

# Energy Data Mining Greek Case Study

## ADSL-based AMR Methodology

The **Web Enabled Electric Meter (WEM-MX)** [7] from our unique US Partner (EnergyTracking) that is used for the Greek pilot, is an Internet enabled, broadband ready smart electric meter for commercial and industrial applications (Fig. 1). It can be deployed as a primary meter, sub meter or used for other electric metering applications such as demand reduction. Besides tracking peak demand (kW) and energy consumption (kWh), this advanced meter integrates many important features and provides enhanced functionality.

Its open system design facilitates world-wide deployment to populate applications with real time data based on accurate measurements. This electric meter is designed to meet requirements for data on demand from multiple users. Traditional meters focus only on single user applications at fixed time intervals. It provides peak demand (kW) with a date and time stamp informing you as to when the peak demand occurred. It also has the capability to periodically record and store interval data usage (load profile) based on a user defined interval of 1 minutes to 60 minutes or more. This functionality helps identify where, when and how much energy was consumed say, every 15 minutes. It can also store energy consumption by time-of-use (TOU). This allows end users to identify how much energy was consumed during different periods of the day. Configuration settings are done via its on board web server

The output of the measured energy data are in XML format and thus can be easily imported to the EMIR middleware for direct processing from the web algorithms. XML data are generated every 15 mins (traditional Demand side interval) and are uploaded automatically to a dedicated FTP server that acts as a gateway to the created Energy Warehouse that was used. Sequentially, the generated XML data are inserted automatically through data cleansing and ETL mechanisms to a dedicated database and are processed by Matlab beans, in order to create data mining outputs and table results.

## Greek Case Study in Schools & Buildings

The first Greek Pilot web load profiling project was executed in one of the **biggest Greek Private Schools in Athens and two Public buildings in the region of Athens**. The above AMR methodology was used, with WEM-MX meter (Fig. 1) and web XML energy data integration. EMIR system with hypercubic clustering theory [2], [5], [6] was used to analyse and mine energy data in order to extract trends. Values and physical parameters that were generated and used were kWh, CO<sub>2</sub>, kWh/m<sup>2</sup>, Current and Voltage, Heating and Cooling variables. Additionally, location-based services were also integrated to the existing Matlab middleware (Fig. 4) for geo-spatial correlation of profiling and local climate conditions (temperature, m<sup>2</sup>, opaque, etc).



Fig. 1 – WEM-MX AMR installation to Greek School

From the data and the output graphs, many results and comments can be made, especially for the effectiveness and the power of EMIR EIS and its embedded algorithms (EnergyRank [2]). Firstly, it can be said that there are huge possibilities of energy conservation and minimization using personalized Energy Services from ESCOs, given the fact that the characteristic curves (kWh/m<sup>2</sup>) and energy load profiles are highly correlated.

**PAN Energy Mining Graphical Analysis**

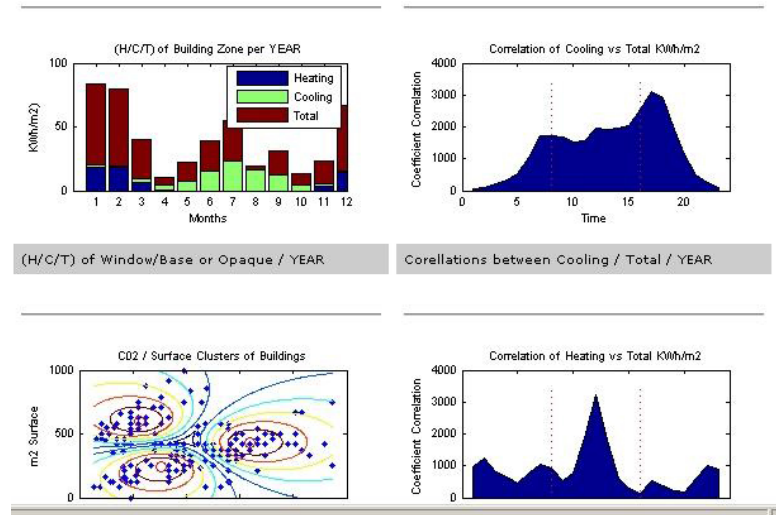


Fig. 2 - EMIR System Technical Architecture

From Fig.2 it can be seen that the energy mining algorithms for the private school give correlated profiles (autocorrelation functions for Heating and Cooling) and this can direct energy services according to specific time slots (elastic periodicity) with variable price philosophy. Specific clustering methodologies, group together CO<sub>2</sub> emissions from various other buildings (in the same or different regions) and EMIR system provides correlated clustering outputs with their surface (m<sup>2</sup>) and load profile per month, indicating where there is an old building that needs services from an ESCO, or a new building that needs probably different methodologies (CHP, Gas integration, RES, etc). Adaptive peak analysis and seasonality trend modelling (Fig. 3)

