Energy Audit Report

Combino Pharm

Summary of Report

June 2016

Reference Number: EA_CP_07/16

SCICLUNA & ASSOCIATES
ENGINEERING CONSULTANTS

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Executive Summary

This energy audit goes into detail to illustrate the energy consumed at Combino Pharm, a pharmaceutical company operating from its' plant at HalFar industrial estate. The analyses show areas of energy consumption mainly, electrical energy, water and LPG. The data gathering and analysis strategy are in compliance with LN196/2014 and based on the ISO 50002 guidelines. The premises being audited are divided into 3 main areas;

- **Administration**: The main offices with an area of 350 m^2;

- **Warehouse**: Area of 400 m^2 used to store goods;

- **Production Zone**: Area of 1200 m^2 used as a production area, at controlled temperatures;

The entire exercise was useful to evaluate the amount of energy used including;

Electrical energy; used to run the plant on a 24/7 basis, supplied from the main electricity provider. This accounts for up to 222 grams of heavy fuel oil and 0.78kg of CO^2 for each kWh produced. An average of 1573791 kWh of electrical energy per year is consumed.

Gas consumption; used to run the boiler that supports the production facility with hot water supply. An average of 9516 m3 of LPG is consumed each year,

Water consumption; used in the production process, a relatively high consumption due to the nature of the process in the pharmaceutical industry with a yearly average of 6911 m^3.

The full report includes a number of recommendations such as the construction of a rain water reservoir, efficient light fittings and variable drive air handling units including heat recovery mechanism.

Statement by the Directors

As directors of Combino Pharm, we declare our independence from the auditors and have no relationship whatsoever.

Signature:

Date:

Identification of Experts

The experts who compiled the audit include:

- Lead senior auditor: Ing. Simon Scicluna B.Eng (hons), MSc.(Building Services)
- Field auditor: Ing. Karl Agius B.Eng (hons), MSc.(Sustainable Energy)

Signature:

Date:

Background

The production plant audited is being classified in to 3 different activities. The area of production composed of several clean rooms with different ambient requirements, the warehouse area and the offices area. In general all these areas have specific requirements. The warehouse is used to keep both the raw material and finished goods at the optimal conditions before use /shipment.

The production area requires specific ambient conditions that are to be continuously maintained throughout the process. Special personal protective equipment including overall vests is used in such dedicated areas known as clean rooms. The production process of the company consists of mixing and processing substances that are used to obtain pharmaceutical products, being medicinal products in different forms, mainly powder tablets, solutions, capsules and other variants. The figure below shows an aerial view of the area being audited situated at Hal Far industrial estate.

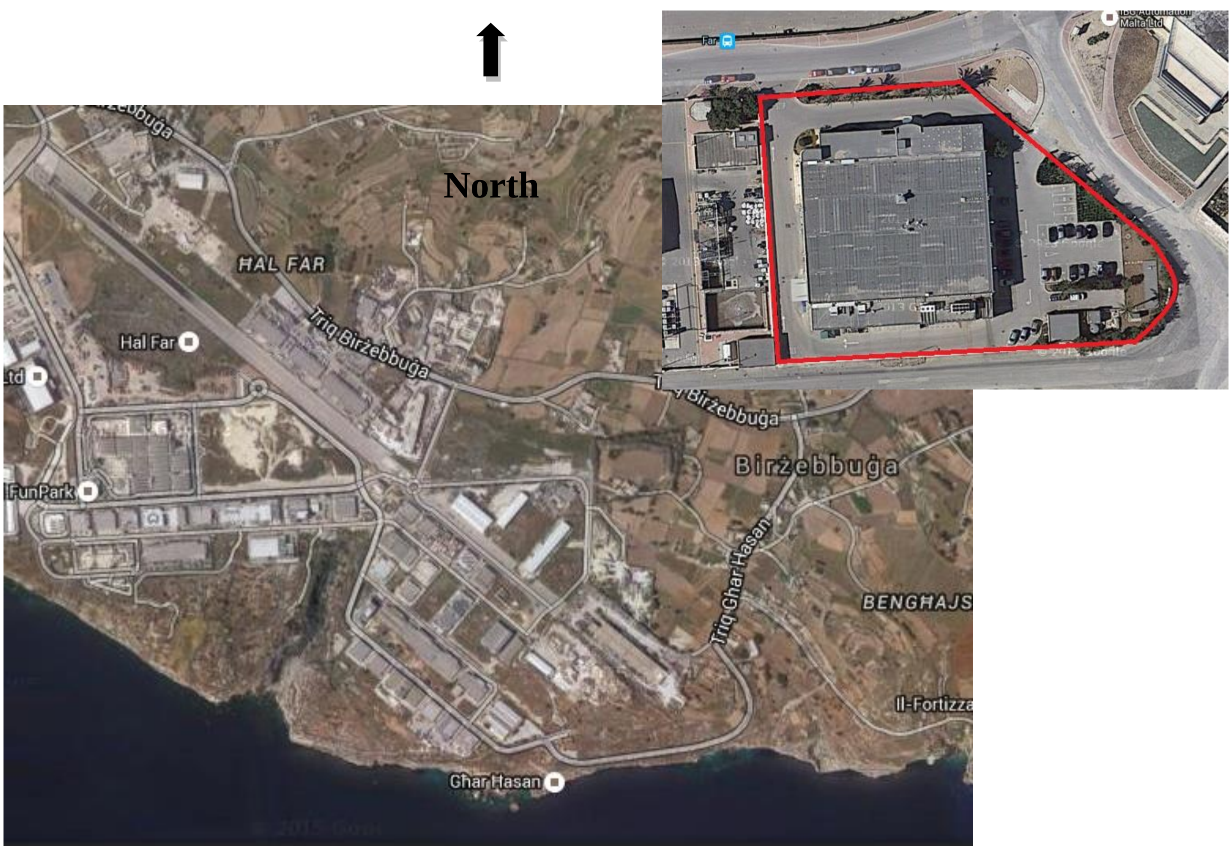


Figure 1. Aerial View of Site

Address of premises: HF 60 Hal Far Industrial Estate, Hal Far. Malta

The production plant located in an open spaced area, is in the vicinity of the cliffs on the West coast of Malta. This makes the plant exposed to harsh weather conditions including a corrosive atmosphere.

Building envelope: The building is mainly built from brick/stone walls with concrete roof. Natural light is minimally used and is mainly coming from the North facing wall where the main offices are situated. The rest of the building facades, i.e. South, West and East have several penetrations with louvered windows to aid natural circulation in the plant. The building envelope including the production process, warehouse and offices has a total footprint of 2500 m^2 with a total area of 6240 m^2 when considering the ring road surrounding the plant mainly including a car park and soft areas.

Scicluna & Associates is engaged as a consulting firm to carry out an energy audit on the premises.

Energy Audit Plan

The following is an energy audit plan in which establish the objectives of the exercise. Mainly the determination of energy consumed in different areas / sections in terms of electrical, water and LPG consumptions.

Steps involved:

- Visual inspection of the building envelope;
- Highlight areas of main consumption;
- Identification of the main energy consumers in terms of electrical energy;
- Initialization of the data collection process on equipment of high consumption;
- Data logging of onsite power meters;
- Review of data gathered;
- Calculation of power consumed by the low energy consumers;
- Data analysis and processing;
- Observation and review;
- Recommendations.

