EMISSION MONITORING IN PEAK-HEAT-PRODUCTION PLANTS

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Introduction

Environment protection is more and more important in our society. Apart from general consciousness of people and companies, environment protection is requested by law. Among others, large emission sources as power plants are obliged to establish emission monitoring according to Slovenian legislation:

- Regulation on the emission of substances into the air from stationary emission sources (1),
- Regulation on the emission of substances into the air from combustion plants (2),
- Regulation on the emission of substances into the air from large combustion plants (3),
- Ordinance on first measurements and monitoring of emission of substances into the air from stationary emission sources and conditions for its implementation (4),
- Decree on form of reports on air emission monitoring measurements (5).

Mentioned Slovenian legislation is already harmonised with EU directives.

Energetika Ljubljana

Energetika Ljubljana is a company that operates a peak-heat-production plant. It consists of several steam and hot-water boilers as well as a cogeneration plant (gas turbine with exhaust gas boiler). The following plants are included in continuous emission monitoring (measuring and evaluation) system:

- combustion plants:
  - hot-water boiler: VKLM3, fuel: oil or natural gas; thermal input: 58 MW,
  - hot-water boiler: VKLM4, fuel: oil or natural gas; thermal input: 58 MW,
  - hot-water boiler: VKLM5, fuel: oil or natural gas; thermal input: 116 MW,
- cogeneration plant:
  - gas turbine, fuel: gas oil or natural gas; thermal input: 20 MW,
  - steam boiler, fuel: natural gas; thermal input: 28 MW.

Figure 1. Mobile AMS at Energetika Ljubljana, Slovenia.

In Energetika Ljubljana a combined emission monitoring has been established with a stationary AMS (Automated Measuring System) for cogeneration plant, a mobile AMS for three boilers (Fig. 1) and EMIDATE an AES (Automatic Evaluation System) linking both of the AMS systems.

Requirements for continuous monitoring

Quantities that need to be monitored are:

- sulphur dioxides and other sulphur compounds (SO_X, i.e. SO_2 only),
- nitrogen oxides and other nitrogen compounds (NO_X, i.e. NO only),

- carbon monoxide (CO),
- oxygen (O_2).

Cogeneration AMS named COGEN measures the following quantities:
- concentrations of CO, NO, O_2 (analyser ULTRAMAT 23, manufacturer SIEMENS),

Mobile AMS named MOBILE measures the following quantities:
- concentrations of CO, NO, SO_2, O_2 (analyser ULTRAMAT 23, manufacturer SIEMENS).

Analyser ULTRAMAT 23 uses NDIR spectroscopy for measurement of CO, NO and SO_2 concentrations and electrochemical sensor for O_2 concentration. Extractive sampling is used for all measuring sites. The analyser has a certificate according to 13. BImSchV (Germany) (6).

Devices used for continuous emission monitoring must have:
- upper measurement limit at least 2,5 times higher than the required limit value for the concentration of the measured substance,
- automatic internal functionality control and
- possibility for manual functionality control.

Analyser calibration is automatic with ambient air in preset time intervals (every 6 hours).

Mobile AMS system has the same performances as the stationary one. The only difference is that it is movable and can be quickly installed on any boiler mentioned above to ensure emission measurement on an operating boiler.

EMIDATE Automated Evaluation System - AES

Gaseous concentrations are given as mass of a particular gas per unit volume of dry gas at standard conditions (4) (273 K (0°C) and 101,3 kPa). Where appropriate, the particular concentration must be referred to a specified oxygen concentration (3 vol. % is prescribed for boilers firing liquid or gaseous fuels) using the expression

$$E_{\mathrm{N}} = \frac{21 - O_{2\mathrm{N}}}{21 - O_{2\mathrm{M}}} E_{\mathrm{M}} \qquad (1),$$

where:
E_N is emission concentration referred to standard oxygen concentration in mg/m^3,
E_M is measured emission concentration in mg/m^3,
O_{2N} is standard oxygen concentration of flue gas in vol. %,
O_{2M} is measured oxygen concentration in dry flue gas in vol. %.

