Open University of Cyprus

FACULTY OF PURE AND APPLIED SCIENCES

Master in Sustainable Energy Systems

Energy Management and Sustainability in non Residential Buildings Based on Green Deal

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Master Thesis

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Summary

This study deals with providing some solutions to a print factory, located in Nicosia, Cyprus, in order to reduce electricity energy consumption and also reduce its carbon footprint to the environment.

Based on national requirements for protecting the environment and reducing CO2 emissions, we will use software to simulate the existing needs of the factory and how the proposals contribute and affect energy demand balance.

All necessary data to plot existing energy demand for the printer factory have been taken officially from the electricity authority.

In order to justify possible investments we will use various financial indicators and factors to check also if are feasible, profitable or not.

Acknowledgements

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In addition, many thanks to my family: my husband, my daughter and my son for the patience and understanding until accomplishing this post graduate program.

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Chapter 1 : Introduction

Nowadays the consequences of irrational use of natural energy resources of Earth are much perceived through climate change and global temperature increasing. Therefore, mitigating this phenomenon is a must and all governments need to take actions but also all of us individually too. We have to raise awareness and take correct decisions to protect the environment and natural life.

Energy production and energy usage account more than 75% of greenhouse gas emissions in Europe continent. So the decarbonization of the European Union's energy system is vital to achieve the climate targets by the year 2030 in short-term, and also meet the long term strategy for neutral balance of carbon emissions by 2050. This is a defined plan that prepared from EU, without any exceptions, for intermediate goals by 2030 and final targets achievement by 2050.

Taking this in account, we will deal in this study with the case of energy efficiency for a printing factory and at the end we will suggest ways to reduce energy consumption and moreover the carbon footprint reduction.

Chapter 2: Literature Review

Industrial revolution and sustainable development are two very related between each other concepts. At 20th century we had lots of economical, social, healthy and environmental crisis guiding us to the need of alternative thinking and shifting to a different way of production and consumption in the society. During the conference in Stockholm in 1972 about Natural and Human Environment it was the first introduction to the way of sustainable development where countries have defined the rights of human societies and therefore for citizens for a sustainable and healthy environment.

In 1983, United Nations undertook the launching of a process to establish the World Commission on Environment and Development in order (WCED) to review the relation between the environment and development. This commitment prepared and presented in 1987 the report study about 'Our Common Future', with the aim to set as a UN guide line for sustainable development.

In 1994 start the application of United Nations' framework for climate change that was signed in 1992 at Brazil by 197 countries or parties to the convention. This conference considered as one of the most important for environment and that because start the dialogue for sustainable development all over the world.

During the period of September and December 2015, presidents of the 197 countries agreed on 17 global goals for sustainable development. Implementation of these goals set until 2030 in order to tackle the poverty, inequalities and climate change with all negative effects. The 21st session of the conference of parties of United Nations framework convention on climate change and the 11th session conference of the parties to the Kyoto Protocol took place in Paris to set additional global agreements for climate change. Main concept was to reduce the global warming by 2 C^o.

2.1 Green Deal from European Union

In 2019, the new president of European Commission announced six political priorities of the European Union for the next 5 years. In these priorities, the European Green Deal is included which transform the Europe into neutral emissions continent until 2050. In order to make this happen, lots of changes must taking place in the sectors of energy production, transportation, environmental pollution and energy security but also must change the way of food production and consumption, distribution and supply chain methods. All the above transitions require expenses in all sectors and areas.

Aiming to become the leader globally for fighting against the climate change negative effects, EU presented the key pillars of Europe Green Deal in order to cause independent economic development from reckless use of natural sources, to ensure a fair transition between European countries, turn production and consumption model towards to the bioeconomy and circular economy and set a legal framework for climate change. This plan focuses on the detection and isolation of carbon emissions with policies that increasing tariffs of conventional fuels and developing a stricter taxing system for services and markets that are related on carbon based products, so any investments on these sectors are not encouraged any more.

Individual risks in total, are directly related to human needs but on the other hand every footprint or catastrophe action has adverse effect on human life and economy too. When taking no actions, the result to the economy will be as significant as that of nature. That is the reason and one way decision for countries get involved to adjust new ways of public life to environmental requirements.

European Union considers industry and supply chain mobilization as a must in order to implement the transition to the circular economy. Between 1970 and 2017 the materials extraction has been tripled and it follows the rising trend until today. During the process of exploitation then collection and finally transportation of materials, has been estimated that more than 90% of biodiversity of specific areas has been lost and also depletion or even pollution of water resources has been noted. At the same time, industrial sector remains linear for the dependence of these kinds of materials when the main volume of them becomes waste. Maximum record of recycling the exploited materials was only at 12%.

Europe’s action plan for this case is to minimize the waste and pollution by providing incentives for reusing and recycling materials. This is the way that EU deposits the revitalization of industry sector by following the circular economy but in a way with essential interaction of biodiversity, environment and production.

2.1.1 Circular Economy

A circular economy can be named a model of production and consumption which includes the exchange, the reuse, the rental, the repair, the renovation and finally the recycle of existing materials as much is possible in order to get the optimum from them and extend their life cycle. In practice, the circular economy suggests to reduce the waste to the maximum level because when a product is at the end of it life, all related materials for its construction are retained in the economy in any way to be reused again.

This is a contrast with the traditional model of economy that is based on take – make – consume – throw model which requires large quantities of cheap raw materials that are easy accessible. And because world population is growing and there is an increased demand of raw materials lots of countries depend on others to cover their needs. Extraction of these materials also has major impact to the environment by using lots of energy amounts, so a wiser usage can therefore reduce carbon dioxide emissions.

At the same time, new job vacancies will be created from the new type of activities for example during the process of materials' recycling. EU will enrich the recycling plan and can do that by establish minimum recyclable material usage in each product in order to stimulate recyclable raw materials market, redefining with this way the policy of waste management.

In March of 2020, European Commission presented the action plan for the circular economy which aims the ecological product design, waste reduction and empowerment of citizens and particular emphasis also is placed on industries with high energy resource intensity. Actions for the transition to the circular economy from high energy demand markets such as steel and cement factories will take place because the effectiveness will be greater due their high level of materials and energy usage. As for the building construction sector, electronics, batteries, plastics and fabrics will be available with very high standards in terms of recycle and repairment under a sustainable way. The same for imported items, very high standards with strictly checks in order to follow the regulations because of the high carbon footprint of this action.

In February of 2021, EU adopts a resolution of action plan related with circular economy, by setting additional measures to achieve a carbon neutral and non toxic environment by 2050 with even more stringent binding targets for energy usage and materials consumption by 2030.

Another section of EU legislation deals with old buildings renovation and for new constructions following an efficient way in terms of energy. What is happening previous years until today with buildings, only 1% of the existing buildings get renovated when at the same time round to 40% of total energy demand goes for domestic usage.

Resulting of this EU set another objective about massive renovation of old buildings based on energy efficiency with low carbon emissions. Lots of the buildings in European countries do not meet energy efficiency criteria because maybe they are too old or the construction did not follow energy efficiency guide lines.

Significant benefits will come following this direction because there is high potential of renovations and high needs of manpower and high need of reusable materials from cement and steel sector. Future energy savings will cover the needed cost for the renovation, so the projects will follow a sustainable way for the implementation and operation too. In the same way, there is an important need for renovation of school units, and health care units. By reducing the operational cost on this kind of units can be translated to an investment with a low risk but a significant rate on incomings in the form of energy savings. Following the building renovation plan, additional job vacancies will be available in the construction sector.

Due to uncertainty of the health crisis for COVID-19 pandemic, construction sector's activities get decreased, buildings and land investments get decreased but also the improvement of building's energy efficiencies get lower. Consequences of COVID-19 crisis seems to be long term for the construction sector, so the buildings renovation will be a positive way of actions both to achieve the 2030 targets of EU but also to stimulate the economy in general. The NextGenerationEU22 program in cooperation with EU's financial framework will fund the implementation of buildings renovations waves. Estimation from the EU is a renovation of 35 million buildings until 2030.

In order to achieve the goals until 2030, EEU will monitor and control the whole process. With all related legislations EU seeks to urge landlords and tenants to comply with regulations for the lifespan of the building. In addition, energy performance certificates of buildings will be uploaded and linked to databases, ensuring the transparency of procedures and material installations. All supervision control will be handled from European Building Observatory.

2.2 National Energy and Climate Plans

Each member of Europe has already developed plans for the energy and climate following legal requirements and guidelines for EU, so for each country was set according their own data, energy demand ad consumption. All the plans focused on the next decade in order to help the EU countries to reach their energy targets for renewable sources, energy efficiency and carbon emissions.

Our country, Cyprus, announced the approved from the government national energy and climate plan in the beginning of 2020. Main goals were set based on EU targets for 40% reduction of carbon emissions, 32% increment of energy efficiency, 32% energy production coming from Renewable energy sources and 15% electricity interconnection and also based to guidelines in the topics of Energy Security, Energy Market, Energy Efficiency, Renewable Energy Sources and on Research / Innovation/ Competitiveness.

More specific, Cyprus set lots of measures and priorities for the optimal achievement of national goals in the field of energy, environment social-economy policies and green deals development.

- CO_2 emissions reduction by 25% compared to the year 2005

- Reach quantitative targets to reduce emissions for specific air pollutants
- Involve Renewable Energy Sources at 23% of total energy consumption
- Involve Renewable Energy Sources at 26% of total electricity energy consumption
- Involve Renewable Energy Sources at 39% in heating and cooling sectors
- 14% must be the percentage of RES in transportation sector
- Promote Natural gas as an intermediate solution to get rid high pollutant fuels
- Replacement of all solar panels in houses that are very old and thus with low efficiency
- Replacement of solar panels in commercial premises and use solar technology for heating and even cooling purposes
- Support a variety of plans for improving energy efficiency in houses, businesses and general public
- Promote also geothermal energy technologies
- Promote the usage of renewable sources in public buildings sector
- Program for energy upgrades and improve the energy efficiency in public buildings
- Promote the recall plan for old vehicles by giving benefits for purchasing electric vehicles
- Other plans for promoting biofuels in transportation sector e.g for buses
- Upgrade energy efficiency of street lighting system

For Cyprus, main targets for renewable systems by 2030 is to reach up to 23% RES in total energy consumption, 14% RES involvement to total fuel consumption for transportation sector, and 1% RES per year for buildings heating and cooling purposes.

2.3 Energy Audit and Energy Efficiency

Energy behavior of the majority existing buildings is detrimental to the environment, so the energy inspection and further study for improvements related with energy efficiency is a must. This energy inspection concerns the collection of all data about building construction, building energy consumption, all electromechanical equipments and finally operational pattern of the building.

Person, who is taking over this audit, visits the building and take those data to study the energy behavior of the building. All final results are the main numbers to proceed with energy saving proposals and simulate the future behavior in case of upgrades. All efficient interventions are selected and proposed based on energy consumption but implementation cost also.

A different approach of energy inspection is the green energy inspection. Main peculiarity of the green inspection is the combination of standard energy audit with the effects on the environment. Four steps that need to be followed are:

- the study of energy consumption
- identification of possible actions that will reduce energy consumption
- the economic and environmental cost of possible measures
- final decisions

By energy savings term we mean the amount of used energy. In case of savings achievement there are greater benefits in financial way but also on the environment which is the most important. Most of the energy that is used nowadays requires exploitation of valuable natural resources such as coal oil and gas, so using less of that energy type we can save resources for future needs and also decrease the carbon emissions.

As one of the most important tools for reducing CO2 emissions and achieve the goal for neutral carbon footprint by 2050, energy efficiency is currently at the center of EU energy policy. Regulations are now providing tools and guide lines for integrated design of new or under renovation buildings with the aim of reducing energy consumption and with this way achieve better energy efficiency and protecting the environment. So the study of energy efficiency is a must using some methodologies to get necessary results to give us the final classification of the building according the EU standards based on the consumption of primary energy. So energy saving and energy efficiency are two interrelated terms.

