Kandó Kálmán Faculty of Electrical Engineering

Institute of Power Systems

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1 Introduction

The power supply is one of the basic services of the present life. Beside the traditional generation, transmission and distribution techniques a lot of high tech application is applied, such as renewable energy sources, GSM, GPRS and satellite controlled Wide Area Measurement Systems. The power system institute teaches the traditional and the most up-to-date techniques as well for the young engineer students who maintains and develops the future power systems. The appropriate knowledge transfer covers power engineering basics, informatics and electronics areas too. The system oriented basic education is followed by flexible subjects in different modules.

Through the continuous development of the education, the following topics gain more and more importance:

- New types of the power generation,
- SCADA systems,
- Energy resources,
- Protection devices,
- Monitoring of high voltage equipments,
- Measurement techniques,
- Environment protection,
- Isolation techniques,
- Bidding & contracting,
- Energy markets, liberalization,

- Renewable sources,
- Microprocessor based relaying schemes,
- Demand side management,
- Microgrids,
- Load measurement,
- Transformer monitoring,
- Power quality.

The institute has traditionally subtle industrial relation through the education, the research and the prospective employers of the students

- Power utilities, power plants,
- ABB, SIEMENS, SCHLUMBERGER,
- MAVIR, HOLCIM, Észak-Budai Tervező és Szolgáltató Kft.,
- Other industrial customers, etc.

2 Educational Profile

Far beyond the basic matters as the Theory of the electricity the Institute teaches the following professional topics in the frame of lectures, laboratories, projects and specialized group tasks:

- Energetics,
- Power supply,
- Power systems,
- Power management,
- Power information technology,
- Special energy sources,
- Relaying techniques,
- Power plant operation, etc.

3 Research and Scientific Activity

In the frame of the Institute operates two special research groups: Research group for Energetics and Research group for the Renewable Energy Sources. These workshops perform special R + D projects contracting the power industry sector.

Among the researchers are members of the Energetics and Electrotechnical Committees of the Hungarian Academy of Sciences, the Hungarian Electroctechnical Association, of CIGRÉ and of IEEE. In the last year the colleagues published more than a dozen papers, made several presentations in local and international conferences as well.

Among the 20 performed research project one can mention the *Renewable Energy Park on the Roof*, the *Cement Kiln Control*, the *Transformer Monitoring* and the *Energetic Audit and Application of Renewables in the Building Energetics* projects.

In the followings we introduce some projects performed by the research groups of the Institute.

3.1 Demonstration Park of the Renewable Energies

Scientific and Technological Objectives

Although EU directive for increasing the REN share in the portfolio have existed for long time, the practical application is retained in the countries having poor REN resource and poor REN culture.

The power Engineering Department of Budapest Tech, Faculty of Electrical Engineering is highly involved in the dissemination of the REN and DG culture, in the region that is why a project has been started with the following objectives:

1 Setting up a laboratory test environment for the REN/DG tools where the students can physically investigate the characteristics of these units.

2 Disseminate project findings in educational institutions. The future generation of power engineers should have sufficient knowledge on RE applications. In order to include project findings in the curriculum instructors in major educational institutions should be adequately informed.

3 Share existing knowledge on REN integration. The REN is hot topic in all European countries and many parallel operated research centres can be found. The project aims to make use of existing knowledge in this field instead of duplicating research efforts. It may include inducing other Central European Countries setting up similar projects in the future using the project findings.

4 Visibly decrease obstacles to application of REN resources. There is continuous development of the basic REN unit (wind turbine, micro water turbine, solar unit, heat pump, etc. but all these tools can be purchased on the

market. In spite of the commercial possibility, the penetration in Central Europe is really low. Increase the physical penetration rate is beyond the time frame of this project but it should contribute to decreasing the numbers of identified barriers.

5 Create support information for electric utilities in order to handle REN related issues. The attitude of electric utilities is crucial to the success of integrating RENs. The project targets them by organizing a forum for exchanging ideas (conference) and by providing them with written information (booklet) on the project findings.

6 Increase awareness and raise interest of RENs for the small scale users. For lack information concerning the technical requirements, the legal requirements and the pros and cons of REN resources. In order to make them aware of the potential of this energy source they should be supplied with adequate information on the subject. The activity of professional associations and new targeted publications can contribute to the achievement of this objective.

