

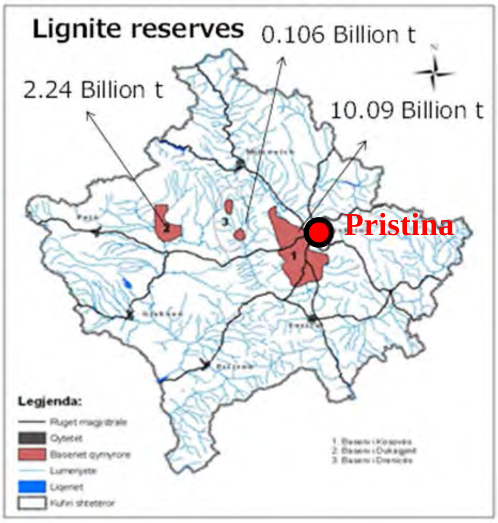


Fig. 2-1 Coal mine locations and reserves in Kosovo

b) Kosovo's transmission system (Fig. 2-2) is connected to 5 neighboring countries (Albania, Macedonia, Bulgaria, Montenegro, and Serbia[7]), which gives Kosovo a very strong transmission system. The connecting lines with neighboring countries are 400kV, and domestic lines are 220KV, 110KV, 35KV, 10KV, etc. Furthermore, a main line is connected to Russia; here, 700kV is used to reduce transmission loss because of the long distance.

KOSTT invested 130 million Euros in the transmission system between 2006 and 2014, and is planning to invest a further 120 million Euros in the future to strengthen transmission.

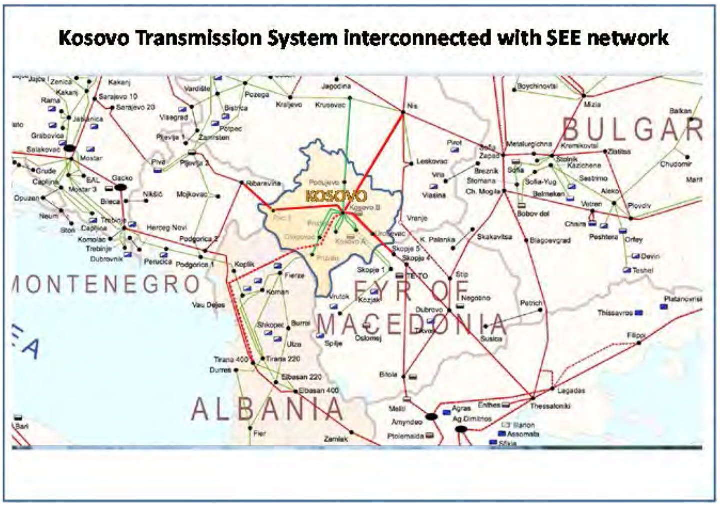


Fig. 2-2 Transmission systems in Kosovo

c) The present total power generation capacity in Kosovo is 1,054MW. The share of TPP is 974MW, while that of hydro power (HPP) is 75MW. Small HPP and wind power have a share of 5MW. Thus, the share of TPP, i.e., Kosovo A TPP and Kosovo B TPP, is more than 90%. The capacities of the TPP are not the nominal values but the present de-rated ones (Fig. 2-3[7]).

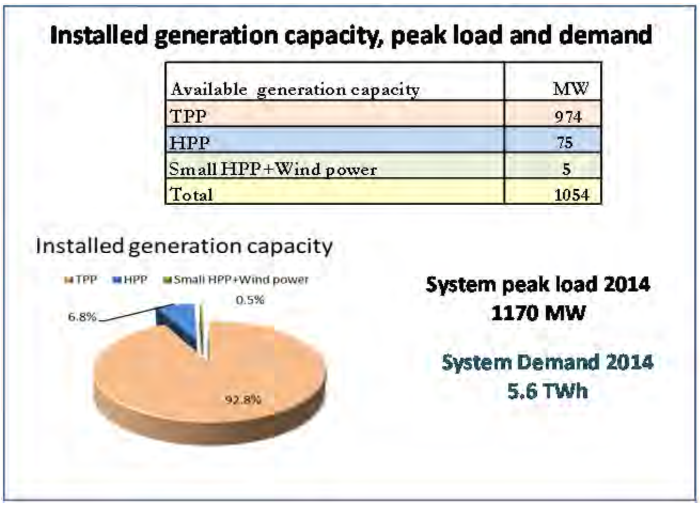


Fig. 2-3 Total power generation capacity in Kosovo

2-1-2 Problems of energy situation in Kosovo

a) Kosovo A TPP and Kosovo B TPP are obsolete TPPs which have difficulty following rapid load changes. However, the immediate problem is to respond to power peak load. HPP is the most appropriate power source for peak load, but Kosovo has poor hydraulic reserves, and must collaborate with Albania, which has a HPP share of more than 50%. In this situation, power development in Kosovo is concentrated on the construction of thermal power plants using lignite, which is abundant in the country.

b) In 2014, peak load occurred around 21:00 in the winter season. The following table shows the actual data for 2014.

Peak Load	TPP Kosovo A	TPP Kosovo B	HPP UJMANI	Total Gen	Import
1157 MW	290 MW	2x280=560 MW	32 MW	882 MW	275

c) A German consulting company consulted on future policy for the next 20 years of power generation. It recommended that Kosovo should introduce renewable energy, mainly consisting of wind power (the EC Directive also sets a goal for renewable energy) and respond to peak load by collaborating with Albania, which has abundant HPP. However, it is very hard for Kosovo to invest in wind power because the country is considered a poor credit risk by many banks.

d) At present, the price of the Feed in Tariff for renewable energy is 7.5 cents-Euro/kWh for wind power, 12.6 cent-Euro/kWh for photovoltaic power generation, 6.03 cent-Euro/kWh for HPP and 7.13 cent-Euro/kWh for biomass power generation. On the other hand, the average power generation cost of Kosovo A and B TPP is 2.8-3.0 cent-Euro/kWh, and their power sales price is 7 cent-Euro. Because this is a very small price difference in comparison with renewables, introduction of renewable energy will be difficult to achieve.

e) The import price of power is 4-5 cent-Euro/kWh, which is significantly cheaper than the price of renewable energy. However, imported power is not always available due to various restrictions such as the supply capacity of neighboring countries, time-variable pricing, etc.

2-1-3 Environmental regulations and future energy plans

a) The Ministry of Economics, Department of Energy (MED) manages energy strategy and MESP manages environmental regulation and its legislation. The content of legislation basically follows the EC Directive, which is under discussion in the Parliament.
b) MED and MESP have started to study NERP. At present, they are drawing up drafts, which are now under study in the Assembly. MED thinks Kosovo must make a future energy plan as a national policy strategy in order to develop a NERP.
c) Because the present TPPs (Kosovo A TPP and B TPP) are obsolete and not reliable, Kosovo is planning to construct new TPP in the future.

Kosovo has abundant lignite reserves, and TPP using lignite will be the center of the future energy plan. Kosovo must recognize the ELVs, advance the plan, and consider the ELVs when modernizing TPP.

2-2 Environmental regulation and the NERP development

Because MED, which mainly controls environmental regulations, has announced a policy of following the EC Directive[3], the NERP must be a plan that achieves the ELVs required by the EC Directive. ELVs are the ceiling values which EC sets for LCP, and EC demands that the emission values of LCP must satisfy the ELVs. Furthermore, EC will gradually strengthen the ELVs beginning in 2018, and demands that LCP reach the final goal of ELVs in 2027.

2-2-1 Environmental regulation values under EC Directive

Thermal power plants whose heat input is higher than 50MW are subject to the EC Directive, but the ELVs are different depending on the type of fuel (solid, liquid, gas), the time of operation start, the capacity of the plant (the values vary according to heat input at capacities from 50 to 500MW, but are constant at capacities of 500MW and over), and the type of plant (gas turbine, etc.).

Fig. 2-4 shows the ELVs for the TPPs in Kosovo in the year of 2018 as determined by the conditions mentioned above. That is, the numerical values in the figure are based on the fact that the TPP in Kosovo are not new plants and they consume lignite as a solid fuel. TPPs in Kosovo are positioned larger than heat input of 500MW.

Fig. 2-5 shows the ELVs from 2018. This regulation takes effect in 2018 and gradually reaches the final goal in 2027. If a LCP cannot satisfy this regulation, the plant must be shut down.

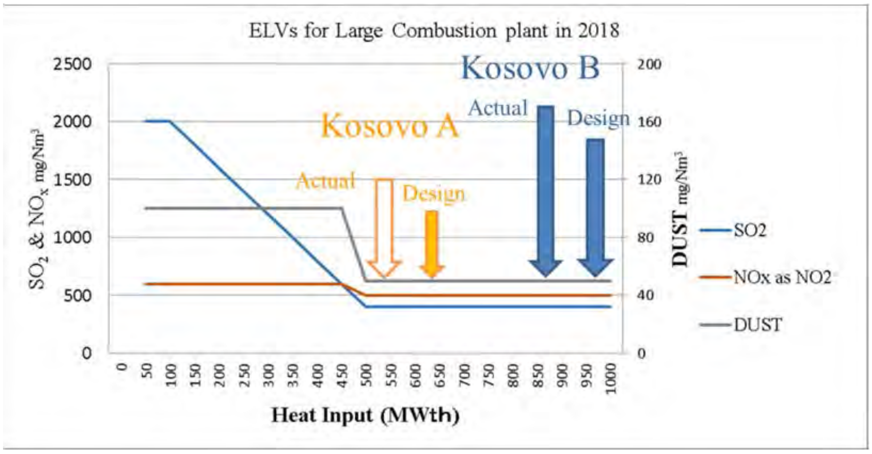


Fig. 2-4 ELVs for Kosovo A and B TPP at the year of 2018

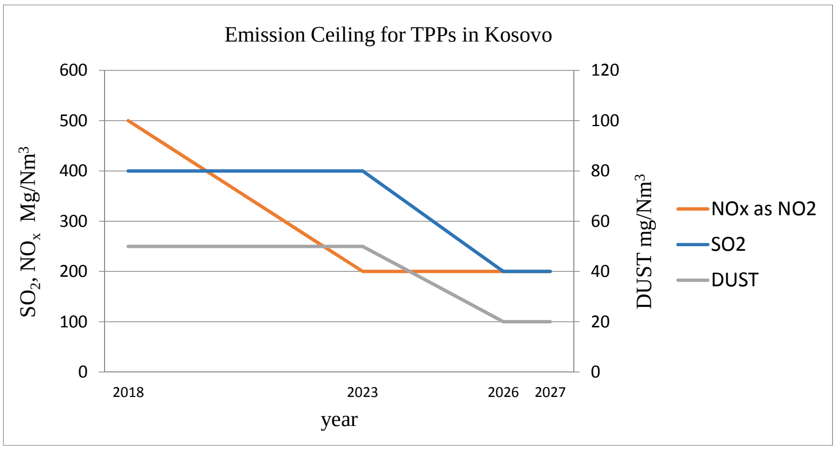


Fig. 2-5 ELVs required by the EC Directive (Kosovo A TPP, B-TPP）

The following is the Japanese regulations applied to coal-fired boilers of the same scale.

a) Dust: 50mg/Nm^3 or 100mg/Nm^3 (depending on the region)

b) SO_X: regulated by K-value method

Regulation of SO_X stipulates the SO_X discharge rate according to the region and the effective stack height, and the K-value is different from region to region.

$q=K\times10^{-3}\times He^2$

q: SO_X discharge rate (Nm^3/h)

K: unique value of each region

He: Stack height stipulated by specific equations (m) (equivalent to effective stack height)

c) NO_X: 200ppm (= up to 411 mg/Nm^3)

These regulatory values are generally applicable, but in the major metropolitan areas, a total volume control law regulates the amount of the SO_X and NO_X discharge rate itself, which is stricter than the above-mentioned condition.

2-2-2 NERP development

NERP is a national plan in which each member country of EC describes how it plans to achieve the EC Directive. EC requested that its members submit NERP[8] by the end of 2015. MESP laid out an action plan and drew up a roadmap (Fig. 2-7) to develop a NERP at the task training course "Capacity building for atmospheric environmental management" held by JICA in 2014. The action for the roadmap is slightly behind schedule, which may require revision of the schedule.

In this roadmap, this project supports the following items.

No. 6 Inspection and monitoring of emissions
No. 7 Assessment of results
No. 8 Collection of information and monitoring of emissions

Kosovo submitted a draft NERP at the end of last year. However as this draft was lacking in concreteness, the Secretariat of the EC sent a questionnaire to Kosovo, and JET supported drawing up answers to this questionnaire. Based on the current condition, Kosovo will have a difficulty meeting the requirement of the EC guideline[8], which starts from the year 2018. Because of this situation, the government of Kosovo decided to delay the plan for 4 years and negotiate with EC by proposing a plan under which NERP of Kosovo starts from the year 2022. Based on this decision, Kosovo reviewed the execution plan and worked out the plan showed in Fig. 2-6, and prepared answers to the questionnaire. Under this plan, Kosovo will carry out a feasibility study of rehabilitation of Kosovo B TPP for 15 months from 2016. As the new plant construction is not in sight, Kosovo A TPP will continue operation by implementing environmental measures satisfying EC directive at each point of the planned years.

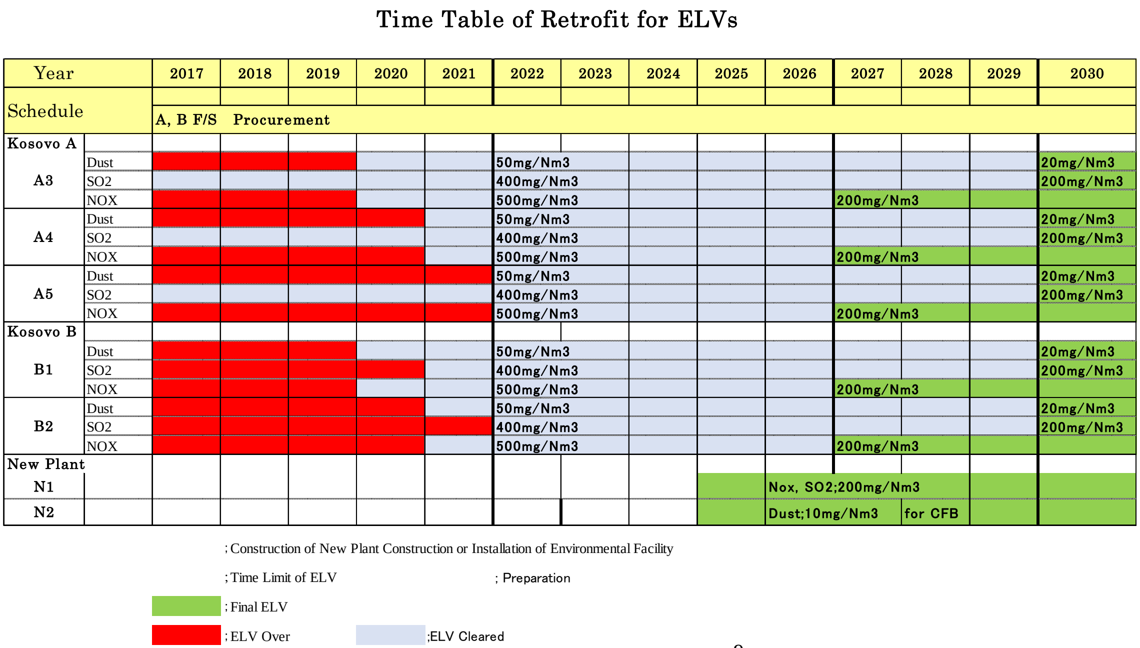


Fig. 2-6 Future modification plan[9]

8 Policy Guidelines by the Energy Community Secretariat PG 03/2014 / 19 Dec 2014
9 From the answer of MESP to the questionnaire from EC Secretariat

	Task name Preparation and management	**2015**												**Stackh.**
		Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec	
1	Definition of responsibilities of bodies for NERP preparation													MESP
2	Determination of financial implications													MESP,MED.MF
3	Determination of stakeholders													MESP
4	Definition of duties													MESP,MED,MTI
4	Establishment of system to define and classify LCP to design NERP													MESP, MED
5	Distribution of questionnaire to operators													MESP
6	Inspection and monitoring of emissions.													MESP
7	Assessment of results													MESP
8	Collection of information for emission inventories													MESP
9	Training for emission inventories													MESP
10	Development of database													MESP
11	Generation of emission inventories													MESP
12	Compilation of list of plants included in NERP													MESP, MED
13	Definition of total emission ceilings for SO_2, NO_X and dust for each year from 2018 until 2027													MESP
14	Determination of individual plant contributions to total emission ceilings													MESP
15	Calculation of emission ceiling contributions for 2018, 2023 and 2026													MESP, MED
16	Listing of measures to be applied in order to ensure NERP execution													MESP, MED
17	Preparation of NERP document													MESP, MED, MID
17	Start of implementation													MESP, MED, MTI

Fig. 2-7 Roadmap of action plan for development of NERP

Chapter 3 Thermal Power Plants in Kosovo

As mentioned above, Kosovo has abundant lignite resources which are mainly located close to the country's two large TPPs in Obliq close to the city of Pristina and are extracted at a large coal mine by surface mining. The two main TPPs cover more than 90% of power demand in Kosovo. The following introduces this large coal mine and the two main TPPs.

3-1 Coal mine in Kosovo

Kosovo has large lignite reserves, which ranks the 4^{th} or 5^{th} largest in the world. This lignite is mined by surface mining, which is very favorable for the environment. Most of the reserves exist close to the country's two main TPPs. Vacant lots after mining are used to dispose of ash from the TPP by landfilling.

JET visited the coal mine site to confirm that the site supplies lignite to Kosovo A TPP and Kosovo B TPP by surface mining and the vacant lots become landfilling sites for incineration bottom ash and fly ash, which are transported as a mixture with water.

Photo 3-1 shows the lignite conveyer and ash transport piping of Kosovo A TPP. Photo 3-2 shows the lignite storage yard at Kosovo A TPP. The storage capacity is 250,000 tons; in the summer season, the plant usually stores 100,000-150,000 tons, but in winter, it stores a larger amount considering problems with the lignite handling system. The lignite consumption of Kosovo A TPP is approximately 5,000ton/day/boiler, so the storage yard can store a supply of approximately 25 days, assuming 2 boilers are in operation.

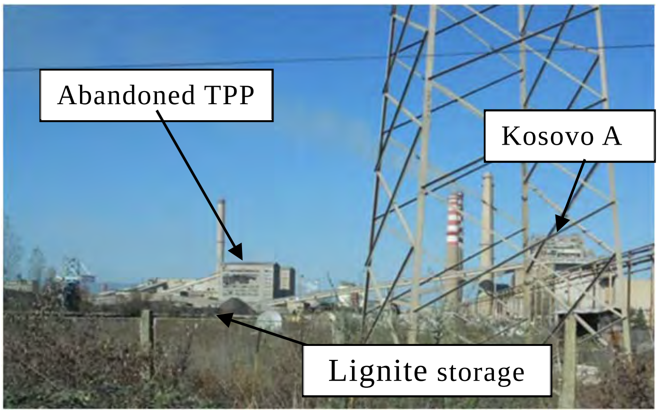


Photo 3-1 Lignite storage yard at Kosovo A

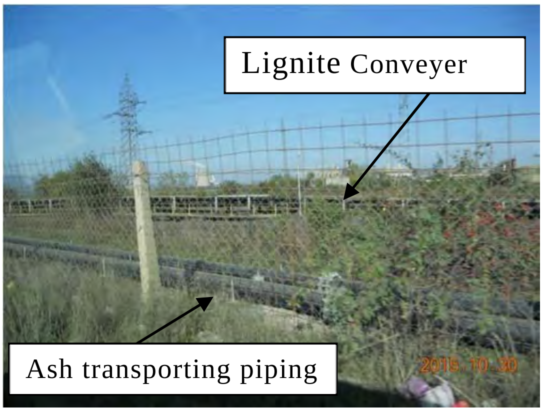


Photo 3-2 Lignite conveyor and transport ash transporting pipe

Photo 3-3 shows an overview of the coal mine. The right side is a formerly-mined area (1,000ha) which is scheduled to be returned to use as agricultural land. The center part is an area where mining was completed recently. The area at the left is now being backfilled. Surface soil from coal mining is used as backfilling soil. The far left is currently being mined (Photo 3-4 shows the overview from a different side.) Photo 3-5 shows the landfill used for disposal of bottom ash and fly ash.

Photo 3-3 Overview of coal mine

At the area now being mined, mining will continue until 2025. Environmental measures are taken to ensure that there is no damage to the environment (no harmful water flows out, and outflowing water is treated to clean water), and areas where mining has been completed are reused as agricultural land, etc.

Photo 3-4 Another view of surface mining

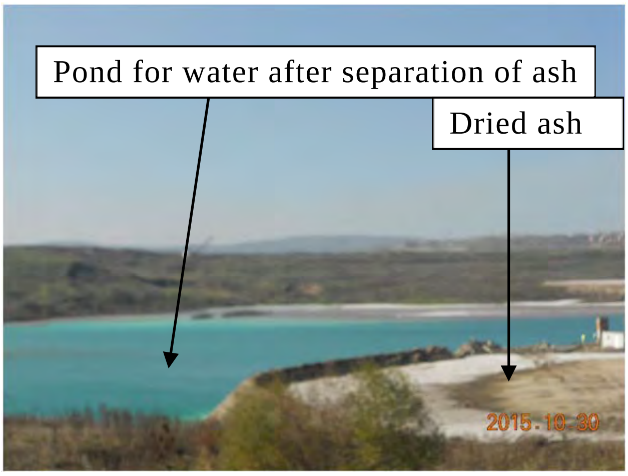


Photo 3-5 Landfill for bottom ash and fly ash

3-2 Facilities of Kosovo A TPP

3-2-1 Outline of power plant

Kosovo A TPP comprises five units, A-1 to A-5. Each unit has an independent stack. Units A-1 and 2 are now under long-term stops, and units A-3, 4 and 5 are in operation. Among these three units, two units are normally in operation and one unit is on stand-by.

Table 3-1 to Table 3-4 shows the specifications of the facilities and the history of the TPP.

Photo 3-6 View of Kosovo A TPP

(1) Organization of power plant

Kosovo A TPP belongs to KEK (Kosovo Energy Corporation, a state-owned company). The total number of employees is 844. There are eight departments in the power station, and the breakdown is as follows

Department	No. of person
Production Department	250
Machinery Maintenance Department	270
Electrical Maintenance and Regulation Department	91
Engineering Department	23
Water Chemical Preparation Department	75
Work Safety and Fire Protection Department	65
Business Support Department	22
Chemical Separation Department	48

(2) Facilities of Kosovo A TPP

a) Unit A-1 : Commissioned in 1962. The 56MW turbine-generator was made by Westinghouse Co., and the boiler was made by German Babcock Co. This unit has been stopped since 2006 due to environmental requirements.

b) Unit A-2: Commissioned in 1964. The 124MW turbine-generator was made by General Electric, and the boiler was made by German Babcock. This unit has been stopped since 2000.

c) Unit A-3: Commissioned in 1970. The 200MW turbine-generator was made in Russia, and the boiler was made by Poland Manufacture. This unit now usually operates at 140MW to 150MW. The operating pressure of the boiler drum was reduced to 115kg/cm^{2}g (specification: 152kg/cm^{2}g) to prevent steam leakage from the tubes. After these operating conditions were established, continuous operation for five months was achieved in 2014.

d) Unit A-4: Commissioned in 1971. A-4 is the same design as A-3.
e) Unit A-5: Commissioned in 1975. The 210MW turbine-generator was made in Russia, and the boiler was made in Poland. The boiler design is similar to that of A-3 and A-4, but some improvements were introduced, such as the furnace wall construction and duct configuration around the burner.
f) The steam turbines of units A-3 and A-4 were improved in 2012 and 2014, respectively, and the steam turbine and generator of A-5 were improved in 2015.
g) Unit A-1 and A-2 are currently under long term stops, but have received no maintenance since being stopped. Thus, they are substantially in the abolition stage.
h) Two of the three units A-3, 4 and 5 usually operate according to electricity demand in relation to the electrical power balance, and one unit is a spare.

(3) Environmental measures

An investment of about 45 million Euros mainly realized the following environmental measures.

a) Security of land reclaimed as an ash processing measure (backfilling in vacant lots of coal mine)
b) Installation of high efficiency ESP to reduce dust in exhaust gas (A-3 and A-5 ESP were replaced in 2012, and A-4 was replaced in 2013). However, it is not possible to maintain these facilities properly due to the difficulty of procuring spare parts and training of maintenance people.
c) Construction of an ash transport system with high density water slurry.

(4) Others

a) The number of people working in the power station, including affiliates, is approximately 800. As the operational duty group, one supervisor and six operators are assigned to one unit. Operation is carried out by five groups working in three shifts, as working hours are limited to 40 hours per week.
b) The major trouble of the boiler is steam leakage from the tubes, especially at the bending portion of the heating elements. As decreased tube wall thickness due to erosion and/or corrosion is the main cause of tube leakage, there is no choice but to reduce the boiler operating pressure in order to keep continuous stable operation.

c) The content of moisture, ash and sulphur in the lignite is as high as 45%, 20% and 1.2%, respectively (Note: The sulphur content per calorific value is substantially very high due to the low calorific value of the lignite used in these plants.)

d) As the boiler control system is an old type, the operators adjust the boiler manually. Eight lignite mills (pulverizers) serve each boiler. Raw lignite is pulverized by the mill and fed to the burners. Each mill serves 3 sets of burners. Due to the high moisture of the lignite, hot gas introduced from the furnace outlet (around 850°C) and air are mixed to around 850°C, and this is also mixed with air from the air pre-heater outlet (around 250°C), and the mixed gas is used to dry the lignite.

e) The operation room of A-5 unit is an independent control room. The operation rooms of A-3 and A-4 unit are in one room, and the operation panels of A-3 and A-4 are arranged in a symmetric form (like mirror images of each other).

3-2-2 Operational condition of Kosovo A TPP

(1) Configuration of Kosovo A Boilers (A-3, A-4, and A-5 Boiler)

a) The cross-sectional shape of the furnace is octagonal, but the shape of the furnace is not an equilateral octagon, but rather is wider in some width directions (Fig. 3-1).

b) Horizontal type primary, secondary, tertiary and quaternary superheaters are located at the upper part of the furnace, and pendant type primary and secondary reheaters are arranged in the horizontal gas path at the top of the boiler. An economizer is arranged in the back path. (Photo. 3-7)

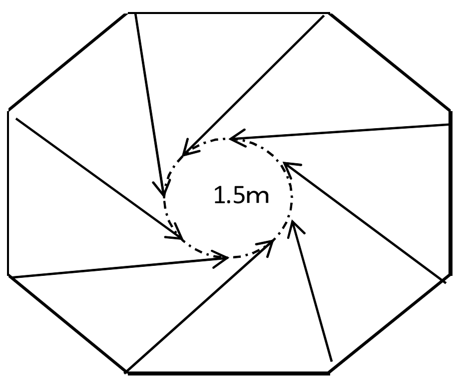


Fig.3-1 Plan view of furnace

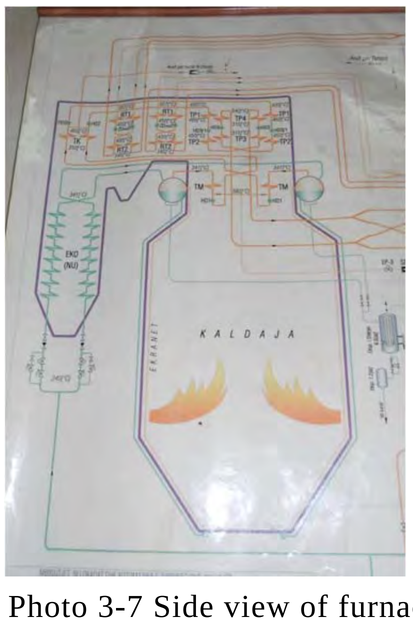


Photo 3-7 Side view of furnace

c) Each boiler is equipped with 8 mills (lignite pulverizers). Each mill has the capacity to pulverize 40-60t/h of lignite. The number of mills in operation varies according to the lignite properties, but usually 5-6 mills are operated for the current power generation output.

d) This type of mill is called a “ventilation Mill,” as the mill is shaped like a centrifugal fan. Abrasion-resistant blocks are attached to the fan blades, and have the functions of both crushing lignite and transporting primary air (mixture of gas, air and pulverized lignite).

In the mill, the lignite is crushed while being dried. Very hot air/gas is necessary to dry the lignite because of its high moisture content. Therefore, the temperature of the mixture of gas/air/lignite particles after the mil is controlled to approximately 170°C by introducing high temperature combustion gas from the furnace with mixed air from the pre-heater outlet.The crushed lignite is transported to the burner by primary air (gas/air mixture). In the transporting pipe, the combustion gas and evaporated moisture form an inert atmosphere which prevents fire or explosion of the lignite particles. A separator is installed at the exit of the mill, and separates large lignite particles bigger than 0.6-0.8mm, with which perfect combustion is difficult; this oversize lignite is returned to the mill inlet to be crushed again (Fig. 3-2a).

e) The burner consists of three levels, and secondary air is supplied between the primary air (mixture of crushed lignite and air) (Fig. 3-2b, Photo 3-8).

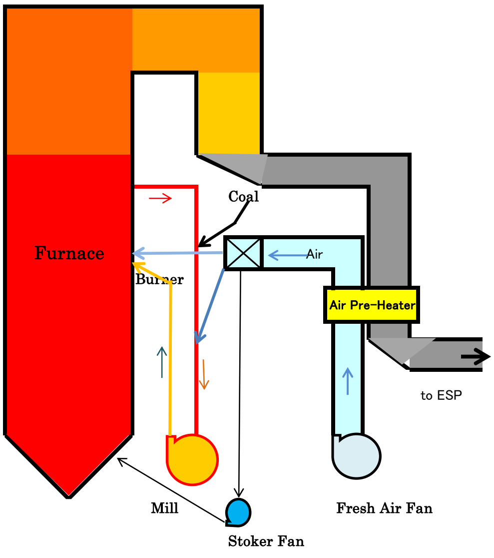


Fig. 3-2a Air and gas flow

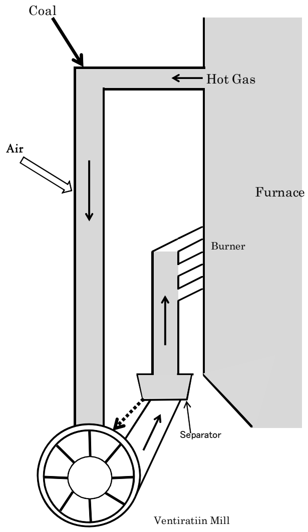


Fig. 3-2b Mill and burner

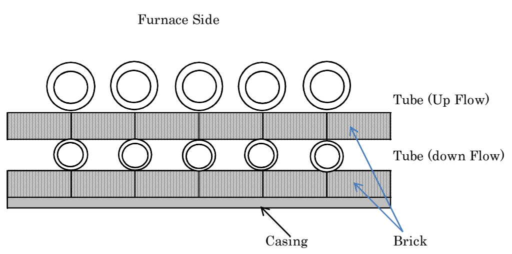
Photo 3-8 Burner

f) The structure of the burner is different in A-5 boiler and A-3 and 4 boilers. In A-5 boiler, an orifice is installed to control the distribution of the primary air flow uniformly to each level of the burner, but this was not originally used in A-3 and A-4 boilers. Therefore, this part of A-3 and A-4 boilers was remodeled later.

g) In the original design, the mixing point of the furnace outlet gas and the air pre-heater outlet air in the mill suction duct was located close to the mill inlet. A plugging problem occurred due to adhesion of the supplied raw lignite because the lignite is roasted by the hot gas. In order to solve this problem, the place of the mixing point of the hot gas and the air was moved to upstream of the lignite injection point, as in Kosovo B, and the problem was no longer observed after this modification.

h) The furnace wall configurations of A-3 and A-4 boilers are the same. Tubes are placed in two folds, and with a large inside tube facing the furnace (i.e., evaporation tube), where the internal water rises while evaporating by heat from the furnace. Behind the outside tube, a small-sized tube is arranged as a down-comer where the water from the drum comes down and is supplied to the furnace tube at the bottom of the furnace, which keeps the water circulation (Fig. 3-3a).

i) The furnace wall construction of A-5 is different from that of A-3 and A-4 boilers. There is no tube along the surface wall in which water goes down, and instead, large pipes (down-comer) are installed outside, and the water is supplied to the furnace tube from this large pipe. (This system is common in large boilers.) (Fig. 3-3b).



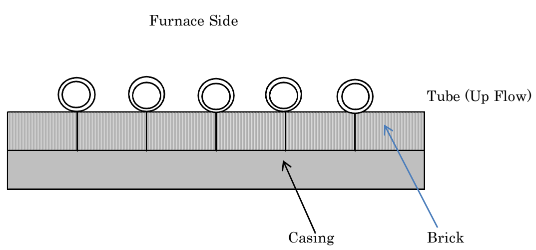


Fig. 3-3a Furnace wall structure of A-3, A-4   Fig. 3-3b Furnace wall structure of A-5

j) A traveling stoker is installed at the bottom of the combustion furnace. Large unburned lignite particles drop and burn here.

k) A straightening vane has not been installed at the bending part of the air preheater outlet gas duct and there is no discharge hopper for the accumulated ash at the horizontal section of the duct. As a result of the observation of A-5 boiler by Kosovo A TPP, there is no accumulation of ash in the ducts. However the measurement results shows a large velocity distribution in the duct at the ESP inlet, and this may have an adverse influence on the dust collecting efficiency of the ESP.

l) Ambient air is used for combustion air. In winter, this air is heated up by a steam air heater before going to the air preheater in order to prevent corrosion of the cold end element of the air preheater by sulphuric acid generated from the SO_3 in the exhaust gas by preventing the gas from reaching the acid dew point.

(2) Ash handling

a) At the opening of the furnace bottom, a submerged scraper conveyor is installed in a water pool, where the ash and unburned lignite from the stoker drop and are scraped out by a chain-driven scraper as bottom ash. After the bottom ash is dewatered, it is sent to the ash processing system by the belt conveyor (Fig. 3-4).

b) The fly ash collected in the ESP falls into the lower part of the ESP hopper through the rotary gate valve. This ash is conveyed by compressed air to a buffer tank, and is then sent to the ash processing system by compressed air (Fig. 3-5).

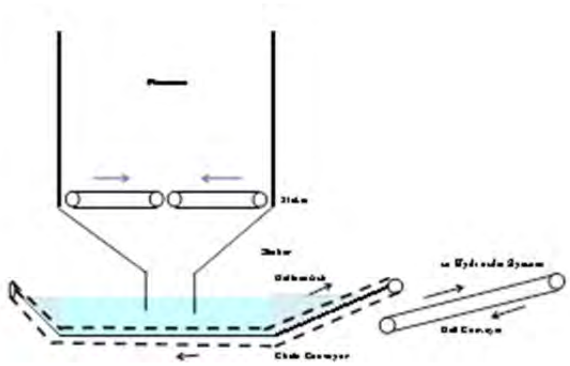


Fig. 3-4 Bottom of furnace

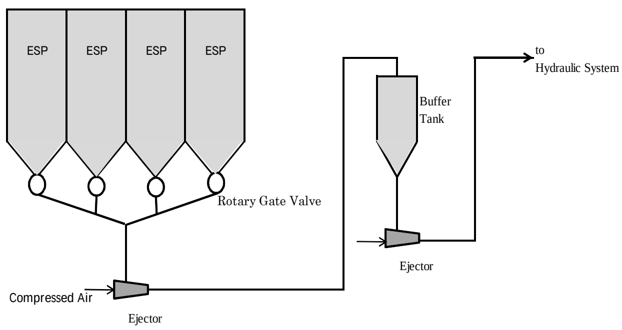


Fig. 3-5 Recovery of fly ash from ESP

c) The ash processing system crushes the fly ash and bottom ash to the appropriate size, and mixes the crushed ash with water to form high density slurry (the water/ash ratio is around 1.0). The system transports the slurry through a pipeline to the ash landfill at the coal mine. This is a new system which was installed in 2014. The old system, which was used previously for A-1 and A-2 boilers, was a low density slurry system (the water/ash ratio was around 10), which required much water and electric power compared with new one (Photo 3-9).

d) After the ash dries at the ash landfill site, it forms lumps of cement and does not scatter.

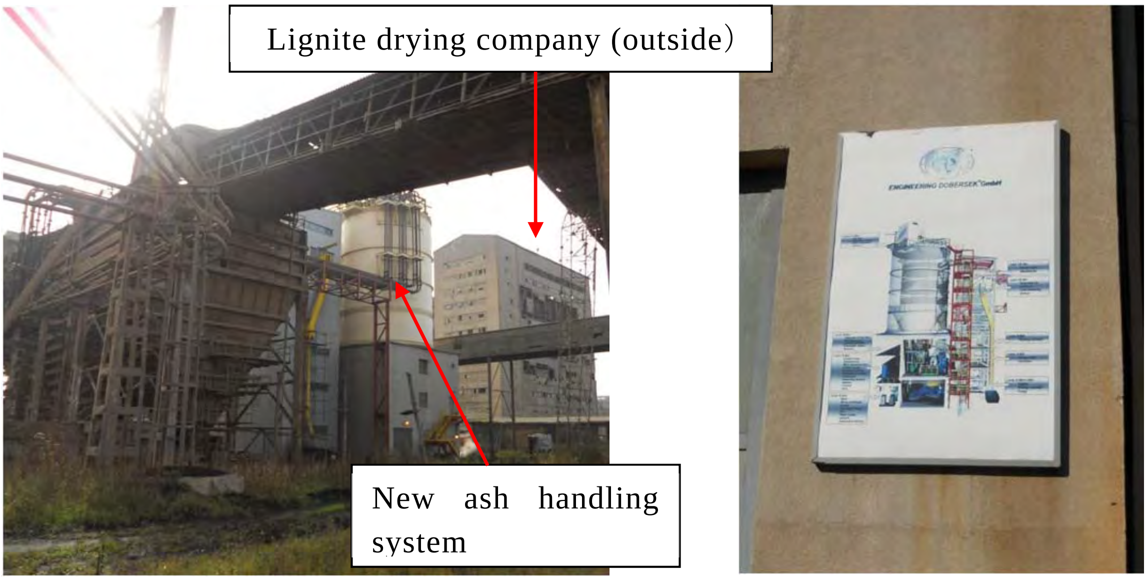


Photo 3-9 Hydraulic ash transportation system

(3) Others

a) Boiler output: In spite of the designed rated output of 200MW, the boiler is operated with the constant load of approximately 158MW by reducing the operating pressure to 110k/cm^{2}g in order to avoid tube leakage. The minimum load for lignite firing without oil support is approximately 140MW (120MW may be possible depending on the lignite quality), and when less than 100MW, oil support is essential.

b) Boiler startup takes about 4 hours. First, the boiler is warmed up by oil firing for about 50 minutes. When the furnace gas temperature reaches 350°C, the mill starts and supplies lignite to the furnace. During the startup period, the generated steam passes through a turbine by-pass tube because the turbine is not running. Therefore, the main steam generated in the boiler reaches the reheater of the boiler by by-passing the HP turbine. (If a large amount of heat goes into the boiler, the metal temperature of the reheater tube may increase, as only a very small amount of steam reaches the reheater in this period. This is more likely to be a cause of leakage of the high temperature reheater tube in 50 hours of operation after replacement.)

c) Kosovo A TPP operates with a constant load, while Kosovo B is mainly used to respond to load changes.

d) All the steam generated by the boiler is consumed in Kosovo A TPP, and there is no heat supply to outside of the plant (Kosovo B TPP supplies heat to outside for district heating.)

e) The TPP has had no periodical checks of boiler efficiency up to now.

f) A light scattering type dust meter is installed in each duct of the ESP outlet (Photo 3-10). The meter always displays 25-30mg/Nm^3, but the actual dust content is higher because a smoke color is clearly observable.