The targets of energy planning, taking into account climatic change, socially conditions and cost to benefit ratio, are the improving of energy efficiency of buildings and utilization of renewable energy sources. Mainly solar energy, with the very high potential in Cyprus, reduction of CO2 emissions that contribute to greenhouse effect in order to protect the environment. The usage of environmental friendly materials that are not require much energy for their production and have low emissions during their total lifecycle, following EU standards for buildings which are very high with lots of requirements.

As for the benefits can be summarized to the energy sector by energy saving and achieving thermal comfort of the space, the financial sector by reducing the cost and save money from buying energy or fuel and also buying equipment for electromechanical applications for heating-cooling-ventilation-lighting functions, the environmental sector by reduction of pollutants that coming from using conventional sources and tackling the climate change and the social sector by improving the life quality and the correct development of a city plan.

2.4 Building Design and Upgrades

In order to achieve energy savings in a building, a proper design and the usage of correct and efficient systems and elements is a must, but on the other hand there is another factor that is defining as critical. The energy management of the building is a systematic –continuous activity, very well organized that consists a planned set of technical, financial and administrative actions in order to achieve energy savings. That may concerns the building shell (for example the openings/windows, orientation and insulation), the electromechanical appliances, the surrounding area of the building (for example usage of trees) and finally rational and correct usage of the building (for example natural light and natural ventilation).

2.4.1 Building Shell

The shell of a building is the natural boundary between interior space where people spend the most of their lives, home and work place, and the outside area of the environment, so it is very important to have comfortable conditions all over the year, summer or winter. To achieve this, building must be constructed in such a way to minimize heat transfer from outside to inside area and the opposite. In more details we have to avoid on cold days the heat transfer from interior space to the environment and on hot days the solar radiation and heat transfer from the environment to inside the building.

Thermal insulation is one way solution that covers the surface of the building using various set of materials in order to limit the heat flow between the areas on either side of material. Successful thermal insulation ensures the reduction of the heat permeability coefficient U of the structural element, it restricts the flow of heat through the element. Each material is characterized by a specific value of Ro heat dissipation resistance but higher values are the thermal insulation materials. When we insulate the shell of a building using these materials, we increase the heat resistance of the building. Theoretically we can zero the heat flow by increasing the thickness of the thermal insulation material. But this means increasing the thickness of the walls take up more space and increase the amount of thermal insulation material thus increasing the cost of materials.

In central buildings the total thickness of the walls is of great economic importance, because the cost of the available usable area is very high. In these cases, the use of strong insulation materials is costly because energy savings are paramount. The increase of the thermal insulation capacity of the building shell includes interventions:

- In the external walls.
- In the roof.
- In the floor as it borders with unheated spaces like basement or with the outside air.
- In interior walls bordering unheated spaces like warehouses.

The degree of intervention depends on whether the building is constructed or renovated. In renovations it is very difficult to do big improvements in the shell's thermal insulation. The correct thermal insulation of a building results in greater thermal comfort inside the building as we mentioned before, but on the other hand there is an increase in construction costs round to 4%. This cause a reduction in the initial costs for the installation of the heating system, because it reduces the projected heat losses, a reduction in operating costs. Building costs, because it reduces energy consumption for heating and cooling, as well as maintaining the solar thermal gains for a long time inside the building.

2.4.2 Waterproofing of the building

Humidity is a major threat to the building shell and the health of the residents and waterproofing combined with thermal insulation, is considered as an essential design factor. Old days, increasing thickness of the walls provided a solution to the problem but today improvement of the materials' quality elaborate construction allow the usage of thinner walls. Proper waterproofing requires good design, the best choice of materials and careful application during the construction phase.

2.4.3 Windows Openings

Windows openings of the building are there to allow light and air to enter indoors. While heat exchange between indoor and outdoor environments is required especially the winter, windows can be the leading cause of heat loss if not constructed with the right materials and properly insulation. The shell of a building can be properly insulated and there can be heat loss from the frames and glass of the windows. Therefore it is very important to improve the air tightness of the windows and to reduce the heat loss from the frames and glasses of the windows without this meaning that the building should be airtight, as if it does not have adequate ventilation it will face moisture problems. One of the most important interventions in the opening is the replacement of the windows with new double glazing because the gap between these two windows achieves thermal insulation. The most common frames are made of wood, aluminum or PVC (a synthetic thermoplastic material made by polymerizing vinyl chloride). Aluminum frames due to their mechanical properties and their behavior in climatic conditions are an ideal solution but with higher cost.

2.4.4 Bioclimate drawing with the contribution of trees and plants

Trees and plants are significantly affect the microclimate of a building and that because they provide sun protection, they reduce ambient temperature, wind speed, noise, air pollution and finally prevent soil erosion caused by a heavy rainfall.

2.4.5 Energy upgrade of the building

The energy upgrade of electromechanical installations includes changes to various appliances as below:

Energy upgrade of building heating installations

Most of the energy in a building is consumed to meet energy needs for heating or cooling. Upgrading thermal autonomous or central systems is considered as one of the most important interventions in a building. Older systems need lot of energy and therefore need to be replaced with new innovate technology systems with certified characteristics. Conventional heating systems consist of: the boiler - burner (oil or gas), the pipes, the circulator and the radiators.

Installing a heat pump or gas boiler can offer quite large savings and efficiency. Combined solar heating systems for domestic hot water production and heating can meet from 10 to 100% the needs of a building in heating and domestic hot water. A boiler room upgrade has several advantages too, for example reducing fuel consumption, protecting the boiler from unnecessary operating hours, reducing damage to the boiler room, reducing the noise level, avoid the stress to the pipe line and maximizing heat dissipation.

Energy upgrade of cooling-air conditioning system

Most buildings in Cyprus are using air conditioning units because of the extreme high temperatures, during the summer period. It is a big electricity consumer but following some tips for its operation, waste energy consumption can be prevented. For example by set the desired temperature within the 24-27 ^{o}C limits because each degree of temperature below that limit increases electricity consumption. Another tip is to do a preventing maintenance and cleaning of the device.

Correct choose of air conditioning unit. The cooling capacity of an air conditioner is mainly proportional to the surface of the installing area but also depends on the orientation and insulation of the building. Furthermore if energy class of the device is at the top of the range there is lower energy consumption. For example, if we proceed with a replacement of a 'C' energy class air conditioner with an energy class 'A+' air conditioner there is about 34% energy savings, while if we replace it with energy class 'A +++' technology, savings are estimated up to 95%. New technologies with variable speed driver mechanisms inside the compressors of air conditioners operate at a variable rate depending on the needs of the space and work continuously at low speeds instead of following the Start and Stop modes all the time. Another factor is the installation point of the device which must be selected to provide good air flow in the space without any obstacles around. The same for the outdoor unit / compressor of air-conditioner to has good exterior air flow, small distance to the indoor unit, protection from direct exposure to bad weather conditions in order to follow a good refrigeration cycle.

Artificial lighting

Significant percentage of electricity consumption comes from the lighting system and its very poor management. This percentage of energy for old buildings or old lighting systems, ranges from 20% - 50%, but there are various ways to reduce the energy consumption for this sector by 80%. We can save electricity following good habits, proper management with lighting automation and by replacing old light bulbs with LED technology. This technology can save up to 80% energy compared to the old incandescent, fluorescent and halogen lamps. Except their low energy consumption other significant advantages are that they provide high brightness, last a long time and they do not contain toxic substances that are harmful to the environment.

Use of Renewable Energy Sources

The use of renewable energy sources (RES) are increasingly integrated in buildings today, greatly reducing the energy costs of the building. RES are considered practically inexhaustible and Cyprus is a country that has a remarkable RES potential especially coming from the sun. It is an alternative for the country's energy needs leading to its dependence on conventional fuels and environmental pollution due to of them. The main RES that are integrated in buildings are:

- **Thermal solar systems** that convert the solar radiation from the sun into immediately exploitable energy for heating assistance and hot water. The most famous solar thermal systems are firstly the solar water heaters which are also divided into two types depending on the circulation circuit of the heated medium. The open circuit where the heating medium is the water itself and there is rapid heating but is not recommended in areas with hard water and the closed circuit where the heating medium circulates in a separate circuit which heats the water to be used without mixing with it. This device delays heating the water but does not clog easily even if there is hard water. Secondly, central solar systems which the collectors are located on the roof and the container are located in the boiler room. This arrangement helps to reduce heat loss because the container is well insulated and is not direct exposed to weather conditions.

- **Photovoltaic systems** generate electricity by exploiting the solar. It consists of one or more panels of photovoltaic cells together and using appropriate devices for the conversion of electricity they produce energy in the desired form. It is the best solution for electricity generation because their technology is environmentally friendly. Solar energy is inexhaustible type of energy and inexpensive, has quiet operation, low maintenance requirements, long life, expandability, and can be installed on roofs or facades buildings. Of course there is a reduction of system performance between 0.5% and 0.8% per year as degradation rate and more specific 0.7% each year for the first ten years. The cost can be considered as disadvantage but in the same time it is an investment that will undoubtedly bring depreciation and significant gains in energy and money savings. For the case of Cyprus, total cost of buying and installing PV system varies from 900 to 2500 Euro per KWp and that based on the system capacity and additional costs related with structure panel supports. The annual maintenance cost varies also depending the system capacity from 0.5 to 2% and main maintenance activities are the panels cleaning for keeping the performance at high levels.

- **Geothermal pumps or ground source heat pumps** are using the ground constant temperature to provide cooling, heating and hot water. Utilizing electricity, they ensure the transfer of heat from the basement to the building during the heating period, during the cooling period and the reverse operation takes place from the building to the basement. The efficiency coefficient of geothermal pumps (COP) is higher than that of air heat pumps because they use as a heat source from the subsoil or groundwater which has a stable temperature all the year with a temperature proportional to the temperature of the atmosphere.

Chapter 3: Energy Savings Approach - Printing Factory Case

In this section we will look at the energy consumption and electricity energy usage of an industry specializing in printing paper packaging. We will propose ways to save energy through the European Green Energy Directive, and we will also present a financial analysis for each upgrade solution we propose.

In order to take a view of energy consumption, energy statements from Electricity Authority of Cyprus will be study to identify the total profile.

3.1 Software Usage

For the solution for photovoltaic system installation in order to cover part of energy needs, we will use 2 related softwares for such systems.

3.1.1 Ret Screen program

RETScreen International is a clean energy project analysis program. It is decision support software that can be used worldwide to evaluate energy production and greenhouse gas emission reductions for different types of energy. This software significantly reduces the costs (both financial and time) associated with identifying and evaluating potential energy projects. These costs, which arise in the stages of pre-feasibility, feasibility, development and design, can be significant obstacles to the development of Energy Efficient Technologies and RES Technologies. By helping to remove these barriers, RETScreen software allows decision makers and professionals to determine whether a proposed renewable energy, energy efficiency, or cogeneration project (combined heat and power) is economically viable.

The program consists of a series of worksheets and uses the Excel interface. These worksheets follow a standard approach for all RETScreen templates and are as follows:

- Start Sheet
- Energy Model
- Cost analysis
- Emission Analysis
- Financial analysis
- Risk Analysis

In this way, decision makers can perform a standard five-step analysis. RETScreen also includes databases of products, projects and costs as well as hydrological and climatic data.

3.1.2 PVsyst program

PVsyst Software is a comprehensive solar design tool used by thousands of engineers globally. PVSyst is a program for large solar installations, for sizing and balancing systems. It is useful for understanding various aspects of a system and determining where additional efforts should be made. It is providing real-time information about the system's size and components.

It has the following feature: a) system designing, b) system sizing, c)creating a shading scene d) creates simulation and results, e) model storage systems, f) some additional feature include importing data, g)simulate the aging effect of solar modules.

3.2 Financial Indicators

Moreover we are going to use dome factors and indicators for economic purposes and to justify that the proposed solutions worth as investments. All of them are used in capital budgeting and investment planning for further profitability analysis.