7 Foster wider application of REN units in the low penetrated countries, mainly in Central Europe.

At Budapest Tech one of the most current educational topic is the renewable energy application. For years runs theoretical investigation of these different techniques from fuel cells to wind turbines. Nowadays these equipments are off-the-shelf tools, one can get billion pieces of information in this area. The present value is not the simple information, but the filtered knowledge can be used at a real application case. This is why Budapest Tech made decision not to theoretical, but practical handling of these machines. An Energy Park (EP) developed for the real investigation and education of these techniques.

Setting up Test Environment

We started the realisation of a '*mini REN park*' on the top of the college. The REN units are mass products that can be applied by any small customers. This project is the test area of our work regarding the intelligent control of the small units and the development of the grid connections (utility contracting, measurement, etc.)

The REN park includes heat collector, photovoltaic unit, wind turbine and prospectively fuel cell, too. The units get a common intelligent measuring and controlling system. The small energy system will be connected to the central building heating system and to the electric utilities' system too.

The Renewable Park on the Roof

The Budapest Tech is located in Budapest in urban area. We set up the energy park on the roof of a college (PV, Wind and Heat collector). This is not the optimal place for the energy generation, but the best place for the educational and investigation purposes.

Photovoltaics

The task is to get detailed information about the generable energy with the local meteorological climate. We applied the low cost amorphous silicon technology panels (2-3 USD/W). (Fig. 1) Characteristics:

- Nominal power: 40 W
- Nominal voltage: 44.8 V
- Nominal current: 900 mA
- Free running voltage: 62.2 V
- SC current: 1150 mA
- area: 0,8 m^2

Running investigations are:

- Definition of operational efficiency
- Find the optimal position angle
- Effects of the dispersed light
- Aging features
- Planning the best mounting accessories
- Make help for the architects to plan more PV application

Figure 1
The Photovoltaic test site

Windturbine

We apply a 400W AIR-X 401 turbine. The electronics, the load (night illumination) and the National Instrument measurement system was built by students (see Fig. 2). Main characteristics:

- Rotor diameter: 1.15 m
- Voltage: 12 V
- Cut in speed: 3 m/s
- Nominal power: 400 W/11.5 m/s
- Maximal output: 520 W/18 m/s
- Built in charging controller

Figure 2
The turbine installation

Figure 3
The fuel cell

Figure 4
Vacuum tube collector

Fuel Cell

The 20 W FLEXIVA fuel cell unit transforms pure hydrogen into electricity (see Fig. 3). The produced heat is dissipated by air cooling fan. The energy is stored recently in 12 V accumulator.

This equipment is capable for the independent auto (car) accumulator charging too, but we operate and measure it through a personal computer system.

Heat Collector

The communal energy usage can not be investigated only from the electricity side. The heat consumption has effect on the gas and electricity bills too, because heating and cooling can run by electricity and gas as well. For the education of the energy consciousness thinking we apply heat collectors too. The different types of primary equipment (vacuum tube solar collector, flat collector – see Fig. 4) cooperate with the hot water system of the college building. The gas boilers heat the solar preheated water. The measurement system collects the data from the accumulated, stored and used heat. One must mention that the application of the heat collectors seems to be financially the most profitable investment into the renewable.

3.2 Transformer Monitoring System

To increase the availability and to achieve optimised performances of the transformer operation the on-line condition monitoring is useful and necessary. In Hungary this system is unique. In frame of this project we developed a system. We took into account the special aspects of the Hungarian 'Ganz' transformers. Transformer outages have a considerable economic impact on the operation of an electrical network. Therefore our aim is to ensure an accurate assessment of the transformer condition. Especially in case of the block-transformers of electrical plants the outages gives direct financial losses. Majority of the transformers -80%- are older than 20 years.

We have to mention that in last year the Hungarian Electricity Company lost 3 important units from the National Grid. This project is a complex development where we used the latest results of metering techniques and insulation technology. We studied the leader-producer specifications too (GE, ALSTOM, TECHNO-Service, etc.)

