# SCIENTIFIC ENERGY MANAGEMENT DMCC (SEMAN DMCC) SCIENTIFIC ELECTRIC ENERGY SAVING PROJECT IN ALMARAI FACTORY AT AL KHARJ, KSA

## A. ALMARAI DAIRY FACTORY IN AL KHARJ

ALMARAI was established in Riyadh, in the Kingdom of Saudi Arabia, in 1977, as a partnership between the Irish agri-foods pioneer Alastair McGuckian and the Prince Sultan bin Mohammed bin Saud Al Kabeer. **Today, Almarai is the largest vertically integrated dairy company in the world.** Under the ALMARAI umbrella brand, the company offers a range of food and beverages, including fresh and long-life dairy products, fresh yoghurt, desserts, cheese and natural juices.

Picture 1: General plant view

The plant of the ALMARAI Group in which the scientific energy saving project of SEMAN DMCC has been installed at, is characterized **as one of the biggest factories in the world**. For its facilities, **National Geographic has produced a documentary at**

**Megafactories Series**, which can be viewed in the following website: https://www.youtube.com/watch?v=qUAIMqXU3mE.

Picture 2: One of the Main Electric Power Distribution Substations

Picture 3: Medium Voltage Panels in one of the Main Electric Power Distribution Substations

The total installed electric power of ALMARAI comes up to 80 MW. The grid is in 60Hz and there are 23 Substations feeding around 60 Power Transformers of 13.8/0.38-0.48 kV, while there are also 14 medium voltage motors at 13.8kV.

Picture 3: Production Line

Picture 4: Compressors & Pumps distribution panel room

Picture 5: Inner photo from the Bottling Machine lines sector

**B. The scientific electric energy saving project of SEMAN DMCC**

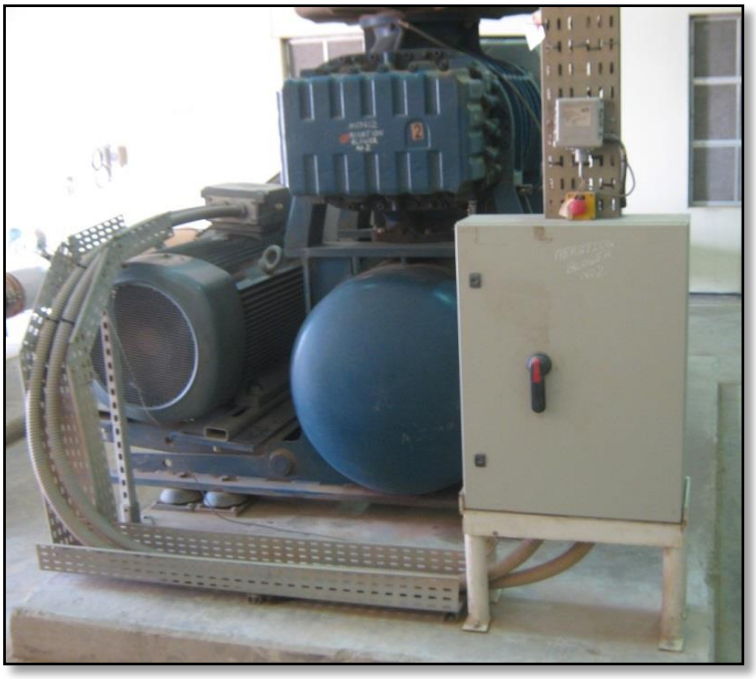
SEMAN DMCC's scientific project for electric energy saving and current - voltage quality improvement has been set in operation **at the beginning of November 2014**.

In order to elaborate the scientific study for ALMARAI's Electric Power Grid, the engineers' staff of SEMAN DMCC performed measurements and recordings – of all the required electrical values – in each individual load of the installation (AC & DC motors, motors operating with Inverters, DC Converters, Star- Delta switches etc., both in Low and Medium Voltage).