Cash flow : refers to the net amount of cash that being transferred in and out of the company. For our occasion we have to calculate this amount taking in account the investment cost, annual maintenance cost, performance losses over the years and incoming energy savings on the other hand.

NPV (Net Present Value) : is the difference between the present value of cash inflows and the present value of cash outflows over a period of time

$$NPV = \frac{R_t}{(1+i)^t}$$

where Rt= net cash flow, i= discount rate, t= time of cash flow

IRR (Internal Rate of Return) : is a metric used in financial analysis to estimate the profitability of investments. Basically is a discount rate that makes the NPV of all cash flows equal to zero.

BCR (Benefit – Cost Ratio) : is an indicator that attempts to summarize the total value for money that a project needs. It is comparing the present value of all benefits to the total cost of the investment.

If the result is bigger than 1 investment option is profitable, if the result is lower than 1 it is not profitable but generates losses. In case that is equal to 1 then the option has no profit and no losses.

BCR = PV (Benefits) / PV (Cost)

ROI (Return of Investment) : is a performance measure that is used to evaluate the efficiency of the investment and measures the amount of return on a particular investment relative to the investment cost. If an investments' ROI is net positive then it seems that is worthwhile.

ROI (%) = (Net Profit / Investment Expenses) x 100

Chapter 4: Presentation and data analysis of the research

4.1 General Description of the building

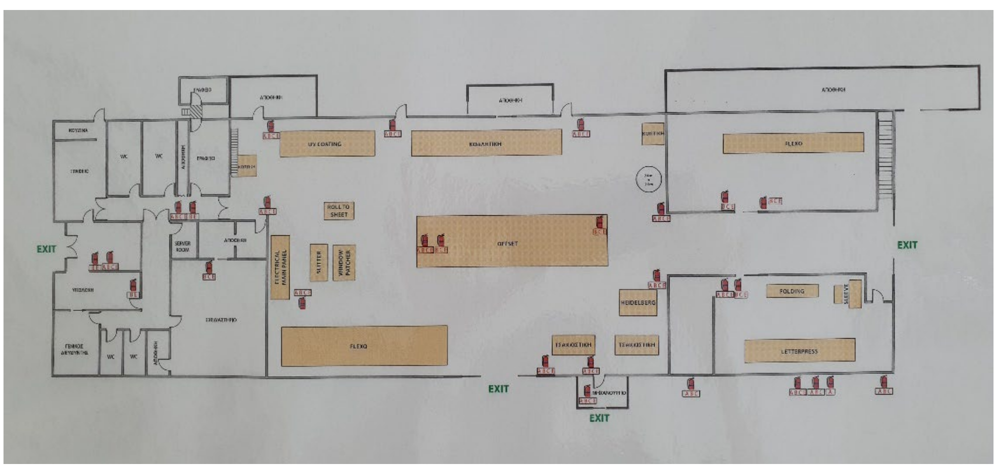
Printing factory is located in industrial area of Nicosia City and the building structure is 32 years old.

The factory is in operation only during the weekdays for 9 hours a day. More specific, it starts the operation at 7:00 in the morning and stops at 16:00 in the afternoon. Rarely continues its operation for 1-2 hours more, if there is bigger demand of work to finish some urgent requests and more rarely opens for works completion during Saturdays.

The factory usually stops its operation one week for Christmas holidays, one week for Easter holidays, two weeks in August for summer vacations and for public holidays.

There are 2 large ‘storage’ structures with 1170 square meters surface area each (the first one is the printing factory and the second one is used as warehouse), and the offices building with 300 square meters surface area (150m^2 ground floor and 150m^2 at the first floor). The two large spaces that make up the factory area have metal sloping roofs without any insulation or any other direct solar radiation protection.

Picture 1: View form above of the building



Picture 2: Building layout

4.2 Company electricity consumption

The company's owner took the commitment to upgrade energy efficiency of the factory and also reduce its carbon footprint. Until now lots of deals with recycling companies took place to handle scrap raw materials which most of them are paper and plastic but also machinery devices upgrade. The next step is to examine the possibility of installing a photovoltaic panels system to produce some energy and gain potential benefits by doing this. For example reducing business operational cost, after few years, which will be an advantage against the competitors. Taking in account last prices of electricity cost increment, this action will must be considered as critical for the company's short term strategy programming.

In general terms, main energy that is used is electricity energy coming from the main electricity grid of Cyprus and the provider is Electricity Authority of Cyprus (EAC). Below are the tables 1 related with electricity consumption for the last 4 years, for each month separately. All data have been taken from statements that provider gives on monthly basis. This statement is the record of electricity flow meter and shows all the details for the charging method in order to raise the monthly invoice. Details we used for this case study is of course monthly flow meters readings giving us also the opportunity to separate the consumption between weekdays and weekends and also peak and off-peak hours.

Total Electricity Consumption (KWh)				
	2018	**2019**	**2020**	**2021**
January	39794	35634	40064	34485
February	30035	33801	40033	42725
March	36429	32114	40664	39673
April	33403	30303	36523	39117
May	44157	43035	42775	45807
June	48244	56647	46924	52360
July	52187	64319	61255	53233
August	29280	28362	24603	27344
September	47403	46172	58166	44683
October	39518	43640	43258	42982
November	28589	33415	32341	35012
December	21246	22037	24321	26458

Table 1: Total Electricity Energy Consumption for the period 2018-2021

What we see from the above chart 1 is that there is a standard pattern for each month the last 4 years and it is related with factory production demands. The biggest amount /

consumption is 64319 KWh for July 2019 and lowest energy consumption is 21246 KWh for December 2018.

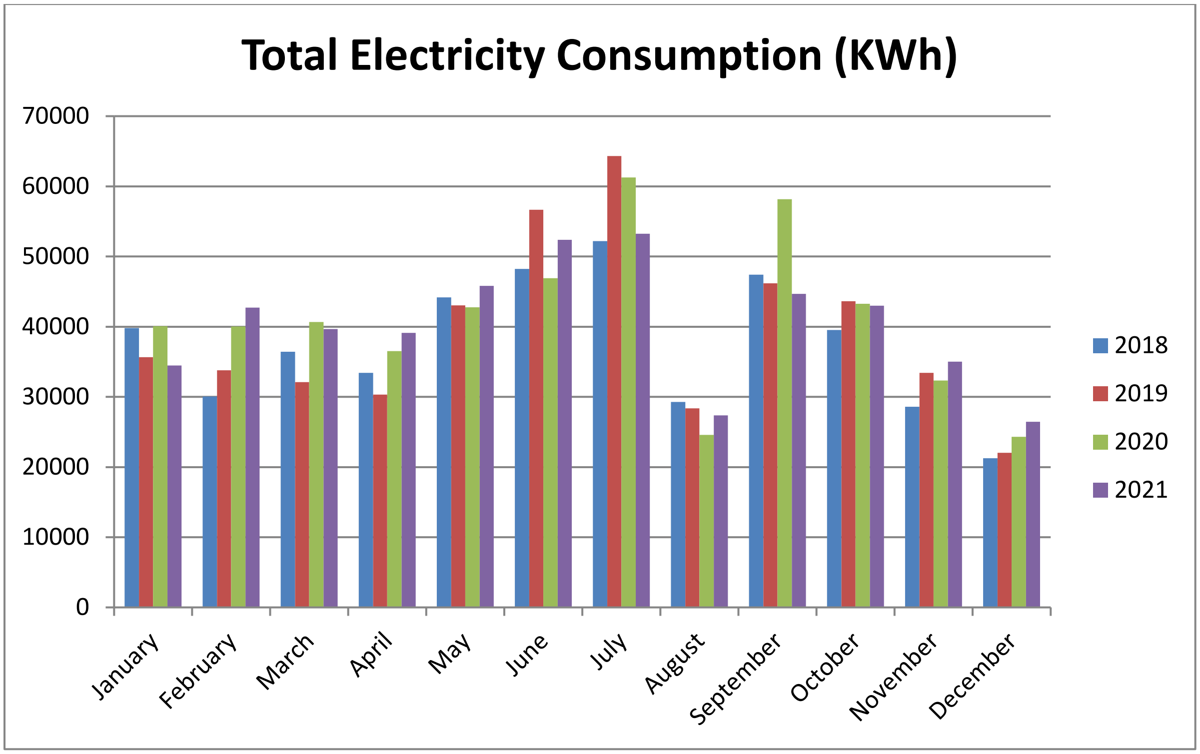


Chart 1: Total Electricity Consumption for the period 2018-2021

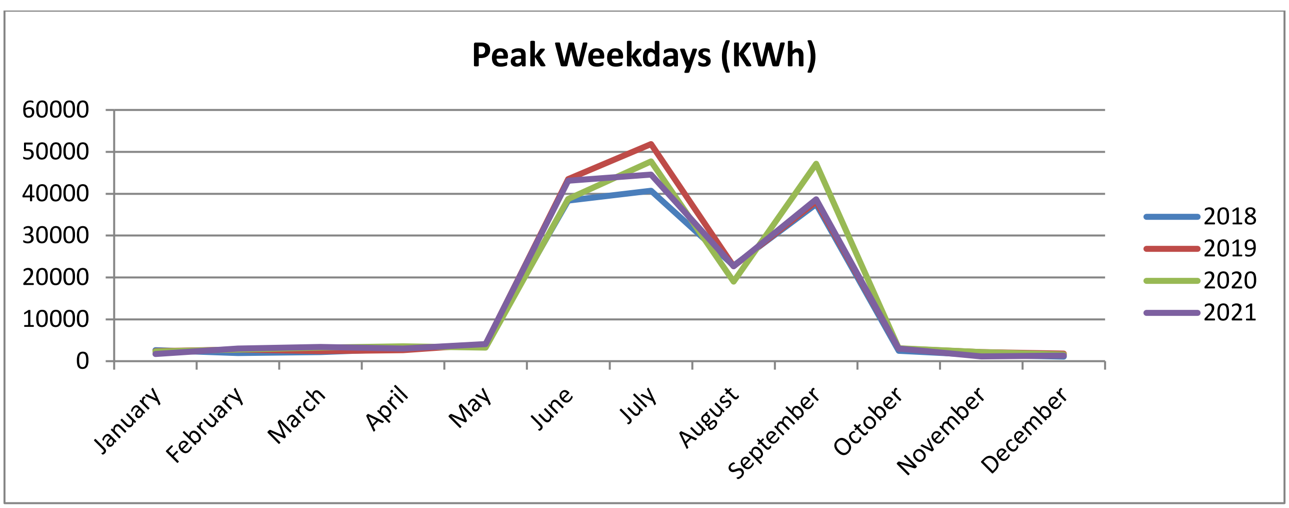


Chart 2: Electricity Consumption on pick period for weekdays

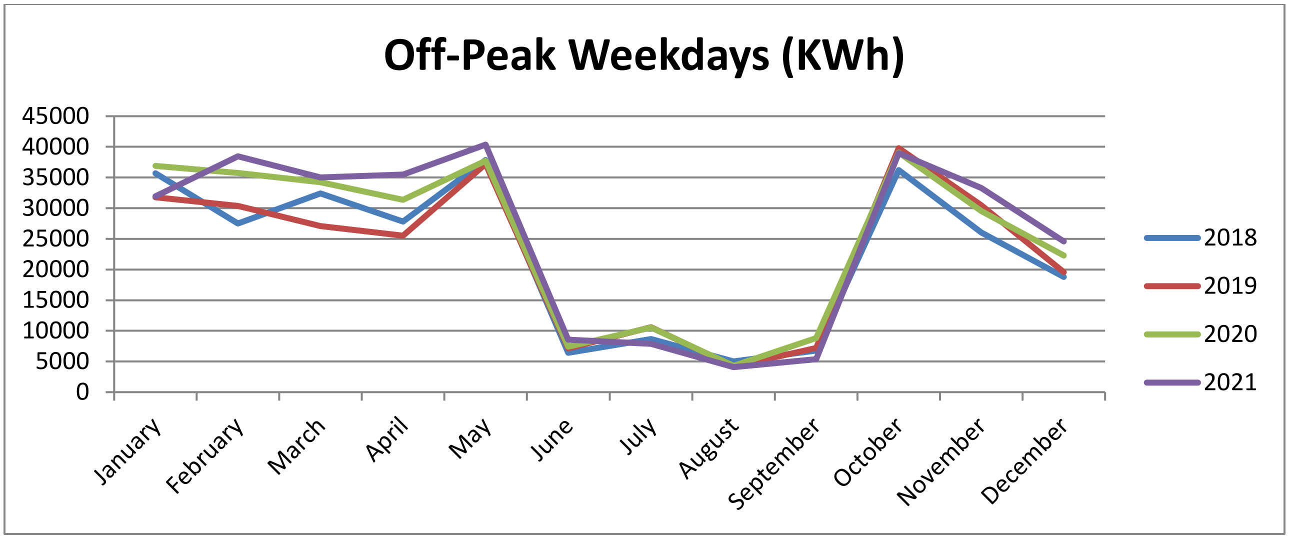


Chart 3: Electricity Consumption on off-pick period for weekdays

About separating the consumption in peak (chart 2) and off-peak (chart 3) periods for weekdays, we can see that during the high season where the production level is at the top – summer period (except August), coincides also with the peak electricity demand hours off the day (morning hours) and that because during summer period the energy demand especially at midday is very high because of the high temperature too, where air conditioning systems are working unstoppable to handle and balance thermal comfort of the areas. We have to take this chart into account at the feasibility study because the cost of electricity is getting bigger when at peak periods and is related with high rate factory's consumption.