The energy audit, scheduled on a spread of 4 months, include 2 months of data gathering and logging of real time consumption and another 2 months of data analysis and preparation of report. The data gathered is used to determine the optimal energy saving measures that optimize the operations of the plant.

The data gathering process is a crucial part of the audit that highlights the areas of high consumption, thus recommendations for energy savings will follow.

Statement of Confidentiality

The parties hereto acknowledge that any information given as requested by the auditor is kept confidential and shall be used exclusively for the fulfilling of the exercise under this agreement and for no other purpose other than by the consent of the disclosing party.

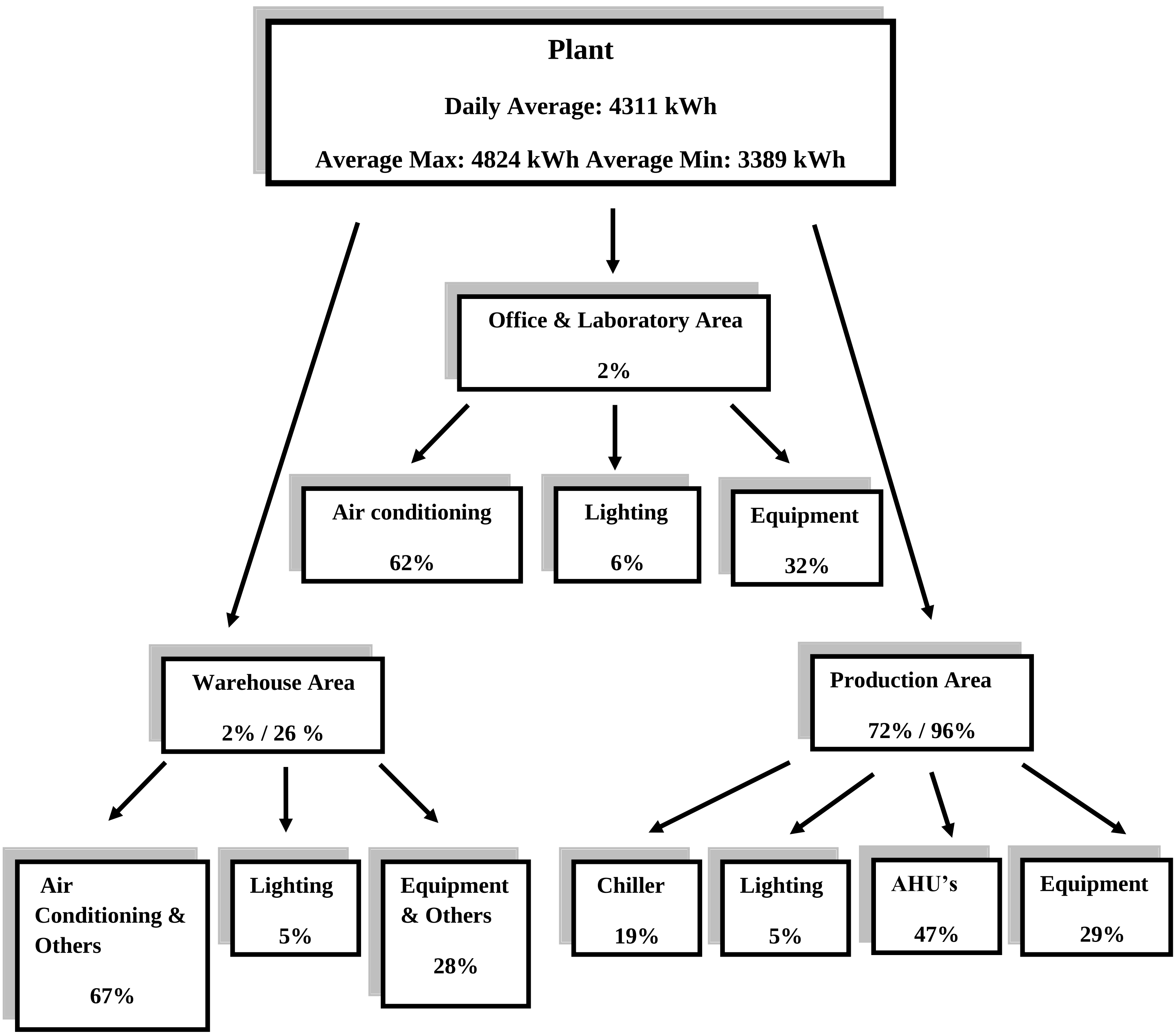
Plans of Audited Buildings

In the coming pages, plans showing the buildings being audited are shown. These areas are mainly composed of the production area, office area and warehouse. The different atmospheric pressures that are kept throughout the plant are indicated accordingly.

Plant Energy Consumption Layout

As shown in the figure below, the production facilities are the main electrical energy consumers.

Figure 2 Electrical Consumption Layout



Offices: The office areas include personal desks with their respective computers that are used for the daily office work;

Laboratory: The laboratory area includes several work stations that are used for daily tests that are carried out as required;

Warehouse: The warehouse area includes the area used to store both the incoming materials and the outgoing products;

Production / Technical Area: The production area includes power consumed by the equipment designated in such area that keeps the atmospheric conditions required. Also including the compressed air system and the production machinery such as the granulator, dryer, coater, blister etc…

The HVAC system mentioned in the warehouse and production area includes a number of air handling units, chiller system and other split and multi split air conditioners.

Data Gathering and Analysis

As previously explained the data gathering process is initiated by logging power consumed by specific equipment and machinery. This process goes into a particular detail when dealing with high consumption equipment and machinery.

A challenging aspect of the data recording process was the limited number of installed sub meters. Therefore, the data gathering process consisted of real data measurements of power consumed by specific equipment. In parallel with the above, an exercise to identify the number of light fittings, air conditioning split units and other ancillary equipment, including office equipment was done. This was useful to calculate the energy consumed by low power equipment.

The main bulk of the power consumed is absorbed by the air handling units and chiller system that conditions the indoor environment. The compressed air system is also considered as a main consumer of energy. The illustrations below depict the measured & calculated power consumption over the 8 week period, compared with the actual power consumed and measured by the main electrical meter.