Continuous monitoring is obligatory when limit amount for any of the substances, for which continuous monitoring is required, or a certain thermal input, is exceeded (1,2,3,4). Continuous monitoring is carried out with analysers that allow automatic measurements. Automatic measurement is measurement of emission values with analysers, which with uninterrupted sampling allow for measurement of current values in intervals not exceeding 10 seconds, their storage or printout. Automatic evaluation is on-line evaluation of automatically measured current values, calculation of average values from results of automatic measurements, storage of average values on a suitable electronic medium and printout of average values at the end of the day.

Protocol defines the method of collection and processing of data, gathered by AMS. Data acquisition is made possible by suitable computer equipment. Automatic evaluation (protocol) is basically a validated computer programme executing corresponding algorithms for:
- data acquisition,
- averaging,
- calculation,

- evaluation,
- printout,
- transmission, and
- storage.

Data acquisition is possible using appropriate software and hardware equipment. The system concept from Energetika Ljubljana is shown in Fig. 2. It is built up in modules so it can be used to control single or multiple emission sources, from one or several workplaces. With it, all capabilities of SIMATIC system and PROFIBUS network are used. Basic component of the system is a PC with EMIDATE 2000 V5.5 SLO software.

The EMIDATE system is based on distributed periphery units SIMATIC ET 200M, that are used as I/O units. These PLC units do not have their own processor, which is included in a PC as an extra card. In this way we can control all periphery units through PROFIBUS connections from a workplace (PC). In case of need (safety reasons), standard optical elements (OLM) can be used, as were used in Energetika Ljubljana. EMIDATE AES (Automated Evaluation System) is located in room M11. Stationary KOGEN AMS is located at cogeneration plant. MOBILE AMS can be installed on any boiler and simply connected to one of the repeaters with PROFIBUS cable. System itself recognises where the AMS is connected and generates appropriate protocol for selected measured boiler. In this way both emission AMS are connected to the PC by PROFIBUS link. In each AMS one SIMATIC ET 200M is used with several I/O modules. It is possible to expand the EMIDATE system with additional ET 200M groups, i.e. emission AMS, or with process signals, as has been done in Energetika Ljubljana in boiler control room (flue gas temperatures, fuel flow, etc.). For higher availability the system (PC) is powered through an UPS and uses a HP LASERJET printer for printouts.

The reference method is wet chemical method; therefore evaluation of automatic measurements is based on its requirements (1,2,3,4). Basic averaging time is a half-hour period. For every single measurement half-hourly average values of concentrations of all substances in flue gas and condition parameters are calculated. Half-hourly values of substance concentrations are calculated to unit volume of dry gas at standard conditions, as appropriate. Concentrations, calculated in the above-stated way, are used for comparison with emission limit values.

Half-hourly **A**verage **V**alue (**HAV**) is a result of calculation of basic measurement data in a half-hour interval. Half-hourly average value is valid, if at least 50 % of current values inside the half-hour interval during operation of an emission source are measured correctly. From valid half-hourly average values daily average values are calculated. **D**aily **A**verage **V**alue (DAV) is an arithmetic mean of half-hourly average values, calculated for a full calendar day, when emission source is in operation.

For comparison to emission limit values all valid half-hourly average values (HAV) and daily average values (DAV) are used. For evaluation of continuous measurement at least 80 % of half-hourly average values during operation of emission source in a calendar month must be valid.

Automatic evaluation system must ensure online evaluation of automatically measured current values, calculation of average values from results of automatic measurements, storage of calculated average values on a suitable electronic medium and printout of average values at the end of every day.