As for the weekends there is a standby mode where some PCs are working 24 hours per day as server system, some lights, refrigerators for staff, some lights and of course a CCTV system for security issues.

That we can see from chart 4, at June of year 2019 there is a spike with high consumption during the weekends and asking the production managers of the company, they told us during summer period there is often a need for working during Saturdays to cover and finish production order requests because of summer vacations. This may be continued and on September because customers want to refill their stocks related with labels, boxes, etc. For year 2021 the production set up was at the top level efficiency during weekdays because of additional printer machine with result of reducing energy the weekends.

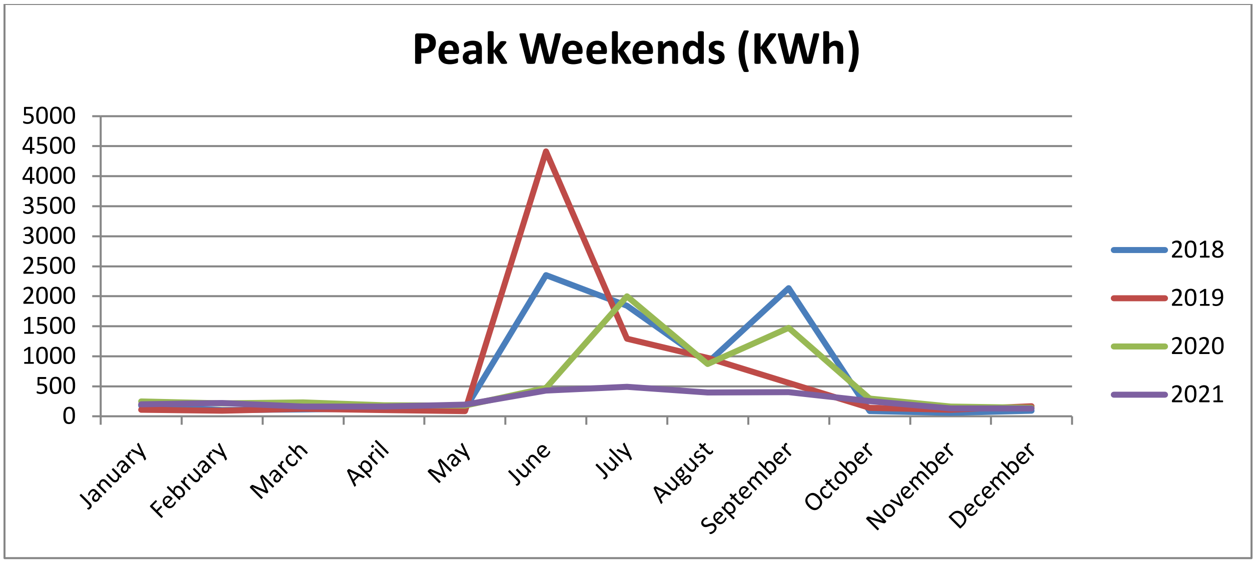


Chart 4: Electricity Consumption on pick period for weekends

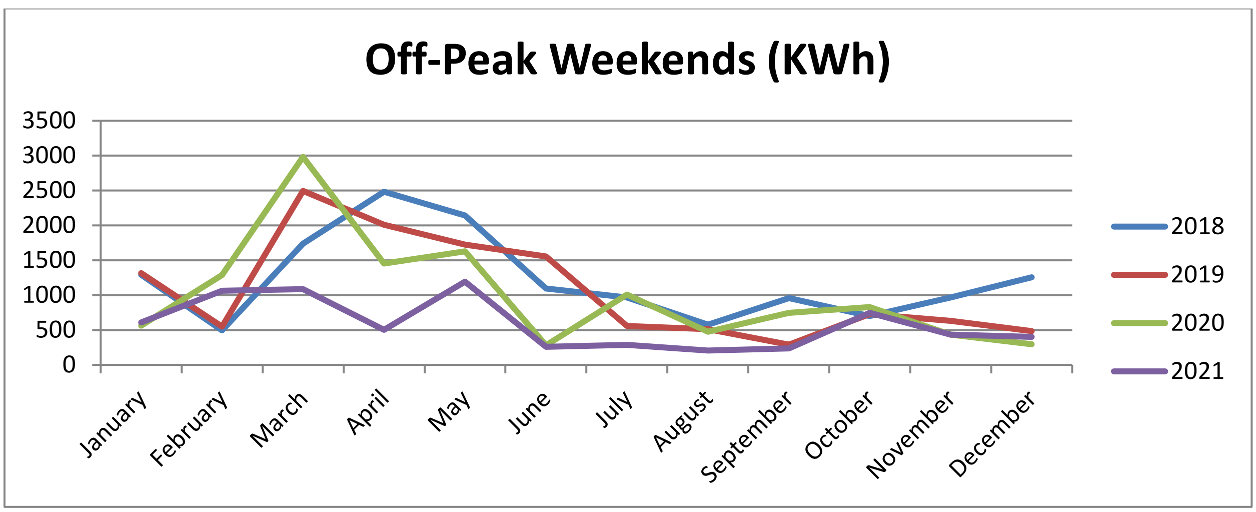


Chart 5: Electricity Consumption on off-pick period for weekends

Electricity bill statement give us more details for charging method and by doing some calculations we can find the cost of each KiloWatt-hour. What we see at chart 6 is the decrease of the electricity cost during the first phase of COVID-19 pandemic during the year of 2020 and in more detail the average price for the year was at 0,18 euro / KWh compared with 2018 and 2019 that was round to 0.20 euro / KWh. As for the year 2021 the electricity cost at the second half year was average at 0,25 euro / KWh.

This 25% increment of electricity cost affecting the total production cost and in combination of raw materials higher prices, transportation and delivery difficulties cause various problems to keep the company's services standards.

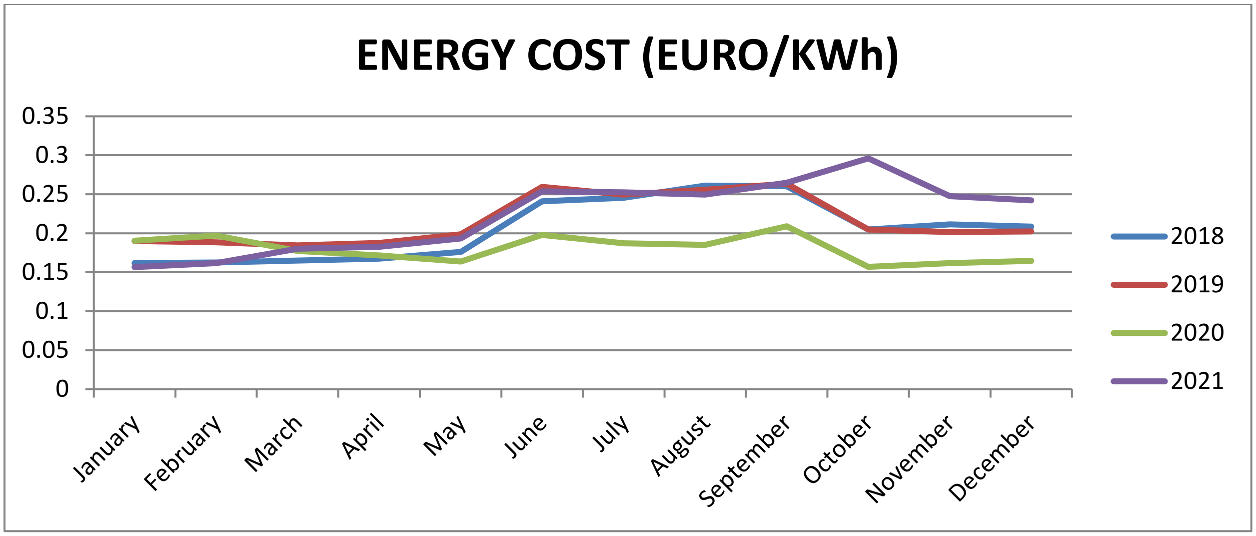


Chart 6: Energy cost for the period 2018-2021 per KWh

Another detail is the fuel adjustment factor that EAC calculate to finalize the price in accordance with the actual fuel price that was used to the Power Generation Plant, as we can see on chart n7. This factor is multiplied with the total electricity consumption in KWh and the amount is added to the total basic price.

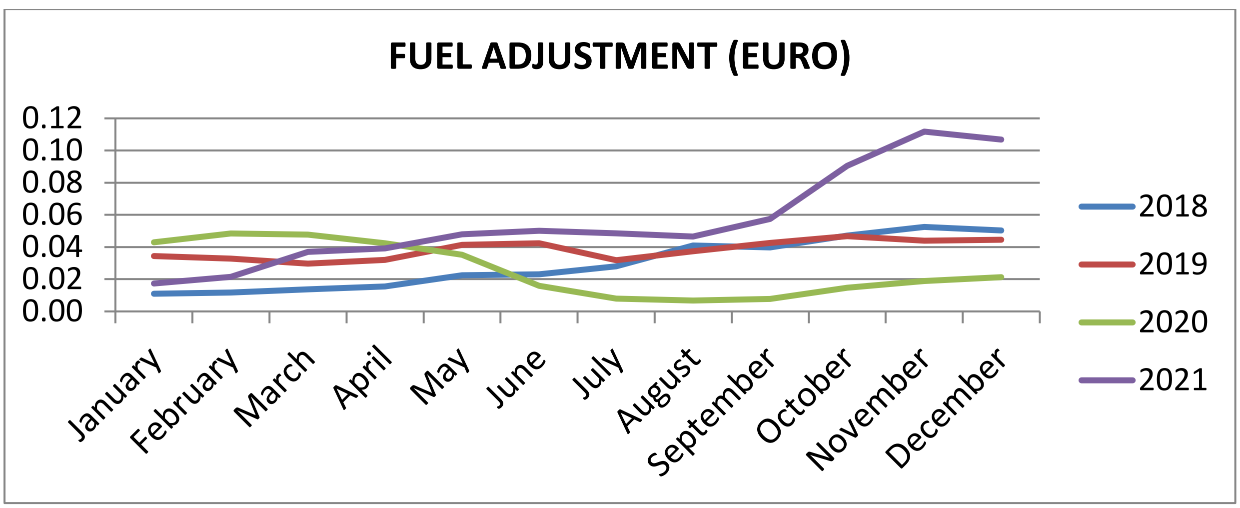


Chart 7: additional cost for Fuel Adjustment per KWh

What we see again on chart 7 and chart 8 is the low bend within the 2020, the first pandemic period start from March 2020, with the first lockdown where fuel demand was very low but on the other hand the higher fuel cost of the latest period of 2021 and also the rising trend for the near future.