Picture 6: Power Quality Analyzers & Laptops were used for measurements and recordings

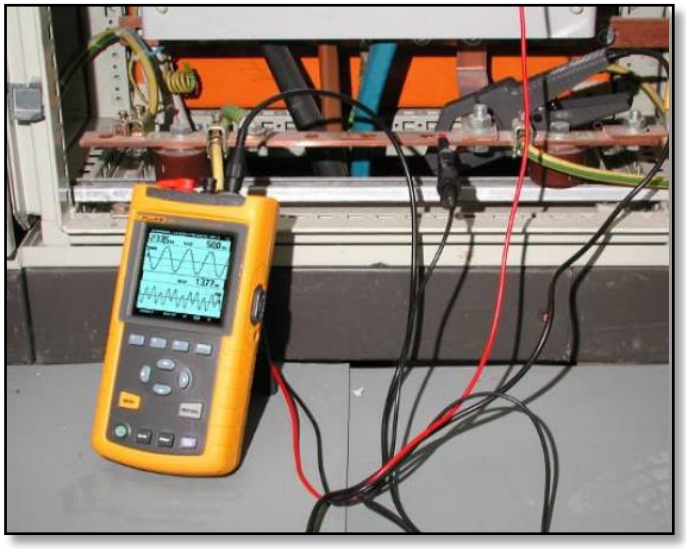
Measurements and recordings (see pictures 6, 7, 8 & 9) concerned the basic electric values (power, reactive power, voltage, current, frequency) as well as current & voltage harmonics (up to the 35$^{th}$ class) and transient phenomena.

Inside the Electric Power Grid of ALMARAI Industry, transient phenomena occur not only from the disturbances catering from Public Power Distribution Network, but also from their own big electric loads that start and stop sharply during production process.

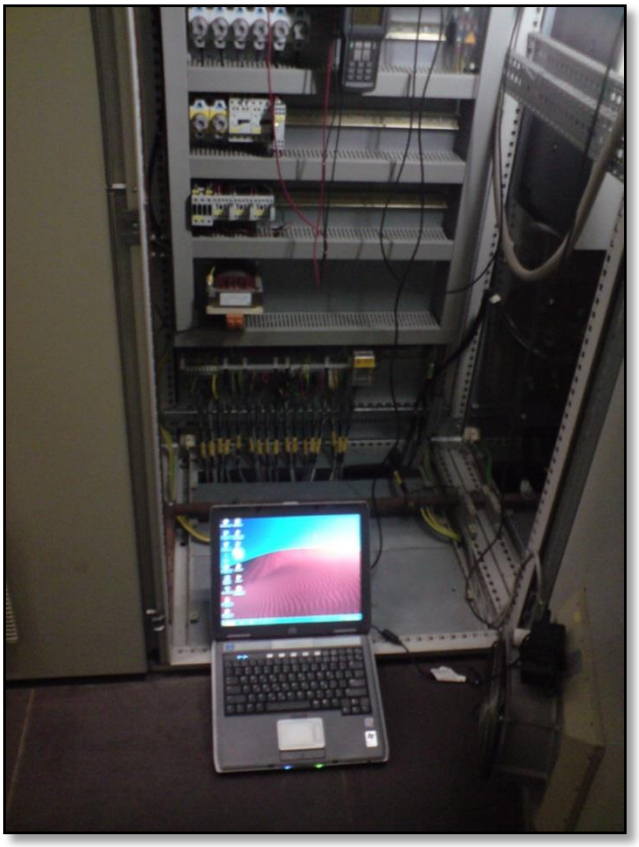


Picture 7: Measurements & recordings have been performed also in the core of the electrical installations next to the loads

Moreover, the engineers' staff of SEMAN DMCC 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 others also necessary for elaborating the scientific study for the energy saving project.



Picture 8: Measurements & recordings with state-of-the-art power quality analyzers & laptops



Picture 9: Portable power quality analyzers & laptops were used for the measurements & recordings of the electrical loads of the plant

Based on the above, a number of simulation scenarios of ALMARAI's electrical network were carried out. According to the scientific study results, SEMAN DMCC's engineers designed **243 customized interventions** (see pictures 10 - 17), in order to fulfill the electrical energy saving goal. The total installed power of the interventions was **13MVA**.