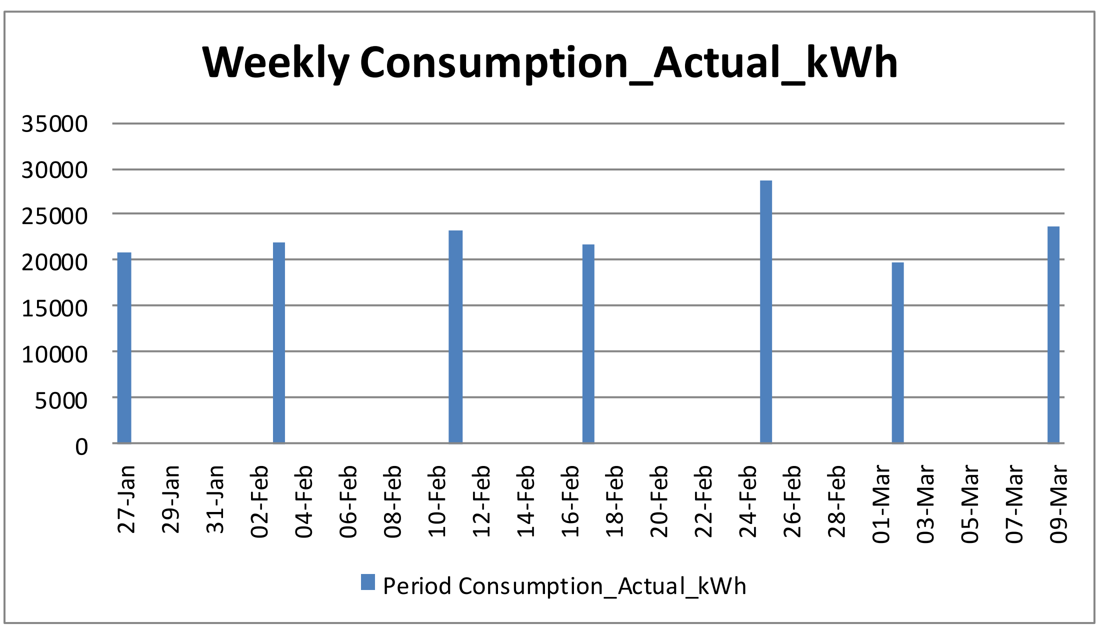


Figure 3. Electrical Energy Consumption on an 8 Week Period

Such a difference is highlighted in the following illustration. It shows that the mismatch between the measured consumption and the actual consumption is less than 2%.

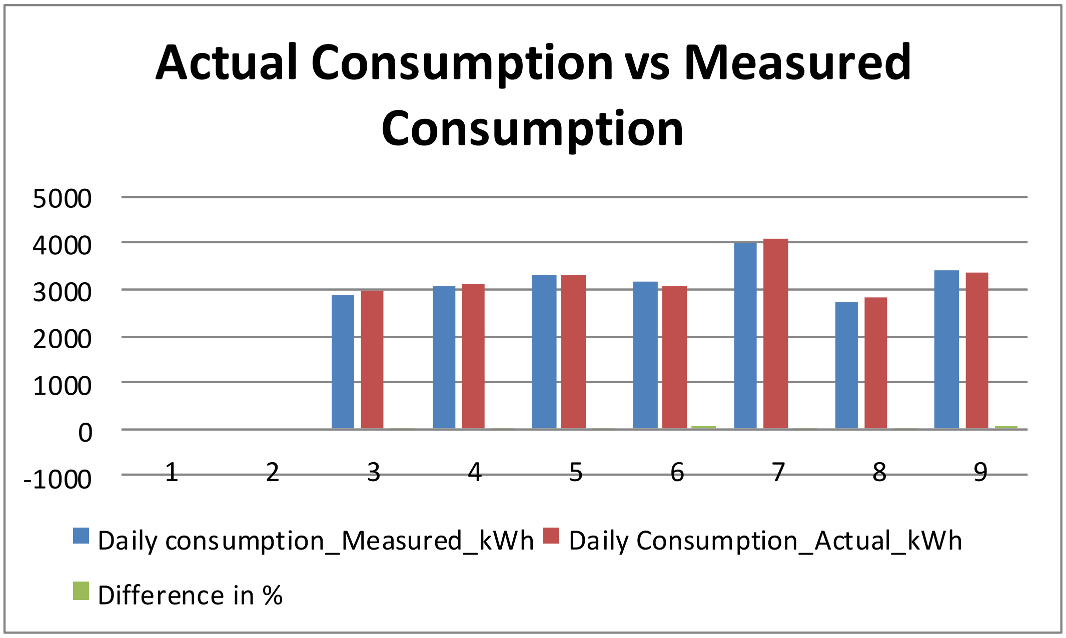


Figure 4. Actual vs. Calculated Consumption in kWh

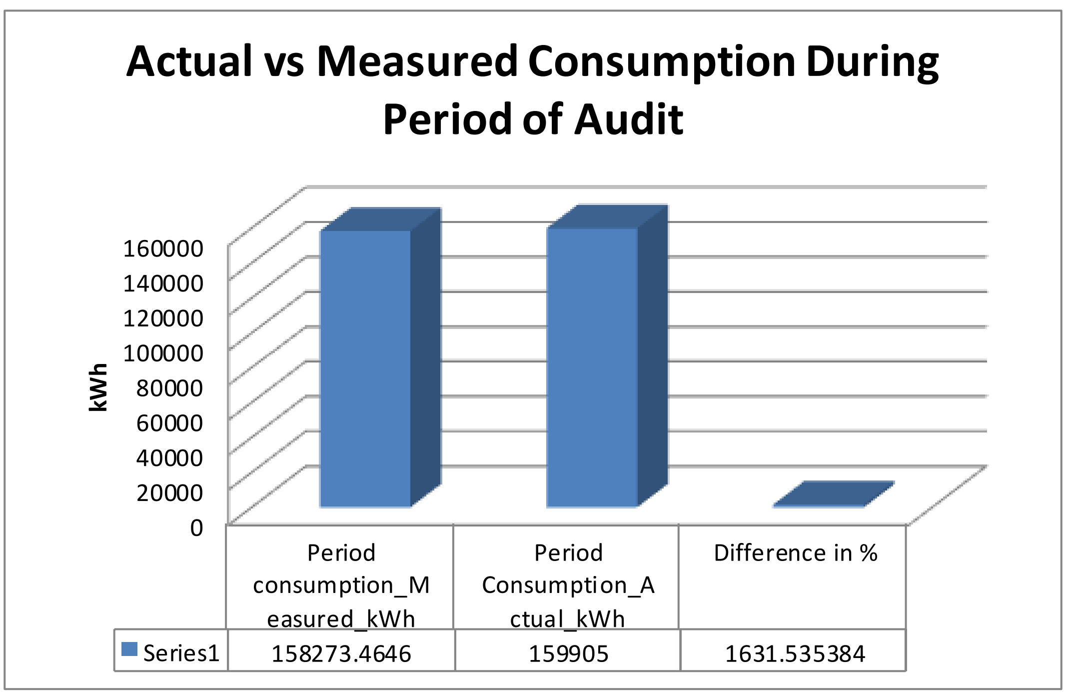


Figure 5. Actual vs. Calculated Consumption in kWh_ During Period

Overview of Electrical Energy Consumption

As previously described the process involves the conditioning of the environment both in terms of pressure and temperature. Thus, the consumption of the air handling units and chillers/ air conditions to keep the indoor ambient conditions, tends to consume the absolute majority of the energy consumed in the plant. The illustrations below show the monthly consumption during the year and the portioned percentages of the total electrical energy consumed on a typical production day during the audit.