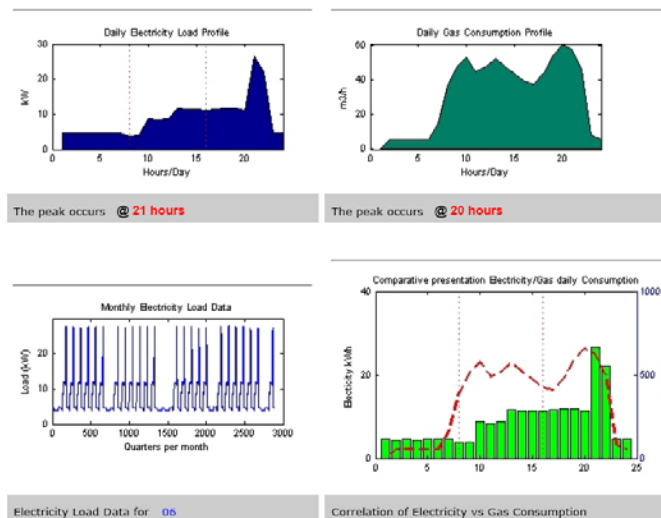


Fig. 3 - EMIR System Technical Architecture

of the School and some buildings, from EMIR methods (two months energy data), indicated also strong correlations and strict periodicities. Peak analysis, correlated with kW peak and Gas consumption gave great hidden trends for CHP services or Demand Response programs to reduce peak load and shift loads towards other time slots with lower price of kW. Variable kW prices correlated with Gas prices and gain margins from the minimised load, give great results for an ESCO, in order to invest on personalized energy services. The system, using back-end energy crawlers, ranks the buildings (energy customers) and generates high probable customers.

Furthermore, the combination of location-based services and embedding Google Maps to the existing middleware, give great geo-spatial results. Using Google markers (Fig.4) geo-correlated load profiles are indicated on a dynamic map that changes according to the variable consumption. Geographical ranking of max customers with periodicity or correlated peaks are indicated with EMIR system, giving the opportunity to an ESCO or an Energy Consultant/Company to direct its services towards specific customers with positive ROI margin and high probability of energy minimization. Energy markers are dynamic and an overall geo-spatial search can be effectuated, over regions that are measured with our system. Micro-climate conditions and local physical parameters (temperature, humidity) were also included into the middleware, in order to produce correlated data for contraction companies (building according to best energy characteristics)

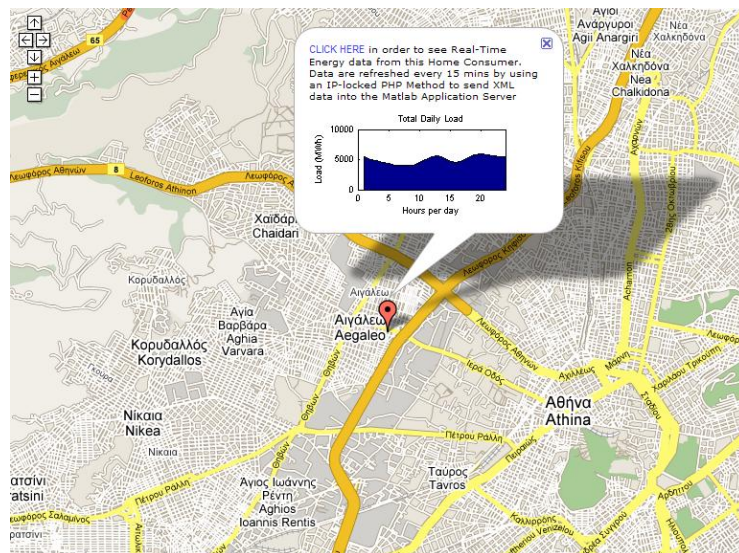


Fig. 4 - EMIR Location based Services in Energy (Building in Aigaleo region in Athens)

Correlated graphs were also generated from measurements inside a building or inside the School (pool, various Electro-Mechanical devices, etc). Correlating those measurements over time (Fig. 5) can expose hidden energy patterns and trends for Demand Response. For example in Fig. 5, there is a sequential periodic trend of 3 E/M devices inside the building. This hidden trend indicated a sequential peak of energy that was corrected by shifting two devices to neighbouring time slots.

