Med-EcoSuRe

Energy Efficiency Development Pilot initiatives

# Energy Audit Report

**FOR**

**Faculty of educational science and teachers' training building,**
**Faculty of humanity and economics building& Library building**
**Faculty of Agriculture and Veterinary Medicine**

**Prepared by:**
**An-Najah national university (ANNU)**

2023

| | |
|---|---|
| **Project Acronym** | University building |
| **Project Name** | “Mediterranean University as Catalyst for Eco-Sustainable Renovation” (Med-EcoSuRe) |
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This project is part of the Mediterranean University as Catalyst for Eco-Sustainable Renovation (Med-EcoSuRe). The project aims to implement full scale experimentation of innovative retrofit technologies, validation and testing in real lifein An-Najah university campuses, in order to allow a relevant energy demand reduction and mitigate greenhouse gas emission.

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# 1. Introduction

Low energy educational buildings are becoming the standard for new buildings in European and Mediterranean countries. Technical solutions are continuously developed by universities for eco-sustainable building renovation, but there is still a gap between designed models and their actual application. This is due to several barriers, such as the insufficient collaboration between key actors and the lack of efficient suitable tools from the public sector to develop solutions.

Under framework of the Mediterranean University as Catalyst for Eco-Sustainable Renovation (Med-EcoSuRe), the partnership universities of project havetaken action that aims to find Technical solutions for eco-sustainable building renovation. The Med-EcoSuRe project offers an innovative approach to the definition and diffusion of cost-effective energy renovation within university buildings, with the perspective of extending results to the whole public buildings sector in the long term. A Mediterranean cross-border living lab - bringing together researchers, building managers, companies, public organisations and students - will be established to develop energy efficiency and renewable energy solutions as well as retrofitting schemes to be implemented in 9 university buildings. The final aim behind the project is to turn university managers into active players contributing to the co-creation and experimentation of emerging ideas, breakthrough scenarios and innovative concepts, where the Low energy educational buildings are becoming the standard for new buildings in European and Mediterranean countries.

The project aims to achieve the following: -

- ❖ Environmental protection, climate change adaptation and mitigation
- ❖ Improving energy efficiency in university building and installing On-grid PV solar system.
- ❖ Reduce the energy demand from local public electrical network, which reduce electricity bills and contribute in educational process positively.
- ❖ A sustainable, reliable, safety and cost-effective electrical energy supply

- ❖ PV power Plant is tested, evaluated and monitored using monitoring, sensor and data logging system which monitored remotely and at site for public demonstration & display

At the same pace, ANNU aims through its facilities and activities to achieve environmental sustainability as follow: -

- ➢ Promote and create a campus which supports academic, research and enterprise activities in a sustainable way
- ➢ Provide the education, advancement, dissemination and application of sustainable development
- ➢ Maximize the wider impact of ANU's environmental sustainability activities at local, regional, national and international level through collaboration, partnership and communications
- ➢ become a leader across the HE sector in terms of environmental sustainability

Accordingly, ANNU through Med-EcoSuRe project had conducted a comprehensive energy audit of all university buildings in order to determine the measures to improve the energy efficiency of university and achieve cost reduction.

The energy efficiency can be improved by three different approaches as follow:

1. Energy saving by management
2. Energy saving by Highly efficient technology
3. Energy saving by policies / regulations

Thus, using energy renovation strategy will ensure applying Energy conservation measures a real improvement in energy usage, decreasing GHG emissions and as a result which reflect on environment, create a comfortable and healthy atmosphere on campuses.

## 2. An-Najah National University Campuses/site description

An-Najah National University is located in Nablus and consists of four educational campuses; namely, the New Campus, the Old Campus, HishamHijjawi College of Technology, and Khadouri Campus in Tulkarem, in addition to An-Najah National Hospital.

There are two main sources of energy used in buildings; The source of power in all buildings is electricity from grid and in time of shortage is backup generator to cover some important load of each building in campuses.

### 2.1. Old Campus

The Old Campus was constructed on a 30 dunums of land and houses the Faculties of Humanities, Economics and Social Studies, Islamic Law, Educational Sciences and Honor. The Campus also hosts the Scientific and Languages Centers, the Administration, the Admission and Student Activities Buildings, a library and the Zafer Al-Masri Auditorium, in addition to the General Medicine and Dental Clinics.

### 2.2. New Campus

In 2000, the University began the construction of the New Campus which located at Nablus on around 116 acres and houses the Faculties of Graduate Studies, Medicine, Science, Law, Fine Arts, Engineering and Information Technology, Optometry, Pharmacy, Nursing, Media and Physical Education.

The New Campus is also home to the Prince Turki Bin Abdul Aziz Theatre, the Hikmat Al-Masri Amphitheater, the Korean-Palestinian IT Institute of Excellence as well as a number of other facilities and laboratories. The New Campus features a state-of-the art library, a cutting-edge media center, a new swimming pool, a sports complex and a mosque.

### 2.3. Hijjawi Campus

HishamHijjawi College of Technology, located east of Nablus, is a three floor facility with a total area of 18 acres. The college was constructed according to the most advanced engineering standards.

Hijjawi College offers a wide range of programs relating to technology to its students, including industrial automation, telecommunications, computer networking, auto mechanics, mechanical engineering, graphic design and others

### 2.4. Khadouri Campus

In 1996, the Faculty of Agriculture was moved to the Khadouri Campus in Tulkarem, northwest of Nablus. The Faculty's new site is one of the most beautiful landscapes in Palestine, as it is located only 14 km from the Mediterranean Sea. The campus' area is about 164 dunums and it houses a cow shed, chicken coops and land for cultivation. It hosts the Faculties of Agricultural Engineering and Veterinary Medicine, which are the only faculties of their kind in Palestine.

# 3. Energy Audit methodology

Energy audit is process that facilities energy usage pattern, equipment efficiency, and overall building efficiency is determined in order to propose energy efficiency measures.

The implementation of these measures will reduce Consumption energy costs and also negative effects on environment.

The energy audit steps as in following diagram:

(1) • Data collection/historical data

(2) • Data processing / load forecasting

(3) • Technology and measures proposed

(4) • Description of proposed technology and its advantage (energy consumption reduction , CO2 emission)

(5) • Economic analysis

# 4. Data collection&Historical data analysis

## 4.1. Historical data

A study of historical energy consumption in buildings is necessary to better understand long-term changes aimed at improving comfort and increasing energy efficiency In other words, study such result in a set of practices, called "codes of good practice".

The comfort of the indoor in building is achieved on one hand by fulfilling certain measures which is inherently economical and also increased energy efficiency.

So, the electrical consumption of university according to electricity bills was shown in figure (1) below.

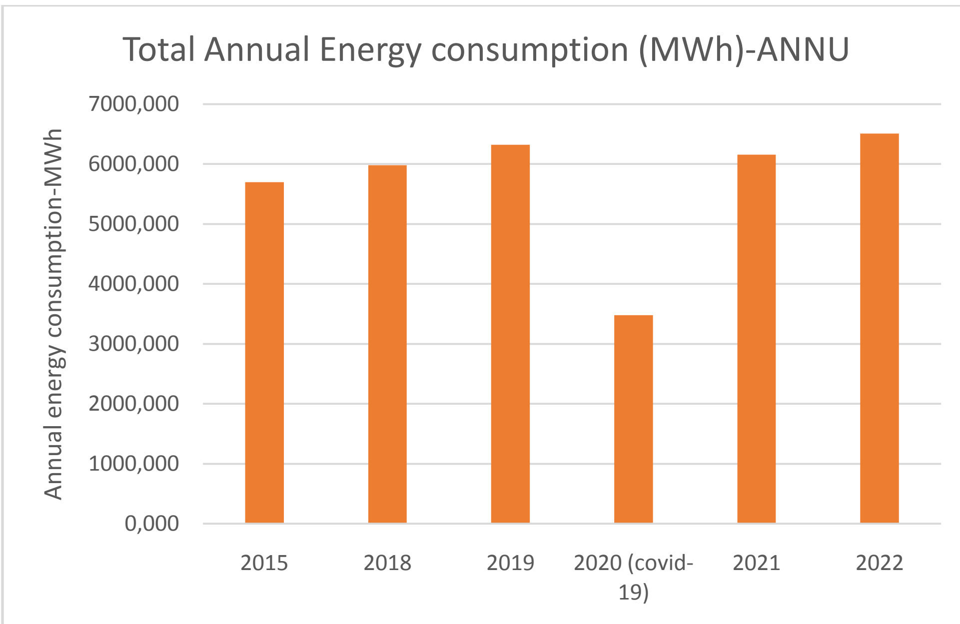


Fig. 1: electricity consumption in ANNU buildings for recent 5 years

The data shows that the loads in last two years has been increased, which it expected to increase in next five years as a result of the university's development plans in modernizing the university laboratories and keeping pace with technological development continuously.

It is worth noting that the consumption in 2020 decreased significantly by 39-44% due to covid-19 situation, as the university was not operating at its full capacity of staff and students, and this is abnormal situation and it did not give an indication of the university's actual consumption.

Accordingly, the electricity bill of university cost about one million Euros per year.

## 4.2. Electricity Usage:

The university`s campuses electricity consumption was studied individually, as shown in table-1.

Table-1: Electrical consumption for each campus of university

| month | new campus KWh/month | Old campus KWh/month | Hijjawi campus KWh/month | Agriculture campus KWh/month |
|---|---|---|---|---|
| January | 266063.08 | 130253.85 | 27687.69 | 17904.42 |
| February | 228178.46 | 111575.38 | 38998.46 | 15226.42 |
| March | 370825.38 | 123618.46 | 34360.00 | 17346.11 |
| April | 229098.46 | 117766.15 | 37275.38 | 19869.47 |
| May | 267305.38 | 110220.00 | 28535.38 | 12740.00 |
| June | 323958.46 | 126896.92 | 28933.85 | 23031.89 |
| July | 343721.54 | 161855.38 | 41990.77 | 17136.74 |
| August | 311710.77 | 117698.46 | 32192.31 | 26358.53 |
| September | 426626.15 | 170761.54 | 46686.15 | 12594.95 |
| October | 291180.00 | 129244.62 | 39567.69 | 20072.00 |
| November | 248404.62 | 131100.00 | 36916.92 | 20371.68 |
| December | 226772.31 | 97410.77 | 29669.23 | 16456.63 |
| annual consumption (KWh) | 3533844.62 | 1528401.54 | 422813.85 | 219108.84 |
| **MWH** | 3533.84 | 1528.40 | 422.81 | 219.11 |

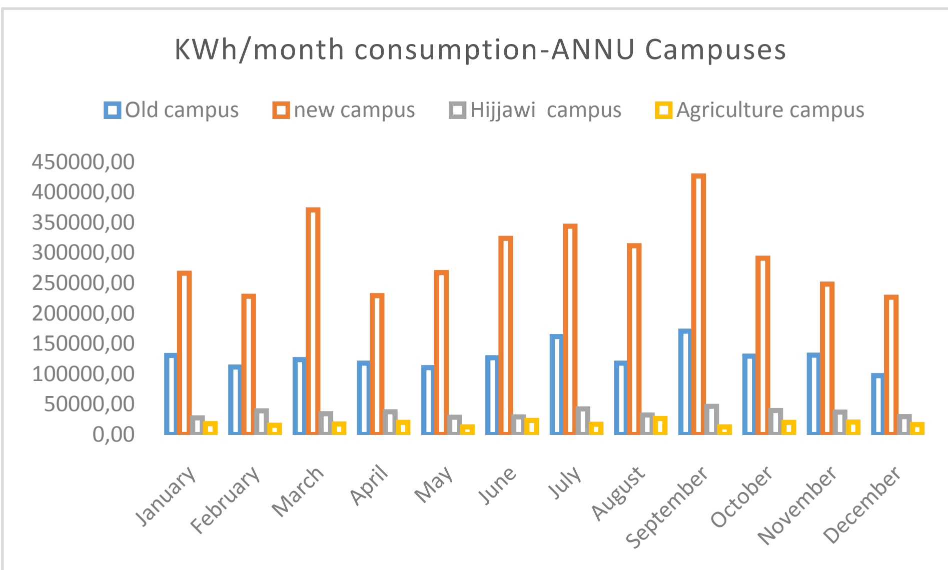


Fig.2 monthly energy consumption in ANNU campuses

The table (1) show variation in electricity consumption in range (219 MWh/year – 3.5 GWh/year) as a result of different loads in each campus, which requires a study of building loads individually, considering each building as a case study.

### 4.3. Other energy Usage:

The university is consuming diesel for back-up generator which used in case of electricity shortage and operating boilers, reach annually 111,532.5 Euros.

Also, there is another energy source in university which is gas, which used in some modern building for space heating reason, and the annual gas expenditure are reached to be 986 Euros annually.

### 4.4. Energy flow inspection:

In this step, we inspect and analyze the energy use and consumption of each building in university to identify the energy flows, potential opportunities for improving energy performance.

Table-2: old campus buildings stock energy data

| **Old campus** | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| | Offices and administration building | Deanship of Student Affairs Building | old campus library Building | Zafer Al-Masri Amphitheatre's Building |
| Construction date | 1987 | 1996 | 1998 | 1998 |
| Floor | under 2, above 3 | under 1, above 3 | under 1, above 4 | under 1, above 1 |
| Total floor area (m2) | 718 | 1091 | 1126 | 1372 |
| Gross floor area (m2) | 3590 | 4364 | 5630 | 2744 |
| Heated floor area (m2) | 200 | null | null | null |
| Building performance (u-value) | External wall 4-layers with total overall U-value of 2.0 W/m2K, the roof is a concrete slab with a total overall U-value 2.1 W/m2K, the windows are double glazing with a total overall U-value of 3.4 W/m2K | | | |
| Energy consumption kWh/m2/year | 205.08 | 146.95 | 117.16 | 178.52 |

| Old campus | 5 | 6 | 7 |
|---|---|---|---|
| | Faculty of Humanities & Faculty of Economics | Faculty of Educational Sciences | Faculty of Islamic Law Building |
| Construction date | 1980 | 1977 | 1999 |
| Floor | under 0, above 4 | under 1, above 3 | under 0, above 5 |
| Total floor area (m2) | 2968.6 | 1719.4 | 687 |
| Gross floor area (m2) | 11874 | 6878 | 3435 |

| | | | |
|---|---|---|---|
| Heated floor area (m2) | null | null | null |
| Building performance (u-value) | External wall 4-layers with total overall U-value of 2.2 W/m2K, the roof is a concrete slab with a total overall U-value 2.3 W/m2K, the windows are double glazing with a total overall U-value of 5.1 W/m2K | | External wall 4-layers with total overall U-value of 2 W/m2K, the roof is a concrete slab with a total overall U-value 2.1 W/m2K, the windows are double glazing with a total overall U-value of 3.2 W/m2K |
| Energy consumption kWh/m2/year | 44.74 | 64.14 | 157.82 |