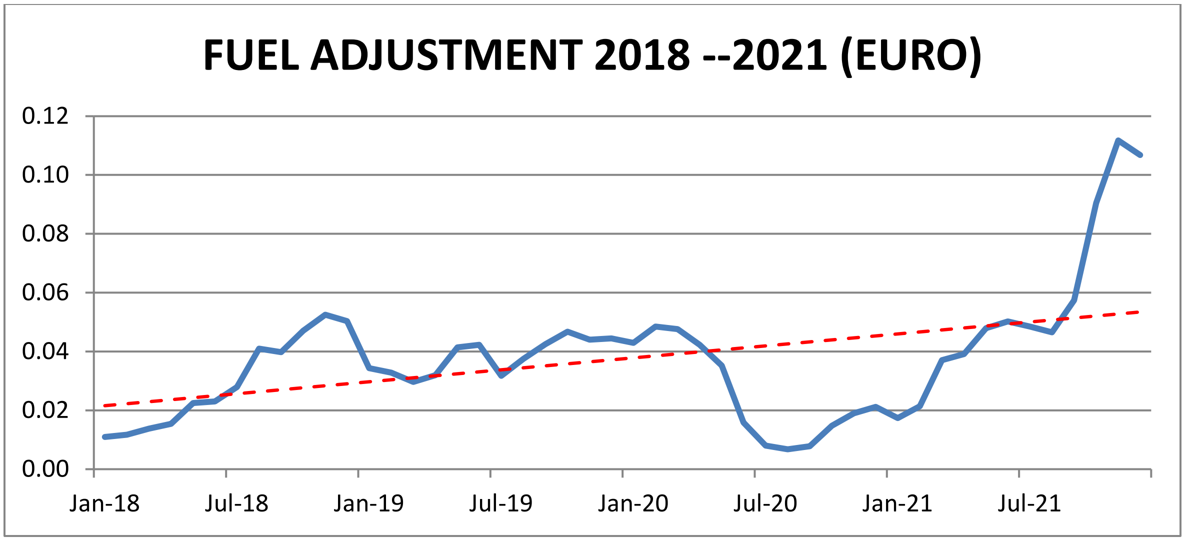


Chart 8: Fuel Adjustment Trend-Line (January 2018 until December 2021)

4.3 CO2 Emissions coming from company operations

Another parameter that we have to examine is the carbon footprint of the factory. Given data from EAC tell us that CO2 emissions coming from the Power Generation Plant, for electricity production is about at 710 g of CO2 per KWh.

Totally for the last 4 years, CO2 emissions coming from factory operation was up to 1350 tonnes CO2. That amount is equal for example with 245 cars to stop their usage for an entire year or equal to 123 hectares of tree forest that absorbs and store CO2 for one year.

CO2 emissions g	
2018	3.20×10^8
2019	3.33×10^8
2020	3.49×10^8
2021	3.44×10^8
Total	1.35×10^9

Table 2: Annual CO2 emissions for each year (g)

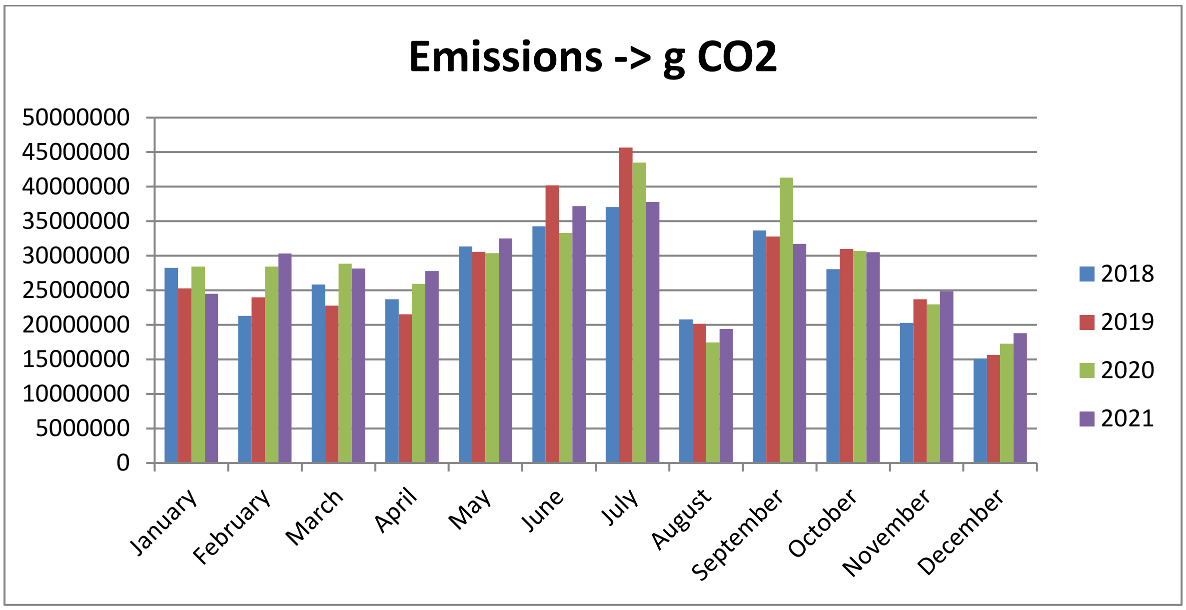


Chart 9: Monthly CO2 emissions (g)

4.4 Energy consumers of the factory

In order to proceed with more detailed examination of the building usage, we have to define the energy profile of the company and identify energy gaps and energy losses.

The energy consumption of the factory could be separated in four main sectors

1. Heating/ Ventilation/ Air-Conditioning systems (HVAC)
2. Lighting
3. Office equipment
4. Factory operation equipment

Heating/ Ventilation/ Air-Conditioning systems (HVAC)

As we mentioned above, the building has no any roof insulation and big Air Conditioning devices are used to balance the temperature in the mass area of the first building during the summer period. Furthermore, very old air conditioners are used in the ground floor offices and new type of split units with inverters are used in the first floor offices during heavy winter and summer periods.

Lighting

The factory has lots of lights and that because there are no enough openings/ windows and because of the type of the jobs enough light is necessary to do the product quality control and check printing colors. Positive step was the upgrade to the lighting system on factory ceiling and offices. They replaced all lights with LED type in order to provide better light quality, reduce energy cost and also minimize carbon emissions.

Office equipment

Office equipment is consists of 13 Desktop PCs complete with 21'' LED monitors(2 of them working as server and backup system 24 hours a day), 4 office multi-printer devices, 2 refrigerators for staff purposes, internet grid routers and security system with CCTVs

Factory operation equipment

As we mentioned above the factory is dealing with preparing and printing carton/paper boxes for various products such as foods, pharmaceuticals, packages etc. There are 5 massive machines that form the production line from cutting, printing, crunching / slitting, gluing and packaging. There are also various other machines for shredding scrap materials, levels for other machines, cylinders for simulate knifes for cutting, etc. It was difficult to define exactly the power consumption of each machine and that because they are very old without any energy label on them, so we will find rest of the other sectors and remaining amount is for those devices which are all important for smoothing production.

What we can say for factory machinery equipment energy consumption and one section of production is the ink drying equipment during the printing stage of the procedure. This equipment uses for the drying process conventional UV lamps with its own refrigeration and extractor fan system. There is 1 system after each printing division with 8 lamps each system, so 16 lamps in total. Power of each lamp is at 7.2KW and they are ON for 6 hours per working day, so we estimate annual electricity consumption at 152064KWh which is round to 31.5% of total factory's energy demand. Future plan is the replacement of the specific UV lamps with new technology LED bulbs but for the moment is not achievable because LED technology is not compatible with the printing machine and present ink drying process.

Energy Consumption Profile

The below pie chart 10 shows the electricity consumption profile of the company, divided to the four main consuming sectors.

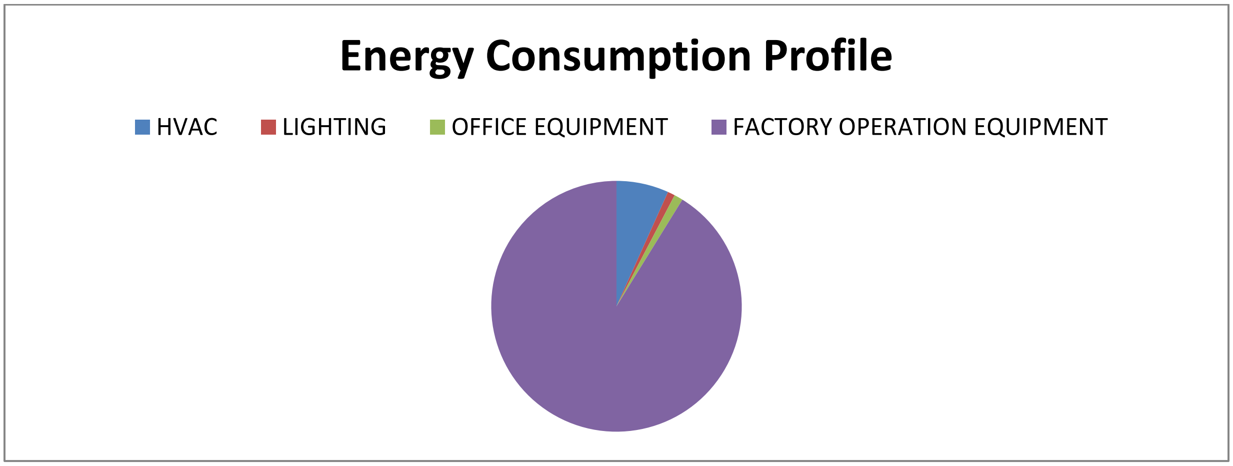


Chart 10: Energy Consumption Profile

Electricity Consumption Profile				
	Annual Electricity Consumption (KWh)		euro/KWh	Cost (euro)
HVAC	32640	6.75%	0.22	7180.8
LIGHTING	4553	0.94%	0.22	1001.6
OFFICE EQUIPMENT	5475	1.13%	0.22	1204.5
FACTORY OPERATION EQUIPMENT	441211	91.18%	0.22	97066.4

Table 3: Electricity Consumption Profile for the factory

We can see that the main consumer is the Factory Operation Equipment with more than 91% because these specific machineries need high demand of energy. Devices have big electricity motors for rotating the relevant parts and also use high voltage UV lamps during the operation time to dry the printed liquid colors and finish coatings. Second comes the HVAC system and we will examine the possibility for some upgrades at the next stage of the study. As for the lighting system and office equipment, upgrades will not cause any significant energy reduction.

4.5 Upgrade Solutions for reducing energy consumption

Main objective of this study is to determine of course energy efficiency improvements in order to reduce electricity energy consumption and also reduce company carbon footprint. By taking the relevant data and measurements we can identify some upgrades or solutions that will increase energy efficiency and gain some energy savings. At all proposed solutions, feasibility study and payback period will be provided in order to give needed emphasis to each investment.

4.5.1 HVAC system upgrade – Suggestion 1

At the moment and taking in account the minimum payback period we can suggest the 5 old A/C systems that are located in the offices of ground floor. By doing this, company will decrease annual energy consumption up to 3600 KWh and save round to 792 Euro per year.