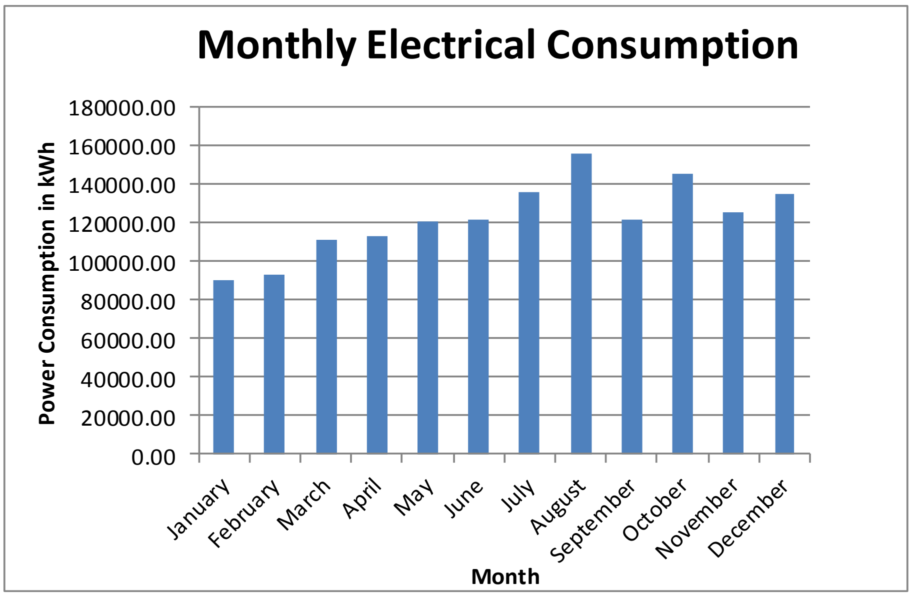


Figure 6 Monthly Electrical Consumption

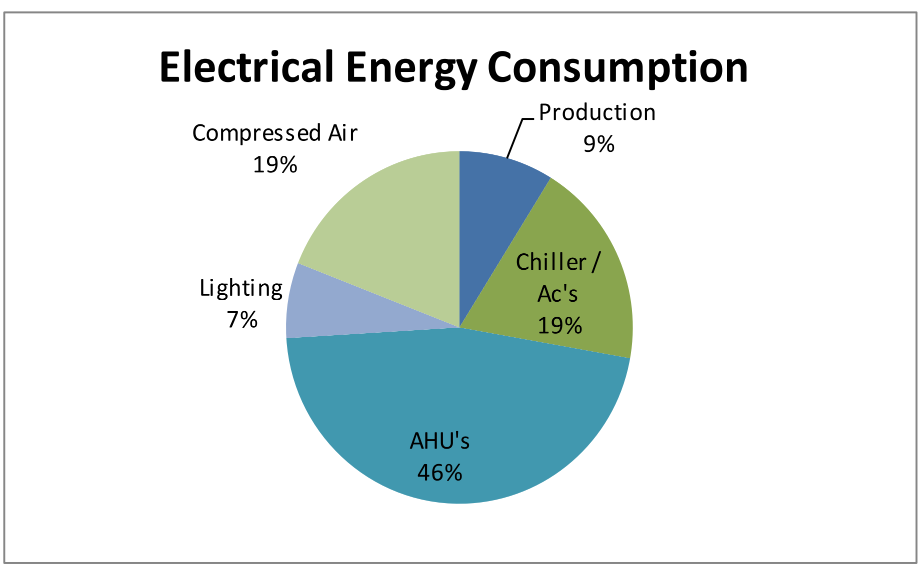


Figure 7. Electrical Energy Consumption_ During Audit

It has to be appreciated that the above illustrations are representing a period with average outdoor conditions. As earlier explained the difference in outdoor temperature has a direct impact on the energy profile consumed by the plant. Due to the fact that the chillers and ac equipment absorb a large amount of energy, their consumption masters the general trend of electrical load. In general such consumption reflects the difference in seasonal load profiles.

Lighting

In general, light fittings are of the T8 linear fluorescent tube lamps. These vary from fittings incorporated with 4 by 36 Watts or 4 by 18 Watts. Other light fittings include TC-D 18 Watts compact fluorescent lamps and 250 Watts metal halide lamps. Such light fittings are deemed to be quite efficient and reliable. The table below shows the location, quantity and power of the installed light fittings.

Table 1 Light Fixtures

Type	Power	Quantity	Location
T8 FL	36	174	Offices/ Warehouse/ Laboratory
T8 FL	18	41	Offices/ Production Area
TC-D Compact FL	18	32	Corridors
HID- Metal Halide	250	15	Warehouse
HID	150	15	Outdoor

Therefore, a maximum installed capacity of 13.5 kWh, however not all light fittings are kept in service at the same time in particular at the production and offices area.

The energy absorb by light fittings is in the region of 7% of the total energy consumed by the plant. The below illustration shows the lighting consumption as per different departments. Calculations show that the main consumption of lighting is used at the production area. This is mainly due to the amount of light fittings that need to be in service nearly at all times during production as no type of apertures / skylights are found in the production area. Therefore, it is totally dependent on artificial lighting.

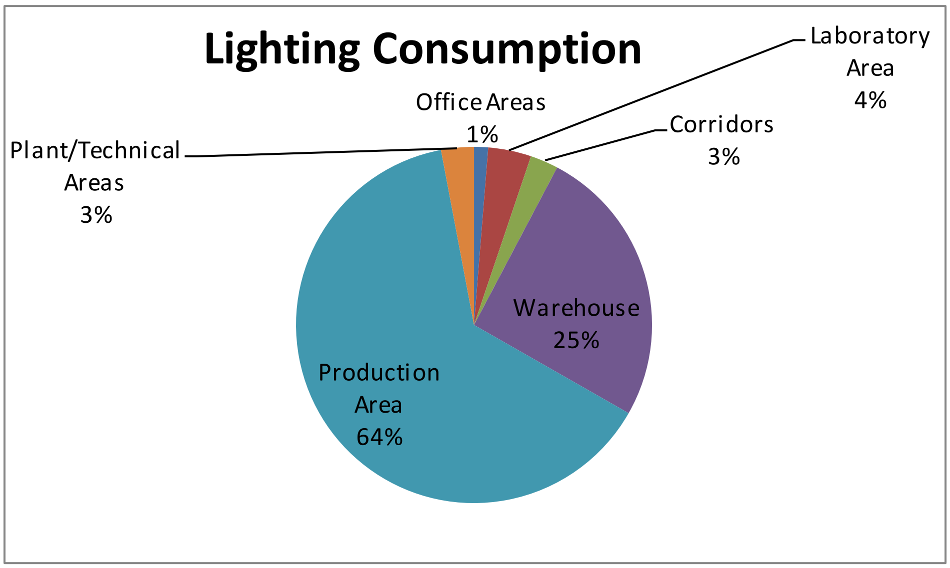


Figure 8. Overall lighting consumption

In the recommendations section, suggestions to replace the fluorescent type of fittings with LED technology are discussed in order to aid the possibility of altering the lighting consumption during the day. This includes:

- Occupancy sensing;
- Providing better energy management for ongoing fine tuning;
- Enhanced reliability and durability.

HVAC System

In general the plant is designed with a chiller system servicing the main area. The coolant running through the chiller is used to cool the air supplied/circulated by the air handling units and other areas including the offices. Others, including the laboratory and warehouse are equipped with split unit systems in order to condition the atmosphere accordingly. The illustration below shows the electrical consumption used by the air handling units and chiller/ac systems on a typical day with average outdoor conditions. As stated before a day with average outdoor conditions is considered as having an average temperature ranging between 10 to 20 degrees Celsius, thus representing November to April. From May to October is considered to present warm / hot outdoor conditions.

