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EFFECT OF COAL COMPOSITION ON SO_2 EMISSIONS FROM KOSOVIAN POWER PLANTS

DP/YUG/87/020
11-01

The Socialist Federal Republic of Yugoslavia

Expert Report* (19 September - 5 October 1988)

Prepared for the Government of Yugoslavia by the United Nations Industrial Development Organization acting as executing agency for the United Nations Development Programme

Based on the work of Mr. S.C. WALIN, Expert in the monitoring & control of atmospheric emissions of SO_2 from coal-fired power station boilers (19 September - 5 October 1988) to YUGOSLAVIA

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United Nations Industrial Development Organization Vienna

2

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<u>**CONTENTS**</u>

		Page No.
1.	INTRODUCTION	3
2.	DIARY OF VISITS AND MEETINGS	4
3.	DISCUSSION	8
4.	APPARATUS AND EQUIPMENT, FELLOWSHIPS, TRAINING, VISITS AND ACTIVITY	10
	4.1 Apparatus and Equipment	10
	4.1.1 Instruments/Equipment for the Measurement of Source Emissions Using a Mobile Laboratory	11
	4.2 Fellowships, Training and Activity	13
	4.2.1 Key to Bar Chart Activity	13
	4.2.2 Fellowships and Training	14
5.	SAMPLING PROGRAMME	16
	5.1 Boiler Fuel	16
	5.2 Boiler Operating Conditions	17
	5.3 Boiler Emissions	17
	5.3.1 Flue Gas Composition	17
	5.3.2 Ash and Slag	17
6.	MONITORING DATA IN TERMS OF ENVIRONMENTAL IMPACT AND OCCUPATIONAL HYGIENE	17
	6.1 Assessment of Risk from Recurring Emissions	17
7.	CONCLUSIONS AND RECOMMENDATIONS	18
8.	REFERENCES	20
APPENDIX A.	United Nations Industrial Development Organisation Job Description	A1

1. INTRODUCTION

In the autonomous province of Kosovo there is a large open cast lignite mining operation at Obilic near the capital city of Pristina. Associated with this source of fossil fuel are two electricity generating stations, a gasification plant and a fertilizer factory. To provide scientific and technical support for the Electric Power industry of Kosovo the Institute for Research and Development (INKOS), which is located adjacent to one of the power plants, has been functioning in its present form since 1979. INKOS is a small institute (about 100 total staff) and covers a wide range of disciplines including mining and mineral processing, chemical engineering, electric power generation and environmental science.

One of the two projects set up by UNIDO to strengthen the facilities and expertise of INKOS is described in Appendix A, and its objectives for the present mission given as follows:

Project DP/YUG/87/020

The expert will execute the following tasks in co-operation with the Institute for Research and Development (INKOS), in the Scoialist Autonomous Province of Kosovo:

1. Advise INKOS staff on, and participate in the preparation of a detailed work plan for the activities to be undertaken within the scope of project DP/YUG/87/020. This will include:

   - Preparation of neutral technical specifications for project equipment, (instrumentation for atmospheric pollution monitoring and analysis).

   - Suggest potential host institutions for the proposed fellowships and study tours and advise on the content of the training programmes.

   - Advise INKOS on the tasks, which should be undertaken by the project's International Experts and, where possible, suggest possible candidates to fill these posts.

   - Preparation of a realistic schedule of activities and assignment of start dates and durations for each activity.

2. Provide technical guidance to project staff on:

- Sulphur capture in ash during coal combustion in utility PF boilers.

- Equipment and methods for monitoring SO_x concentration in stack gases (source monitoring).

- Transport and dispersion of SO_2 in the atmosphere.

3. Prepare a report in English, setting out the achievements of the mission, (particularly those of paragraph 1, above), for the concerned national authorities, UNDP and UNIDO.

At this stage in the report it should be appreciated that although the present study and DP/YUG/87/019 have separate objectives in certain areas such as the environment, Figure 1, and also in the laboratory facilities, there is a commonality of interest. Furthermore, both missions were undertaken during the same time period and at some meetings the two projects were both under discussion. However, it is essential to report the two missions separately, but where appropriate cross references will be made to items relevant for both projects.

2. DIARY OF VISITS AND MEETINGS

As already pointed out there are some common features to the two projects therefore for the two reports paragraph 1 (except for the objectives) and paragraph 2 are identical. The subsequent paragraphs in the report will be specific to each project.

19.9.88

DAY 1 Briefing session at UNIDO Vienna. Owing to the postal strike in the UK it was necessary to visit Ms Ann Emery, Ms L Taylor and Ms Draxler to complete the administrative procedures. Full technical briefing was received from Mr R O Williams.

DAY 2 Flight to Belgrade

DAY 3 Briefing session at UNDP Belgrade. Background information to the work in Kosovo was given by the Programme Officer - Caroline Heider. Administrative requirements were also dealt with by Ms Heider.

I was given a copy of the general description of the gasification plant at Obilic, which I promised to return after completion of the mission. Ms Heider asked me to forward some general articles on important environmental issues which I agreed to do.

The flight from Belgrade to Pristina was delayed and being met at the airport by Mr B Jonuzi and Mr M G Jockie very much appreciated.

DAY 3 Visited INKOS. Meeting with Dr Slobodan Djekie (engineer business board), Dr Januz Zeqa (chief chemist?), Mr Basri Jonuzi (department of environmental protection), Mr Milan Jockie (Department of environmental protection) and Prof Alajdin Abazi (president of business board). Prof Abazi was introduced but owing to another concurrent meeting could not stay.

A general review of the Institute's activities was presented and I indicated areas of my own and other research and development work relevant to the situation at Obilic.

Following the meeting to prepare an itinerary of visits a short presentation on the significance of emissions and immissions (the concentrations at receptors in the ambient atmosphere) was made. Options were considered on the way to determine emissions from stationary sources.

DAY 4 Dialogue with Mr Januzi and Mr Jockie covered INKOS activities at the power stations, gasification and fertilizer plants. The facilities relevant to the projects were examined and included:

A mobile laboratory for the measurement of ambient concentrations of gases viz O_3 (Bendix 8002); SO_2 (Monitor Labs 8450) - 2 modules; NO_x (Bendix 8440) - 2 modules; CO (Bendix 8501); Environmental Chromatograph (Bendix 8270); Dynamic Calibration System (Bendix 8852) and Air Purification System (Bendix 8833). The Laboratory was not in operational condition owing to no span gases being available (but are on order).

Equipment for measuring particulate emissions at source by an extractive method included a Ströhlein dust collection system and an 'in-stack' Andersen impactor.

The analytical facilities within INKOS are rather limited, but cover basic instruments and equipment such as atomic absorption, reflux and extraction units, calorimeters and spectrographs.

In addition one Andersen (General Metal Works Inc) Hi-Vol sampler for determining ambient particle concentrations is available.

26.10.88

DAY 5 Visits to Kosovc 'A' and Kosovo 'B' Power Plants.

Figure 2 indicates the location of the two power plants and Figure 3 the local topography and river Sitnica.

The director of 'A' station is Mr Janakovic and the total complement of his staff numbers about 1700. There are five steam boilers burning lignite as a fuel and generating the following nominal outputs:

A1	65 MW	Installed	1962
A2	125 MW	"	1965
A3	200 MW	"	1969
A4	200 MW	"	1971
A5	200 MW	"	1975

Each boiler has its own stack with discharge heights of A1-A5 of 90, 96, 106, 106 and 120 metres respectively. A general inspection of the plant covered the combustion systems, boilers, steam turbines, electrostatic precipitators and ash/clinker disposal. Facilities for sampling emissions and general instrumentation were also inspected.

The annual consumption of lignite is of the order of 3.8 Mte at the 'A' station.