Table-3: new campus buildings stock energy data

| New campus | 1<br>Faculty of Engineering and IT Building | 2<br>Faculty of Science Building | 3<br>medicine faculty Building | 4<br>Faculty of Fine Arts Building |
|---|---|---|---|---|
| Construction date | 2005 | 2005 | 2005 | 2003 |
| Floor | under 1, above 4 | under 2, above 4 | under 2, above 3 | under 1, above 3 |
| Total floor area (m2) | 15975 | 18400 | 6000 | 8000 |
| Gross floor area (m2) | 78975 | 110400 | 30000 | 32000 |
| Heated floor area (m2) | 11846 | 11592 | 2880 | 3760 |
| Building performance (u-value) | External wall 4-layers with total overall U-value of 1.8W/m2K, the roof is a concrete slab with a total overall U-value 1.9 W/m2K, the windows are double glazing with a total overall U-value of 3.1 W/m2K | | | |
| Energy consumption kWh/m2/year | 32.15 | 41.64 | 40.33 | 64.78 |

| New campus | 5<br>Faculty of sport Building | 6<br>new campus library Building | 7<br>Korean Palestinian IT Institute of excellence Building | 8<br>Faculty of Law Building |
|---|---|---|---|---|
| Construction date | 2008 | 2010 | 2005 | 2006 |
| Floor | under 1, above 2 | under 2, above 2 | under 2, above 1 | under 1, above 7 |
| Total floor area (m2) | 7600 | 7400 | 3667 | 5709 |
| Gross floor area (m2) | 22800 | 29600 | 11001 | 45672 |
| Heated floor area (m2) | 14865 | 27600 | 2891 | 11418 |
| Building performance (u-value) | External wall 4-layers with total overall U-value of 1.5W/m2K, the roof is a concrete slab with a total overall U-value 1.3 W/m2K, the windows are double glazing | | External wall 4-layers with total overall U-value of 1.8W/m2K, the roof is a concrete slab with a total overall U-value 1.9 W/m2K, the windows are double glazing with a total | |

| | | | | |
|---|---|---|---|---|
| | with a total overall U-value of 2.5 W/m2K | | overall U-value of 3.1 W/m2K | |
| Energy consumption kWh/m2/year | 67.49 | 38.23 | 79.78 | 49.06 |

| New campus | 9<br>Scientific centre Building | 10<br>An-Najah Child institute Building | 11<br>Faculty of Optical & nursing college Buildings |
|---|---|---|---|
| Construction date | 2017 | 2015 | 2005 |
| Floor | under 1, above 6 | under 1, above 4 | under 2, above 4 |
| Total floor area (m2) | 6000 | 2500 | 7720 |
| Gross floor area (m2) | 36000 | 12500 | 46320 |
| Heated floor area (m2) | 23760 | 10000 | 3598 |
| Building performance (u-value) | External wall 4-layers with total overall U-value of 0.55W/m2K, the roof is a concrete slab with a total overall U-value 0.67 W/m2K, the windows are double glazing with a total overall U-value of 1.27 W/m2K | | External wall 4-layers with total overall U-value of 1.8W/m2K, the roof is a concrete slab with a total overall U-value 1.9 W/m2K, the windows are double glazing with a total overall U-value of 3.1 W/m2K |
| Energy consumption kWh/m2/year | 50.81 | 29.27 | 31.68 |

Table-4: HishamHijjawi College&Tulkarem campus buildings stock energy data

| | HishamHijjawi campus<br>Vocational college | Tulkarem campus<br>Faculty of Agriculture and Veterinary Medicine |
|---|---|---|
| Construction date | 2001 | 1978 |
| Floor | under 1, above 2 | under 0, above 2 |
| Total floor area (m2) | 12500 | 4560 |
| Gross floor area (m2) | 37500 | 9120 |
| Heated floor area (m2) | 8613 | null |
| Building performance (u-value) | External wall 4-layers with total overall U-value of 1.8W/m2K, the roof is a concrete slab with a total overall U-value 1.9 W/m2K, the windows are double glazing with a total overall U-value of 3.1 W/m2K | External wall 4-layers with total overall U-value of 2.5W/m2K, the roof is a concrete slab with a total overall U-value 3.1 W/m2K, • the windows are single 6 mm glazing with a total overall U-value of 5.1 W/m2K and not shaded |
| Energy consumption kWh/m2/year | 37.29 | 80.91 |

Also, the energy use pattern in buildings stock was distributed as shown in figure (3).

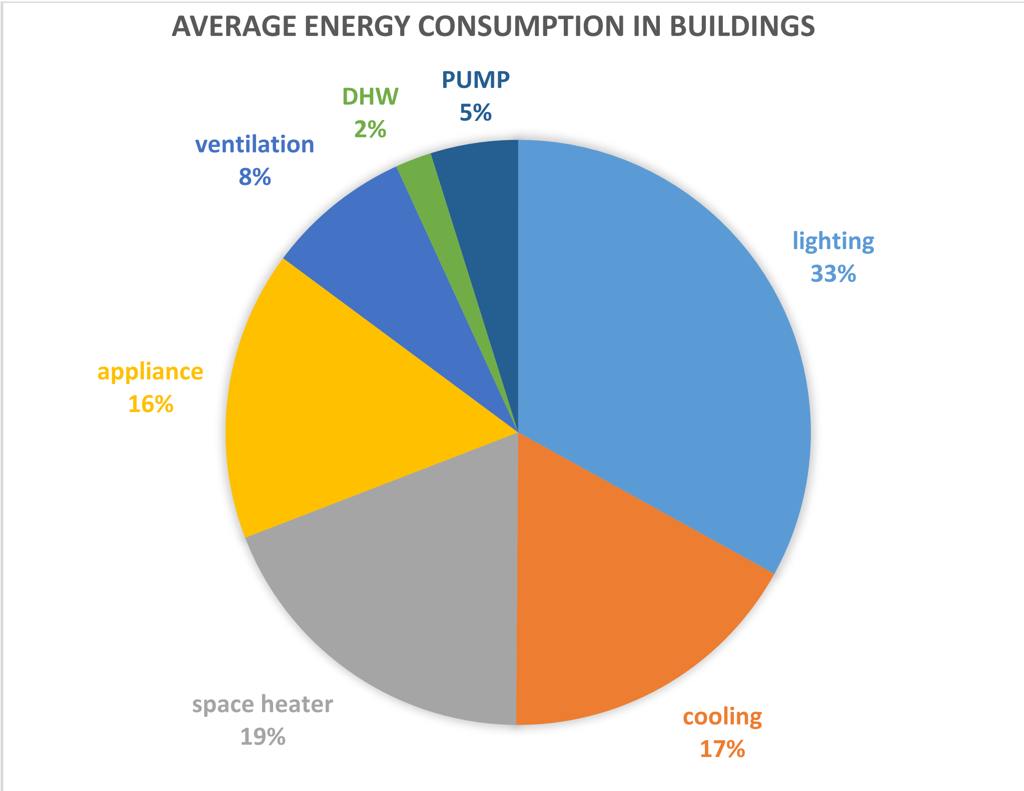


Fig.3Energy Consumption pattern in ANNU campuses

## 5. Data Processing &Load Forecasting

Better knowledge of present patterns of energy use in the buildings stock, in addition Knowledge of the university's development plans in modernizing the university laboratories and keeping pace with technological development will contribute to obtaining a more accurate future model in terms of energy consumption.

The total electricity demand in university will increase by the next 5 years as a result and that shown in the figures below; the expected forecasting energy consumption for period 2022-2027 in each campus of An-Najah University

The modelling results show that by 2027 the electrical peak demand could reach 3.7 MW (assuming an annual demand increase of about 1.3%, which mean the electrical consumption in university will increase by 6.8% by the end of 2027).

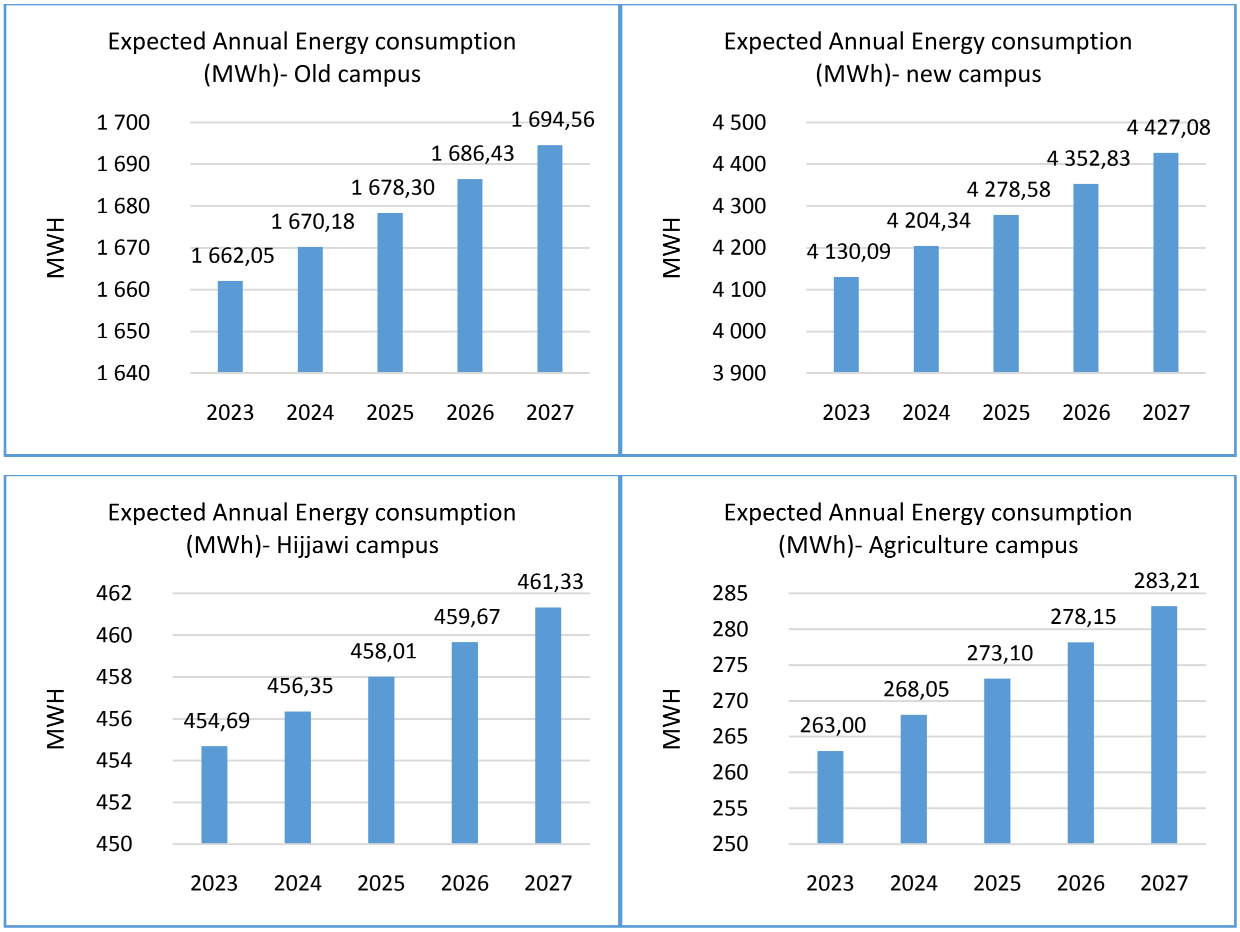


Fig.4Expected Annual Energy consumption (MWh)- ANNU Campuses

# 6. EE Improvement recommendation:

According to observation that carried out throughout the campuses buildings, the recommendations were as follow:

- Periodic maintenance and rehabilitation of buildings
- Improve energy efficiency of existing building and o Use efficient appliances (replacing the FL lamp by using high efficient elements and LED lamps in some old buildings)
- Promote smart technologies (12 of 18 buildings needs individual smart meters)
- Energy management system to control
- Installing PV solar system to achieve zero electrical bills
- Replacement of Boiler diesel with gas fuel

Also, it was found during walk through stage in buildings that many electronic and electrical appliances are consuming power whilethey are switched off or in standby mode (consuming electricity at a cost but not doing anywork), which called vampire loads, as follow:

- Electronics appliances (computer, printer, etc.) are still ON even though they areturned off.
- Appliances on STANBY MODE are draining power even though they are notdoing any use full task.
- Faulty fittings which are left without bulb (outdoor/ passage unit) are also vampire loads.

So, the recommendations in this case as follow:

- All Electronic appliances should always be ‘unplugged’ or turned from the power sockets, after office hours.
- avoid putting appliances on ‘STANBY MODE’.
- Remove faulty lightings, and Make maintenance to lighting units where cleaning the lamps and reflectors
- Use the natural light as possible.

## 7. Methodology work Description

The building considers a crucial pillar of energy efficiency policy and applying EE and RE measures, so An-Najah University seek to achieve Net Zero Energy building by 2027.

So, in order to complete the work and achieve the goals successfully, we will take the following steps to verify of validation of implemented measures:

- Conducted measurements and verifications on energy conservation measures had implemented in each building, by using available special instruments such as: power analyser, lux meter, pressure and temperature gauges if needed

Energy Analyzer Light MeterThermometer   Digital Multimeter

Fig.5Measurements and Verifications devices

- conduct measurements of energy consumption after the proposed measure have been implemented and compare the results with measured data before it was installed.
- Identified and prioritized the measures intended to be implemented according to the largest saving potential for energy efficiency improvement and cost reduction.

The following the planned measures which will executed in university,

| | Measures | schedule | Project through Med-EcoSuRe project |
|---|---|---|---|
| 1 | Installation of Solar system (KWp) | 2019-2026 | 278 KWp |
| 2 | Replacing Boiler diesel with gas | 2023-2026 | |
| 3 | Completing the energy audit in all university buildings | 2023 | ✓ |
| 4 | replace Outdoor/indoor low efficient lampswithhighly efficient and LED lamps | 2023-2024 | 400-units lamp |
| 5 | Installing smart meter for all building in campuses individually | 2024-2026 | |
| 6 | Install energy management system | 2024-2025 | |
| 7 | monitored and analyzed the energy consumption saving | 2027 | |

### 7.1. PV solar system

Implementation of RE system will lead to cost-effective renovation scale, which will cover the electrical loads needs of all ANNU facilities and achieve Zero energy from grid and thus will provide a financial source for the university after completing the payback period of the capital cost for installing solar systems.

According to historical consumption data, ANNU needs around 3.75 MW PV system to cover all university`s needs.

ANNU has installed the following:

- in 2016: PV system = 41 kWp on medicine faculty/new campus
- in 2018: PV system = 72.8 kWp on engineering faculty/new campus
- in 2020: PV system = 997 kWp NASSARIAH LAND of ANNU

- in 2022: PV system = 105 kWphijawi building

ANNU has installed the following pilots through MED-EcoSuRe project:

- in 2020: PV system = 145 kWp old campus
- in 2022: PV system = 50 kWp PV carport-new campus
- in 2022/2023: PV system = 77.8kWp agriculture faculty building
- in 2022/2023: off-grid solar tree-3.18 KWp

ANNU is installing/planning to implement the following:

- in 2023/2024: 50 KWp PV system, NASSARIAH LAND of ANNU (in process)
- in 2023-2026: 2 MWp PV system (for future)

This will reduce the total electricity consumption of university by 92-94% considering there is Increasing loads in buildings.

### 7.2. High efficient lamp

Taking some EE/RE measures may lead to cost-effective renovation due to economies of scale which can be achieved in carrying out energy-related renovation measures simultaneously with other necessary works or already-planned renovations.

Through Med-EcoSuRE project EE plan was carried out specially in old buildings and therefore the loads have been studied through energy auditing in order to put measures to raise energy efficiency and replacing the FL lamp by using high efficient lamps in some old buildings; as follow:

- old campus library Building
- Faculty of Humanities & Faculty of Economics and Social Studies Building
- Faculty of Educational Sciences and Teachers' Training Building
- Faculty of agriculture

Replacing the lamp of these four buildings with more efficient lamp is expected to save around 2106 Euro/year and reducing $CO_2$ emission by 9.9 ton/year.

### 7.3. Promote smart technologies

Using smart technology will optimize the working environment for the staff and students and get better and efficient energy use.

In University case, the technology aspects were as follow:

- smart meters: the university has a meter for each campus, and therefore in order to monitor energy demand for each building in same campus more accurately, the university has started to install a digital meter for each building to achieve this purpose, and thus 12 buildings need individual smart meters out of 18 buildings.