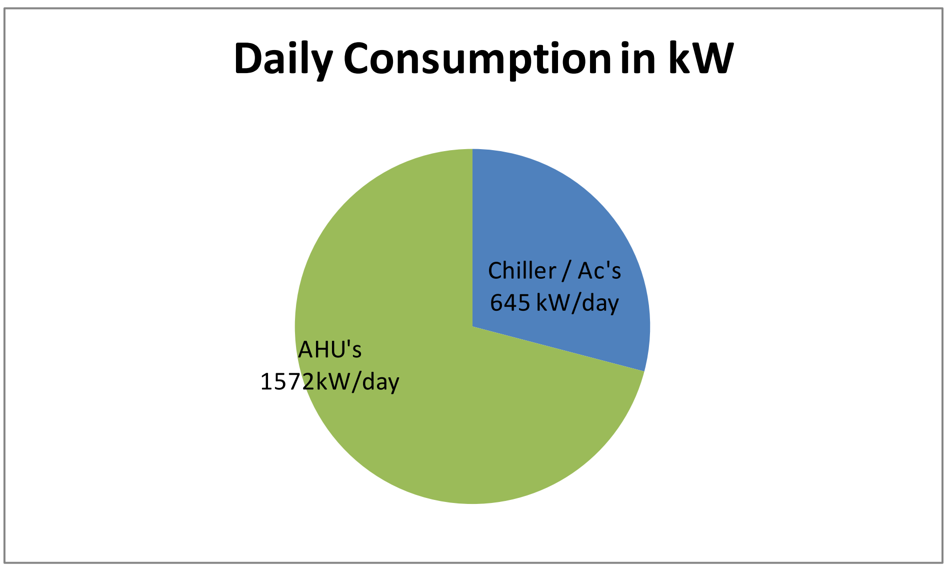


Figure 9. Air Conditioning and Air Handling Units Consumption

The next illustration shows the consumption during average outdoor ambient temperature. This indicates that the power consumed is almost absorbed by the production plant.

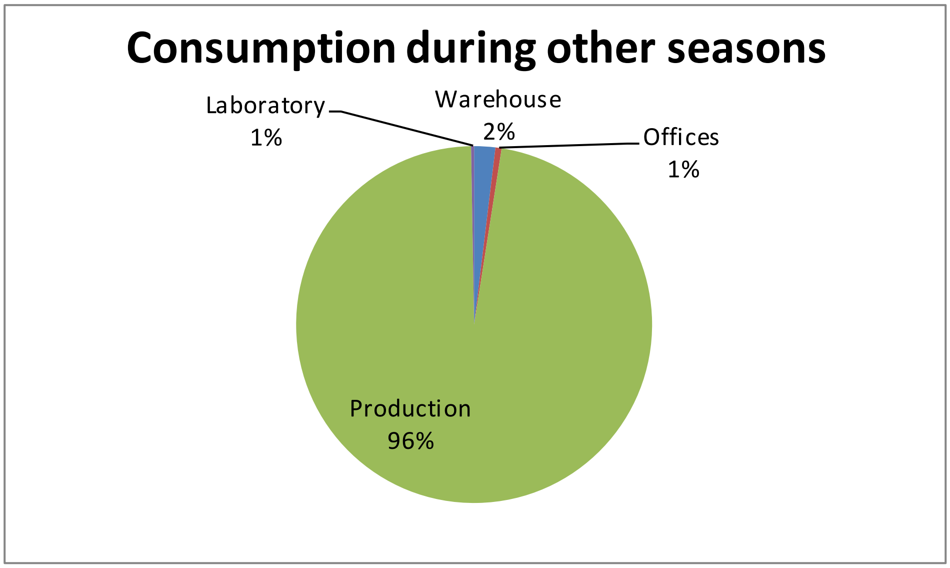


Figure 10. Overview of General Consumption_Average Outdoor Temperature

On the other hand, it is being calculated that during the warm periods the electrical energy consumed is apportioned between the warehouse and the production area.

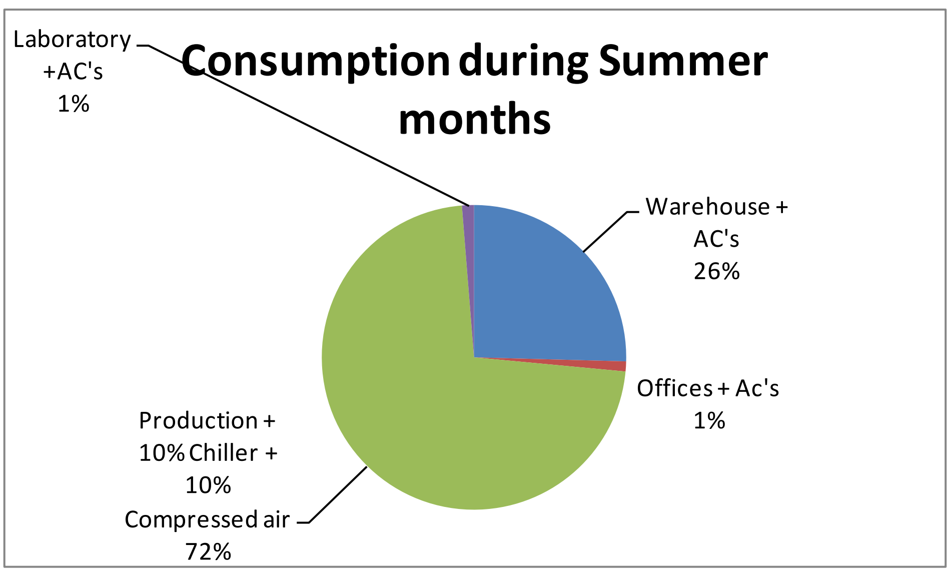


Figure 11 Overview of General Consumption_Warm Outdoor Temperature

Air Handling Units

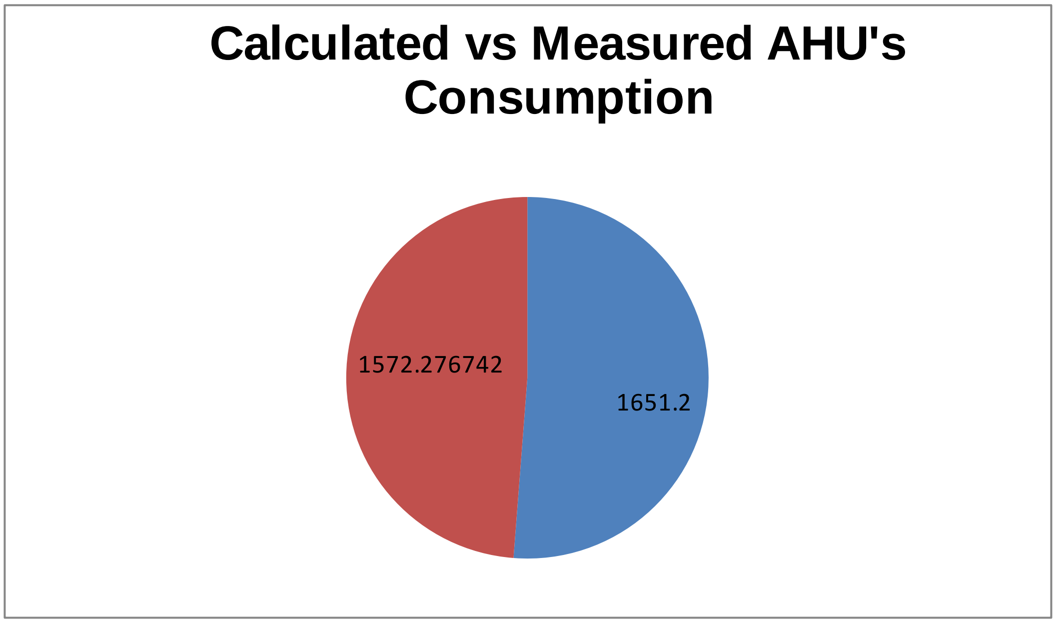


Figure 12. Daily Consumption of Air Handling Units in kWh

The above illustration shows that the difference between the actual power consumption and the calculated consumption, i.e. manufacturer specifications, is relatively low.