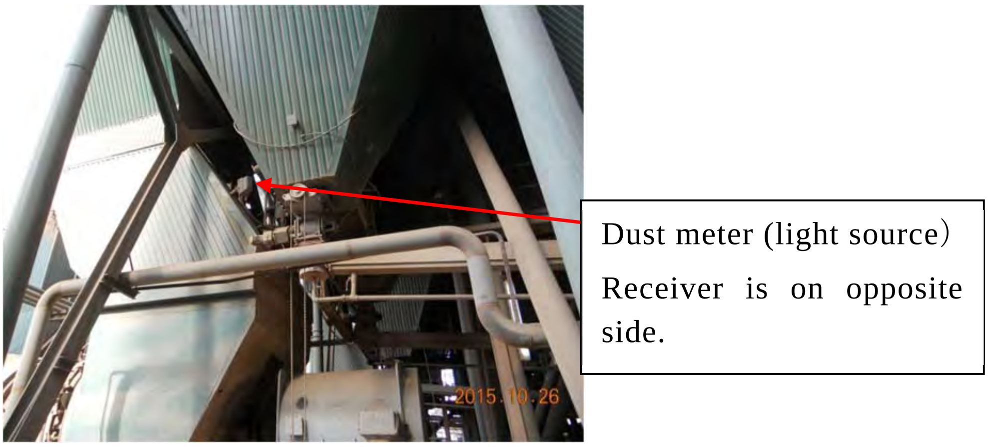


Photo 3-10 Dust meter at ESP outlet

Photo 3-11 View of Kosovo A TPP (A-1 to A-5 from left)

Photo 3-12a From right, A-2 (stopped) and A-3, A-4 (in operation)

Photo 3-12b 3 ESP lines installed for each boiler (shown here: A-3)

Table 3-1 Design conditions of Kosovo A-3, 4 and 5 boilers

	Item	Unit	Description
1	Manufacturer Type		"RAFAKO" Poland OP – 650 –b
2	Start of Operation	Year	A_3 – 1970, A_4 – 1971, A_5 – 1975.
3	Boiler Height	m	60
4	Furnace Size (Width x Depth)	m	12.5/15.24
5	Type of Boiler		Natural Circulation Boiler with free semi-suspended construction, with two drums, with a natural circulation of water-steam scheme and with removal of bottom ash in the solid state.
6	Firing System		Pulverized lignite assisted by liquid fuel oil and with constant air blowing.
7	Draft System		Forced draft
8	Furnace Wall		Membrane or brick
9	Furnace Bottom		Scraper conveyor with water seal
10	Evaporation	T/h	650
11	Steam Temperature	℃	540
12	Steam Pressure	bar.	162 (FW), 152 (Drum), 138 (SH Out)
13	Feed Water Temperature	℃	Projected 240
14	Reheat Steam Flow	T/h	570
15	RH Inlet Steam Temperature	℃	357
16	RH Outlet Steam Temperature	℃	540
17	RH Outlet Steam Pressure	bar	25
18	Boiler Design Coal		Lignite
19	Lignite Consumption	T/h	316
20	Ambient Air Condition (Temperature)	℃	-16 to 35
21	(Humidity)	%	60 – 90
22	Excess Air Ratio	%	30 – 50
23	Combustion Air Flow Rate	Nm^3/h	855 000 Nm^3/h
24	Furnace Pressure	mmH_2O	-3 to -5
25	Economizer Outlet Pressure	mmH_2O	-400
26	Precipitator Inlet Pressure	mmH_2O	-400
27	Stack Inlet Pressure	mmH_2O	-433
28	Burner Inlet Air Temperature	℃	270
29	Furnace Outlet Gas Temperature	℃	Up to 1000
30	Economizer Outlet Gas Temperature	℃	300

31	Precipitator Inlet Gas Temperature	℃	160 - 200
32	Precipitator Outlet Gas Temperature	℃	160 - 195 (cannot be measured)
33	Stack Inlet Gas Temperature	℃	160 - 190 (cannot be measured)
34	Flue Gas Flow Rate	T/h	
35	O_2 Content at Economizer Outlet	%	6 to 10
36	O_2 Content at Stack Inlet	%	6 to 10
37	Type of Precipitator		Electrostatic Precipitator (ESP)
38	Dust Content (Precipitator Inlet)	mg/Nm^3	41110
39	SO_X Content (Precipitator Inlet)	ppm	NA
40	NO_X Content (Precipitator Inlet)	ppm	NA
41	CO Content (Precipitator Inlet)	ppm	NA
42	Dust Content (at Stack Inlet)	mg/Nm^3	50
43	SO_X Content (at Stack Inlet)	ppm	NA
44	NO_X Content (at Stack Inlet)	ppm	NA
45	CO Content (at Stack Inlet)	ppm	NA
46	Boiler Efficiency	%	86.5
47	Plant Efficiency	%	31
48	Stack Size (Height, Diameter)	m	A_3 and $A_{4,}$ H=100.2 D_{mb} = 8.50/5.20 m A_5, H = 120.0 m D_{mb} = 9.64/6.00 m
49	Cooling System		Cooling Tower (Water from river)

Table 3-2 Design conditions of Kosovo A-3, 4, 5 ESP

	Item	Unit	Description
1	Manufacturer Type		Hamon Environmental GmBH “Kompakt Plus”
2	Start of Operation	Year	2012
3	Number per Boiler		3 sets/boiler
4	Number of Sections		4 rooms
5	Cumulative Electrode Surface	m^2	9728
6	Height[1]	m	16
7	ESP Inlet Gas Flow	m^3/h	716,784
8	ESP Inlet Gas Temperature	℃	150 - 210
9	Gas Velocity	m/s	1.41
10	ESP Draft Loss	mbar	(-30)
11	ESP Inlet Dust Content	g/Nm^3	41.110 (g/Nm^3)
12	ESP Outlet Gas Content	mg/Nm^3	50
13	Dust Collecting Efficiency	%	99.88

Table 3-3 Design conditions of Kosovo A-3, 4, 5 steam turbines

	Item	Unit	Description
1	Manufacturer and Type		K-200-130-1 LMZ K-200-130-5 LMZ
2	Start of Operation	Year	1970 (A-3), 1971 (A-4), 1975 (A-5)
3	Output	MW	200 MW (A-3, A-4), 210 MW (A-5)
4	Steam Flow	t/h	614 for 200 MW (A-3, A-4) 645 for 210 MW (A-5)
5	Steam Temperature	℃	535
6	Steam Turbine Efficiency	%	37.6

Table 3-4 History of Kosovo A-1, 2, 3, 4, 5, 6 boilers

Plant	Latest Condition	Remarks
Kosovo A-1	Constructed in (year) Use discontinued in (year)	1962 2006. Last repair of unit was performed in 1988. In the end, the unit was stopped with 4 mills and load of 35 MW.
Kosovo A-2	Constructed in (year) Use discontinued in (year)	1965 First stopped in 1998 as a result of frequent leakages in the boiler, especially in furnace tubes. Started up in 2002 for 10 days, and last load was 100MW. When A-2 was restarted after failure of the unit, the transformer station for own consumption of the unit burned down. The major problems are frequent leakages in the boiler, especially in the furnace tubes, the ash removal system, boiler drum and the condensation tubes with the cooler (spray water).
Kosovo A-3	Constructed in (year) ESP installed in (year)	1970 2012
Kosovo A-4	Constructed in (year) ESP installed in (year)	1971 2013
Kosovo A-5	Constructed in (year) ESP installed in (year)	1975 2012

3-3 Facilities of Kosovo B TPP

3-3-1 Outline of power plant

Kosovo B TPP comprises two units, B1 and B2, and the exhaust gas from the two units merges into one common stack.

The specifications of the facility and the history of the TPP are shown in Table 3-5 to Table 3-8.

(1) Organization of power plant

Kosovo B TPP belongs to KEK (Kosovo Energy Corporation; state owned company) and has a total of 629 employees. There are four departments in the TPP (Engineering, Maintenance, Production, and Business Support).

Photo 3-13 View of Kosovo B TPP

(2) Facilities of Kosovo B TPP

a) Unit B1 and B2 have the same design and started operation in 1983 and 1984, respectively. Kosovo B TPP is newer than Kosovo A TPP. The rated output of the units is 339MW each, but the present output is 290-300MW (corresponding thermal heat input: 850MW). Power generation efficiency is 33-35%, in comparison with the design efficiency of 40%. The lignite consumed is the same as at Kosovo A TPP. The water used in the plant is supplied from a manmade lake (Ujman) about 40km from the TPP.

b) As at Kosovo A, surface-mined lignite is transported to the TPP by a conveyor.

c) A DCS (Distributed Control System), which was newly retrofitted in 2015, is used for operation of the boiler and turbine.

(3) Environmental measures

The following environmental improvements were implemented as the result of an investment of about 175 million Euros beginning in 1999.

a) Introduction of an ash transportation system with water slurry to transport old ash to the landfill in the coal mine, which is located about 4-5km from the TPP. (This old ash was formerly piled on the land beside the power plant.

b) ESPs are installed in 2003. The specified dust content at the ESP outlet was 260mg/Nm^3. Later, the ESP of B-1 was retrofitted for higher dust collecting efficiency of 150mg/Nm^3.

At present, a considerable quantity of fly ash is sold to a cement company (Photo 3-14).

Photo 3-14　Truck for ash transportation

c)　Environmental monitoring

The sensor of the CEMs (Continuous Emission Monitoring system) is installed at the 90m level of the stack and measures NO_X, SO_2, O_2 and the dust content.

It is thought that the reason why the sensor was installed at such a high place is to consider good mixing of the exhaust gas from both boilers (B-1 and B-2 boilers) as the exhaust gas ducts of both boilers are connected to the same stack. The sensor has not been maintained since the spring of 2015 because it is necessary to climb a perpendicular ladder to access it. As a result, measurements are not carried out at present (Photo 3-15).

According to the former data, NO_X and SO_2 seem to show accurate values but the dust content is not reliable.

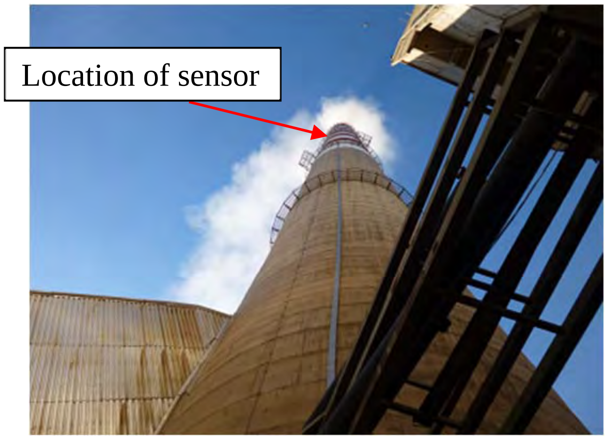


Photo 3-15 Environmental monitoring panel (left) and location of sensor (right)

3-3-2 Operational situation of Kosovo B TPP

a)　The designed steam condition of the boiler is as follows.

Main steam flow rate: 855t/h, main steam pressure: 159kg/cm^2 (156bar), main steam temperature: 539°C, reheating steam flow: 760ton/h, reheating steam pressure: 32.6kg/cm^2 (32bar), reheating steam temperature: 528°C. This low steam temperature was chosen considering the material cost of the turbine.

b) The boiler is a tower-type boiler made by Stain Industry Co. in France. The boiler height is very high at 85.6m, which is almost the same as that of a 1,000MW class boiler in Japan. The water circulation system of the furnace wall tube is a forced circulation system, and a water separator is used instead of the boiler drum to separate the steam and water. The BWCP (Boiler Water Circulation Pump) circulates water at the circulating water flow rate of 1,100 t/h (circulation ratio: 2.0). A horizontal type evaporator, superheater, reheater and economizer are located at the top of the boiler.

c) Steam temperature control of the main steam and the reheating steam is performed by an attemperator by using water spray. However, in this method, an excessive flow of spray water will affect power generation efficiency. In Japan, damper control is applied to boilers in order to achieve higher power generation efficiency; in this type of system, the gas flow rate is distributed to the superheater path and the reheater path so as to control the reheating steam temperature.

d) The combustion gas travels down a duct after leaving the economizer at the top of the boiler, and is then introduced into the regenerative air preheater. Heat exchange between the flue gas and the combustion air is performed in the air heater, and the temperature of the flue gas is reduced to around 180°C. The flue gas is sent to the ESP for dedusting, and is discharged from the common stack of B-1 and B-2 boilers.

e) The spray water flow rate for the superheater is 240t/h; this is considered to be too high.

f) The reheater outlet steam temperature is controlled by the above-mentioned attemperator by using water spray.

g) Trouble at the high pressure feed water heater sometimes causes that the feed water temperature to the boiler economizer to decreases from 290-315°C to 180°C, and the flue gas temperature of the economizer outlet decreases from 316-350°C to 250 °C.

h) To prevent corrosion of the low temperature element of the air preheater, it is necessary to raise the inlet air temperature to keep the cold end metal temperature (average of air preheater inlet air and outlet flue gas temperature) above the dew point of the SO_3 in the flue gas. For this purpose, the hot air preheater outlet gas is returned to the forced draft fan inlet, and is used to control the air preheater inlet air temperature.

i) The combustion air suction system takes in atmospheric (outside) air in summer season and air from the top of the boiler house in the winter season.

j) Because the temperature of the mixture of gas/air/lignite particles at the mill outlet varies depending on the moisture content in the lignite, this temperature is controlled to 180°C by controlling the mixing gas ratio of the hot gas from the furnace, the hot air from the air preheater, and the flue gas from the ESP outlet. However, the ESP outlet flue gas mixing equipment is the second control medium and is not usually used. (This type of equipment has not been installed at Kosovo A TPP.) Eight mills are installed for each boiler; 5 mills are in normal operation, 2 mills are on standby and 1 mill is under repair, as the mill blades are worn by lignite.

k) The burner consists of 4 levels. Secondary air is supplied between the primary air (mixture of crushed lignite and air).

l) There is a lignite analysis device which automatically measures the calorific value and moisture content of the lignite on the belt conveyor at Kosovo B. However, it is not being used at present, and thus is totally wasted.

m) Two stokers are installed at the bottom of the furnace to burn large unburned lignite particles. At the furnace bottom, a submerged scraper conveyor is installed in a water pool, where the ash and unburned lignite burnt in the stoker drops and is scraped out by a chain-driven scraper as the bottom ash.

n) Kosovo B tried to sample the ash for analysis from the hopper after the air preheater duct before the ESP inlet, but sampling was not possible due to clogging of the openings. JET was informed that sand-like dust similar to furnace bottom ash had accumulated in the hopper after the air preheater duct. The results of the on-site stack gas measurement showed a large deviation in the exhaust gas flow distribution at the ESP inlet duct. The cause of this phenomenon is presumed to be the shape of the duct (sharp-angle bending part) , an accumulation of ash at the bottom of the duct bend, or the configuration of the reinforcing structure and guide vane, etc. (Fig.3-6)

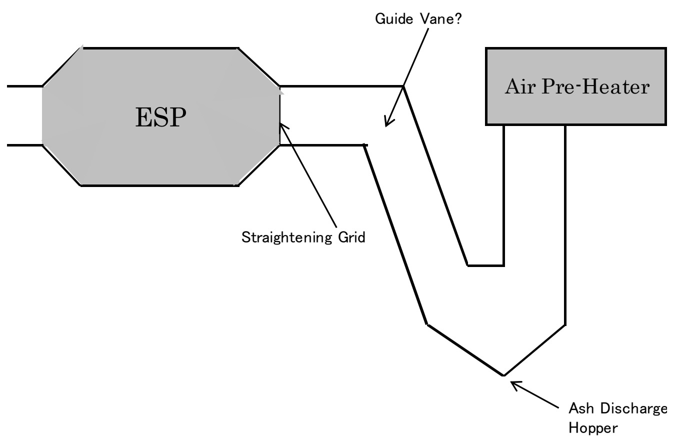


Fig.3-6 ESP inlet Duct

Table 3-5 Design conditions of Kosovo B-1, 2 boilers

	Item	Unit	Description
1	Manufacturer Type		Stein Industry Tower Type
2	Start of Operation	Year	1983/1984
3	Boiler Height		96 m
4	Furnace Size (Width x Depth)		15.75 x15.38 m
5	Type of Boiler		Forced circulation
6	Firing System		Pulverized lignite assisted by liquid fuel oil and with constant air blowing (atmospheric air).
7	Draft System		Forced draft
8	Furnace Wall		Membrane
9	Furnace Bottom		Scraper conveyer with water seal
10	Evaporation	T/h	1000T/h
11	Steam Temperature	℃	540℃
12	Steam Pressure	bar.	174bar (for 339MW)
13	Feed Water Temperature	℃	251℃
14	Reheat Steam Flow	T/h	895 T/h
15	RH Inlet Steam Temperature	℃	336℃
16	RH Outlet Steam Temperature	℃	480℃
17	RH Outlet Steam Pressure	bar	42 bar
18	Boiler Design Coal		Lignite
19	Lignite Consumption	T/h	1.3 ton-lignite/1MW
20	Ambient Air Condition (Temperature)	℃	24-40^{0}C
21	(Humidity)	%	
22	Excess Air Ratio	%	
23	Combustion Air Flow Rate	Nm^3/h	1.813.800 Nm^3/h (Flow of gases at boiler outlet.
24	Furnace Pressure	mmH_2O	-5 to -20 mmH_2O
25	Economizer Outlet Pressure	mmH_2O	NA
26	Precipitator Inlet Pressure	mmH_2O	NA
27	Stack Inlet Pressure	mmH_2O	NA
28	Burner Inlet Air Temperature	℃	
29	Furnace Outlet Gas Temperature	℃	
30	Economizer Outlet Gas Temperature	℃	
31	Precipitator Inlet Gas Temperature	℃	NA
32	Precipitator Outlet Gas Temperature	℃	NA
33	Stack Inlet Gas Temperature	℃	

34	Flue Gas Flow Rate	T/h	
35	O_2 Content at Economizer Outlet	%	
36	O_2 Content at Stack Inlet	%	
37	Type of Precipitator		Electrostatic Precipitator (ESP)
38	Dust Content (Precipitator Inlet)	mg/Nm^3	NA
39	SO_X Content (Precipitator Inlet)	ppm	NA
40	NO_X Content (Precipitator Inlet)	ppm	NA
41	CO Content (Precipitator Inlet)	ppm	NA
42	Dust Content (Stack Inlet)	mg/Nm^3	
43	SO_X Content (Stack Inlet)	ppm	
44	NO_X Content (Stack Inlet)	ppm	
45	CO Content (Stack Inlet)	ppm	
46	Boiler Efficiency	%	89.95% (LHV base)
47	Plant Efficiency	%	
48	Flue Gas Duct Size (Width x Depth)	m	D=12 m
49	Stack Size (Height, Diameter)	m	H=210 m
50	Cooling System		Cooling tower (water from lake)

Table 3-6 Design conditions of Kosovo B-1, 2 ESP

	Item	Unit	Description
1	Manufacturer		Alstom
2	Start of Operation	Year	1983
3	Number per Boiler		2
4	Number of Section		8
5	Cumulative Electrode Surface	m^2	$19.448m^2$
6	Height	m	10.7m
7	ESP Inlet Gas Flow (Filtering Capacity)	Nm^3/h	2 x $2000000Nm^3/h$
8	ESP Inlet Gas Temperature	℃	160℃
9	Gas Velocity through ESP	m/s	1.8 m/s
10	ESP Draft Loss	mbar	
11	ESP Inlet Dust Content	g/Nm^3	30 g/Nm^3
12	ESP Outlet Gas Content	mg/Nm^3	B-1=150, B-2=260
13	Dust Collecting Efficiency	%	99.14%

Table 3-7 Design conditions of Kosovo B-1, 2 steam turbines

	Item	Unit	Description
1	Manufacturer		Stein industri
2	Start of Operation	Year	1983 (B-1), 1984 (B-2)
3	Output	MW	339MW
4	Steam Flow	t/h	1000t/h at 339MW
5	Steam Temperature	℃	540^0C
6	Steam Turbine Efficiency	%	44.7%
7	Cooling System of Condenser		Cooling towers (wet type)

Table 3-8 History of Kosovo B-1, 2 boilers

Unit	Latest Condition	Remarks
Kosovo B-1	Constructed in (year)	1983
	ESP installed in (year)	1983
Kosovo B-2	Constructed in (year)	1984
	ESP installed in (year)	1084

Chapter 4 On-site Stack Gas Measurement and Evaluation of Results

On-site stack gas measurement is the key technology for measuring and monitoring emission values. Kosovo has not established on-site stack gas measurement technology yet. The aims of JET are to transfer on-site stack gas measurement technology, deepen the understanding of the measurement technology and establish the measurement technology. As the EC Directive calls for monitoring of LCP emissions and submission of data, the C/P must master the on-site attack gas measurement technology.

The mission conducted the measurement of the emission data of Kosovo A TPP and Kosovo B TPP and also provided demonstrations. The measurement objects are dust content, SO_2 and NO_X. However, because the 1st mission could not bring an automated gas analyzer for SO_2, and NO_X measurements, only dust measurement was conducted. Among the required measurements, dust measurement is the most difficult to master, and also takes time to learn. As a substitute for the automated gas analyzer, SO_2 and NO_X are measured with a detection tube as a simple measurement method in place of the official methods.

The 2nd mission not only repeated the dust measurement but also conducted a continuous measurement of SO_2 and NO_X by carrying an automated gas analyzer into Kosovo.

Measurement of emissions was the first priority of the 1st mission because NERP development requires the submission of measurement results of LCP. After the 1st mission, JET sent the Standard Operating Procedure (SOP) of dust measurement, and C/P measured the dust content as On-the-Job Training (OJT). At the same time, JET measured SO_2 and NO_X by using the automated gas analyzer.

4-1 Regulation of measurement and monitoring under EC Directive

The EC Directive calls for the following items.

a) Continuous monitoring of dust content, SO_2 and NO_X and reporting of the results

Although the ELVs are different depending on the type of fuel, facility size, etc., the EC Directive presents the ceiling values of the time mean, the daily mean and the monthly mean for each emission, and calls for monitoring and controlling these values by installing CEMs (Continuous Emission Monitoring system). Furthermore, the EC Directive also requires periodical calibration and correction of CEMs.

b) In addition to the above-mentioned continuous measurement, confirmation of the emission values by a different official method (Reference method[10]) at least once a year

In order to confirm the values measured by the continuous measuring instrument, it is necessary to master a different official analysis method (Reference method) for emissions. JET has already provided this Reference method for dust measurement, but has not provided this kind of method for SO_2 or NO_X. This is a future assignment for the C/P.

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[10] Reference method is stated in "Technical Guidance Note (Monitoring) M2: Monitoring of stack emission to air Environmental Agency Version 11 November 2015"

c) When using lignite, measurement of total mercury emission in the exhaust gas at least once a year

JET will not prepare for this measurement; therefore, this is another assignment for the C/P.

Among the required items mentioned above, the objectives of JET are measurement of dust content, SO_2 and NO_X.

Item b) is thought to have the following meaning: The value close to the upper limit (80 to 100%) and zero values of the continuous measuring instrument for SO_2 and NO_X are usually adjusted periodically by using a standard gas, and then the values are recorded. However, as there are some interfering components for measurements by the continuous measuring instrument, the EC Directive may require the use of the Reference method which confirms the recorded values and the effect of these interfering components.

On the other hand, in dust measurement, a dust meter such as a light scattering type dust concentration meter is normally used for continuous measurement. This meter is strongly influenced by dust properties such as particle size, particle color, particle shape, etc. The dust measurement method (JIS method) for which JET gives instructions is the only method to certify the accuracy of dust meter. Therefore, mastering dust measurement is one of the key points of on-site stack gas measurement.

4-2 Measurement activities at Kosovo A TPP and results

4-2-1 Measurement locations

Fig. 4-1 shows a schematic diagram of the exhaust gas system of Kosovo A boiler. Photo 4-1 shows the measurement points at the inlet and the outlet of the electrostatic precipitator (ESP).

The actual plant is different from the information obtained ahead of the 1st mission, but the plant is served by 3 ESPs (and not 1 ESP). Therefore, the number of measurement points was larger than expected.

In the 1st mission, JET decided to measure A-3 and A-5, as A-3 and A-5 were in operation and A-4 was stopped.

In the 2nd mission, JET conducted measurement at A-3 and A-4 boiler, because they were in operation.

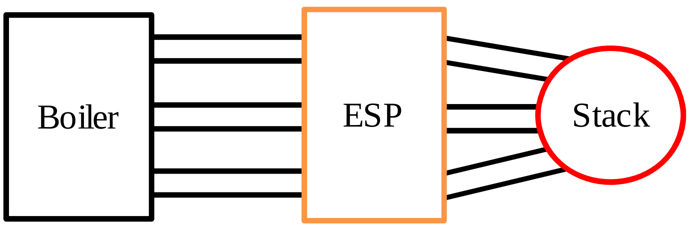


Fig. 4-1 Schematic diagram of exhaust gas system of Kosovo A boiler

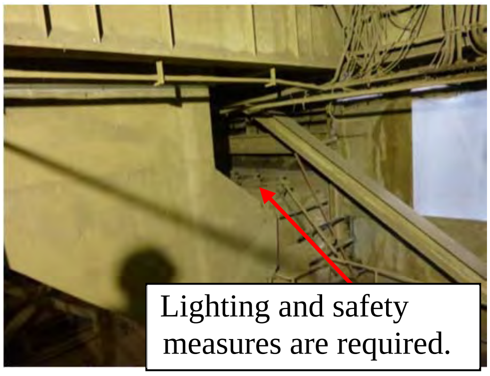


Photo 4-1a Measurement point for ESP inlet

Photo 4-1b Measurement point for ESP outlet

Fig. 4-2 shows the dust measurement positions boilers. Both the inlet and outlet positions are located just before/after a bending duct. This duct structure will presumably make accurate measurements difficult, as a large velocity distribution must exist at the measurement points. However, since there was no other choice, the dust content was measured at these points. In particular, the inlet has a very short straight portion, as can be seen in Photo 4-1a, which makes the measurement very difficult.

In the 1st mission, both the velocity distribution and dust contents at the inlet and outlet of the ESP were measured. In the 2nd mission, only the velocity distribution was measured at the inlet of the ESP and both the velocity distribution and the dust content were measured at the outlet of the ESP, and at the same time, SO_2 and NO_X were measured continuously by the automated analyzer at the inlet of the ESP.

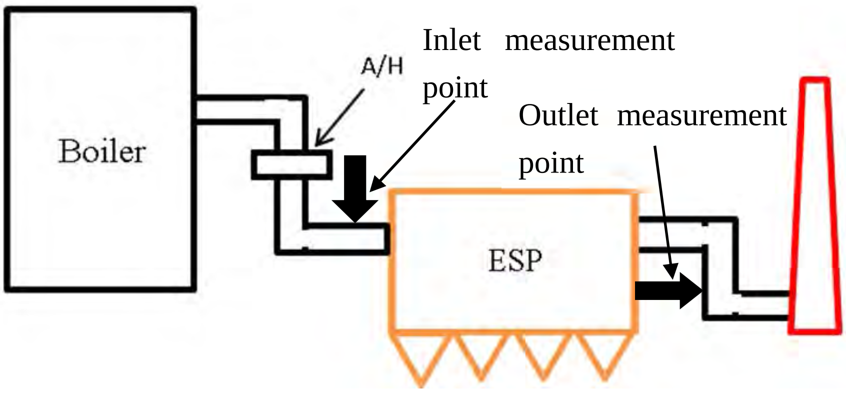


Fig 4-2 Vertical cross-sectional image of measurement points

In the 1st mission the measurement objects were A-3 and A-5 boilers. Due to the large number of measurement points and the difficulty of the measurement, the 1st day was used for a dust measurement trial, and after specifying the measurement points, the full measurement was conducted from the 2nd day.

Both the inlet and the outlet measurements points were narrow, and the inlet area was especially narrower, dusty and hot. Considering health and safety issues, use of masks, lifelines and safety belts was indispensable. These measures enabled successful measurements.

Photo 4-2a View of inlet side measurement

Photo 4-2b View of outlet side measurement

4-2-2 Measurement results

(1) Measurement results in the 1st mission

After bringing the measurement equipment to A-5 boiler on 26th October 2015, JET conducted a trial dust measurement of some points at A-5 boiler on 27th October and A-3 boiler on 29th October.

Fig. 4-3 and Fig. 4-4 summarize the measurement results of A-5 boiler and A-3 boiler, respectively.

The attached document shows the operating condition of the boiler on the measurement day, the record of the results and more detailed measurement results.

During the measurements, A-5 boiler was kept in a stable condition of 158Mw power generation, and A-3 TPP was also kept in a stable condition of 128-135MW power generation.

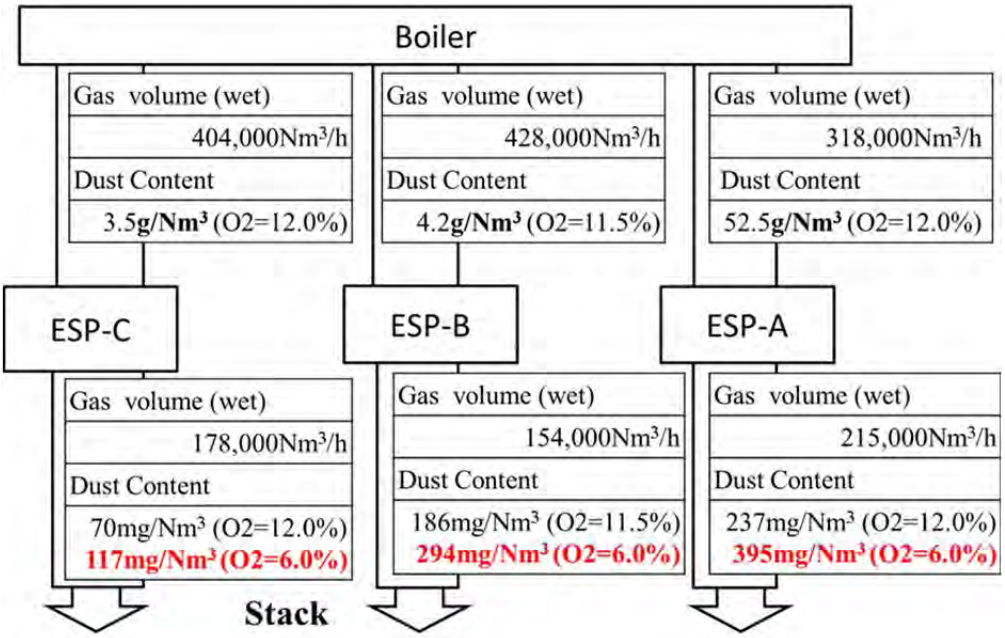


Fig. 4-3 Measurement results of A-5 boiler

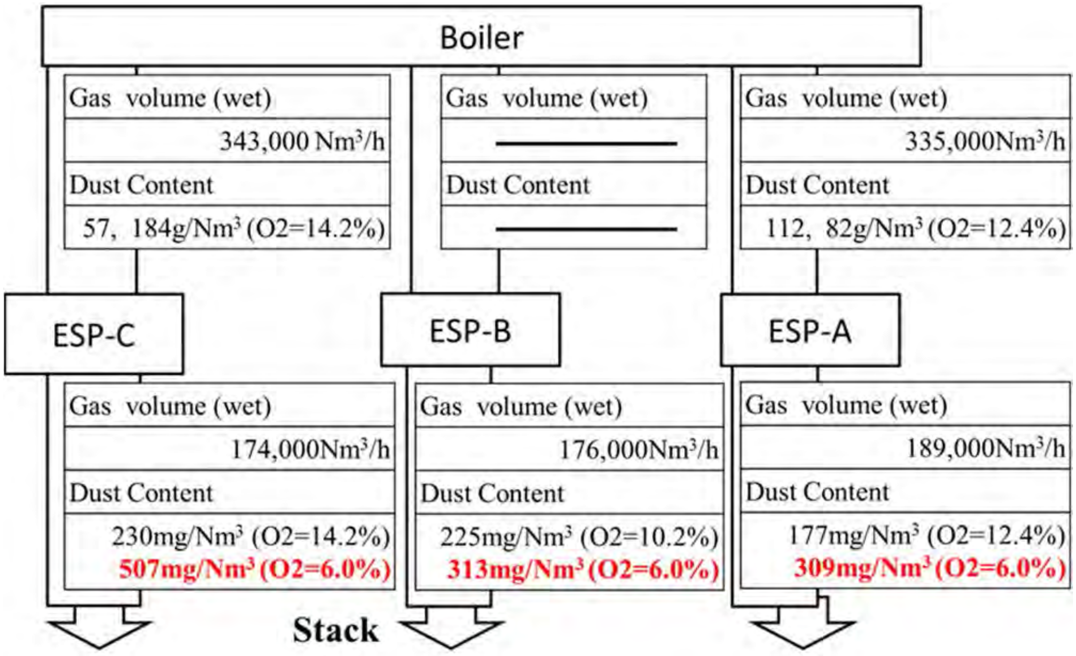


Fig. 4-4 Measurement results of A-3 boiler

In accordance with the EC Directive, the measured dust content at reference O_2=6% is shown in red in the figures. When measuring A-3 boiler, the center inlet duct was not measured because the center forced draft fan was stopped. However, the 3 ESPs are connected to common duct, so the center outlet was also measured.

Based on the above measurement results, the following problems remain to be solved.

1) The measured and calculated exhaust gas volumes are different. The inlet and outlet exhaust gas volumes are also different.
   a) Although an accurate lignite composition analysis is required, the measured inlet exhaust gas volume is larger and the measured outlet exhaust gas volume is smaller than the exhaust gas volume calculated from the lignite input (approximate value: 800,000Nm^3/h).
   b) The measured exhaust gas volumes of both A-3 boiler and A-5 boiler show that the inlet gas volume is much larger than the outlet gas volume.

   The calculated expected gas flow rate based on the lignite composition analysis and the measured value has a large difference. This inconsistency in the measurement results is presumed to be affected by a large velocity distribution.

   As shown in the attached documents, the velocity distribution results at this measurement point varied widely for both the inlet and the outlet. The results show some points have no velocity, and another has a high velocity, which makes accurate measurement very difficult.

2) The dust content is different from point to point.
   a) From the dust measurement results at A-5 boiler, the dust content differed greatly

along the depth direction. Therefore, the dust measurements which JET performed for A-3 had both short depth and long depth results.

b) The inlet dust content of the ESP greatly exceeded the value calculated from the lignite composition, which may decrease the reliability of the measurements. The calculated dust content was approximately 40g/Nm^3, but the measured value was 2-3 times larger.

c) As the outlet dust content is also different along the depth direction, JET used a dust measurement method in which dust was sampled at equal induced gas volume at 3 points in the depth direction in order to obtain a value as close to the average value as possible.

Although measurements were performed by the method mentioned above, verification was difficult because there were no previous data. A larger accumulation of data is required to ensure accurate measurement results.

3) Others

a) JET performed simple measurements of SO_2 and NO_X by using a detection tube because JET was not able to bring in the automated gas analyzer during this mission. As a result, NO_X showed values in the range of 300 to 400 ppm (600-800 mg/Nm^3), as expected, but SO_2 showed no detection or showed at most 100ppm (300 mg/Nm^3). Because the CaO content in the lignite is very high, it is conceivable that in-furnace desulfurization may be occurring in the boiler in the combustion stage. Analysis of the ash sample which JET took to Japan may help in studying this phenomenon. JET plans to adopt a suitable analysis method for this study. Ultimately, however, the official emission values of SO_2 and NO_X must wait for the measurements in the 2nd mission.

b) In measurement of O_2 in the exhaust gas, Testo (O_2, CO detector) was used instead of using Orsat analysis because the ambient temperature was low, and the oxygen absorbing solution cannot absorb oxygen adequately under this condition. Measurements of O_2 showed 11-13 %, but the oxygen meter in the operation room showed only 6-7%. The air leakage of the air preheater (A/H) seems to be very large.

Although the measurement results were as mentioned above, JET and C/P discussed the measurement results, and in the 2nd mission, JET and C/P will focus on a specified boiler (now presumed to be A-5 boiler) and conduct more detailed measurements (increased number of measurement points along the depth direction, etc.), which will result in improved measurement accuracy.

In the 1st mission, the dust measurement at Kosovo A TPP prioritized obtaining measurement results, and JET did not have enough time to transfer the technology. However, observation of the dust measurement was the first such experience for almost all members of the C/P, and many C/P members visited and observed the dust measurement activities.

Photo 4-3a Meeting before measurement

Photo 4-3b View of dust measurement

The assignment of the dust measurement in the 1st mission was the difference between the measured exhausted gas volume and the calculated gas volume. This inconsistency more or less negated the reliability of the dust measurement results. Although the poor measurement points are the problem, the need to keep the consistency of the measured and calculated exhaust gas volume is recognized. Therefore, in the 2nd mission, it will be necessary to spend more time on this issue and, in particular, to increase the number of measurement points in order to obtain more consistent results.

(2) Measurement results in the 2nd mission

In the 2nd mission, the priority was placed on specifying the emission values from the stack, and dust measurement was only conducted at the outlet of the ESP. However the velocity distribution was measured at both the inlet and the outlet of the ESP. In order to improve the accuracy of the velocity distribution and the dust content, the number of measurement points was increased, and at the same time, SO_2 and NO_X were measured continuously by the automated analyzer at the outlet of the ESP. The SO_2 and NO_X concentration at the outlet of the ESP are the same as those at the inlet when converted to the values at the reference O_2 concentration (O_2=6%).

The measurement results of the dust content are shown in Fig. 4-5 and 4-6. The attached document shows the operating condition of the boiler on the measurement day, the record of the results and more detailed measurement results. During the measurements, A-4 boiler was kept in a stable condition of 120 to 130 Mw power generations, and A-3 TPP was also kept in a stable condition of 137-145MW power generation.

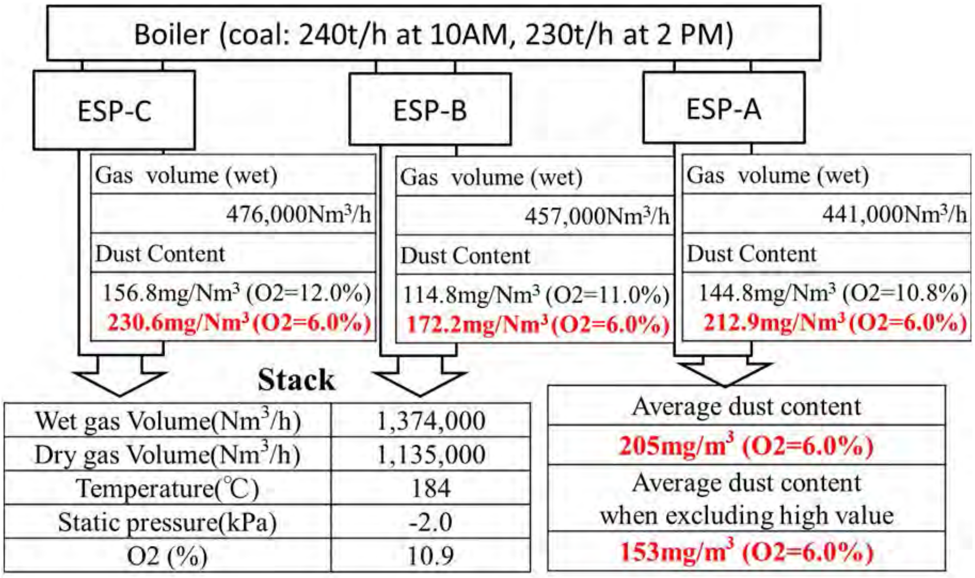


Fig. 4-5 Measurement results of Kosovo A A-4 boiler (10th Mar.: at outlet of ESP)

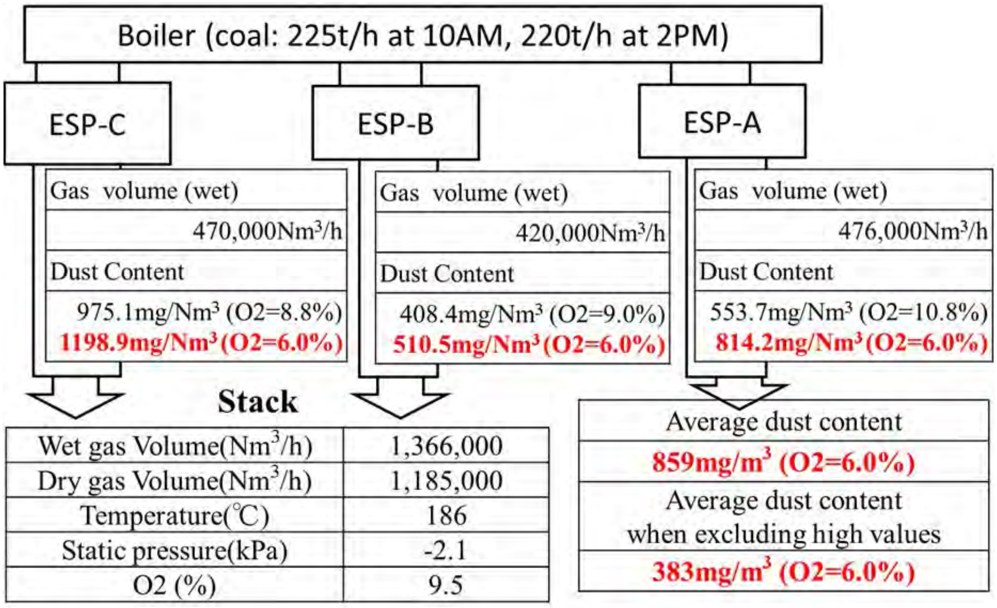


Fig. 4-6 Measurement results of Kosovo A A-3 boiler (11th Mar.: at outlet of ESP)

The Final dust content converted to the value at reference O_2=6% is shown in red in the figure. However, since the dust content at each measurement point varied widely, as shown in the attached documents, the figure shows 2 kinds of values. One is the simple average (Average dust content) and the other is the average value excluding extraordinarily high values (Average dust content excluding high values).

Although the average values of the dust content through the 1st mission and 2nd mission were approximately 300 to 400 mg/Nm^3, high values sometimes appeared and it is hard to specify the accurate dust content. The measurement results of the dust content are summarized as follows.

1) The dust content measured in the 2nd mission shows a large dispersion although the measurement in the 1st mission did not show such results due to the smaller number of measurement points. The dust content is different from point to point even in the same duct. One of the reasons for high dust content may be soot-blow of the boiler tubes or hammering of the dust collecting plates inside the ESP. In order to continue the measurement it is desirable to specify one measurement point which is representative of the average value. This is also important for measurement by CEMs. The location where JET conducted the measurement in this mission shows a dispersion of data and therefore is not suitable for choosing the representative point. It is necessary to find another location which is suitable as a representative measurement point.

2) In the 2nd mission, measurement of the exhaust gas volume at the inlet of the ESP was conducted in order to confirm the relation between the measured exhaust gas flow rates and calculated one. The following result was obtained (Detailed data are in the attached document).