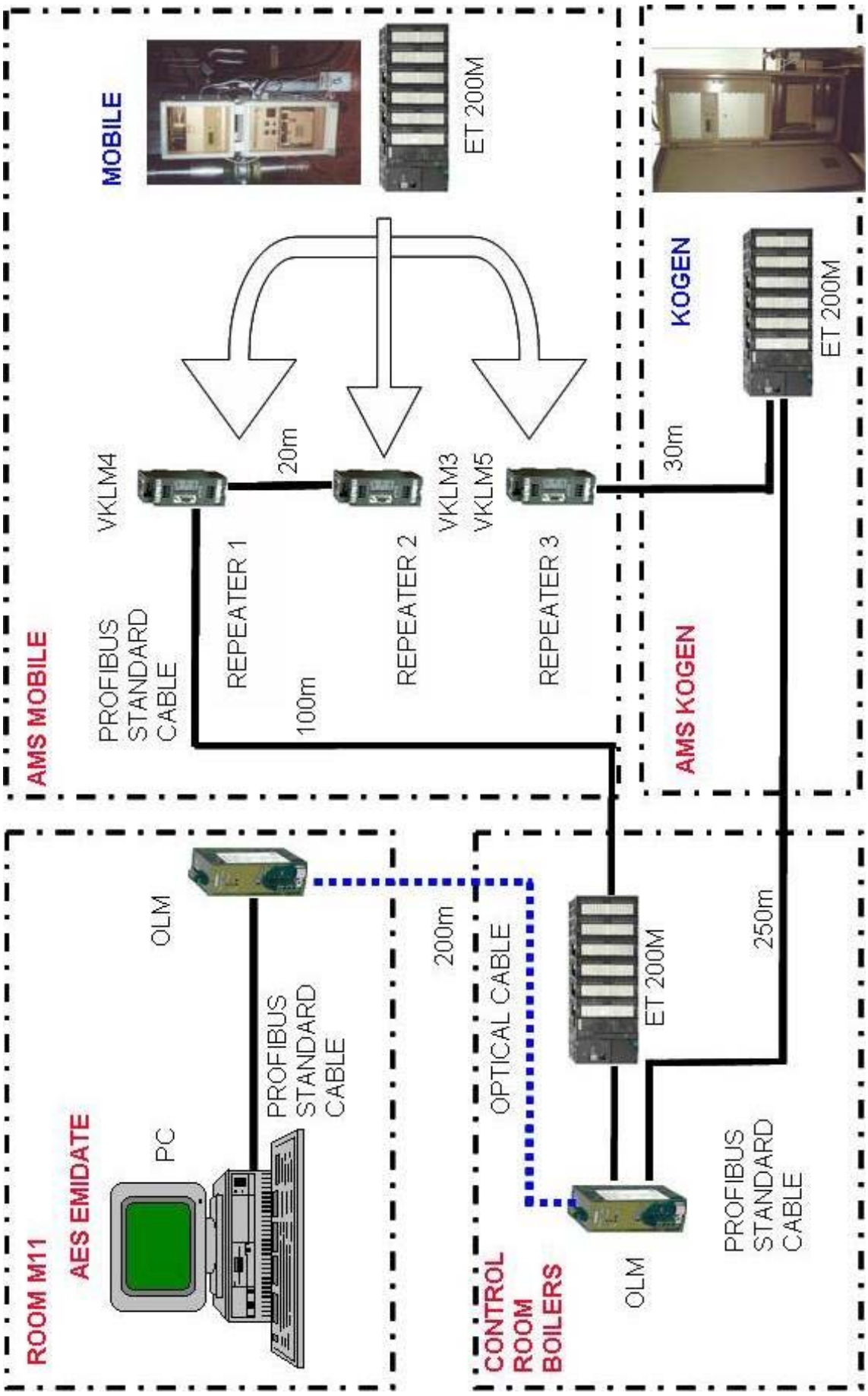

Figure 2. CEMS (Continuous emission monitoring system) in Energetika Ljubljana SLO.

Conclusion

For operators with several combustion plants the demands of European directive on large combustion plants can prove to be very expensive. This is especially the case in peak heat production plants, where combustion plants often do not operate simultaneously. In such cases individual monitoring and evaluation systems are not cost effective and a mobile monitoring system is a suitable solution. A system with an individual AMS for gas turbine, a mobile AMS for hot water boilers and a common evaluation system with access points at every measuring place has been built in a peak-heat-production plant in Energetika Ljubljana.

RACI firm has developed a complete solution of flue gas control. We supply analysers from well known manufacturers (SIEMENS, ABB, ENOTEC, etc.) with adequate additional equipment and an automatic evaluation system EMIDATE 2000 V5.5 SLO (developed in co-operation with SIEMENS, ETD, Vienna, Austria). System EMIDATE has been validated by TÜV Wells and adapted to Slovenian legislation. The entire system software allows use of the package in Slovenian and corresponding Slovenian printouts. In addition, it allows control of the whole system from a distant location (for example from software developer in Vienna) as well as control from several workplaces, which makes it sensible to put one workplace in the control room, where it gives the staff additional information on plant operation.