The 'B' station employs a staff of about 1000 and the director is

Mr F Nahi. There are two steam boilers, burning lignite as a fuel, each unit with a nominal output of 339 MW (boiler B1 installed in 1983 and B2 in 1984). The flue gas from the two boilers feeds into a common stack with a discharge height of 200 metres. Sampling positions were examined as well as the general instrumentation of the boiler plant.

DAY 6 Visit to Gasification and Fertilizer Plant

The first discussion was with the director of the fertilizer plant (Mr Mitat) and directors of the gasification plant (Mr Djerlek and Mr Restelica). Unfortunately the two plants were not working owing to problems with the steam plant supplying process steam for the gasifier and other technical difficulties.

Production of gas has an installed capacity of 400×10^6 Nm^3/year and present production is about 120,000 Nm^3/year. The targetted capacity of the fertilizer plant is 250,000 tonnes/year and 120,000 tonnes/year achieved. It is necessary to receive ammonia from another source to keep fertilizer production at its present level owing to difficulty with the NH_3 synthesis plant.

Problem areas were identified as the gasification and fertilizer plants together with suitable sampling points for potential pollutants. Although the gasification plant was not operational, at certain locations on the site residual H_2S and mercaptans were evident. Methodologies for sampling at the sites were also considered.

DAY 7 Discussion with technical staff at INKOS on the plant visited and the questions posed in my mind. Reports of interest to the technology[1-6] were presented and those produced by INKOS[7] studied.

DAY 8 The requirements for equipment, fellowships and training were established and where possible specified. Work programmes were identified and a timetable for activity prepared.

DAY 9 A review of all the INKOS activities was held at the institute and I prepared network and activity charts. A visit was made to the Pristina University library to obtain information on local topography and sites of interest to the project.

DAY 10 Visited gasification plant because one gasifier unit was coming on stream.

Returned to INKOS and presented network and activity charts.

DAY 11 Obtained further combustion information from the chief engineer of Kosovo 'A' power station. Presented a verbal and outline written report to the Director and staff of the Institute.

DAY 12 Flight from Pristina to Belgrade and Belgrade to Vienna.

DAY 13 Debriefing session with Mr R O Williams.

DAY 14 Completed debriefing in the morning and returned to the UK in the afternoon.

3. DISCUSSION

The present mission has raised a number of issues regarding the two power plants (Kosovo A and B stations) and these will be considered in order of process activity. The lignite is a low grade fuel and its composition and combustion characteristics have a wide range, Table 1 giving the essential properties as fired. Crushed lignite 5 mm is presented to the mill which is swept by hot recirculated gas from the upper part of the vertical combustion chamber. It is reported that all the lignite is pulverised to 100 um but no measurements are made on the mill performance to verify this.

All the boilers operate with dry bottom ash removal and direct tangential firing. The boilers at the 'A' station appeared to operate at 10% O_2 and at 'B' station 5% O_2. Combustion with the higher excess air is likely to increase not only fouling in the furnace but also in the superheater and secondary reheater. In my view more attention should be given to the combustion conditions, e.g. temperature and oxygen control, to minimise fouling due to high temperatures and ensure good carbon burn-out by maintaining an adequate temperature. Reported fires in the electrostatic precipitator at 'A' station could be the result of low combustion temperatures. Co-firing with a small percentage of gas (uncleaned) could have a beneficial effect on combustion, facilitate the boilers operating nearer their rates output and reduce problems downstream.

TABLE 1. - Analysis of Lignite

Parameter	From	To	Typical
Proximate analysis (%)			
Moisture	34.4	50.3	45.0
Ash	9.9	34.5	19.0
C-fixed	11.2	15.8	12.0
Volatile matter	16.8	28.2	24.0
Lower heating value, KJ/kg	4350	9420	7500
Ultimate analysis (%)			
Hydrogen	0.9	2.6	2.2
Carbon	19.8	28.4	21.6
Sulphur	0.6	1.7	0.8
Nitrogen + Oxygen	7.1	13.2	11.4
Oxygen			11.0
Fusibility temperatures (°C)			
IT 940	1100	980	
ST 1120	1190	1140	
HT 1190	1380	1290	
FT 1200	1400	1300	
Ash composition (%)			
SiO_2	19.4	39.4	26.2
Fe_2O_3	5.2	10.2	5.5
Al_2O_3	6.9	12.8	8.5
CaO	24.6	45.0	40.4
MgO	2.3	6.7	5.8
Na_2O	0.8	1.6	1.5
K_2O	0.2	1.0	0.3
SO_3	6.4	13.1	10.8

The particle abatement systems for the 'A' station are 3 field electrostatic precipitator (EP) with no inertial preseparator. It seems that some attempt has been made to incorporate a separator in the transition section leading to the EP's, but in view of the high particle loading in the gas stream modifications to this section are highly desirable. Space limitations will require a redesign of the ductwork to allow a preseparator to be incorporated, and to increase the EP's efficiency an extra field should be incorporated (the 'B' station EP's are 4 field). A further reason for ensuring the EP's operate with a high collection efficiency is the high percentage of sulphur oxides retained on the solid residues. Using Gronhovd equation[8] about 70% S is retained on the particles.

Gaseous and particulate measurements will be made at the outlet sections of all the EP's ('A' and 'B' Power Stations). INKOS staff expressed a firm view regarding an emissions laboratory for this type of work. The equipment for the measurement of particles is a Ströhlein 15 discontinuous extractive type. This should be used to calibrate a double pass transmissometer to be positioned in the outlet duct so that continuous measurements of particles can be obtained as well as gases.

The disposal of ash and clinker uses wet and dry methods and problems with the conveyor systems can result in switching 'off' the EP's. This is a most unsatisfactory feature and back-up ash/clinker disposal systems should be available. A network diagram in Fig. 4 inicates process measurement sections.

The ash and clinker is transported by conveyors to two lagoons Fig. 2. The slag heaps are a considerable distance from houses, and even under high wind conditions wind-blown dust may not present a problem. However, other activity near the slag heaps may create a need for the abatement of the dust. For the measurement of deposition particles (<35 um) from all sources it is possible to use low cost simplified gauges[9] that also facilitate subsequent particle chemical characterisation.

4. INSTRUMENTS AND EQUIPMENT, FELLOWSHIPS, TRAINING, VISITS AND ACTIVITY

4.1 Instruments and Equipment

The need to carry out emission monitoring at a number of sites makes it highly desirable to have a mobile emissions laboratory. Within the present budget it is not possible to purchase a commercially available laboratory, and therefore suitable instruments and a vehicle are specified for such a purpose. A detailed arrangement of the schematic, Fig. 5, will be supplied following instrument/equipment selection.

4.1.1 Instruments/Equipment for the Measurement of Source Emissions Using a Mobile Laboratory

Electrical supply 240V, 50 cycle AC unless otherwise stated.

- One sulphur dioxide non-dispersive infra-red (extractive type) analyser, suitable for rack mounting (nominal width 0.43 m). Low sensitivity to vibration.
- Operating ranges 0-50, 0-500, 0-5000 ppm (vpm).
- Precision - better than plus or minus 2 ppm.
- Response time less than 30 seconds to 95 per cent of full-scale deflection (FSD).
- Resolution better than 1 per cent FSD.
- Heated cell (greater than 80°C).
- Sample pump for analyser required.
- 0-10 MV and/or 0-1V linearised output.

One nitrogen oxides analyser - chemiluminescence - for the determination of total nitrogen oxides (NO_x) and nitrogen monoxide (NO) in flue gases. Instrument to have heated cells and associated inlet and outlet ports to avoid condensing vapours. Suitable for rack mounting (nominal width 0.43 m).