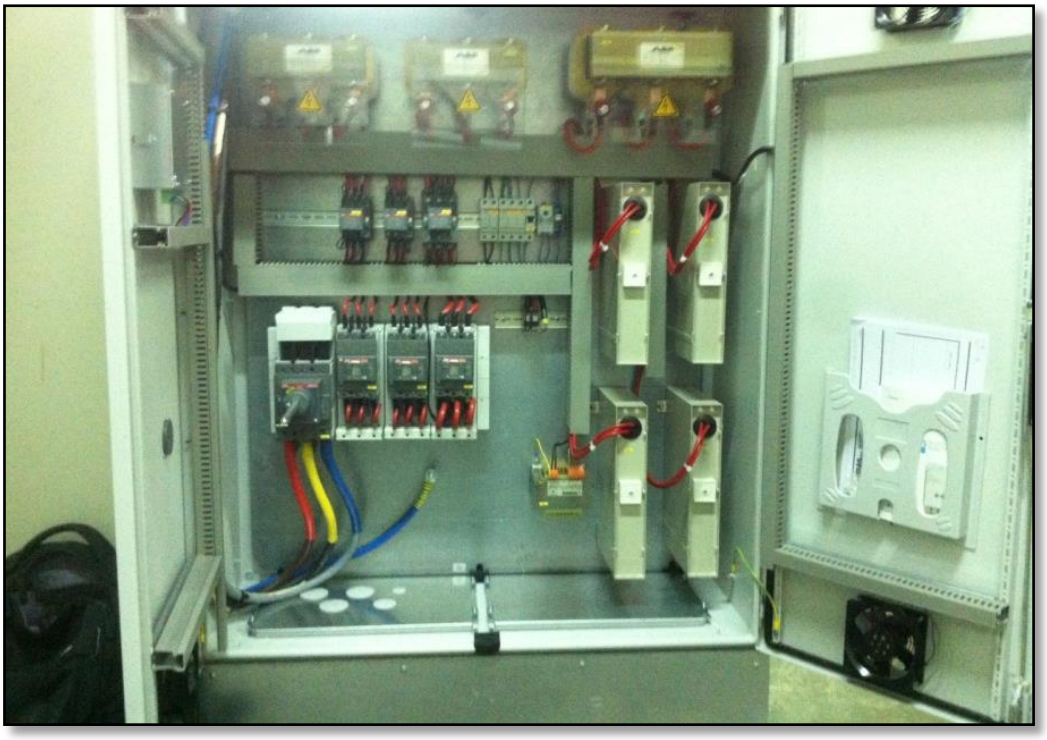
Picture 10: Four (4) different SEMAN DMCC's customized Low Voltage (LV) Variable Interventions, combined at a single enclosure installed at ALMARAI's electrical installations

The target of the installed customized interventions was to minimize the current-voltage harmonics, to improve the current-voltage quality of the electric installation of ALMARAI's plant **and to achieve electric energy saving**.

SEMAN DMCC's customized interventions managed to:

- **maximize** the total efficiency of the Electrical Installation,
- **improve** the motors' efficiencies, 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.
- **improve** the power transformers' efficiencies by the reduction of their copper and iron losses,
- **reduce** the following thermal losses:
    - ❖ Thermal losses of supply.
    - ❖ Contiguity Effect Losses.
    - ❖ Skin Effect Losses.
    - ❖ Eddy Current Losses.

**All the above led to a considerable electric energy saving.**



Picture 11: Inside view of SEMAN DMCC's customized LV Variable Intervention installed at ALMARAI's electrical installations

It should also be mentioned that the design of SEMAN DMCC's customized interventions **took into consideration** not only **all the interactions between all the electric loads of the network**, but also **the resonance frequencies of the electric power cables of the grid**.