   Measured exhaust gas volume at inlet of ESP of A-4 boiler (from attached document)

   Wet exhaust gas volume: 1,168,000Nm^3/h, dry exhaust gas volume: 976,000Nm^3/h (exhaust gas O_2=10.1%)

   Measured exhaust gas volume at outlet of ESP of A-4 boiler (from Fig 4-5)

   Wet exhaust gas volume: 1,374,000Nm^3/h, dry exhaust gas volume: 1,135,000Nm^3/h (exhaust gas O_2=10.9%)

   These numbers show good coincidence considering that the error is within 10% because the calculated dry exhaust gas volume at the outlet of the ESP becomes 1,052,000 Nm^3/h when the dry exhaust gas volume at the inlet of the ESP is corrected by using exhaust gas O_2.

   The calculated exhaust gas volume is shown as follows when using the results of analysis of the lignite sampled in the 1st mission. (The lignite analysis results of A-3 boiler are shown later.)

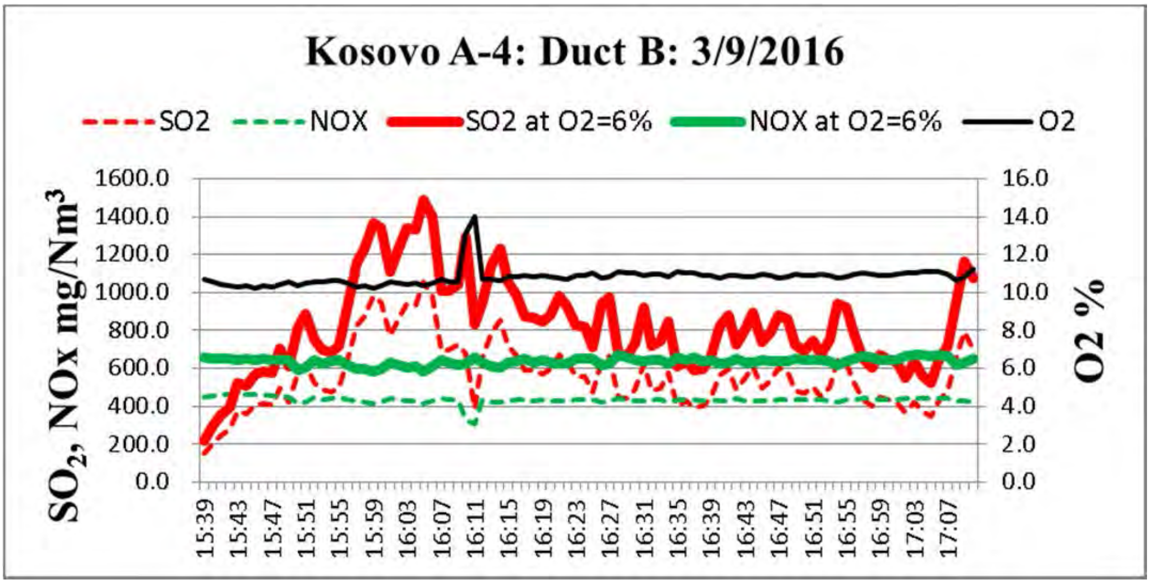
   Calculated exhaust gas volume at outlet of ESP of A-4 boiler

   Wet exhaust gas volume: 1,326,000Nm^3/h, dry exhaust gas volume: 1,138,000Nm^3/h (exhaust gas O_2=10.9%)

   This result also shows good coincidence.

   In the 2nd mission, the increased number of measurement points improved the precision and gives good results. However this means that a large velocity distribution affects the measurement results, which in turn means that this location cannot be specified as a representative measurement point. It is necessary to find another suitable location for dust content measurement.

In the 2nd mission, SO_2 and NO_X are continuously measured by using the automated gas analyzer. One example of this measurement result is shown in Fig.4-7 (All the data which is obtained in the 2nd mission is in the attached document).



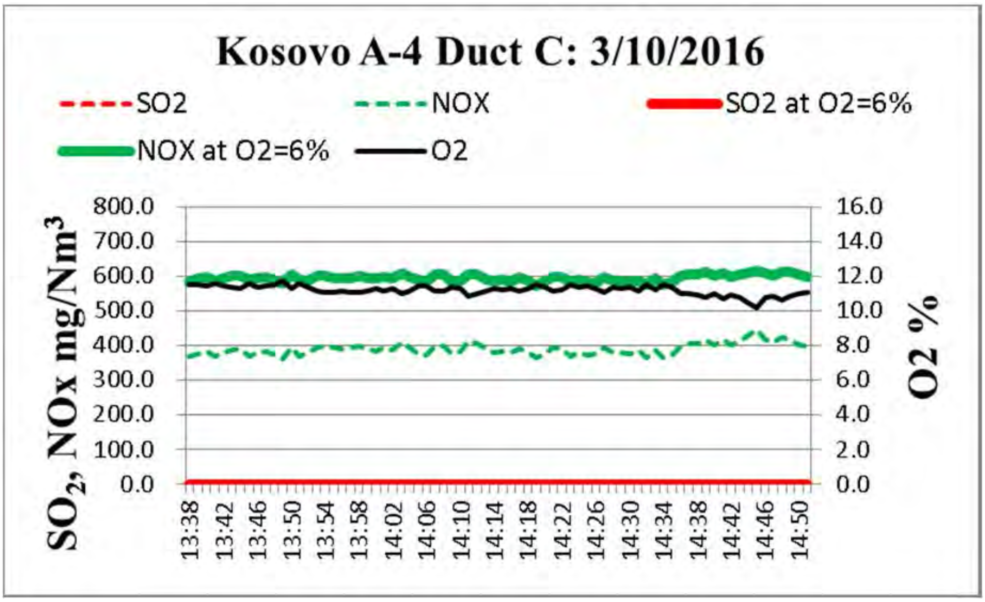


Fig.4-7 One example of SO_2 and NO_X behavior in Kosovo A boiler

The results show the following features.

- NO_X (Reference O_2=6%) showed a stable value of 700~800 mg/Nm^3.
- SO_2 (Reference O_2=6%) fluctuated in a wide range, sometimes showings 0 mg/Nm^3, but also exceeding 1,000 mg/Nm^3. During the measurement period SO_2 showed 0 mg/Nm^3 more than half of the time.
- Kosovo A boiler has 3 exhaust ducts. When the measurement point was moved from one duct to another, change in the SO_2 concentration was observed. This phenomenon mat indicate the possibility that the SO_2 concentration may be different inside the boiler.

From above-mentioned results, the NO_X concentration obviously exceeds the ELVs, which requires some environmental measures. On the other hand, the SO_2 concentration fluctuates in a wide range, which is an inconceivable phenomenon in a conventional boiler. Hence, it is hard to specify the average value of SO_2, and furthermore there is possibility that SO_2 is different from one location to another in the boiler. More data and continuation of the measurements are required for investigation of the cause. This also suggests the possibility that clarification of this phenomenon may enable the design of the optimal desulfurization equipment.

4-3 Measurement activities at Kosovo B TPP and results

4-3-1 Measurement location

Kosovo B TPP has 2 boilers, B-1 and B-2, and each boiler has 2 ESPs, as shown in the schematic diagram in Fig. 4-8. Furthermore, the exhaust gas from each boiler merges into one stack, and that stack discharges all the exhaust gas.

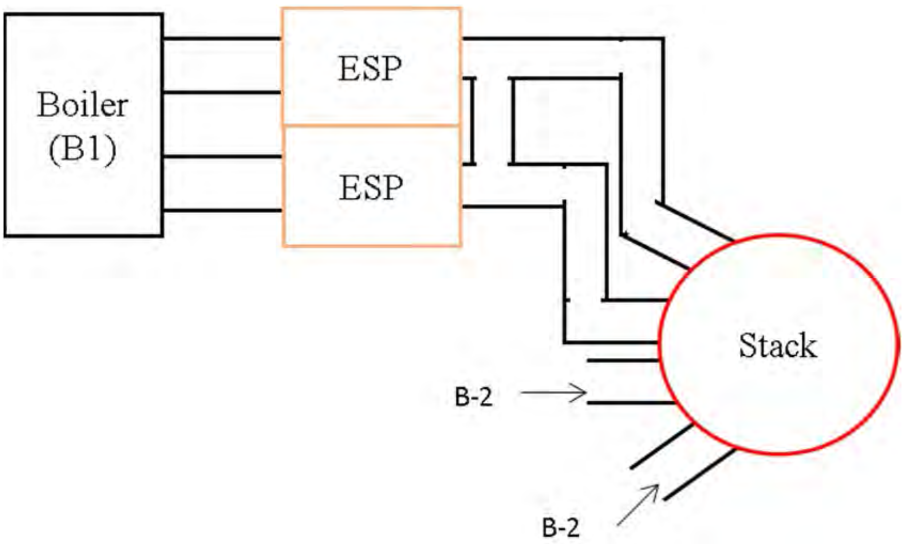


Fig. 4-8 Schematic diagram of exhaust gas system of Kosovo B boiler

Photo 4-4 shows the measurement points at the inlet and the outlet of ESP and Fig. 4-9 shows the location of the measurement points at the inlet and the outlet of the ESP. Because the inlet position only had 1 inch diameter holes, JET requested for C/P to make 6 new measurement holes in the crosswise direction at the rise portion of the duct. That request was accepted, and the holes were made. The newly installed outlet measurement points had a temporary stage for the measurement work. However, the depth of this stage was small, which made the handling of long instruments difficult (Pitot tube, dust sampling pipe, etc.).

Photo 4-4a Measurement point at inlet of ESP

Photo 4-4b Measurement point at outlet of ESP

Fig. 4-9 is the vertical cross sectional view at the ESP, including the new measurement holes, including measurement points.

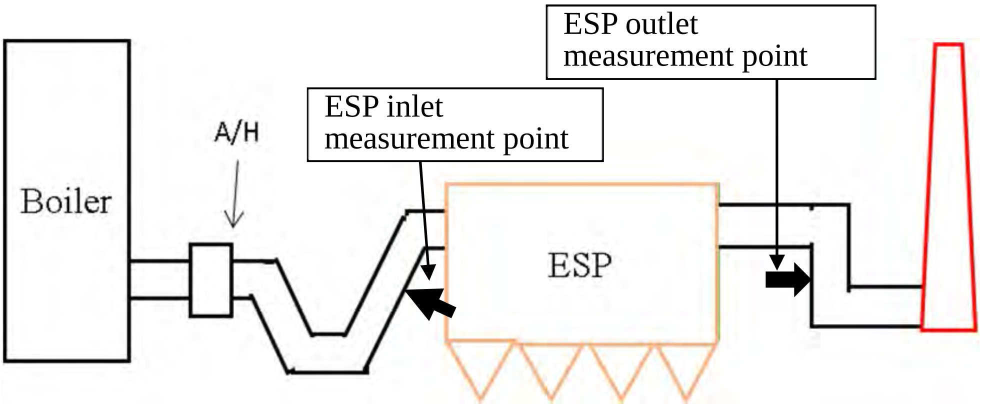


Fig. 4-9 Vertical cross-sectional image of measurement points

Although the measurement environment at Kosovo B TPP is much better than that at Kosovo A, the positions of the measurement points are not suitable for measuring velocity and dust content, because both positions are located just before/after duct bends, and furthermore, the inlet duct of the measurement points has a gradual expansion, and the outlet position is just before the induced draft fan. However, since there was no other choice except these points, JET performed the measurements at these points.

Photo 4-5a View of dust measurement at inlet of ESP

Photo 4-5b View of dust measurement at outlet of ESP

4-3-2 Measurement results

(1) Measurement results in the 1st mission

JET carried out the dust measurements at Kosovo B-1 boiler on the 3rd and 4th November. The object of the dust measurement was only B-1 boiler in the 1st mission.

The following are the results of the dust measurement.

JET brought in the measurement equipment on 2nd November and measured the dust content at No. 1 ESP on 3rd November and at No. 2 ESP on 4th November. Measurements were done at both the inlet and outlet of the ESPs. Fig. 4-10 shows the measurement results. The attached documents show the operating condition of the boiler on the measurement day, the record of the results and more detailed measurement results.

During the measurement of B-1, stable operation of the TPP at 281-289MW power generation was maintained.

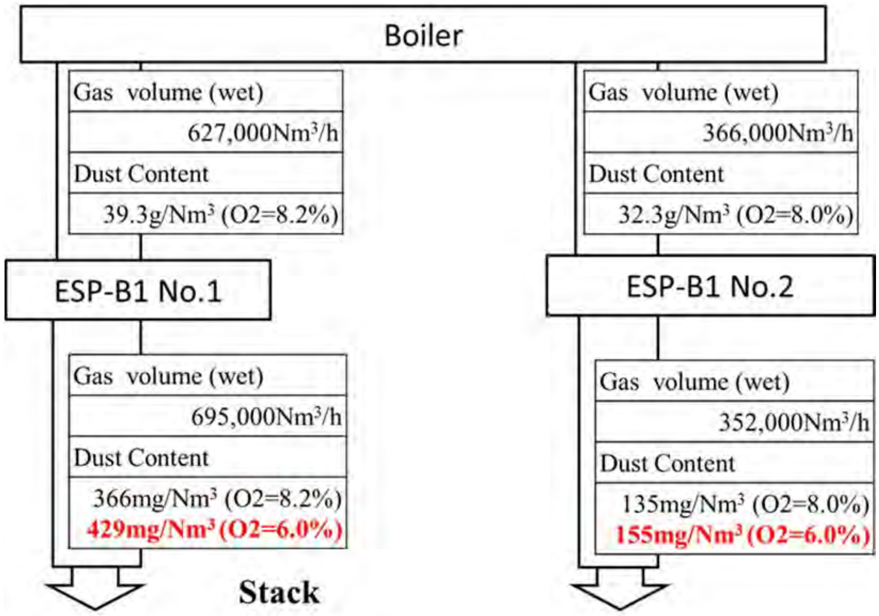


Fig. 4-10 Dust measurement results of Kosovo B-1 boiler

Similar to the results of Kosovo A boiler, the weighted average value of the dust content was a rather high value of 350mg/Nm^3, which was converted to the value at reference O_2=6% following the EC Directive. The converted results are shown in red in Fig. 4-10.

The following are the assignments for measurements at B-1 boiler.

1) The exhaust gas volumes of No. 1 ESP and No. 2 ESP are different.

   a) The exhaust gas volume measured at No.1 ESP was almost half of that at No. 2 ESP for both the inlet and outlet, and the dust content of No. 2 ESP was also lower. The measured exhaust gas volume seemed to be low compared with the calculated total exhaust gas volume although a lignite analysis is required in order to determine the exact calculation. Furthermore, both the inlet and the outlet exhaust gas volume of No.2 ESP are almost half of those of No.1 ESP as shown in Fig. 4-10. There is another question on this point, that is, why the exhaust gas volume of the outlet duct from No.2 ESP is small same as the inlet gas volume of No.2 ESP because at the outlets of each ESP, the ducts are connected with a common duct and the load of the exhaust gas induced draft fan showed almost the same value, which indicates the outlet gas volumes are not greatly different.

   b) The total measured exhaust gas volume seems to be slightly small compared with the calculated exhaust gas volume.

   c) There is a large deviation in the velocity distributions of both the inlet and outlet, as shown in the attached documents. The same phenomenon was also seen in the Kosovo A results. Furthermore, there were some points with no velocity, and disturbances such as inclined flows or spiral flows are presumed to exist. This may be explained by the fact that the measuring points are not suitable for accurate measurements.

2) Others

a) More sampling points were used in the dust measurements for both the inlet and outlet of the ESP considering the large velocity distribution in the flow. As a result, the dust content of the inlet of the ESP showed almost the same value as the calculated result. The dust content of the outlet of the ESP is also thought to be basically accurate.

b) As at Kosovo A boiler, SO_2 and NO_X were measured by using a detection tube. As a result, NO_X showed 400-500 ppm (800-1,000mg/Nm^3), as expected. However, SO_2 was not detected or was at most 100 ppm (300mg/Nm^3), as in the Kosovo A results. Accurate values must wait for the 2nd mission, which uses an automated gas analyzer.

The dust content at the inlet of the ESP was close to the calculated value; this was different from the results at Kosovo A, and there was no objective discussion about this value. The outlet of the ESP also showed a value which far exceeded the ELVs. However, the reason why there was no discussion or objection to this result is unknown, but the awareness of the importance of the ELVs among C/P members seemed to be low.

On the other hand, as the assignment of JET, in the same manner as the assignment at Kosovo A, the measured exhaust gas volume was not consistent with the calculated one, and this inconsistency more or less negated the reliability of the measurement. Although the measurement points are the problem, the need to keep the consistency of the measured and calculated exhaust gas volumes is recognized. Therefore, JET plans to carry out the same measurement as part of the 2nd mission.

(2) Measurement results in the 2nd mission

In the 2nd mission, the target of the measurement was Kosovo B-2 boiler. As in the measurement at Kosovo A TPP, the priority was placed on specifying the emission values from the stack. Therefore dust measurement was only conducted at the outlet of the ESP, but the velocity distribution was measured at both the inlet and the outlet of the ESP. In order to improve the accuracy of the velocity distribution and dust content, the number of measurement points was increased, and at the same time, SO_2 and NO_X were measured continuously by the automated analyzer at the outlet of the ESP.

The measurement results of the dust content are shown in Fig. 4-11. The attached document shows the operating condition of the boiler on the measurement day, the record of the results and more detailed measurement results. During the measurements, B-2 boiler was kept in a stable condition of 292-297 Mw power generations.

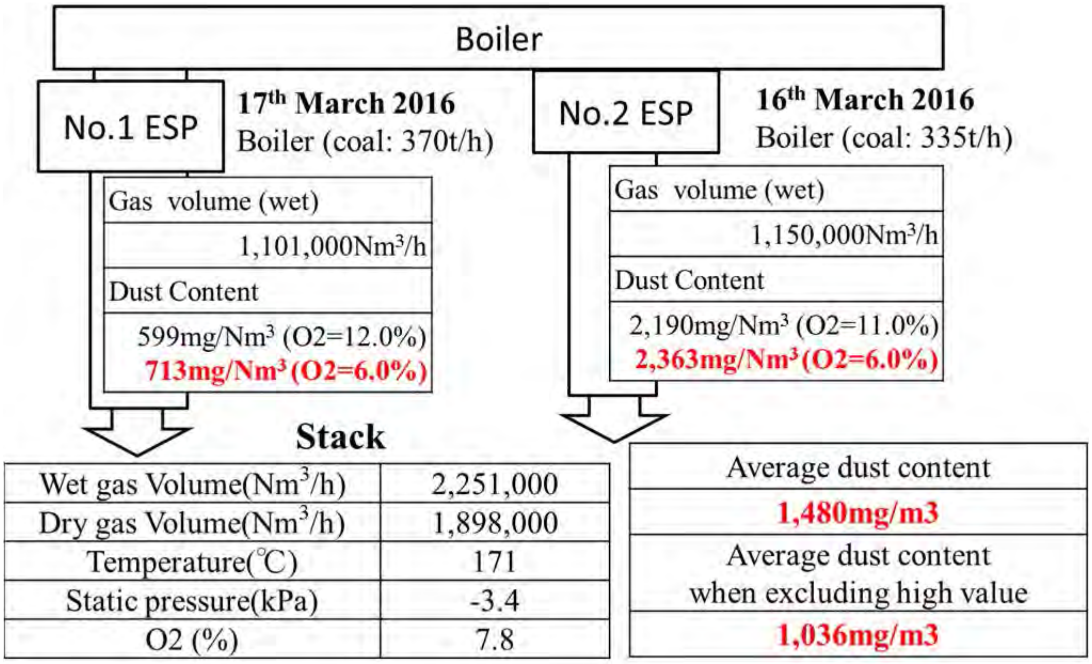


Fig. 4-11 dust measurement results of Kosovo B-2 boiler

As shown in the attached documents, the dust content at each measurement point varied widely. The figure shows 2 kinds of values. One is the simple average (Average dust content) and the other is the average value excluding extraordinary high values (Average dust content excluding high value).

The dust content through the 1st mission and the 2nd mission varied widely from 150 to 1,000 mg/Nm^3, and high values sometimes appeared. It is difficult to specify the accurate dust content because of the dispersion of the data. The measurement results of the dust content are summarized as follows.

1) The dust content measured in the 2nd mission showed a large dispersion. The dust content is different from point to point even in the same duct. One of the reasons for the high dust content may be soot-blow of the boiler tubes or hammering of the dust collecting plates inside the ESP. It is desirable to specify one measurement point which is representative for deriving average values. The measurement location in Kosovo B boiler is not suitable for use of the representative point. It is necessary to find another location which can be used as a representative measurement point. Furthermore Kosovo B has a CEMs which is installed at the height on 90m of the stack. The CEMs has not been in operation for almost one year because the location is dangerous to access and hard to maintain. The EC Directive also requires measurement by a Reference method at a point close to CEMs. The location is very dangerous and it is difficult to conduct measurement especially for dust measurement. This situation also requires another location for the CEMs. For these reasons, it is very important to specify the representative measurement point.
2) In the measurement in the 2nd mission, the difference in the exhaust gas volume between No.1 ESP and No2 ESP seen in the measurement in the 1st mission did not

appear. Measurement of the exhaust gas volume at the inlet of the ESP was conducted in order to confirm the relation between the measured exhaust gas flow rates and the calculated one. The following results were obtained (The detailed data are in the attached document).

Measured exhaust gas volume at inlet of ESP of B-2 boiler (from attached document)

Wet exhaust gas volume: 2,986,000Nm^3/h, dry exhaust gas volume; 2,744,000Nm^3/h (exhaust gas O_2=8.4%)

Measured exhaust gas volume at outlet of ESP of B-2 boiler (from Fig 4-11)

Wet exhaust gas volume: 2,251,000Nm^3/h, dry exhaust gas volume: 1,898,000Nm^3/h (exhaust gas O_2=7.8%)

These numbers show an error of almost 15%, because the calculated dry exhaust gas volume at the outlet of the ESP becomes 2,620,000 Nm^3/h when the dry exhaust gas volume at the inlet of the ESP is corrected by using the exhaust gas O_2.

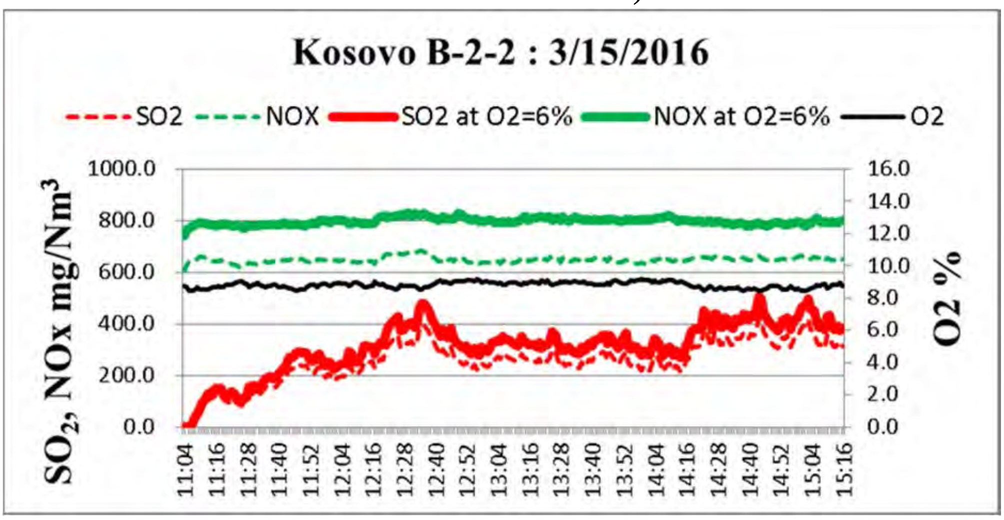
The calculated exhaust gas volume is shown as follows when using the lignite analysis results sampled in the 1st mission.

Calculated exhaust gas volume at outlet of ESP of B-2 boiler. (The lignite analysis result of A-3 boiler shown later)

Wet exhaust gas volume: 1,588,000Nm^3/h, dry exhaust gas volume: 1,307,000Nm^3/h (exhaust gas O_2=7.8%)

In spite of the increase in the number of measurement points in the 2nd mission, the measurement result showed a large difference of 50%. One of the reasons for this difference may be a change in lignite properties. However a large velocity distribution is thought to be a main cause of this result. This means that this location cannot be specified as a representative measurement point, and it is necessary to find another suitable location for measurement of the dust content.

In the 2nd mission, SO_2 and NO_X were continuously measured by using the automated gas analyzer. One example of this measurement result is shown in Fig.4-12 (All the data obtained in the 2nd mission are shown in the attached document).



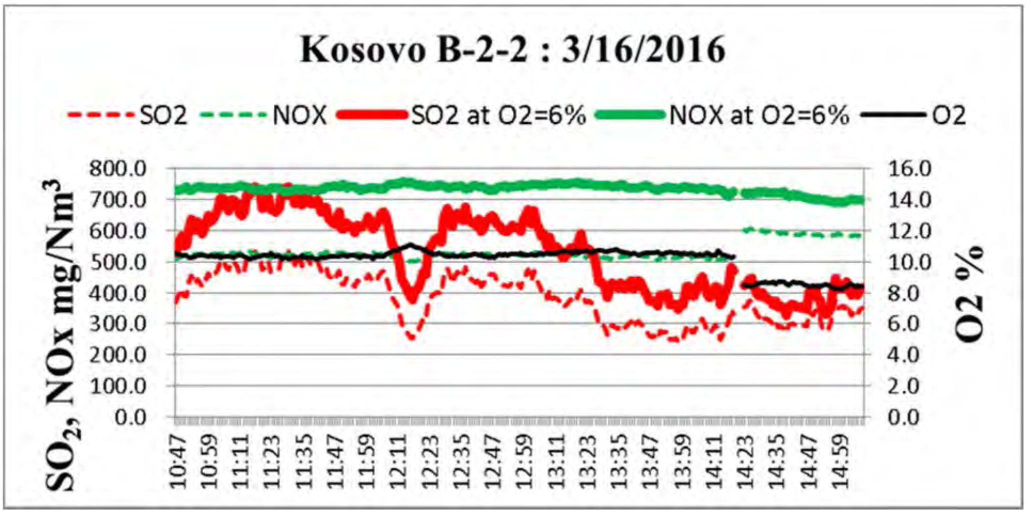


Fig.4-12 One example of SO_2 and NO_X behavior in Kosovo B boiler

The results show the following features.

- NO_X (Reference O_2=6%) shows a stable value of 700-800 mg/Nm^3.
- SO_2 (Reference O_2=6%) fluctuates in a wide range from 0 mg/Nm^3-1,000 mg/Nm^3. However during the measurement period the time of 0 mg/Nm^3 was less than that of Kosovo A.

From the above-mentioned results, the NO_X concentration obviously exceeds the ELVs, which requires some environmental measures. On the other hand, the SO_2 concentration shows the same phenomenon as that at Kosovo A. Hence, it is difficult to specify the average value of SO_2, and the same proposal is suggested for Kosovo B.

4-4 About the review of measurement location of Kosovo A & B TPP

Based on the measurement results of Kosovo A & B TPP, neither of the current measurement points can satisfy a representative condition of measurement because both measurement results have large dispersions. Therefore, it is indispensable to find other candidate locations for these measurements.

Through discussion with C/P, it was agreed that the location shown in Photo 4-6 will be used as the new measurement locations, and platforms will be installed for future measurements.

These locations have the following features

- It is easier to obtain representative values of SO_2 and NO_X because the locations are positioned after an induced draft fan (IDF) and the exhaust gas is well mixed by IDF.
- The locations are located after the straightening vane of the IDF and are only the straight parts of the exhaust gas duct. Therefore, it is expected that both the exhaust gas flow distribution and dust distribution will be uniform.
- Although the diameters of the ducts are large, handling of the measurement equipment is easier because the handling space is wide enough, and equipment will be handled downwards from the platform on the ducts.

However after installation of the measurement locations, it will be necessary to confirm that these locations are sufficiently representative.

⇩ : Agreed locations

Kosovo A TPP　　　　Kosovo B TPP

Photo 4-6　Agreed measurement locations

In case of Kosovo B TPP, it is possible to use the exhaust gas recirculation line shown in Photo 4-6 for measurement of SO_2 and NO_X because this line induces and mixes exhaust gas from both lines.

After confirmation of representativeness, the specified measurement points will make it possible to obtain more dust content data and conduct continuous measurement of SO_2, and will also make it easier to study the relationship among boiler operation, dust content, SO_2 concentration, etc., which will contribute to evaluation of improvement and future retrofitting for environmental measures.

This location will also be a suitable for installation of the CEMs, making it possible to secure maintenance and safety.

4-5 Sampling of lignite, etc. from Kosovo A and Kosovo B TPP

Kosovo A TPP and Kosovo B TPP regularly analyze lignite but do not perform detailed analyses of fly ash and bottom ash. Therefore, JET collected samples of all three materials, took them to Japan and performed an analysis in order to confirm consistency with the analysis in Kosovo. At the same time, this analysis enabled JET to study the operational condition of the boilers in Kosovo.

Concerning the unique phenomenon of SO_2 seen in the measurement by the automated analyzer in the 2nd mission, in “5-4 SO_X reduction measures” the amount of sulphur desulfurized by the in-furnace desulfurization reaction is estimated based on the following analysis results. Both the measurement results and the estimated results suggest the existence of in-furnace desulfurization.

4-5-1 Sampling from Kosovo A and Kosovo B TPP

The sampled materials are lignite, fly ash and bottom ash from Kosovo A-3 and A-5 boilers and Kosovo B-1 boiler.

The purposes of sampling are as follows.

a) Study of lignite (water content, ash content, heating value)

Both TPPs regularly conduct this analysis, but the heating value seems to be low; therefore, the purpose of sampling is to confirm the accuracy of the analysis in Kosovo. At the same time, JET also conducts an ultimate analysis, etc.

b) Study of properties of fly ash and bottom ash

Study of the ash composition provides basic data for evaluating the operational condition of the boilers in Kosovo. In particular, the measured SO_2 emissions fluctuates widely, which may mean that in-furnace desulfurization proceeds in the furnace due to the high Ca content in the lignite. The analysis also studied this point.

Because lignite has a moisture-absorbing property, JET dried the lignite and measured its moisture in Kosovo immediately after sampling, and then brought the samples to Japan and conducted an analysis of the lignite. As both fly ash and bottom ash have small contents of moisture, moisture has very little effect on the ash analysis results. Therefore, the ash samples were analyzed in Japan without drying in Kosovo.

4-5-2 Analysis results of lignite, etc. received in Kosovo

As a reference, the following shows the analysis data received in Kosovo A TPP:

【Analysis results of lignite and ash】 from Additional Questionnaire

Lignite, which is the main fuel of the Kosova-A TPP, is supplied by surface coal mines in Mirash, Bardh and South-West Sibovc. The lignite has these characteristics:

Table 4-1 Analysis results of lignite（wet base）

Component	**Value**
Moisture Content	38-48 %
Ash Content	21.32-9.84 %
Hydrogen Content	2.01-2.25 %
Total Sulphur Content	1.51-0.68 %
Sulphur Content in Ash	1.02-0.61 %
Combusted Sulphur Content	0.49-0.07 %
Fixed Carbon Content	38.58-27.47 %
Volatile Matter	24.12-26.37 %
Carbon for Combustion	39.38-44 %

The data for the ash from the lignite combustion process at Kosova-A TPP are as follows:

Table 4-2 Analysis results of ash

Component	Value
SiO_2	31.76 - 21.65 %

Fe_2O_3	12.21 - 5.5 %
Al_2O_3	5.95 - 9.5 %
CaO	28.56 - 45.0 %
MgO	2.95 - 9.0 %
SO_3	10.35 - 14.0 %
P_2O_5	0.2 - 0.5 %

4-5-3 Anlysis results in Japan

JET conducted the following analyses of the samples.

(1) Proximate analysis, ultimate analysis, etc. of lignite

(2) Proximate analysis, ultimate analysis, melting point test, etc. of fly ash

(3) Ultimate analysis and ignition loss of bottom ash

(4) Qualitative analysis, particle size distribution, electrical resistivity test of fly ash

The following explains the results.

(1) Proximate analysis, ultimate analysis, etc. of lignite

Table 4-3 shows these analysis results. These results are the corrected values which were obtained by using the moisture content of the lignite measured in Kosovo. Table 4-4 shows the comparison of the analysis results obtained in Kosovo and those in Japan.

Table 4-3 Anlysis results of sampled lignite

Items		Unit	Analysis results			Measurement method
			A-3	A-5	B-1	
Proximate Analysis	Moisture	wt%	45.64	45.74	47.68	JIS M 8812
	Ash	Wet-wt%	15.20	15.14	11.90	
		Dry-wt%	27.96	27.91	22.74	JIS M 8812
	Volatile Matter	Wet-wt%	25.41	24.68	25.11	JIS M 8812
		Dry-wt%	46.75	45.48	47.99	JIS M 8812
	Fixed Carbon	Wet-wt%	13.75	14.44	15.31	From calculation
		Dry-wt%	25.29	26.61	29.27	From calculation
Ultimate Analysis	Carbon (C)	Dry-wt%	45.28	45.76	49.89	JIS M 8819
	Hydrogen (H)	Dry-wt%	3.87	3.89	4.11	JIS M 8819
	Nitrogen (N)	Dry-wt%	0.82	0.80	1.12	JIS M 8819
	Total Suphfur (S)	Dry-wt%	1.44	1.54	1.57	JIS M 8813
	Sulphur in Ash	Dry-wt%	1.16	1.11	0.89	JIS M 8813
	Total Chorine (Cl)	Dry-wt%	0.01>	0.01>	0.01	Potentiometric titration
	Oxygen (O)	Dry-wt%	20.63	20.10	20.57	From calculation

Calcium (Ca)	Dry-wt%	7.60	7.52	6.26	ICP[11] emission spectral analysis
Mercury (Hg)	µg/g	0.10	0.09	0.06	Reduction vaporizing atomic absorption
Higher Heating Value	Dry-kJ/kg	17,700	17,380	19,420	JIS M 8814
	Dry-kcal/kg	4,230	4,150	4,640	
	Wet-kJ/kg	9,620	9,430	10,160	
	Wet-kcal/kg	2,300	2,250	2,430	
Lower Heating Value	Wet-kJ/kg	8,000	7,810	8,470	
	Wet-kcal/kg	1,910	1,870	2,020	
X-ray Diffraction	-				X-ray diffraction

Analysis results of ash in lignite after treating lignite at 815°C

Items	Unit	Analysis results			Measurement method
		A-3	A-5	B-1	
Calcium (Ca)	Dry-wt%	28.58	28.58	28.58	ICP emission spectral analysis
Silicon (Si)	Dry-wt%	22.71	23.52	23.51	Gravimetric method
Magnesium (Mg)	Dry-wt%	2.27	2.31	3.18	ICP emission spectral analysis
Aluminum (Al)	Dry-wt%	3.14	3.10	4.34	ICP emission spectral analysis
Sulphur (S)	Dry-wt%	3.78	3.69	3.47	JIS M 8813

Table 4-4 Comparison of analysis results（Wet base）

Component	**Received Data**	**Analysis Result**
Moisture Content	38-48 %	45.64-47.68 %
Ash Content	21.32-9.84 %	11.90-15.20 %
Hydrogen Content	2.01-2.25 %	2.10-2.15 %
Total Sulphur Content	1.51-0.68 %	0.78-0.82 %
Sulphur Content in Ash	1.02-0.61 %	0.47-0.63 %
Combustible Sulphur Content	0.49-0.07 %	0.15-0.35 %
Fixed Carbon Content	38.58-27.47 %	13.75-15.31 %
Volatile Matter	24.12-26.37 %	24.68-25.41 %
Carbon for Combustion	39.38-44 %	24.61-26.10 %
	Contact Mission Report	**Analysis Result**
Heating Value (LHV)	6000-9500 KJ/kg	7810-8470 KJ/kg
	1430-2278 Kcal/kg	1870-2020 Kcal/kg

11 Inductively Coupled Plasma

Although the weighted percentages of each component in the lignite shows large variations, the analysis results of the calorific value and the moisture, ash and sulphur contents are in the same range. However, there is a large difference between volatile matter and fixed carbon; in particular, there is a large difference in the fuel ratio (Fixed carbon/Volatile matter).

Fixed carbon is more likely to be replaced by volatile matter in the data received from Kosovo A TPP because the fuel ratio of lignite is generally less than 1.0. Considering the high ash content and high moisture content, carbon seems unlikely to show such a high percentage, suggesting that the analysis value probably shows the “dry state.”

Including the results of the X-ray diffraction analysis of the lignite, which can identify the substances existing in the lignite, these analysis results indicate the following.

a) The sulphur content (Total sulphur content - Sulphur content in ash) means the content of combustible sulphur. The results of this analysis showed that combustible sulphur comprises approximately 30% of total sulphur. The analysis conducted in Japan defines combustible sulphur as that which forms in combustion at 815°C.

b) The ash in the lignite has a high content of sulphur, and the basicity (CaO/SiO_2) of the ash is very high, at approximately 0.7. X-ray diffraction analysis aims at identifying the main substances which exist in lignite. This analysis found high contents of CaO and $CaSO_4$ (gypsum) in the lignite. (Other substances were not identified because of their small contents.) This result confirms that a large amount of sulphur is already fixed in the form of $CaSO_4$. Because $CaSO_4$ does not resolve at low temperatures of around 800°C, the content of combustible sulphur is considered to be small.

c) This result shows that the lignite contains mercury, which is presumed to exist in the form of mercury sulfide (HgS).

(2) Proximate analysis, ultimate analysis, melting point test, etc. of fly ash

Table 4-5 shows the analysis results of the fly ash.

Table 4-5 Analysis results of fly ash

Items		Unit	Analysis results			Measurement method
			A-3	A-5	B-1	
Proximate Analysis	Moisture	wt%	0.03	0.04	0.24	JIS M 8812
	Ash	Wet-wt%	98.78	98.78	96.53	JIS M 8812
		Dry-wt%	98.81	98.82	96.76	JIS M 8812
	Volatile Matter	Wet-wt%	1.14	1.12	3.08	JIS M 8812
		Dry-wt%	1.14	1.12	3.09	JIS M 8812

Ultimate Analysis	Carbon (C)	Dry-wt%	0.51	0.46	0.80	JIS M 8819
	Hydrogen (H)	Dry-wt%	0.01<	0.01<	0.01<	JIS M 8819
	Nitrogen (N)	Dry-wt%	0.01<	0.01<	0.01<	JIS M 8819
	Total Sulphur (S)	Dry-wt%	4.69	4.77	10.05	JIS M 8813
	Combustible Sulphur (S)	Dry-wt%	0.05	0.23	0.06	JIS M 8813
	Total Chlorine (Cl)	Dry-wt%	0.02	0.01	0.04	Potentiometric titration
	Oxygen (O)	Dry-wt%	0.68	0.72	2.44	From calculation
Silica Dioxide (SiO_2)		Dry-wt%	21.86	23.47	11.81	Gravimetric method
Aluminum Oxide (AL_2O_3)		Dry-wt%	5.83	5.87	2.99	ICP emission spectral analysis
Ferric Oxide (Fe_2O_3)		Dry-wt%	8.11	8.97	4.84	ICP emission spectral analysis
Calcium Oxide (CaO)		Dry-wt%	39.38	38.32	44.72	ICP emission spectral analysis
Magnesia Oxide (MgO)		Dry-wt%	3.74	3.83	3.41	ICP emission spectral analysis
Gypsum ($CaSO_4$)		Dry-wt%	19.91	20.25	42.67	Calculation from sulphur content
Specific Density		Dry Base	2.52	2.70	2.68	JIS Z 8807
Mercury (Hg)		μg/g	0.04	0.05	0.25	Reduction vaporizing atomic absorption
Softening Temperature		Deg. C	1,350	1,320	1,600>[12]	JIS M 8801 12 (reducing atmosphere)
Melting Temperature		Deg. C	1,380	1,350	1,600>	JIS M 8801 12 (reducing atmosphere)
Slag Flowability Temperature		Deg. C	1,515	1,495	1,600>	JIS M 8801 12 (reducing atmosphere)
Qualitative Analysis		-				ICP emission spectral analysis
Particle Size Distribution		-				Laser light scattering method
Electrical Resistivity Test		-				JIS B 9915(1989)

These analysis results indicate the following.

a) The unburnt combustible content (carbon and hydrogen contents) in the ash is less than 1%; from this, the combustion state inside the furnace seems to be very good.

b) Because the sulphur content in the ash is very high, a large amount of sulphur in the lignite is presumed to move to the ash. The content of $CaSO_4$ is calculated from the sulphur content in the ash, assuming that the sulphur in the ash is fixed as $CaSO_4$. However, as a result, the calculated result of $CaSO_4$ for B-1 overestimates the content of $CaSO_4$. Repetition of this kind of anlysis is required in order to confirm the true

[12] Reason for “1,600>”: The sample did not show any flowability as stipulated in JIS at over 1,600°C, which is the maximum temperature of the laboratory furnace.

values.

c) The basicity (CaO/SiO_2) of the fly ash is very high (>1.0), although part of Ca is fixed as $CaSO_4$, which means the actual basicity is lower. The high basicity leads to high values of the softening temperature, melting temperature and slag flowability temperature. In particular, the result for Kosovo B-1 shows a high CaO content, and this ash also had higher values for the softening temperature, melting temperature and slag flowability temperature. Fig. 4-13 is the state diagram (melting temperature) of CaO, SiO_2 and FeO, which are the main substances in fly ash. (Here, the oxide of Fe is FeO at high temperature.) The area circled in red in the figure is the main composition of this sampled fly ash, and this composition ensures a high melting temperature.