  The smart meters were installed in the following buildings:

  1- Meter -1 Scientific centers Building
  2- Meter -2 Faculty of Fine Arts Building
  3- Meter -3 medicine faculty Building
  4- Meter -4 Faculty of Science Building
  5- Meter -5 Faculty of sport Building
  6- Meter -6 engineering faculty

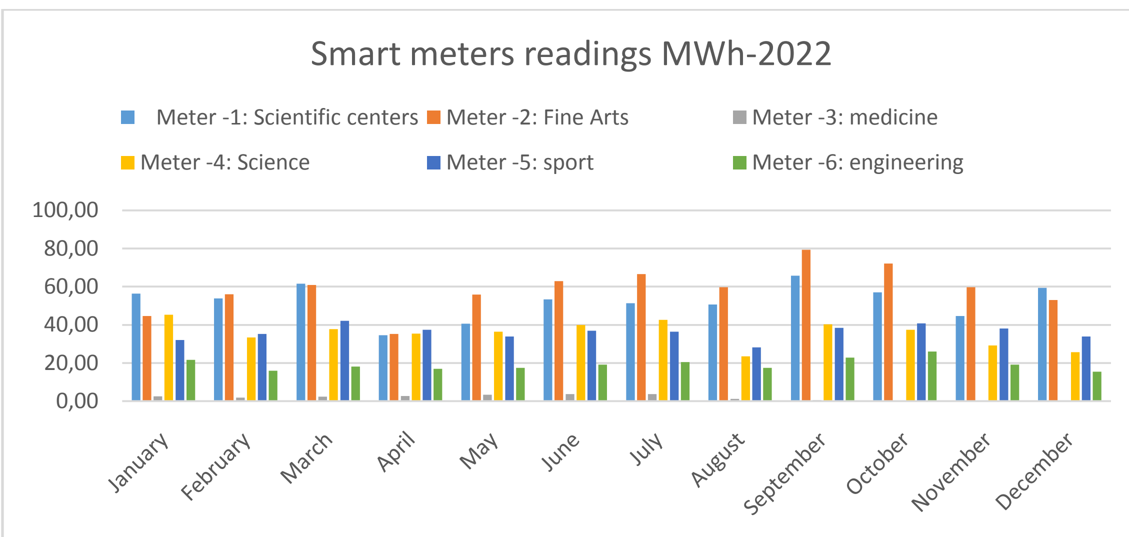


Fig.6 implemented Smart meter results

- Energy management system to control the operation of (Lighting, Heating, cooling) loads.

- Installation of Bidirectional and digital energy meter to monitor energy production of PV system, the PV system until 2023 cover around 40% of energy consumption yearly by installing 1.5 MW.

# 8. Techno-Economic and Environmental Impact Towards 2027

Implementing energy audit results and proposed measures will depends on their potential to achieve significant improvement in building efficiency and environment with reasonable capital cost to achieve expected results.

## 8.1. Technical impact

The expected results of proposed approach were shown in table below:

| | Planned measures | Estimation/expected impact | Timeline |
|---|---|---|---|
| **1** | 2000 KWp ground mounted PV system in Salem area<br>50 KWp in nassariah university land | Reduce electricity consumption by 94.32 % , Reduce energy need in total by 83% and increase of RES by 57% | 2023-2026 |
| **2** | Replace diesel boilers with gas boiler | Reduce energy need in total by 3.7% | 2023-2026 |
| **3** | Completing the energy audit in all university buildings | Reduce energy need in total by 1-3% | 2023-2024 |
| **4** | Replace Outdoor/indoor low efficient lamps with highly efficient and LED lamps | | |
| **5** | Installing smart meter for all building in campuses individually | Reduce losses by 4%, and that by Monitoring and periodic maintenance of building loads and devices and early detection of problems | 2024-2026 |
| **6** | Install energy management system to control lighting, heating and cooling (where applicable) | Reduce energy need in total by 8% | 2024-2025 |
| **7** | Conduct energy monitoring, analyzing and evaluating the energy consumption saving | bringing a more in-depth and accurate understanding of energy use and the efficiency opportunities that may exist | 2027 |

## 8.2. Financial impact:

The capital cost of proposed measured was calculated as table below:

| year | # | projects | budget (Euro) |
|---|---|---|---|
| 2023 | 1 | installation of 500kwp solar PV | 500,000 |
| | 2 | replacement of diesel boiler to gas boiler - for two buildings | 20,000 |
| | 3 | Completing the energy audit in all university buildings | 14,000 |
| | 4 | replace 50% Outdoor lamp to LED | 18,000 |
| | | **total (Euro)** | 552,000 |
| 2024 | 1 | installation of 500kwp solar PV | 500,000 |
| | 2 | replacement of diesel boiler to gas boiler - for three buildings | 22,000 |
| | 3 | replace 50% Outdoor lamp to LED | 18,000 |
| | 4 | Installing smart meter for two buildings | 1,000 |
| | 5 | Install energy management system -HVAC for Five buildings | 10,000 |
| | | **total (Euro)** | 551,000 |
| 2025 | 1 | installation of 500kwp solar PV | 500,000 |
| | 2 | replacement of diesel boiler to gas boiler - for five buildings | 24,000 |
| | 3 | Installing smart meter for four buildings | 2,000 |
| | 4 | Install energy management system -HVAC for six buildings | 12,000 |
| | | **total (Euro)** | 538,000 |
| 2026 | 1 | installation of 500kwp solar PV | 500,000 |
| | 2 | replacement of diesel boiler to gas boiler - for three buildings | 19,000 |
| | 3 | Installing smart meter for six buildings | 3,000 |
| | | **total (Euro)** | 522,000 |
| 2027 | 1 | monitored and analyzed the energy consumption saving | 12,000 |
| | | overall budget= | **2,175,000** |

Accordingly, the saving in energy purchasing bill will be around = 815,624 Euro/year

So, simple payback period will be 3 years

And also, the reduction in $CO_2$ emission will be around = 3800 ton annually

# 9. Conclusions &Recommendation

- The role of energy efficiency should be enhanced and accommodated in Palestine especially in higher educational Institutions were reducing the operating cost through minimizing the energy bill is of great deal;
- The energy efficiency measures which proposed in university are considered as the most appropriate and potential for implementation and replication in other institute and public buildings around Palestine
- Measurements and verifications will be performed for all measures after implementation and its expected according to saving energy by 2027, and the average simple payback period is ( 3-4 years)for the project including non-technical measures and labour cost.
- We recommend the administration of university to take into account this energy audit with its details because it's saving money; as reducing the bill, reducing the fuel; and reducing the $CO_2$ emissions.
- Increase awareness between employees of the university for the importance of energy conservation.

Rolling out the energy efficiency project into university strategy as part of the infrastructure projects is an absolute recommendation, Furthermore, its recommended to support awareness campaign to introduce the staff and students to energy efficiency and other energy resources and to introduce the role of energy saving in minimizing operational cost in university, mainly the attitude, and operation habits

** for more in-depth details, see the following annexes:

- Annex-1: Energy Audit in old Campus (educational &literature buildings) report
- Annex-2:Energy Audit in agriculture Campus report
- Annex-3: Energy Audit in library building report

# Energy Audit For Old Campus (old library)- An Najah National University

**PREPARED BY:**

**ENERGY RESEARCH CENTER**

2020

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# 1. Executive Summary

This report presents analyzed of energy audit in Old Campus (Literature & educational building) - An Najah National University, The characteristics of energy consumption, methodology and expected result of energy efficiency (E.E.) improvements technically and financially are presented.

The energy efficiency can be improved by three different approaches as follow:

1) Energy saving by management

2) Energy saving by High efficient technology

3) Energy saving by policies / regulations

**Energy audit**- a process to evaluate where a building or plant uses energy, and identify opportunities to reduce consumption and delivers the following benefits to customers:

- Educates and creates awareness regarding energy usage and conservation opportunities.
- Provides customers with recommendations which will increase the comfort, health , safety and prolong the durability of the property .

The improvement of energy efficiency can provide effective way of achieving three simultaneous objectives:

- Reducing cost
- Improving productivity
- Minimizing the impact of industrial activity on the environment

This report highlights the opportunities to implement ECM in university by improving the power factor, reducing harmonics, avoid voltage drop, reducing cable losses and avoid equipment malfunction and illustrate the results of energy consumption , using R.E. technology and the daily load curves of the distribution boards.

# 2. Introduction

### 2.1. Energy Research Center (ERC)

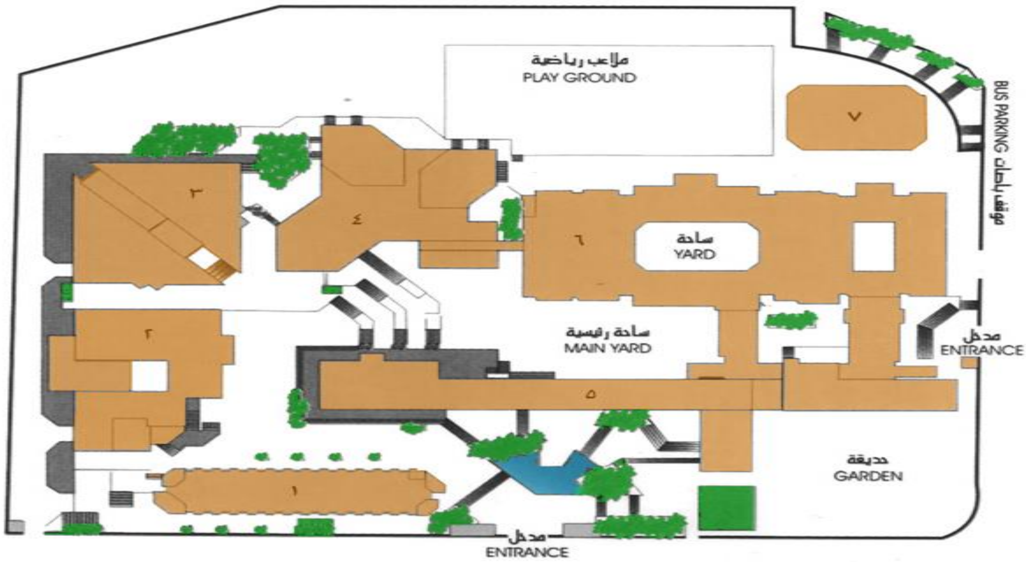
The Energy Research Center (ERC) is one of partners in the project which will provide entrepreneurs (or potential ones) in the solar, wind, grid integration sector with technical assistance and improve Research-Industry cooperation.

ERC was established in 1996 by a decision of the Board of Trustees of An-Najah National University (ANU). The ERC is concerned with research, development, system design, feasibility studies, training in all conventional and renewable energy fields, energy management and energy conservation.

## 2.2. University building

The Old Campus is located in western Nablus, houses the Faculties of Educational Sciences, Humanities, Economics and Social Sciences, and Islamic Studies. The Campus also includes a library, the Zafer Al-Masri Auditorium, and the Administration and Student Activities buildings, in addition to a number of research laboratories.

**Work days** : 5 days a week for 7.5 hours a day (8:00 AM to 3:30 PM)



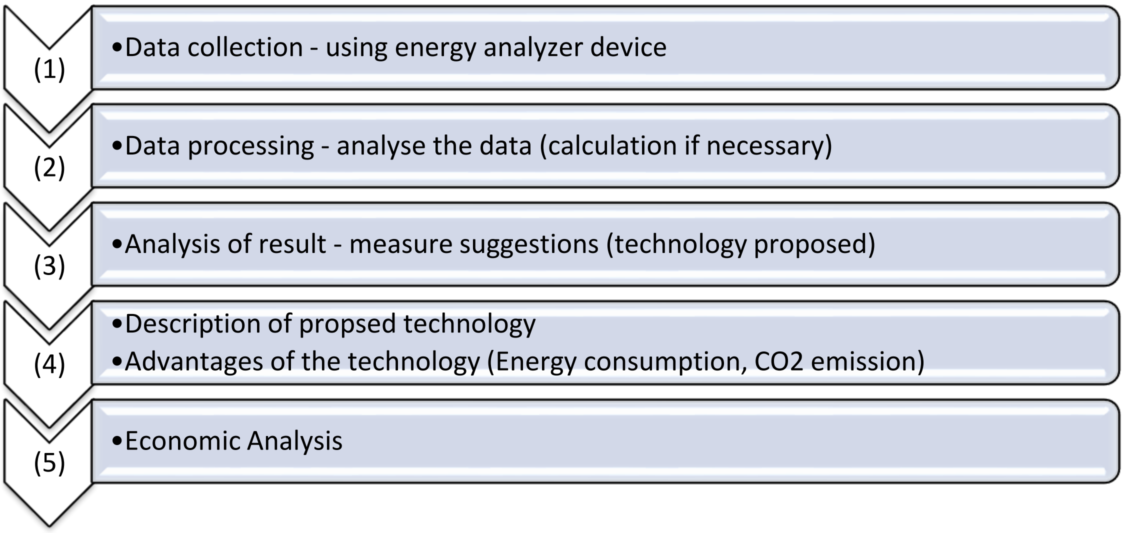

## 2.3. Motivation of study

The study aims to select a proper Energy measure (E.M) in order to reduce electricity demand and the environmental impact, which lead to improve energy efficiency and achieve security of supply and environmental protection.

# 3. Energy Audit methodology

Energy audit is process that facilities energy usage pattern, equipment efficiency, and overall building efficiency is determined in order to propose energy efficiency measures.

The energy audit steps as in following diagram:




## 3.1. Data collection

One of main step of energy audit is estimated production parameters using measuring method as energy analyzer device , which is used for measuring electrical parameters ( KWh, KVA, POWER FACTOR, Frequency, Harmonics) and record the real data for period of time, where there is no accurate data, the energy audit cannot be successfully accomplished.

The energy audit in the University planned to include all load systems (lighting systems, computers, printers, photocopiers, fans and other loads. The University takes the electricity mainly from Electricity Company, and there have a generator in order to produce electricity when the main source (Electricity Company) is off.

## 3.2. Data Analysis

The recorded data from energy analyzer were analyzed to define if there is a problem or not which may cause excess in energy usage and making the necessary calculations in order to identify the possibility of energy efficiency improvement as follow:

1- Energy audit of library building is conducted as follow:

| Parameters | | Average | Comment |
|---|---|---|---|
| Frequency | | 50.18 | (acceptable value) |
| Voltage | V1 | 239.1 | (acceptable value) |
| | V2 | 240.3 | |
| | V3 | 239.6 | |
| Current | I1 | 94.26 | |
| | I2 | 83.16 | |
| | I3 | 99.51 | |
| P (W) | | 52960 | (acceptable) |
| Q (VAR) | | 32730 | |
| S (VA) | | 60340 | |
| Power factor | | 0.897 | (acceptable) |

The data of Lighting, printer.. etc was collected (Annex-1)

## 3.3. Analysis of result

According to result and loads in building, which we collected from previous data, the daily energy consumption in building is 784.0317 KWh/day. (more information see annex-1).

According to electricity bills, the monthly consumption was shown in table below:

| Month | Electricity (KWh) |
|---|---|
| January | 14699.94 |
| February | 11740.60 |
| March | 14642.32 |
| April | 15433.58 |
| May | 16990.58 |
| June | 17066.01 |
| July | 15666.53 |
| August | 14754.01 |
| September | 16528.72 |
| October | 13049.66 |
| November | 13803.32 |
| December | 11094.96 |
| Annual Total= | 175470.23 |

Accordingly, the electricity cost annually for building about 30,000 Euro.

### 3.4. Improvement recommendation

Based on the analyzed data: we recommended to install an alternative power source to reduce the costs of operation, produces little or no waste products such as carbon dioxide or other chemical pollutants, and so has minimal impact on the environment in addition to using high efficient devices.

## 4. Energy Analysis methodology

Based on the result of analyzed data from Energy analyzer, the following can be recommended as measures to conserve energy and make the system technically more efficient and financially sustainable:-

- In general, as operation and maintenance measures:
  - Turn off the lighting unit in the places that does not use.
  - Turn off the machine that is not necessary to use.
  - Make a periodic maintenance to the machines.
  - Switch off the lights after leaving the offices.
  - Use the natural light as possible as.
  - Concentrate working with heavy loads in low price time.
  - Unplug the electrical devices after ending working day.
  - Use efficient appliances.
  - Make maintenance to lighting units where cleaning the lamps and reflectors.
- Installing R.E. measures: solar PV system with capacity 90Kwp to reduce energy consumption, cost and the environmental impact but because there is no space on rooftop so it was thinking to install the system as umbrella in garage of university behind the building.