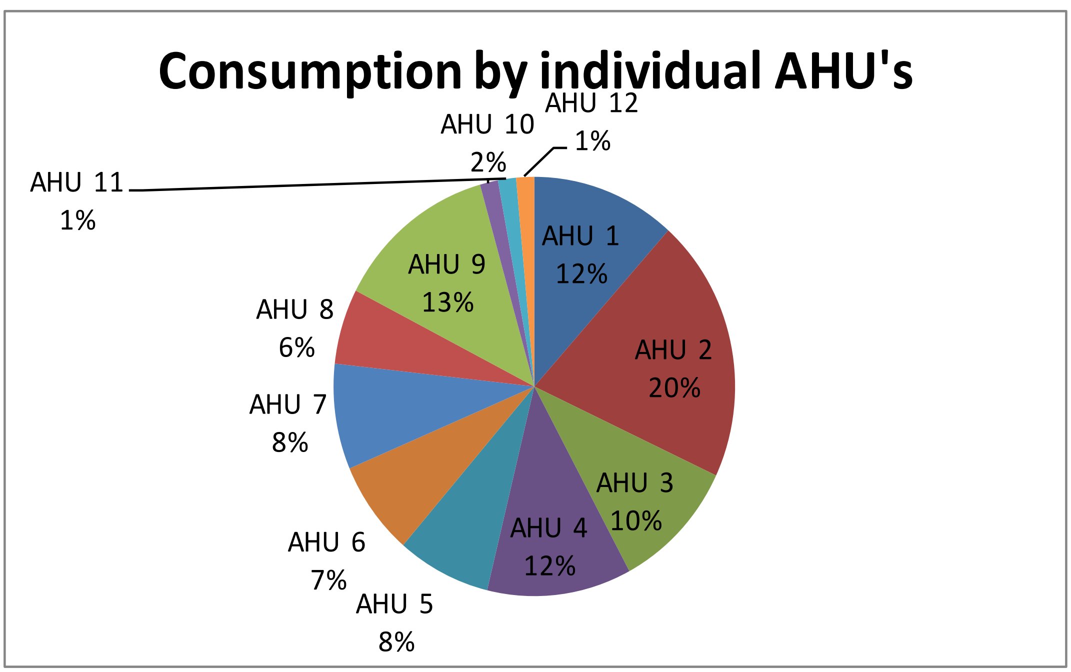


Figure 13. Electrical Consumption of AHU's

Water Consumption

The main consumption of water is used in the process itself. Water is widely used as a direct ingredient as well as during rinsing, sanitizing and cleaning. The cleaning of the equipment requires large amounts of water. Some minor consumption is used for the daily requirements of staff at the administration and warehouse respectively. The Reverse Osmosis (RO) system is kept in service in recirculating mode, even when there is no demand for water. This is done to control the microbial proliferation within the water and the wet system themselves.

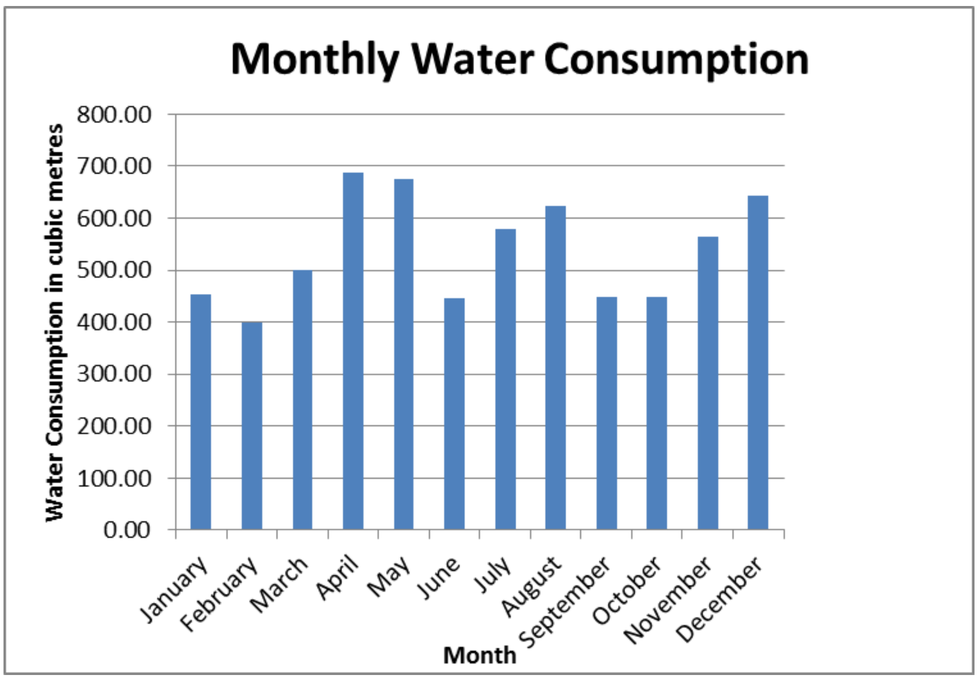


Figure 14 Monthly Water Consumption

LPG Consumption

The consumption of LPG is used to run a gas fired boiler to produce hot water for production purposes. The use of LPG gas is an effective measure with improved efficiency with respect to diesel or other light fuel oils. It is recommended to keep abreast with new technologies and conduct LCCA's on any emerging technologies that potentially reduce the consumption of energy with respect to the amount of heat energy produced. As earlier indicated, condensing boilers can potentially improve efficiency also combined systems making use of solar energy also contribute to better efficiencies. The following consumption profile shows a change in demand that is not directly related to the outdoor air temperature; however this can be attributed to increased production during a particular period.