HVAC EQUIPMENT			
	Nr. Of Units	Annual Energy Consumption (KWh)	Annual Cost (Euro)
FACTORY / MASS AREA			
Package Units 11KW, R410	3	15840	3484.8
GROUND FLOOR OFFICES			
A/C Split Units 3KW, R407	5	10800	2376
FIRST FLOOR OFFICES			
A/C split Units 5KW inverter, R32	4	6000	1320

Table 4: HVAC Equipment at each division

In case of new A/C split Units installation for the price of 600 Euro / Unit (installation including) with normal operation lifetime at 10 years and with maintenance costs at the same level as before, then the payback period will be after 5 years with Net Present Value>0, more specific at 4200 and Internal Rate of Return at 20.18 (chart 11) which is bigger than the Required Rate of Return which for this occasion was set to 10%.

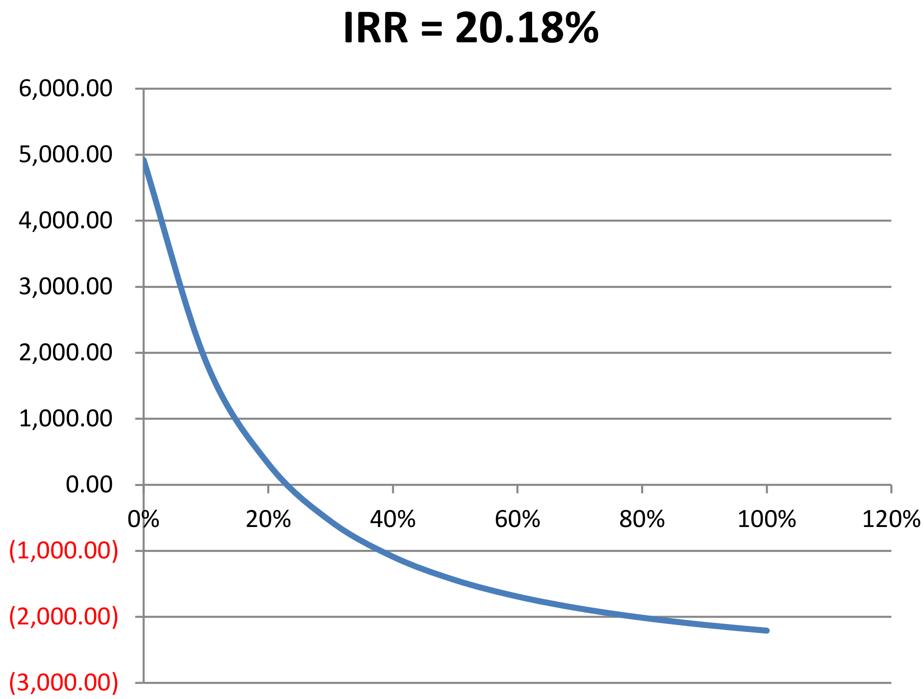


Chart 11: Internal Rate of Return

	YEAR - BEGINING BALANCE (Euro)	INTEREST RATE	IR Losses (Euro)	SAVINGS (Euro)	YEAR - END BALANCE (Euro)
NEW A/Cs purchasing and installation					-3000
YEAR 1	-3000	3%	-90	792	-2298
YEAR 2	-2298	3%	-68.94	792	-1575
YEAR 3	-1575	3%	-47.24	792	-830
YEAR 4	-830	3%	-24.90	792	-63
YEAR 5	-63	0%	0	792	729
YEAR 6	729	0%	0	792	1521
YEAR 7	1521	0%	0	792	2313
YEAR 8	2313	0%	0	792	3105
YEAR 9	3105	0%	0	792	3897
YEAR 10	3897	0%	0	792	4689

Table 5: Investment Cash-flow

YEAR	NET INFLOW	REQUIRED RATE of RETURN	PRESENT VALUE
NEW A/Cs purchasing and installation	-3000	0.1	-3000
YEAR 1	792	0.1	720
YEAR 2	792	0.1	720
YEAR 3	792	0.1	720
YEAR 4	792	0.1	720
YEAR 5	792	0.1	720
YEAR 6	792	0.1	720
YEAR 7	792	0.1	720
YEAR 8	792	0.1	720
YEAR 9	792	0.1	720
YEAR 10	792	0.1	720
Net Present Value (NPV)			4200
Internal Rate of Return (IRR)			0.201

Table 6: Net Present Value calculations, Solution 1

4.5.2 Photovoltaic system installation – Suggestion 2

Second suggestion and the most important is to produce some electricity in order to reduce the dependence from EAC and also reducing the operation cost. Giving the opportunity of the working during weekdays peak period in the summer, we can install photovoltaic panels that would be connected on the EAC grid but on the other hand using the Net Billing program we can achieve kind of balance between energy production and energy consumption. In order to identify the exact amount of energy production there is a need of specific study about the PVs installation potential in terms of space availability and also project's total cost.

For the installation place we can use the metal roof of the 2 big buildings to install a significant amount of PV panels. There is a space on south direction of each building equal with the half surface of the roof. On the below picture 3 we mark perimeter of company's area with red color and also marked with blue color lines the available space on the roof. Calculating roofs surface we found that the available total space is close enough to 1100m^2. In addition the roof as we mentioned before is inclined with 10^o.

Picture 3: Aerial photo of factory location and roof surface, using Google Maps application.

For the calculation of the PVs potential we need to define the total solar radiation on the specific area and we extracted some data from an application that deals with various sustainable solutions, RETScreen. In more detail for the exact location of the factory, there is a daily solar radiation at 5.2 KWh/m^2/day average for the year. We can see also separately for each month the potential of solar radiation and for the peak period (summer period May - August) it can reach up to 7.6 KWh/m^2/day, average.

	Unit	Climate data location	Facility location	Source
Latitude		35.2	35.1	
Longitude		33.4	33.4	
Climate zone		2A - Hot - Humid		NASA
Elevation	m	63	219	NASA – NASA
Heating design temperature	°C	7.7		NASA
Cooling design temperature	°C	32.0		NASA
Earth temperature amplitude	°C	15.1		NASA

Month	Air temperature	Relative humidity	Precipitation	Daily solar radiation - horizontal	Atmospheric pressure	Wind speed	Earth temperature	Heating degree-days 18 °C	Cooling degree-days 10 °C
	°C	%	mm	kWh/m²/d	kPa	m/s	°C	°C-d	°C-d
January	12.2	63.8%	77.59	2.49	99.2	5.0	14.8	181	67
February	11.9	61.7%	67.18	3.44	99.1	5.3	14.9	170	54
March	13.9	59.3%	47.66	4.83	98.9	4.7	16.9	127	121
April	17.5	57.4%	48.38	5.98	98.8	4.1	20.7	14	226
May	21.6	55.6%	23.63	7.24	98.7	3.7	25.4	0	359
June	25.9	50.6%	10.29	8.12	98.4	3.9	29.8	0	477
July	29.3	45.3%	2.13	7.93	98.2	4.2	33.3	0	598
August	29.4	46.8%	2.61	7.08	98.3	4.2	33.4	0	601
September	26.8	48.6%	13.12	5.88	98.6	4.0	30.6	0	505
October	22.7	53.7%	34.15	4.26	99.0	3.7	25.8	0	394
November	17.7	59.4%	65.64	2.87	99.2	4.3	20.3	9	231
December	13.7	63.8%	91.06	2.20	99.3	4.7	16.3	132	116
Annual	**20.3**	**55.5%**	**483.44**	**5.20**	**98.8**	**4.3**	**23.6**	**634**	**3,747**
Source	NASA	NASA	NASA	NASA	NASA	NASA	NASA	NASA	NASA
Measured at					m	10	0		

Climate data

Table 7: Extracted Data from RETScreen software about solar potential for the specific area

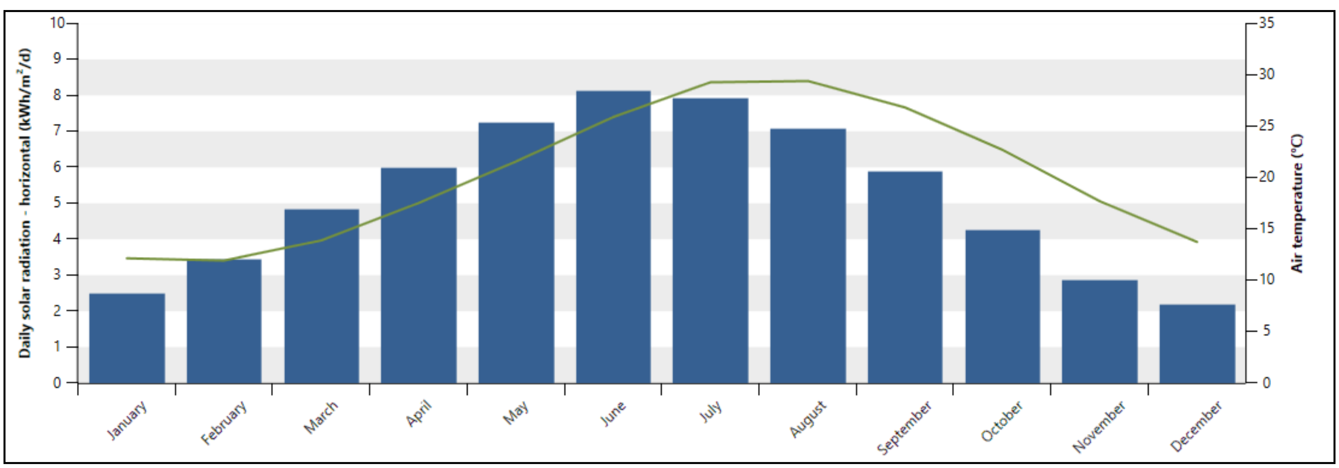


Chart 12: Extracted Data from RETScreen software for daily solar radiation in KWh/m² for each month separately.

By using second application (PVsyst) which is dealing with solar panels, choosing from map the same territory, we have the total amount of 1898 KWh/m^2/year which is the same with previous value from RetScreen by multiplying the mean value for a day 5.2 KWh/m^2/day with 365 days for a year.

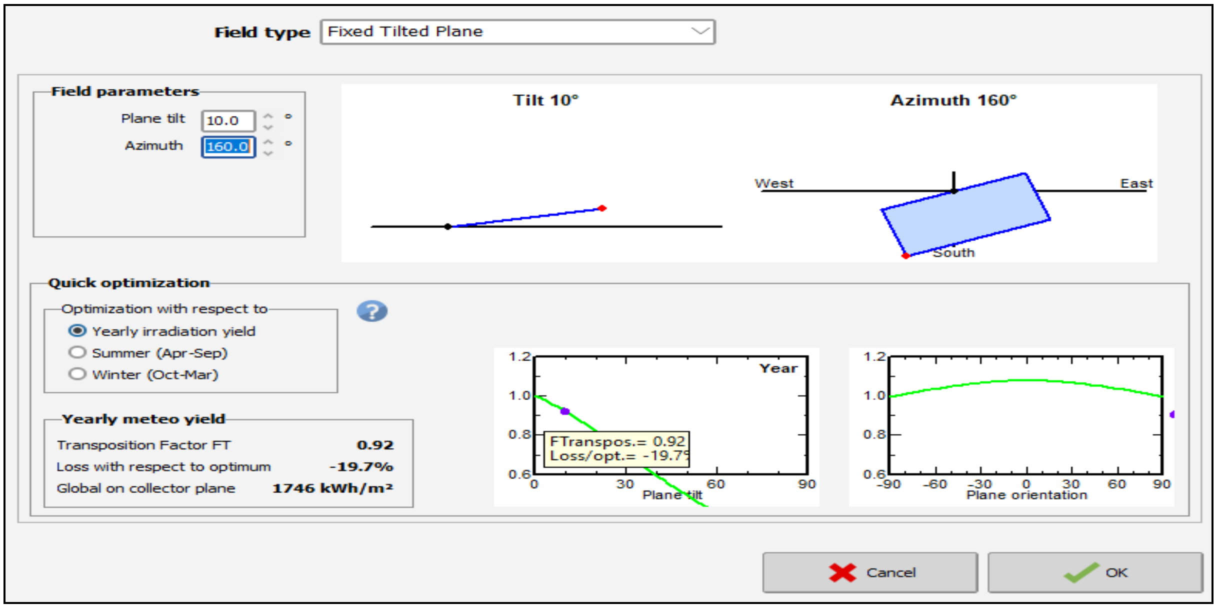
Site: Agios Georgios (Cyprus)