### 4.1. Design of On-grid PV solar system

#### I. Summary of characteristics of electric generation system

| | | |
|---|---|---|
| **Photovoltaic Generator** | **PV Capacity at STC (Wp)** | **≥100kWp** |
| | Type of module | Crystalline 60 cells / 72 cells |
| | Tilt | 30º (+5º, -10º) |
| | Orientation | 0 º S |
| | Standards | IEC 61215 edition 2, IEC 61730 |
| **Three phase Grid connected inverter** | Rated power | 50.000 W |
| | Number of MPP tracker | ≥ 1 |
| | Protection Class | ≥ IP20 |
| | Biggest voltage MPP range | 150 V - 800 V |
| | Maximum DC voltage | 1.000 V |
| | Output AC voltage | 3 / N / PE 230, 400 V (adjustable) |
| | Output AC frequency | 50 Hz (adjustable) |

| | | |
|---|---|---|
| | Phi cosine | 1 |
| | THD | ≤ 3% |
| | Consumption at night | ≤ 3 W |
| | Maximum efficiency | ≥ 97 % |
| | Euro-efficiency | ≥ 95 % |
| | Standards | Harmonic Current (IEC61000-3-2 and/or IEC61000-3-4), IEC62109-1/2 |
| | Anti -islanding protection | Yes / VDE 0126-1-1 or similar |
| | Communication | MODBUS, allowing reading and writing on the inverter |
| | Additional requirements | Phase balancing, Dynamic compensation of reactive power, inverter automatic reconnection conditions, output power control from a third device (read and write capabilities), utility-interactive photovoltaic inverter system. |
| | Number of MPP tracker | ≥ 1 |

# II. PV generator

## II.1 Orientation for optimum yield

To optimize the PV generator's production with respect to the estimated load it is necessary to fulfil the following requirements:

The tilt angle and azimuth of the modules has been established to optimize the production in relation to the needs. (in our design: the tilt angle = 30 . Azimuth = 0)

Shadowing of the PV modules from trees, buildings or any other obstacles should be minimized over the whole day and there shall be no shadows in a period of ± 4h w.r.t. solar noon.

## II.2 PV modules

PV modules must be crystalline silicon PV modules that comply with the norm IEC 61215 edition 2 and shall be qualified to and be classified by Class according to IEC 61730. I-V curve must be supplied.

The modules shall be made of a series-connection of 60 cells. Modules of 72 cells are acceptable, only if the final solution meets the specifications of minimum power requirements.

The design is based on a module capacity at STC of 395 Wp but it is technically possible to achieve the same characteristic of the PV generator with smaller or larger modules and a different layout.

The PV matrix is composed by 366 PV modules of 395 Wp, PV array is distributed by 3 sub arrays of 10/8 strings and each string is composed by 14/15 modules. The total capacity of PV generator is 144570 Wp.

The modules shall have a separate connection box on the rear part with protection class IP 65. The terminals must be clearly marked with + and – for the corresponding connections. The PV STRING BOXES are exposed to the environment, shall be readily available, shall be at least IP 54 and shall be UV resistant.

## III. Grid dependent Inverter

For grid-dependent operation, the inverter is grid-dependent and it controls the current into the grid to meet the requirements for interaction functionality. These standards include a voltage and frequency range and requirement for "anti-islanding" to ensure that the inverter disconnects from the utility grid if not within the specified conditions.

When the inverters are located in indoor environments the enclosure should be at least IP 20 or better. Inverters have to be installed according to their environmental protection rating and ambient temperature range.

The Grid-dependent inverter requirements should also include the following:

- Dynamic compensation of Reactive power
- Inverter automatic reconnection conditions
- Output power control from a third device (read and write capabilities)
- Utility-Interactive Photovoltaic inverter system

In our design we choose 3 inverter with capacity of 50kw

## IV. Interconnection to grid

### IV.1 PV Connection point

The grid-dependent inverters output will be connected on the main AC bus bar after their respective protection box and differential switch. The main AC bus bar is prepared to feed the loads and/or back-feed the surplus of PV production to the grid

### IV.2 AC meters

Three phase (grid, genset, grid-dependent inverters) power analyzer will monitor the energy flow of the PV Power Plant.

### IV.3 Voltage Surge protection

To protect against surge overvoltage from the utility side it is required to install an SPD (Surge Protective Device) as near as possible to the grid-dependent inverters output. It is not necessary to supply such SPD if already included in the equipment.

This equipment will leak the energy of the overvoltage to the ground. For this reason, it is essential that earth terminals be of a good quality and moreover, it is required that all of the earth terminals be properly connected so as to assure equi-potentiality.

The required SPD has to be able to discharge high currents caused by an induced overvoltage, for that reasons, it needs to be a type 2 according with IEC 61643 standard and also type 3 SPDs which are specially designed to protect the most sensitive equipments.

### V. Cables

The cables to be installed throughout the facility will be RZ1-K unipolar copper conductors with a rated voltage up to 0.6 / 1 kV. Their insulation with thermoplastic, low emission of corrosive gasses (XLPE) and their maximum admissible service temperature will be of 90 º C.

All cables will go inside a tube or inside a PVC tray.

The AC cables will be provided with the following colour code:

- Black for phase(s)
- Blue for neutral
- Bicolour Yellow / green for grounding

The DC cables will be provided with the following colour code:

- Black for positive polarity
- Red for negative polarity
- Bicolour Yellow / green for grounding

### VI. Grounding

The objective is to create an earth connection to which all relevant components of the new installation will be bonded and also to protect the new installations with differential switches.

The groundings will be done by:

E1: Connect to earth the PV-frame modules and all the metallic constructive elements of structure.

The grounding resistance must have a value between 2 and 5 Ohms.

## 5. Recommendation

- We recommend the administration of factory to take into account this energy audit with its details because it's saving money; as reducing the bill, reducing the fuel; and reducing the $CO_2$ emissions.
- Increase awareness between employees of the factory for the importance of energy conservation
- Install PV solar system with capacity of 90 KWp to reduce the electricity demand.

## 6. Appendix

**p-1 site:**

## Energy Audit Data collection form

**site data**

| Building Name | Address | Building square meter (m2) | age of building (years) | Date of last major renovation | purpose of building | Number of floors | Name of utility company |
|---|---|---|---|---|---|---|---|
| Library -Old Campus | old campus/ANU | 1148.96m2/floor =5744.8 m2 all building | 1998 | ------- | libraries' role as key partners in scientific research and knowledge exchange and excellence | 5 | NEDCO |

**Total Daily Hours of Operation**

| | | | | | |
|---|---|---|---|---|---|
| Sunday | 10 | Thursday | 10 | Months of Operation per Year? | 10 |
| Monday | 10 | Friday | 0 | Total Weekly Hours | 56 |
| Tuesday | 10 | Saturday | 6 | Total Annual Hours | 2240 |
| Wednesday | 10 | | | | |

please check all that apply:

- ☐ this building is leased
- ☑ this building is owned
- ☐ the organization recieves monthly bills based on accurate meter readings
- ☐ meters are read regularly by on-site staff
- ☐ bills are compared to monthly meter readings on a regular basis
- ☐ A building automation system or energy management control system is in place and used to track utility data regularly
- ☑ the building is sub-metered
- ☐ the building has automated 15-minute interval or SMART meters

| | |
|---|---|
| **If the building is leased:** when is the lease up for renewal (date/year)? | Null |
| How long does the lease contract last (years)? | Null |

**p-3 kwht:**

## Saving Energy in Commercial Buildings/Energy Audit Data collection form

### Annual Utility Consumption

| Building Name | Library Building-Old Campus | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Month | Electricity (KWh) | Electricity cost ($) | Electricity cost ($/KWh) | Natural Gas (MMBtu*/Thermal) | Natural Gas cost ($) | Natural Gas rate ($/MMBtu) | Water (Gallons) | Water Cost ($) |
| January | 14699.94 | 2498.99 | 0.17 | | | | | |
| February | 11740.60 | 1995.90 | 0.17 | | | | | |
| March | 14642.32 | 2489.19 | 0.17 | | | | | |
| April | 15433.58 | 2623.71 | 0.17 | | | | | |
| May | 16990.58 | 2888.40 | 0.17 | | | | | |
| June | 17066.01 | 2901.22 | 0.17 | | | | | |
| July | 15666.53 | 2663.31 | 0.17 | | | | | |
| August | 14754.01 | 2508.18 | 0.17 | | | | | |
| September | 16528.72 | 2809.88 | 0.17 | | | | | |
| October | 13049.66 | 2218.44 | 0.17 | | | | | |
| November | 13803.32 | 2346.57 | 0.17 | | | | | |
| December | 11094.96 | 1886.14 | 0.17 | | | | | |
| Annual Total= | 175470.23 | 29829.94 | 0.17 | 0 | 0 | 0 | 0 | 0 |

| electricity Usage (KWh) | Natural Gas Usage (KWh) | Total energy (KWh) | Energy Use Intensity (KWh/m2) |
|---|---|---|---|
| 175470.23 | | | |

**p-4 Lighting:**

| Saving Energy in Commercial Buildings/Energy Audit Data collection form | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Lighting-Building data | | | | | | | | |
| Floor Name or room number | location description (near window, internal office.etc) | lamp type | Ballast type | Wattage | total Number of lamps | Number of Hours light are left on each day | Total KWh/day | how are lights controlled? |
| basement | near window | FL. | Elect. Mag. | 36 | 114 | 7.5 | 30.78 | Switch |
| | near window | FL. | Elect. Mag. | 88 | 18 | 7.5 | 11.88 | Switch |
| | distributed | PL | | 15 | 4 | 7.5 | 0.45 | Switch |
| G-Floor | near window | FL. | Elect. Mag. | 18 | 536 | 7.5 | 72.36 | Switch |
| | near window | FL. | Elect. Mag. | 56 | 4 | 7.5 | 1.68 | Switch |
| | distributed | PL | | 26 | 2 | 7.5 | 0.39 | Switch |
| | distributed | PL | | 11 | 15 | 7.5 | 1.2375 | Switch |
| 1st-Floor | near window | FL. | Elect. Mag. | 18 | 540 | 7.5 | 72.9 | Switch |
| | near window | FL. | Elect. Mag. | 56 | 4 | 7.5 | 1.68 | Switch |
| 2nd-Floor | near window | FL. | Elect. Mag. | 18 | 556 | 7.5 | 75.06 | Switch |
| | near window | FL. | Elect. Mag. | 56 | 4 | 7.5 | 1.68 | Switch |
| 3rd-Floor | near window | FL. | Elect. Mag. | 18 | 532 | 7.5 | 71.82 | Switch |
| | near window | FL. | Elect. Mag. | 56 | 4 | 7.5 | 1.68 | Switch |
| | distributed | PL | | 18 | 2 | 7.5 | 0.27 | Switch |
| | distributed | PL | | 11 | 6 | 7.5 | 0.495 | Switch |
| | | | | | | | | |
| | | | | | | total KWH/sheet-1 | 344.3625 | |

**p-6 other:**

## Saving Energy in Commercial Buildings/Energy Audit Data collection form

### Plug loads-Building data

| Equipment type | Manufacturer | Model or size | Total Number | Wattage | Number of Hours usage per day | Total KWh/day | how is equipment controlled? | Notes |
|---|---|---|---|---|---|---|---|---|
| Fan | ----- | ----- | 7 | 92 | 5 | 3.22 | manual | |
| Computer | hp/dell | ----- | 51 | 180 | 7.5 | 68.85 | manual | |
| printer | ----- | ----- | 9 | 560 | 0.33 | 1.6632 | manual | |
| photocopier | ----- | ----- | 7 | 1100 | 0.33 | 2.541 | manual | |
| Projector | ----- | ----- | 1 | 880 | 1 | 0.88 | manual | |
| TV | ----- | ----- | 1 | 150 | 1 | 0.15 | manual | |
| other loads:water cooler | ----- | ----- | 1 | 1300 | 1 | 1.3 | manual | |
| other loads: Scanner | ----- | ----- | 1 | 65 | 1 | 0.065 | manual | |
| other loads: HEAD Lamps | ----- | ----- | 8 | 500 | 10 | 40 | manual | |
| other loads:cooling pumps | ----- | ----- | 6 | 44000 | 1 | 264 | manual | |
| other loads: water pumps | ----- | ----- | 3 | 4000 | 1 | 12 | manual | |
| other loads: air pumps | ----- | ----- | 9 | 5000 | 1 | 45 | manual | |

**Please specify where you feel there is room for improvement either in efficiency measures or renewable energy technology:**

install PV system on roof will reduce the grid consumption of building

please check all the information below is being provided to ERC/An-Najah university :

- ☐ copy of utility bill
- ☐ screenshots of EMCS or DDC control system
- ☐ copies of previous energy audits report-if applied
- ☐ copies of action plans or capital improvements plans
- ☐ copies of M & V plans
- ☐ copies of O & M cotract
- ☐ copies of nameplates from HVAC and chiller

| | Total KWh/day |
|---|---|
| Lighting-sheet? | 344.3625 |
| plug loads | 439.6692 |
| | **784.0317** |

In average E= 449 KWH as Energy analyzer data

# Energy Audit For Old Campus (Literature & educational building)- An Najah National University

**PREPARED BY:**

**ENERGY RESEARCH CENTER**

2020

# TABLE OF CONTENTS

# 1. Executive Summary

This report presents analyzed of energy audit in Old Campus (Literature & educational building) - An Najah National University, The characteristics of energy consumption, methodology and expected result of energy efficiency (E.E.) improvements technically and financially are presented.

The energy efficiency can be improved by three different approaches as follow:

1) Energy saving by management

2) Energy saving by High efficient technology

3) Energy saving by policies / regulations

**Energy audit**- a process to evaluate where a building or plant uses energy, and identify opportunities to reduce consumption and delivers the following benefits to customers:

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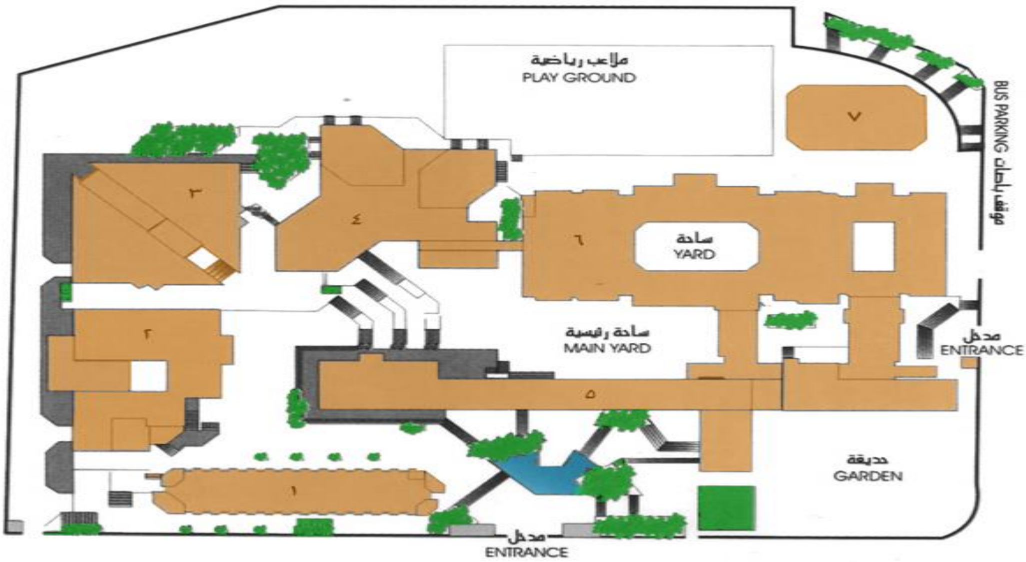



## 2.3. Motivation of study

The study aims to select a proper Energy measure (E.M) in order to reduce electricity demand and the environmental impact, which lead to improve energy efficiency and achieve security of supply and environmental protection.

# 3. Energy Audit methodology

Energy audit is process that facilities energy usage pattern, equipment efficiency, and overall building efficiency is determined in order to propose energy efficiency measures.