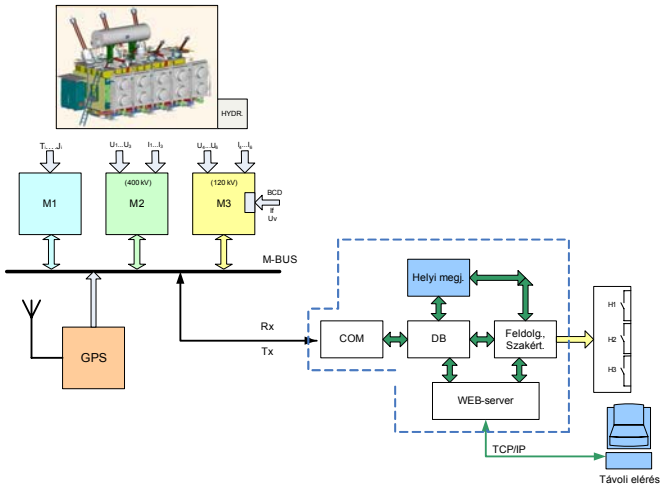

Figure 5

Block-diagram of the monitoring system

The function of units:

- M1: temperature meters and gas-analyse inputs.
- M2 monitor for all currents and voltages at 400 kV side in normal and transient regimes.
- M3 is the same on the 120 kV side.

The data are transferred to a database where organised by an expert system. This part is built on PC hardware. This database is accessed by webserver too.

A fundamental part of our development is the acoustic sensor and analyser of the acoustic signals with non-traditional methods. From the spectral analysing methods we use the wavelet tech that works on burst-type signals.

The decision function x(t) is a serial $\{x_1,..,x_i,\ldots,x_N\}$ so the Sequential Probability Ratio Test = SPRT give the result.

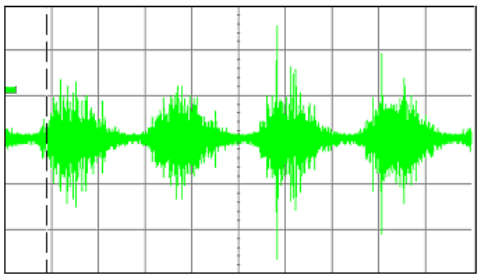

Figure 6
PD signals

3.3 Integrated Multifunctional Machine Condition Monitoring System (IMCMS)

Goal of the Project

Condition based PdM technologies are playing key role in competitive production providing high level of overall efficiency and reliability decreasing operation costs and losses.

Available condition monitoring technologies are expensive and low efficient in case of the huge, high powered and complicated slow speed cement making machines (kilns, mills, etc.).

The R&D project efforts were concentrated – surveying the large scale of theoretical and technical tools – to create and experimentally realize an integrated on-line machine condition monitoring system (IMCMS) of the central cement cliker making machine a Polysius made twin-driven, rotary kiln with satellite coolers.

Methods and Tools

Electromechanical drive and kiln motion control simulation, verification and validation. State-of-the-art measuring devices and sensors integrated by the latest NI HW&SW technologies.

Project Achievements

1 Verified and validated simulation models enabling detailed analysis of kiln motion in different critical operation. An interactive version simulating kiln motion dynamics including twin-drive control system and several operational

deficiencies (overloads, coupling spring fractures, brakings, increased backlashes, assymetries, etc.) proved to be excellent for the maintenance and operation personal.

2 Commissioned an on-line IMCMS based upon NI PXI-SCXI LabVIEW technology, including low and high frequency mechanical vibration, motor current, brush sparkling, speed dynamics, kiln slip, backlash, etc. monitoring, providing automatic measurement and evaluation, alarm, trend and statistical analysis. Remote monitoring via LAN (Ethernet) and WEB communication available.

3 There are developed specialty low-frequency (0…24 Hz) vibration sensors using MEMSIC gas-filled microchips controlling the girth-gear drive.

4 The monitoring system and the interactive simulation model made possible to create and apply such a kiln twin-drive motion control algorithm which stabilizes the kiln dynamics in many critical operation decreasing the torsional loads of the kiln increasing the lifetime of mechanical components and the refractory.

Figure 7
The cement kiln

3.4 Energetical Audit and Application of Renewable Energy in the Building Architecture

The most important role of the innovation is the spread over of the results of basic research. The power industry works with hundred year old technology, but the present lack of primary energy sources requires the efficient energy usage. By a general experience in most of the newly built buildings the energy consumption can be reduced with 3-5% by the better energy management. It is a lot of money.

In the frame of the project we investigated

- What is the performance of the present system like?
- How can be developed the energy management?
- How can one spare with the energy and
- Where can one by cheaper energy?

Main statements:

- The half of the energy is used by the heating system, one fifth belongs to the mall section. The heating/cooling is performed by roof-top units.
- The present utility contracts are not the best, so new offers are required from the energy traders.
- There is no active energy management but there is no any serious anomaly.
- The load is well forecastable.
- Small maintenance works are necessary.
- Adumbration is not recommended.
- The heating system most be tuned.
- The new cooling system can by set up with absorption units.
- The photovoltaics had PR vale.
- Through the improvement of the SCADA system energy could be spared.
- The energy bills were analysed in details.

