PRESENTATION REVIEW OF
SEMAN VOLTAGE-CURRENT QUALITY IMPROVEMENT &
ELECTRICAL ENERGY SAVING PROJECT
INSIDE THE ELECTRICAL INSTALLATIONS OF

LOCATED IN IMEROS TOPOS at ASPROPYRGOS ATTICA -
GREECE

A. PAPASTRATOS CIGARETTE MANUFACTURING COMPANY (CMC) SA, a
PHILIP MORRIS INTERNATIONAL AFFILIATE IN GREECE

PAPASTRATOS CMC SA, Philip Morris International’s affiliate in Greece, is the largest
tobacco company in the country, producing many well-known cigarette brands, such
as Marlboro, Philip Morris and L&M as well as Greek brands such as Assos and Zante.

Picture 1: PAPASTRATOS CMC SA facilities in Imeros Topos at Aspropyrgos, ATTICA – GREECE
The total installed electric power of PAPASTRATOS CMC SA comes up to **6MW**. The grid is in **50Hz** and there are **8 Transformers** that supply loads to low voltage level of **380-400V**.

The electrical loads of PAPASTRATOS CMC SA plant are divided to three very district categories and thus areas of the factory. The **Primary** line loads that has to do with the tobacco processing, the **Secondary** Line loads that has to do with the cigarette manufacturing and the **Auxiliary** loads (chillers, air compressors, Air Handling Units (AHUs), water pumps, exhaust fans etc.) that has to do with the support of the first two main production lines.

The **average annual cost of electricity** is approximately **1.855.000 €** in current prices.

### B. The scientific project of SEMAN SA

The scientific project of SEMAN SA for the current - voltage quality improvement & electrical energy saving inside the electrical installations of PAPASTRATOS CMC SA had been assigned to SEMAN on December 2010 and concluded before the end of May 2011.

In order to elaborate the scientific study for the PAPASTRATOS CMC SA Electric Power Grid, SEMAN SA staff of engineers performed Measurements and Recordings concerned the basic electric values (Active & Reactive power, Voltage, Current, Frequency) as well as current & voltage harmonics (up to the 35th class) and transient phenomena in each individual load of the installation (AC motors, motors with Inverter drives, Star- Delta contactors etc.), in the Low Voltage level of the grid.
Moreover SEMAN SA staff of engineers proceeded to the collection of all the essential data that had to do with lengths and cross-sections of cables, number of cables headed together in canals, nominal values of motors, power transformers and many other data also necessary for elaborating the scientific study for the voltage-current quality improvement & electrical energy saving project.

Picture 3: Laptops used for measurements and recordings

Picture 4: Measurements have been performed also in the core of the electrical installations next to the loads
Based on the above, the engineers of SEMAN SA were able to simulate the behavior of PAPASTRATOS CMC SA Electric Power Distribution Grid and detect all the problems that were causing bad quality of voltage and current, low electric loads and power transformers efficiency, harmonic resonances and multiple other energy losses. The simulations conducted are based on SEMAN’s know-how, which has been awarded by the university of Cambridge and USA institutes. More particularly, models based on the Finite Elements Method (FEM) in combination with load flow analysis were used to complete all the required simulations (more information concerning SEMAN’s simulation models can be found at www.seman.gr).

The PAPASTRATOS CMC SA Electric Power Grid main power quality problem that had been detected by the help of Power Quality Analyzers and proper recording devices had been not only the reactive but also the quite big harmonic currents that flowed through the inner power distribution cables. Particularly the total harmonic distortion, especially near the inner power distribution panels in some cases reached the 8,5 - 9% for the Voltage (THD-V%) and the 75-80% for the Current (THD-I%). The source of the above-mentioned harmonics are the numerous big power motors that run by the help of inverter drives inside the Power Distribution Network of PAPASTRATOS industry.
Picture 6: Voltage & Current Harmonic Distortion recordings inside the Power Distribution Network

Picture 7: Power Quality Analyzers used for the measurements & recordings
After the gathering of all the above mentioned data (measurements, recordings etc.) a number of energy saving scenarios, for the specific Electrical Power Grid – all based on the know-how of SEMAN SA – had been carried out by the use of simulations and finally the scientific study concluded 21 customized interventions (pictures 8, 9, 10, 11 & 12) that have been installed inside the Electric Power Network of PAPASTRATOS CMC SA plant.

The total installed power of the interventions for the voltage-current quality improvement and energy saving project was approximately 1,3 MVA.

The target of the installed customized interventions was to minimize the current-voltage harmonics and to improve the current-voltage quality of the electric installation of PAPASTRATOS CMC SA plant.