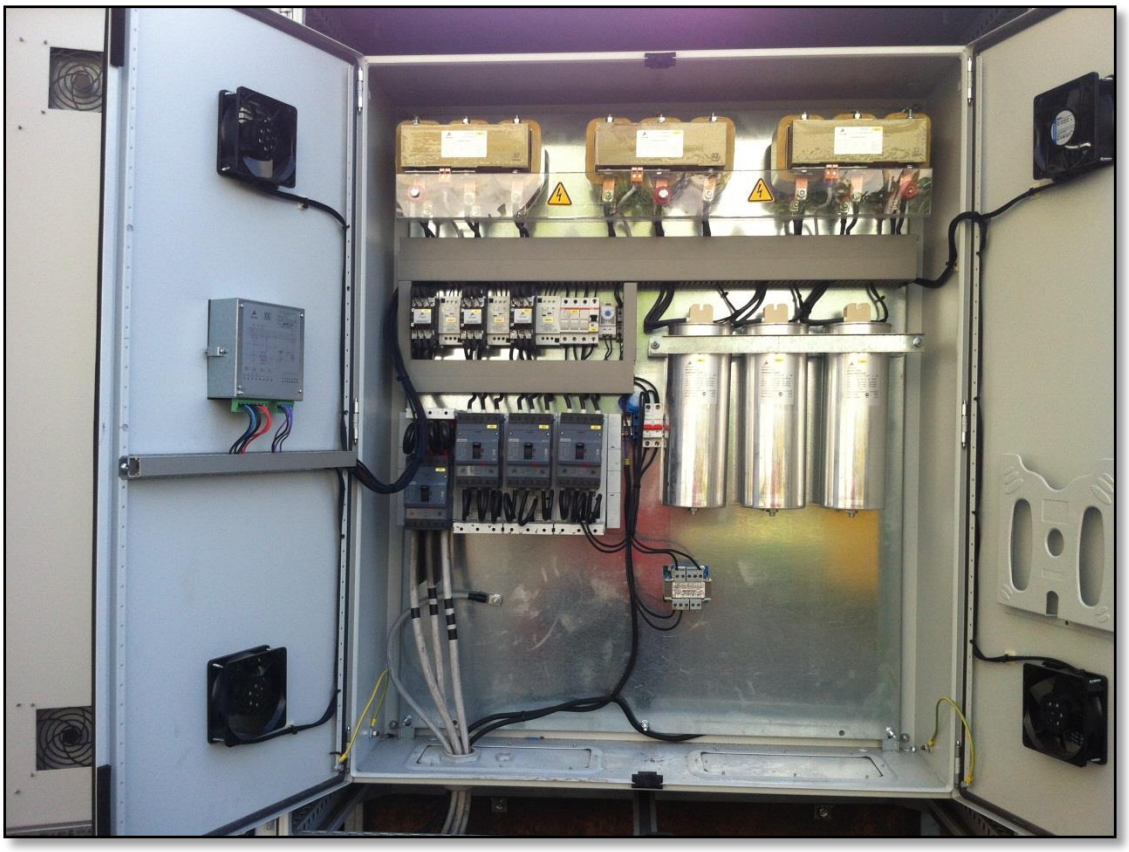
**Picture 12: Outside view of SEMAN DMCC's customized LV Intervention installed at ALMARAI's electrical installations**

**Picture 13: Inner side of SEMAN DMCC's customized LV Variable Intervention installed at ALMARAI's electrical installations**

The customized interventions for voltage-current quality improvement and electric energy saving **were connected in parallel to the electric loads of ALMARAI's inner power distribution network and led to harmonics absorption** and their important

reduction inside the electrical installations of the plant. Furthermore, **resonance frequencies that could lead to dangerous tuning are being cut off**.

PLC with **specially designed software from SEMAN DMCC's engineers**, based on the results of the scientific study, **control the dynamic operation of each intervention** according to the fluctuations of the electric load and ensure the cutting of dangerous interactions between all the electric loads of ALMARAI's electrical installations.



**Picture 14: Inner side of SEMAN DMCC's customized LV Variable Anti-resonance Harmonic Filter, with adverse environmental conditions standing materials, installed at ALMARAI's electrical installations**

For the protection and thus the perpetual and proper operation of the interventions in areas of ALMARAI's plant with very adverse conditions, such as extreme heat and dust, all the necessary measures have been taken.

**Picture 15: SEMAN DMCC's customized LV Variable Intervention installed at ALMARAI's electrical installations – Detail of Inside view**

Picture 16: SEMAN DMCC's customized LV Variable Intervention installed at ALMARAI's electrical installations – Detail of Inside view

Picture 17: SEMAN DMCC's customized LV Variable Intervention installed at ALMARAI's electrical installations – Detail of Inside view

Furthermore, SEMAN DMCC's customized interventions have the ability **to compensate "useless" reactive currents** that flow inside the electric power grid, **by using the useless harmonic energy**.