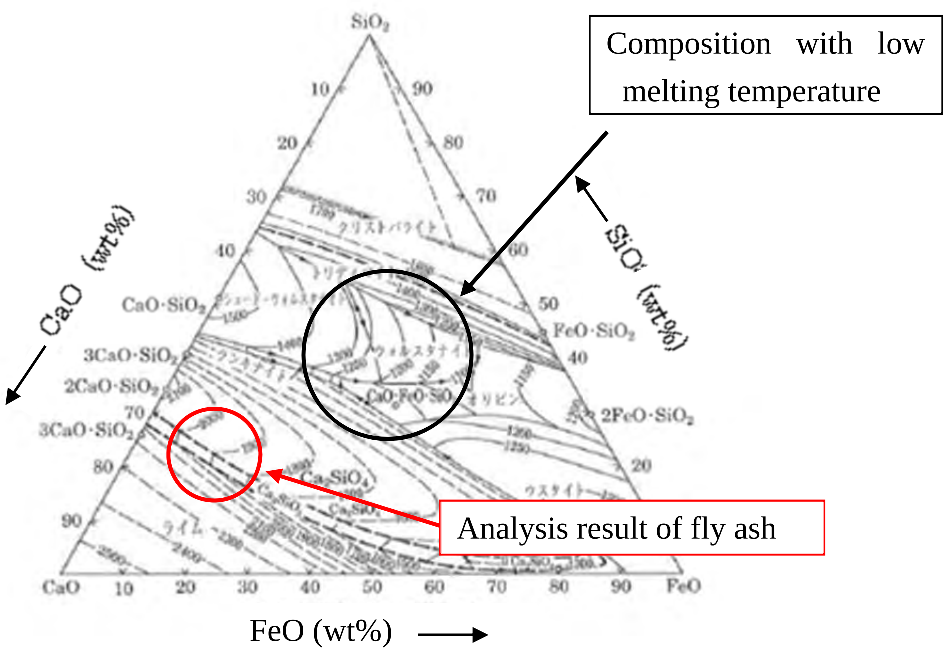


Fig. 4-13 State diagram of CaO－SiO2－FeO[13]
(The numbers in the figure show the melting temperature.)

This analysis examines the possibility of slag adhesion to the boiler tube surface when the combustion temperature is high (slagging phenomenon). Slag adhesion is not likely to occur because of the high temperature property of slag. However, monitoring of the Ca content in slag is necessary because the melting temperature decreases when the content of Ca is low.

d) This ash anlysis also revealed that mercury is present in the ash. This mercury is presumed to exist in the form of HgS.

[13] From Japan Institute of Metals and Materials.

(3) Ultimate analysis and ignition loss of bottom ash

Table 4-6 shows the analysis results of the bottom ash.

Table 4-6 Analysis result of bottom ash

Items	Unit	Analysis results			Measurement method
		A-3	A-5	B-1	
Unburnt Carbon	Dry-wt%	17.96	8.91	14.02	JIS R 9101
Calcium (Ca)	Dry-wt%	7.54	7.23	9.87	ICP emission spectral analysis
Total Sulphur (S)	Dry-wt%	0.69	0.47	0.83	JIS M 8813
Ignition Loss	Dry-wt%	18.61	12.28	15.06	Bottom sediment measurement method Ⅱ.4.2

The analysis results show a high value of ignition loss, which means that the content of unburnt materials remains high in the bottom ash. On the other hand, the results show low percentages of Ca and S. The high unburnt component may indicate that the combustion temperature is low and the desulfurization reaction does not proceed.

(4) Qualitative analysis, particle size distribution, electrical resistivity test of fly ash

A qualitative analysis, examination of the particle size distribution and electrical resistivity test of the fly ash were performed. The following shows the results.

Qualitative analysis of fly ash is performed to investigate the components which exist in the fly ash. Table 4-7 presents the qualitative analysis results, which show the same tendency as the ultimate analysis of the fly ash.

Table 4-7 Qualitative analysis results of fly ash

	Substances detected
>10%	Ca
1-10%	Mg, Al, S, Fe
<1%	Na, P, K, Ti, Mn, etc.

Fig. 4-14 shows the particle size distribution of the fly ash.

The reason why the shape of the graph is slightly different from a normal distribution is presumed to be because large particles of lignite are removed by the separator before combustion. The average particle diameter of Kosovo A-3 and A-4 is 29μm and 26μm (mean: 25μm and 15μm), respectively, and on the other hand, that of Kosovo B-1 is 12μm (mean: 5μm). The formation of the fly ash may be different due to differences in the crushing capability of the lignite mill, combustion conditions (burner, temperature, etc.), etc. These particles may become PM10 and PM2.5 because they are discharged into the air through the stack.

Fig. 4-15 shows the measurement results of the electrical resistivity of the fly ash.

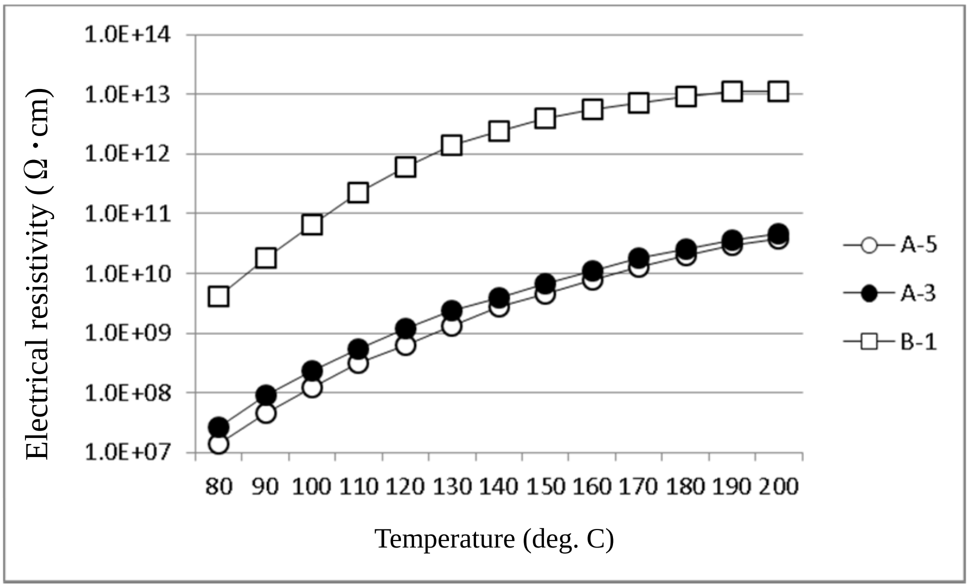
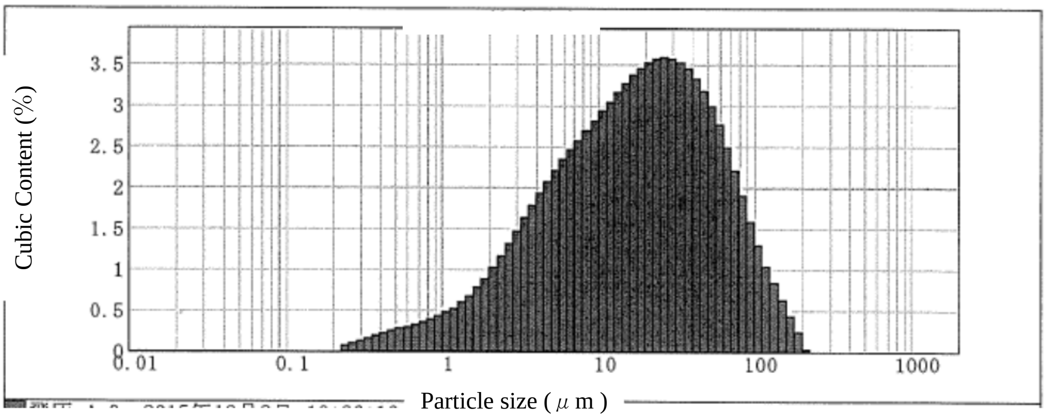


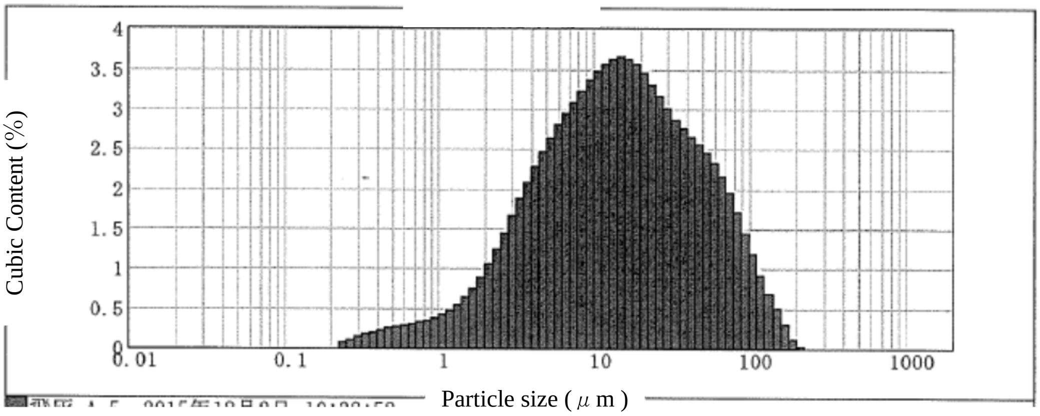
Fig. 4-15 Electrical resistivity of fly ash

This figure indicates a large difference in the electrical resistivity values of Kosovo A and Kosovo B boilers. The reason for this difference is presumed to be a difference in the composition of the compounds generated under the different atomosphere in the furnace, such as different combustion temperatures and O_2 concentrations. Electrical resistivity has a large effect on dust collection efficiency of an ESP which is mentioned later in “5-2 Dust Reduction Measures”. It is generally thought that the dust collection efficiency of an ESP decreases when electrical resistivity is over 10^{11} Ω・cm. The electrical charging of the particles may become unstable, considering the fact that the present exhaust gas temperature is around 180℃.

Kosovo A-3 boiler fly ash



Kosovo A-5 boiler fly ash



Kosovo B-1 boiler fly ash

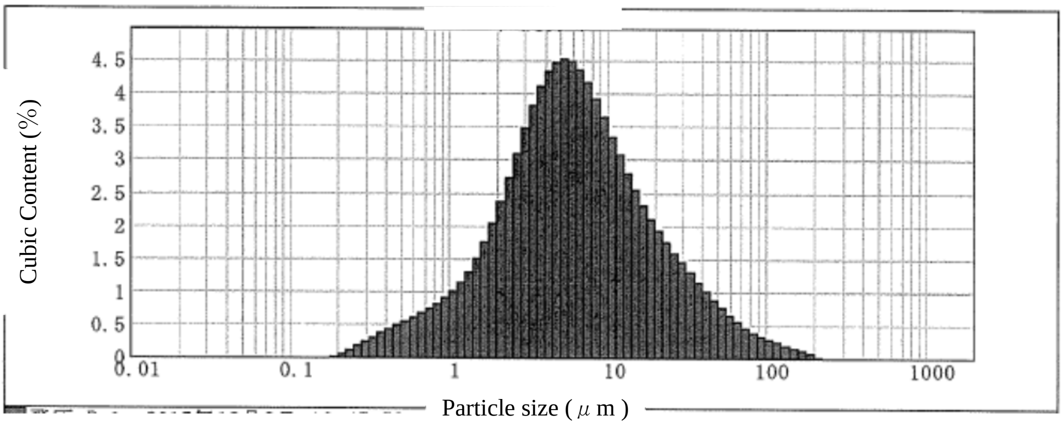


Fig 4-14 Particle size distribution of fly ash at Kosovo A boiler & B boiler

4-6 About technology transfer of on-site stack gas measurement

One of the main purposes of the mission is to transfer on-site stack gas measurement technology. However this mission placed priority on obtaining current emission data, which did not allow JET to spend enough time on technology transfer. The C/P members in charge of measurement are eager to learn and some of the members read and translated the SOP (Standard operating Procedure) into Albanian. However because of a lack of experience, it is hard to say that they fully understand it and are ready to implement it by themselves.

The C/P members in charge of measurement took part in all the measurement, and during the 2nd mission they conducted some part of the measurement by themselves.

The followings are the activity done by the C/P members.

(1) Exhaust gas volume measurement (No.1, No.2 ESP) and dust measurement at Kosovo B TPP

Photo 4-7 Dust measurement by C/P members at the inlet of ESP at Kosovo B-2 boiler

(2) Zero-span adjustment of the automated gas analyzer (NO_X, SO_2) (calibration)

Photo 4-8 Calibration of the automated gas analyzer by C/P members

(3) Lectures on calculation required for dust measurement

Photo 4-9 Lectures of calculations necessary for dust concentration measurement

The C/P members in charge of dust measurement consist of two persons from KHMI, and one person from MESP. These three activities were OJT conducted by the C/P members. As a result, it was confirmed that the C/P members could conduct exhaust gas volume measurements by themselves which is one of the processes of dust measurement. However, they are still not be able to prepare for the dust measurement itself, for example, by performing calculations of the gas velocity, setting gas suction rate for isokinetic gas sampling, etc. which JET must support. The C/P members have not reached the sufficient level yet. It is necessary that JET gives instructions to the C/P members so that they can learn the equations, setting method, etc. in SOP, and let the C/P members to learn on-site work through OJT.

Regarding the automated gas analyzer, the C/P members conducted the zero-span check (calibration) procedure. The members seemed to learn how to calibrate the instrument to some extent, but still must learn such as how to export data, how to arrange data, etc. The C/P members need to gain experiences and to become familiar with these procedures.

Separate lectures were given on velocity calculation and suction gas volume setting for dust measurement. Although these lecture covered the complete range of dust measurement, it is not sure whether they were understandable or not. Confirmation at the site is necessary.

Chapter 5 Pollution Abatement Measures

Based on the information concerning Kosovo A and B TPP presented in Chapter 3 and the findings of the dust measurement results in Chapter 4, pollution abatement measures for these boilers are studied in this chapter.

These measures are related to “1-3-2 Reinforcement of knowledge of application of on-site stack gas data to ELVs" and “1-3-3 Reinforcement of ability to evaluate and implement improvements toward formulation of emission inventories”.

In particular, these studied measures become a part of the support for the development of the NERP.

5-1 Pollution abatement

As the boiler of a power plant uses a large quantity of lignite, sufficient attention must be paid to the exhaust gas from the stack to the environment.

It is essential to keep the discharge of air pollutants in the exhaust gas as low as possible. Air pollutants such as dust, SO_X and NO_X are regulated in the EC Directive as industrial emissions. Table 5-1 again shows the ELVs.

Table 5-1 Emission Limit Values by EC Directive 2010 (Part 1 of Annex V)

Pollutant	2018	2023	2026
SO_2 (mg/Nm^3)	**400**	**400**	**200**
NO_X (mg/Nm^3) as NO_2	**500**	**200**	**200**
Dust (mg/Nm^3)	**50**	**50**	**20**

Reference O_2=6% O_2 Base

Note; considering the actual conditions in Kosovo, it is not realistic to start the NERP in 2018. The Kosovo government decided to delay the start for four years and start in 2022; however, this must be negotiated with EC.

As environmental protection facilities, both Kosovo A and B TPP have ESPs for reduction of discharged dust, but neither plant satisfies the current ELV of 50mg/Nm^3. Neither plant has any environmental protection facilities for NO_X and SO_X. Particular environmental measures for SO_X and NO_X have not been taken. These are originally implemented at the time of construction of a TPP.

Regarding SO_X, according to the results of measurement by the automated gas analyzer in the 2nd mission, the SO_2 values sometimes showed 0 mg/Nm^3 and sometimes reached a high value of 1,000 mg/Nm^3 indicating a very unstable situation. If a low SO_2 level can be kept by a proper choice of the lignite used by the plant, injection of limestone, improvement of the boiler operating method of etc. there is a possibility that the ELVs (now; 400mg/Nm^3, future; 200mg/Nm^3) can be satisfied without installing desulfurization equipment or by installing small capacity equipment in the future. Therefore, it is important to investigate and to clarify the cause of the wide range of SO_2 values.

NO_X does not satisfy the environmental standard of the EC Directive (now; 500mg/Nm^3, future; 200mg/Nm^3), and measures must be taken, such as replacement of the existing burner with low NO_x burners.

These measures must not only satisfy the current environmental standard, but also consider future environmental standards. In addition, it is also necessary to take into account the design of new environmental facilities if there is a possibility of a large change in the quality of the lignite which will be used in the future.

The following describes the study of measures for air pollution abatement at Kosovo A and B TPP.

5-2 Dust reduction measures

There are two general approaches to dust reduction measures. One is to reduce the generation of dust, and the other is to collect the generated dust.

As the ash content in the lignite is the main source of dust generation in a coal-fired boiler, if it is possible to procure coal which contains less ash, this is an effective measure to reduce dust generation.

Because the unburned carbon produced during combustion of the coal also increases dust, complete combustion of coal is important. In order to achieve this, the adoption of a combustion system suitable for the kind of coal being used and proper operation/maintenance of the mill and the burner are necessary.

On the other hand, for dust collection to reduce the dust content, it is necessary to install higher dust collection efficiency facilities such as the electrostatic precipitator (ESP) or the bag filter. However, considering the maintenance cost, the bag filter is not recommendable for large plants.

Even though a boiler is already equipped with ESP, the ESP cannot demonstrate its full performance if there is a rise in the gas temperature and/or the inlet gas velocity distribution is heterogeneous due to the sedimentation of large ash particles in the ESP entrance duct, etc. In the case of installation of additional ESP or replacement to a high performance ESP, these issues should be taken into account in the ducting system. Otherwise, these measures will not achieve the expected performance (Fig. 5-1, 5-2).

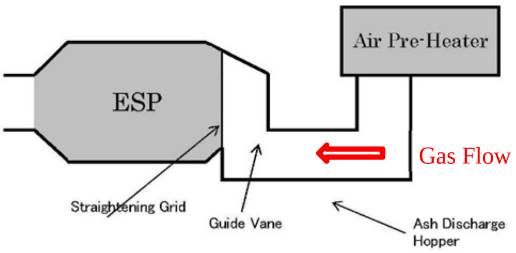


Fig. 5-1 Duct shape of A TPP at ESP inlet

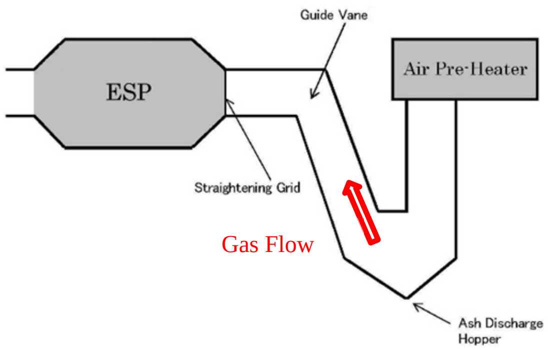


Fig. 5-2 Duct shape of B TPP at ESP inlet

Fig. 5-3 shows a summary of dust emission reduction measures.

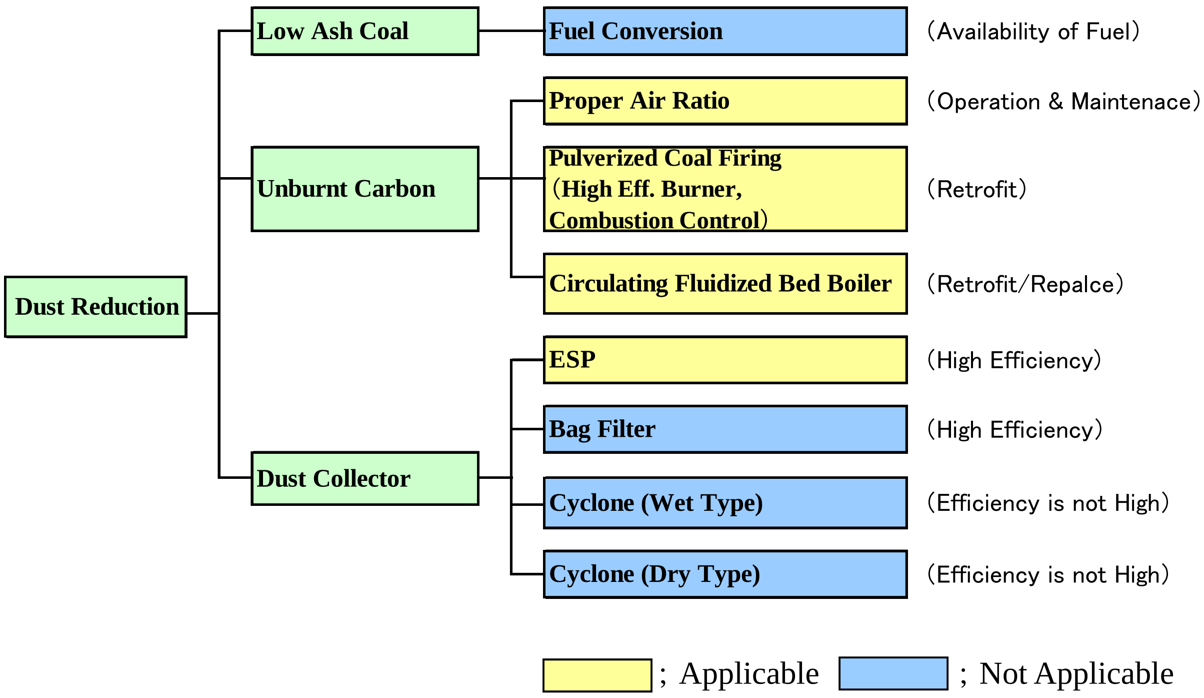


Fig. 5-3 Dust emission reduction measures

(1) Dust reduction measures for candidate for Kosovo A and B TPP

Concerning dust reduction for Kosovo A and B TPP, the 1st priority is for the ESPs to perform at their original capacity. In order to achieve this, the following improvements must be implemented, namely equalization of the exhaust gas velocity distribution at the inlet of the ESP, reduction of the exhaust gas temperature to the ESP, reduction of the air/fuel ratio, reduction of air infiltration into the boiler, etc. It is desirable to implement as many of these measures as possible.

However, further improvements will also be required, as it will be difficult to satisfy the ELVs even if the above-mentioned measures are implemented. The following two methods are candidate improvement measures.

a) Remove the existing ESP and replace the existing ESP with a new higher efficiency ESP.

b) Add a new ESP after the existing ESP (between ID fan and stack) to compensate for the inadequate capacity of the existing ESP (improve current capacity of 200-300 mg/Nm^3 to 20mg/Nm^3).

Plan a)

In this case, it is necessary to change the layout of the ESP inlet gas duct in order to improve the gas flow distribution to the ESP. This will require a new foundation for the new ESP and new installation of larger capacity ID fan, etc. As a result, a long plant outage for the retrofit work will be necessary.

Plan b) (Fig. 5-4, Fig. 5-5)

The new additional ESP will be installed behind the gas duct between the existing ID fan and the stack. The construction work will not affect plant operation. After the added ESP is installed, the duct must be re-routed (connect ID fan outlet to ESP inlet, and ESP outlet to stack inlet). However, this plan will make the outage of the plant as short as possible.

For Kosovo A TPP, considering the gas flow of the boiler, one idea is to install one large additional ESP with a size sufficient to cover three ESPs.

In order to reinforce the ESP, the ESP system must be maintained properly, and the actual capacity of the ESP must be estimated in order to clarify the necessary specification of the additional ESP. The correct specification (which determines the capacity and size) and the layout of the ESP are necessary for the study of the implementation cost of the additional ESP.

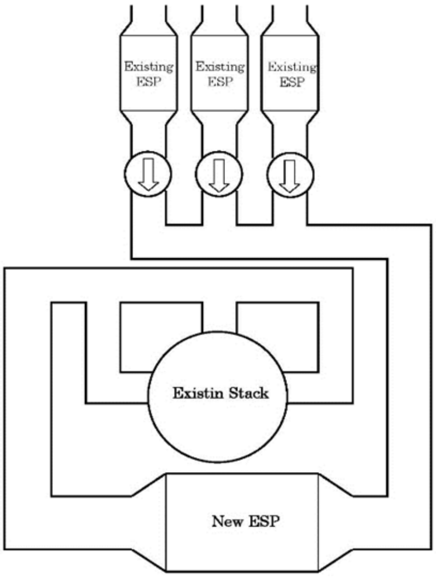


Fig. 5-4 Layout of Kosovo A (Plan b)

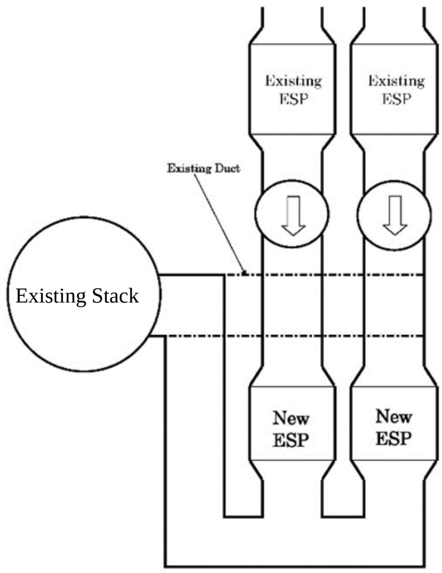


Fig. 5-5 Layout of Kosovo B (Plan b)

Modern power plants equipped with desulfurization systems generally use a low-low gas temperature ESP system[14], in which the boiler outlet gas is cooled by a gas cooler installed upstream of the ESP. This system can stabilize the electrical resistance of the ash by reducing the gas temperature, and as a result, good dust collection performance can be achieved (Fig. 5-6, 5-7). This system has the further advantage that it is possible to use a compact ESP because the gas volume decreases as the gas temperature decreases. The heat

[14] An ESP installed in the hot gas temperature zone of the economizer outlet is called a “high gas temperature ESP,” and an ESP installed in a low gas temperature zone (less than 100°C) is called a “low-low gas temperature ESP system” (Fig. 5-10).

collected in the gas cooler can be utilized to heat the gas of the desulfurization system outlet; this is effective for reducing white smoke and improving the diffusion of the exhaust gas from the stack.

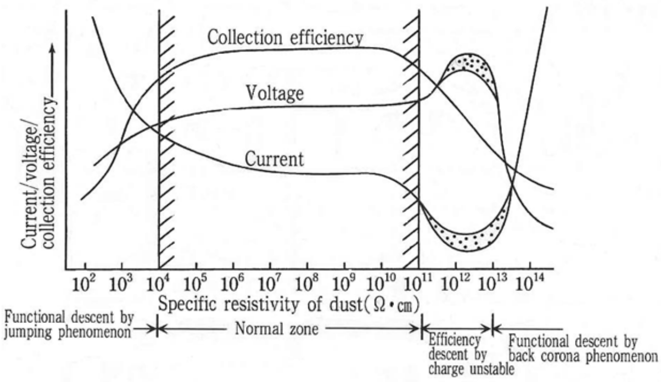


Fig. 5-6 Gas temperature vs. efficiency[15]

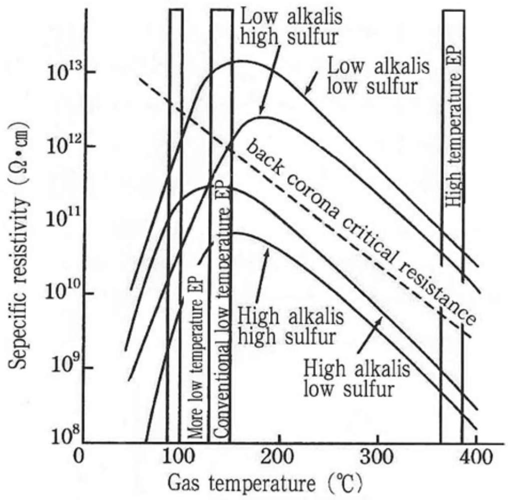


Fig. 5-7 Resistivity vs. gas temperature of ash[15]

The exhaust gas temperature of Kosovo A and B boilers is 180°C or higher. According to the analysis results of the fly ash collected from the ESP at Kosovo A and B, the resistivity of the fly ash is almost 10^{11} and 10^{13} (Ω, cm), respectively, which is near the limit for good ESP performance. From the viewpoint of ESP performance, lowering the exhaust gas temperature is recommended.

The low-low gas temperature ESP system14 can also be applied to plants which do not have a desulfurization system. The heat collected by the gas cooler of the gas-gas heat exchanger (GGH) can also be effectively utilized (resulting in a 3-4 % increase in boiler efficiency), for example, as a heat source for district heating, heat source for lignite drying or heat source for the low pressure feed water heater of the turbine plant (Fig. 5-8).

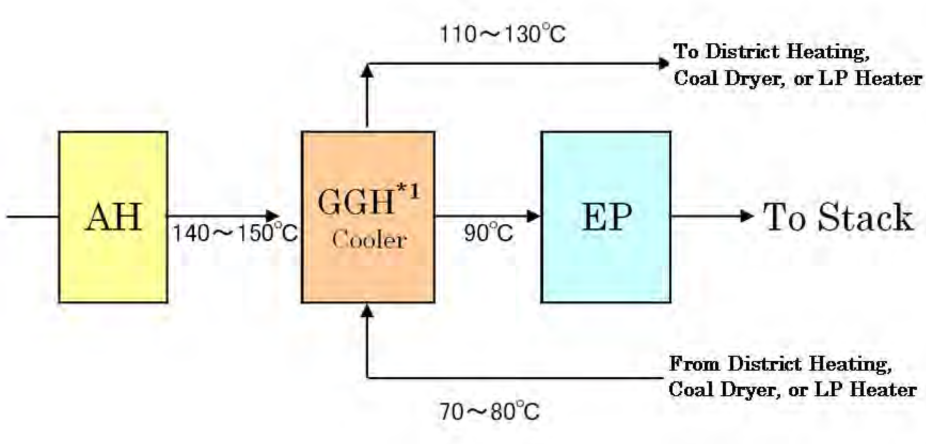


Fig. 5-8 Effective utilization of boiler exhausts gas

[15] Handbook for Thermal and Nuclear Power Engineers

Implementation of these schemes will require a detailed feasibility study of the heat balance of the boiler, load changes in district heating, etc. The operational data of the boiler, collection of district heating data, etc. and design based on these data is necessary for the feasibility study.

A wet type ESP, which prevents rescattering of the collected dust, is sometimes installed at plants where very strict emission control is required (Fig. 5-11).

A bag- filter can be installed in order to achieve strict emission values, but when installed after an ESP, filter clogging becomes a concern, as only fine particles reach the bag filter. These fine particles may easily penetrate into the filters, make backwashing difficult, and lead to filter clogging. At the same time, the ash in Kosovo appears to be adhesive and may also makes filter clogging worse. The adoption of a bag filter should be evaluated in advance considering the above-mentioned concerns.

The following are the kinds of systems introduced above. The abbreviations are as follows:

- SCR: Selective Catalytic Reactor (for De- NO_X)
- AH: Air Preheater
- GGH: Gas-Gas Heat Exchanger (consists of Gas Cooler and Gas Reheater)
- FGD: Flue Gas Desulfurizer (for De-SO_X)

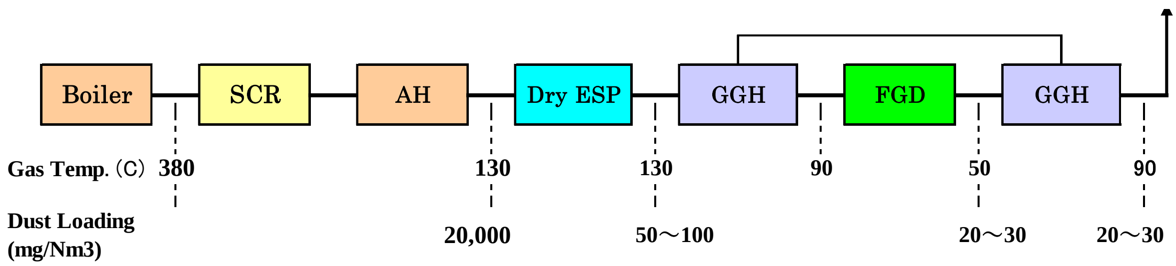


Fig. 5-9 Low temperature ESP system

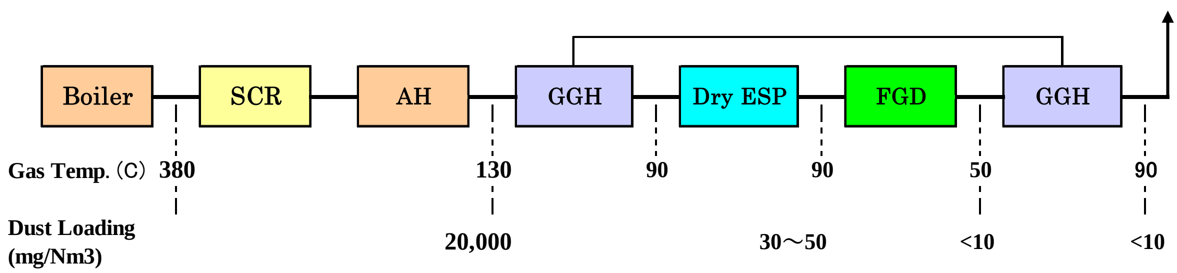


Fig. 5-10 Low-low temperature ESP system

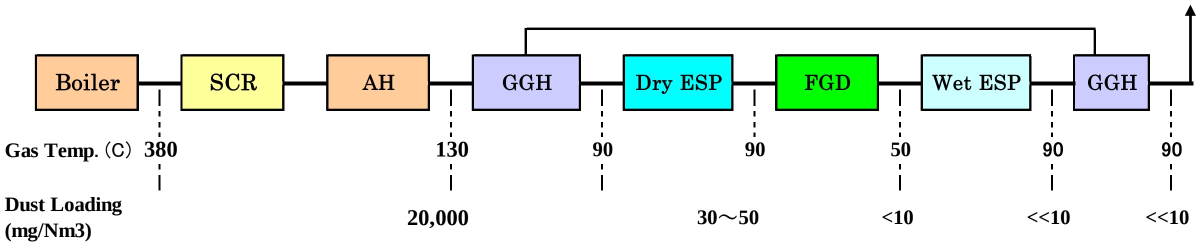


Fig.5-11 Low-low temperature wet type ESP system

5-3 NO_X reduction measures

Two approaches to NO_X reduction are possible. One is to reduce the generation of NO_X in the combustion process, and the other is to reduce the generated NO_X by chemical reaction. The nitrogen (N) in coal forms NO_X (fuel NO_X) when the coal is burned, so if it is possible to procure coal which contains less N, this is effective to reduce NO_X generation.

The amount of NO_X (thermal NO_X) which is produced by the reaction of N_2 and O_2 in the combustion air under the high temperature atmosphere in the combustion process can be reduced by changing the combustion conditions. Low excess air combustion is an important method, both to improve boiler efficiency and to reduce NO_X generation. Under low excess air combustion operation, it is necessary to pay attention to burning the coal at an appropriate excess air ratio because the amount of unburned carbon will increase if the excess air ratio is extremely low. If the combustion condition is inappropriate, NO_X will not decrease. Proper operation and maintenance of the burner is important to achieve good combustion in order to reduce the generation of dust and NO_X.

Because the generation of NO_X varies according to the structure of a boiler, it is difficult to estimate how much reduction of NO_X can be achieved by applying NO_X reduction technology at Kosovo A and B boilers. However, considering the ELVs, it is thought that a de-NO_X system such as SCR may not be necessary if 2-stage combustion technology is applied, the primary air supply system is improved, high performance low NO_X burners are applied, etc.

Recently, application of the circulating fluidized bed combustion boiler (CFB) to low grade coal has increased. (CFB is another alternative for newly-installed boilers.) CFB has the good features of low NO_X generation and in-furnace desulfurization (de-SO_X) by charging $CaCO_3$ because the furnace temperature is low (around 850°C). Furthermore, it has a drying mechanism for the moisture in coal inside the furnace. However, care is necessary, as it is generally thought that N_2O will be generated if a CFB is operated under extreme low O_2.

Fig. 5-12 shows a summary of NO_X emission reduction measures.

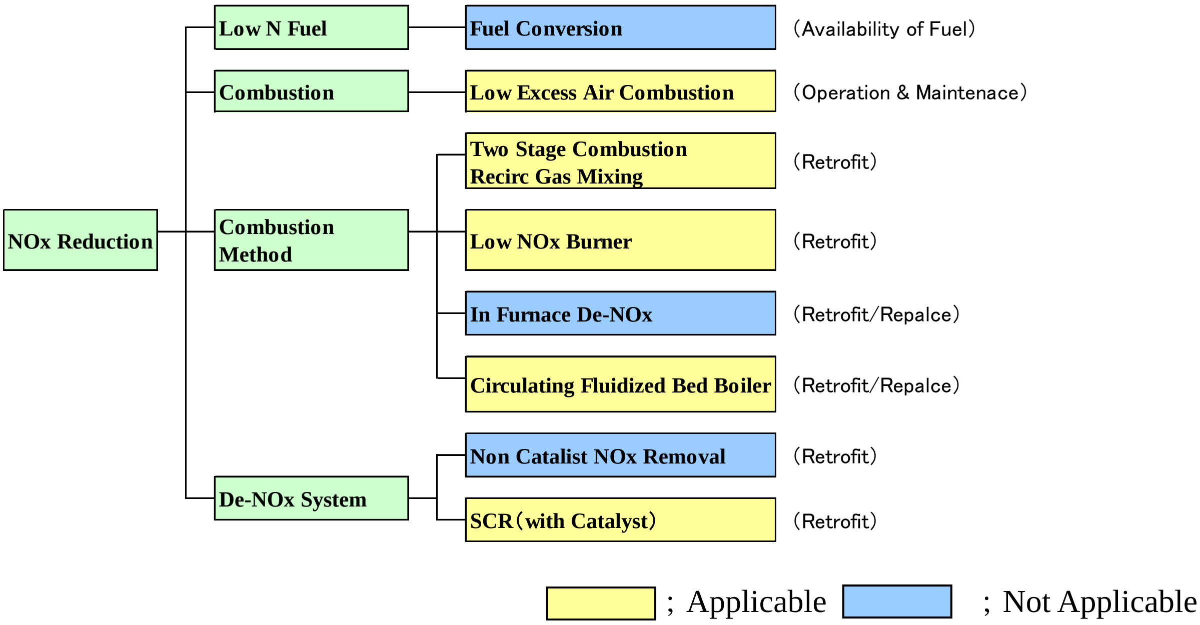


Fig. 5-12 NO_X reduction measures

(1) NO_X reduction measures by low NO_X burner

The condition of the combustion air supplied to the burners at Kosovo A and B boilers, which burn lignite, is different from that in the general coal-fired boiler. Because lignite contains a large quantity of water, the boiler uses high temperature combustion gas from the furnace in order to dry the lignite. The pulverized lignite is sent to the burner with this air/gas mixture, and is burned in the furnace.

Fig. 5-13 shows a comparison of the air proportion at the burner in general coal (Bituminous coal) combustion and the distribution with lignite.

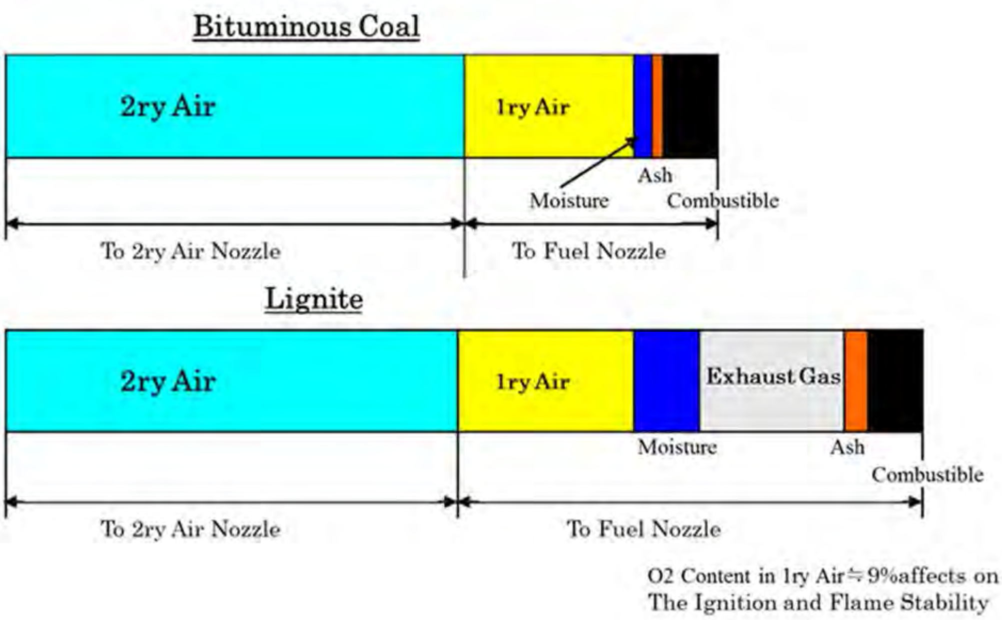


Fig. 5-13 Proportion of combustion air and pulverized coal and lignite to burner

The total quantity of air required to burn the combustible component of the lignite is almost the same, and there is also little difference in the distribution of the combustion air as primary air and secondary air. The major difference is the amount of primary air. In general coal combustion, the primary air supplied to the burner consists of a mixture of pulverized coal and air. However, in lignite combustion, the primary air consists of a mixture of pulverized lignite, combustion air and hot gas from the furnace, which means the gas volume is more than double that in general coal combustion. This is because the primary air contains a large amount of water which has evaporated from the lignite, as well as a large amount of exhaust gas. As a result, the O_2 content in primary air is less than 9%, which forms an inert atmosphere. The low O_2 content and large gas volumes have a serious influence on the ignition properties of the fuel, and make it very difficult for the coal to ignite. In turn, poor ignition makes combustion unstable.

The NO_X reduction measures using the conventional burner are low excess air combustion (low O_2), two-stage combustion (installing the over fire air nozzle (OFA)), and mixing of recirculation gas in the combustion air. However, since the NO_X reduction by these methods is limited to 30-40%, these methods are not considered adequate to satisfy the ELVs. A further problem is also anticipated, in that unstable ignition will become worse in lignite combustion, as the O_2 content of the primary air is less than 9%.