- Multi-range capability of 0-10 ppm (vpm) by five steps to 0-10,000 ppm.
- Precision - better than plus or minus 0.2 ppm.
- Response time less than 30 secs to 95 per cent FSD.
- Accuracy 2 per cent of range or better.
- Drift - zero less than 1 per cent of range in 8 hours
  span less than 1 per cent of range in 8 hours
- Linearity 1 per cent of range or better.
- Unit to be heated above 130°C, also sample by-pass to be heated.
- 0-10 MV or 0-1 V linearised output.
- Vacuum pump with ozone removal filter.

One NDIR carbon dioxide analyser. Rack mounted (nominal width 0.43 m).

- Suitable for use with flue gases, cross sensitivity to other gases less than 1 per cent.
- Multirange 0-1 per cent, 0-5 per cent, 0-10 per cent, 0-20 per cent.
- Voltage outputs 0-10 MV or 0-1 V, linearised output.
- Linearity plus or minus 1 per cent or better.
- Response time 95 per cent of FSD in 10 secs.
- Precision plus or minus 1 per cent of range or better.
- Accuracy plus or minus 2 per cent of range or better.
- Sample pump required.
- Heated cell to greater than 80°C.

One NDIR carbon monoxide gas analyser. Rack mounted.

- Multi range 0-100 ppm, 0-500 ppm, 0-5000 ppm.
- Voltage outputs 0-10 MV or 0.1 V linearised.
- Linearity plus or minus 1 per cent or better.
- Response time 95 per cent FSD in 10 secs.
- Precision plus or minus 1 per cent of range or better.
- Accuracy plus or minus 2 per cent of range or better.
- Sample pump required.
- Heated cell to greater than 80°C.

Sample dilution system capable of sampling hot wet flue gases containing high concentrations (2 g/m^3) of particulate matter and up to 40 per cent v/v of water vapour and diluting to provide a particle free gas sample at about 20/30°C.

- Fixed and known dilution ratios up to 20:1.
- Suitable for rack mounting (0.43 m wide).
- Gas scrubbing system for dilution air to remove NO_x, CO_2, CO and hydrocarbons.
- Pump to operate from 240 V, 50 cycle AC.
- To provide a diluted flow of at least 5 litres/min at 25°C.
- Heated dilution block adjustable up to at least 200°C.

One oxygen analyser for use with flue gases of the paramagnetic type.

- Multirange 0-50 per cent, 0-10 per cent, 0-20 per cent.
- Linearised output 0-1 V or 0-10 MV.
- Response time 90 per cent FSD in 10 secs.
- Temperature range 0-200°C.
- Accuracy i per cent of range.
- Precision plus or minus 1 per cent of range.
- Zero drift up to 1 per cent of range in 8 hours or better.
- Span drift up to 1 per cent of range in 8 hours or better.

One multipen potentiometric chart recorder plus two spare sets of pens and 6 rolls of chart paper.

- Six pens and six input modules.
- Flat bed configuration.
- 10 MV to 10 V total range in decade ranges.
- Variable speed chart feed.
- Fast response.

One motorised panel van to be equipped as a mobile emissions laboratory. The van to provide a working area of approximately 2.1 m wide x 4 m long x 2 m high. It requires rear opening doors and a 3 seater separate driving section. A minimum load carrying capacity of at least 2 tonnes is necessary.

4.2 Fellowships, Training and Activity

Figure 6 is a 'Bar Chart' indicating the proposed activity plan. The plan has taken into account the requirements given by INKOS and seeks to present activity in a logical way leading to an adequately equipped and trained staff. Clearly there will be variations from the plan caused by problems such as INKOS staff availability and the organisation of host institutions but in my view the overall timescale is realistic.

4. 1 Key to Bar Chart Activity

(1) Circulation of tenders for instruments and equipment.

(2) Assessment of tenders and placing orders for instruments and equipment. At this stage additional items, depending on major items of equipment selected, can be ordered. Also a check will be made of conformity to the budget ceiling of $116K.

(3) Take delivery, check and bench test instruments with span gases.

(4a) Prepare 'panel van' to receive instruments* (Ventilation system, installation of electrical connections, pipework, racking and workbench). Install instruments and check system in Emissions Laboratory (converted panel van).

(4b) Make Immissions Laboratory Operational.

(5) Carry out short site test (shake-down) with the Emissions Laboratory. Make any modifications found to be necessary.

(6) Make trial full scale sampling campaign and assess. If satisfactory commence source measurement sampling campaigns.

(7) Prepare analytical laboratory for sample analysis required for emission sampling campaigns.

(8) Position Immissions laboratory at a selected site and set in operation.

4.2.2 Fellowships and Training

(9) (i) The measurement of SO_2 and SO_3 in flue gases. Instruction will include familiarisation with instruments and data acquisition.

(ii) An introduction to atmospheric dispersion models, including meteorological and topographical parameters. The application of emissions and dispersion on the determination of chimney height.

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* In accordance with detailed design.

A period of 3 months is required for training and it is suggested that for 9(i) fellowships are arranged at two locations.

(i) RUV Rheinland, Köln, Federal Republic of Germany 3 weeks (contact F Brieda or K-W Buhn).

(i) and (ii) Warren Spring Laboratory, Stevenage, Herts 9 weeks (contact Dr M L Williams and Dr C Schofield).

(10) Introduction to methodologies for monitoring gaseous particulate pollutants in the ambient atmosphere with special reference to SO_2.

A period of 2 months is required for training and the following candidate host institutes are proposed:

- Central Electricity Research Laboratory, Leatherhead, Surrey, UK.
- Warren Spring Laboratory, Stevenage, Herts.

(11) Training in the principles and application of instruments for the measurement of SO_2, SO_3, NO_x, CO_2, O_2 in combustion flue gases.

A period of 1 month. Proposed host institutes:

- TUV, Rheinland, Köln, Federal Republic of Germany
- Warren Spring Laboratory, Stevenage, Herts, UK.

(12) To obtain state-of-the-art information on the combustion of lignite, the influence of combustion in relation to sulphur capture on alkaline particles, the problems of slagging and boiler fouling.

A period of 1 month, if possible two weeks at each of two institutes

Candidate host institutes:

Canadian Combustion Research Laboratory, Ontario, Canada (contact George Lee)

Tallinskij Politehnicestzij Institut, Kafedra Teploenergetika, 2000 17g Tallin, Ul. Kalinina 116, SSSR.

(13) To obtain state-of-the-art information on methods for coal analysis with special reference to:

Sulphur in coal and ash.
Alkaline metals including Ca, Mg, Mn, Na and K.

Candidate host institute:

British Coal, Coal Research Establishment, Stoke Orchard, Nr Cheltenham, Gloucestershire, UK.

5. SAMPLING PROGRAMME

The main emphasis of the sampling programme will be focussed on the source emissions, although ambient measurements at selected sites are envisaged. For these two activities a fully operational mobile emissions laboratory and an immissions (ambient) measurement laboratory are essential.

Statistically designed sampling and measurement campaigns are proposed to cover the three different boilers in operation at Power Station 'A' and the one boiler type at Power Station 'B'. Ambient (Immission) concentrations should be monitored for periods of approximately 2-3 months at locations where power station operation (and other industrial activities) and weather patterns are likely to give maximum predicted ground level concentrations of SO_2 and/or NO_2.

The sampling methodology for the Power Stations is outlined below.

5.1 Boiler Fuel

- Feed rate of lignite
- Discrete and cumulative samples of lignite feed
- Composition of lignite, CHNOS, volatile matter, water, ash and calorific value
- Ash fusion temperatures and chemical composition.

5.2 Boiler Operating Conditions

- Feed water rate
- Steam conditions, flow and pressure
- Air flow and distribution
- Temperature distribution in the combustion chamber.

5.3 Boiler Emissions

5.3.1 Flue Gas Composition

- SO_2, NO_x, CO, CO_2, O_2 (continuous measurement)
- SO_3, total hydrocarbons, H_2O, particulates (intermittent measurement)
- Gas flow and temperature.

