



**PERMANENT
M&V Plan for
Automatic Filtration Control
In A Ceramics Factory, Czech Republic**



Developed within the project Performance Risk Management for Energy Efficiency through
Training – PERMANENT – IEE/08/657/SI2.528420

November 2010
Pavel Sitný, ENVIROS, s.r.o.

Contents

1. PLÁN M&V	3
2. ECM INTENT	3
3. SELECTED IPMVP OPTION	3
3.1. MEASUREMENT BOUNDARY.....	3
3.2. MEASUREMENT EQUIPMENT	4
3.3. INTERACTIVE EFFECTS	4
3.4. IPMVP OPTION	4
4. BASELINE	4
5. REPORTING PERIOD	5
6. BASIS FOR ADJUSTMENTS	5
7. ANALYSIS PROCEDURE	6
8. ENERGY PRICES	6
9. METER SPECIFICATIONS	6
10. MONITORING RESPONSIBILITIES	7
11. EXPECTED ACCURACY	7
12. BUDGET	7
13. REPORT FORMAT	7
14. QUALITY ASSURANCE	7
15. APPENDIX 1	8
16. APPENDIX 2	10

1. Plán M&V

An industrial plant producing ceramics systematically improves energy use efficiency using existing energy management system. As a result of the detail consumption data analysis has been identified an energy conservation measure. This M&V plan's main aim is to define explicit procedure of the energy saving measure commissioning and proper evaluation of its impacts.

2. ECM Intent

Introduction of the system for dust removal units automatic control. The project aim is to reduce electricity consumption by automatic control over starting and shutting down dust removal units based on the actual need. The de-dusting machine-room is furnished with 11 identical dust removal units. Each unit provides de-dusting for set of several equipments within production hall. When no equipment in the set is running, the relevant dust removal unit can be stopped.

The de-dusting machine-room is operated manually. All units are usually running all the time within production hours. Each de-dusted equipment has its own manually operated damper plate on the exhaust pipe. Responsibility of equipment operators thus plays a key role in energy efficiency of the dust removal. Neither reliability of the personnel in the production hall can not avoid idle running the de-dusting units when all corresponding equipments are switched off as the de-dusting machine room is operated by mechanics from different division. The automatic control system introduction will avoid useless operation of de-dusting units and will remove the dependency on the human factor to some extent.

The new automatic control system will be installed and tested during planed maintenance stop. It is expected, that all units will be adjusted at once. For safety reasons there will be an option to by-pass the implemented option and degrade the system to the current stage.

3. Selected IPMVP option

3.1. Measurement boundary

Project savings will be determined within a measurement boundary comprising de-dusting machine-room. Measurements will include electricity consumption of dust removal units only. The filtration units use for filter's cleaning purpose compressed air supplied by the plant's central air-compressor station. The consumption of the compressed air is due to lack of data and additional M&V costs ignored. It is clear that intended ECM project will have positive impact on compressed air consumption thus it is on the save side to ignore it. This impact may improve the ECM's effect by 10 – 20 %. This is a very rough estimation based on a basic test. During the test was measured the difference in on/off load air compressor ratio with open and closed compressed air line to the de-dusting machine-room.

The de-dusting machine-room is located outside the technology of the production hall on top of the silo storage building. The room is power supplied by one dedicated line directly from the main distribution station. All the equipment within the room serves as a part of the de-dusting technology. The most important electricity consumers are already mentioned fans.

Except fans, there are conveyor's drives. Each dust removal unit has it's own belt conveyor. Two central belt conveyors collect captured dusty material and transport it to packaging line where it is filled into the big bags.

Equipment	Number [-]	Nominal capacity [kW]
Filtration unit fan	11	22
Filtration unit conveyor	11	2
Central conveyour	2	4

3.2. Measurement equipment

The electricity consumption of de-dusting machine room is measured by two true RMS electricity sub-meters installed in the main distribution station. These meters are dedicated only to de-dusting area. The meters have a valid calibration certificates. The rated accuracy of both meters is expressed as 2% of reading with 95% of confidence level. The meters are connected to automatic data collection system and the 15 minutes consumption data are stored in the database.