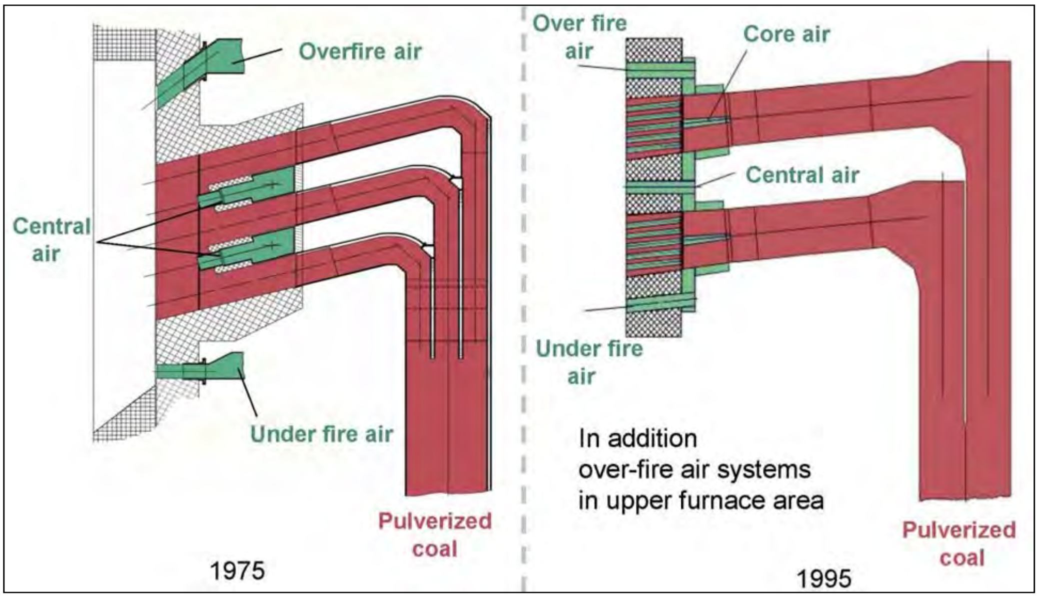


Fig. 5-14[16] Conventional burner and two-stage combustion

To comply with the ELVs, a further low NO_X reduction measure is necessary. Replacement of the existing type of burner with the low NO_X burner is considered to be

[16] HPE Lignite Technology (Hitachi Power Europe Gmbh 2013).

essential for improving NO_X reduction.

The low NO_X burner is a burner technology which was developed to control NO_X generation by adjusting the ratio of air and coal particles introduced from the burner nozzle.

NO_X generation can be reduced by forming a fuel rich (high coal/air ratio) region and a fuel lean (low coal/air ratio) region in the burner. The fuel rich region will also contribute to improvement of ignition stability (Fig. 5-15).

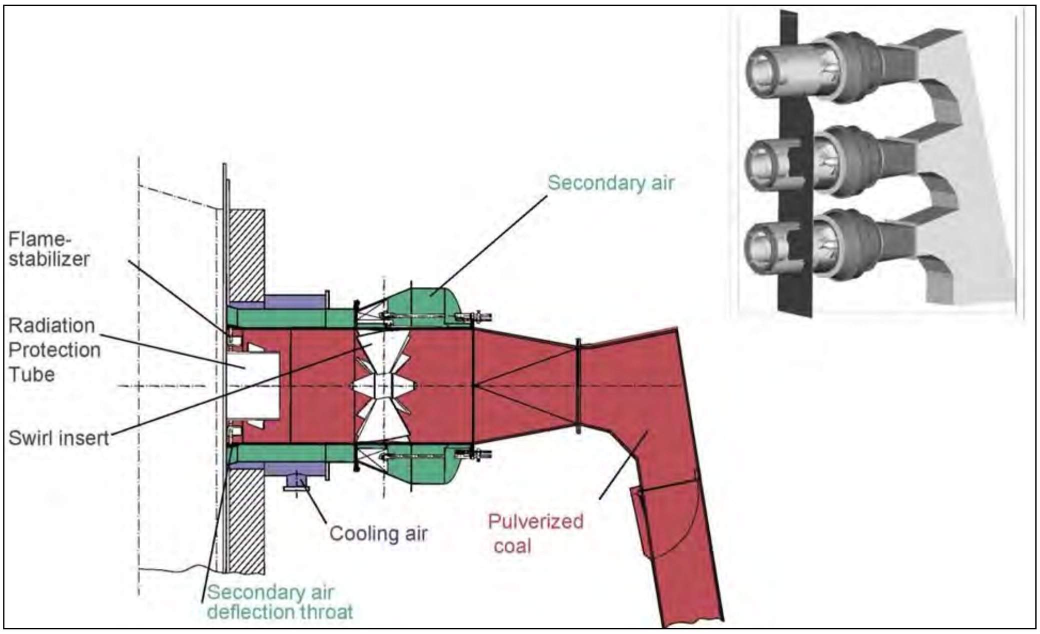


Fig. 5-15[16] Lignite firing low NO_X burner

In the Kosovo A and B boilers, a traveling stoker is installed at the bottom of the furnace to burn the unburned large lignite particles which fall to the furnace bottom. However, if the amount of air supplied to the stoker is excessive, it may affect the NO_X reduction of the main burner, as the air from the furnace bottom may affect the oxidization atmosphere around the main burner zone and disturb NO_X reduction. In this case, it may be necessary to uninstall the stoker; this would require improvement of the classification performance of the separator at the mill outlet in order to reduce the amount of the large lignite particles supplied to the burner. If these measures are carried out, the standard value of the EC Directive may be satisfied.

Nevertheless, the extreme high moisture content in the lignite is still the major issue for burner design and boiler efficiency. Therefore, pretreatment processes which make it possible to dry lignite (reducing the water content to the same 10- 20% level as general coal) before feeding it to the boiler are under development recently. There are two methods to remove water. One is to remove the water as vapor, and the other is to remove the water as condensate water. Actual application requires a feasibility study, including items such as the heat balance around the lignite dryer, an energy cost comparison of the utilized heat and compressor power requirement, the system cost, etc. Various coal drying systems are shown in the following Fig. 5-16 to 5-18.

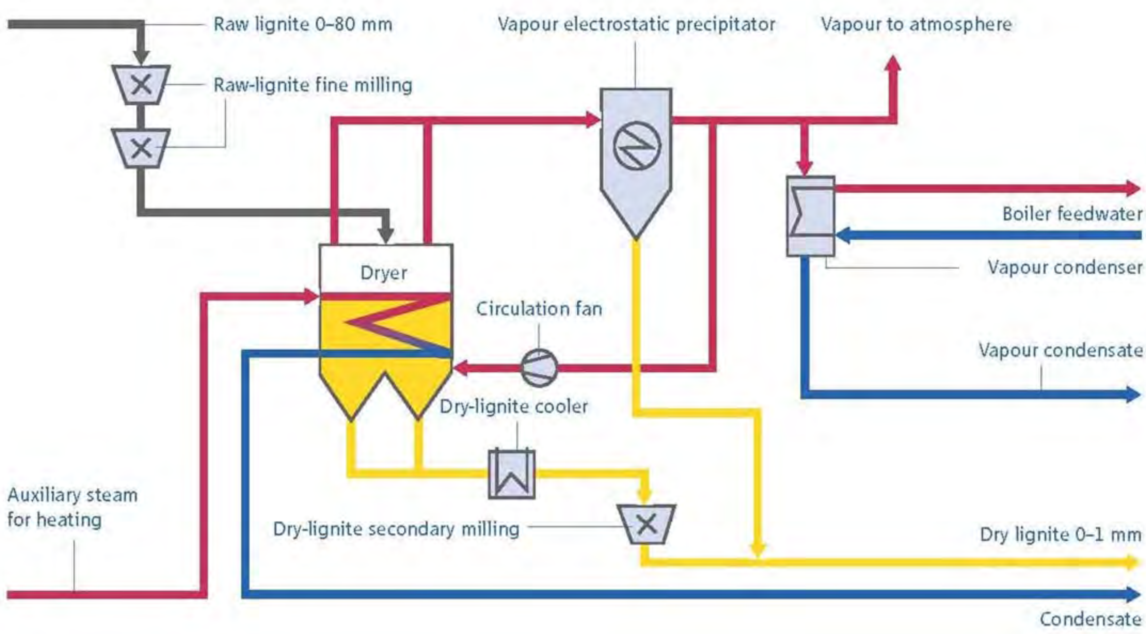


Fig. 5-16[17] Coal drying system (by auxiliary steam/waste heat, vapor discharge)

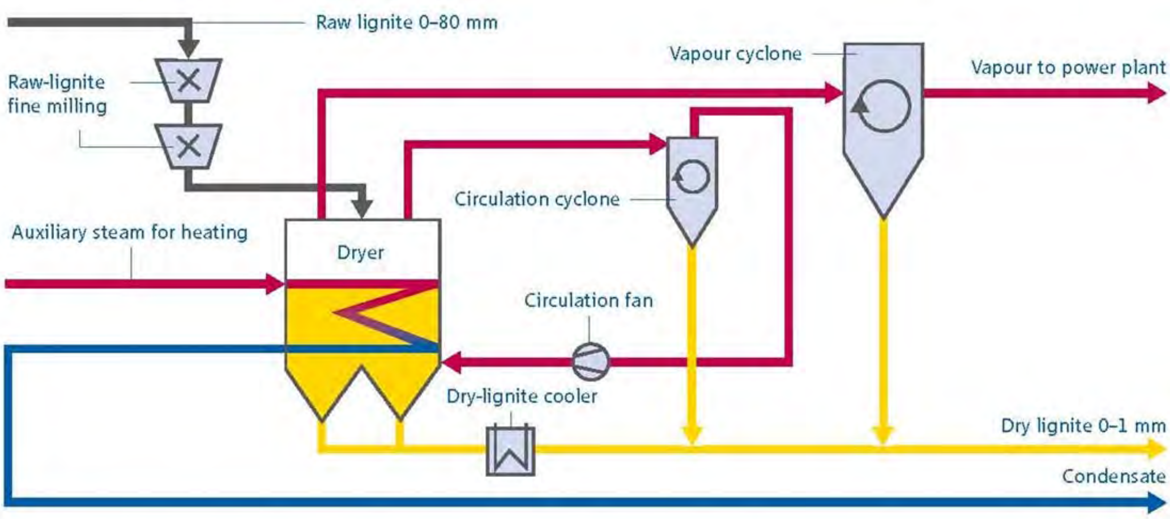


Fig. 5-17[17] Coal drying system (by auxiliary steam/waste heat, condensate recovery)

[17] A modern process for treating and drying lignite (RWE Power 2009).

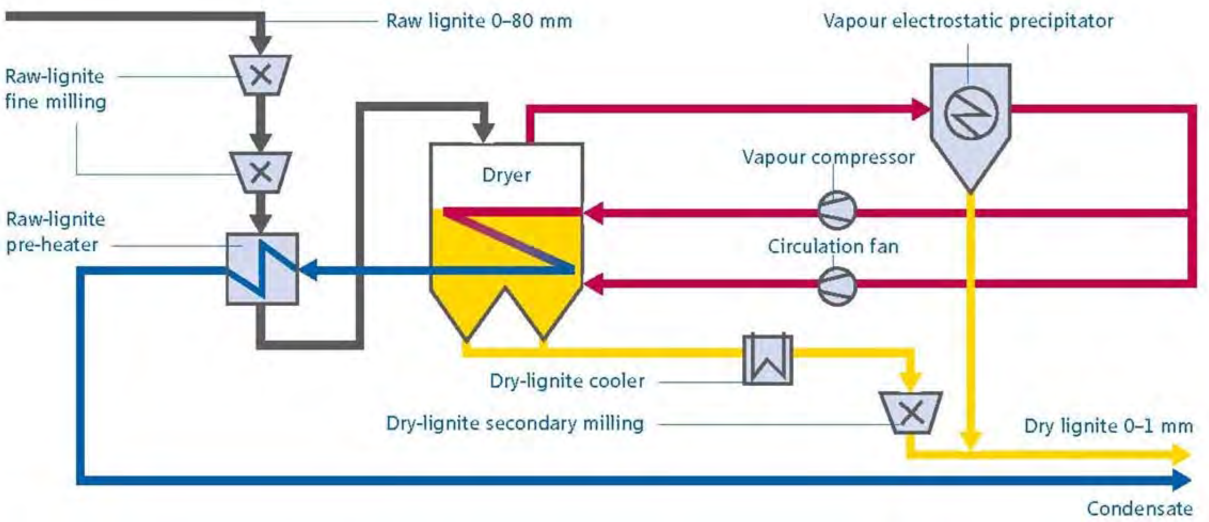


Fig. 5-18[17] Coal crying system (by compressor, condensate recovery)

When installing a new plant, the possible choices are the pulverized coal fired boiler with low NO_X burner or the circulating fluidized bed boiler. Since these two systems do not differ greatly in boiler efficiency and reliability, it is necessary to consider the construction cost, maintenance cost, etc.

(2) Selective Non-Catalytic NO_X Reduction (SNCR)

Injection of ammonia (NH_3) into a suitable high temperature zone (850 to 950℃) in a boiler induces denitrification reaction (de- NO_X). However, if the temperature is higher than the suitable range, NH_3 resolves and becomes NO_X, and if the temperature is lower, NH_3 is exhausted without any reaction. It is difficult to obtain higher de-NO_X efficiency with conventional boilers because of the difficulty of forming a well-mixed condition and securing an adequate residence time. De-NO_X efficiency is said to be 30-40%.

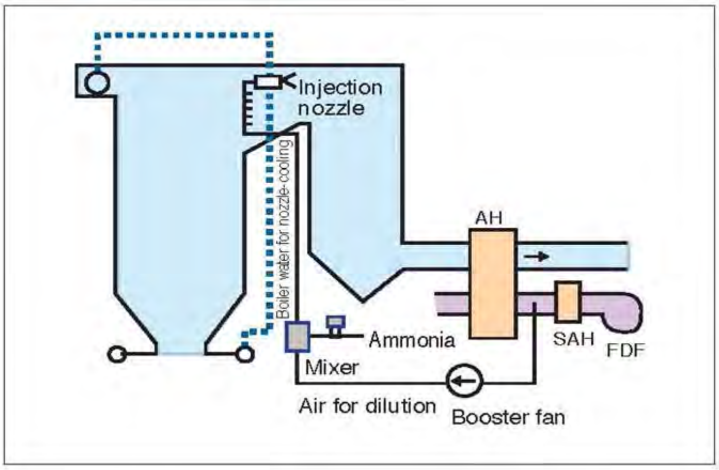


Fig. 5-19 Selective Non-Catalytic Reduction[18]

[18] "Clean Coal Technology in Japan" 2nd version April, 2015 New Energy and industrial Technology Development Organization

In the case of Kosovo, as the NO_X emission limit is 200 mg/Nm^3, high de-NO_X efficiency is not required. This method can be applied to improve de-NO_X efficiency as an auxiliary measure in combination with the low NO_X burner or CFB boiler in order to satisfy a strict emission limit.

$4NO + 4NH_3 + O2= 4N_2 + 6H_2O \quad 6NO_2 + 8NH_3 = 3N_2 + 6H_2O$

(3) Selective Catalytic NO_X Reduction (SCR)

NH_3 is injected into exhaust gas at around 350℃ and denitrification is performed by reduction of NO_X to N_2 and H_2O on a catalyst. Catalysts include the lattice, honeycomb and plate type, and each type can achieve high de-NO_X efficiency. However advance study is very important because the ash in Kosovo includes fairly high amount of alkali metal which may poison the catalyst, a large amount of ash which may abrade the catalyst, and large ash particles, which may clog the catalyst.

$4NO + 4NH_3 + O2= 4N_2 + 6H_2O \quad 6NO_2 + 8NH_3 = 3N_2 + 6H_2O$

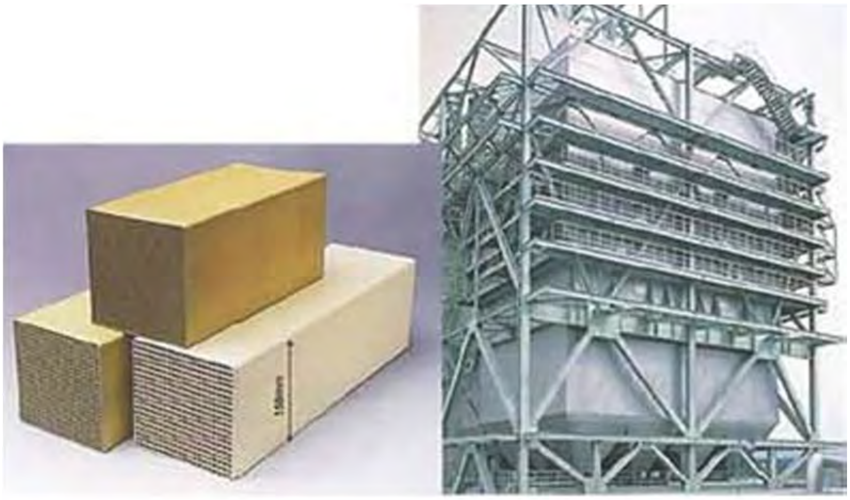


Fig 5-20 De-NO_X catalyst and exhaust gas denitrification facility[18]

It should be noted that both SNCR and SCR require NH_3 in order to reduce NO_X. Therefore, it is necessary to secure a stable supply of NH_3 if either method is to be adopted.

5-4 SO_X reduction measures

The amount of SO_X generation mainly depends on the sulphur (S) content in the coal which forms during combustion. If it is possible to procure coal which contains less sulphur, this is an effective way to reduce SO_X generation. The high stack also has a long history of use to promote diffusion of SO_X into the atmosphere in order to lower the landing density of SO_X.

Two SO_X removal measures are possible. One is to inject limestone into the furnace, which results in the formation of gypsum ($CaSO_4$) in the furnace; this is termed "in-furnace desulfurization." The other is to use the chemical reaction between $CaCO_3$ slurry and SO_X, which proceeds in a wet type desulfurization system (FGD system) installed between the boiler and the stack.

In in-furnace desulfurization, the chemical reaction between CaO (produced from $CaCO_3$ in the furnace by limestone injection) and SO_X proceeds in the furnace at a gas temperature around 850°C, and SO_X is captured as $CaSO_4$. In this system, higher desulfurization requires a suitable gas temperature for the reaction and a large amount of limestone injection, which is necessary for the reaction with SO_X. In the application of this system, attention must be paid to the design of the ash handling system because the quantity of dust in the flue gas will be increased by the $CaSO_4$ formed in the process, together with the remaining unreacted CaO.

As boiler technologies, the circulating fluidized bed boiler (CFB) can maintain a suitable furnace temperature for desulfurization, but the pulverized coal-fired boiler is difficult to keep high desulfurization efficiency because control of the furnace gas temperature is difficult and the residence time at the suitable temperature for the reaction is limited (short).

Fig. 5-21 shows a summary of SO_X emission reduction measures.

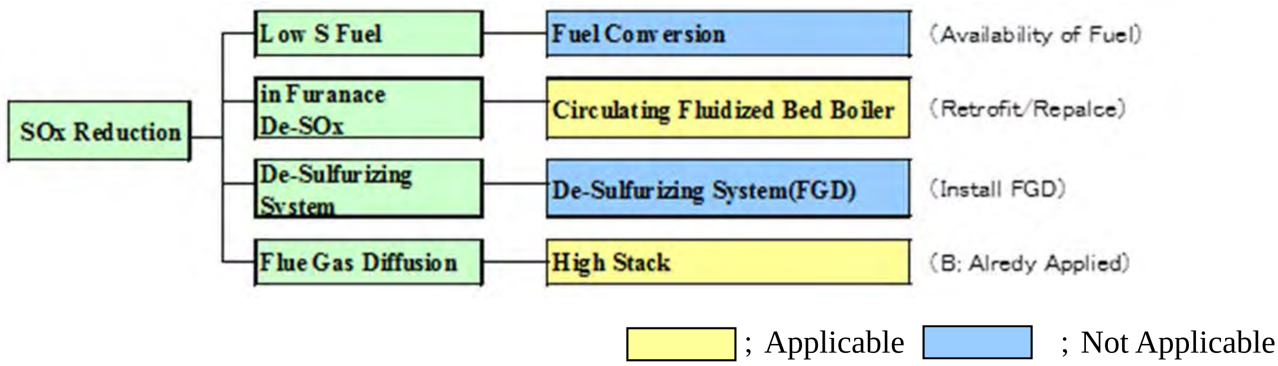


Fig. 5-21 SO_X reduction measures

(1) In-furnace desulfurization at Kosovo A and B TPP

The in-furnace desulfurization method is a method in which sulphur oxide (SO_X) is reacted and removed by introducing a desulfurization agent such as the limestone into the furnace.

The desulfurizing process utilizes the following reaction at the appropriate gas temperature with a desulfurization agent and retention time suitable for efficient reaction.

Fig. 5-22 and 5-23 show examples of the influence of the Ca/S ratio and temperature on desulfurization efficiency in the CFB, respectively.

【In-furnace desulfurization reaction】

$CaCO_3 \rightarrow CaO + CO_2$

$CaO + SO_2 + 1/2O_2 \rightarrow CaSO_4$

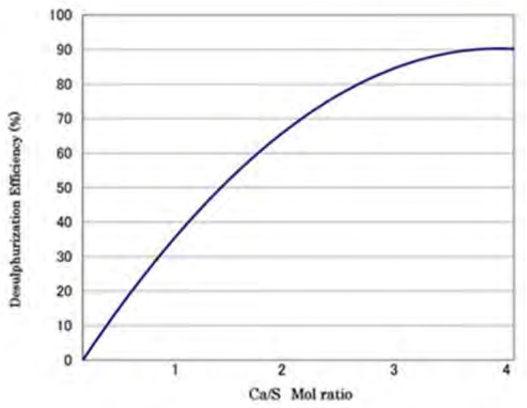


Fig. 5-22 Gas Ca/S vs. efficiency[19]

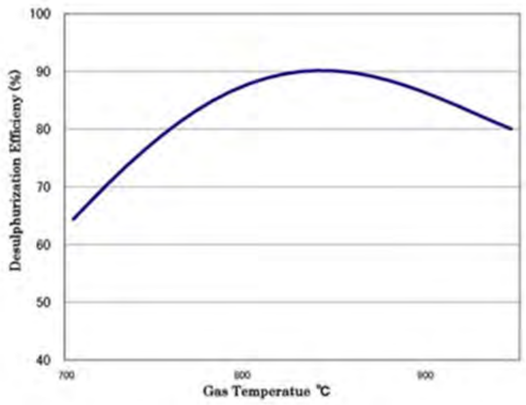


Fig. 5-23 Temperature vs. efficiency[19]

As the lignite consumed in Kosovo A and B boilers includes a large quantity of Ca, a desulfurization reaction may occur without limestone injection because the Ca component in the lignite acts as a desulfurization agent. Furthermore, the gas temperature in the furnace is approximately 900°C, which is suitable for the reaction.

There are two key points for achieving good desulfurization: One is to keep a suitable temperature (800-850°C) for the desulfurization reaction, and the other is to secure a sufficient reaction time.

Kosovo A and B boilers are pulverized coal-fired systems. While the temperature is suitable for the desulfurization reaction, but the retention time may not be long enough for the reaction, as the suitable region is restricted to the heat transfer area just after the combustion region. This means it is difficult to achieve higher desulfurization efficiency, even though Ca is supplied at a higher rate than that in the CFB. CFB is a better technology for this type of desulfurization, since, in principle, CFB can keep both the gas temperature suitable for the desulfurization reaction and the retention time necessary for the reaction.

(2) SO_X content in flue gas

As mentioned in section 4-5, the part of the sulphur in the lignite is combustible sulphur. Based on the analysis result, JET made the following calculation to determine how much sulphur in the fuel is converted to SO_X and captured in the ash (the sulphur in the ash exists as $CaSO_4$).

The ash in the lignite is analyzed by keeping the sample at 815°C. This is a suitable temperature for the reaction to form $CaSO_4$ when SO_2 exists in the presence of CaO.

If the amount of CaO is sufficient for reaction with the amount of SO_X, most of the SO_X

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[19] Figures are compiled from "Coal utilization technology" by New Energy and industrial Technology Development Organization, etc.

should form $CaSO_4$. However, in the laboratory experiment, some of the SO_X did not react and was discharged into atmosphere because the measurement was made in an open space. On the other hand, the actual condition in the boiler is different. The lignite is burned in a closed space in the boiler, and SO_X can react with floating CaO in the furnace. As a result, the discharged SO_2 content in the flue gas may be lower than the SO_X formed from the combustion of combustible S in the lignite when measured in the laboratory.

It is very difficult to clarify the detailed desulfurization process in the furnace, which takes place in the boiler. However, it is possible to estimate the SO_X content in the flue gas by comparing the sulphur content in the lignite and the ash which is generated as a result of the combustion of the lignite.

In the following calculation, SO_X is all assumed to be SO_2.

[Calculation for A-3 sample]

From the lignite analysis result: Total sulphur Sc=1.44%, Ash Ac = 27.96% (dry base)

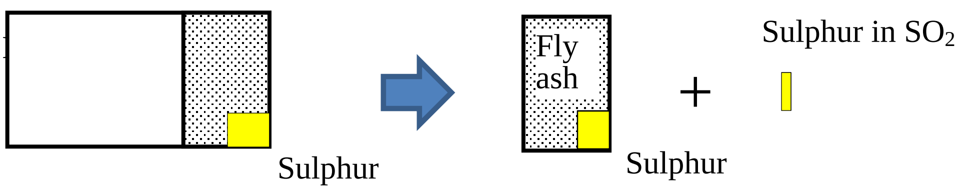
From the fly ash analysis result: Total Sulphur Sa=4.69%

Therefore, the sulphur absorbed (trapped) in the fly ash is as follows:

Sa * (Ac/100) = 4.69x0.2796 = 1.31(%)

The total sulphur in the ash is the sulphur trapped by the ash from the lignite. The difference between the total sulphur in the lignite and the total sulphur in the fly ash is discharged as SO_2 gas in the flue gas.

The sulphur discharged as SO_2 in the flue gas is 1.44-1.31 = 0.129%. On the other hand, combustible sulphur in the lignite is 1.44-1.16=0.28%. The former value is approximately 55% less than this latter value.



The SO_2 content in the flue gas can be calculated by the combustion gas volume and the burned S by the following combustion calculation:

Ultimate analysis (dry base): C=45.28%, H=3.87%, N=0.82%, Combustible S=0.28% (Total sulphur – Sulphur in ash) O=20.63%

Theoretical gas volume: V_{do} = [8.89*C+21.1*(h-O/8)+3.33*S+0.8*N]/100 = 4.31 (Nm^3/kg dry-fuel)

Theoretical air: Ao＝[8.89*C+26.7*(h-O/8)+3.33*S]/100＝4.38 (Nm^3/kg dry-fuel)

Following the EC Directive, actual dry gas at O_2=6% is calculated as follows (air ratio: m ＝1.394)

Actual dry gas flow: V_d＝V_{do}+(m-1)*Ao＝6.04 (Nm^3/kg dry-fuel)

2g SO_2 is generated from 1g S (S: atomic weight =32, SO_2 molar weight =64)

Because SO_2 is evaluated by the concentration at O_2=6% in the dry state, the SO_2 content in the flue gas is

SO_2 = (2*S /Vd) x 1000= 1.29*2/7.53 *1000=427mg/Nm^3

The same calculation for A-5 sample is as follows.

[Calculation for A-5 sample]

From the lignite analysis result: Total sulphur Sc=1.54%, Ash Ac = 27.91% (dry base)

From the fly ash analysis result: Total sulphur Sa=4.77%,

Therefore, the sulphur absorbed (trapped) in the fly ash is as follows:

Sa * (Ac/100) = 4.77*0.2791=1.33(%)

Sulphur discharged as SO_2 in the flue gas: 1.54-1.33 = 0.21%

For this calculaton, combustible sulphur in the lignite is 1.54-1.11=0.43%. The former value is also less than this latter value.

Actual dry gas volume by combustion calculation at O_2=6%:

Vd==6.133 (Nm^3/kg dry-fuel)

Therefore, SO_2 content in the flue gas: SO_2=685mg/Nm^3

The same calculation was also attempted with sample B-1, but the discharged sulphur was negative, and it was not possible to obtain a value of SO_2. In this case, SO_2 is presumed to be 0 mg/Nm^3.

From these results, the differences between the analysis of lignite and ash may contain an error, as the calculation is done near the limit (significant digit) of the analysis level. Thus, it seems to be difficult to estimate the SO_2 content in the flue gas by a calculation using the difference of the analysis results.

However, it is a fact that a large quantity of sulphur is absorbed (trapped) in the fly ash and a desulfurization reaction proceeds in boilers. Therefore, study of the material balance becomes an indicator of how the in- furnace desulfurization reaction occurs in these boilers.

Considering the SO_2 measurement results obtained by the automated gas analyzer in the 2nd mission, it is important to find the cause of the very unstable levels of SO_2 (continuation of 0 mg/Nm^3 and appearance of a high value of 1,000 mg/Nm^3). It is extremely important to identify the cause of this phenomenon. If it is possible to maintain a stable and low value of SO_2 by measures such as appropriate selection of lignite, injection of limestone, and/or improvement of boiler operation, it will be possible to satisfy the ELVs (present limit: 400mg/Nm^3, future limit; 200mg/Nm^3) by choosing between the alternatives of either no installation of a desulfurization unit or installation of a small desulfurization unit (assuming a unit is installed). A further detailed examination is required in the future.

If the in-furnace desulfurization is occurring properly and the SO_2 content meets the environmental standard of the EC Directive, it will be possible not to implement measures.

On the other hand, if the in-furnace desulfurization is not adequate to meet the EU standard, it will be necessary to go ahead with a study of the installation of desulfurization equipment.

It should be noted that the above calculation is an approximate evaluation, and is not an exact material balance calculation, in that the following points were not considered in this evaluation.

a) In the ash, sulphur exists as gypsum, and the quantity of ash (ash content %) is affected by the quantity of gypsum which is generated by the calcium in the lignite.

b) Because the temperature and atmosphere in the boiler are different from the analysis in the laboratory, the components and content of the ash are also different.

c) The bottom ash, which is approximately 10% of the total ash, contains less gypsum.

However, even if the effects of the bottom ash and generated gypsum in the ash are considered, the influence of these items will be within ±10%.

If the existing burner is replaced with a low NO_X burner for NO_X reduction in the future, attention must be paid to the in-furnace desulfurization reaction, because the condition of the furnace atmosphere may change. Specifically, because an oxidizing atmosphere is necessary for in-furnace desulfurization, in-furnace desulfurization may decrease if the furnace atmosphere becomes a slightly reducing atmosphere after remodeling of the burner. However, if the desulfurization reaction occurs outside the combustion area, the effect on desulfurization will be small, as O_2 must exist at this region.

Chapter 6 Summary of Other Activities including Workshops

JET held two workshops and a reporting session to disseminate information and knowledge about air pollution. The 1st mission held 2 workshops. JET also held a reporting session on the dust measurement results. During the 2nd mission, 3 workshops were held, and the measurement results, environmental measures etc. were presented. In particular, C/P were quite concerned about the dust measurement results and discussed these issues very actively.

At the same time, JET discussed the future requirement for on-site stack gas measurement with KHMI, as also described below.

6-1 Workshops and reporting session

Table 6-1 shows the titles and contents of the workshops and the reporting session. JET conducted these activities to promote the understanding of C/P.

Table 6-1 Workshops and reporting session

First mission (October 19, 2015 to November 12, 2015)		
Date	Title	Content
21st Oct.	1st workshop Exhaust Gas Measurement and Analysis in Japan (Air environment)	・ History of air pollution measures in Japan, lecture on dust measurement
2nd Nov.	Reporting session Exhaust Gas Measurement Interim Report (Dust measurement)	・ Reporting of dust measurements results of Kosovo A TPP
10th Nov.	2nd workshop Exhaust Gas Measurement Report (Dust measurement) Air Pollution and Boiler	・ Reporting of dust measurements results of Kosovo B TPP ・ Lecture on countermeasures to improve boiler emissions
2nd mission (March 7th, 2016 to March 31st, 2016)		
22nd Mar.	1st workshop Exhaust Gas Measurement (SO_2, NO_X, dust measurement) Report On-site stack gas measurement	・ Reporting of dust, SO_2, NO_X measurement results of Kosovo A & B TPP ・ Regulations, rules, etc. for on-site stack gas measurement
25th Mar.	2nd workshop Pollution Control of Boiler Lignite & ash analysis result Introduction of the similar project for	・ Measures for environmental protection for cola fired boiler ・ Results of analysis of lignite etc. in Japan ・ Introduction of Mongolian

	air pollution	Project
29th Mar.	3rd workshop Wrap-up workshop	・ Discussion and confirmation of outcomes and future problems

6-1-1 1st mission: First workshop

Venue: MESP

Attendants: C/P

This workshop explained the history of Japanese environmental pollution, the major types of pollutions in Japan, and the history of legislation. The schedule of dust measurement during the 1st mission, the principle of dust measurement, the measurement activity, and the method of calculating the dust content were also explained.

Because the 1st workshop was held on the 3rd day of the 1st mission, the C/P members were interested in the content but did not have a concrete image of the dust measurement, as almost all C/P members had never seen the dust measurement activity and its equipment before. The timing of the workshop seemed to be too early, and it should have been scheduled after the measurement activity.

At this workshop, C/P and JET agreed to take samples of fly ash and bottom ash in addition to lignite, and to compare the results between Kosovo and Japan.

Photo 6-1 View of 1st workshop

6-1-2 1st mission: Interim reporting session

Venue: MESP Conference Hall

Attendants: C/P

The interim reporting session was held immediately after completion of the dust measurement at Kosovo A TPP. In addition to explaining the results of the dust measurement at Kosovo A TPP, the mission also repeated the explanation of the dust measurements. Because many C/P members visited the measurement site, where they saw the dust measurement for the first time, it was easier for the C/P members to understand the measurement procedure presented in this explanation. Thus, this explanation contributed to the better understanding of the C/P members.

The dust measurement carried out by JET was the first experience for almost all C/P members, and in this sense, the explanation of the dust measurement results was also their first experience. This leads to an active discussion of the dust measurement results. At the same time, most C/P members also seemed to recognize Emission Limit Values (ELVs) for the first time.

The question and answer session and discussion are summarized below.

a) There was a question about the ELVs for dust content. The present EC Directive indicates $50mg/Nm^3$, and the future EC Directive requires $20mg/Nm^3$. JET explained that the present emission value far exceeds the ELVs.

b) There was discussion about the accuracy of the dust measurement results. As already mentioned in Chapter 4, the key points of this discussion were the fact that the dust content at the inlet of the ESP at Kosovo A boiler was too high, and that there was a big difference between the measured exhaust gas volume and the calculated volume. This inconsistency more or less negated the reliability of the data. (The increase of the measurement point in the 2nd mission solve the problem)

c) The measurement of SO_2 by the detection tube showed a low value of SO_2 even though the lignite used in Kosovo A has a high S content. C/P did not have any doubt about this result. SO_2 is always a big concern for boilers, but C/P did not seem to have any reason why SO_2 shows such a low value.

Although this was the first experience for C/P members to see the measurement results, this workshop was also an opportunity to understand the situation that C/P is not sufficiently sensitive to the present emission value, does not have an adequate recognition of the ELVs under the EC Directive, has not investigated the reason why SO_2 is so low, etc.

This session also stress the need for the C/P to be able to conduct measurement by themselves, and to determine accurate values by repeating measurement. At the same time, improvement of the reliability of the dust measurement results (the dust content and exhaust gas volume at the inlet of the ESP, etc.) became an assignment for the 2nd mission.

On the other hand, there was a mistaken understanding that the value indicated by the light scattering-type dust meter shows the accurate value, even though the values of this meter must be corrected based on the dust measurement results. This is one more assignments for JET in the future.

6-1-3 1st mission: Second workshop

Venue: MESP Conference Hall

Attendants: C/P

Because the 2nd workshop was scheduled to introduce boiler technology, a larger number of persons attended this workshop, including not only the C/P members but also engineers from KEK. The measurement results of Kosovo B TPP were also reported at this workshop.

(1) Dust measurement results of Kosovo B TPP

The discussion included not only the measurement result of Kosovo B boiler, but also the results of Kosovo A boiler.

a) The discussion on the results of Kosovo A boiler basically covered the same content as at the interim reporting session. JET promised that JET would repeat the measurements considering these points, and would study the cause of the difference.

b) The comment from KEK was that the dust content at Kosovo B boiler was reasonable, except that the measured exhaust gas volume was slightly small.

The dust measurement results obtained in this 1st mission showed that the dust content of Kosovo B boiler was 350mg/Nm^3, which was almost the same as the result at Kosovo A boiler. For some reason, there was no comment about this fact from the C/P side.

(2) Boiler lecture

Following the explanation of the measurement results, JET presented a lecture on the boiler process from the viewpoint of boiler design and environmental measures. Since there was no time for a question and answer period after this session, questions will be sent later by e-mail and answered during the 2nd mission. The content of the lecture was as follows.

a) This lecture explained the classification of coal and the fact that the design of a boiler must depend on the properties of the coal. Because the boilers in Kosovo consume lignite, the design must consider the properties of lignite. Regarding environmental measures, JET pointed out that most boilers in Japan use the selective catalytic reactor (SCR), flue gas desulfurizer (FGD) and ESP in order to keep low emissions.

b) In on-site stack gas measurement, not only measurement of emissions but also confirmation of consistency with the boiler operational condition is necessary.

c) The explanation about the process and characteristics of the generation of dust, SO_X and NO_X in the boiler.

d) In order to keep efficient boiler operation, daily operation and maintenance are very important.

Photo 6-2 View of 2nd workshop

6-1-4 2nd mission: First workshop

Venue: MESP Conference Hall

Attendants: C/P and KEK engineers

The dust measurement results and results of SO_2 and NO_X measurements by the automated gas analyzer were reported and explained, and the ELVs in the EC Directive, principles of measurement of each gas component by the automated gas analyzer, and one examples of an environmental impact calculation by pollutants from a stack were explained.

Regarding the measurement results, JET explained that the dust content of Kosovo B (B-2) boiler was especially high, and both Kosovo A and B boilers showed abnormal behavior, in that the SO_2 content was sometimes 0mg/Nm^3 and sometimes went up to 1,000mg/Nm^3.

(1) Results of on-site stack gas measurement at Kosovo A and B

The followings points were reported and explained.

a) The dust contents of both Kosovo A and B boilers far exceed the ELVs. The data have large dispersion and it is difficult to derive an average value of dust content. These results suggest that the measurement locations are not sufficiently representative.

b) NO_X of both Kosovo A and Kosovo B boilers exceeds ELVs, and it is necessary to study the introduction of low NO_X burner.

c) SO_2 of both Kosovo A and Kosovo B boilers shows unique behavior as SO_2 fluctuates from 0 to 1,000mg/Nm^3.

In the 2nd workshop, a supplemental explanation of measure for these problems was presented. On the other hand, the measurement points at Kosovo A and B boilers do not have representativeness for measurement, and it is important to find other appropriate measurement points. JET proposed other measurement points and C/P agreed with this proposal.

(2) Explanation of regulations for on-site stack gas measurement

The following points were presented and explained.

a) Along with an explanation of the ELVs stipulated in the EC Directive, the EC Directive requires continuous measurement by CEMs, and also prescribes the measurement methods. Ms. Hakaj of MESP explained in detail how Kosovo would cope with these problems in the future.

b) The principle of measurement, usage of the instrument and maintenance method of the automated gas analyzer and the method of observing dust in Japan were explained.

The principle and calibration method of the dust meter were explained. The isokinetic sampling measurement method (JIS method) is the only method for calibration of the dust meter. It is important to master the dust measurement method.

Visible smoke from the stack means that the dust content in the exhaust gas exceeds

$50mg/Nm^3$. In Japan many boilers are equipped with dust meters, but operators usually observe the exit of the stack and when the smoke from the stack becomes visible, they judge that the dust content is over $50mg/Nm^3$ and take measures. This is the common action used in Japan.

c) The meaning of the environmental standard was explained. A simple environmental simulation was introduced in order to explain the influence of the pollutants from the stack. This explanation described the relationship between the ground-level concentration and the environmental standard.

There was a question about whether the smoke from the stack of Kosovo A boilers is visible or not. JET presented Photo 6-3 and pointed out that the dust content of Kosovo A boilers was over $50mg/Nm^3$, because the smoke was visible.

Photo 6-3 smoke from stacks of Kosovo A

An opinion was presented that the property of lignite changes depending on the mining depth, and this might affect the above-mentioned phenomenon.

Photo 6-4 View of first workshop

6-1-5 2nd mission: Second workshop

Venue: MESP Conference Hall

Attendants: C/P and KEK engineers

Environmental measures for dust, SO_2 and NO_X for coal fired boiler were explained based on the information obtained in the 1st mission, analysis results of lignite brought back to Japan in the 1st mission, and the measurement results through the 1st and 2nd mission.

(1) Measures for dust

The properties of the fly ash at Kosovo A and B boilers are different. The particles size of the fly ash at Kosovo B boiler is finer than that at Kosovo A boiler and the electrical resistivity of the fly ash at Kosovo B boiler is higher than that at Kosovo B boiler. In particular, the electrical resistivity of the fly ash at Kosovo B boiler is very high at the present exhaust gas temperature which does not satisfy the appropriate collection condition for the ESP. At the same time, the velocity distribution of both Kosovo A boiler and Kosovo B boiler is not uniform, which also affects dust collection efficiency. Lowering the exhaust gas temperature and/or optimizing the air/fuel ratio will contribute to improving ESP dust collective efficiency. A close study of the present situation of the ESPs is very important. There are also many points which require attention when installing another ESP or a bag filter.