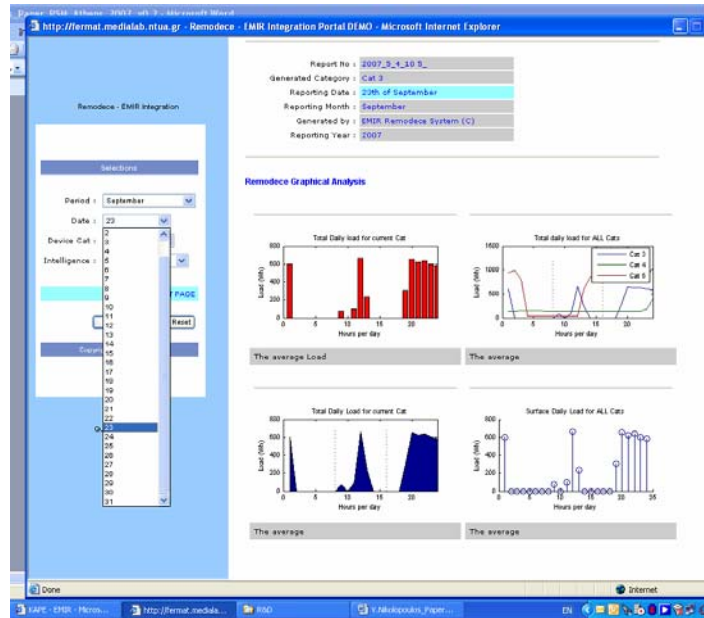


Fig. 5 - Statistical energy trends from Building entries

The above Energy Mining analysis, was effectuated from EMIR system and the patented algorithms that reside inside the Matlab middleware (MSP). Various application Graphs were used in order to indicate the ability of the system to analyse, manage and provide hidden energy information to an ESCO for Energy Services provision. The results indicated also that we could have extremely important results and create actions, if we use the stored data to extract information and create useful energy knowledge.

## References

- [1] **E.M.I.R. Project** (Energy Management & Intelligent Reporting) : <http://fermat.medialab.ntua.gr/emir> - <http://www.intelen.gr>
- [2] 'Analyse et Simulation des méthodes de routage dans la topologie d'hypercube', V. Nikolopoulos, mémoire Ingénieur, Ecole Polytechnique, promotion X99, 2002
- [3] MATLAB Web Server. Natick, MA: The Mathworks Inc., 1999.
- [4] V. Nikolopoulos, "EMIR - Energy Management and Intelligent Reporting" Bulletin of Electrical and Mechanical Engineers Bulletin, No 382, 1 December 2005"
- [5] V. Nikolopoulos, V.Loumos, "'A Web-based system for optimal Energy Sources Management, through Ontologies and Semantic Clustering" Technical Chamber of Greece (TEE) Research Conference 2006, Athens, Greece
- [6] V. Nikolopoulos, Vassili Loumos, "A Web-based Information System for Optimal Energy Sources Management through Ontologies and Hypercubic Clustering ", Energy 2006 International Conference, Athens Greece
- [7] <http://www.energytracking.com>
- [8] V. Nikolopoulos, George Bardis, Vassili Loumos "Energy Profile Management based on web adaptive Algorithms and LBS Google Maps", in AUEB FSDET 2008 Conference, Athens, GREECE
- [9] V. Nikolopoulos, George Polymenopoulos "The new Philosophy of Energy Governance, based on modern Energy Information Systems", in EnergyRes 2008 Conference, Athens GREECE
- [10] V. Nikolopoulos, Vassili Loumos, "Web-based energy information system for optimal bi-directional behavioural control of various energy customers using ADSL hypercubic clustering and internet services (emir system)", Power Systems Modelling Conference 2007, ([PSM 2007](#)), June in Athens GREECE

Contacts at [info@intelen.gr](mailto:info@intelen.gr)

# Energy Tracking

## Web Enabled Meter (WEM-MX)

The Web Enabled Meter Model MX is an Internet enabled, broadband ready, revenue grade solid state electric meter for commercial and industrial applications. It can be deployed as a primary meter, sub meter or used for other electric metering applications such as demand reduction. Besides tracking peak demand (kW) and energy consumption (kWh), this advanced meter integrates many important features and provides enhanced functionality.