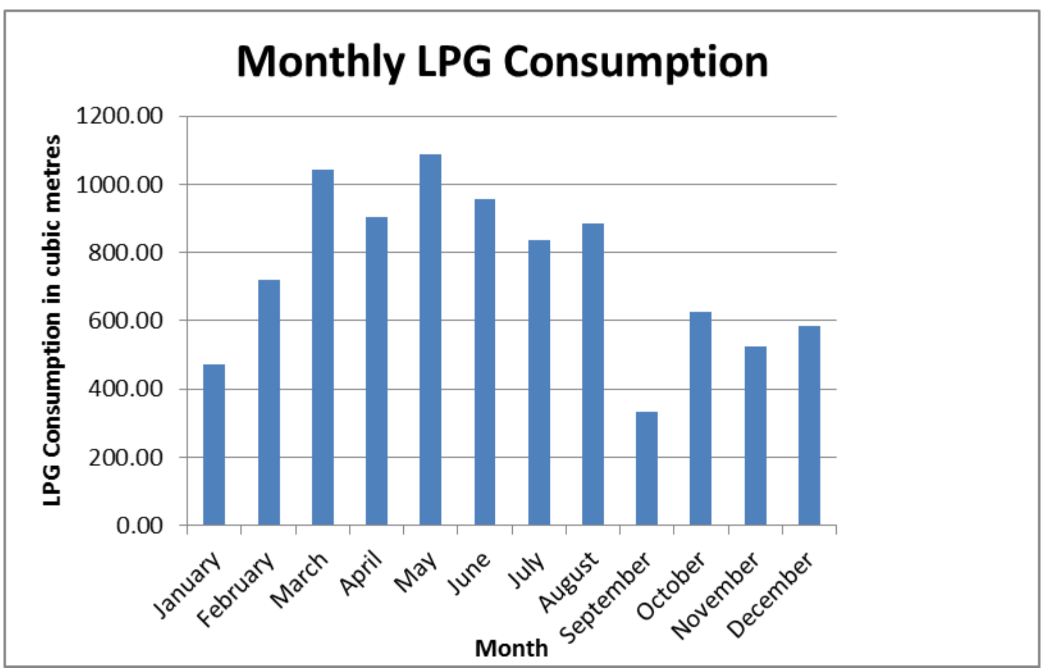


Figure 15 Monthly LPG Consumption

Benefits of Renewable Technologies

The existent roof area available for PV's installation is 1700 m^2. This can be used to contribute towards a reduced consumption in fossil fuel energy. Installation of such a system enhances the energy mix used by the plant and buffer any sudden changes in utility rates. Considering that every 1kWp requires 15m^2 of shade free area a total of 110 kWp system can potentially be installed with a yearly contribution of 170000 kWh of electrical energy. Moreover, this will contribute to a reduced heat transfer to and from the plant due to the shading and cooling effect that the panels create during the hot summer months. This reduces the overall energy used to condition the air supplied. The below illustration shows the potential overall shading pattern of a PV system It is being estimated that 75% of the roof area will benefit from the shading effect with a potential heat reduction transferred from the roof into the plant.

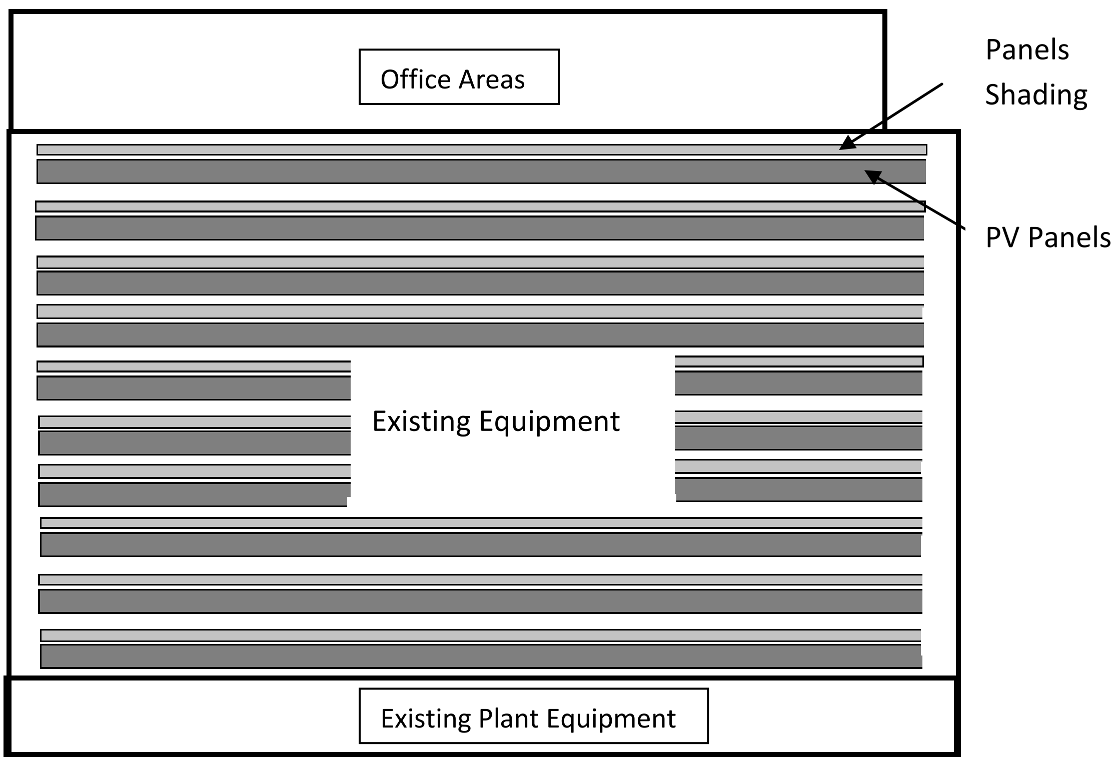


Figure 16. Shading of Photovoltaic Panels

Recommendations

Air Handling Units

The current air handling unit technology is based on an extraction and supply system with integrated heating and cooling coils for air cooling/heating. Such units are also equipped with High Efficiency Particulate Arrestance filters (HEPA). These filters are able to catch contaminants including allergens, mold, dust and others. In principle the AHU's are used to circulate the air inside the plant with an air circulation of 80%, thus the other 20% are deemed to be fresh air. One of the installed AHU's is operated on 100% fresh air. The table shows a proposal to gradually change the AHU's technology to variable type motor with integrated heat recovery mechanism. The below estimations illustrate the replacement of an AHU with a supply of 19500 m^3 and an extraction rate of 3000 m^3, including a heating / cooling coil for air conditioning, and a heat recovery unit with 69% efficiency, at a fresh air inlet of 35 °C and exhaust air temperature of 22°C at a 50% relative humidity.

Table 2 LCCA AHU's

Life Cycle Cost Analysis												
	Year 0	1	2	3	4	5	6	7	8	9	10	11
Initial Cost of Heat Recovery System (€)	€ 18,000											
4% reduction in running cost of Chiller	16997 kWh/year											
Savings per year (€)	0	2192	2192	2192	2192	2192	2192	2192	2192	2192	2192	2192
NPV (€)	€ 17,340.63											
Assuming that a variable drive AHU installed with HRU (both supply / extraction) at a cost of € 18000 Based on cost per unit of 12.9 c/kWh												

The above calculations show that the HRU unit will contribute to annual savings of 968 Euros per year and another 1225

Euros due to the variable drive concept based on 4 hours per day at 25% of nominal load. This new concept can potentially works in parallel with a building management system that triggers the presence of any activity and alters the amount of circulated air accordingly. Such control can potentially be adopted during the whole night from 22:00 Hrs. to 06:00 Hrs when no production is taking place. This doubles the estimated savings, thus reducing the payback period to 6 years. Such a long payback period is mainly due to the fact that the majority of the AHU's are operated in circulation mode, thus reducing the effectiveness of a heat recovery unit. However the installation of variable drive fan units, can potentially reduce the payback period by half if the load on AHU's is reduced to a minimum during the night hours when no personnel is in the production areas.