Data source: NASA-SSE satellite data 1983-2005

	Global horizontal irradiation kWh/m²/mth	Horizontal diffuse irradiation kWh/m²/mth	Temperature °C
January	77.2	28.5	12.2
February	96.3	32.8	11.9
March	149.7	45.0	13.9
April	179.4	54.0	17.5
May	224.4	57.7	21.6
June	243.6	51.3	25.9
July	245.8	51.5	29.3
August	219.5	47.7	29.4
September	176.4	39.0	26.8
October	132.1	35.0	22.7
November	86.1	28.5	17.7
December	68.2	26.4	13.7
Year	**1898.8**	**497.3**	**20.2**
	Paste	Paste	Paste

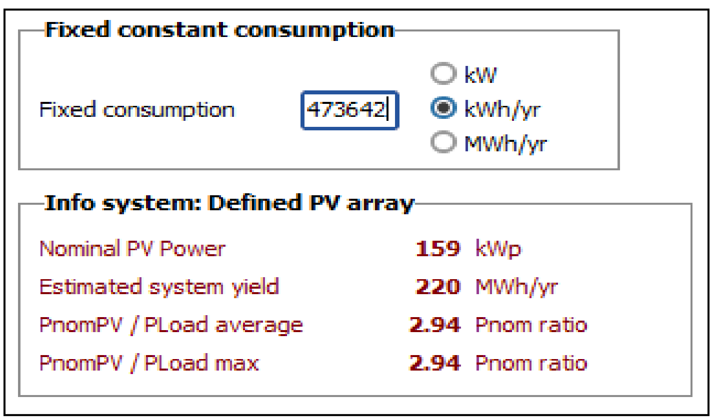
Table 8: Extracted Data from PVsyst software for monthly solar (horizontal) radiation in KWh/m^2.

By move to the next step through the PVsyst program, there is a request to select the field type, if it is fixed or for trucking system, the tilt of panel installation and also azimuth to south direction. What we get from this step is the annual solar radiation drops to 1746 KWh/m^2/year, a reduction rate of 8% for our occasion because of the system orientation.



Picture 4: Define orientation and direction for this occasion and losses calculations from PVsyst software.

Then we have the PV system selection. We chose polycrystalline solar panels to cover an area of 1000m2 at least, with the relative inverter devices for a constant annual consumption of 473642 KWh which is the average electricity energy consumption for the last 4 years.



Picture 5: Total PVs potential for given available surface and annual total electricity needs.

The system calculations gave us the option to install a system of 159 KWp with ratio energy consumption to energy production at 2.94 taking also in consideration the system losses at 20.8% as below table 9.

PV System Losses	%
Temperature	10
Reflection	3
Mismatch	3
Inverters	2.1
Soiling	1.8
A/C system	0.4
Irradiance	0.3
Wiring	0.2
Clipping	0
Shading	0
Total	**20.8**

Table 9: Determination of PV system operation losses

With losses factor because of orientation and direction at 0.92 means we have 8% losses for that reason and additional system losses at 20.8%

	SOLAR RADIATION (KWh/m2/day) - RetScreen	**SOLAR RADIATION (KWh/m2/month)**	**After Orientation and Direction losses 8% (KWh/m2/month)**	**After also PV System Losses 20.8% (KWh/m2)**
January	2.49	77.19	71.0148	56.24
February	3.44	96.32	88.6144	70.18
March	4.83	149.73	137.7516	109.09
April	5.98	179.4	165.048	130.71
May	7.24	224.44	206.4848	163.53
June	8.12	243.6	224.112	177.49
July	7.93	245.83	226.1636	179.12
August	7.08	219.48	201.9216	159.92
September	5.88	176.4	162.288	128.53
October	4.26	132.06	121.4952	96.22
November	2.87	86.1	79.212	62.73
December	2.2	68.2	62.744	49.69
TOTAL		1898.75	1746.85	**1383.50**

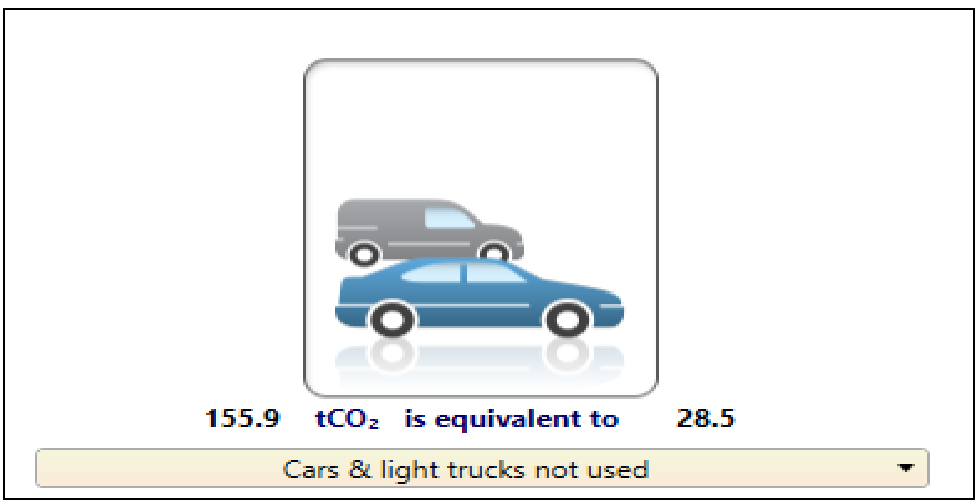
Table 10: Calculation of annual PV system production in KWh/m^2.

Finally we have chosen a system at 160KWp and comparing it with theoretical potential values we got the following results for AC Energy. Main conclusion by installing the suggested PV system is the coverage of company energy needs at 47%.

	For 160 KWp System (KWh)	Average Energy Consumption for the last 4 years (KWh/month)	% coverage of PV system for each month
January	8999	37494.3	24%
February	11229	36648.5	31%
March	17456	37220.0	47%
April	20915	34836.5	60%
May	26166	43943.5	60%
June	28399	51043.8	56%
July	28659	57748.5	50%
August	25588	27397.3	93%
September	20565	49106.0	42%
October	15396	42349.5	36%
November	10038	32339.3	31%
December	7951	23515.5	34%
TOTAL	**221361**	**473642.5**	**47%**

Table 11: Total coverage of factory needs from PV system electricity production.

By reducing the energy consumption to half levels, the company will make a significant step forward to reduce CO2 emissions. Estimated amount is at 156 tonnes of CO2 emissions per year. Comparing again of how many cars will remain unused for an entire year is equivalent with 28.5 cars or 14.3 hectares of forest absorbing carbon.



Picture 6: Extracted data from RETScreen software for CO2 reduction emissions by installing 160KWp PV system at the factory area.

In economic terms we have to examine the payback period of the PV system cost and do some additional calculations for the Net Present Value (NPV) and further analysis for the Internal Rate of Return (IRR) of the investment and Benefit to Cost Ratio (BCR).

First of all we present the yearly income for the project in a forecast of 25 years lifetime of the project but also calculating an additional 3% of losses after the starting year of operation and another 0.7% every year losses because of system efficiency decrease. For the calculations we took the average cost of electricity which is 0.22 Euro/KWh.

	PV SYSTEM PRODUCTI ON (KWh)	ELECTRICITY COST (Euro/KWh)	YEARLY INCOME (Euro)
YEAR 1	221361	0.22	48699
YEAR 2	214720	0.22	47238
YEAR 3	213217	0.22	46908
YEAR 4	211725	0.22	46579
YEAR 5	210243	0.22	46253
YEAR 6	208771	0.22	45930
YEAR 7	207309	0.22	45608
YEAR 8	205858	0.22	45289
YEAR 9	204417	0.22	44972
YEAR 10	202986	0.22	44657
YEAR 11	201565	0.22	44344
YEAR 12	200154	0.22	44034
YEAR 13	198753	0.22	43726
YEAR 14	197362	0.22	43420
YEAR 15	195981	0.22	43116
YEAR 16	194609	0.22	42814
YEAR 17	193246	0.22	42514
YEAR 18	191894	0.22	42217
YEAR 19	190550	0.22	41921
YEAR 20	189217	0.22	41628
YEAR 21	187892	0.22	41336
YEAR 22	186577	0.22	41047
YEAR 23	185271	0.22	40760
YEAR 24	183974	0.22	40474
YEAR 25	182686	0.22	40191

Table 12: Gross annual savings from PVs 160KWp production for a 25 year period.

Based on current market values for buying and installing a PV system for a size between 100 and 200 KWp, the price is at 1000 Euro / KWp. So, for this case the estimated total system cost is at 160000 Euro. Taking this in account, the fact that PVs lifetime is 25 years with tiny efficiency reduction year by year and what company earns by this installation we have to say that payback period is after the fourth year of system operation. Assuming that the lending / interest rate is at 3% with 0% deposit rate and maintenance cost at 900 euro per year then the cash flow of the investment will be as below table 13:

	YEAR BEGINING BALANCE (Euro)	INTEREST RATE	Interest Losses (Euro)	Maintenance Costs (Euro)	SAVINGS (Euro)	YEAR END BALANCE (Euro)
PV SYSTEM STARTING YEAR						-160000
YEAR 1	-160000	3%	-4800	-900	48699	-117001
YEAR 2	-117001	3%	-3510.02	-900	47238	-74172
YEAR 3	-74172	3%	-2225.16	-900	46908	-30390
YEAR 4	-30390	3%	-911.687	-900	46579	14378
YEAR 5	14378	0%	0	-900	46253	59732
YEAR 6	59732	0%	0	-900	45930	104761
YEAR 7	104761	0%	0	-900	45608	149469
YEAR 8	149469	0%	0	-900	45289	193858
YEAR 9	193858	0%	0	-900	44972	237930
YEAR 10	237930	0%	0	-900	44657	281687
YEAR 11	281687	0%	0	-900	44344	325131
YEAR 12	325131	0%	0	-900	44034	368265
YEAR 13	368265	0%	0	-900	43726	411091
YEAR 14	411091	0%	0	-900	43420	453611
YEAR 15	453611	0%	0	-900	43116	495826
YEAR 16	495826	0%	0	-900	42814	537740
YEAR 17	537740	0%	0	-900	42514	579354
YEAR 18	579354	0%	0	-900	42217	620671
YEAR 19	620671	0%	0	-900	41921	661692
YEAR 20	661692	0%	0	-900	41628	702420
YEAR 21	702420	0%	0	-900	41336	742856
YEAR 22	742856	0%	0	-900	41047	783003
YEAR 23	783003	0%	0	-900	40760	822863
YEAR 24	822863	0%	0	-900	40474	862437
YEAR 25	862437	0%	0	-900	40191	**901728**

Table 13: PV investment cash-flow

Diagram with Payback period where negative cash flow becomes equal to zero and follows a positive trend is illustrated below – Chart 13. This diagram has been plotted by using the RetScreen software for this suggestion of power generation.