Its open system design facilitates world-wide deployment to populate applications with real time data based on accurate measurements. This electric meter is designed to meet requirements for data on demand from multiple users. Traditional meters focus only on single user applications at fixed time intervals.

It is the right solution in today's complex energy markets combining low cost, high accuracy, minimum cost of communications with real time data access and reporting.

This sophisticated meter combines elements of simplicity, is highly functional and reduces overall ownership costs. Since most facilities already have an existing network, the cost of communication is virtually nil.

### Applications:

- Energy Management
- Sub Metering
- Remote Meter Reading
- Billing Analysis
- Energy Usage Analysis
- Real Time Data Measurement and Reporting
- Demand Reduction
- Load Curtailment Projects

### Accuracy:

- $\pm 0.2\%$  at unity power factor
- $\pm 0.5\%$  at 0.5 power factor



### Standard features include:

- kW, kWh, kVARh, voltage, current, power factor, VA, frequency.
- kWh & kVARh (Delivered, Received, Sum, Net - Instantaneous).
- Load Profile 4 Channels: kWh & kVARh (delivered and received).
- Configurable demand reset date and load profile logging interval.
- Internet connectivity via dynamically IP addresses or static IP addresses.
- Email notification with cc: option, data transfer via ftp, web server.
- FTP client - send load profile, demand and consumption summary details.
- SNTP for time synchronization.
- Log-in to web server is authenticated.
- Data encapsulation format - XML.
- Programmable alpha-numeric meter ID and meter serial number.
- Programmable demand (kW) threshold sends email when exceeded.
- Programmable email/ftp (daily) report of peak demand, consumption and previous month energy usage.
- Programmable email/ftp report of load profile.
- Auto reports include total kWh, last interval's kW, voltage, current, power factor values by phase and frequency.
- Mail and ftp reports can be setup to be sent every 5 minutes or daily.
- Open Protocols XML, HTTP, SMTP, SNTP, FTP, DHCP, DNS.

### Load Profile and Peak Demand Capability:

This advanced meter measures peak demand (kW) with a date and time stamp informing you when the peak occurred. It also records and stores interval data usage (load profile) on user defined intervals (5 to 60 minutes). This helps identify where, when and how much energy was used. It can also store energy consumption by utility time-of-use (TOU) allowing users to match energy use to utility tariffs and calculate mid-month bill estimates.

Using the smart meter to mimic utility demand meters, TOU meters or load profile meters enables sub-metering, energy management and other metering applications such as demand reduction.

### Versatile Communications:

Open protocol communication features send data over the Internet using file transfer protocol (ftp), email or via an board web server. Users can get data anywhere anytime via email. Using existing, or local area network connections, avoids telephone modems and lowers communication costs.

### Customize applications to your needs:

Energy Tracking's Internet enabled solid state ANSI C12.20 meter and its leading edge software applications <http://www.energytracking.com/software.htm> can be simply configured to match your needs.

For pulse metering applications, the web enabled pulse logger will meet your needs to integrate gas, oil and steam usage and works with the Energy Tracking software.

Measure and control external load for a low cost energy management solution using two switching outputs that are optically isolated and can be triggered based on user defined kW threshold values.



### Extended features include:

- Li-ion battery backup
- 2-Channels for external Load Control. (optional)
- 2-Channels for Watts and VARs pulse output. (optional)
- Power outage and restore notification via email.
- Integrate gas, oil, steam etc. with the sister web enabled pulse logger

### Benefits:

- Better management of energy usage.
- Get details about the amount and timing of your energy use, so you can adjust accordingly and save money.
- Improve purchasing strategies
- Compare costs between competing suppliers.
- Secure a better pricing from the retail energy markets.
- Improve operating strategies to control load and reduce waste.
- Understand and improve consumption patterns.
- Measure energy savings from energy efficiency modifications.
- Highlight anomalies in electric consumption.
- Interface the meter to a smart IP enabled thermostat for automatic demand and energy reduction.



### Energy Tracking, LLC

16 Southwind Drive  
Flanders, NJ 07836  
Phone: 973.448.8660  
E-mail:

[support@energytracking.com](mailto:support@energytracking.com)



DS-WEM-MX-1207