(2) Measures for NO_X

The principle of NO_X generation was explained.

The measures for NO_X are the low NO_X burner, Selective Non-Catalytic NO_X Reduction (SNCR) and Selective Catalytic NO_X Reduction (SCR). The low NO_X burner has a possibility to satisfy ELVs of the EC Directive. In the case of SCR, some matters require attention when considering installation.

(3) Measures for SO_2

SO_2 fluctuates in a wide range at both Kosovo A and B boilers. As this fluctuation may be caused by the in-furnace desulfurization, the principle of the in-furnace desulfurization was explained. However, it is not yet known what factors contribute the most to this in-furnace desulfurization.

Future study may enable more effective use of the in-furnace desulfurization. On the other hand, desulfurization unit costs very expensive and hard to operate Therefore, application of a CFB boiler is preferable, because it can realize both low SO_2 and low NO_X.

(4) Analysis of lignite etc.

The analysis results of lignite, fly ash and bottom ash were explained in detail. The material balance of sulphur for lignite, fly ash and exhaust gas explains the existence of two kinds of sulphur exists. One is sulphur in gypsum which is very stable and hard to resolve even at high temperature and the other is combustible sulphur of which some part becomes SO_2 and other part reacts with CaO by the in-furnace desulfurization. This shows the existence of the in-furnace desulfurization.

(5) Introduction of similar project for air pollution

The Mongolian project was explained mainly by using photographs. The situation of air pollution in Ulan Bator and activities of JICA were explained.

Photo 6-4 View of Second workshop

The organizations expressing interest in environmental measures most are MESP and KEK (company managing TTP). They have general information on environmental measures to some extent. However, as they do not have enough knowledge and experience of problems and cautious points for implementing these environmental measures, they showed great interest to the presentation. They are still lacking of knowledge and experiences because there is only two coal-fired boilers in Kosovo. It is difficult for them to fully understand the explanation in this situation. At the same time, EU manufacturers who constructed the boilers in Kosovo do not provide enough information and problems, and furthermore, there seems to be few consultants who possess enough knowledge on these environmental measures.

6-1-6 2nd mission: Third workshop

Venue: MESP Conference Hall

Attendants: Ms. Hakaj Nezakete (MESP)、Mr. Lulzim Korenica(MED)、Mr. Agim Morina(KEK)、Ms. Letafete Latifi(KHMI)、Mr. Abdlillah Pirce((MESP)、Ms.Qefsere Mulaku(KEPA)

The main C/P members and JET discussed the outcomes and future assignment of this activity. The attendee wrapped up the outcomes and future assignments of this mission. At the same time, the main C/P members expressed their hope related to this mission. A MOU was concluded based on this discussion.

6-2 Meeting with Kosovo Hydro-Meteorological Institute (KHMI)

KHMI and JET discussed the level of acquisition of on-site stack gas measurement technology and the future direction, and also discussed concrete items and other measurement items stipulated in the EC Directive, especially concerning the Reference method.

(1) On-site stack gas measurement

a) Procurement of the standard gas for the automated gas analyzer was confirmed. Although KHMI started the procedure, procurement would take 3 -4 months.

b) The KHMI members and JET agreed that the technology transfer of on-site stack gas measurement was not sufficient, because data acquisition was the priority in this mission. Both agreed that further training is required.

(2) Ion chromatograph

a) The KHMI members and JET confirmed that the Ion chromatograph possessed by KHMI was the most appropriate method to use as the Reference method. However both also confirmed that adjustment of instruments and training for operation was required.

b) Adjustment of the instruments will require fact-finding in advance. This fact-finding will clarify the necessities for the instrument. Based on the fact-finding, an instructor for the Ion chromatograph will adjust the instrument and give instruction on its operation. Adjustment will take 1 week and instruction will take 2 weeks. Instruction on the sampling method will be given separately.

(3) Measurement of mercury in exhaust gas

a) It was confirmed that the EC Directive requires the measurement of mercury in exhaust gas in case that lignite is consumed as a fuel.

b) It was confirmed that KHMI can analyze mercury itself. KHMI requires sampling apparatus and its technology.

c) It was confirmed that sampling of mercury requires $KMnO_4$ and KHMI can procure this reagent.

Chapter 7 Outcomes and future issues

This chapter summarized the outcomes and future issues obtained and discussed through this mission. C/P and JET discussed the following items and agreed on the content as MOU. The underlined parts in the following articles are the items where the support implementations are strongly requested by C/P in order to keep efforts for developing NERP.

7-1 Technology transfer of on-site stack gas measurement

(1) Outcomes

a) C/P and JET confirmed that the dust concentrations in the exhaust gas from the boilers of both Kosovo A TPP and Kosovo B TPP far exceed the ELVs defined in the EC Directive.

- Both the Kosovo side and JET confirmed that these dust concentration values also far exceed the specification of the ESP.
- In addition, JET communicated to C/P the fact that the dust meters installed in the boilers do not show reliable values (calibration has not been completed).

b) Measurement of SO_2 and NO_X showed the following results.

- NO_X showed a stable value of 700-800 mg/Nm^3 (reference O_2=6%).
- SO_2 showed a wide fluctuation from 0 to 1,000 mg/Nm^3 (reference O_2=6%).

In particular, the SO_2 measurement by the automated gas analyzer brought to Kosovo played an important role in the 2nd mission in showing this abnormal behavior.

c) C/P and JET confirmed that the location of the CEMs installed in Kosovo B TPP is problem form the viewpoints of maintenance and calibration.

- The CEMs is installed at the 90m position of the stack, where access is very difficult for maintenance personnel. It is very important to specify new sampling points. After specifying these points, Kosovo B TPP must study a relocation of CEMs. (The existing CEMs was granted by EU.)
- According to the EC Directive, calibration of the CEMs must be conducted at a position close to the CEMs. In particular, the dust meter must be calibrated by the isokinetic dust measurement method. It is difficult and dangerous to handle instruments in this location.

Furthermore, the points where JET conducted the measurements in this mission at Kosovo A TPP and Kosovo B TPP were not appropriate, because the measurement results were not uniform, indicating that there are not representative measurement points.

Because of the above-mentioned situation, C/P and JET agreed to install new measurement points for both Kosovo A TPP and Kosovo B TPP, which are envisaged to be representative points.

d) C/P and JET agreed that the technology transfer of on-site stack gas measurement was not sufficient. The acquisition of emission data was set as a priority in the mission, upon the request from MESP for NERP elaboration. C/P requested more training about technology transfer for on-site stack gas measurement.

e) C/P expects to use the ion chromatograph method as the Reference method for on-site stack gas measurement for SO_X and NOx. However, the ion chromatograph requires adjustment and operational instructions.

Furthermore, the EC directive mandates measurement of mercury in the exhaust gas which requires sampling and analysis technology.

(2) Future issues and directionality

a) C/P and JET agree that present measurement points are not appropriate, and there is a need to install other measurement points for future on-site stack gas measurement. These measurement points must be confirmed as representative by conducting on-site stack gas measurement.

It is important to specify the representative measurement points, not only for monitoring and reporting of emission data to the EC, but also for clarifying the mechanism of the fluctuation of the dust content and SO_2 concentration in the exhaust gas. The most appropriate dust and SO_2 reduction measures can be designed based on such a study.

In order to study the behavior of the dust and SO_2 it is strongly recommended to find representative measurement points and prepare for measurement before starting the next step.

b) CEMs is required to be installed at an appropriate position in order to monitor and report emissions to the EC. Kosovo B TPP has a CEMs which monitors dust, SO_2 and NO_X, but the location of the measurement point is problematic for operation and maintenance of the equipment. It is necessary to secure an appropriate place for operation (measurement)

c) C/P have not yet conducted on-site stack gas measurement by themselves. More instruction and experience is required in order to master this technology. C/P and JET have set mastery of this technology as a priority for KHMI and the Environmental Inspectorate, but KEK is also interested in participating in this process.

d) KHMI is in possession of an ion chromatograph made in Japan. However they do not have the necessary experience to utilize it. KHMI needs to use the ion chromatograph as a Reference method for on-site stack gas measurement and JICA support is necessary in this connection. Use of the ion chromatograph method requires the following:

- The ion chromatograph method requires training in sampling and instruction in operation
- In order to operate the ion chromatograph, one week is required for the set-up and adjustment of its instruments by the manufacturer
- Training for operation by the manufacturer requires two weeks.

e) Measurement of mercury in the exhaust gas requires sampling and analysis technology.
  - KHMI has instruments and the experience for analyzing mercury
  - KHMI can provide reagents but needs a sampling technology and its instruments.

7-2 Enforcement of knowledge of application of on-site stack gas data to ELVs

(1) Outcomes

a) The measurement results that dust and NO_X obviously exceeds the ELVs were explained. The dust content also far exceeds the projected values of the ESPs.

b) NO_X showed a stable value of 700-800 mg/Nm^3 (reference O_2=6%). As the value exceeds the ELVs, measures are required.

c) SO_2 showed a fluctuation from 0 to 1,000 mg/Nm^3 (reference O_2=6%). It is difficult to specify the average emission values. It is necessary to identify the cause of this phenomenon.

d) In the workshop environmental measures for dust, NO_X and SO_2 for coal fired boilers applied in Japan as well as troubles were introduced.

(2) Future issues and directionality

a) The present ESPs do not show the projected capacity, as they are affected by many factors (exhaust gas temperature, exhaust gas volume, heterogeneity of gas flow, etc.). In order to confirm the present condition of the ESPs, it is necessary to analyze the lignite and fly ash and to study boiler operation at the same time, which will contribute to the study of the cause of low dust collection efficiency. This study will contribute to the evaluation of proper and effective measures to achieve the ELVs, and will become the base data for deciding the specification of ESP reinforcement.

b) Reduction of SO_X and NO_X;
  - NO_X shows a stable value of 700-800 mg/Nm^3 (reference O_2=6%). It is indispensable to evaluate the introduction of the low NO_X burner.
  - The fact that SO_2 sometimes shows the value of 0 mg/Nm^3 suggests that the in–furnace desulfurization occurs in the boiler. Utilization of this phenomenon can provide an effective measure for reduction of SO_2. Study of factors which influence this phenomenon (percentage of CaO, combustion temperature, O_2 concentration in combustion area, etc.) will make it possible to evaluate effective and economic improvement or reinforcement for desulfurization.
  - Study of the relationship among SO_2 fluctuation, the properties of lignite, fly ash and boiler operation is very important to design measures for desulfurization.
  - It is immediately required to collect data on chronological changes (at least one month for both Kosovo A and Kosovo B) showing how SO_2 is fluctuating. This enables an analysis of the mechanism of this SO_2 fluctuation phenomenon in the

future, leading to the design of the most optimized desulfurization process.

c) JET introduced not only the probable dust, SO_2 and NO_X reduction methods but also the points that require attention when applying those methods. In case of introduction of emission control technology to the boilers, it is important not only to know the present emission values but also to understand the lignite quality and the features of the boiler in order to design appropriate measures and specifications.

7-3 Enforcement of ability to evaluate and implement improvements toward formulation of emission inventories

(1) Outcomes

a) Dust and NO_X clearly exceeds ELVs, and measures are required. The ESPs do not show their projected performance and improvement is required. The low NO_X burner is indispensable for NO_X measures.

b) SO_2 fluctuates widely. Study of the cause is effective for SO_2 measures.

c) It is important to apply environmental measures by considering the properties of lignite and features of the boilers. Application of measures without these studies may lead to troubles. In order to prevent troubles, further study is required.

d) In order to acquire accurate measurement results, not only measurement technology but also understandings of the measurement results are necessary. It is also important to understand the choice of appropriate measurement points and to master the Reference method requested by the EC Directive.

e)

(2) Future issues and directionality

a) Measures for dust and NO_X are indispensable. Measures for dust require study of the present condition. Measures for NO_X require study of the introduction of the low NO_X burner.

b) SO_2 fluctuates widely. The in-furnace desulfurization may contribute to this phenomenon, but the cause must be studied.

c) The lignite in Kosovo has a high content of Ca, low calorific value, and high water content. These features must be considered when studying environmental measures.

d) For the immediate future, it is necessary to master the technology for monitoring by CEMs and to confirm emissions by the Reference method. It is also important to specify representative measurement points for monitoring.

7-4 Promotion of understanding of this project by related organizations though workshops

Workshops were held 5 times and an interim reporting session was also held.

- 1^{st} mission: First workshop: Presentation about Japanese environmental problems and explanation about dust measurement method

- 1st mission: Interim reporting session: Reporting of dust measurement results of Kosovo A boiler
- 1st mission: Second workshop: Presentation of general explanation of coal fired boilers, such as combustion calculations, and general explanation of environmental measures for dust, SO_2 and NO_X, and reporting of measurement results of Kosovo B boiler
- 2nd mission: First workshop: Reporting of dust, SO_2 and NO_X measurement results of Kosovo A and B boilers, and explanation of regulations, etc. for on-site stack gas measurement
- 2nd mission: Second workshop: Presentation on environmental measures for coal fired boilers in Kosovo, explanation of analysis results of lignite etc., sampled in Kosovo, and the introduction of similar project for air pollution
- 2nd mission: Third workshop: Discussion with C/P of outcomes and future issues

Through the above-mentioned workshops, the present environmental conditions of Kosovo A and B TPP were discussed and measures for environmental issues were proposed.

Attached Document-1 List of Counterparts

Ms. Hakaj Nezakete	In charge of NERP development	MESP
Mr. Abdullah Pirce	In charge of measurement (1/3)	MESP
Ms. Letafete Latifi	Director of KHMI In charge of ion chromatograph	KEPA
Mr. Mentor Shala	Sector for soil In charge of measurement (3/3)	Hydrometeorological Institute of Kosovo (KHMI)
Mr. Shkumbin Shala	Sector for Air In charge of measurement (2/3)	KHMI
Ms. Anbenerha Ysuy		MZHE-MED
Mr. Lulzim Korenica	In charge of NERP development	MZHE-MED
Ms. Qefsere Mulaku		Institution MMPH
Ms. Visare Hoxha Istrefi		MESP
Mr. Agim Morina		KEK-Dep.i mjedisit
Mr. Sabri Simnica	Sector of environment In charge of safety of Kosova A Boiler information Coal sampling, etc.	KEK, Kosova A
Mr. Xhemajl Sejdiu	Chief Engineer In charge of Safety of Kosova B Boiler information Coal sampling etc.	KEK, Kosova B
Mr. Milaim Kelmendi	Department for Environment, KEK	KEK, Kosova B
Mr. Zeqirtahta Htseni		KEK, Kosova B
Mr. Salsit Resfelicu		MMPH-AMMK

Attached Document-2 Measurement Results

2-1 Measument Results of Kosovo A TPP

2-1-1 Operational data of Kosovo A boiler

(1) Operational Data of Kosovo A -5 boiler on 27th October (the 1st mission)

Boiler Operation Data （Kosovo A-5 boiler） 27th Oct. 2015

	Item	Date / Time / Unit	27th Oct.	27th Oct.
			10:10	15:30
1	Power Generation	MW	158	158
2	Ambient Air Condition (Temp.)	℃		
3		%		
4	Evaporation	T/h	580	580
5	Steam Temperature	℃	510	509
6	Steam Pressure	atg.	80	86
7	Feed Water Temperature	℃	155	160
8	Coal Analysis			
9	Coal Consumption	T/h	220	220
10	Combustion Air Flow Rate	%		
11	Furnace Pressure	mmH_2O	-3/-5	-3/-5
12	Economizer Outlet Pressure	mmH_2O		
13	Precipitator Inlet Pressure	mmH_2O	-220/-250/-240	-240/-250/-240
14	Stack Inlet Pressure	mmH_2O		
15	Burner Inlet Air Temperature	℃	260/260/260	260/260/260
16	Economizer Outlet Gas Temperature	℃	280/280/280	280/290/280
17	Precipitator Inlet Gas Temperature	℃	180/180/190	190/190/200
18	Precipitator Outlet Gas Temperature	℃		
19	Stack Inlet Gas Temperature	℃		
20	O_2 Content at Economizer Outlet	%	6.2/6.2	6.2/6.2
21	O_2 Content at Stack Inlet	%		
22	Feed Water Control Valve Opening	%		
23	Forced Draft Fan Motor Ampere	A	42/60/39	42/60/33
24	Damper	%	40/40/50	43/45/54
25	Outlet Draft	mmH_2O	110/110/110	110/110/110
26	Induced Draft Fan Motor Ampere	A	115/120/115	125/115/115
27	Damper	%	90/90/90	95/95/95
28	Inlet Draft	mmH_2O		-360/-370/355
29	Outlet Draft	mmH_2O		
30	Dust Content (at ESP Inlet)	mg/Nm^3		
31	Dust Content (at Stack Inlet)	mg/Nm^3	31/41/-	29/43/-
32	SO_X Content (at Stack Inlet)	ppm		
33	NO_X Content (at Stack Inlet)	ppm		
34	CO Content (at Stack Inlet)	ppm		

(2) Operational Data of Kosovo A -3 boiler on 29th October (the 1st mission)

Boiler Operation Data (Kosovo A-3 boiler)

29th Oct. 2015

	Item	Date / Time	29th Oct	29th Oct
			10:30	15:30
1	Power Generation	MW	128	135
2	Ambient Air Condition (Temp.)	℃	24	26
3		%	6	6
4	Evaporation	T/h	500	530
5	Steam Temperature	℃	570	515
6	Steam Pressure	atg.	74	80
7	Feed Water Temperature	℃	158	150
8	Coal Analysis			
9	Coal Consumption	T/h	220	230
10	Combustion Air Flow Rate	%		
11	Furnace Pressure	mmH_2O	-2/-5	-2/-3
12	Economizer Outlet Pressure	mmH_2O		
13	Precipitator Inlet Pressure	mmH_2O		
14	Stack Inlet Pressure	mmH_2O		
15	Burner Inlet Air Temperature	℃	240/250/240	240/240/250
16	Economizer Outlet Gas Temperature	℃	190/180/195	190/190/190
17	Precipitator Inlet Gas Temperature	℃		
18	Precipitator Outlet Gas Temperature	℃		
19	Stack Inlet Gas Temperature	℃		
20	O_2 Content at Economizer Outlet	%	7.7/6.4/7.6	6.9/5.5/7.2
21	O_2 Content at Stack Inlet	%		
22	Feed Water Control Valve Opening	%		
23	Forced Draft Fan Motor Ampere	A	36/39/35	38/-/32
24	Damper Opening	%	22/20/20	45/-/50
25	Outlet Draft	mmH_2O		
26	Induced Draft Fan Motor Ampere	A	95/85/100	85/86/94
27	Damper Opening	%	70/72/65	80/76/55
28	Inlet Draft	mmH_2O		
29	Outlet Draft	mmH_2O		
30	Dust Content (at Precipitator Inlet)	mg/m^3N		
31	Dust Content (at Stack Inlet)	mg/m^3N	65/59/50	65/59/54
32	SO_X Content (at Stack Inlet)	ppm		
33	NO_X Content (at Stack Inlet)	ppm		
34	CO Content (at Stack Inlet)	ppm		

(3) Operational Data of Kosovo A -4boiler on 10th March (the 2nd mission)

Boiler Operation Data (Kosovo A-4 boiler)

10th Mar. 2016

	Item	Date / Time / Unit	10th Mar.	10th Mar.	
			10:00	14:00	
1	Power generation	MW	130	120	
2	Ambient Air Condition (Temp.)	℃	33	30	
3	(Humidity)	%			
4	Evaporation	T/h	510	490	
5	Steam Temperature	℃	520	520	
6	Steam Pressure	atg.	71	66	
7	Feed Water Temperature	℃	158	158	
8	Coal Consumption	T/h	240	230	6 mills
9	Furnace Pressure	mmH_2O	-2/-3	-1/-3	
10	Economizer Outlet Pressure	mmH_2O	143/-141/-145		
11	Precipitator Inlet Pressure	mmH_2O	-215/-220/-222	-145/-140/-142	
12	Stack Inlet Pressure	mmH_2O			
13	Burner Inlet Air Temperature	℃	245/245/245	243/242/241	
14	Economizer Outlet Gas Temperature	℃	305	305	
15	Precipitator Inlet Gas Temperature	℃	175/185/182	180/185/185	
16	Stack Inlet Gas Temperature	℃			
17	O_2 Content at Economizer Outlet	%	6.1/6.7/6.7	6.8/7.7/7.6	
18	O_2 Content at Stack inlet	%			
19	Forced Draft Fan Motor Ampere	A	42/39/39	43/40/37	
20	Damper Opening	%	10/15/16	10/15/15	
21	Outlet Draft	mmH_2O	39/40/39	32/33/33	
22	Induced Draft Fan Motor Ampere	A	86/91/90	89/87/	
23	Damper Opening	%	62/60/63	60/57/61	
24	Inlet Draft	mmH_2O	-210/-231/-215	-200/-195/-210	
25	Outlet Draft	mmH_2O			
26	Dust Content (at Precipitator inlet)	mg/Nm^3			
27	Dust Content (at Stack inlet)	mg/Nm^3			
28	SOX Content (at Stack inlet)	ppm			
29	NOX Content (at Stack inlet)	ppm			
30	CO Content (at Stack inlet)	ppm			

Operational Data of Kosovo A -3 boiler on 11th March (the 2nd mission)

<u>Boiler Operation Data</u> (Kosovo A-3 boiler)

11th Mar. 2016

	Item	Date / Time / Unit	11th Mar.	11th Mar.	
			10:00	14:00	
1	Power generation	MW	145	137	
2	Ambient Air Condition (Temp.)	℃	29	30	
3	(Humidity)	%			
4	Evaporation	T/h	545	535	
5	Steam Temperature	℃	520	520	
6	Steam Pressure	bar	77	72	
7	Feed Water Temperature	℃	150	152	
8	Coal Consumption	T/h	225	220	5mills
9	Furnace Pressure	mmH_2O	-2/-3	-1/-2	
10	Economizer Outlet Pressure	mmH_2O			
11	Precipitator Inlet Pressure	mmH_2O	-140/-170/-170	-160/-180/-180	
12	Stack Inlet Pressure	mmH_2O			
13	Burner Inlet Air Temperature	℃	242/250/238	242/245/230	
14	Economizer Outlet Gas Temperature	℃	320	318	
15	Precipitator Inlet Gas Temperature	℃	195/195/195	188/172/192	
16	Stack Inlet Gas Temperature	℃			
17	O_2 Content at Economizer Outlet	%	6.5/5.4/5.5	5.6/5.9/5.9	
18	O_2 Content at Stack inlet	%			
19	Forced Draft Fan Motor Ampere	A	38/35/36	30/38/35	
20	Damper Opening	%	20/;20/24	20/;20/25	
21	Outlet Draft	mmH_2O			
22	Induced Draft Fan Motor Ampere	A	78/82/82	90/80/90	
23	Damper Opening	%	60/65/65	70/65/80	
24	Inlet Draft	mmH_2O			
25	Outlet Draft	mmH_2O			
26	Dust Content (at Precipitator inlet)	mg/Nm^3			
27	Dust Content (at Stack inlet)	mg/Nm^3			
28	SOX Content (at Stack inlet)	ppm			
29	NOX Content (at Stack inlet)	ppm			
30	CO Content (at Stack inlet)	ppm			

2-1-2 Summary of measurement results of Kosovo A boiler

(1) Summary of measurement results of Kosovo A-5 on 27th October (the 1st mission)

Measurement Results of Exhaust Gas at Kosovo A-5 TPP

27th Oct. 2015

Measurement point		A-5 Inlet-A	A-5 Inlet-B	A-5 Inlet-C	A-5 Outlet-A	A-5 Outlet-B	A-5 Outlet-C
Wet exhaust gas volume	Nm^3/h	318,000	428,000	404,000	215,000	154,000	178,000
Dry exhaust gas volume	Nm^3/h	278,000	375,000	354,000	186,000	135,000	156,000
Gas velocity	m/s	17.3	19.6	18.5	19.2	13.8	15.9
Exhaust gas temperature	℃	172	176	176	179	180	180
Water content	%	12.4	12.4	12.4	12.4	12.4	12.4
Static pressure	kPa	-2.4	-2.4	-2.4	-2.8	-2.8	-2.8
Composition (%)	CO_2 (%)	11.0	11.0	11.0	11.0	11.0	11.0
	O_2 (%)	12.0	11.5	12.0	12.0	11.5	12.0
	CO (ppm)	59	80	107	59	80	107
	N_2 (%)	77.0	77.5	77.0	77.0	77.5	77.0
Dust content	g/Nm^3	52.492	4.225	3.495	0.237	0.186	0.070
Dust content at O_2 = 6%	g/Nm^3	87	6.7	5.8	0.395	0.294	0.117
Detection tube (NO_x)	ppm	250					
NO_x (NO_2) at O_2 = 6%	mg/Nm^3	856 (417ppm)					
Detection tube (SO_2)	ppm	110					
SO_2 at O_2 = 6%	mg/Nm^3	524 (183ppm)					

Power voltage	—	230V	230V
Length of power cable	—	25m cable reel + 20m extension cable	25m cable reel
Length of sampling hose	m	30m	30m
Location of instruments	—	Directly below	Directly below
Length of sampling pipe	m	1.0m	1.0m
Length of Pitot tube	m	2.0m	4.0m
Remarks	—	Dusty environment, dark place	Dusty environment, dark place

(2) Summary of measurement results of Kosovo A-3 on 29th October (the 1st mission)

Measurement Results of Exhaust Gas at Kosovo A-3 TPP

29th Oct. 2015

Measurement point		A-3 Inlet-A		A-3 Inlet-C		A-3 Outlet-A	A-3 Outlet-B	A-3 Outlet-C
Wet exhaust gas volume	Nm^3/h	335,000		343,000		189,000	176,000	174,000
Dry exhaust gas volume	Nm^3/h	297,000		304,000		168,000	156,000	154,000
Gas velocity	m/s	16.4		16.8		17.6	16.6	15.9
Exhaust gas temperature	℃	212		210		202	210	193
Water content	%	11.3		11.3		11.3	11.3	11.3
Static pressure	kPa	-1.6		-1.8		-2.0	-2.0	-2.0
Composition (%)	CO_2 (%)	9.6		7.8		9.6	11.8	7.8
	O_2 (%)	12.4		14.2		12.4	10.2	14.2
	CO (ppm)	29		53		29	59	53
	N_2 (%)	78.0		78.0		78.0	78.0	78.0
Dust content	g/Nm^3	UP	Down	UP	Down	0.1770	0.0225	0.0230
		112.51	82.19	56.897	183.77			
Dust content at O_2 = 6%	g/Nm^3	196	143	126	405	0.309	0.0313	0.0507
Detection tube (NO_x)	ppm	400						
NOx at O2 = 6%)	mg/Nm^3	1,433 (698ppm)						
Detection tube (SO_2)	ppm	0						
SO_2 at O_2 =6%	mg/Nm^3	0 (0ppm)						

Power voltage	―	230V	230V
Length of power cable	―	25m cable reel + 20m extension cable	25m cable reel
Length of sampling hose	m	30m	30m
Location of instruments	―	Directly below	Directly below
Length of sampling pipe	m	1 .0m	1.0m
Length of Pitot tube	m	2.0m	4.0m
Remarks	―	Dusty environment, dark place	Dusty environment, dark place

(3) Summary of measurement results of Kosovo A-4 on 10th March (the 2nd mission)

Measurement Results of Exhasut gas at Kosovo A-4 TPP

10th Mar. 2016

Measurement point		A-4 outlet A duct	A-4 outlet B duct	A-4 outlet C duct
Wet Exhaust gas volume	Nm^3/h	476,000	457,000	441,000
Dry Exhaust gas volume	Nm^3/h	393,000	377,000	364,000
Gas velocity	m/s	27.3	26.6	25.0
Exhasut gas temperature	℃	184	191	178
Water content	%	17.4	17.4	17.4
Static pressure	kPa	-2.0	-2.0	-2.0
Composition (%)	CO_2(%)	9.2	9.0	9.2
	O_2(%)	10.8	11.0	10.8
	CO(ppm)	140	61	94
	N_2(%)	80.0	80.0	80.0
Dust Content	g/Nm^3	0.144	0.118	0.200
Dust Content (O2 at 6%)	g/Nm^3	0.225	0.184	0.306
TEMP (Ave)	℃	197	199	186
O2(PG-350)(Ave)	%	11.4	11.4	11.2
CO2(PG-350)(Ave)	%	9.3	9.3	9.5
CO(PG-350)(Ave)	ppm	53	24	40
Nox(PG-350)(Ave)	ppm	177	192	190
	mg/Nm^3	363	394	390
Nox O2 at 6%)	ppm	277	300	291
	mg/Nm^3	567	615	596
SO2(PG-350)(Ave)	ppm	0	0	0
	mg/Nm^3	0	0	0
SO2 O2 at 6%)	ppm	0	0	0
	mg/Nm^3	0	0	0

Power voltage	―	230V
Length of the power cable	―	25m Cable reel
Lengthh of the sampling hose	m	30m
The place of the instruments	―	right below
Lengthh of the sampling pipe	m	1.0m
Lengthh of the Pitot tube	m	4.0m
Reference	―	Dusty environment

(4) Summary of measurement results of Kosovo A-4 on 11th March (the 2nd mission)

Measurement Results of Exhasut gas at Kosovo A-3 TPP

11th Mar. 2016

Measurement point		A-3 outlet A duct	A-3 outlet B duct	A-3 outlet C duct
Wet Exhaust gas volume	Nm^3/h	491,000	420,000	470,000
Dry Exhaust gas volume	Nm^3/h	437,000	374,000	419,000
Gas velocity	m/s	28.5	24.0	26.9
Exhasut gas temperature	℃	192	188	187
Water content	%	10.9	10.9	10.9
Static pressure	kPa	-2.5	-2.0	-2.3
Composition(%)	CO2(%)	10.7	11.0	11.2
	O2(%)	10.3	9.0	8.8
	CO(ppm)	46	20	23
	N2(%)	79.0	80.0	80.0
Dust Content	g/Nm3	0.663	0.524	0.815
Dust Content (O2 at 6%)	g/Nm3	0.912	0.715	0.986
TEMP (Ave)	℃	194	212	194
O2(PG-350)(Ave)	%	10.1	10.0	8.6
CO2(PG-350)(Ave)	%	10.2	12.0	12.1
CO(PG-350)(Ave)	ppm	22	25	32
Nox(PG-350)(Ave)	ppm	220	231	217
	mg/Nm3	451	474	445
Nox O2 at 6%)	ppm	303	315	263
	mg/Nm3	621	646	538
SO2(PG-350)(Ave)	ppm	144	203	214
	mg/Nm3	412	581	612
SO2 O2 at 6%)	ppm	198	279	294
	mg/Nm3	567	799	842

Power voltage	―	230V
Length of the power cable	―	25m Cable reel
Lengthh of the sampling hose	m	30m
The place of the instruments	―	right below
Lengthh of the sampling pipe	m	1.0m
Lengthh of the Pitot tube	m	4.0m
Reference	―	Dusty environment

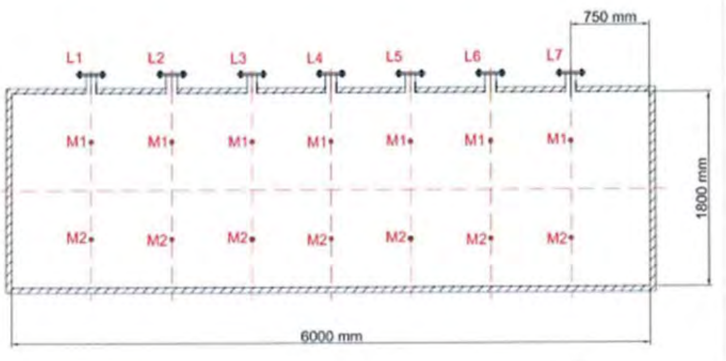
2-1-3 Measurement results of Kosovo A boiler (detailed data)

(1) Measurement points of Kosovo A boiler (same for A-3 and A-5)

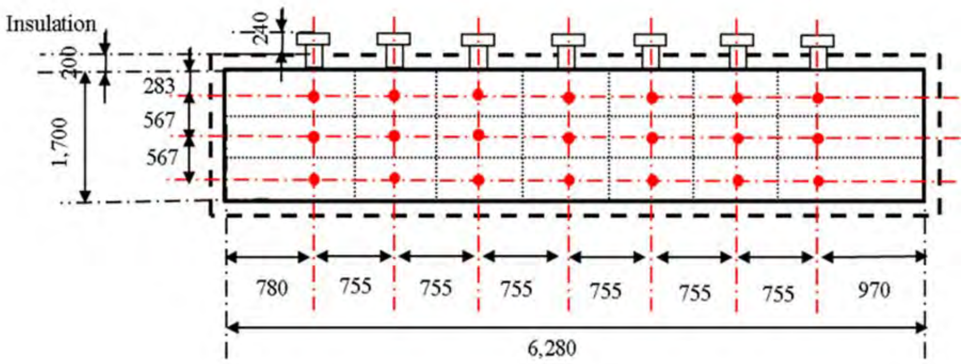
a) Measurement points of ESP inlet

Measured at horizontal duct (below is vertical cross-sectional view).

- The 1st mission



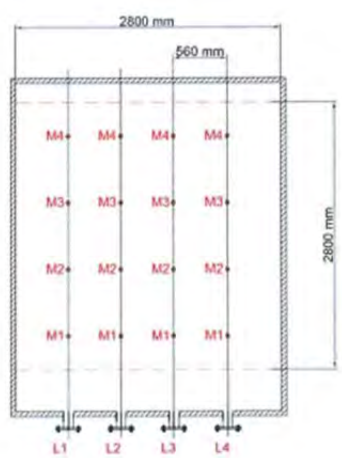
- The 2nd mission



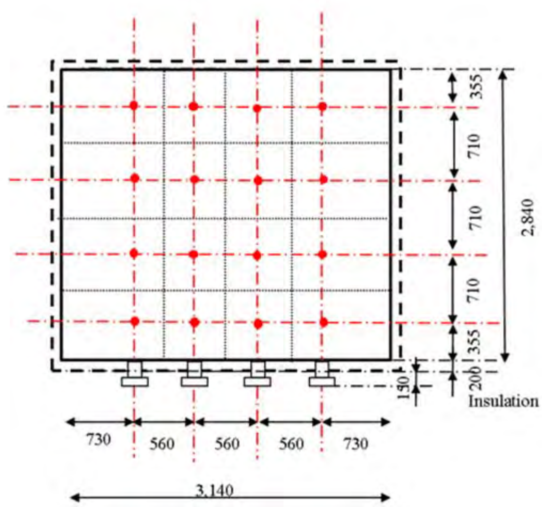
b) Measurement points of ESP outlet

Measured at vertical duct (below is horizontal cross-sectional view). The flow is downward. (The duct narrows in the downward direction. The following figure shows the measurement points.

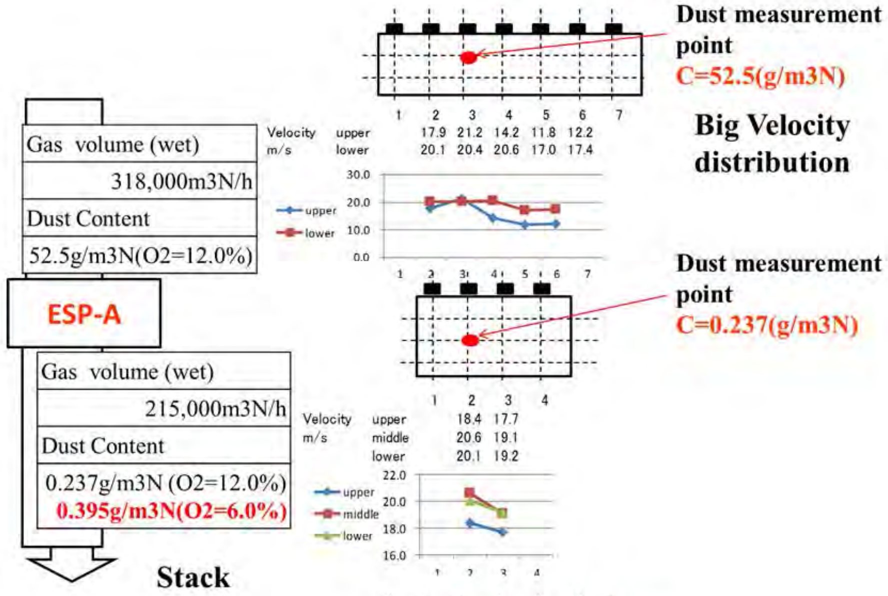
- The 1st mission

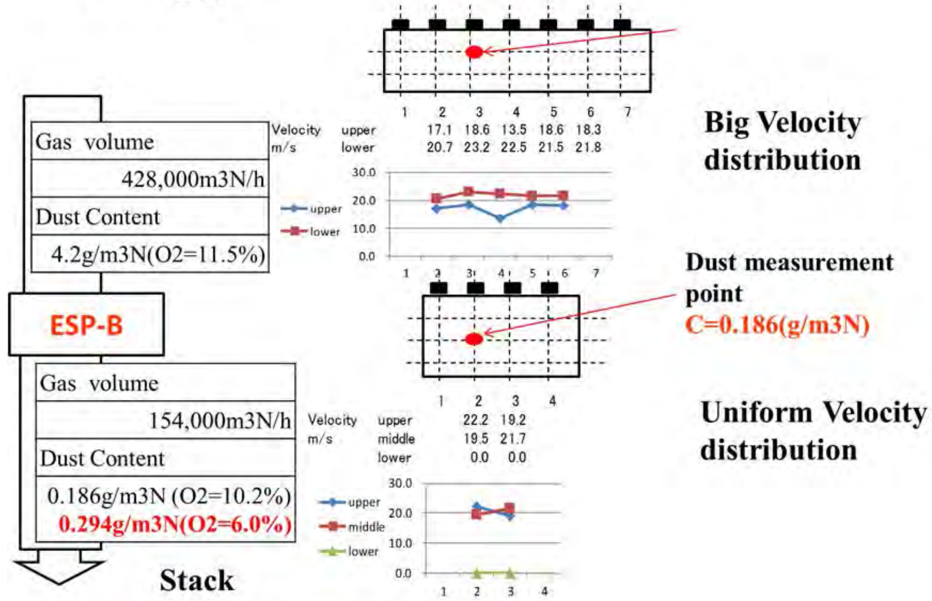


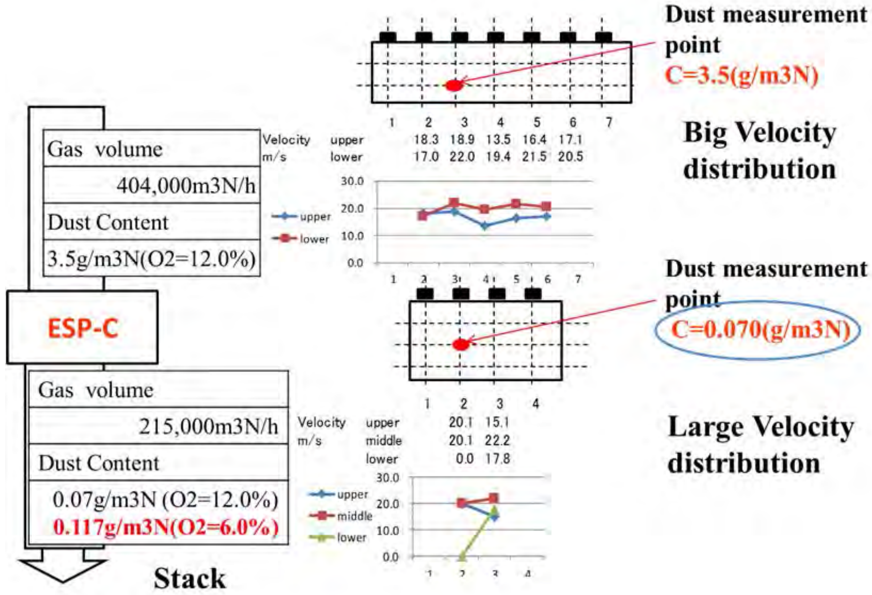
The 2nd mission



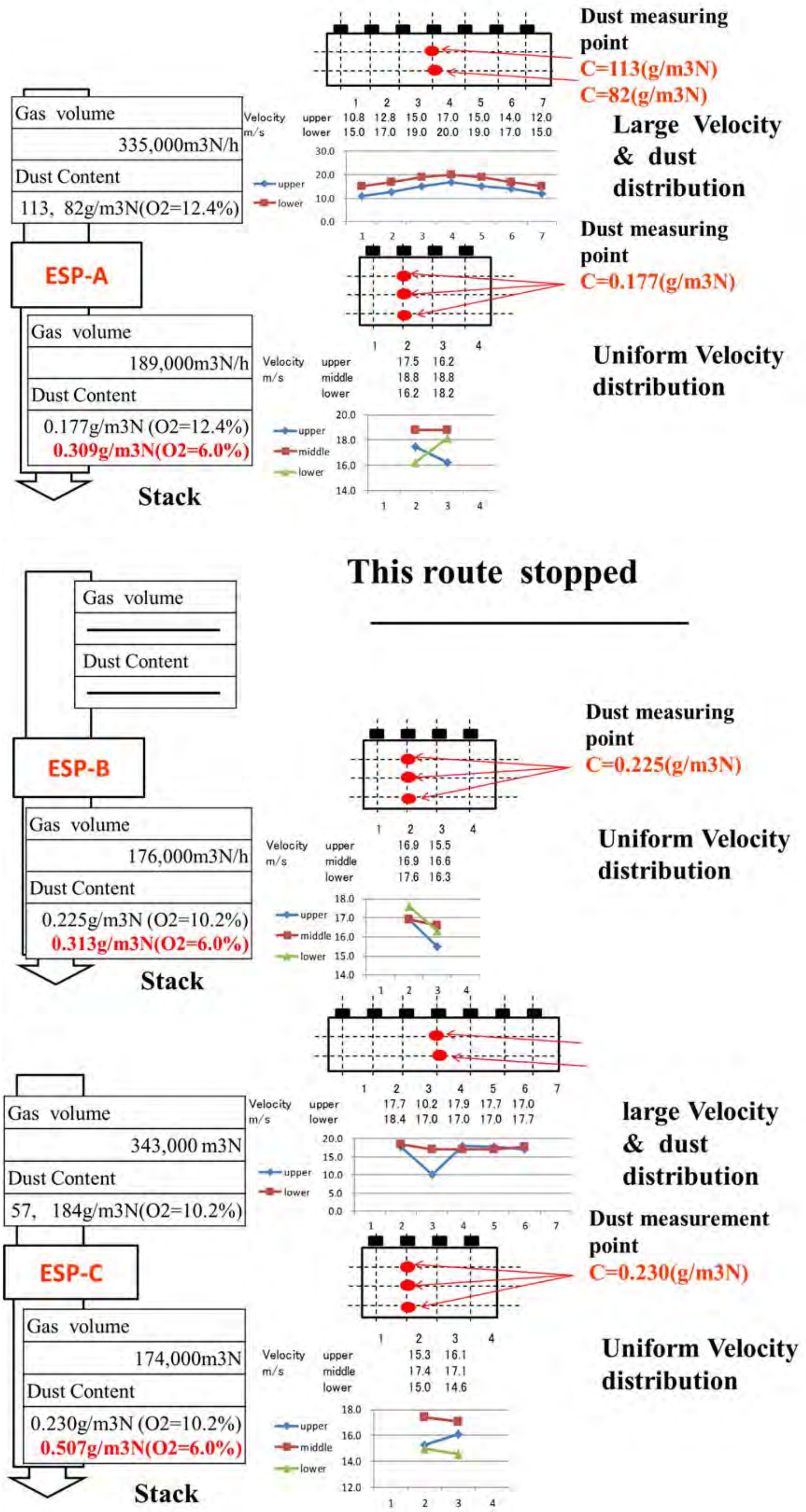
(2) Measurement results of Kosovo A-5 boiler 27th Ocotober (the 1st mission) 27th Oct. 2015