The production volume as the independent variable is based on the number of produced pieces of product multiplied by the specific weight known for each type of the production portfolio stored in the production information system. For the raw material dosing are used the precise scales. The scales are regularly calibrated and the accuracy is expressed as 1% of reading with 90% of confidence level.

3.3. Interactive effects

There is enough process heat in the production hall. The heating system is operating only few days in the coldest winter. No air-conditioning system in the production hall is installed. Despite of the project's considerable impact on the air exchange in the production hall will be heating and cooling interactive effects ignored.

3.4. IPMVP option

IPMVP Vol 1, 2009, Option B was selected as operation of the de-dusting units and consequently achieved savings vary on production equipment needs. The energy consumption monitoring system is in place thus the option selection does not significantly influence M&V costs.

4. Baseline

The baseline period of last six months will be used for construction of the mathematical model for routine adjustments. In case of non-standard production regimes occurrence (maintenance stops, site-holidays etc.) will be the influenced daily data sets excluded from the analysis.

The baseline energy data are represented by de-dusting unit's electricity consumption. The consumption is continuously measured by two installed electricity meters and is recorded in the database in 15 minutes interval. The data are available on-line on the client's network.

The production volume realized on the de-dusted production area will act as the independent variable. These data are available in the client's production information system with up to two working days delay.

The production hall is usually operated in 4 shift pattern (24 hours a day, 7 days a week). During weekends is the production area less occupied, some equipment is stopped. It is believed that there is important part of the potential for energy savings through this ECM project. The department responsible for dust removal units operation does not communicate well with the production managers and usually leaves the units running to be on the safe side. The consumption of de-dusting area use to be understood as a fixed overhead.

In the de-dusting machine room are installed 11 identical independent filtration units. Each unit has one fan with nominal power of 10.000 Nm³ of air/hour. Each fan is driven by asynchronous motor of nominal input power 22 kW. The filters are textile filters with automatic cleaning by compressed air pulses in constant time periods.

5. Reporting period

The payback period of the ECM project is expected within first few months. Therefore the reporting will be examined on monthly basis within the first year. Later can be this frequency reduced to annual reporting as in case of this ECM project it is not likely that its effects may degrade over the time.

6. Basis for Adjustments

For the ECM savings reporting purpose will be baseline energy data adjusted to the reporting period using a mathematical model correlating baseline energy data with an independent variable. The mathematical model will be created by linear regression analysis of the original de-dusting energy consumption dependency on the appropriate production volume. The analysis will be performed on daily basis for the period of last 6 months using the least squares approach.

The final model will be expressed by the formula

$$Y = k * X + q \quad [1]$$

where:

Y ... adjusted de-dusting consumption [kWh/day]

X ... daily production volume in the de-dusted production area [t/day]

k ... marginal consumption coefficient [kWh/t]

q ... fix part of the consumption [kWh/day]

No needs for non-routine adjustments are identified. The quality of the inner production hall environment fulfills current health and safety requirements and has to remain at the same level.

7. Analysis Procedure

Savings will be reported as avoided energy use under the condition of the reporting period. For the routine adjustments to reporting period conditions will be used the mathematical model described in the previous chapter. Savings will be calculated on the daily basis as the difference between the real consumption and baseline energy consumption adjusted to the production volume of the appropriate day

$$S_d = Y - Z \quad [2]$$

where:

S_d ... daily saving [kWh/day]

Y ... adjusted de-dusting consumption [kWh/day]

Z ... real (recorded) de-dusting consumption [kWh/day]

In case of non-standard production regimes occurrence (maintenance stops, site-holidays etc.) will be the savings considered to be zero. The reporting period energy savings will be calculated as summary of daily savings.

$$S_r = \sum_{\text{reporting_period}} S_d \quad [3]$$

where:

S_d ... daily saving [kWh/day]

S_r ... reporting period energy saving [kWh/day]

8. Energy Prices

For calculation of the avoided costs will be used energy price actual for the corresponding reporting period. The current Client's contracted price consists of fixed payment for the reserved maximum demand and of the fixed unit price per kWh. Under these circumstances the fixed unit price per kWh can be used as the marginal cost and period avoided costs will be calculated by multiplying the reporting period energy saving and the marginal cost.