The energy audit steps as in following diagram:

(1) • Data collection - using energy analyzer device

(2) • Data processing - analyse the data (calculation if necessary)

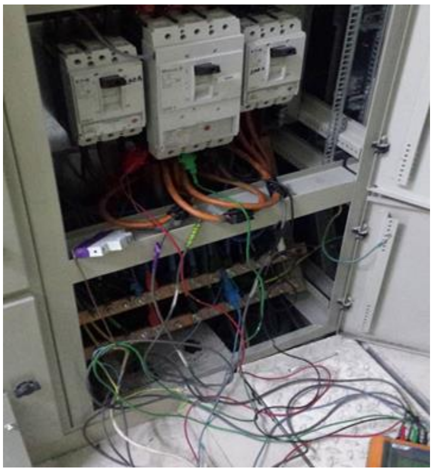
(3) • Analysis of result - measure suggestions (technology proposed)

(4) • Description of propsed technology
• Advantages of the technology (Energy consumption, $CO_2$ emission)

(5) • Economic Analysis

## 3.1. Data collection

One of main step of energy audit is estimated production parameters using measuring method as energy analyzer device , which is used for measuring electrical parameters ( KWh, KVA, POWER FACTOR, Frequency, Harmonics) and record the real data for period of time, where there is no accurate data, the energy audit cannot be successfully accomplished.




The energy audit in the University planned to include all load systems (lighting systems, computers, printers, photocopiers, fans and other loads. The University takes the electricity mainly from Electricity Company, and there have a generator in order to produce electricity when the main source (Electricity Company) is off.

### 3.2. Data Analysis

The recorded data from energy analyzer were analyzed to define if there is a problem or not which may cause excess in energy usage and making the necessary calculations in order to identify the possibility of energy efficiency improvement as follow:

1- Energy audit of Educational building is conducted as follow:

<table>
<tr><th colspan="2">Parameters</th><th>Average</th><th>Comment</th></tr>
<tr><td colspan="2">Frequency</td><td>50.04</td><td>(acceptable value)</td></tr>
<tr><td rowspan="3">Voltage</td><td>V1</td><td>232.4</td><td rowspan="3">(acceptable value)</td></tr>
<tr><td>V2</td><td>232.9</td></tr>
<tr><td>V3</td><td>232.37</td></tr>
<tr><td rowspan="3">Current</td><td>I1</td><td>18.74</td><td rowspan="3"></td></tr>
<tr><td>I2</td><td>22.76</td></tr>
<tr><td>I3</td><td>31.32</td></tr>
<tr><td colspan="2">P (W)</td><td>15000</td><td rowspan="3">(acceptable)</td></tr>
<tr><td colspan="2">Q (VAR)</td><td>5900.5</td></tr>
<tr><td colspan="2">S (VA)</td><td>16317.2</td></tr>
<tr><td colspan="2">Power factor</td><td>0.937</td><td>(acceptable)</td></tr>
</table>

The data of Lighting, printer..etc was collected (Annex-1) and total energy consumption per day was 301.8 KWh/day

2- Energy audit of Literature building is conducted as follow:

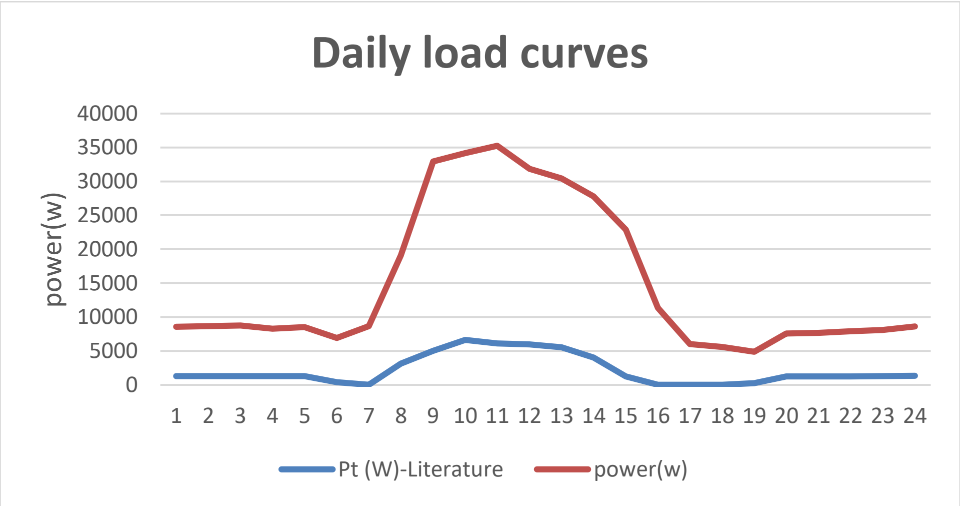
<table>
<tr><th colspan="2">Parameters</th><th>Average</th><th>Comment</th></tr>
<tr><td colspan="2">Frequency</td><td>50.1</td><td>(acceptable value)</td></tr>
<tr><td rowspan="3">Voltage</td><td>V1</td><td>225.4</td><td rowspan="3">(acceptable value)</td></tr>
<tr><td>V2</td><td>226.4</td></tr>
<tr><td>V3</td><td>224.8</td></tr>
<tr><td rowspan="3">Current</td><td>I1</td><td>14.1</td><td rowspan="3"></td></tr>
<tr><td>I2</td><td>19</td></tr>
<tr><td>I3</td><td>10.1</td></tr>
<tr><td colspan="2">P (W)</td><td>7485</td><td rowspan="3">(acceptable)</td></tr>
<tr><td colspan="2">Q (VAR)</td><td>5061</td></tr>
<tr><td colspan="2">S (VA)</td><td>8898</td></tr>
<tr><td colspan="2">Power factor</td><td>0.85</td><td>(acceptable)</td></tr>
</table>

The data of Lighting, printer..etc was collected (Annex-2) and total energy consumption per day was 499.71 KWh/day

### 3.3. Analysis of result

From previous data, we get the daily load curve to provide us with information of load in building during different running hours per day as follow:

| Time | Pt (W)-Literature | Pt (W)-educational |
|---|---|---|
| 1:00:00 AM | 1268 | 8532.333 |
| 2:00:00 AM | 1279 | 8634 |
| 3:00:00 AM | 1294 | 8721 |
| 4:00:00 AM | 1292 | 8268 |
| 5:00:00 AM | 1292 | 8525 |
| 6:00:00 AM | 373 | 6892 |
| 7:00:00 AM | 0 | 8639 |
| 8:00:00 AM | 3143 | 19081 |
| 9:00:00 AM | 5013 | 32926 |
| 10:00:00 AM | 6627 | 34158 |
| 11:00:00 AM | 6089 | 35261 |
| 12:00:00 PM | 5948 | 31834 |
| 1:00:00 PM | 5529 | 30443 |
| 2:00:00 PM | 4035 | 27788 |
| 3:00:00 PM | 1213 | 22858 |
| 4:00:00 PM | 0 | 11329 |
| 5:00:00 PM | 0 | 5988 |
| 6:00:00 PM | 0 | 5589 |
| 7:00:00 PM | 221 | 4850 |
| 8:00:00 PM | 1212 | 7571 |
| 9:00:00 PM | 1222 | 7672 |
| 10:00:00 PM | 1238 | 7897 |
| 11:00:00 PM | 1258 | 8103 |
| 12:00:00 AM | 1303 | 8578 |




### 3.4. Improvement recommendation

Based on the analyzed data: we recommended to install an alternative power source to reduce the costs of operation, produces little or no waste products such as carbon dioxide or other chemical pollutants, and so has minimal impact on the environment.

# 4. Energy Analysis methodology

Based on the result of analyzed data from Energy analyzer, the following can be recommended as measures to conserve energy and make the system technically more efficient and financially sustainable:-

- In general, as operation and maintenance measures:
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  - Use the natural light as possible as.
  - Concentrate working with heavy loads in low price time.
  - Unplug the electrical devices after ending working day.
  - Use efficient appliances.
  - Make maintenance to lighting units where cleaning the lamps and reflectors.
- Installing R.E. measures: solar PV system with capacity 144Kwp to reduce energy consumption, cost and the environmental impact.

## 4.1. Design of On-grid PV solar system

### I. Summary of characteristics of electric generation system

| | | |
|---|---|---|
| **Photovoltaic Generator** | **PV Capacity at STC (Wp)** | **≥144kWp** |
| | Type of module | Crystalline 60 cells / 72 cells |
| | Tilt | 30º (+5º, -10º) |
| | Orientation | 0 º S |
| | Standards | IEC 61215 edition 2, IEC 61730 |
| **Three phase Grid connected inverter** | Rated power | 50.000 W |
| | Number of MPP tracker | ≥ 1 |
| | Protection Class | ≥ IP20 |
| | Biggest voltage MPP range | 150 V - 800 V |
| | Maximum DC voltage | 1.000 V |
| | Output AC voltage | 3 / N / PE 230, 400 V (adjustable) |
| | Output AC frequency | 50 Hz (adjustable) |
| | Phi cosine | 1 |
| | THD | ≤ 3% |
| | Consumption at night | ≤ 3 W |
| | Maximum efficiency | ≥ 97 % |
| | Euro-efficiency | ≥ 95 % |
| | Standards | Harmonic Current (IEC61000-3-2 and/or IEC61000-3-4), IEC62109-1/2 |
| | Anti -islanding protection | Yes / VDE 0126-1-1 or similar |
| | Communication | MODBUS, allowing reading and writing on the inverter |

| | | |
|---|---|---|
| | Additional requirements | Phase balancing, Dynamic compensation of reactive power, inverter automatic reconnection conditions, output power control from a third device (read and write capabilities), utility-interactive photovoltaic inverter system. |
| | Number of MPP tracker | ≥ 1 |

# II. PV generator

## II.1 Orientation for optimum yield

To optimize the PV generator's production with respect to the estimated load it is necessary to fulfil the following requirements:

The tilt angle and azimuth of the modules has been established to optimize the production in relation to the needs. (in our design: the tilt angle = 30 . Azimuth = 0)

Shadowing of the PV modules from trees, buildings or any other obstacles should be minimized over the whole day and there shall be no shadows in a period of ± 4h w.r.t. solar noon.

## II.2 PV modules

PV modules must be crystalline silicon PV modules that comply with the norm IEC 61215 edition 2 and shall be qualified to and be classified by Class according to IEC 61730. I-V curve must be supplied.

The modules shall be made of a series-connection of 60 cells. Modules of 72 cells are acceptable, only if the final solution meets the specifications of minimum power requirements.

The design is based on a module capacity at STC of 395 Wp but it is technically possible to achieve the same characteristic of the PV generator with smaller or larger modules and a different layout.

The PV matrix is composed by 366 PV modules of 395 Wp, PV array is distributed by 3 sub arrays of 10/8 strings and each string is composed by 14/15 modules. The total capacity of PV generator is 144570 Wp.

The modules shall have a separate connection box on the rear part with protection class IP 65. The terminals must be clearly marked with + and – for the corresponding connections. The PV STRING BOXES are exposed to the environment, shall be readily available, shall be at least IP 54 and shall be UV resistant.

# III. Grid dependent Inverter

For grid-dependent operation, the inverter is grid-dependent and it controls the current into the grid to meet the requirements for interaction functionality. These standards include a voltage and frequency range and requirement for "anti-islanding" to ensure that the inverter disconnects from the utility grid if not within the specified conditions.

When the inverters are located in indoor environments the enclosure should be at least IP 20 or better. Inverters have to be installed according to their environmental protection rating and ambient temperature range.

The Grid-dependent inverter requirements should also include the following:

- Dynamic compensation of Reactive power
- Inverter automatic reconnection conditions
- Output power control from a third device (read and write capabilities)
- Utility-Interactive Photovoltaic inverter system

In our design we choose 3 inverter with capacity of 50kw

# IV. Interconnection to grid

## IV.1 PV Connection point

The grid-dependent inverters output will be connected on the main AC bus bar after their respective protection box and differential switch. The main AC bus bar is prepared to feed the loads and/or back-feed the surplus of PV production to the grid

## IV.2 AC meters

Three phase (grid, genset, grid-dependent inverters) power analyzer will monitor the energy flow of the PV Power Plant.

## IV.3 Voltage Surge protection

To protect against surge overvoltage from the utility side it is required to install an SPD (Surge Protective Device) as near as possible to the grid-dependent inverters output. It is not necessary to supply such SPD if already included in the equipment.

This equipment will leak the energy of the overvoltage to the ground. For this reason, it is essential that earth terminals be of a good quality and moreover, it is required that all of the earth terminals be properly connected so as to assure equi-potentiality.

The required SPD has to be able to discharge high currents caused by an induced overvoltage, for that reasons, it needs to be a type 2 according with IEC 61643 standard and also type 3 SPDs which are specially designed to protect the most sensitive equipments.

# V. Cables

The cables to be installed throughout the facility will be RZ1-K unipolar copper conductors with a rated voltage up to 0.6 / 1 kV. Their insulation with thermoplastic, low emission of corrosive gasses (XLPE) and their maximum admissible service temperature will be of 90 º C.

All cables will go inside a tube or inside a PVC tray.

The AC cables will be provided with the following colour code:

- Black for phase(s)
- Blue for neutral

- Bicolour Yellow / green for grounding

The DC cables will be provided with the following colour code:

- Black for positive polarity
- Red for negative polarity
- Bicolour Yellow / green for grounding

### VI. Grounding

The objective is to create an earth connection to which all relevant components of the new installation will be bonded and also to protect the new installations with differential switches.

The groundings will be done by:

E1: Connect to earth the PV-frame modules and all the metallic constructive elements of structure.

The grounding resistance must have a value between 2 and 5 Ohms.

## 5. Recommendation

- We recommend the administration of factory to take into account this energy audit with its details because it's saving money; as reducing the bill, reducing the fuel; and reducing the Co2 emissions.
- Increase awareness between employees of the factory for the importance of energy conservation
- Install PV solar system with capacity of 100 KWp to reduce the electricity demand.

## 6. Appendix

## Energy Audit Data collection form

### site data

| Building Name | Address | Building square meter (m2) | age of building (years) | Date of last major renovation | purpose of building | Number of floors | Name of utility company |
|---|---|---|---|---|---|---|---|
| Faculties of Educational Sciences | old campus/ANU | m2/floor=6200 m2 all building | 1977 | ------- | College to prepare competent teachers | 4 | NEDCO |

### Total Daily Hours of Operation

| | | | | | |
|---|---|---|---|---|---|
| Sunday | 8 | Thursday | 8 | Months of Operation per Year? | 10 |
| Monday | 8 | Friday | 0 | Total Weekly Hours | 40 |
| Tuesday | 8 | Saturday | 0 | Total Annual Hours | 1600 |
| Wednesday | 8 | | | | |

please check all that apply:

- ☐ this building is leased
- ☑ this building is owned
- ☐ the organization recieves monthly bills based on accurate meter readings
- ☐ meters are read regularly by on-site staff
- ☐ bills are compared to monthly meter readings on a regular basis
- ☐ A building automation system or energy management control system is in place and used to track utility data regularly
- ☑ the building is sub-metered
- ☐ the building has automated 15-minute interval or SMART meters

| | |
|---|---|
| **If the building is leased:** when is the lease up for renewal (date/year)? | Null |
| How long does the lease contract last (years)? | Null |

## Saving Energy in Commercial Buildings/Energy Audit Data collection form

### Lighting-Building data

| Floor Name or room number | location description (near window, internal office.etc) | lamp type | Ballast type | Wattage | total Number of lamps | Number of Hours light are left on each day | Total KWh/day | how are lights controlled? |
|---|---|---|---|---|---|---|---|---|
| 30 | near window | FL. | Elect. Mag. | 36 | 2 | 2 | 0.144 | Switch |
| 0040 A | near window | FL. | Elect. Mag. | 36 | 2 | 2 | 0.144 | Switch |
| 0040 B | near window | FL. | Elect. Mag. | 36 | 2 | 2 | 0.144 | Switch |
| 50 | near window | FL. | Elect. Mag. | 36 | 12 | 4 | 1.728 | Switch |
| 60 | near window | FL. | Elect. Mag. | 36 | 8 | 4 | 1.152 | Switch |
| 70 | near window | FL. | Elect. Mag. | 36 | 8 | 3 | 0.864 | Switch |
| 80 | near window | FL. | Elect. Mag. | 36 | 8 | 4 | 1.152 | Switch |
| 90 | near window | FL. | Elect. Mag. | 36 | 8 | 5 | 1.44 | Switch |
| 100 | near window | FL. | Elect. Mag. | 36 | 8 | 6 | 1.728 | Switch |
| 110 | near window | FL. | Elect. Mag. | 36 | 8 | 3 | 0.864 | Switch |
| 120 | near window | FL. | Elect. Mag. | 36 | 4 | 7 | 1.008 | Switch |
| 130 | near window | LED | | 26 | 2 | 5 | 0.26 | Switch |
| 140 | Hall way | LED | | 26 | 2 | 7 | 0.364 | Switch |
| 150 | near window | LED | | 26 | 2 | 7 | 0.364 | Switch |
| 160 | near window | FL. | Elect. Mag. | 36 | 2 | 2 | 0.144 | Switch |
| 170 | near window | FL. | Elect. Mag. | 36 | 2 | 2 | 0.144 | Switch |
| | | | | | | total KWH/sheet-1 | 11.644 | |