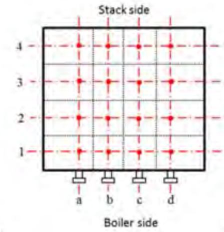


(3) Measurement results of Kosovo A-3 boiler 29th Ocotober (the 1st mission) 29th Oct. 2015



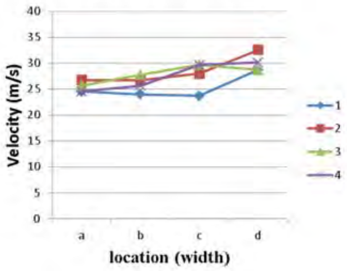
(4) Measurement results of Kosovo A-4 boiler 10th March (the 2nd mission) 10th Mar. 2016

ESP-A (A-4 Boiler)

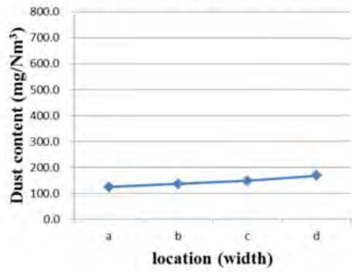


10th March 2016
Boiler
(coal: 240t/h at 10AM
230t/h at 2 PM)

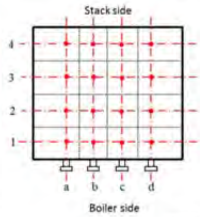
Velocity distribution



Dust distribution

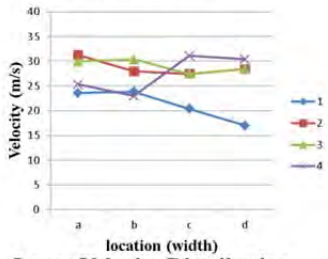


ESP-B (A-4 Boiler)



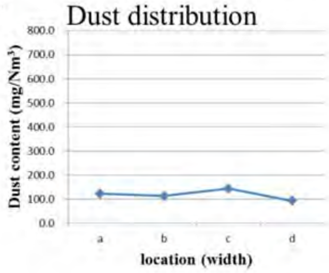
10th March 2016
Boiler
(coal: 240t/h at 10AM
230t/h at 2 PM)

Velocity distribution



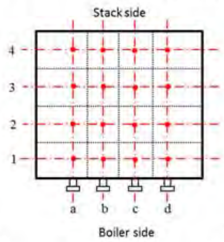
Large Velocity Distribution

Dust distribution



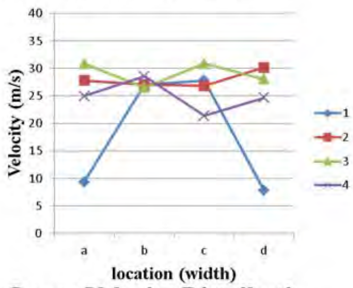
Uniform Dust Distribution

ESP-C (A-4 Boiler)



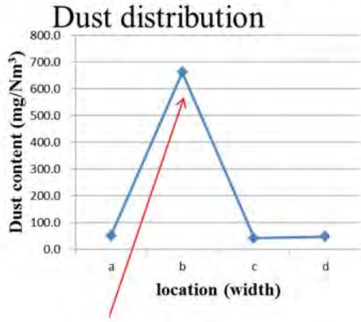
10th March 2016
Boiler
(coal: 240t/h at 10AM
230t/h at 2 PM)

Velocity distribution



Large Velocity Distribution

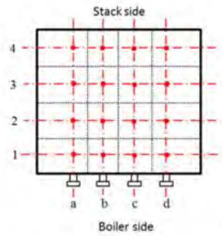
Dust distribution



Large value appears

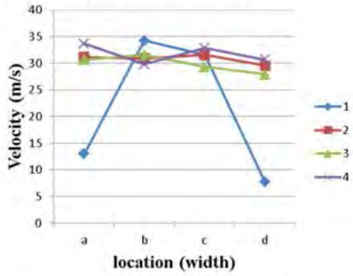
(5) Measurement results of Kosovo A-3 boiler 11th March (the 2nd mission) 11th Mar. 2016

ESP-A (A-3 Boiler)



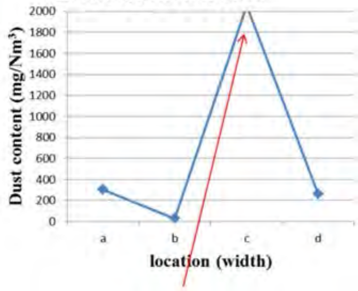
11th March 2016
Boiler
(coal: 225t/h at 10AM
220t/h at 2 PM)

Velocity distribution



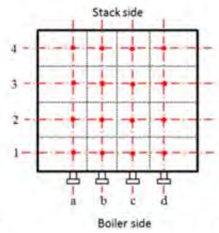
Large Velocity Distribution

Dust distribution



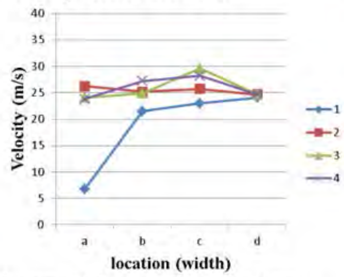
Large value appears

ESP-B (A-3 Boiler)



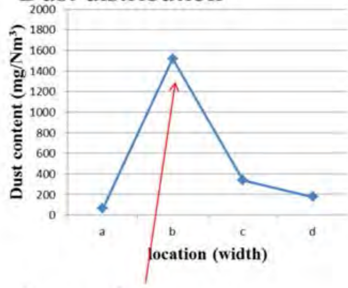
11th March 2016
Boiler
(coal: 225t/h at 10AM
220t/h at 2 PM)

Velocity distribution



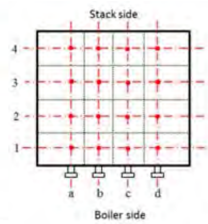
Large Velocity Distribution

Dust distribution



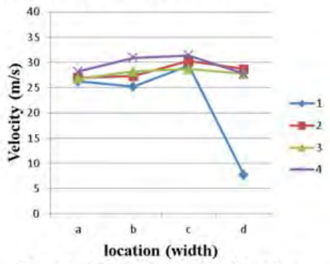
Large value appears

ESP-C (A-3 Boiler)



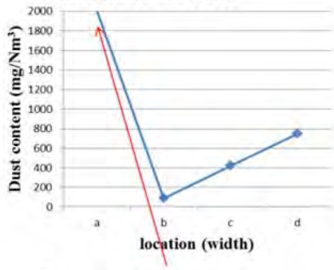
11th March 2016
Boiler
(coal: 225t/h at 10AM
220t/h at 2 PM)

Velocity distribution



Large Velocity Distribution

Dust distribution



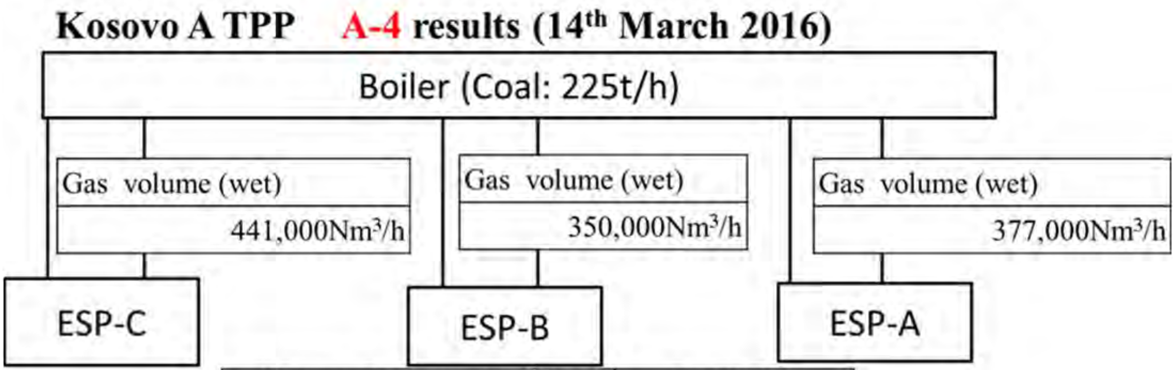
Large value appears

(6) Measurement results of Kosovo A-3 boiler 14th March (the 2nd mission)

The measurement of velocity distribution and exhaust gas volume at inlet of ESP was conducted only for A-4 boiler.

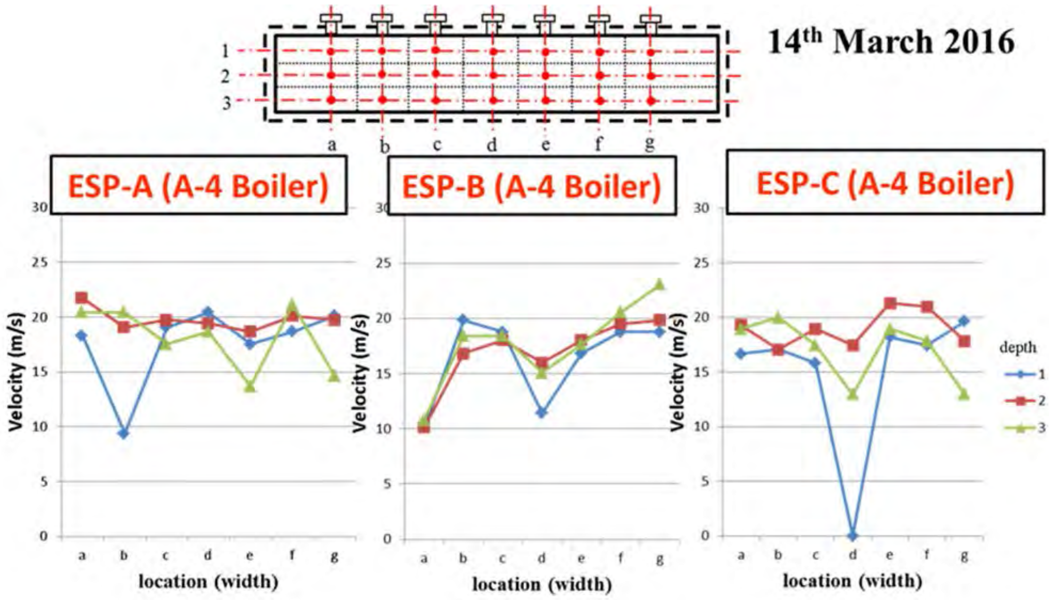
14th Mar. 2016

1) Exhaust gas volume (at inlet of ESP)

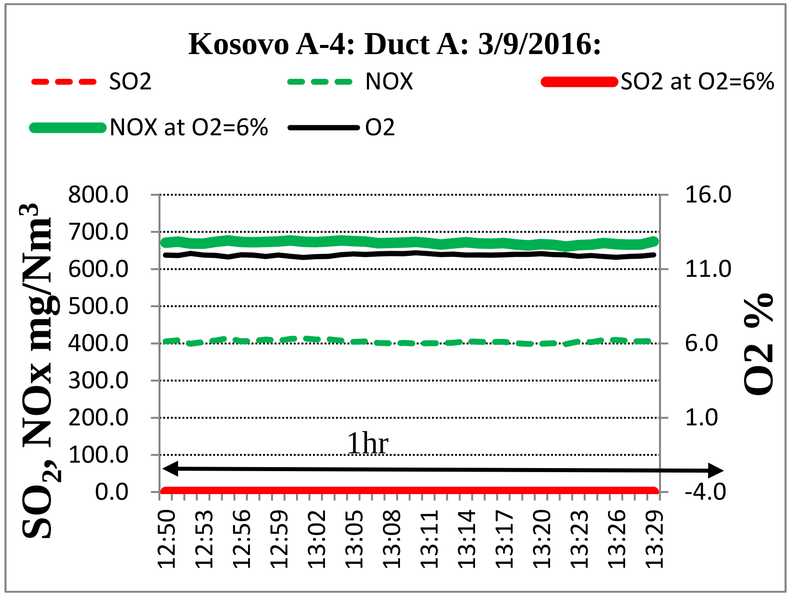


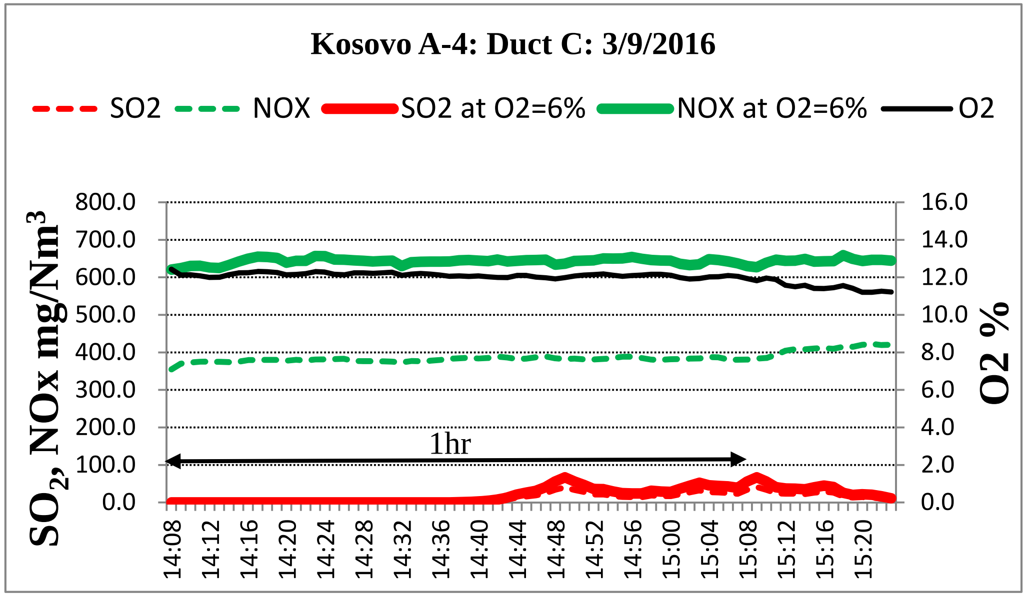
Wet gas Volume(Nm^3/h)	1,168,000
Dry gas Volume(Nm^3/h)	976,000
Temperature(℃)	187
Static pressure(kPa)	-2.0
O2 (%)	10.1

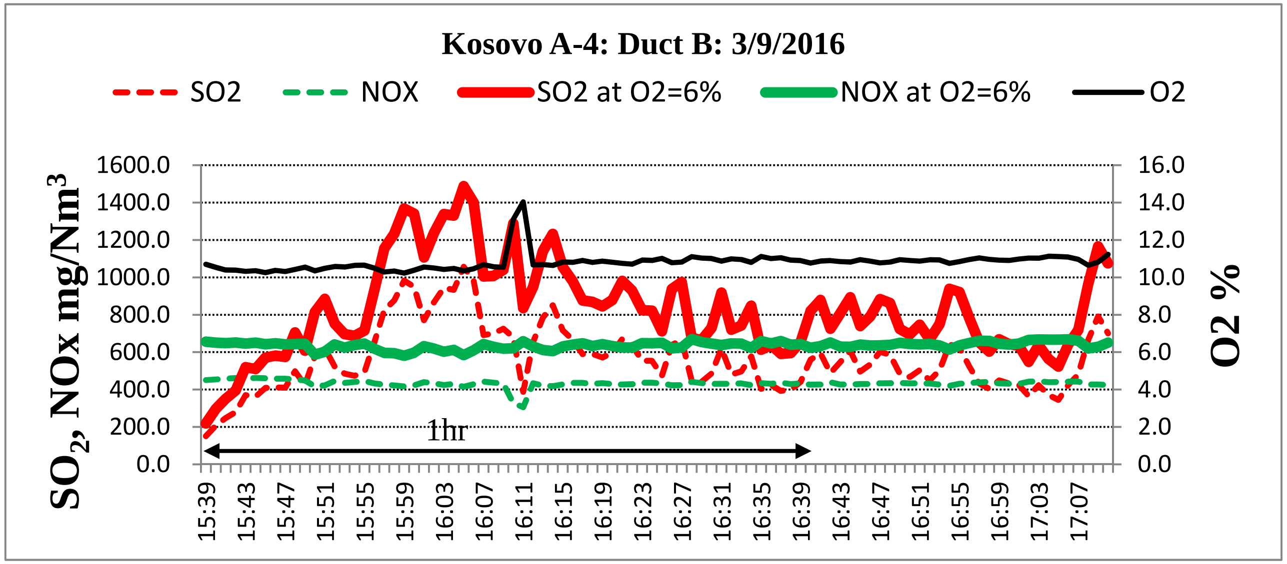
2) Velocity distribution(at inlet of ESP)

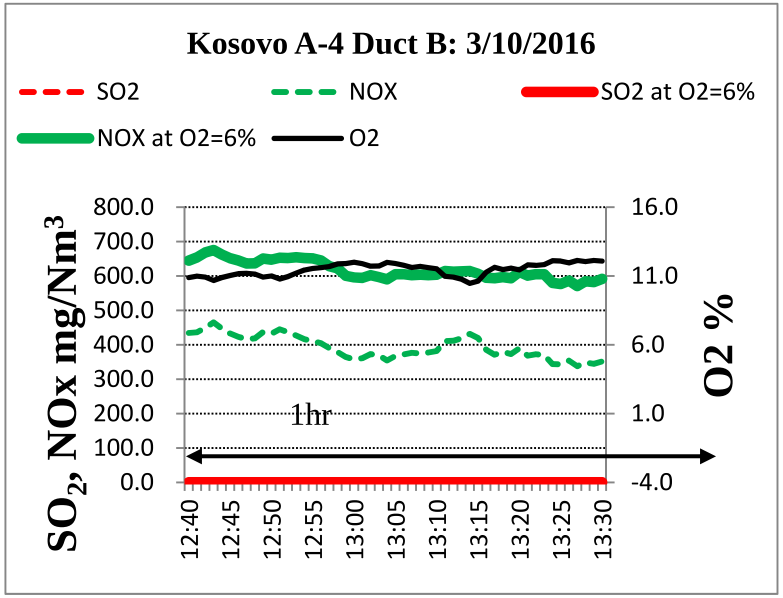


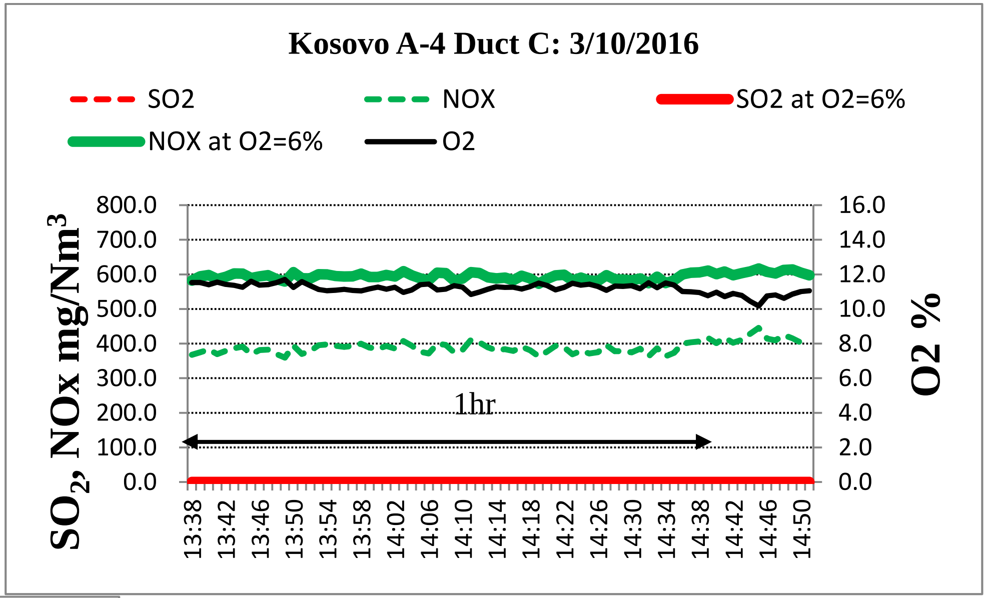
(7) Measurement results of SO_2, and NO_x in Kosovo A boiler (the 2nd mission) 9th Mar. 2016

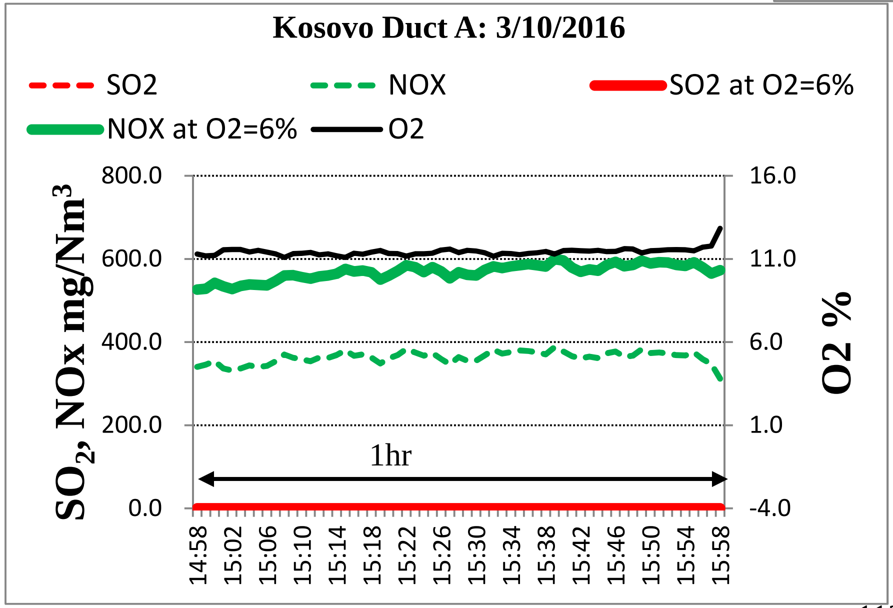




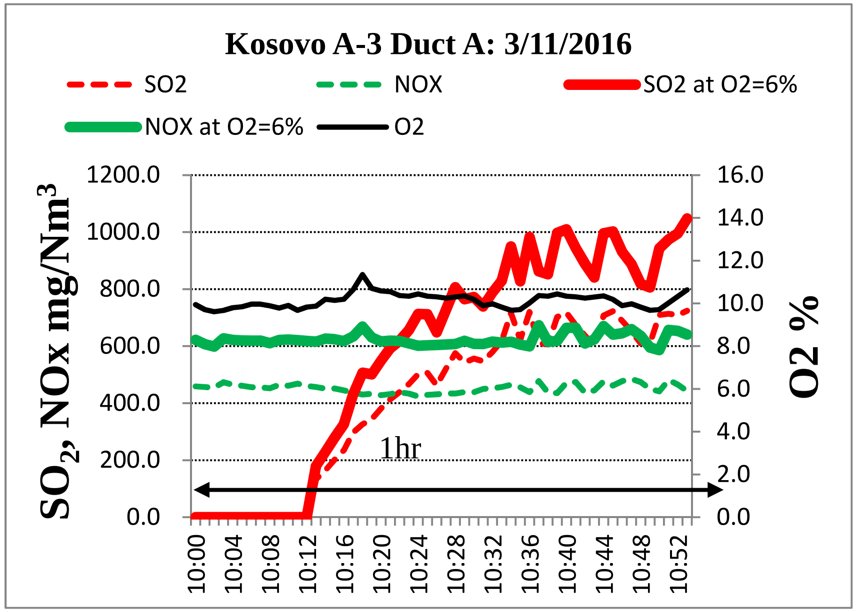


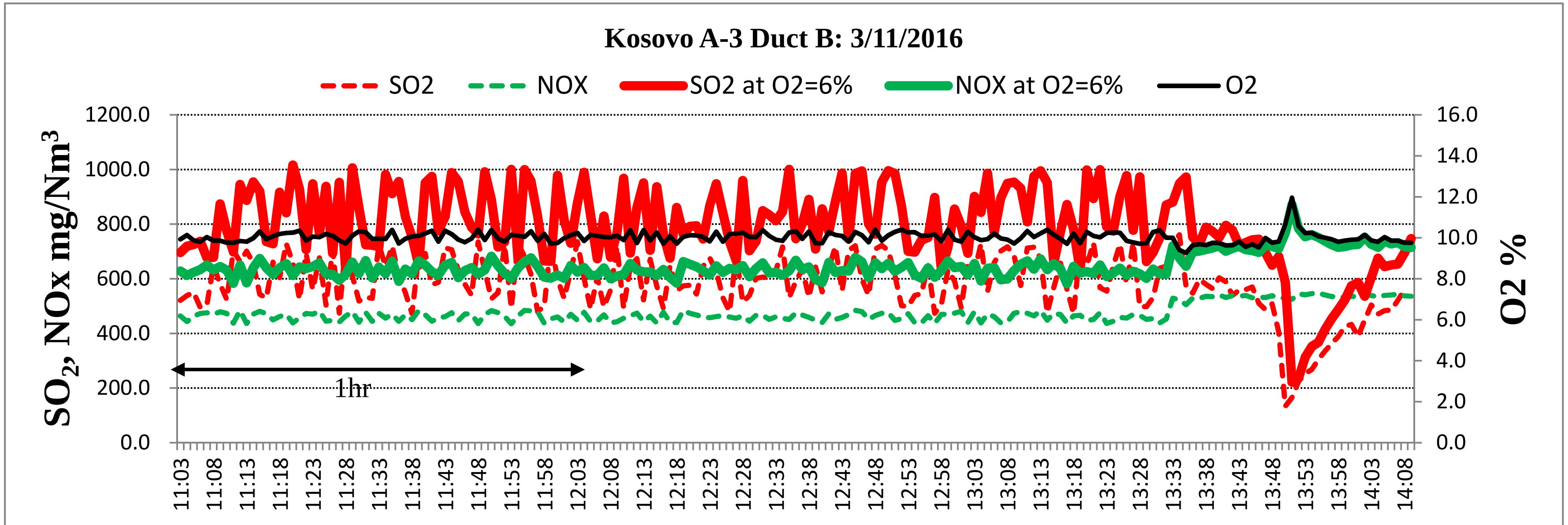

Kosovo A-4 Duct B: 3/10/2016
SO2
NOX
SO2 at O2=6%
NOX at O2=6%
O2
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
16.0
11.0
6.0
1.0
-4.0
1hr
SO2, NOx mg/Nm3
O2 %
12:40
12:45
12:50
12:55
13:00
13:05
13:10
13:15
13:20
13:25
13:30

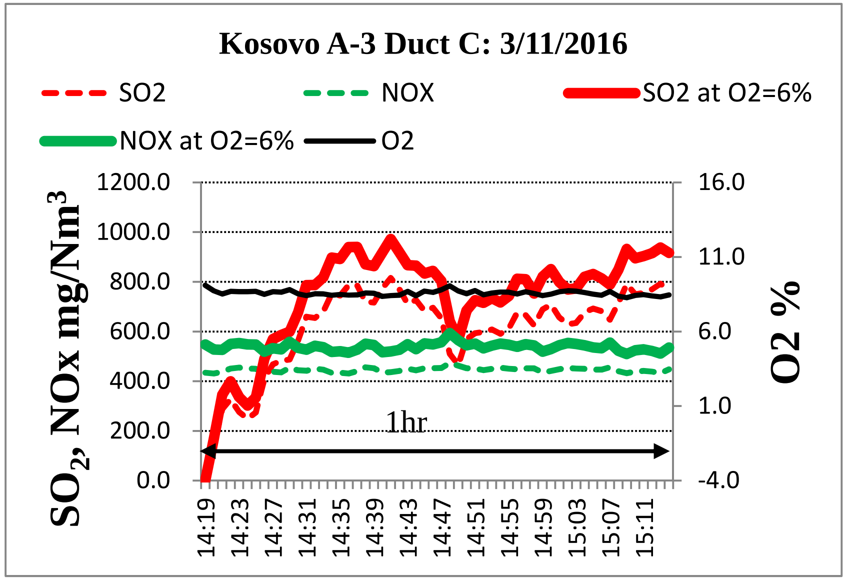

Kosovo A-4 Duct C: 3/10/2016
SO2
NOX
SO2 at O2=6%
NOX at O2=6%
O2
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
1hr
SO2, NOx mg/Nm3
O2 %
13:38
13:42
13:46
13:50
13:54
13:58
14:02
14:06
14:10
14:14
14:18
14:22
14:26
14:30
14:34
14:38
14:42
14:46
14:50

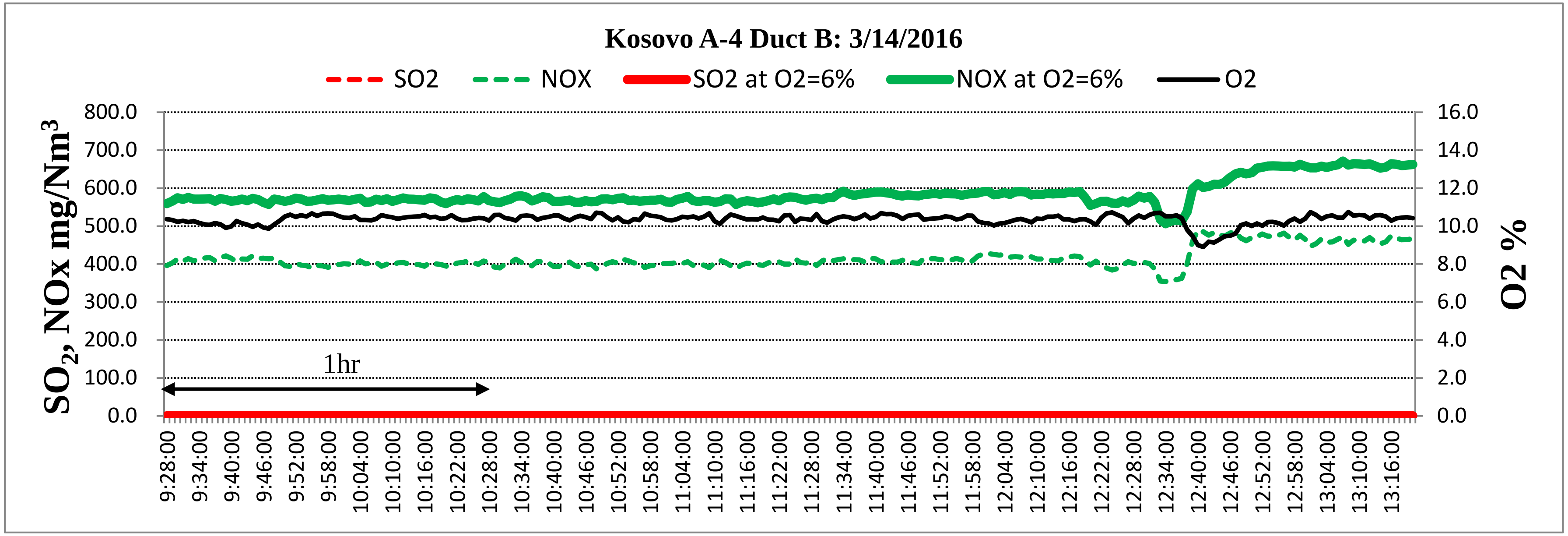

Kosovo Duct A: 3/10/2016
SO2
NOX
SO2 at O2=6%
NOX at O2=6%
O2
800.0
600.0
400.0
200.0
0.0
16.0
11.0
6.0
1.0
-4.0
1hr
SO2, NOx mg/Nm3
O2 %
14:58
15:02
15:06
15:10
15:14
15:18
15:22
15:26
15:30
15:34
15:38
15:42
15:46
15:50
15:54
15:58

11th Mar. 2016






Kosovo A-3 Duct C: 3/11/2016
SO2
NOX
SO2 at O2=6%
NOX at O2=6%
O2
1200.0
1000.0
800.0
600.0
400.0
200.0
0.0
16.0
11.0
6.0
1.0
-4.0
SO2, NOx mg/Nm3
O2 %
1hr
14:19
14:23
14:27
14:31
14:35
14:39
14:43
14:47
14:51
14:55
14:59
15:03
15:07
15:11


Kosovo A-4 Duct B: 3/14/2016
SO2
NOX
SO2 at O2=6%
NOX at O2=6%
O2
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
SO2, NOx mg/Nm3
O2 %
1hr
9:28:00
9:34:00
9:40:00
9:46:00
9:52:00
9:58:00
10:04:00
10:10:00
10:16:00
10:22:00
10:28:00
10:34:00
10:40:00
10:46:00
10:52:00
10:58:00
11:04:00
11:10:00
11:16:00
11:22:00
11:28:00
11:34:00
11:40:00
11:46:00
11:52:00
11:58:00
12:04:00
12:10:00
12:16:00
12:22:00
12:28:00
12:34:00
12:40:00
12:46:00
12:52:00
12:58:00
13:04:00
13:10:00
13:16:00

2-2 Measurement results of Kosovo B TPP

2-2-1 Operational data of Kosovo B boiler

(1) Operational data of Kosovo B-1 boiler on 3rd November (the 1st mission)

Boiler Operation Data (Kosovo B-1 boiler)

3rd Nov. 2015

	Item	Date / Time / Unit	3rd Nov. 11:00	3rd Nov 14:30
1	Power Generation	MW	282	290
2	Ambient Air Condition (Temp.)	℃	25.2	24.6
3	Main Steam Flow	T/h	844	878
4	Sat. Steam Flow	T/h	588	623
5	Spray Water Flow	T/h	240	240
6	Steam Temperature	℃	532	532
7	Steam Pressure	atg.	160	160
8	Feed Water Temperature	℃	243	248
9	Reheat Steam Temperature	℃	533	530
10	Reheat Steam Pressure	atg.	32.5	33.1
11	Coal Consumption	T/h	347	
12	Combustion Air Flow Rate	kNm^3/h	756	768
13	Furnace Pressure	mmH_2O	-6	-6
14	Economizer Outlet Pressure	mmH_2O	-113	-112
15	Precipitator Inlet Pressure	mmH_2O	-233	-227
16	Stack Inlet Pressure	mmH_2O	-58	-52
17	Hot Gas from Furnace	℃	788/837	751/807
18	Hot gas to Mill Temperature	℃	647	667
19	Air Heater Outlet Air Temperature	℃	298/301	310/304
15	Burner Inlet Air Temperature (Mill Outlet Temperature)	℃	180	180
16	Economizer Outlet Gas Temperature	℃	317	327
17	Precipitator Inlet Gas Temperature	℃	150/158	155/167
18	Precipitator Outlet Gas Temperature	℃	180/172	174/164
20	O_2 Content at Economizer Outlet	%	5.5/9.4	4.9/5.6
21	O_2 Content at Stack Inlet	%	13,7	
30	Dust Content (at Precipitator Inlet)	mg/Nm^3		
31	Dust Content (at Stack Inlet)	mg/Nm^3		

(2) Operational data of Kosovo B-1 boiler on 4th November (the 1st mission)

Boiler Operation Data (Kosovo B-1 boiler)

4th Nov. 2015

	Item	Date / Time / Unit	4th Nov. 10:20	4th Nov 14:15
1	Power Generation	MW	281	283
2	FDF Inlet Air Temp.	℃	29.6	34.0
3	Main Steam Flow	T/h	858	876
4	Sat. Steam Flow	T/h	573	580
5	Spray Water Flow	T/h	239	239
6	Steam Temperature	℃	530	528
7	Steam Pressure	bar	160	160
8	Feed Water Temperature	℃	248	249
9	Reheat Steam Temperature	℃	531	532
10	Reheat Steam Pressure	bar	33	34
11	Coal Consumption	T/h	-	-
12	Combustion Air Flow Rate	kNm^3/h	697	-
13	Furnace Pressure	mmH_2O	-6	-3
14	Economizer Outlet Pressure	mmH_2O	-113/-105	-110/-107
15	Precipitator Inlet Pressure	mmH_2O	-231/-220	-227/-217
16	Stack Inlet Pressure	mmH_2O	-62	-53
17	Hot Gas from Furnace	℃	786/743	791/700
18	Hot Gas to Mill Temperature	℃	661	741
19	Air Heater Outlet Air Temperature	℃	299	304
15	Burner Inlet Air Temperature (Mill Outlet Temperature)	℃	177	179
16	Economizer Outlet Gas Temperature	℃	209/320	213/322
17	Precipitator Inlet Gas Temperature	℃	154/160	160/166
18	Precipitator Outlet Gas Temperature	℃	177/166	183/172
20	O_2 Content at Economizer Outlet	%	4.9/10.3	4.0/10.0
21	O_2 Content at Stack Inlet	%	-	-
30	Dust Content (at Precipitator Inlet)	mg/Nm^3		
31	Dust Content (at Stack Inlet)	mg/Nm^3		

(3) Operational data of Kosovo B-2 boiler on 16th March (the 2nd mission)

Boiler Operation Data (Kosovo B-2 boiler)

16th Mar. 2016

	Item	Date / Time / Unit	16th Mar.	16th Mar.
			10:00	14:00
1	Power generation	MW	297	292
2	FDF Inlet Air Temp.	℃	19.4/17.2	20.5/18.4
3	Main Steam Flow	T/h	910	901
4	Sat. Steam Flow	T/h	680	646
5	Spray Water flow	T/h	107	153
6	Steam Temperature	℃	542	531
7	Steam Pressure	bar	156	152
8	Feed Water Temperature	℃	250	248
9	Reheat Steam Temperature	℃	538	538
10	Reheat Steam Pressure	bar	35.7	34.7
11	Coal Consumption	T/h	336	334
12	Combustion Air Flow Rate	kNm^3/h	796	807
13	Furnace Pressure	mmH$_2$O	-10	-9
14	Economizer Outlet Pressure	mmH$_2$O	-114/-91	-114/-92
15	Precipitator Inlet Pressure	mmH$_2$O	-311/-308	-309/-287
16	Stack Inlet Pressure	mmH$_2$O	-55/0	-48/0
17	Hot Gas from Furnace	℃	688/708	720/752
18	Hot gas to Mill Temperature	℃	460	473
19	Air Heater outlet Air Temperature	℃	280	279
20	Burner Inlet Air Temperature (Mill outlet Temperature)	℃	182/196/180 174/180	165/184/173 179/178
21	Economizer Outlet Gas Temperature	℃	318/319	314/314
22	Precipitator Inlet Gas Temperature	℃	151/150	146/149
23	Precipitator Outlet Gas Temperature	℃	173/148	169/147
24	O_2 Content at Economizer Outlet	%	~~19.9~~/4.7	~~19.9~~/5.3
25	O_2 Content at Stack inlet	%		
26	Dust Content (at Precipitator inlet)	mg/Nm^3		
27	Dust Content (at Stack inlet)	mg/Nm^3		
28	SOX Content (at Stack inlet)	ppm		
29	NOX Content (at Stack inlet)	ppm		
30	CO Content (at Stack inlet)	ppm		

(4) Operational data of Kosovo B-2 boiler on 17th March (the 2nd mission)

Boiler Operation Data (Kosovo B-2 boiler)

