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ENERGY SUPPLY MONITORING SYSTEM FOR INDUSTRIAL PLANT

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Abstract - A Supervisory Control and Data Acquisition (SCADA) based system for monitoring and control of the energy supply and the peak load in industry plant has been designed and algorithm for short-term energy forecast was implemented. The paper describes design and implementation of Energy Management System (EMS) consisted of cost effective elements combined with SCADA software application, which makes platform for supporting the economical energy management of industrial businesses. Trend SCADA screen with necessary on-line data for operator peak load limiting action was designed and real time data for control automatic power limiting system was prepared. System was tested and is in use more than three years in chemical industry plant with 1200 kW average power peak load. Such plant was representative sample for Eastern Europe common mid-size industry energy consumer and it was concluded that implemented energy monitoring system indicate investment turn back in less than six months.

Keywords: SCADA, Energy monitoring

1. INTRODUCTION

Competition in the industry leads to increased cost pressure, which forces companies to implement rationalization measures also with regard to energy supply and consumption. By monitoring and control of the energy supply and the peak load, costs can be reduced and own power production can be optimised. In today deregulated energy market environment monitoring also makes it possible optimal energy supply contracting.

In the electricity sector, normally a rate is used that covers both the investments made by the suppliers (building costs for power plants and the supply system) as well as the arising costs for energy generation (primarily fuel costs). The price has a energy and power output portion.

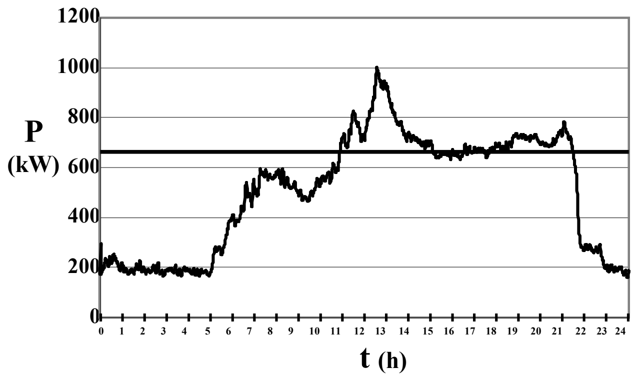


Fig. 1 Power load profile without monitoring

Rational energy usage is based on energy and power measurement data collection, analysis and real time forecast of average output of a measuring period to recognize in a timely manner when the fixed imported power limit is going to be exceeded and correspondingly intervene. Fig. 1 indicates "blind" power consumption one industry consumer without knowledge about load profile. Peaks can rise up to 150% of rational and necessary load.

2. START PIONTS

When started with design of the energy supply monitoring system, following start points were considered:

- Industrial plant where system is to be used is some existing one, one with low or mid automation level.
- Investment turn back is to be as faster as possible counting with rationalisation in energy costs.
- Standard, modular and expandable design to be used with possibility of connecting with business computer network.
- Necessity of synchronisation with official accounting meters intervals and tariff periods.
- Submetering data are also to be concerned.
- Possibility of gas, steam, heat, coal, oil, water and other industry energy and water quantity inputs acquisition is welcome.

3. MONITORING SYSTEM DESIGN

Optimal solution founded based on stated tasks is shown in Fig. 2. System consists of main and submetering energy meters with pulse output connected to Programmable Logic Controllers (PLC) and via communication system connected with PC computer with SCADA application. System is open for different media metering data acquisition. Each meter pulse indicates flow of one unit of energy. PLC calculate electrical power from energy in every 20 seconds. Taking into account worst case of low pulse frequency from official meter regarding counting error, and necessary speed of switching reaction, 20 seconds intervals for power counting was a good compromise.