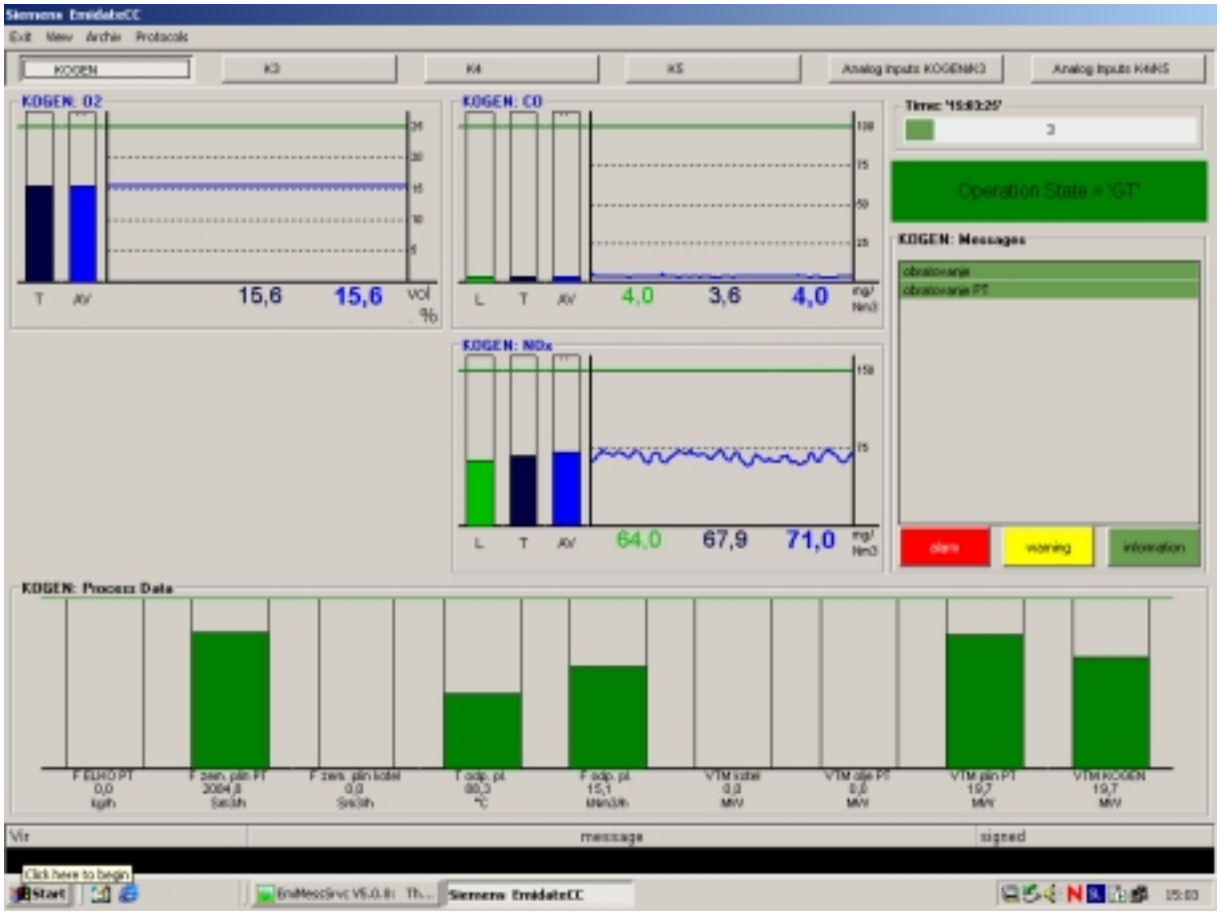

Figure 3. Display of EMIDATE AES (Automated Evaluation System) at Energetika Ljubljana SLO.