5.3.2 Ash and Slag

- Rate of ash and slag
- Chemical composition (including free and combined S)
- Carbon in ash

6. POWER PLANT DATA OUTPUT AND ANALYSES

The data output and analyses will provide information in four main areas:

(i) Combustion chemical characteristics and fouling

(ii) Sulphur capture

(iii) Emissions and pollutant pathways

(iv) Thermal and relevant chemical balances

6.1 Assessment of Risk from Recurring Emissions

The data obtained from the measurement campaigns should enable risk assessments to be made on human health and environmental damage. It is not proposed to deal with the complex issue of environmental damage by emissions.

To assess risk to health the following steps should be used:

(i) Identify the health effects of concern as a function of concentration level.

(ii) Predict and/or measure the concentrations to which the general public may be exposed and determine "worker exposure' by measurement (personal sampling or fixed point sampling).

(iii) Estimate the health impact of such concentration exposures.

A comprehensive publication[1]1 on different NO exposure methodologies has been prepared for the United States Federal Register and covers the requirements of the present study. Using these methodologies it is possible to apply published models in conjunction with meteorological and topographical conditions. Figure 3 indicates the local topography and Fig. 7 a wind rose.

7. CONCLUSIONS AND RECOMMENDATIONS

- Within the financial budget technical specifications have been prepared for the on-line measurement of a range of gases emitted from Kosovo A and B power stations. For the measurement of particles extractive discontinuous methods are used therefore it is recommended that a double pass transmissometer be purchased for the continuous measurement of emission rate. It will still be necessary to use an extractive method of sampling for the physical and chemical characterisation of the particles emitted.

- Instruments purchased for the continuous measurement of emitted gases will be installed in a suitable panel van so that it can be used as a mobile emission laboratory. Although there are commercially available emission laboratories the financial constraints of the project preclude this option. When the suppliers of instruments and van are known a detailed design of the laboratory will be forwarded.

- It is recommended that a small team of experts (two persons) be appointed to commission the emission laboratory and take part in a pilot (shake down) sampling campaign at a power station. Bearing in mind the similar principles of operation for the source emission and ambient monitoring laboratories it is proposed that the experts should commission the two laboratories.

- Rapid changes in the wind direction and/or speed can occur in the local situation (within 5 km of the power stations) and therefore a mast, anemometer and wind vane (with recorder) should be purchased and used during measurement campaigns.

- The ambient pollutant monitoring laboratory should be positioned at one site for a period of at least 2/3 months. Location of the ambient monitoring sites can be determined from the emissions inventory and dispersion characteristics. Additional data on NO_2 concentrations in the ambient atmosphere can be obtained by the use of low-cost passive sampling diffusion tubes .

- The existing operating conditions in the boiler combustion chamber should receive better control so that the temperature regime is maintained within closely specified limits. For sampling campaigns the purchase of suction pyrometers to obtain good data on combustion/flame temperatures is recommended.

- A technical and economic feasibility study should be carried out to explore the possibility of combustion improvement at the 'A' station by using gas from the nearby gasifier plant.

- An improved classification of lignite, e.g. using simplified screening tests, so that the fuel supply can be optimised with regard to combustion, minimising boiler fouling and maximising sulphur capture.

- Consideration should be given to using a range of Kosovo lignites in a small-scale combustion rig to study relevant operating parameters. A number of European (and possibly Yugoslavian) laboratories is already able to undertake these investigations.

- The elemental analysis of particulate matter can be made at IMKOS using atomic absorption spectrophotometry (AA). No facilities such as x-ray diffraction are available for phase identification.

- Improvement in the abatement efficiency of the 'A' power station electrostatic precipitators (EP's) is required. Conversion from 3 field to 4 field and an inertial preseparation stage to the EP's should be considered. This would necessitate a redesign of the existing ductwork.

- The conveyor systems for the transportation of flyash, clinker and slag should provide a 'back-up' procedure in cases of break-down. Consideration should be given to returning the waste solids stream to the open cast mine at a suitable time in the mining operation.

- Evaluation of wind-blown dust deposition can be made by using simplified low cost dust deposition gauges . The abatement of wind-blown dust from ash and clinker dumps can be achieved by spraying stabilising agents which are readily available from European manufacturers.

8. REFERENCES

1.* Workbook of Atmospheric Dispersion Estimates. D. Bruce Turner - Air Resources Field Research Office, Environmental Science Services Administration, Cincinnati, Ohio.

2.* Katzberger, S.M. and Rymarczyk, W.J. Treatment and Disposal of Wastes from Dry SO_2. Environmental Progress (Vol. 5, No. 4), November 1986.

3. Brieda, F., Wallin, S.C. et al. Methods of Sampling for Sulphur Dioxide, Oxides of Nitrogen and Particulate Matter in the Exhaust Gas of Large Combustion Plant. CEC Contract No. 84-B-6642-11-005-11-N, October 1985.

4.* Brown, T.D. and Lee, G.K. Sulphur Neutralization by Lignite Ash: Pilot-Scale Combustion Experiments, Journal of Engineering for Power, October 1979, Vol. 101.

5.* Borgwardt, R.H. and Bruce, K.R. Effect of Specific Surface Area on the Reactivity of CaO with SO_2, AIChE Journal (Vol. 32, No. 2), February 1986.

6. Slobodan, V. Djekic. The Effect of the Combustion Conditions on the Fouling Intensity in the Power Plant Boilers Burning Kosovo Lignite, INKOS Report. To be published.

7. Atkins, D.H.F. et al. The Measurement of Nitrogen Dioxide in the Outdoor Environment using Passive Diffusion Tube Samplers. AERE Harwell: HMSO, 1986, AERE R12133.

8. Gronhovd, H. et al. Some Studies on Stack Emissions from Lignite-Fired Power Plants, 1973 Symposium, Bismark, ND.

9. Hall, D.J. and Upton, S.L. A Wind Tunnel Study of the Particle Collection Efficiency of an Inverted Frisbee used as a Dust Deposition Gauge. Atmospheric Environment, Vol. 22, No. 7, p 1383-1394, 1988.

10.* Seminar on Dust Control, Warren Spring Laboratory, 1984.

11. United States Federal Register, Vol. 51, p 33992-34504, September 1986.

* Reports given to INKOS marked thus * and:

- A Bibliography covering the adsorption of sulphur oxides on alkaline particles - Unpublished.

- A number of publications covering Acid Deposition, Source Emission Measurement and Occupational Exposure Limits for the Working Environment.