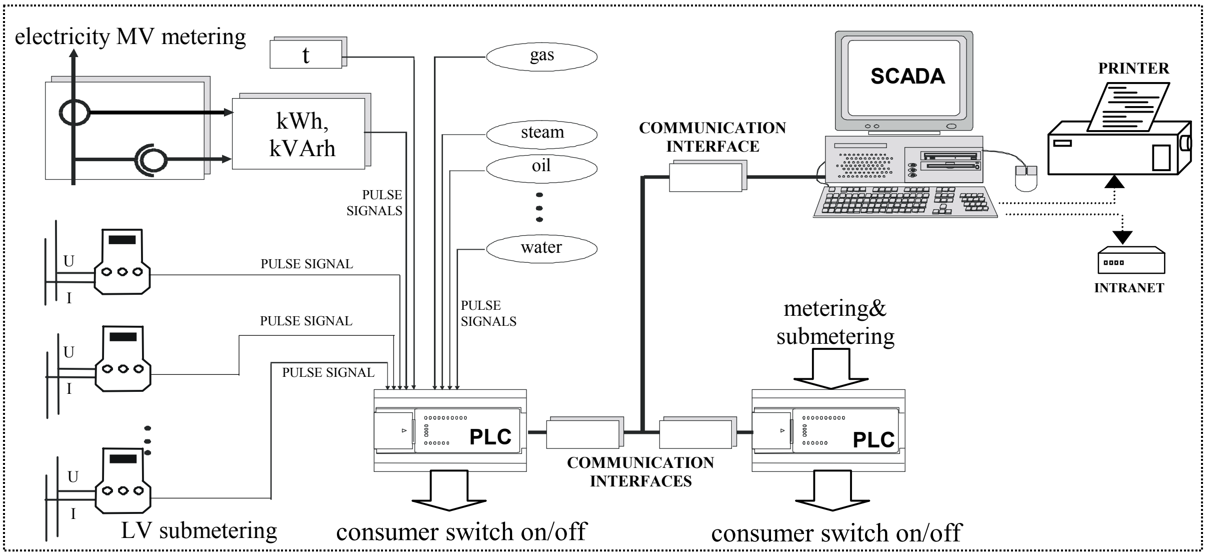


Fig. 2 PC SCADA system with pulse output energy meters connected via PLCs

Power and energy monitoring system was organised in three levels:

- Plant level,
- Communication level and
- Operator level.

3.1. Plant level

Tasks of metering, meter data collection in PLC, cyclically calculating average consumption, sending telegrams to PC SCADA, short-term energy forecast calculation and consumption switching control based on commands from SCADA PC, PLC algorithm running are all performing in plant level.

When choosing way of collecting real time measuring data, pulse signal was recognised as best cost effective solution, in comparison with analogue signal with integration in PLC or with communication capability of meter.

Submetering devices are to be placed in some process and energy consumption interesting points, and in way to optimise number of implemented PLCs.

PLC is programmable device that works in operating cycle with steps as follows:

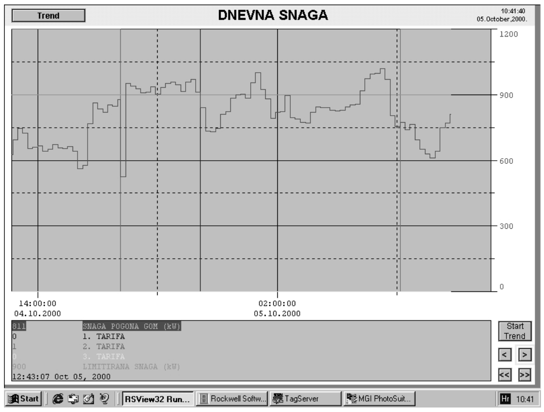
- Input scan - scan and read all input data,
- Program scan – executing application program,
- Output scan – write all output data,
- Service communication – communication takes place with PC.

3.2. Communication level

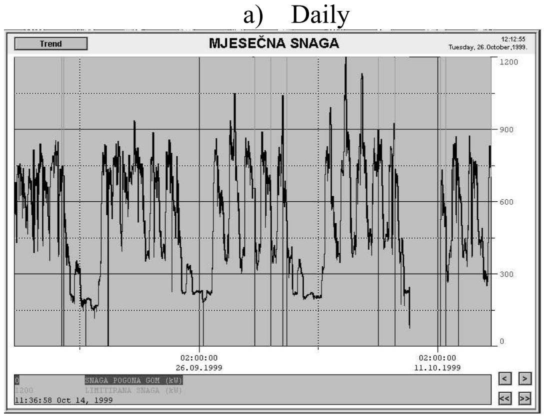
Communication between PLCs and SCADA PC is performing via some standard multipoint communication network. Data transmission flow is, in one way metering data, in another commands for switching consumers on or off, all via some standard protocol.

3.2. Operator level

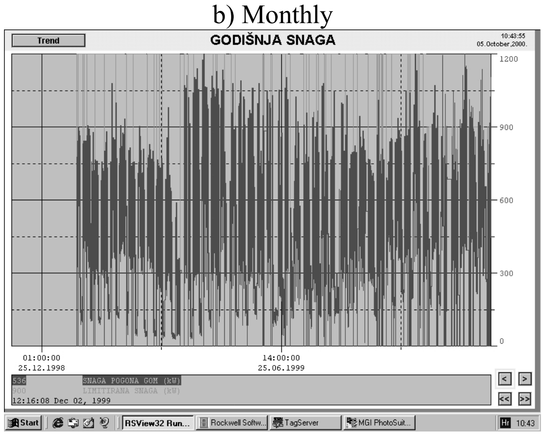
Central data acquisition, data storage and presentation, data manipulation and commands generation is performing on SCADA PC. This level contains system setup too.