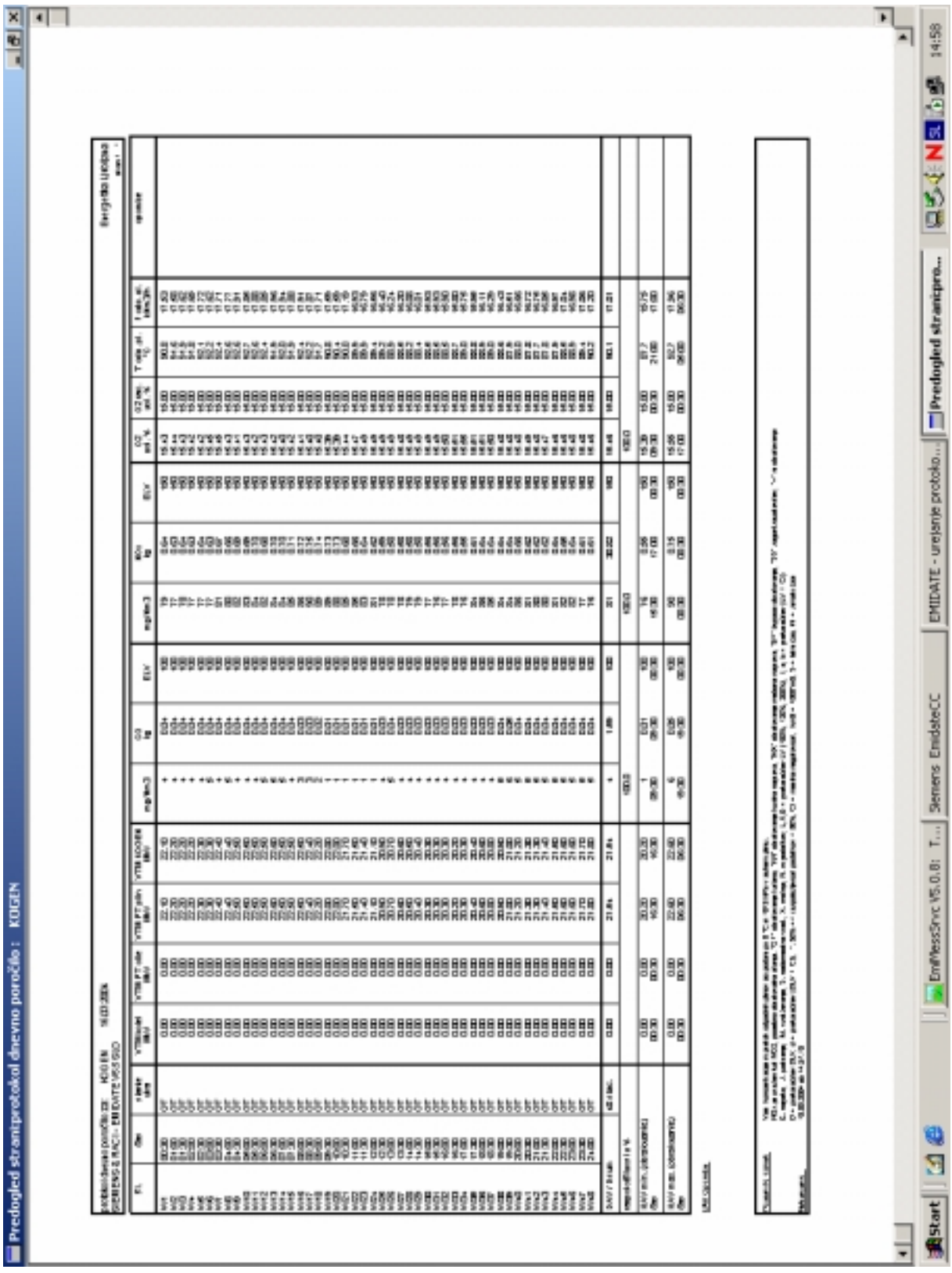

Figure 4. A protocol of EMIDATE AES (Automated Evaluation System) at Energetika Ljubljana.

EMIDATE software is user oriented; therefore user can configure display functions as necessary, check, export and print stored data (Fig. 3 and 4). In standard configuration the following protocols are included:

- Daily report,
- Monthly report,
- Yearly report,
- Report of exceeded values (monthly or yearly),
- Report of yearly availability,
- Table of settings and changes in data evaluation, and
- Table of events (devices disturbances).

In general, EMIDATE AES is a very powerful tool for environmental engineers and enterprises. Some of the major advantages of the system are historical analyses and free export of data into standard formats (csv or xls). It also predicts HAVs for the running period, which enables operators to take appropriate measures to ensure acceptable operation.

References

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