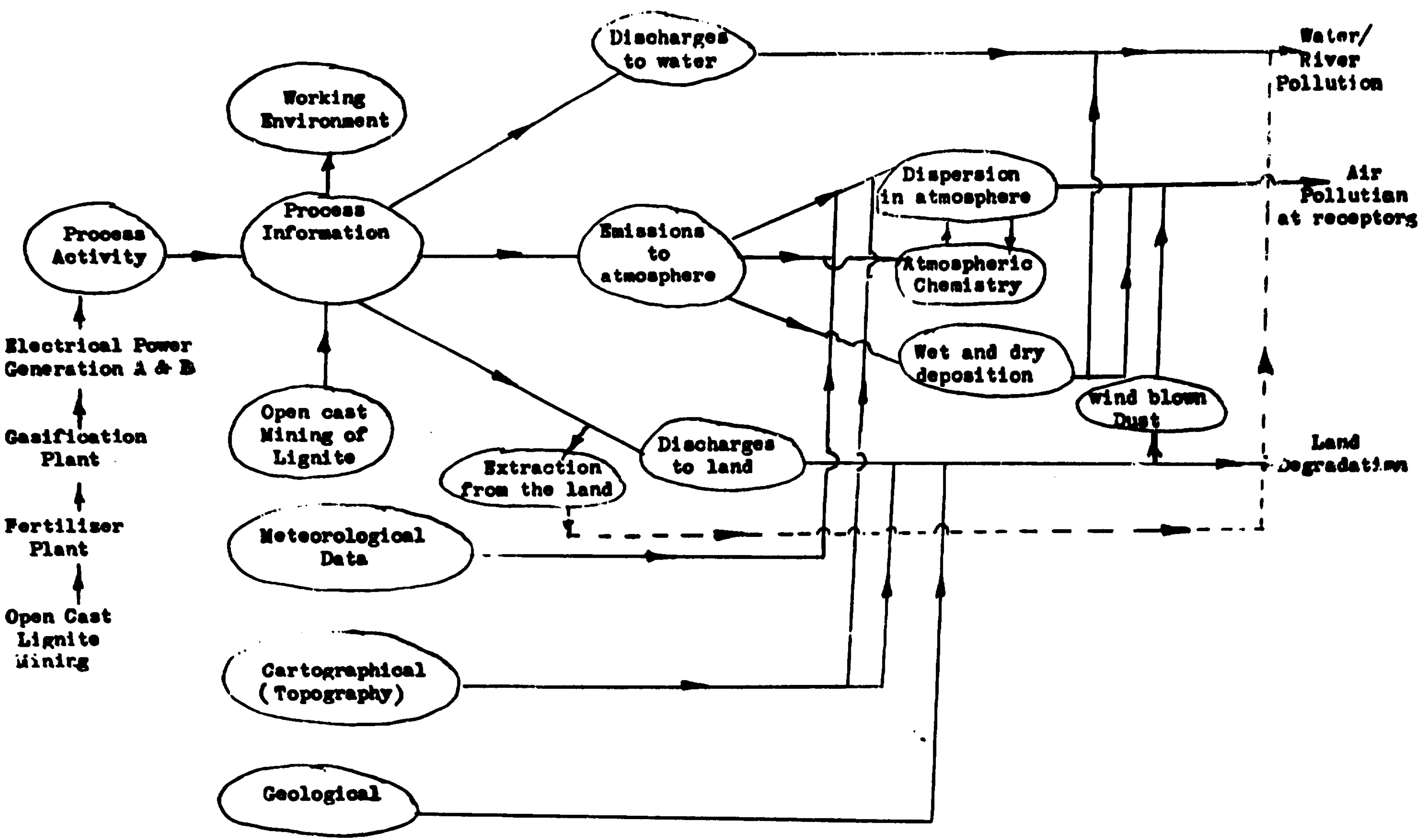

Fig. 1 Network for the Environment

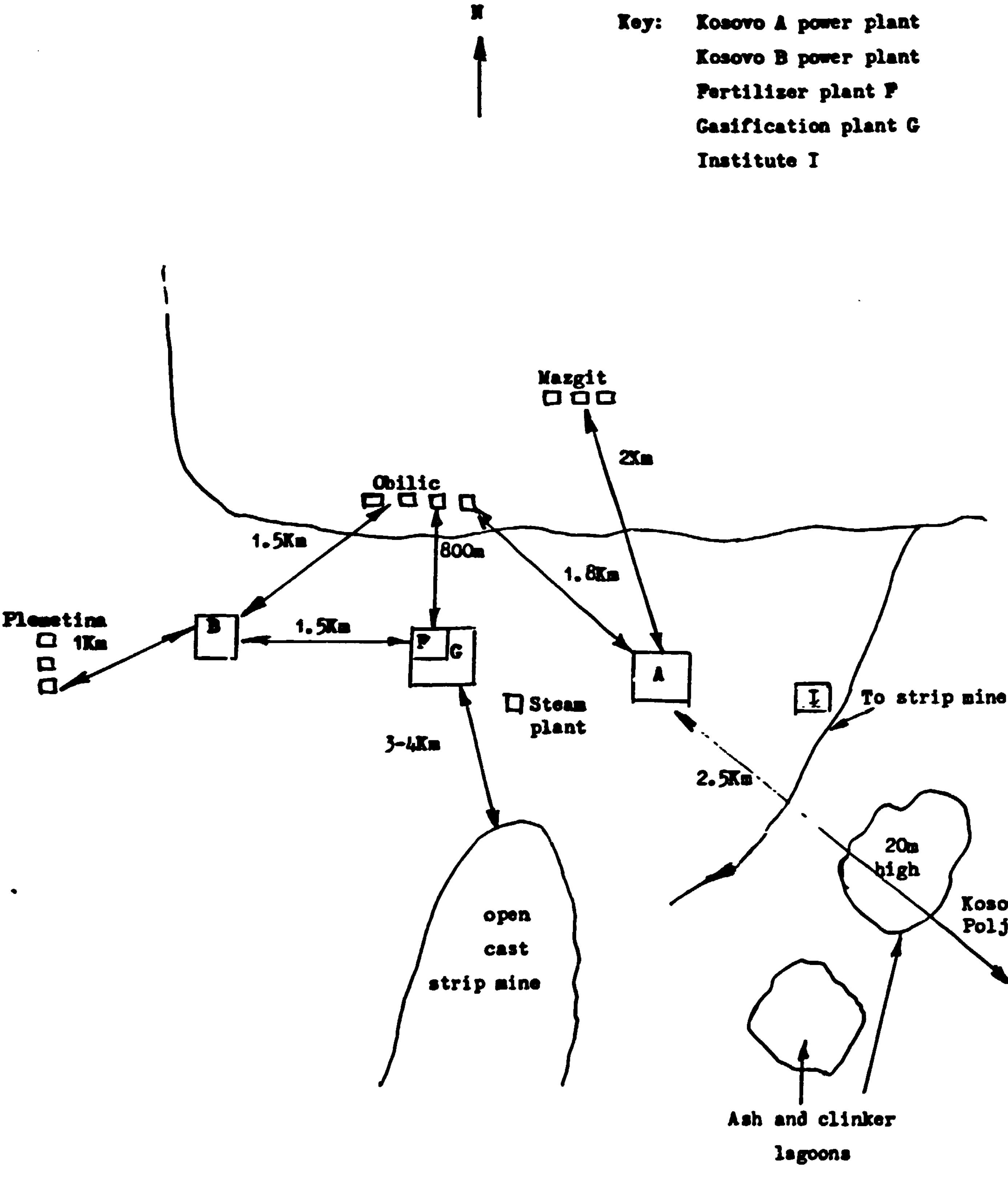

Fig. 2 Approximate locations of areas of interest