A demonstration- and a normal photovoltaic system were recommended.

50 small- and large scale project were recommended too, e.g.:

- Water heating by heat collector,
- Archiving the heat measurements,
- Set up a load forecast system,
- Changing the energy supply contracts,
- Better handling the reactive power,
- Gas consumption from the liberalised gas market,
- Set up 10 kW photovoltaic system,
- Set up 200 kW photovoltaic system,
- Form- or join to an ESCO,
- Education of energetics personnel.

Figure 8
Measurements on specific lines

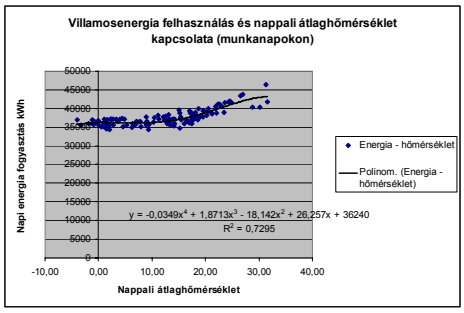

Figure 9
Correlation analysis

The work was performed between July 15 - Sept 25, 2005. The applied methodology:

- Local inspections,
- Investigation of plans,
- Measurements,
- Analysis,
- Thermovision,
- Interviews,
- Information from vendors,
- Negotiation with utilities.

We looked for the answer for the following questions

- Energy usage ratios.
- Is the present contract optimal?
- Are there anomalies?
- What is the energy management with?
- What can one expect from the load-forecast?
- Utility contracts.
- Heating-cooling.
- External adumbration.
- General technical condition.
- Alternative energy supply.

The documentation consist of

- Building engineering overview,
- Analysis of electrical consumption,
- Photovoltaics,
- Thermovision,
- Recommended projects.

The Photovoltaic System

The application of the photovoltaic system can decrease of the electrical energy consumption and can be raised the energy security, specifically in during the summer air conditioning period.

- We introduced a technical solution
- We investigated the placement of the solar panels
- We calculated the quantity of the generable energy.

We investigated the esthetical aspects too. The best placement option is the roof and the southern wall of the building.

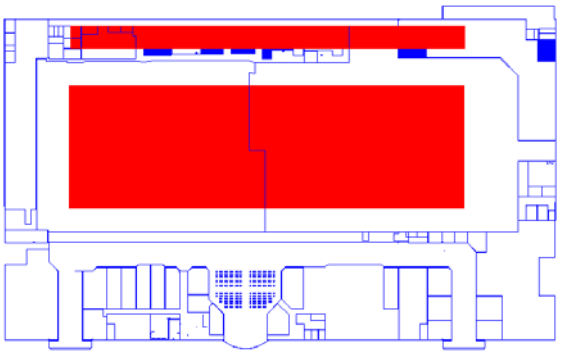

Figure 10
Scheme of the placement of the solar panels on the roof of the mall building

For the calculation of the generable electrical energy we applied the measurement results of the solar test site on the roof of the Budapest Tech. We could define the best orientation and the pitch angle as well. A 10 kW and a 200 kW system was planed too.

One of the result of this project is a real application of the solar technology ina n other mall ot hte mall chain.

Prepared by *Peter Kadar* with the support of *Mr. Ferenc Herbert; Mr. Gyula Gyökér* and *Mr. György Morva.*

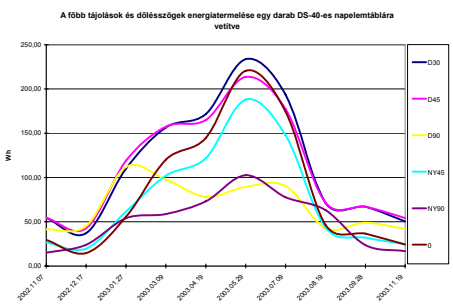

Figure 11
Generation of the DS40 panel

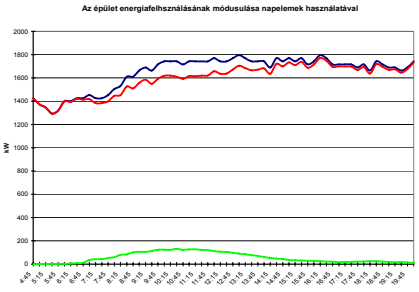

Figure 12
Change of the energy consumption of a building through photovoltaics

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