If the contract has changed, both the consumption and demand part of the total energy price would have to be taken into account.

9. Meter Specifications

For the meter specifications see the chapter "Selected IPMVP Option / Measurement equipment". All the data are under normal circumstances available in the site's information system. In case of failure of any data source, the alternate way of data collection has to be introduced without delay. It is not likely there might be a problem with production data collection as the production volumes are the crucial for the production flow control and the production information system is robust enough to manage quickly eventual failures. More likely is the failure of the energy consumption monitoring system. In such case the energy manager has to quickly analyze the situation and take the relevant actions (start manual meter reading, ensure quick broken element replacement etc.).

10. Monitoring Responsibilities

As stated above are all data stored in the databases and are accessible through information systems user interfaces. The energy manager is the main person responsible for periodic check of functionality and quality of the data sources and eventual troubleshooting.

11. Expected Accuracy

The accuracy of the measurement equipment (electricity meters, scales) is stated in the “Selected IPMVP Option / Measurement equipment”. The accuracy of the final mathematical model for routine adjustments will be calculated and reported during the starting analysis (see Annex 1).

12. Budget

There are no hardware costs as all the necessary meters and systems are already in place. The M&V costs consist of the initial setup cost and costs for periodic reporting. The contractor will charge X,-CZK for the initial M&V plan setup and Y,- CZK for the monthly reporting within the first year.

13. Report Format

The report format is specified in the Annex 2.

14. Quality Assurance

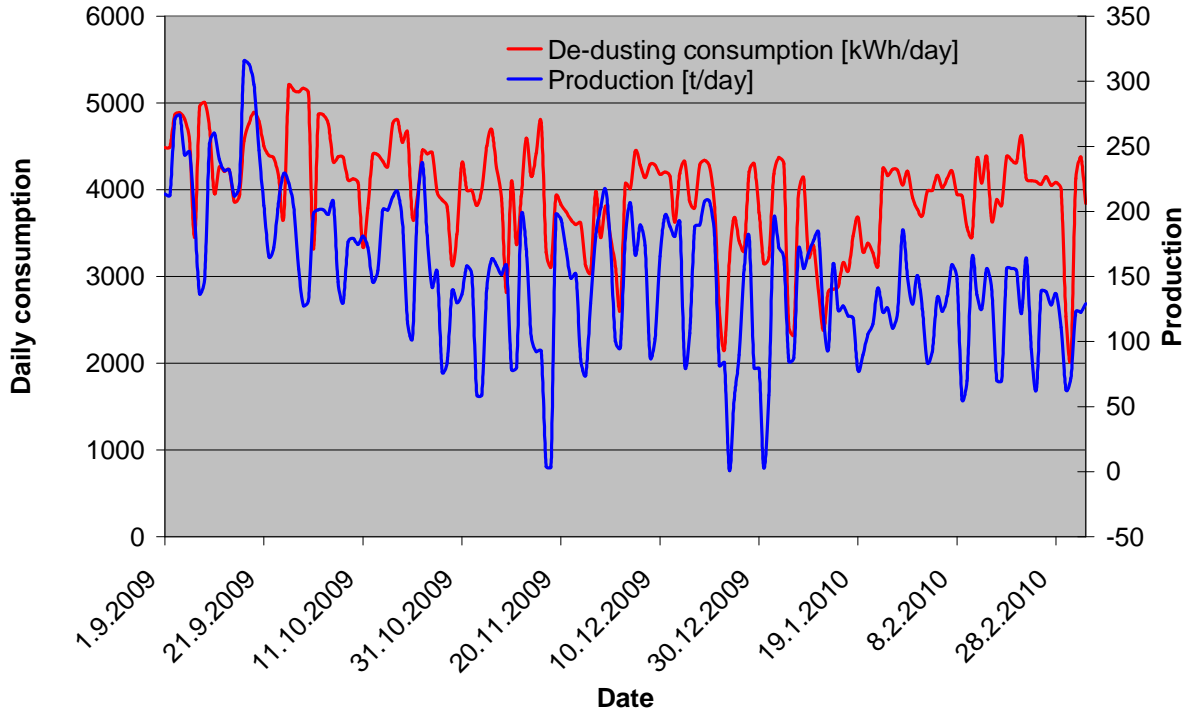
The necessary data for the initial M&V plan setup and monthly reporting will be provided in electronic format by the responsible site’s personnel nominated by the site general manager. This personnel will be also responsible for activities described in the M&V plan. The M&V plan setup and monthly reports will be processed within two weeks after the complete input data set provision.