17th Mar. 2016

	Item	Date / Time / Unit	17th Mar	17th Mar
			10:00	12:40
1	Power generation	MW	297	295
2	FDF Inlet Air Temp.	℃	21.6/18.8	22.0
3	Main Steam Flow	T/h	906	897
4	Sat. Steam Flow	T/h	630	646
5	Spray Water flow	T/h	196	
6	Steam Temperature	℃	538	527
7	Steam Pressure	bar	156	157
8	Feed Water Temperature	℃	250	250
9	Reheat Steam Temperature	℃	538	538
10	Reheat Steam Pressure	bar	36.4	
11	Coal Consumption	T/h	370	365
12	Combustion Air Flow Rate	kNm^3/h	788	820
13	Furnace Pressure	mmH_2O	-7	-9
14	Economizer Outlet Pressure	mmH_2O	-107/-85	-115
15	Precipitator Inlet Pressure	mmH_2O	-302/-279	-
16	Stack Inlet Pressure	mmH_2O	-56/0	-55
17	Hot Gas from Furnace	℃	788/735	
18	Hot gas to Mill Temperature	℃	441	473
19	Air Heater outlet Air Temperature	℃	289	279
20	Burner Inlet Air Temperature (Mill outlet Temperature)	℃	185/179/183 182/173/180	165/184/173 179/178
21	Economizer Outlet Gas Temperature	℃	325/325	316
22	Precipitator Inlet Gas Temperature	℃	155/156	
23	Precipitator Outlet Gas Temperature	℃	178/152	174
24	O_2 Content at Economizer Outlet	%	~~19.9~~/4.5	5.3
25	O_2 Content at Stack inlet	%		
26	Dust Content (at Precipitator inlet)	mg/Nm^3	NA	
27	Dust Content (at Stack inlet) O2=6%	mg/Nm^3	713	
28	SOX Content (at Stack inlet) O2=6%	ppm	450～750	
29	NOX Content (at Stack inlet) O2=6%	ppm	690～720	

2-2-2 Summary of measurement data of Kosovo B-1 boiler

(1) Measurement results of Kosovo B-1 boiler on 3rd and 4th November (the 1st mission)

Measurement Results of Exhaust gas at Kosovo B-1 TPP

3rd and 4th Nov. 2015

		3rd Nov.		4th Nov.	
Measurement point		B-1 Inlet-1	B-1 Outlet-2	B-1 Inlet-2	B-1 Outlet-2
Wet Exhaust Gas Volume	Nm^3/h	627,000	695,000	366,000	352,000
Dry Exhaust Gas Volume	Nm^3/h	575,000	637,000	307,000	295,000
Gas Velocity	m/s	6.8	14.7	4.1	7.5
Exhaust Gas Temperature	℃	171	173	187	177
Water Content	%	8.3	8.3	16.2	16.2
Static Pressure	kPa	-2.3	-2.9	-2.9	-2.4
Composition (%)	CO_2 (%)	12.4	12.4	12.0	12.0
	O_2 (%)	8.2	8.2	8.0	8.0
	CO (ppm)	38	38	46	46
	N_2 (%)	79.4	79.4	80.0	80.0
Dust Content	g/Nm^3	39.258	0.366	32.256	0.135
Dust Content at O_2 = 6%	g/Nm^3	46.005	0.429	37.218	0.155
Detection tube (NO_x)	ppm	500		500	
NO_x (NO_2) at O_2 = 6%	mg/Nm^3	1,203 (586ppm)		1,185 (577ppm)	
Detection Tube (SO_2)	ppm	100		0	
SO_2 at O_2 = 6%	mg/Nm^3	293 (117ppm)		0 (0ppm)	

(2) Measurement results of Kosovo B-2 boiler on 16th and 17th March (the 2nd mission)

Measurement Results of Exhasut gas at Kosovo B-2 TPP

16th and 17th Mar. 2016

Measurement Date		17th Mar.	16th Mar.
Measurement point		B-2-2 outet duct	B-2-2 outet duct
Wet Exhasut gas volume	Nm^3/h	1,100,000	1,150,000
Dry Exhasut gas volume	Nm^3/h	836,000	1,060,000
Gas velocity	m/s	21.0	21.1
Exhasut gas temperature	℃	180	161
Water content	%	24.1	7.7
Static pressure	kPa	-3.3	-3.5
Composition (%)	CO_2 (%)	13.2	12.0
	O_2 (%)	7.1	8.4
	CO (ppm)	57	54
	N (%)	79.7	79.6
Dust Content	g/Nm^3	2.578	0.660
Dust Content (O2 at 6%)	g/Nm^3	3.021	0.908
TEMP (Ave)	℃	181	163
O2(PG-350)(Ave)	%	8.2	10.1
CO2(PG-350)(Ave)	%	12.7	10.5
CO(PG-350)(Ave)	ppm	47	41
Nox(PG-350)(Ave)	ppm	296	259
	mg/Nm^3	607	531
Nox (O2 at 6%)	ppm	347	356
	mg/Nm^3	711	731
SO2(PG-350)(Ave)	ppm	188	134
	mg/Nm^3	538	383
SO2(O2 at 6%)	ppm	220	184
	mg/Nm^3	630	527

Power voltage	―	230V	230V
Length of the power cable	―	25m Cable reel	25m Cable reel
Lengthh of the sampling hose	m	30m	30m
The place of the instruments	―	right below	right below
Lengthh of the sampling pipe	m	1.0m	1.0m
Lengthh of the Pitot tube	m	4.0m	4.0m
Reference	―	Dusty environment	Dusty environment

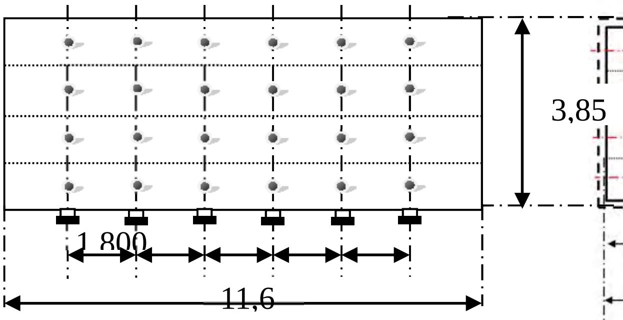
2-2-3 Measurement results of Kosovo B-1 boiler (detailed data)

(1) Measurement points of Kosovo B-1 boiler

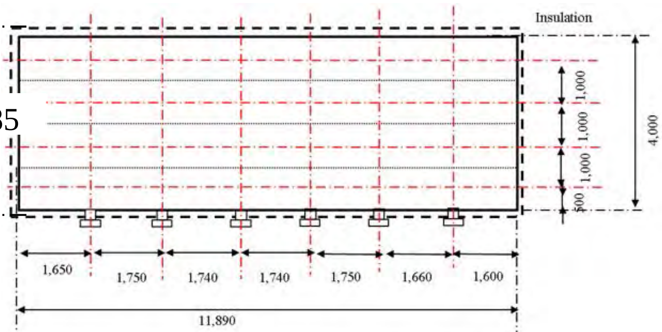
a) Measurement points of ESP inlet

Measured at inclined duct (approx. 20°) (below is vertical cross-sectional view). Flows are upward.

➢ The 1st mission



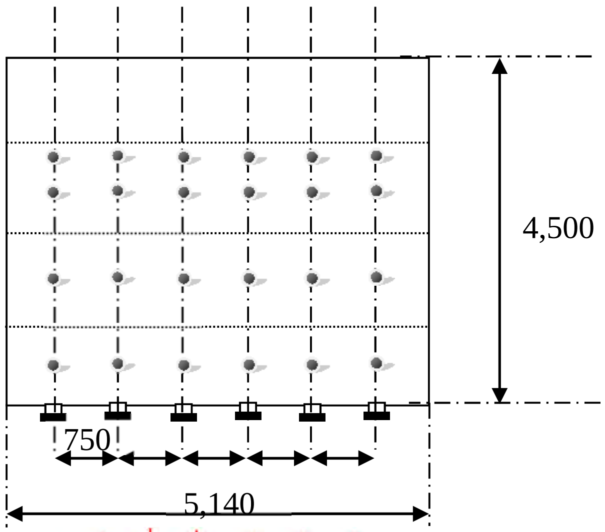
The 2nd mission



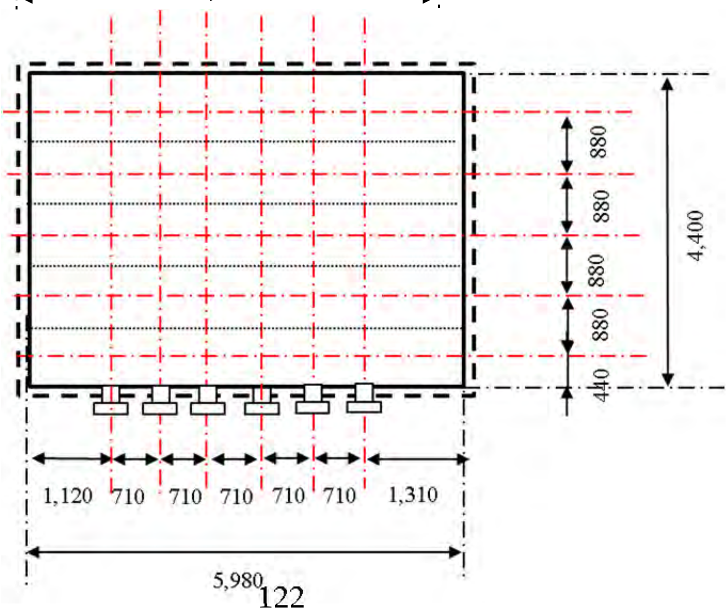
b) Measurement points of ESP outlet

Measured at vertical duct (below is horizontal cross-sectional view). Flows are downwards. The Pitot tube was not long enough to reach the deepest measurement points.

➢ The 1st mission



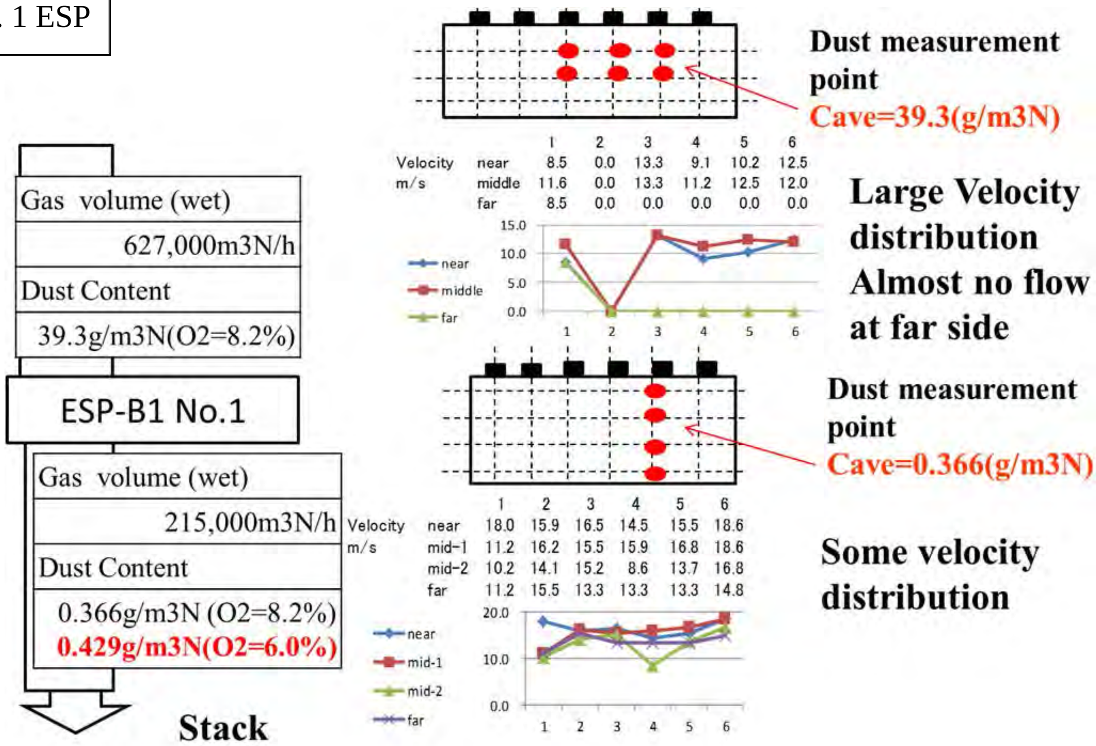
➢ The 2nd mission



(2) Measurement results of Kosovo B-1 boiler on 3rd and 4th November (the 1st mission)

3rd and 4th Nov. 2015

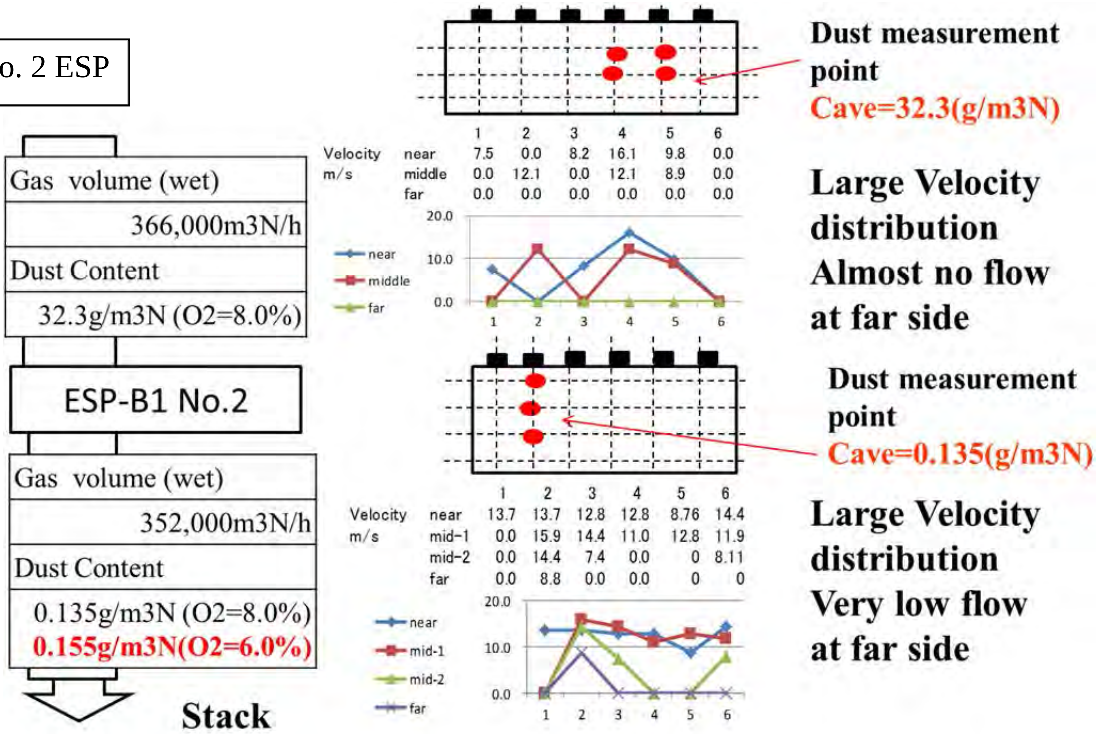
No. 1 ESP



Velocity m/s		1	2	3	4	5	6
	near	8.5	0.0	13.3	9.1	10.2	12.5
	middle	11.6	0.0	13.3	11.2	12.5	12.0
	far	8.5	0.0	0.0	0.0	0.0	0.0

Velocity m/s		1	2	3	4	5	6
	near	18.0	15.9	16.5	14.5	15.5	18.6
	mid-1	11.2	16.2	15.5	15.9	16.8	18.6
	mid-2	10.2	14.1	15.2	8.6	13.7	16.8
	far	11.2	15.5	13.3	13.3	13.3	14.8

No. 2 ESP

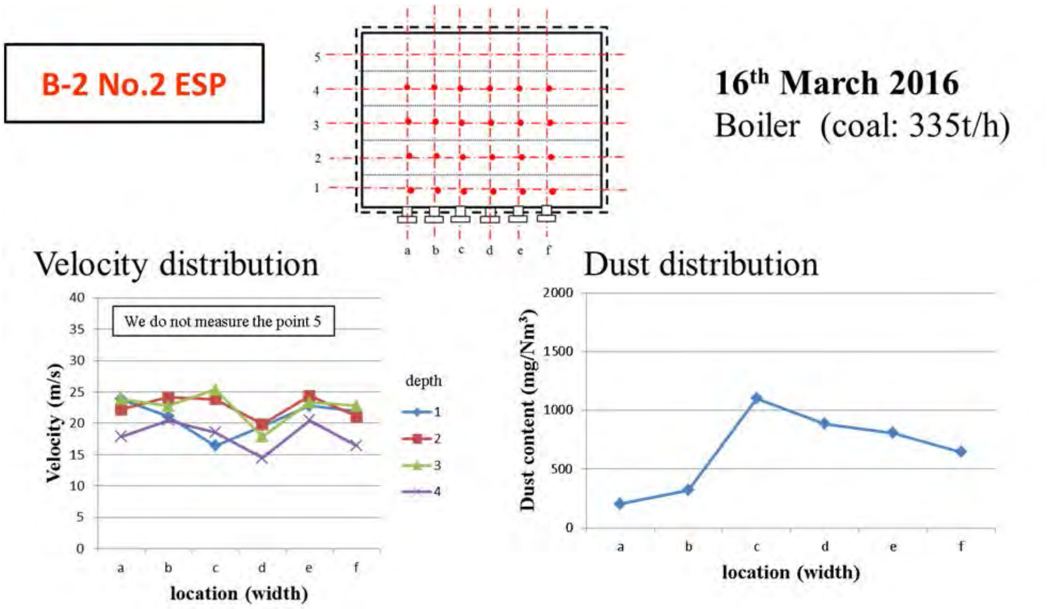


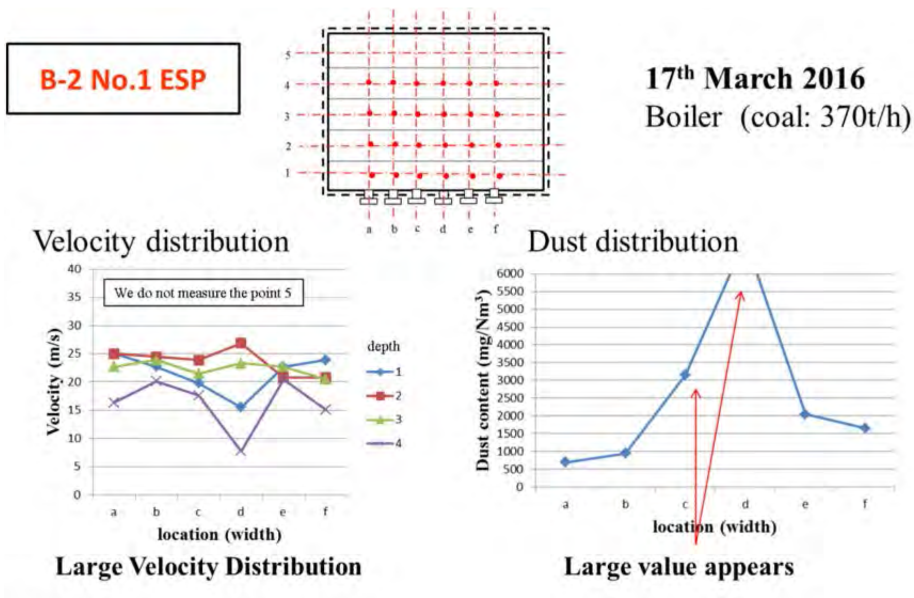
Velocity m/s		1	2	3	4	5	6
	near	7.5	0.0	8.2	16.1	9.8	0.0
	middle	0.0	12.1	0.0	12.1	8.9	0.0
	far	0.0	0.0	0.0	0.0	0.0	0.0

Velocity m/s		1	2	3	4	5	6
	near	13.7	13.7	12.8	12.8	8.76	14.4
	mid-1	0.0	15.9	14.4	11.0	12.8	11.9
	mid-2	0.0	14.4	7.4	0.0	0	8.11
	far	0.0	8.8	0.0	0.0	0	0

(3) Measurement results of Kosovo B-2 boiler on 16th and 17th March (the 2nd mission)

16th and 17th Mar. 2016



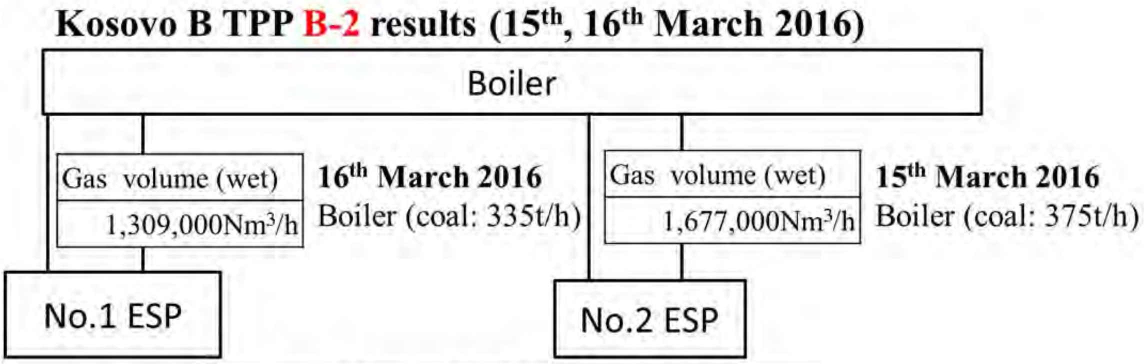


(4) Measurement results of Kosovo B-2 boiler on 16th and 17th March (the 2nd mission)

The measurement of velocity distribution and exhaust gas volume at inlet of ESP was conducted for B-2 boiler.

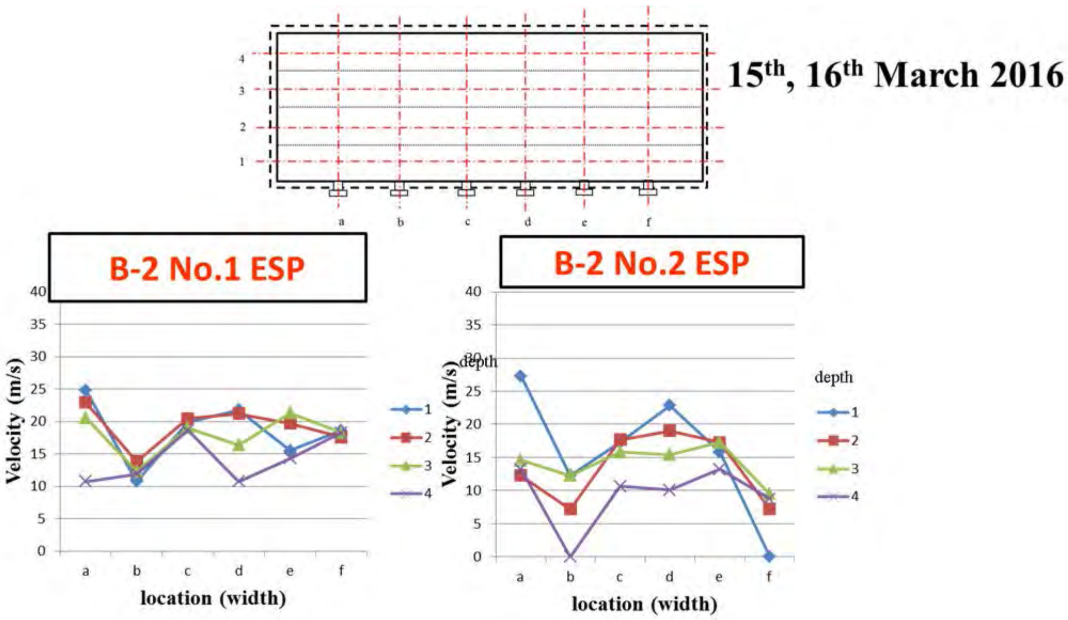
1) Exhaust gas volume (at inlet of ESP)

16th and 17th Mar. 2016



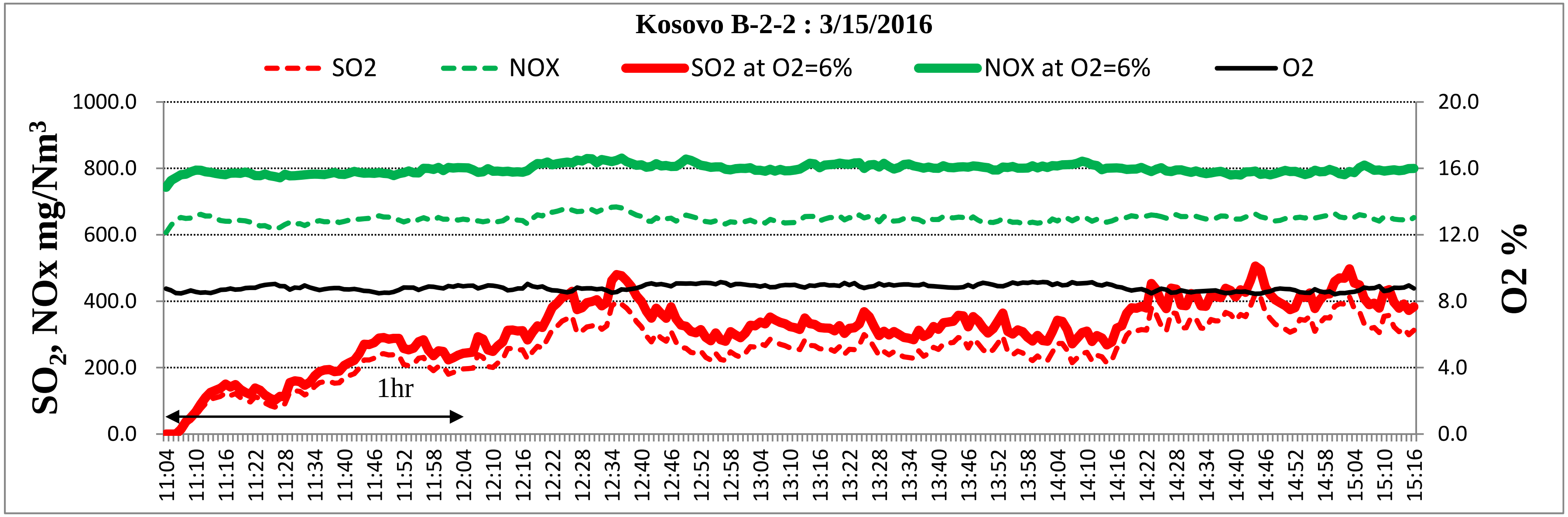
Wet gas Volume(Nm^3/h)	2,986,000
Dry gas Volume(Nm^3/h)	2,744,000
Temperature(℃)	167
Static pressure(kPa)	-3.0
O2 (%)	8.4

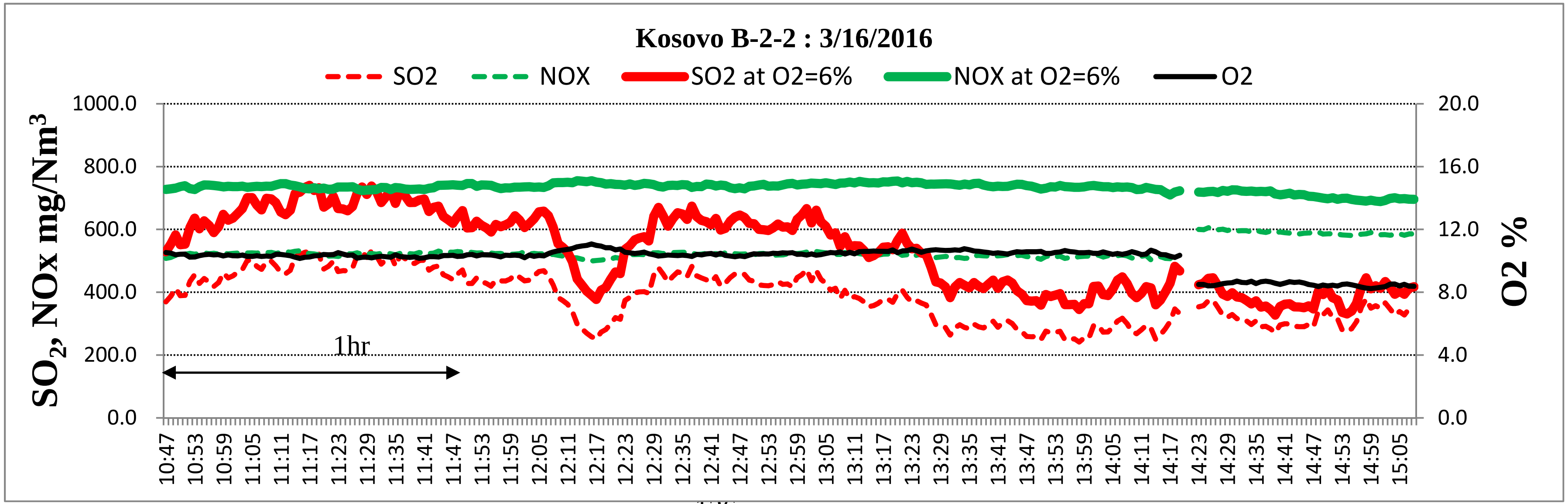
2) Velocity distribution(at inlet of ESP)



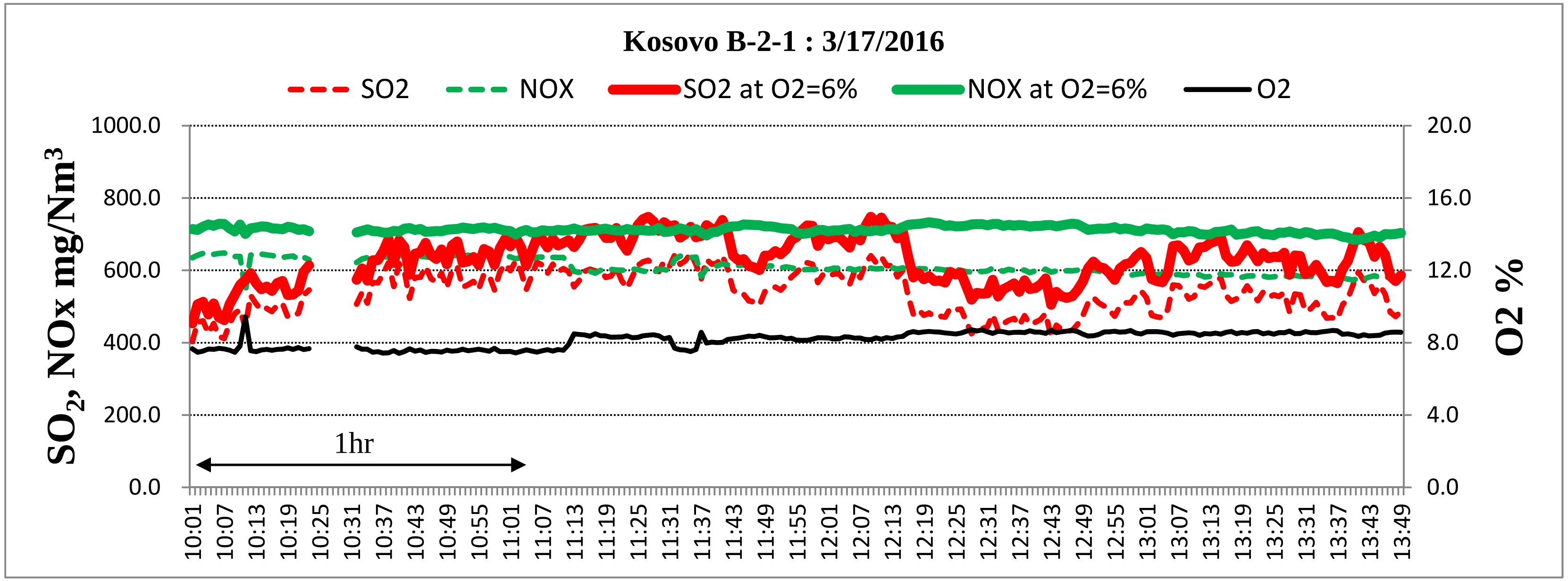
(5) Measurement results of SO_2, NO_x in Kosovo B-2 boiler (the 2nd mission)

15th and 16th Mar. 2016





17th Mar. 2016



Attached Document-3 MOU

REPUBLIKA E KOSOVËS - REPUBLIKA KOSOVA - REPUBLIC OF KOSOVO
QEVERIA E KOSOVËS - VLADA KOSOVA - GOVERNMENT OF KOSOVO
MINISTRIA E MJEDISIT DHE PLANIFIKIMIT HAPËSINOR
MINISTARSTVO SREDINE I PROSTORNOG PLANIRANJA
MINISTRY OF ENVIRONMENT AND SPATIAL PLANNING
Njësia Org. / Org. Jedinica / Org. Unit: 30 Nr. Prot: / Broj Prot: / Prot. No.: 1526/16
Nr i faqeve / Br. Stranica: / Data: / Datum: / Date: 31/03/2016
Prishtinë

MINUTES OF UNDERSTANDING

BETWEEN

JAPAN INTERNATIONAL COOPERATION AGENCY ~~EXPERT TEAM~~

AND

MINISTRY OF ENVIRONMENT AND SPATIAL PLANNING

OF REPUBLIC OF KOSOVO

FOR

"EXPERT FOR AIR POLLUTION CONTROL JFY 2015"

With respect to the signing of MOU in 2015 between Japan International Cooperation Agency (hereinafter referred as "JICA"), and the Ministry of Environmental and Spatial Planning (hereinafter referred as "MESP"), the JICA Expert Team (hereinafter referred as "JET") visited the Republic of Kosovo (hereinafter referred as "Kosovo") from Oct. 19th 2015 to Nov. 11th 2015 and Mar. 7th 2016 to Mar. 31st 2016..

During its stay in Kosovo, Experts carried out activities about on-site stack gas measurement for existing Thermal Power Plant (hereinafter referred as "TPP"), enlightenment to achieve ELVs in the Thermal Power Plant and strengthening of the knowledge of related organizations, strengthening of the ability of MESP to grasp existing conditions in LCP toward developing NERP, and workshops.

JICA Head Office mission (Mr. Taizo Yamada) joined the workshop discussion on March 29th.

Thorough these activities, Experts and MESP confirmed the items described in the attached sheet.

Pristina, March 30th 2016

Mr. Masuto SHIMIZU Leader of the JICA ExpertTeam JFE Techno-Research Corporation	Mr. Arben ÇITAKU General Secretary, Ministry of Environment and Spatial Planning
山田 泰造 Witnessed by Mr. Taizo Yamada JICA Head Office Mission Senior Adviser (Environmental Management) Japan International Cooperation Agency (JICA)	Mr. Muhamet MALSIU Director, Environmental Protection Department, Ministry of Environment and Spatial Planning

ATTACHMENT

JET appreciated very much the Kosovo Side's enthusiasm for JET to execute all scheduled activities planned in both 1st and 2nd mission, and JET extremely appreciated the assistance to their activities.

The results and issues based on this mission activities and the future direction are discussed as follows.

1. Results and issues derived from this mission
   a. MESP and related authorities and organizations (hereinafter referred as "Kosovo Side"). and JET confirmed that Dust concentrations in exhaust gas from the boilers of both Kosovo A TPP and Kosovo B TPP by far exceed the Emission Limit Values (hereinafter referred as "ELVs") defined in Directive 2010/75/EC of the European Parliament and of the council (hereinafter referred as "EC Directive").
      - Both Kosovo Side and JET confirmed that these dust concentration values also by far exceed the specification of Electrostatic Precipitator (hereinafter referred as "ESP").
      - In addition, JET let MESP understand that the dust meter installed in the boilers does not show a reliable value (calibration has not been accomplished).
   b. JET conducted the measurement of SO_2 and NO_X by using the automated gas analyzer for both Kosovo A TPP and Kosovo B TPP. Both Kosovo Side and JET confirmed the following:
      - NO_X showed a stable value of 700 ~ 800 mg/Nm^3 (reference O_2=6%).
      - SO_2 showed a fluctuation from 0 to 1,000 mg/Nm^3 (reference O_2=6%).
   c. Both Kosovo Side and JET confirmed that the Continuous Emission Monitoring System (hereinafter referred as "CEMS") installed in Kosovo B TPP has a problem with the location problem for maintenance as well as calibration.
      - CEMS is installed at the position of 90m of the stack where the access is very hard for the maintenance man.
      - Calibration of CEMS must be conducted at the position close to CEMS according to EC Directive. In particular, the dust meter must be calibrated by the isokinetic dust measurement method. It is hard and dangerous to handle instruments in this location.

      Furthermore, the point where JET conducted measurement in this mission in Kosovo A TPP and Kosovo B TPP were not appropriate, because the measurement results were not uniform, as this was not a representative measurement point.

      Because of the above-mentioned situation, both Kosovo Side and JET agreed to install new measurement points for both Kosovo A TPP and Kosovo B TPP which are envisaged to be a representative point.
   d. Both Kosovo Side and JET agreed that the technology transfer of on-site stack gas measurement was not sufficient. The acquisition of emission data was set as a priority in the mission, upon the request from MESP for NERP elaboration. Kosovo Side requested more training about technology transfer of on-site stack gas measurement.
   e. MESP (Kosovo Environmental Protection Agency/Kosovo Hydro-meteorological Institute) expects

Jilly A.G. y M.S.

to use Ion Chromatograph method as a reference method of on-site stack gas measurement for SOx and NOx. However, Ion Chromatograph requires adjustment and operational instructions.

Furthermore EC directive demands measurement of mercury in the exhaust gas which requires sampling and analysis technology.

2. Future direction based on these results and issues

The underlined parts in the following articles are strongly requested by the Kosovo Side to be addressed urgently, in order to sustain the Kosovo Side's efforts initiated by the JET activities.

a. Kosovo Side and JET agree that present measurement points are not appropriate, and there is a need to install other measurement points for future on-site stack gas measurement. These measurement points must be confirmed as representative by conducting on-site stack gas measurement.

   It is important to specify the representative measurement points, not only for monitoring and reporting of emission data to Energy Community, but also for studying in order to find out the mechanism related to the fluctuation of dust and SO_2 concentration in exhaust gas. The most appropriate dust and SO_2 reduction measures can be designed based on such a study.

   It is strongly recommended to find a representative measurement point and prepare for its measurement arrangement before starting next step to study behavior of dust and SO_2.

b. CEMS is required to be installed at an appropriate position in order to monitor and report emissions to Energy Community. Kosovo B TPP has a CEMS which monitors dust, SO_2 and NO_X, but the location of measurement point is problematic for operation and maintenance of the equipment. It is necessary to secure an appropriate place for operation (measurement)

c. Present ESP does not show the projected capacity, as it is affected by many factors (exhaust gas temperature, exhaust gas volume, heterogeneity of gas flow, etc.). In order to confirm the present condition of ESP, it is required to analyze lignite and fly ash and to study boiler operation at the same time, which will lead to the study of the cause of low dust collection efficiency. This study contributes to the evaluation of proper and effective measures to achieve ELVs, and furthermore it will become the base data for deciding on specification of ESP reinforcement.

d. Reduction of SO_2, NO_X is as follows;

   - NO_X shows a stable value of 700 ~ 800 mg/Nm^3 (reference O_2=6%). It is indispensable to evaluate the introduction of low NO_X burner.
   - The fact that SO_2 sometimes shows the value of 0 mg/Nm^3 suggests that the in-furnace desulfurization occurs in the boiler. Utilization of this phenomenon can provide an effective measure for reduction of SO_2. The study of factors of influence to this phenomenon (percentage of CaO, combustion temperature, O_2 concentration in combustion area, etc.) can enable to evaluate effective and economic improvement or reinforcement for desulfurization.
   - The study of the relation among SO_2 fluctuation, the property of Lignite, fly ash and boiler operation is very important to design measures for desulfurization.
   - It is immediately required to collect data of chronological changes (at least one month for both

Kosovo A and Kosovo B) of how SO_2 is fluctuating. This enables the analysis of the mechanism of this SO_2 phenomena in the future, leading to the design of the most optimized desulphurization process.

e. At the workshops, JET introduced not only the probable dust, SO_2, NO_X reduction methods but also the necessary attention while applying these methods. In case of introduction of emission control technology to the boilers, it is important not only to know the present emission values but also to understand Lignite quality and features of the boiler in order to design appropriate measures and specifications.

f. MESP has not yet conducted on-site stack gas measurement by themselves. More instructions and experience is required to master this technology. MESP has set a priority for KHMI and Environmental Inspectorate to master this technology, but also Kosovo Energy Corporation (hereinafter referred as "KEK") is interested to take part in this process.

g. KHMI is in possession of the Ion Chromatograph, however they do not have the necessary experience to utilize it. KHMI needs to use the Ion Chromatograph as a reference method for on-site stack gas measurement and JICA support is necessary at this point. The use of the Ion Chromatograph method requires the following:

  - Ion Chromatograph method requires training of sampling and instructions for operation
  - In order to operate the Ion Chromatograph, one week is required for the set-up and adjustment of its instruments
  - Training for operation requires two weeks.

h. Measurement of the mercury in the exhaust gas requires sampling and analysis technology.

  - KHMI has instruments and the experience for analyzing mercury
  - KHMI can provide reagents but needs a sampling technology and its instruments.

i. KHMI request to analyze components in the dust by using Ion Chromatograph. However, JET has explained that priority in analysis by Ion Chromatograph shall be placed on the issues related to the EC Directive limited only to NO_X, and SO_2 measurement.

j. In addition to air pollution control issues, KEK requests environmental management of the Power Plants as a whole. The JICA Head Office Mission responded that the air pollution control aspects are included in the MESP request already for JICA's consideration, but other environmental management aspects of TPPs shall be a separate request in future for which JICA's interest is unknown.

k. MESP strongly requests continuity of JICA Experts for future JICA assistance, because JET in this mission is familiar with not only conditions and the situation in Kosovo A TPP, and Kosovo B TPP, as well as the technical ability of each counterpart for both preparation and issues in next project.

l. JICA Head Office Mission will convey the Kosovo Side's requests above discussed to examine any possible supports in the requested technical cooperation project in 2015 - Capacity Development Project for Pollution Control for Major Emission Sources and relevant preparatory activities in 2016.

- End -