## Saving Energy in Commercial Buildings/Energy Audit Data collection form

### Lighting-Building data

| Floor Name or room number | location description (near window, internal office.etc) | lamp type | Ballast type | Wattage | total Number of lamps | Number of Hours light are left on each day | Total KWh/day | how are lights controlled? |
|---|---|---|---|---|---|---|---|---|
| 180 | near window | LED26/ FL 36 | | 62 | 2 | 5 | 0.62 | Switch |
| 190 | near window | FL. | Elect. Mag. | 36 | 4 | 5 | 0.72 | Switch |
| 200 | near window | FL. | Elect. Mag. | 36 | 4 | 4 | 0.576 | Switch |
| 220 | near window | LED | | 26 | 4 | 7 | 0.728 | Switch |
| Hall | near window | PL. | | 18 | 36 | 5 | 3.24 | Switch |
| | | LED | | 25 | 13 | 5 | 1.625 | Switch |
| Bathroom | near window | FL. | Elect. Mag. | 36 | 6 | 5 | 1.08 | Switch |
| 1030 | near window | FL. | Elect. Mag. | 18 | 48 | 7 | 6.048 | Switch |
| 1040 | near window | FL. | Elect. Mag. | 36 | 12 | 4 | 1.728 | Switch |
| 1050 | near window | FL. | Elect. Mag. | 36 | 8 | 3 | 0.864 | Switch |
| 1060 | near window | FL. | Elect. Mag. | 36 | 8 | 2 | 0.576 | Switch |
| 1070 | near window | FL. | Elect. Mag. | 36 | 8 | 3 | 0.864 | Switch |
| 1080 | near window | FL. | Elect. Mag. | 36 | 8 | 4 | 1.152 | Switch |
| 1090 | near window | FL. | Elect. Mag. | 36 | 8 | 4 | 1.152 | Switch |
| 1100 A | near window | FL. | Elect. Mag. | 36 | 4 | 1 | 0.144 | Switch |
| 1100 B | near window | FL. | Elect. Mag. | 36 | 4 | 1 | 0.144 | Switch |
| | | | | | | total KWH/sheet-2 | 21.261 | |

## Saving Energy in Commercial Buildings/Energy Audit Data collection form

### Lighting-Building data

| Floor Name or room number | location description (near window, internal office.etc) | lamp type | Ballast type | Wattage | total Number of lamps | Number of Hours light are left on each day | Total KWh/day | how are lights controlled? |
|---|---|---|---|---|---|---|---|---|
| 1110 | near window | FL. | Elect. Mag. | 36 | 4-Jan | 5 | 0.72 | Switch |
| 1111 | near window | FL. | Elect. Mag. | 36 | 4 | 5 | 0.72 | Switch |
| 1120 | Internal office | FL. | Elect. Mag. | 36 | 2 | 6 | 0.432 | Switch |
| 1130 | near window | FL. | Elect. Mag. | 36 | 2 | 5 | 0.36 | Switch |
| 1140 | near window | LED | | 26 | 2 | 6 | 0.312 | Switch |
| 1150 | near window | FL. | Elect. Mag. | 36 | 2 | 5 | 0.36 | Switch |
| 1160 | near window | FL. | Elect. Mag. | 36 | 2 | 6 | 0.432 | Switch |
| 1170 | near window | FL. | Elect. Mag. | 36 | 2 | 5 | 0.36 | Switch |
| 1200 | near window | FL. | Elect. Mag. | 36 | 2 | 5 | 0.36 | Switch |
| 1210 | near window | FL. | Elect. Mag. | 36 | 4 | 4 | 0.576 | Switch |
| 1220 | near window | FL. | Elect. Mag. | 36 | 8 | 5 | 1.44 | Switch |
| 1230 | near window | FL. | Elect. Mag. | 36 | 8 | 4 | 1.152 | Switch |
| 1240 | near window | FL. | Elect. Mag. | 36 | 8 | 4 | 1.152 | Switch |
| 1250 | near window | FL. | Elect. Mag. | 36 | 8 | 4 | 1.152 | Switch |
| Hall | near window | PL | | 18 | 52 | 4 | 3.744 | Switch |
| | | LED | | 25 | 3 | 6 | 0.45 | Switch |
| | | | | | | total KWH/sheet-3 | 13.722 | |

## Saving Energy in Commercial Buildings/Energy Audit Data collection form

### Lighting-Building data

| Floor Name or room number | location description (near window, internal office.etc) | lamp type | Ballast type | Wattage | total Number of lamps | Number of Hours light are left on each day | Total KWh/day | how are lights controlled? |
|---|---|---|---|---|---|---|---|---|
| Bathroms | near window | FL. | Elect. Mag. | 36 | 8-Jan | 6 | 1.728 | Switch |
| 2040 | near window | FL. | Elect. Mag. | 36 | 16 | 7 | 4.032 | Switch |
| 2050 | near window | FL. | Elect. Mag. | 36 | 8 | 6 | 1.728 | Switch |
| 2060A | near window | FL. | Elect. Mag. | 36 | 4 | 4 | 0.576 | Switch |
| 2060 B | near window | FL. | Elect. Mag. | 36 | 4 | 3 | 0.432 | Switch |
| 2070A | near window | FL. | Elect. Mag. | 36 | 4 | 4 | 0.576 | Switch |
| 2070 B | near window | FL. | Elect. Mag. | 36 | 4 | 5 | 0.72 | Switch |
| 2080A | near window | FL. | Elect. Mag. | 36 | 4 | 3 | 0.432 | Switch |
| 2080 B | near window | FL. | Elect. Mag. | 36 | 4 | 2 | 0.288 | Switch |
| 2090A | near window | FL. | Elect. Mag. | 36 | 4 | 1 | 0.144 | Switch |
| 2090 B | near window | FL. | Elect. Mag. | 36 | 4 | 2 | 0.288 | Switch |
| 2100 | near window | FL. | Elect. Mag. | 36 | 4 | 4 | 0.576 | Switch |
| 2110 | near window | FL. | Elect. Mag. | 40 | 4 | 4 | 0.64 | Switch |
| 2111 | near window | FL. | Elect. Mag. | 36 | 4 | 4 | 0.576 | Switch |
| 2120 A | near window | FL. | Elect. Mag. | 36 | 4 | 4 | 0.576 | Switch |
| 2120 B | near window | FL. | Elect. Mag. | 36 | 4 | 2 | 0.288 | Switch |
| | | | | | | total KWH/sheet-4 | 13.6 | |

**Saving Energy in Commercial Buildings/Energy Audit Data collection form**

**Lighting-Building data**

| Floor Name or room number | location description (near window, internal office.etc) | lamp type | Ballast type | Wattage | total Number of lamps | Number of Hours light are left on each day | Total KWh/day | how are lights controlled? |
|---|---|---|---|---|---|---|---|---|
| 2130 | near window | FL. | Elect. Mag. | 36 | 4 | 3 | 0.432 | Switch |
| 2131 | near window | FL. | Elect. Mag. | 36 | 4 | 4 | 0.576 | Switch |
| 2140 | near window | FL. | Elect. Mag. | 36 | 4 | 4 | 0.576 | Switch |
| 2150 | near window | FL. | Elect. Mag. | 36 | 8 | 5 | 1.44 | Switch |
| Hall | near window | FL. | Elect. Mag. | 36 | 4 | 5 | 0.72 | Switch |
| bathrooms | near window | FL. | Elect. Mag. | 36 | 4 | 5 | 0.72 | Switch |
| | | | | | | | 0 | |
| | | | | | | total KWH/sheet-5 | 4.464 | |

**Saving Energy in Commercial Buildings/Energy Audit Data collection form**

**Plug loads-Building data**

| Equipment type | Manufacturer | Model or size | Total Number | Wattage | Number of Hours usage per day | Total KWh/day | how is equipment controlled? | Notes |
|---|---|---|---|---|---|---|---|---|
| **Fan** | ----- | ----- | 82 | 92 | 4 | 30.176 | manual | |
| **Computer** | hp/dell | ----- | 168 | 180 | 3.5 | 105.84 | manual | |
| **printer** | ----- | ----- | 22 | 560 | 0.33 | 4.0656 | manual | |
| **photocopier** | ----- | ----- | 14 | 1100 | 0.33 | 5.082 | manual | |
| **Projector** | ----- | ----- | 1 | 440 | 1 | 0.44 | manual | **G:40W , F1:280W , F2:120W** |
| **AC conditioning** | ----- | ----- | 1 | 30500 | 3 | 91.5 | manual | **B: 8KW, G:5KW , F1:4KW , F2:13.5KW** |

**Please specify where you feel there is room for improvement either in efficiency measures or renewable energy technology:**

install PV system on roof will reduce the grid consumption of building

please check all the information below is being provided to ERC/An-Najah university :

- ☐ copy of utility bill
- ☐ screenshots of EMCS or DDC control system
- ☐ copies of previous energy audits report-if applied
- ☐ copies of action plans or capital improvements plans
- ☐ copies of M & V plans
- ☐ copies of O & M cotract
- ☐ copies of nameplates from HVAC and chiller

| | Total KWh/day |
|---|---|
| Lighting-sheet1 | 11.644 |
| Lighting-sheet2 | 21.261 |
| Lighting-sheet3 | 13.722 |
| Lighting-sheet4 | 13.6 |
| Lighting-sheet5 | 4.464 |
| plug loads | 237.1036 |
| | **301.7946** |

## Energy Audit Data collection form

### site data

| Building Name | Address | Building square meter (m2) | age of building (years) | Date of last major renovation | purpose of building | Number of floors | Name of utility company |
|---|---|---|---|---|---|---|---|
| Faculties of humanities | old campus/ANU | 2942m2/floor =8826 m2 all building | 1977 | ------- | College to prepare Literature teachers | 3 | NEDCO |

**Total Daily Hours of Operation**

| | | | | | |
|---|---|---|---|---|---|
| Sunday | 8 | Thursday | 8 | **Months of Operation per Year?** | 10 |
| Monday | 8 | Friday | 0 | Total Weekly Hours | 40 |
| Tuesday | 8 | Saturday | 0 | Total Annual Hours | 1600 |
| Wednesday | 8 | | | | |

please check all that apply:

- ☐ this building is leased
- ☑ this building is owned
- ☐ the organization recieves monthly bills based on accurate meter readings
- ☐ meters are read regularly by on-site staff
- ☐ bills are compared to monthly meter readings on a regular basis
- ☐ A building automation system or energy management control system is in place and used to track utility data regularly
- ☑ the building is sub-metered
- ☐ the building has automated 15-minute interval or SMART meters

| | |
|---|---|
| **If the building is leased:** when is the lease up for renewal (date/year)? | Null |
| How long does the lease contract last (years)? | Null |

## Saving Energy in Commercial Buildings/Energy Audit Data collection form

**Lighting-Building data**

| Floor Name or room number | location description (near window, internal office.etc) | lamp type | Ballast type | Wattage | total Number of lamps | Number of Hours light are left on each day | Total KWh/day | how are lights controlled? |
|---|---|---|---|---|---|---|---|---|
| G-Floor | near window | FL. | Elect. Mag. | 56 | 154 | 6 | 51.744 | Switch |
| | near window | FL. | Elect. Mag. | 36 | 12 | 6 | 2.592 | Switch |
| 1st-Floor | near window | FL. | Elect. Mag. | 56 | 194 | 6 | 65.184 | Switch |
| 2st-Floor | near window | FL. | Elect. Mag. | 56 | 176 | 4 | 39.424 | Switch |
| | near window | FL. | Elect. Mag. | 36 | 72 | 5 | 12.96 | Switch |
| outside | near window | FL. | Elect. Mag. | 18 | 222 | 3 | 11.988 | Switch |
| | near window | FL. | Elect. Mag. | 36 | 12 | 4 | 1.728 | Switch |
| | | | | | | | | |
| | | | | | | total KWH/sheet-1 | 185.62 | |

## Saving Energy in Commercial Buildings/Energy Audit Data collection form

**Plug loads-Building data**

| Equipment type | Manufacturer | Model or size | Total Number | Wattage | Number of Hours usage per day | Total KWh/day | how is equipment controlled? | Notes |
|---|---|---|---|---|---|---|---|---|
| **Fan** | ----- | ----- | 99 | 92 | 4 | 36.432 | manual | |
| **Computer** | hp/dell | ----- | 275 | 180 | 3.5 | 173.25 | manual | |
| **printer** | ----- | ----- | 33 | 560 | 0.33 | 6.0984 | manual | |
| **photocopier** | ----- | ----- | 6 | 1100 | 0.33 | 2.178 | manual | |
| **Projector** | ----- | ----- | 25 | 880 | 1 | 22 | manual | |
| **AC conditioning** | ----- | ----- | 12 | 2000 | 3 | 72 | manual | |
| **other loads: refrigerator** | ----- | ----- | 1 | 250 | 8 | 2 | manual | |
| **other loads: Scanner** | ----- | ----- | 2 | 65 | 1 | 0.13 | manual | |

**Please specify where you feel there is room for improvement either in efficiency measures or renewable energy technology:**

install PV system on roof will reduce the grid consumption of building

please check all the information below is being provided to ERC/An-Najah university :

- ☐ copy of utility bill
- ☐ screenshots of EMCS or DDC control system
- ☐ copies of previous energy audits report-if applied
- ☐ copies of action plans or capital improvements plans
- ☐ copies of M & V plans
- ☐ copies of O & M cotract
- ☐ copies of nameplates from HVAC and chiller

| | Total KWh/day |
|---|---|
| Lighting-sheet1 | 185.62 |
| | |
| | |
| | |
| plug loads | 314.0884 |
| | **499.7084** |

# Energy Audit For Faculty of Agriculture and Veterinary Medicine- An Najah National University

2022-2023

## TABLE OF CONTENTS



# 1. Executive Summary

This report presents analyzed of energy audit in Faculty of Agriculture and Veterinary Medicine - An Najah National University, the characteristics of energy consumption, methodology and expected result of energy efficiency (E.E.) improvements technically and financially are presented.

The energy efficiency can be improved by three different approaches as follow:

1) Energy saving by management

2) Energy saving by High efficient technology

3) Energy saving by policies / regulations

**Energy audit**- a process to evaluate where a building or plant uses energy, and identify opportunities to reduce consumption and delivers the following benefits to customers:

- Educates and creates awareness regarding energy usage and conservation opportunities.
- Provides customers with recommendations which will increase the comfort, health, safety and prolong the durability of the property.

The improvement of energy efficiency can provide effective way of achieving three simultaneous objectives:

- Reducing cost
- Improving productivity
- Minimizing the impact of industrial activity on the environment

This report highlights the opportunities to implement ECM in university by improving the power factor, reducing harmonics, avoid voltage drop, reducing cable losses and avoid equipment malfunction and illustrate the results of energy consumption, using R.E. technology and the daily load curves of the distribution boards.

# 2. Introduction

## 2.1. Faculty of Agriculture and Veterinary Medicine

The agricultural education process at An-Najah University commenced in the year 1986, with the establishment of the Department of Agricultural Sciences as one of the departments within the College of Sciences. This continued until 1992 when the Department of Agricultural Sciences was transformed into the College of Agriculture, becoming the ninth college within An-Najah National University. In 1996, the College of Agriculture was relocated from the university's campus in Nablus to the new campus in Tulkarm, known as Khadouri, situated approximately 14 kilometers east of the Mediterranean Sea.