**C. Results – Benefits**

After SEMAN DMCC's project was set in operation, **an improvement of electric motors' and power transformers' efficiency was immediately noticed**, as well as a **significant reduction of thermal losses in the entire electrical installation of the plant**. Moreover, **the charging capability of the plant's electrical installation is increased** because of the great reduction of the "wasteful" harmonic currents. Also, the reduction of the total apparent power in the 23 Substations of ALMARAI's plant makes possible **the installation of new electric loads for future expansions, with no need of power increase**.

Project results evaluation has been made with two very accurate methods:

a. The first evaluation method of SEMAN DMCC's project result was based **on instant live measurements of the RMS values of feeding currents of the plant's electrical installation subpanels**, with and without project interventions in operation. In detail, the above mentioned measurements were realized on November 2014, right after the commissioning of the project, for different production scenarios. Based on this set of measurements, **the energy saving was equal to 10,95%, greater than the guaranteed 8,60%.**

b. The second evaluation method of the electric energy saving project result was based **on procedures referring to the International Bibliography** (please refer to the relative attached files "International Bibliography"). **By using historical data** of the electric energy consumption, the production and other operational data of the several sections of the plant, based on a period before the energy saving project was set in operation, **a mathematical model was developed**, based on regression analysis. This model **correlates the monthly electric energy consumption with the operational parameters affecting it** (such as the various

productions of many different product codes, the relevant ambient temperatures, the operational hours etc.) **with a great accuracy, since the correlation average error was only -0,01%**.

By applying the above mentioned Predicting Mathematical Model for a period of six (6) months after SEMAN DMCC's project was set in operation, **the electric energy consumption of the plant in case that SEMAN DMCC's project had not been executed**, was estimated with great accuracy. By comparing these predicted electric energy consumptions with the real electric energy consumptions (as recorded at the electric energy bills) for the period of six months in which SEMAN DMCC's interventions were operating, it resulted that **the average electric energy saving was 10,95%,** which is **again greater than the guaranteed 8,60%**.

Therefore, the initial electric energy saving target is highly achieved, **leading to a shorter pay-back period**.

The final electric energy and energy cost saving results are presented in Table 1.

**Table 1. Synoptic Results of SEMAN DMCC's Power Quality Improvement and Electric Energy Saving Project accomplished for the ALMARAI plant in Al-Kharj – Kingdom of Saudi Arabia**

| Value | Results |
|---|---|
| **Guaranteed Electric Energy Saving according to the contract (%)** | **-8,60%** |
| **Electric Energy Saving Finally Achieved (%)** | **-10,95%** |
| **Guaranteed Pay Back Period of the project [years]** | **3,14** |
| **Real Pay Back Period of the project [years]** | **2,45** |
| **Annual Money Saving(€)** | **2.053.000,00 €** |

Furthermore, **a great reduction in the maintenance cost of the plant's electrical equipment has been noticed.**

At this point, it should be mentioned that SEMAN DMCC's engineers in cooperation with ALMARAI's technical staff **managed to accomplish for the first time in the**

**history of ALMARAI an accurate correlation between the monthly electric energy consumption and the operational parameters affecting it**, such as the various productions of many different product codes, the relevant ambient temperatures, the operational hours etc.

**D. Conclusions**

The current - voltage quality improvement and electric energy saving scientific project, **which SEMAN DMCC implemented inside the electrical installations of ALMARAI mega factory, was crowned with total success**, because it did not only **fulfilled by far the goals for electric energy saving that had been set**, leading **to a faster payback**, but also contributed to **the reduction of the maintenance cost** and the **increase of the plant's electrical power reserve**. In a mega factory, such as ALMARAI, these kinds of improvements signify much bigger additional money savings, which are **necessary for the smooth operation and the future expansions of the plant's electrical installations** that are always needful.

Finally, after the conclusion of the evaluation of SEMAN DMCC's electric energy saving project great results, there has been an agreement with the management of ALMARAI for the development by **SEMAN DMCC's engineers of a new mathematical correlation model with the presence of the energy saving interventions**, by using the electric energy consumption, production, environmental temperature and other operational data of the plant after the electric energy saving project commissioning. This new mathematical model will be used **for accurate energy cost analysis of different production scenarios**, providing a competitive advantage to ALMARAI.