a) Daily

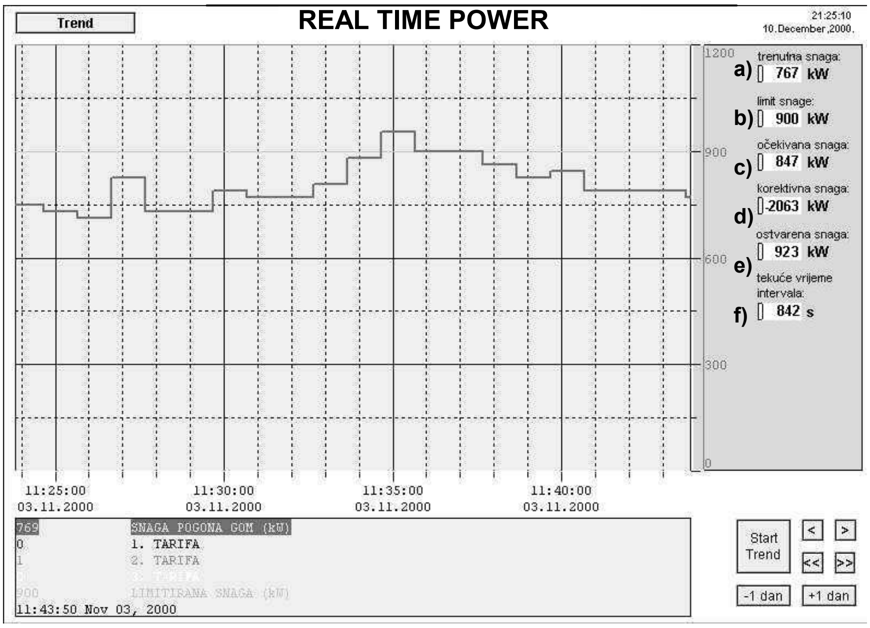


b) Monthly



c) Annual

Fig. 3. Power trend diagrams generated by SCADA



a) *Actual used power,*

b) *User set limit power,*

c) *Forecasted power at the end of counting interval,*

d) *Allowed switch on/off portion of power,*

e) *Realized peak power,*

f) *Actual time in interval (0 – 900 s).*

Fig. 4 Real time SCADA power time diagram with description of indicated measured and calculated values

Data storage capability ensures possibility of presentation of collected data in hourly, daily, weekly, monthly, and annual trend curve (Fig. 3.).

Fig. 4 shows main SCADA screen with real time trend diagram of main electrical power and some usable information for plant operator:

- Actual used power,
- User set limit power,
- Forecasted power at the end of counting interval,
- Allowed switch on portion of power, or suggested switch off portion of power, depending on short term forecast,
- Realized peak power,
- Actual time in interval (0 – 900 s).

From such screen main plant operator or main plant technical person can in time decide about optimal plant running. Main tool for estimation of allowed switch on portion of power or suggested switch off portion of power is “short time energy forecast algorithm”.

4. SHORT TIME ENERGY FORECAST

Power/energy forecast is sequence of time analysis considering measuring data and data in previous interval in purpose estimation average power in the end of 15 minutes (or other) official utility counting interval. Input data are pulses from main meter, 15 minutes and tariff pulses from pulses from official synchronising clock [1].

Algorithm used in forecast purpose was based on linear regression extrapolation method. Linear regression indicates best results in trend analysis and it is possible simple numerical realisation. Best placing regression straight line is done by minimising sum of quadratic deviation from equidistant power measuring points shown in Fig 5 [2, 3].

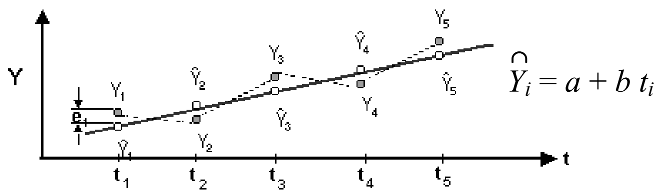


Fig. 5. Deviation from power metering points

Precision of realised method directly depends on frequency of pulses from main meter. Studying forecast algorithm in use indicate approximately 2% uncertainty forecasting after the 1/3 of interval and lowering as the end of interval is closer.

5. CONCLUSIONS

This paper describes basic principles and some results of one cost effective approach in designing system for permanent monitoring and power limiting in industrial plant. System was tested and is in use more than three years in chemical industry plant with present 1200 kW average power peak load. Plant was representative sample for Eastern Europe common mid-size industry energy consumer. Implemented energy monitoring system indicates investment turn back in less than six months.

A modern SCADA system makes possible implementation of the SCADA WEB server application and easy integration with company Intranet as efficient way for real time reaction in Energy management and post time analysis tool too.

System is more usable if more well placed measuring and switching elements exists. Cutting peak energy supply load has primary economical, but reducing environment pollution reasons too.

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