The College of Veterinary Medicine was established in a prominent location in the city of Tulkarm, known as Khadouri, in the year 2000, in response to a national need to enhance animal health, increase production capacity by raising the number of animals, and reduce production costs. As the first college of its kind in Palestine, this institution aims to make a significant contribution to improving the national income, ensuring food security, and safeguarding public health. The college is equipped with various facilities, laboratories, clinics, centers, and medical units.

**Work days** : 5 days a week for 9 hours a day (8:00 AM to 5:00 PM)

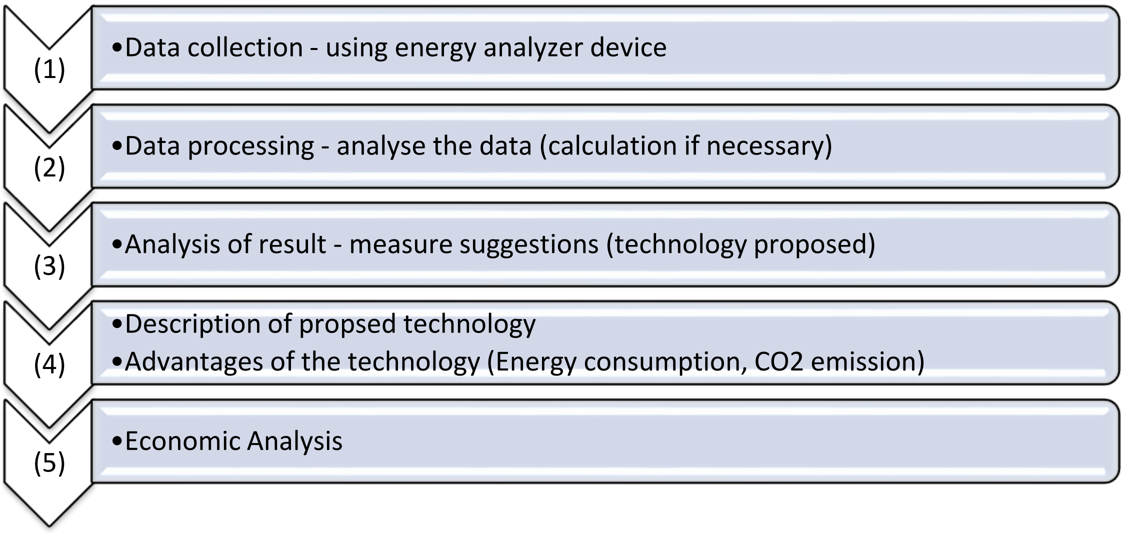
### 2.2. Motivation of study

The study aims to select a proper Energy measure (E.M) in order to reduce electricity demand and the environmental impact, which lead to improve energy efficiency and achieve security of supply and environmental protection.

## 3. Energy Audit methodology

Energy audit is process that facilities energy usage pattern, equipment efficiency, and overall building efficiency is determined in order to propose energy efficiency measures.

The energy audit steps as in following diagram:




### 3.1. Data collection

One of main step of energy audit is estimated production parameters using measuring method as energy analyzer device, which is used for measuring electrical parameters (KWh, KVA, POWER FACTOR, Frequency, Harmonics) and record the real data for period of time, where there is no accurate data, the energy audit cannot be successfully accomplished.

The energy audit in the University planned to include all load systems (lighting systems, computers, printers, photocopiers, fans and other loads. The University takes the electricity mainly from Electricity Company, and there have a generator in order to produce electricity when the main source (Electricity Company) is off.

### 3.2. Data Analysis

The recorded data from energy analyzer were analyzed to define if there is a problem or not which may cause excess in energy usage and making the necessary calculations in order to identify the possibility of energy efficiency improvement as follow:

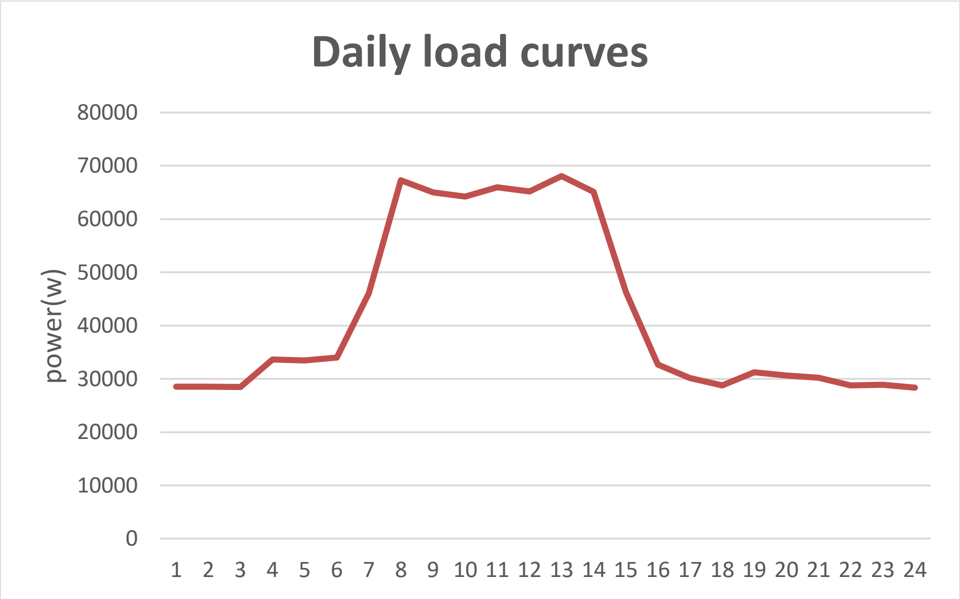
1- Energy audit of Educational building is conducted as follow:

| Parameters | | Average | Comment |
|---|---|---|---|
| Frequency | | 50.01 | (acceptable value) |
| Voltage | V1 | 225.75 | (acceptable value) |
| | V2 | 223.78 | |
| | V3 | 226.26 | |
| Current | I1 | 3.03 | |
| | I2 | 2.9 | |
| | I3 | 2.3 | |
| P (W) | | 1318 | (acceptable) |
| Q (VAR) | | 477 | |
| S (VA) | | 1376 | |
| Power factor | | 0.958 | (acceptable) |

The data of Lighting, printer. etc. was collected (Annex-1) and total energy consumption per day was 680.75 KWh/day

### 3.3. Analysis of result

From previous data, we get the daily load curve to provide us with information of load in building during different running hours per day as follow:



### 3.4. Improvement recommendation

Based on the analyzed data: we recommended to install an alternative power source to reduce the costs of operation, produces little or no waste products such as carbon dioxide or other chemical pollutants, and so has minimal impact on the environment.

# 4. Energy Analysis methodology

Based on the result of analyzed data from Energy analyzer, the following can be recommended as measures to conserve energy and make the system technically more efficient and financially sustainable: -

- In general, as operation and maintenance measures:
  - Turn off the lighting unit in the places that does not use.
  - Turn off the machine that is not necessary to use.
  - Make a periodic maintenance to the machines.
  - Switch off the lights after leaving the offices.
  - Use the natural light as possible as.
  - Concentrate working with heavy loads in low price time.
  - Unplug the electrical devices after ending working day.
  - Use efficient appliances.
  - Make maintenance to lighting units where cleaning the lamps and reflectors.

- Replace the old lamp with high efficient lamp

- Installing R.E. measures: solar PV system with capacity 77Kwp to reduce energy consumption and electricity bills around 60%, and also decrease the environmental impact.

### 4.1. Design of On-grid PV solar system

#### I. Summary of characteristics of electric generation system

| | | |
|---|---|---|
| **Photovoltaic Generator** | **PV Capacity at STC (Wp)** | **≥77 kWp** |
| | Type of module | Crystalline 60 cells / 72 cells |
| | Tilt | 30º (+5º, -10º) |
| | Orientation | 0 º S |
| | Standards | IEC 61215 edition 2, IEC 61730 |
| **Three phase Grid connected inverter** | Rated power | 50.000 W |
| | Number of MPP tracker | ≥ 1 |
| | Protection Class | ≥ IP20 |
| | Biggest voltage MPP range | 150 V - 800 V |

| | | |
|---|---|---|
| | Maximum DC voltage | 1.000 V |
| | Output AC voltage | 3 / N / PE 230, 400 V (adjustable) |
| | Output AC frequency | 50 Hz (adjustable) |
| | Phi cosine | 1 |
| | THD | ≤ 3% |
| | Consumption at night | ≤ 3 W |
| | Maximum efficiency | ≥ 97 % |
| | Euro-efficiency | ≥ 95 % |
| | Standards | Harmonic Current (IEC61000-3-2 and/or IEC61000-3-4), IEC62109-1/2 |
| | Anti -islanding protection | Yes / VDE 0126-1-1 or similar |
| | Communication | MODBUS, allowing reading and writing on the inverter |
| | Additional requirements | Phase balancing, Dynamic compensation of reactive power, inverter automatic reconnection conditions, output power control from a third device (read and write capabilities), utility-interactive photovoltaic inverter system. |
| | Number of MPP tracker | ≥ 1 |

# 5. Recommendation

- We recommend the administration of faculty to take into account this energy audit with its details because it's saving money; as reducing the bill, reducing the fuel; and reducing the Co2 emissions.
- Increase awareness between employees of the faculty for the importance of energy conservation
- Install PV solar system with capacity of 77 KWp to reduce the electricity demand from grid by 60%
- The building is too old, and it needs to replace the old lamp with high efficient lamp to reduce the electrical bill but this process is costly because it includes carrying out civil works and maintenance of the wall in the place of the replaced units and changed all old electrical connections in the building, and so we start by installing PV solar system.

# 6. Appendix

## 6.1. Annex-1

### Energy Audit Data collection form

**site data**

| Building Name | Address | Building square meter (m2) | age of building (years) | Date of last major renovation | purpose of building | Number of floors | Name of utility company |
|---|---|---|---|---|---|---|---|
| Faculty of Agriculture and Veterinary Medicine | Tulkarem campus/ANNU | 4560 m2/floor=9120m2 all building | 1978 | —— | provide a suitable educational environment to prepare agricultural engineers and veterinarians | 2 | Tulkarem Municipality |

**Total Daily Hours of Operation**

| | | | | | |
|---|---|---|---|---|---|
| Sunday | 9 | Thursday | 9 | Months of Operation per Year? | 10 |
| Monday | 9 | Friday | 0 | Total Weekly Hours | 45 |
| Tuesday | 9 | Saturday | 0 | Total Annual Hours | 1800 |
| Wednesday | 9 | | | | |

**Organization Information**

| | | | | | |
|---|---|---|---|---|---|
| Name of orgnization | An-Najah National University | Name of Contact | Mahmoud abu Rabe3 | Position | electrical engineer of university |
| | | contact E-mail | m_aburable@najah.edu | phone number | 599323787 |

please check all that apply:

- ☑ this building is leased
- ☐ this building is owned
- ☑ the organization recieves monthly bills based on accurate meter readings
- ☐ meters are read regularly by on-site staff
- ☐ bills are compared to monthly meter readings on a regular basis
- ☐ A building automation system or energy management control system is in place and used to track utility data regularly
- ☑ the building is sub-metered
- ☐ the building has automated 15-minute interval or SMART meters

**If the building is leased:** when is the lease up for renewal (date/year)? **2096**

How long does the lease contract last (years)? **100 years**

## Saving Energy in Commercial Buildings/Energy Audit Data collection form

| Building data | | | | |
|---|---|---|---|---|
| **Floor Name or number** | **Activity Type (e.g. laboratory, office, reception, lecture room..etc)** | **Floor Square meter or % of building area(m2 or %)** | **Number of Occupants** | **Daily operational hours (e.g. S-Th 8-6, Fr/Sa 10-4)** |
| **G-floor** | computer laboratory, lectures room, lecturer office | 60% | contrasting number | **lamp:** operation hours =7 h/day , **computer:** operation hours =3.5 h/d , **printer & copier:** Oper. H. = 20 min/d , **Fan:** Operation H.= 6 h/day **AC conditioning:** Operation H.= 5 h/d , **projector:** Operation H.= 1 h/day |
| 1st -floor | Dean and secretariat rooms, lecturer office | 25% | 10 | |
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## Saving Energy in Commercial Buildings/Energy Audit Data collection form

**Annual Utility Consumption**

**Building Name**: Faculties of Educational Sciences

| Month | Electricity (KWh) | Electricity cost ($) | Electricity cost ($/KWh) | Natural Gas (MMBtu*/Thermal) | Natural Gas cost ($) | Natural Gas rate ($/MMBtu) | Water (Gallons) | Water Cost ($) |
|---|---|---|---|---|---|---|---|---|
| January | 17904.42 | 3401.84 | 0.19 | | | | | |
| February | 15226.42 | 2893.02 | 0.19 | | | | | |
| March | 17346.11 | 3295.76 | 0.19 | | | | | |
| April | 19869.47 | 3775.20 | 0.19 | | | | | |
| May | 12740.00 | 2420.60 | 0.19 | | | | | |
| June | 23031.89 | 4376.06 | 0.19 | | | | | |
| July | 17136.74 | 3255.98 | 0.19 | | | | | |
| August | 26358.53 | 5008.12 | 0.19 | | | | | |
| September | 12594.95 | 2393.04 | 0.19 | | | | | |
| October | 20072.00 | 3813.68 | 0.19 | | | | | |
| November | 20371.68 | 3870.62 | 0.19 | | | | | |
| December | 16456.63 | 3126.76 | 0.19 | | | | | |
| Annual Total= | 219108.84 | 41630.68 | 0.19 | 0 | 0 | 0 | 0 | 0 |

| electricity Usage (KWh) | Natural Gas Usage (KWh) | Total energy (KWh) | Energy Use Intensity (KWh/m2) |
|---|---|---|---|
| 219108.84 | | | |

* If natural gas is listed on utility bills as CCF or thermal, please refer to conversion table

Calculate the energy use Intensity (EUI) by converting natural gas from Thermal/MMBtu to KWh, as shown below:

| | | |
|---|---|---|
| • Natural gas usage (Btu) | =total MMBtu × 1,000,000 Btu/MMBtu | =______ Btu |
| • Natural gas usage (KWh) | =total Btu ÷ 3,412.14 Btu/KWh | =______ KWh |
| • Total energy Use (KWh) | =Electricity KWh + Natural Gas KWh | =______ KWh |
| • Energy Use Intensity (KWh/m2) | = KWh/m2 | =______ KWh/m2 |

Where another fuel type is being used, please explain where and why it is being used:

Amount of additional fuel type used per year (quantity & units)