Photovoltaic Panels

The installation of PV panels is being considered to contribute in different ways. Apart from the generation of electrical energy, it is contributing to a reduction in heat absorbed by the roof under the panels. The calculated area available of 1700m^2 is deemed as free from any shading that might be experienced during the year. Such an investment contributes to the generation of 170000 kWh of electrical energy per year which equates to about 11% of the total electrical energy consumed by the plant. Such a mix in energy supply can potentially buffer any sudden changes in utility rates and ultimately reduce the net energy consumption used to run the plant.

Table 3 LCCA PV's

Life Cycle Cost Analysis										
	Year 0	1	2	3	4	5	6	7	8	9
Initial Cost of PV's (€)	€ 150,000									
Mean generated units per year (kWh)	170000 kWh									
Income per year (€)		21930	21930	21930	21930	21930	21930	21930	21930	21930
NPV (€)	€ 155,874.53									
Assuming 110 kWp System										
Based on cost per unit 12.9 c/kWh										

Water Reservoir

The yearly consumption of water amounts to 6911 m^3. The aim of this measure is to reduce such consumption by introducing a supply from rainwater. The construction of a reservoir to store rain water is estimated to save about 1400 m^3 from mains consumption. This reduction will contribute to 22% of the total current water consumption. Moreover such a measure opens new operating strategies by introducing the delivery of water by road tankers, which is estimated to lower the current cost of water from €2.37 per cubic metre to €1.85 per cubic metre, which reduces the overall cost by another 22%. The below LCCA refers to the benefits from rainwater consumption only.

Table 4 LCCA Water Reservoir

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19
Initial Cost of Construction and booster pump set (€)	€ 56,000																			
Water saving per year (m3)	1400																			
Income per year (€)		3318	3318	3318	3318	3318	3318	3318	3318	3318	6636	6636	6636	6636	6636	6636	6636	6636	6636	6636
NPV (€)	€ 56,614.44																			
Assuming reservoir capacity of 1400 cubic metres																				
Based on cost per unit of € 2.37/m3 and € 4.74/m3 in ten years time																				

Light Management

It is being proposed to change the current light technology to LED type. This is proposed to be installed in the corridors of technical area and corridors of office / laboratories. In parallel with LED technology, the installation of presence detection sensors that permit the frequent ON and OFF switching of lights in order to reduce light consumption is crucial.

Table 5 Estimations_Light Technology

Replacement of Light fittings in Corridors (Qty)	Replacement of Light fittings in Technical Area (Qty)	Total fittings to replace (Qty)	LED Cost per fitting of 45 Euros	Total cost (€)	Cost to install 10 PIR devices on each circuit (€)	Total Cost (€)	Estimated Savings in Corridors due to LED Power per fitting 18W to 5W (€)	Estimated Savings in Techincal area due to LED Power per fitting 18W to 5W (€)	Estimated Savings in Corridors and Technical Area due to PIR assumed at 50% of current usage (€)	Estimated Total Savings per day (kWh)	Estimated Yearly savings (kWh)	Estimated tyearly savings in Euros at 12.9 c/kWh
32	16	48	45	2160	500	1700	13	13	0.96	10.944	2845.44	367.06176

Below is the LCCA that illustrates the savings and the payback period.

Table 6 LCCA Light Management

Life Cycle Cost Analysis									
	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
Initial Cost of fittings replacement (€)	€ 2,160								
Electrical Energy savings per year (kWh)	2845								
Income per year (€)		367	367	367	367	367	367	367	367
NPV (€)	€ 2,372.00								
Based on cost per unit of 12.9 c/kWh									
Estimated savings of 2845 kWh									

The implementation of the above measure can potentially be extended to the production area, however, it is appropriate to first install in the indicated areas, and then installed all over the plant.

Measures for Efficient Demand Profiles

It is evident that the peak electrical consumption is experienced during the month of August whilst the lowest electrical demands are experienced during the months of January and February. This shows that the plant operating efficiency is directly related to the outdoor ambient temperatures. It is imperative to keep the production at the lowest possible during the months of July and August by scheduling shut downs and plant maintenance while maximizing production during the other months.

In the eventuality that night tariffs are introduced, it will raise the need to study the benefits of scheduling some of the day time operations during the night in order to consume less power during the day while benefiting from lower rates during the night.

The introduction of local integrators is also being recommended. Such a measure would enable better analysis of consumption with regards to particular equipment. Such data can provide trends that might indicate the need for maintenance or replacement of equipment.

Moreover, a building management system can potentially optimize the plant efficiency by managing the startups and shutdowns of particular equipment according to specific requirements. A delayed startup of high consumption equipment can potentially contribute to provide a constant load profile. A building management system can potentially disable non-essential services in order to make up for essential load requirements. The introduction of such a system can even result into an improved power factor on peak demand loads.

With regards to the generation of treated water and water consumption, it is being recommended to explore new technologies concerning water sanitization, to potentially exclude the need of continuous re-circulation of the water loop. These new technologies are also efficient when it comes to water discharge and eliminates the need of high temperatures for sanitization. Moreover, the reuse of discharged water can also contribute to an improved efficiency. The installation of specific membrane solutions, including ultrafiltration, nano filtration, micro filtration and ceramic membranes are potentially effective in removing the organic contaminants that such water presents.

Other recommendations include the scheduled elimination of belt driven motors, in particular the air handling units. Such a setup has low coupling efficiency and has to be regularly supervised in order to keep optimal efficiency. The best electric motors to use in such a system are the brushless DC motors with low maintenance requirements.

The air compressors system is a source of electrical energy losses. Air leakages can result in up to 25% losses of the output. Procedures to check the air leakage rates are to be set in order to reduce leakages. Simple daily visual checks around supply lines can potentially eliminate such leaks. The use of ultrasound leak detectors is also possible in order to detect leakages.

It is also recommended to install a mechanical ventilation system in the compressors room in order to reduce the ambient air temperature, thus reducing the load on compressors.

Conclusions

The measures discussed in the recommendations section are considered to need a budgeted amount of money that will eventually contribute in both economic terms and operational efficiency. On the other hand, minor recommendations as listed in the on-site inspection list, (refer to table 2.0) are deemed to contribute towards an improved overall system efficiency. Improved plant efficiency can potentially result in better production yield due to an increase in production. The following is a priority list that is being suggested for implementation:

- Installation of PV's system;
- Water Reservoir:
- Light Management;
- Change of Air handling Units

The installation of a PV's system has a definite timeframe and has a guaranteed investment in terms of pay back period. Moreover, PV's offer economic stability in terms of budgeting, as the power generated versus the costs incurred are fairly predictable.

The construction of a water reservoir presents a number of benefits that contributes to the overall plant efficiency as discussed. It also contributes to the sustainability of such activity.

The light management measure is the cheapest recommendation with a very attractive payback period. The flexibility offered by such technology can eventually be spread all over the plant, furtherly increasing the benefits offered.

The fourth recommendation has a payback period of 11 years which presents to be the less attractive. However such a recommendation shall be considered in case of the decommissioning of an AHU.

Appendices

[1] Combino_Consumptions, in excel format.

[2] Quotations, in .doc format.