The determination of actual energy and monetary savings will follow current best practice as defined in IPMVP Volume I, EVO 10000 – 1:2009.

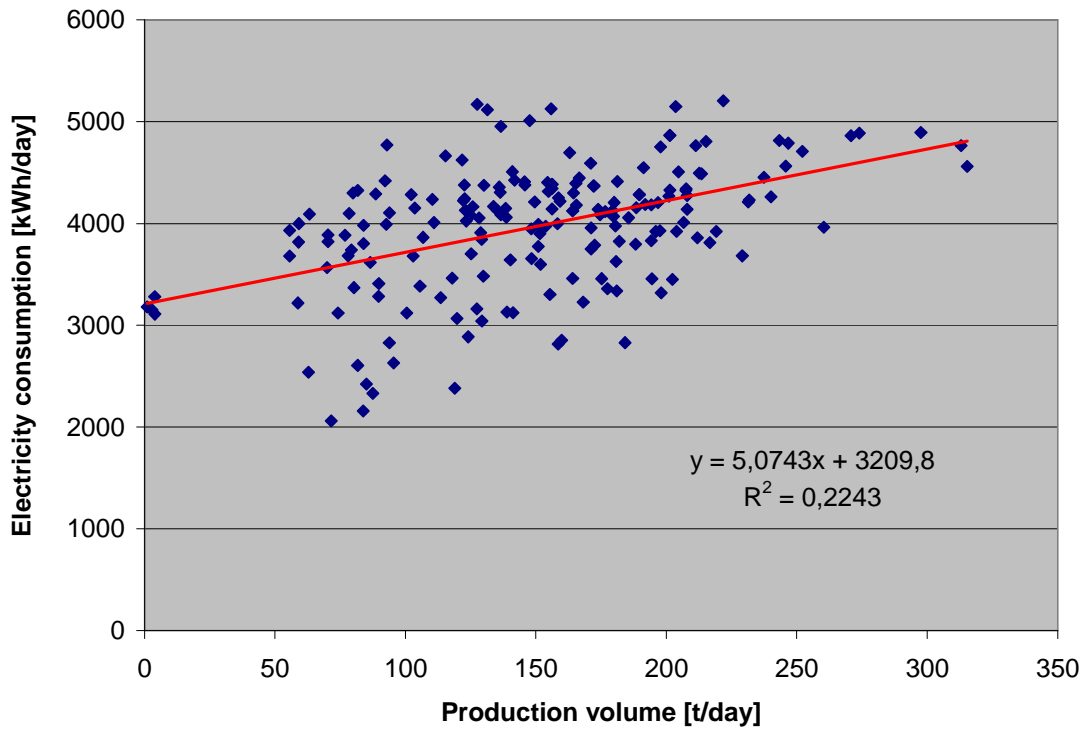
15. Appendix 1

Pre-retrofit data analysis

A) Trends



B) Scatter plot



C) Summary output

<i>Regresní statistika</i>					
Multiple R	0,471016314				
R Square	0,221856368				
Adjusted R Square	0,217627327				
Standard Error	544,8591124				
Observations	186				
	<i>Coefficients</i>	<i>Standard Error</i>	<i>T Stat</i>	<i>Dolní 95%</i>	<i>Horní 95%</i>
Intercept	3211,832609	111,9243172	28,6964682	2991,012591	3432,652627
De-dusting consumption [kWh/day]	5,053971221	0,697778827	7,242941496	3,677295113	6,430647328