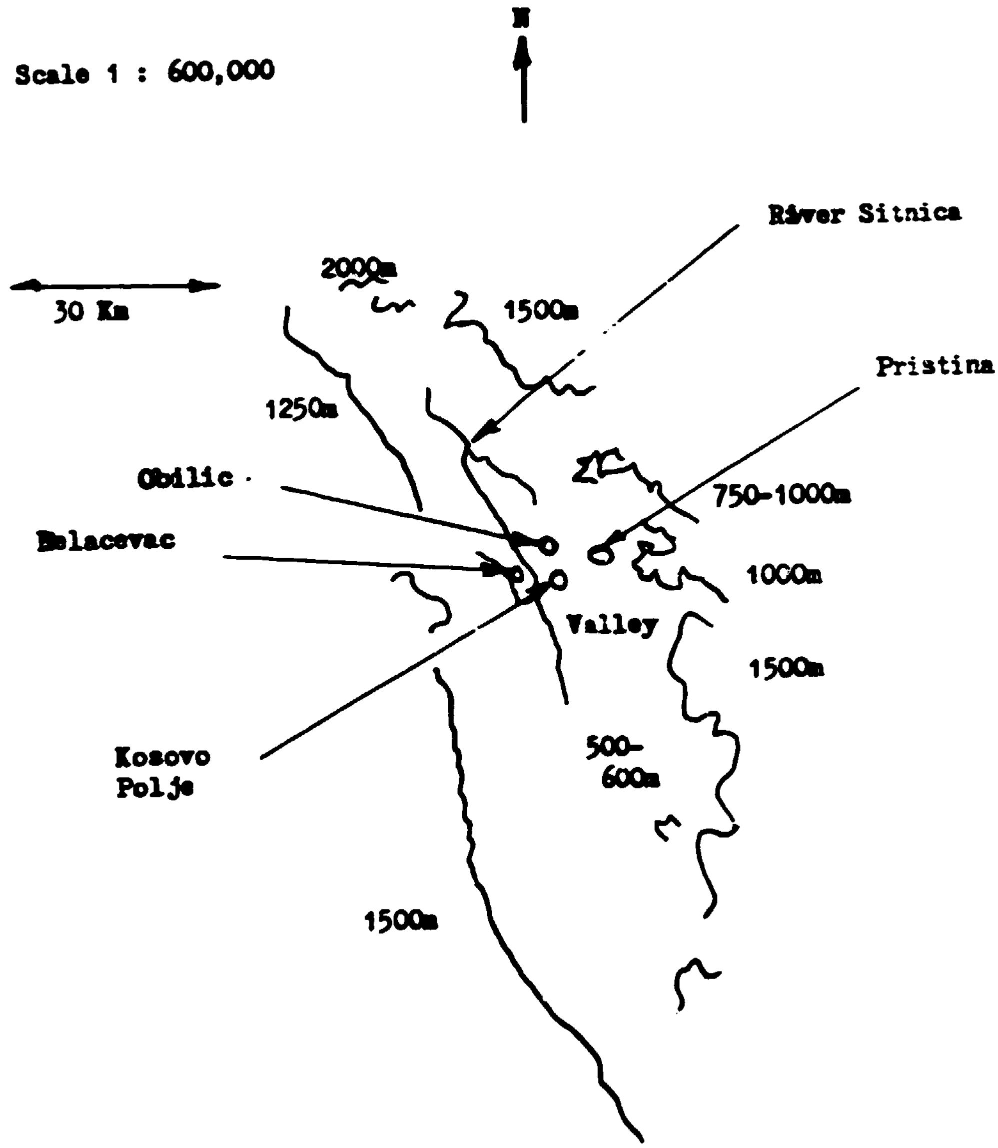

Fig. 3 Topography of Local Area

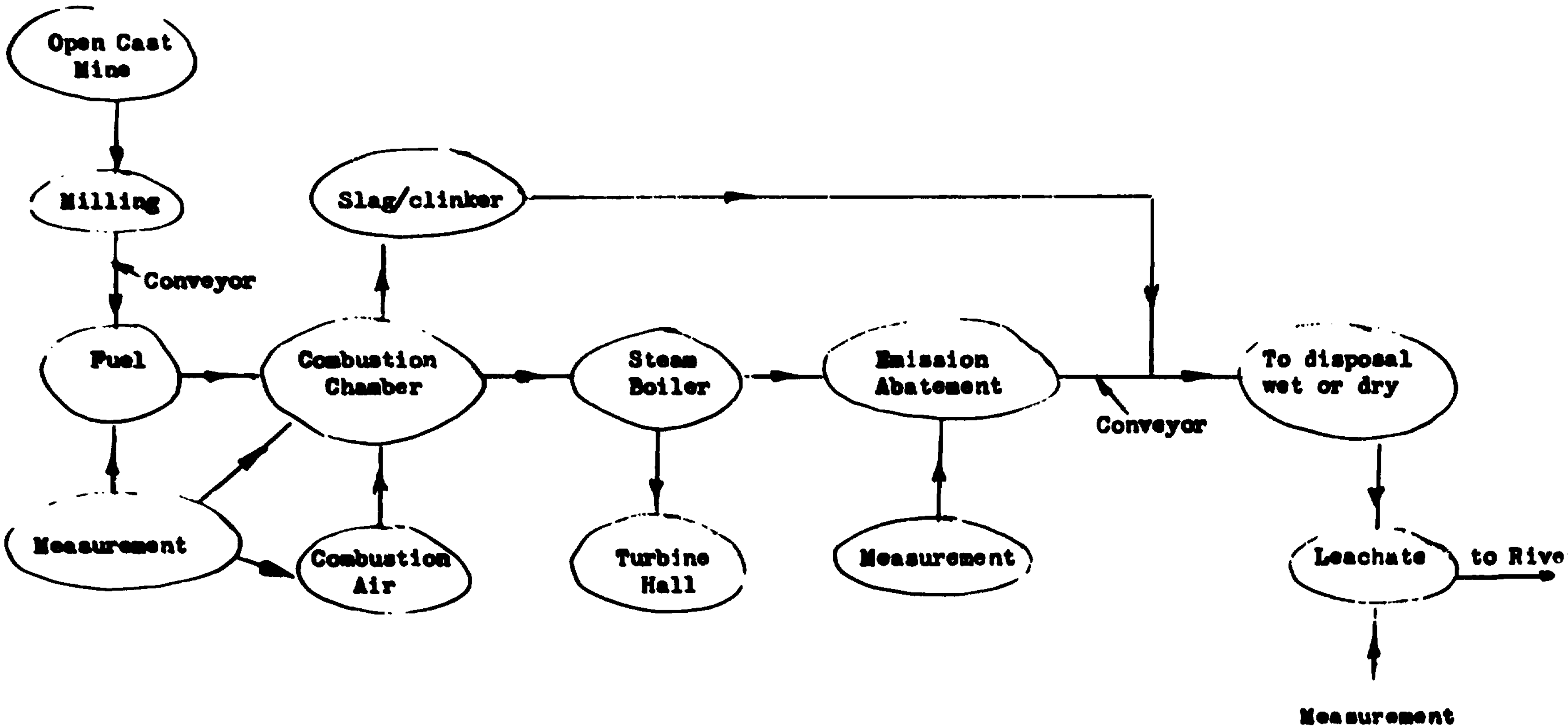

Fig. 4 **Network for Power Stations**