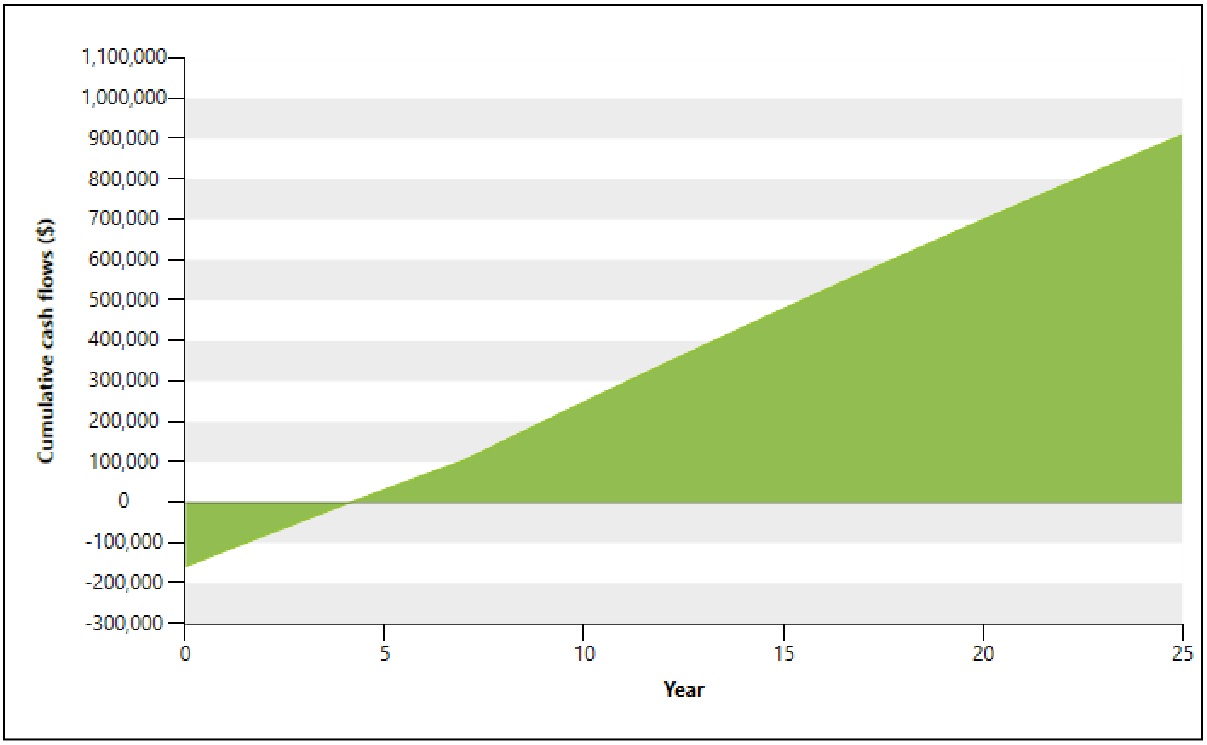


Chart 13: Extracted graph from RETScreen software for Cumulative cash flows

YEAR	NET INFLOW (Euro)	REQUIRED RATE of RETURN	PRESENT VALUE (Euro)
PV SYSTEM STARTING YEAR	-160000	5%	-160000
1	47799	5%	45523
2	46338	5%	44132
3	46008	5%	43817
4	45679	5%	43504
5	45353	5%	43194
6	45030	5%	42885
7	44708	5%	42579
8	44389	5%	42275
9	44072	5%	41973

10	43757	5%	41673
11	43444	5%	41376
12	43134	5%	41080
13	42826	5%	40786
14	42520	5%	40495
15	42216	5%	40205
16	41914	5%	39918
17	41614	5%	39633
18	41317	5%	39349
19	41021	5%	39068
20	40728	5%	38788
21	40436	5%	38511
22	40147	5%	38235
23	39860	5%	37962
24	39574	5%	37690
25	39291	5%	37420

Table 14: Net Present Value calculations.

As for the Net Present Value of the investment is the total of present value from year 0 to year 25 and is equal to 862071 Euro = NPV, coming from total amount of last column of Table 14. By using the M.S Excel platform, Internal Rate of Return was calculated too at 27.16% =IRR. Most of the banking companies, with such IRR rate, will accept the great performance of the investment and the profit is with no major risk and that because is quite bigger than the required rate of return.

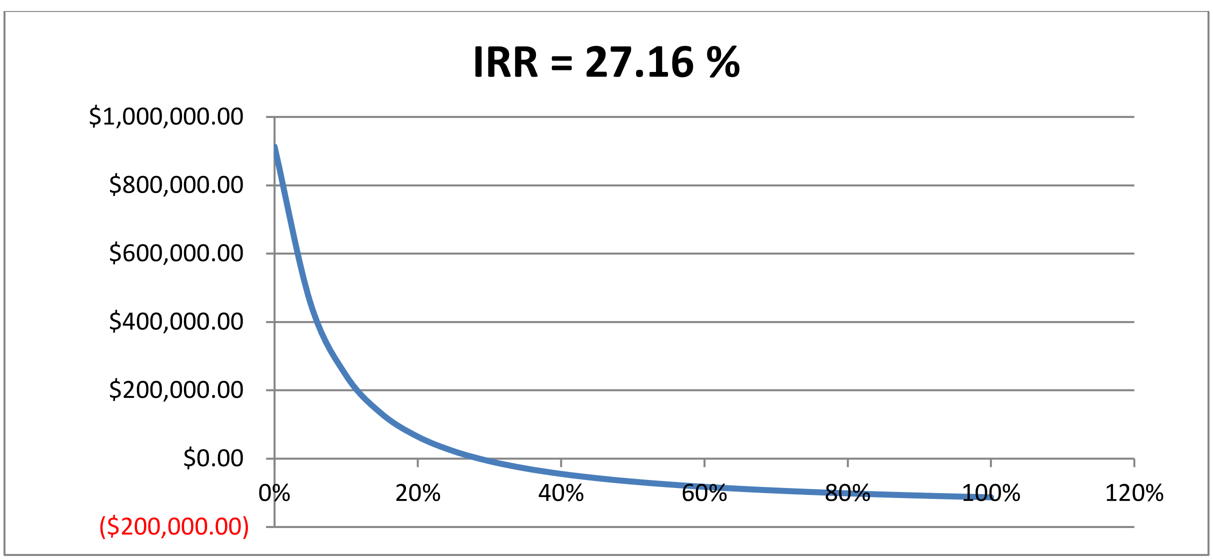


Chart 14: Internal Rate of Return for the investment

The following tables shows two other factors for the project feasibility, Return On Investment (table 16) which is bigger than zero so another factor to justify the low risk, and Benefit to Cost Ratio (table 17), which is bigger than 1 unit and that indicator gives the expectation of positive Net Present Value .

R.O.I	
Investment Cost	160000
Net Present Value	862071
Return On Investment (%)	539

Table 15: Calculations for Return on Investment percentage.

B.C.R	
Investment Cost	160000
Income Present Value	1022071
Benefit to Cost ratio	6.39

Table 16: Calculations for Benefit to Cost Ratio

Chapter 5: Results

Based on the above study, company premises have high energy demand of electricity. Main sectors of consumption are the HVAC system with 6.75%, the lighting system with 0.94%, office equipment at 1.13% and finally the bigger consumer that is Factory Operation Equipment with 91.18% of total needs.

The two above feasibilities studies, as energy saving solution but also as renewable energy solutions too, have identified that investments will be profitable with low payback period, low risk and will achieve high energy savings, decrease the operational cost and finally decrease the CO2 emissions. All this will give an advantage to the company related with competitiveness.

In addition there is the possibility of LED light bulbs replacement for the UV system – factory equipment, in the future which will save lot of energy. A draft estimation using UV lamps' manuals and technical specs shown that proceeding with this move, company will save round to 100000KWh per year, so combined with other 2 solutions factory's operation will minimize CO2 emissions a lot. This type of UV LED technology uses 38% of current energy needs.

Main results of the purposes of the study for reducing energy consumption and therefore reducing carbon footprint of the company are presented in the below table number 17.

	Proposal 1	Proposal 2
	5 pcs A/C split units replacement	Photovoltaic system 160KWp installation
Annual Energy Savings (KWh)	3600	221361
Annual Energy Cost Savings (Euro)	792	48699
Investment Cost (Euro)	3000	160000
Solution Lifetime (Years)	10	25
Payback Period (Years)	5.1	4.7
Innternal Rate of Return (%)	20.18	27.16
Net Present Value	4200	862071
Annual CO2 emissions reduction (tonnes)	2.5	156

Table 17: Main results for studying 2 proposals about energy savings for the case of printing factory.

Chapter 6: Conclusions

Based on the Green Deal framework each one of us has to do what is necessary to achieve set goals. Whatever is the sector of activities, residential, industrial, transportation everyone must get involved in order to achieve the reduction of CO_2 emissions and protect the environment.

We can start with simple things by following easy tips for reducing energy consumption up to big investments but with low financial risks and short payback periods. For economic healthy organizations, the transition to the new era of energy management is a must and there are a lot of tools that helping to fulfill related objectives. Decision makers are thinking seriously carbon footprint coming from their activities because it has direct impact to the society and affect their strategy programming a lot.

By proceeding with energy upgrades and finding alternative solutions for carry over their scopes, companies can reduce their operational cost having this way the opportunity to become more competitive against others. This is an added value because they can promote also their services that are environment friendly and are not coming from pollutant activities.

The same can be followed in all sectors of services even from all of us at residential level. By saving energy, people can increase their incomings per month by reducing energy buying cost especially nowadays where this kind of cost is much higher than ever. That will help local society for providing better quality of living without environment pollutions and following the same pathway from the whole of society we can contribute to catch the goals that our country committed to the European Union.

Literature Sources

Communication from the Commission, Wave of renovations for Europe - green buildings, jobs, a better life, COM (2020) 662 final

Dirk C. Jordan and Sarah R. Kurtz (2012) Photovoltaic Degradation Rates- An analytical Review.

D. Perdios Stamatis (2006), ‘Energy inspection of buildings and industries’, Athens.

Th. Malliaros Christos(2000), ‘Environmental pollution anti-pollution techniques’, Athens.
European Commission, Commission Communication,(2019), ‘The European Green Agreement’ , 640 final

https://www.europarl.europa.eu/news/el/headlines/priorities/kukliki-oikonomia-kai-meiosi-apovliton/introduction

European Commission, Employment and Social Developments in Europe, Annual Review 2019. (https://ec.europa.eu/social/main.jsp?catId=738&langId=en&pubId=8342&furtherPubs=yes)

Eurostat, 2019, File: Final energy consumption, by sector, EU-28, 1990 and 2017. (https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Final_energy_consumption,_by_sector,_EU-28,_1990_and_2017_(%25).png&oldid=448078)

Georgilakis S.Pavlos ,(2006), ‘Electric Economy’, University Traditions, (Chania).

Gregory J. Leng, Alexandre Monarque, (June 2004) ‘*RETScreen International: Results and Impacts 1996-2012’*, CANMET Energy Technology Centre, no.M39-106.

Papagiannakis Lefteris,(2004), ‘Simulation of Investment and Business Decisions’, Small Economic Dictionary. National Technical University of Athens.

Latridis Minas, Karamani Fotini (2015), ‘Energy Efficiency Trends and Policies in Greece’.

Mbarbarigou Mirto, (2011), ‘Economic study of wind park in western Crete using Wasp and Retscreen software’, (Chania)

Natural Resources Canada - Retscreen International Training Material.
(https://retscreen.software.informer.com/4.0/)
United Nations, ‘Transforming our world: the 2030 Agenda for Sustainable Development”.

Zopounidis Konstantinos, (2003), ‘Basic Principles and Modern Issues of Financial Management’, Klidarithmos Publications(Athens).

Directive 2012/27 / EU on energy efficiency. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32012L0027&from=EN

LINKS :
www.gsesinternational.com/blog/introduction-to-pvsyst-the-best-solar-design-software-for-2021/
https://unfccc.int/
https://meci.gov.cy/assets/modules/wnp/articles/202101/103/docs/necpgr.pdf
https://ec.europa.eu/energy/sites/default/files/documents/cy_2020_ltrs.pdf
www.eac.com.cy
www.energeiakes-lyseis.gr
http://www.cres.gr/
www.ecologic-al.gr
https://ktirioservice.gr
https://energycert.gr
https://www.oleng.eu
www.petrolinasolar.com.cy
https://www.pv-magazine.com/features/archive/solar-incentives-and-fits/feed-in-tariffs-in-europe/#cyprus
www.rae.gr
https://en.wikipedia.org/