Average daily consumption	3971,86631				
Average daily production	150,1748663				
Absolut Precision	1067,92386				
Relative Precision	27%				
SE electricity meter	40,52924806				
SE Savings	546,3644135				

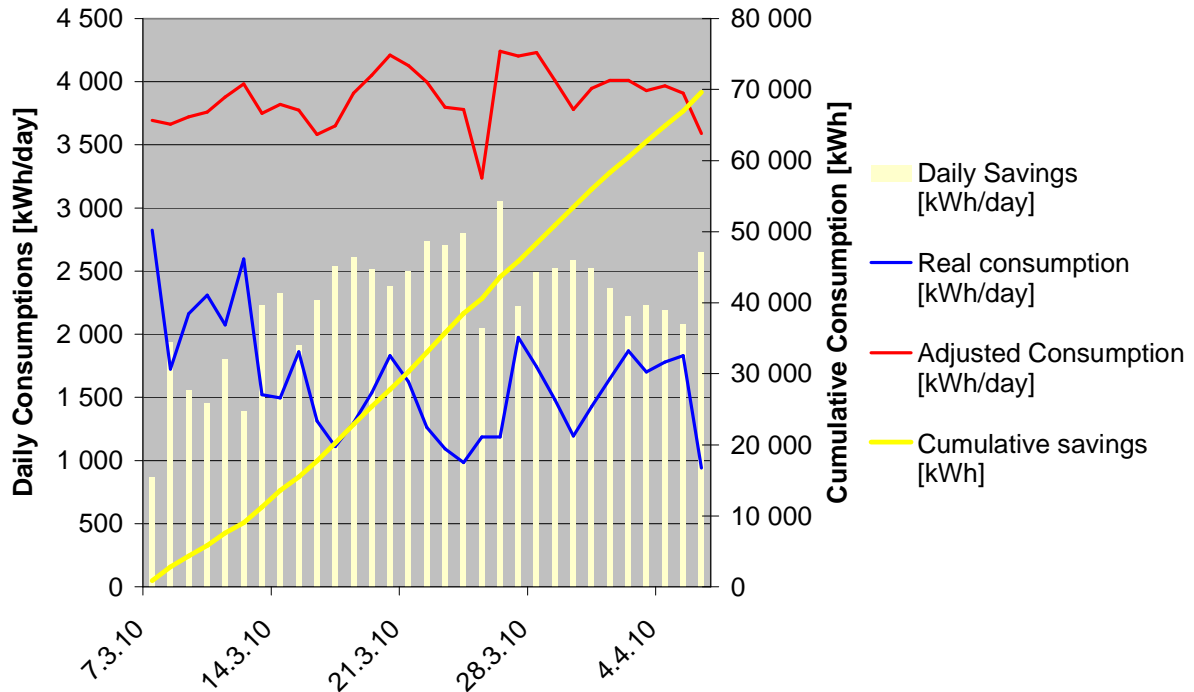
D) Routine Adjustment Formula

$$Y = 5,054 * X + 3212$$

16. Appendix 2

Post retrofit period report

A) Trends



B) Results

In the first reporting period (7.3.2010 – 6.4.2010) after the ECM introduction has been saved 69 600 +/- 5 960 kWh. The relative precision of the saving is 8,6% with the 95% of the confidence.

The current electricity unit price is 3,1 CZK/kWh, the monthly avoided cost are likely to be 215 800 CZK and with 95% of confidence not less than 197 300 CZK.