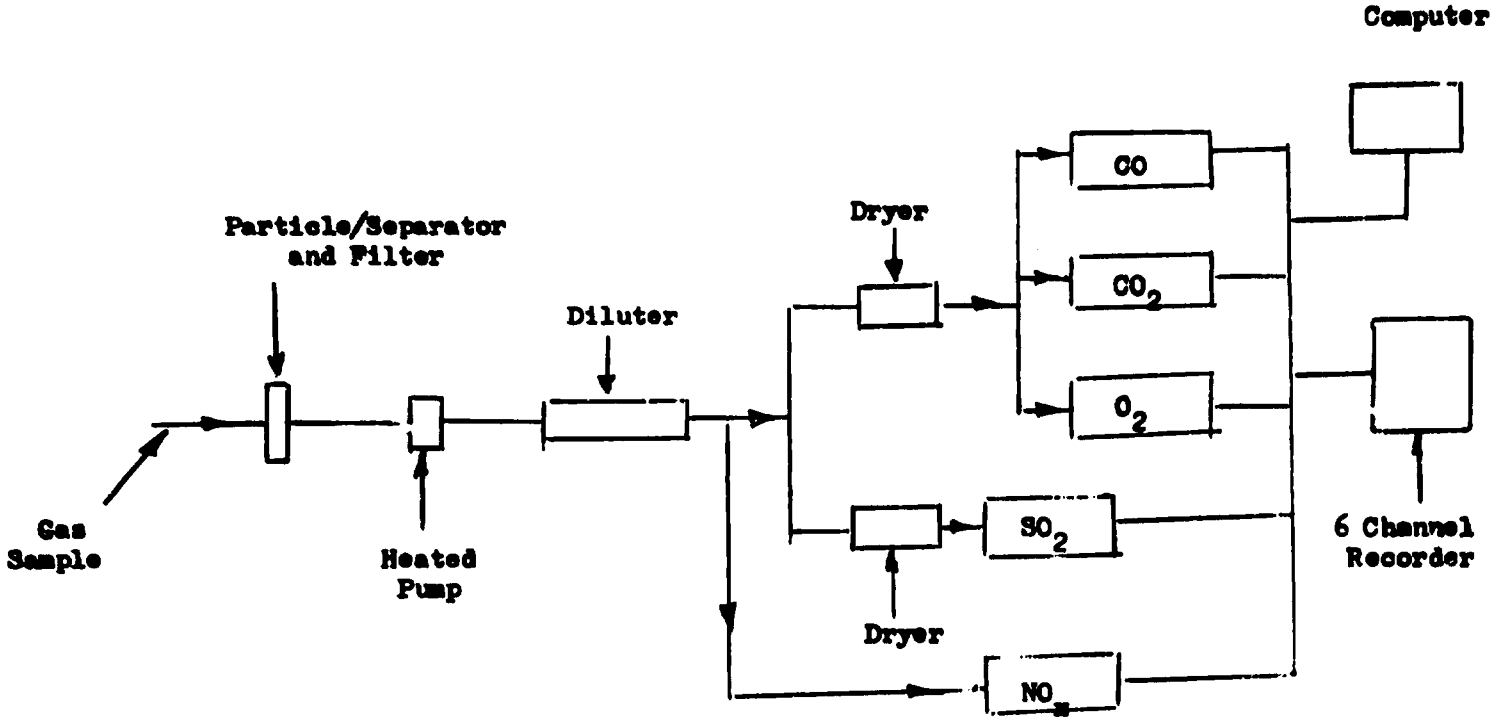

Fig. 5 **Schematic Emissions Laboratory**

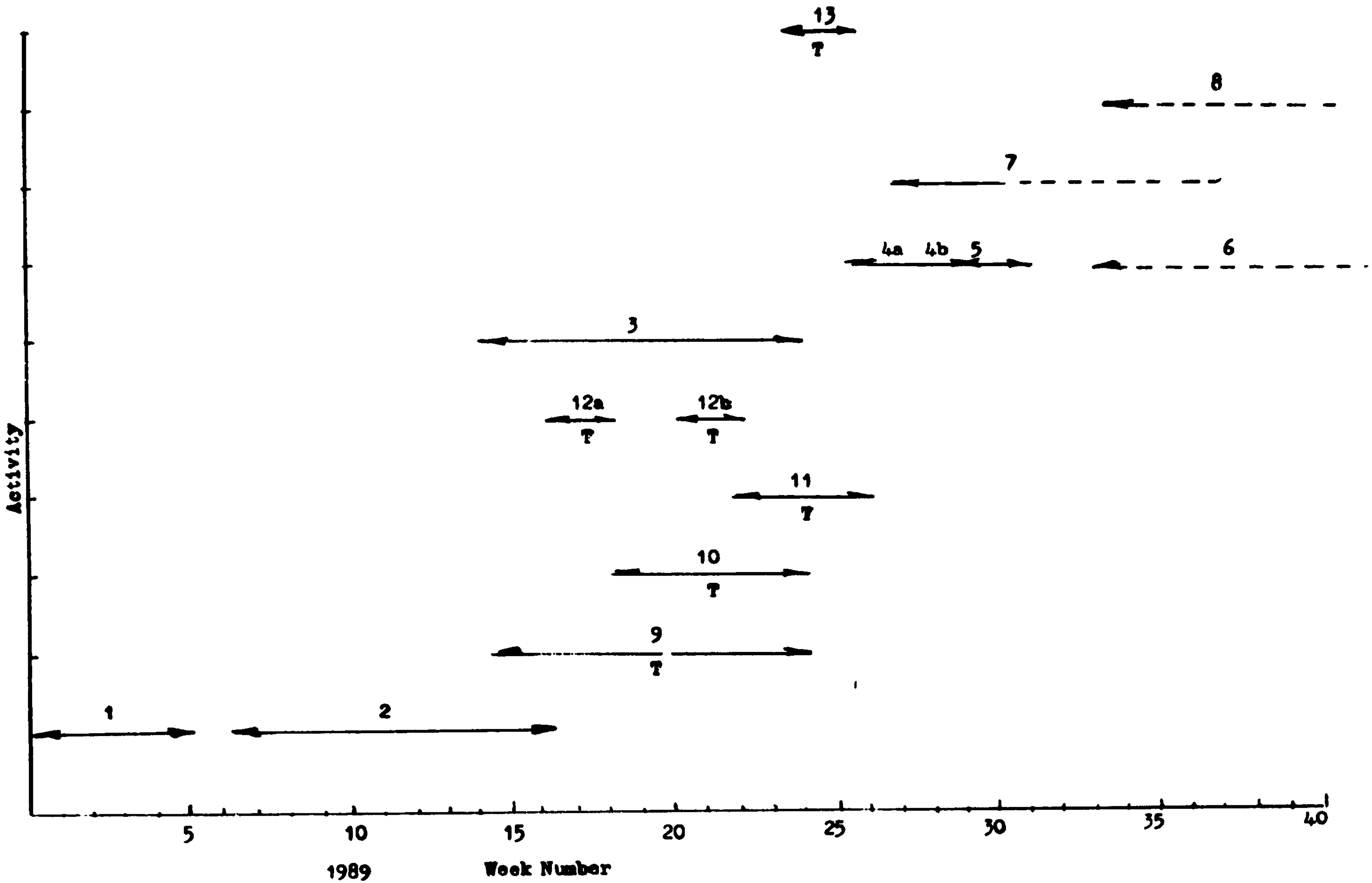

Fig. 6 Bar Chart for Activity (Power Plants)