Moreover, the Current – Voltage Quality improvement & electrical energy saving interventions installed did the following:

• maximized the total efficiency of the Electrical Installation,

• improved the motors’ efficiencies (Air Compressors, Exhaust Fans motors etc.), due to:
  ❖ the minimization of the counterclockwise electromagnetic torques caused by harmonics and
  ❖ the reduction of voltage drops and the higher constant voltage to the motors.

• Improved the power transformers’ efficiencies by the reduction of their copper and iron losses,

• reduced the following thermal losses:
  ❖ Thermal losses of supply.
  ❖ Contiguity Effect Losses.
  ❖ Skin Effect Losses.
  ❖ Eddy Current Losses.

It should be mentioned that the design of interventions took into consideration not only the interaction with other electric loads of the network, but also the resonance frequencies of the electric power cables of the grid.
**Picture 8:** Low Voltage (LV) Variable Anti-resonance Harmonic Filter installed inside the Secondary Line of PAPASTRATOS plant

**Picture 9:** Reactor of the LV Variable Anti-resonance Harmonic Filter installed inside the inner power distribution grid of PAPASTRATOS plant
The customized interventions for voltage-current quality improvement had been connected in parallel to the electrical loads of the plant and led to harmonics absorption and their important reduction inside the electrical installations of the PAPASTRATOS plant.

Furthermore, resonance frequencies that could lead to dangerous tuning had been cut off. PLC with special design from SEMAN engineers, based on the results of the scientific study, controlled the dynamic operation of each intervention according to the fluctuations of the electric load and ensured the cutting of all dangerous interactions between the loads.
Additional to their above characteristics, these customized interventions have the ability to compensate “useless” reactive currents that flow inside the electric power grid.
C. Results – Benefits

For the evaluation of the Voltage – Current Improvement & Electrical Energy Saving Project in PAPASTRATOS CMC SA plant located in Imeros Topos at Aspropyrgos ATTIIKA - GREECE, measurements and recordings were taken place during the delivery of the project (May 2011) with and without the interventions into operation. The measurements and recordings were realized in presence of PAPASTRATOS staff of engineers.

Additionally, with the above-mentioned measurements the evaluation of the electrical energy saving result had been also realized according to the relative international bibliography [see references 1-3 at the end of the present review]. Specifically, a mathematical statistical model had been developed based on Regression Analysis methods.

By using historical data of the electrical energy consumption and operation of the several sections of the plant based on a data period before the voltage-current improvement & electrical energy saving project had been set in operation, a mathematical model had been developed, based on regression analysis, that correlates the monthly electrical energy consumption with plant’s monthly operational data (such as production of the various lines, ambient temperature etc).

Applying the above mentioned Predicting Mathematical Model, which had been created in collaboration with PAPASTRATOS Industry staff of engineers & Managers, to the months that followed the project implementation, the final electrical energy & thus the cost saving results concluded and presented in Table 1.

Table 1. Synoptic Results of Voltage-Current Improvement & Electrical Energy Saving Project accomplished for the PAPASTRATOS CMC SA plant located in Imeros Topos at Aspropyrgos ATTIIKA (PMI affiliate)

<table>
<thead>
<tr>
<th>Value</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guaranteed saving according to the contract (%)</td>
<td>-5,86%</td>
</tr>
<tr>
<td>Saving achieved (%) ( according to the Reference Letter by PAPASTRATOS Company Management &amp; based on the International Bibliography methods of electrical energy saving projects evaluation)</td>
<td>-10,34%</td>
</tr>
<tr>
<td>Guaranteed Pay Back Period of the project (years)</td>
<td>2</td>
</tr>
<tr>
<td>Real Pay Back Period of the project (years)</td>
<td>1,32</td>
</tr>
<tr>
<td>Annual Money Saving(€)</td>
<td>191,718,10 €</td>
</tr>
</tbody>
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In addition, SEMAN’s Voltage – Current Improvement & Electrical Energy Saving Project in PAPASTRATOS CMC SA plant located in Imeros Topos at Aspropyrgos ATTIIKA - GREECE, had some extra benefits, confirmed also by the recordings before and after the installation of the energy saving equipment and the ascertainments of PAPASTRATOS responsible Managers.
These extra benefits are the following:

1. **Reduction of current & voltage harmonics.**

2. **Optimization of the voltage & current quality of the electrical power grid** of the factory.

3. **Maximization of the efficiency ratio** of the electric power grid, motors and power transformers.

4. **Increase of the reserve and capacity charge** of the electrical installation.

5. **Reduction of the maintenance cost** concerning all the components of the electrical installation.
REFERENCES

(1) Council Regulation (EEC) No 1836/93 of 29 June 1993 allowing voluntary participation by companies in the industrial sector in a Community eco-management and audit scheme


(3) North American energy M&V protocol version 1 [March 1996]