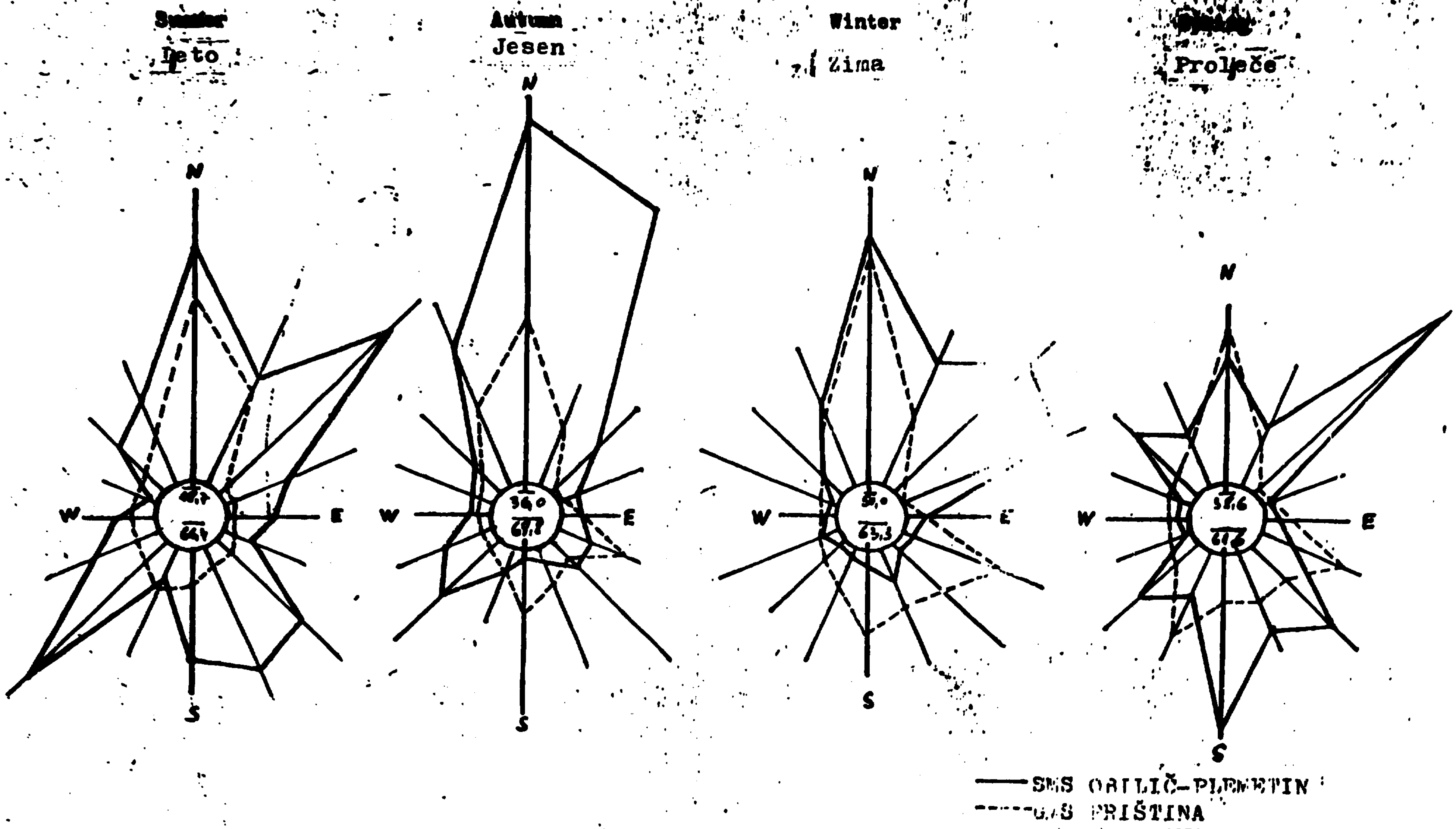

Fig.7 Wind Rose

Sl.8. Ruže vjetrova SMS Obilić-Plemetina i GMS Priština za 1978 god. po godišnjim dobima

APPENDIX A

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

JOB DESCRIPTION

DP/YUG/87/020/11-01

Post title: Expert in the monitoring and control of atmospheric emissions of SO_2 from coal-fired power station boilers

Duration: 0.3 m/m

Date required: September 1988

Duty Station: Pristina, Yugaslavia

Purpose of project:

1. To improve the capability of INKOS to control the emissions of sulfur compounds from power generating stations which use lignite fuel through enhanced knowledge of natural desulfurization occurring within the combustion chamber. This will be achieved through an improved understanding of the following technical issues:

2. Lignite composition, particularly the relative concentrations of sulfur and the oxides of calcium, magnesium, manganese, etc.

3. Composition of SOx in the combustion chamber and flue gases for different combustion chamber configurations and boiler capacities.

4. Atmosphere dispersion of SO_2 in the immediate vicinity of power plants and over larger areas.

5. Wet leaching of sulfur from ash disposal dumps into groundwater.

- The expert will execute the following tasks in cooperation with the Institute for Research and Development, (INKOS), in the Socialist autonomous Province of KOSOVO:

1. Advise INKOS staff on, and participate in the preparation of a detailed work plan for the activities to be undertaken within the scope of project DP/YUG/87/020. This will include:

- Preparation of neutral technical specifications for project equipment, (instrumentation for atmospheric pollution monitoring and analysis).

- Suggest potential host institutions for the proposed fellowships and study tours and advise of the content of the training programmes.

- Advise INKOS on the tasks, which should be undertaken by the project's International Experts and, where possible, suggest possible condidates to fill these posts.

- Preparation of a realistic schedule of activities and assignment of start dates and durations for each activity.

2. Provide technical guidance to project staff on:

- Sulphur capture in ash during coal combustion in utility P.F. boilers

- Equipment and methods for monitoring SOx concentration in stack gases, (source monitoring).

- Transport and dispersion of SO_2 in the atmosphere.

3. Prepare a report in English, setting out the achievements of the mission, (particularly those of paragraph 1, above), for the concerned national authorities, UNDP and UNIDO.

Language: English

Background Information:

Kosova is a socialist autonomous province (SAPK) situated in the Southern part of Yugoslavia. It covers an area of 10.887 km^2 and has a population of 1.585.440 (1981). Such a population makes it the most densely populated part of Yugoslavia but it is still the less developed region.

The industrialization of SAP Kosovo is based on its rich mineral resources such as lignite, non-ferrous metals and others. At present long range programs, call for the erection of new facilities for coal processing and combustion (industrial gas and electricity production). The rapid industrialization of SAPK has caused serious environmental disturbance, i.e. increased environmental pollution (air, water and soil). Nevertheless, due to increased need for energy, new energy generating facilities have to be built in order to use the available abundant natural energy resources.

In order to continue an intensive development of the Province, corrective measures have to be undertaken to counterbalance the environmental impact.

INKOS activities include EIA's and direct measurements of the pollution levels caused by coal fired energy generating plants. Its laboratories are sufficiently prepared to carry out these tasks.

The mineral component of the Kosovian lignite contains a relatively high percentage of calcuim which binds a certain quantity of sulphur into Calcium sulphate during the coal combustion in power plants and hence creates a partial natural reduction of SOx (natural desulphurisation). The main task of the project is to define the influence of the coal sulphur content (from its compounds) and the content of calcium, magnesium and moisture on the emission of SOx from Kosovian power plants. Since the content of these components depends on the coal origin (coal field, working level) the relationship between the SOx emission and the coal will be made. Such a model would be very useful in situations in which a reduction of the SOx emision effected. Investigations will be carried out by control of the plants operation parameters, especially its temperature. The formed calcuim sulphate is very temperature sensitive (over 1000°C). At that temperature it starts to dissolve and SO_2 joins the combustion flue gases. Two different steam generators (650 and 1000MWe) would be planned for investigations of the SOx reduction and the influence of the combustion chamber design and combustion process will be determined. For determination of this interdependance automatic measurement devices would be stack retrofitted to measure the concetration of SOx.

The SO_2 level may be measured at some spots in and outside the power plants yard in order to make an SO_2 dispersion model and the correlation between the SO_2 emission and emmision in relation to weather conditions (wind rose, inversion, etc.). An assessment would be done and measures undertaken for the environmental protection on basis of made sulphur balance. Namely, even if a samller sulphur quantity is emited by flue gases, the environment is again polluted by the ash in which the sulphur is concentrated.

These investiagions will be very important for selection of the equipment and site for new electricity generating plants which are planned to be built in the near future in the territory of SAP Kosovo.

The following outputs are required from the project

1. Full operational capability of INKOS to execute the following environmental monitoring and protection measures:

   a) Lignite fuel analysis including sampling techniques in the field and at stockpiles;

   b) Analysis and monitoring of combustion chamber and flue gases;

   c) Monitoring of sulfur dioxide atmcsphere emissins;

   d) Determination of ash sulfur content and investigation of groundwater pollution caused by wet leaxhing of sulfur from ash dumps.

2. The following technical results and recommendations;

   a) Determination of the correlations between, SOx atmosphere emissions, coal sulfur content and calcium oxide content of the coal mineral matter.

   b) Determination of the most favourable molar ratio of alkali metal to sulfur for the maximum overall reduction in sulphur emissions (atmospheric and terrestrial).

   c) Variation in lignite analysis with seam, depth and geographical locaiton.

   d) Effect of combustion chamber configuration, combustion temperature and boiler capacity on atmospheric sulphur emissions leading to recommendations or combustion chamber design and operationg procedures.

   e) Graphical presentation of atmospheric SO_2 dispersion and generation of a dispersion model under varying weather conditions from which recommendations can be made on the location of sulphur power stations.

   f) Improved understanding of the mechanism for transfer of bound sulphur in coalash to ground water.

   g) Based on a), b) and above, recommendations will be made on the selection of coals to be mined and burned such that sulphur emissions to teh environment are minimized.

3. Technical reports as appropriate addressing the above issues.