## Saving Energy in Commercial Buildings/Energy Audit Data collection form

### Lighting-Building data

| Floor Name or room number | location description (near window, internal office.etc) | lamp type | Ballast type | Wattage | total Number of lamps | Number of Hours light are left on each day | Total KWh/day | how are lights controlled? |
|---|---|---|---|---|---|---|---|---|
| 390010 | near window | FL. | Elect. Mag. | 36 | 2 | 2 | 0.144 | Switch |
| 390020 | near window | FL. | Elect. Mag. | 36 | 2 | 2 | 0.144 | Switch |
| 390071 | near window | FL. | Elect. Mag. | 36 | 2 | 2 | 0.144 | Switch |
| 390090 | near window | FL. | Elect. Mag. | 36 | 2 | 2 | 0.144 | Switch |
| 390040 | near window | FL. | Elect. Mag. | 36 | 8 | 4 | 1.152 | Switch |
| 390050 | near window | FL. | Elect. Mag. | 36 | 8 | 4 | 1.152 | Switch |
| 390060 | near window | FL. | Elect. Mag. | 36 | 8 | 3 | 0.864 | Switch |
| 390070 | near window | FL. | Elect. Mag. | 36 | 8 | 4 | 1.152 | Switch |
| 390080 | near window | FL. | Elect. Mag. | 36 | 8 | 5 | 1.44 | Switch |
| 390150 | near window | FL. | Elect. Mag. | 36 | 4 | 6 | 0.864 | Switch |
| 390170 | near window | FL. | Elect. Mag. | 37 | 4 | 4 | 0.592 | Switch |
| 390180 | near window | FL. | Elect. Mag. | 38 | 4 | 4 | 0.608 | Switch |
| 390190 | near window | FL. | Elect. Mag. | 39 | 4 | 4 | 0.624 | Switch |
| 390200 | near window | FL. | Elect. Mag. | 40 | 4 | 4 | 0.64 | Switch |
| 390210 | near window | FL. | Elect. Mag. | 41 | 4 | 4 | 0.656 | Switch |
| 390220 | near window | FL. | Elect. Mag. | 42 | 4 | 4 | 0.672 | Switch |
| 390230 | near window | FL. | Elect. Mag. | 43 | 2 | 3 | 0.258 | Switch |
| 390240 | near window | FL. | Elect. Mag. | 44 | 2 | 3 | 0.264 | Switch |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 391023 | near window | FL. | Elect. Mag. | 36 | 8 | 6 | 1.728 | Switch |
| 391040 | near window | FL. | Elect. Mag. | 36 | 6 | 6 | 1.296 | Switch |
| 391050 | near window | FL. | Elect. Mag. | 36 | 4 | 5 | 0.72 | Switch |
| 391060 | near window | FL. | Elect. Mag. | 36 | 2 | 3 | 0.216 | Switch |
| 391070 | near window | FL. | Elect. Mag. | 36 | 2 | 3 | 0.216 | Switch |
| 391080 | near window | FL. | Elect. Mag. | 36 | 2 | 3 | 0.216 | Switch |
| | Hall way | LED | | 26 | 10 | 7 | 1.82 | Switch |
| 391091 | near window | FL. | Elect. Mag. | 36 | 2 | 3 | 0.216 | Switch |
| 391092 | near window | FL. | Elect. Mag. | 36 | 2 | 3 | 0.216 | Switch |
| 391093 | near window | FL. | Elect. Mag. | 36 | 2 | 2 | 0.144 | Switch |
| 391094 | near window | FL. | Elect. Mag. | 36 | 2 | 2 | 0.144 | Switch |
| 391101 | near window | FL. | Elect. Mag. | 36 | 2 | 2 | 0.144 | Switch |
| 391102 | near window | FL. | Elect. Mag. | 36 | 2 | 2 | 0.144 | Switch |
| 391103 | near window | FL. | Elect. Mag. | 36 | 2 | 2 | 0.144 | Switch |
| 391104 | near window | FL. | Elect. Mag. | 36 | 2 | 2 | 0.144 | Switch |
| 391120 | near window | FL. | Elect. Mag. | 36 | 2 | 2 | 0.144 | Switch |
| 391130 | near window | FL. | Elect. Mag. | 36 | 2 | 2 | 0.144 | Switch |
| 391140 | near window | FL. | Elect. Mag. | 36 | 2 | 2 | 0.144 | Switch |
| 391150 | near window | FL. | Elect. Mag. | 36 | 2 | 2 | 0.144 | Switch |
| 391160 | near window | FL. | Elect. Mag. | 36 | 2 | 2 | 0.144 | Switch |
| | | | | | | total KWH/sheet-1 | 19.742 | |

## Saving Energy in Commercial Buildings/Energy Audit Data collection form

### Plug loads-Building data

| Equipment type | Manufacturer | Model or size | Total Number | Wattage | Number of Hours usage per day | Total KWh/day | how is equipment controlled? | Notes |
|---|---|---|---|---|---|---|---|---|
| Fan | ----- | ----- | 45 | 92 | 6 | 24.84 | manual | |
| Computer | hp/dell | ----- | 120 | 180 | 4.5 | 97.2 | manual | |
| printer | ----- | ----- | 10 | 560 | 0.33 | 1.848 | manual | |
| photocopier | ----- | ----- | 8 | 1100 | 0.33 | 2.904 | manual | |
| Projector | ----- | ----- | 4 | 440 | 1.5 | 2.64 | manual | F1:280W , F2:160W |
| other device | ----- | ----- | 23 | 3000 | 4 | 276 | manual | |
| AC conditioning | ----- | ----- | 2 | 26250 | 4 | 210 | manual | ,F1:8.75KW , F2:17.5KW |

Please specify where you feel there is room for improvement either in efficiency measures or renewable energy technology:

**The building is too old, and inorder to reduced the electrical bill as 1st phase, we suggest to install PV system on roof then as 2nd phase,the savings' money may use in replacement the lamps with high efficient units, where this phase is costly because it includes carrying out civil works and maintenance of the wall in the place of the replaced units**

please check all the information below is being provided to ERC/An-Najah university :

- [ ] copy of utility bill
- [x] screenshots of EMCS or DDC control system
- [ ] copies of previous energy audits report-if applied
- [ ] copies of action plans or capital improvements plans
- [ ] copies of M & V plans
- [ ] copies of O & M cotract
- [ ] copies of nameplates from HVAC and chiller

| | Total KWh/day |
|---|---|
| Lighting-sheet1 | 19.742 |
| | |
| | |
| | |
| | |
| plug loads | 615.432 |
| | 635.174 |

Med-EcoSuRe

# Med-EcoSuRe Mediterranean University as Catalyst for Eco Sustainable Renovation

# Energy Audit:
# Data collection and recommendations

Institute: An Najah National University – UNIFI

Building complex: Faculty of Educational Sciences and Teacher Training's

Nablus, Palestine
December, 2019

## Executive Summary

---

After analyzing the existing energy situation at the Faculty, several recommendations or opportunities for improving energy efficiency and renewable energy applications have been identified and both technically and financially analyzed. This report illustrates the results of the audit and the recommended measures to achieve energy saving, together with their expected impact on energy consumption, bills paid by the university/Faculty and on the environment. However, it is worth pointing out here that those recommendations are not the only means by which energy efficiency and renewable energy could be improved, because improving energy efficiency is a continuous ever lasting and fruitful process.

# Objectives & Methodology

-----------------------------------------------------------------------------------------

## Energy Management Objectives

An energy audit is one of the tools of energy management, which aims at:

**1**- Conserving energy, thereby maximizing profits and/or minimizing cost.
**2**- Designing of solar thermal system for Sport Complex .
**3**- Developing and maintaining effective monitoring, reporting, and management strategies for wise energy usage.
**4**- Finding new and better ways to increase returns from energy investment through research and development.
**5**- Developing interest in dedicating to energy management program from all employees.
**6**- Reducing the impact of curtailments, brownouts, or any interruption in energy supplies.
7- Designing of Solar PV system for covering shortage of supply

## Energy Management Advantages

**1**- Energy management makes us less vulnerable to energy cutoffs or curtailments due to political unrest.
**2**- Energy management is kind to our environment as it eases some of the strain on our natural resources and may leave a better world for future generation.
**3**- Energy management is good for the Palestinian economy, as the balance of payments becomes more favorable**.**

## Methodology

The following steps summarize the audit methodology:

**1**- Clearly identify the types and costs of energy use, to understand how that energy is being used and possibly wasted.
**2**- Identify and analyze alternatives, such as improved operation techniques and /or new equipment that could substantially reduce energy costs, implementing renewable energy technologies.
**3**- Perform an economic analysis on those alternatives and determines which ones are cost effective for the target group.

# Facility Information

| | |
|---|---|
| ***Facility*** | Faculty of Educational Sciences and Teacher Training's |
| ***Address*** | **Nablus** |
| ***Telephone*** | **09-2345113** |
| ***Fax*** | **09-2345982** |
| ***Contact Person*** | **Mahmoud Abu-Rabaa** |
| ***Contact Person Position*** | **Electrical Maintenance Engineer** |
| ***Activity*** | **Education** |
| ***Date of Establishment*** | **1978** |

## *Energy Information*

| | |
|---|---|
| *Energy Sources* | **Faculty of Educational Sciences** is supplied by NEDCo distribution company with its electrical needs, in case of emergency the faculty has a stand - by diesel electricity generator (250 kVA), to cover lighting and a few number of power load. |
| *Energy Consumption* | 250,000 kWh / year |
| ***Power Factor*** | The company has no power factor correction capacitors, so PF value is 0.86. |
| *Electricity Tariff* | 0.65 NIS=0.18 US$ / kWh |

# *Audit Procedure*

***First stage:***

On 16-19/11/2019 the audit team visited the faculty and met the engineering manager, Eng. Mahmoud and gave him a presentation about the objective of the proposed energy audit at the faculty . Then the team carried out a walk - through tour at all sections

***Second stage:***

The VIP device was connected to the main electric panel for 24 hours; the readings of different parameters (V, I, kW, kVA, kVAR, PF, kWh, kVARh & kVAR) were registered as shown in Charts.

***Third stage:***

Energy analysis was carried out for registered data and suitable recommendations have been identified.

.

# *Audit Recommendations*

***ENERGY CONSERVATION OPPORTUNITIES***

**1- Improving Boiler combustion efficiency**
as shown in Appendix -1

2**. Power Factor Correction**
as shown in Appendix 2

3- **Lighting control in faculty rooms,**
as shown in Appendix 3

4- **HVAC measures for energy savings**
as shown in Appendix 4

5- **Installing solar PV system for covering the shortage of supply and reduction conventional supply**
As shown in Appendix 5

## *General Notes* *"No/Low Cost Measures"*

***Preventive Maintenance & Good Housekeeping (No Cost Measures)***

It is essential to apply preventive maintenance (weekly, monthly, and annually) schedules and good housekeeping measures to maintain high-level equipment performance, improve efficiency and save energy, examples of such measures are shown below:

1. Lighting fixtures (lamps, reflectors, diffusers, etc.) have to be cleaned at least once every 6 months to improve their lighting transparency & reflection. Moreover, space walls and roofs also have to be cleaned to maintain their light reflection ability in order to get the maximum luminous flux of lamps.
2. Chillers, air filters, condensers, evaporators have to be regularly cleaned as their fouling tremendously decreases chiller efficiency.
3. Motors, pumps, fans, compressors, have to be checked and maintained on a periodic basis according to manufacturers' instructions.

***Energy Saving in Motors***

1. Load is to suit motor rating as this affects motors efficiency.
2. Checking for loose connections.
3. Keeping motor clean internally, and externally.
4. Tightening belts and pulleys.
5. Providing proper maintenances and lubrications of motor driven equipments as pumps, fans, compressors.... etc.
6. Checking that applied voltage is fitting the design value with deviation less than 5%.
7. Checking for excessive noise and vibration.
8. Keeping cooling fan screen and blade clean.
9. Couple motor directly with driven equipment to avoid using mechanical transmission elements as belts, gears…etc.
10. Using variable speed drivers (VSD) instead of mechanical control methods.
11. Using start/delta connections starter to reduce starting current.
12. Balancing three-phase power source to motors, unbalance causes inefficient motor operation.

*Good Housekeeping and Human Behavior*

Potential energy savings at the faculty could be increased if human commitment to control their use of lighting and other electrical devices is improved by enhancing their awareness of energy saving and good housekeeping measures.

*Training*

The Management is advised to adopt training plans for operational and maintenance staff in order to upgrade their performance and skills this will result in:
* At operation side, minimizing human errors and improving product quality
* At maintenance side, reducing time of repairing faults and always keeping machines in good conditions by adopting preventive maintenance schedules.
Therefore, training plans will contribute to the objective of reducing loses and saving energy.

*Motivation*

The Management is advised to adopt a motivation policy for the employees to encourage them to improve their performance and to lower skilled manpower turnover.

# *Annexes*

## ***Annex 1-*** Combustion Efficiency in Boilers

Excess $O_2$ in Stack Gas
The amount of oxygen mixed with fuel is directly related to the amount of excess air introduced to the boiler.
The problem of excess $O_2$ is simply this. If there is too little air available to combine with fuel, incomplete combustion take place, the boiler smokes, and hazards of boiler malfunction increase dramatically or the carbon monoxide (CO) concentration builds up (in a gas-fired boiler). If too much air is introduced, a great deal of the energy in the fuel is used to heat up the excess air, and the efficiency of the boiler decreases.

Excessive Stack-Gas Temperature:

Waterside or fireside fouling can cause this problem. If fire-side fouling (i.e., a build up of soot, ash, or other particles) is taking place, the rate of heat transfer from the boiler to the water or steam it is heating is impeded, and the stack gas is comes pounding hotter. The effect of soot on fuel consumption is noticeable, according to the American Boiler manufacturers.
Efficiency losses due to soot are approximately as given. See Tab.1

| Soot layer on heating surface (in) | Increase in fuel consumption (%) |
|---:|---:|
| 1/32 | 2.5 |
| 1/16 | 4.4 |
| 1/8 | 8.5 |

Tab.1 Source Ref. American Boiler Manufacturers Association (ABMA)

Therefore it is recommended that tubes be cleaned once every shift where practical tubes must be cleaned whenever the stack temperature rises 75F.
If the fouling is on the waterside because of scale build up, accumulation of mud or slim, or for some other reason, heat transfer will be impeded as described above, and increased stack temperature will result the effect of this scaling is seen in table 2. The detrimental effect can be severe.

| Thickness of scale (in) | Loss of heat (%) | | |
|---|---|---|---|
| | Soft carbonate | Hard carbonate | Hard sulfate |
| 1/50 | 3.5 | 5.2 | 3.0 |
| 1/32 | 7.0 | 8.3 | 6.0 |
| 1/25 | 8.0 | 9.9 | 9.0 |
| 1/20 | 10.0 | 11.2 | 11.0 |
| 1/16 | 12.5 | 12.6 | 12.6 |
| 1/11 | 15.0 | 14.3 | 14.3 |

Source: American Boiler manufactures Association (ABMA)

If soot blowers are being used, the stack temperature should drop immediately after the tubes are cleaned. If the temperature dose not drop, the soot blowers may not be working or thermometer may have become fouled in any case, something is wrong.

Smoking or excess Co:

Excess Co, in the case of natural gas, or smoking, for oil fuels, gives an indication that something has changed. Changes in the fuel composition or wear in some component of the burner can cause these problems, or there may be a change in the air supply. In any case, the problem should be corrected immediately.

Flame Appearance:

The appearance of the flame can give some valuable information. If the pattern is unusual, there may have been changes in the burner tips or in other parts of the burner, or there may be a malfunction in a related part of the boiler. Also, examining the flame pattern can show if part of the boiler is getting over heated. At the same time the flame is being examined, the inside of the boiler is getting overheating.

## Dairy Boiler Description Sheet

| **Type** | | |
|---|---|---|
| Unit steam production | kg/h | 1500 |
| Water supply temperature | C° | 60 |
| Input power | Th/h | 878 |
| Input power | kW | 1021 |
| Design pressure | bar | 15 |
| Normal pressure | bar | 8.5 |
| Classification in category | Decree of 2/4/1926 | 2 |
| Fuel | Nature<br>L.C.V. kJ/Nm$^3$<br>Start-up procedure | FOD<br>11.86 |
| Water supply control | Type | |

| | | |
|---|---|---|
| Number of supply pumps | | |
| Burner | Manufacturer<br>Type<br>Control<br>Modulation range | BW<br>LNTA 1.1 |
| Heating area | M2 | 28 |
| Water volume (normal level) | Liters | 1535 |
| Steam volume (normal level) | Liters | 417 |
| Total volume | Liters | 1952 |
| Water surface area<br>Efficiency on PCI ± 2% at 100% load<br>Blow down and purges isolated<br>Radiation and convection losses according to French standard NFE 32131 | M2 | 2.61 |
| Power supply voltage | Volts | 400 |
| Installed electric power | KW | 4.2 |

## The Economizer

Installing flue gases/feed water heat exchanger (Economizer) to exploit the heat of flue gases in the chimney to heat feed water.

Flue gases inlet temp. = 230°C, flue gases outlet temp. = 120 °C
Feed water inlet temp. = 45 °C, feed water outlet temp. = Tout
Feed water quantity = 200 liter/hour
Diesel consumption = 12 liter/hour

Heat Loss by gases = Heat Gain by water

Heat Loss by gases $= m_g x\ C_g x\ (Tin\text{-}Tout)$

$$= (12x0.84x13)\ x1\ x\ (250 - 120) = 17035\ kJ\ /hour$$

Heat Gain by water =mw xCw x(Tout-Tin)=200x4.186x(Tout-45) =17035

Tout= feed water outlet temp. = 65 C

Heat Loss by gases/year (3000 hours) $=51105x10^3$ kJ/year =1327 liters of diesel/year

Saved Diesel /year = 1327 liters

.

## *Annex 2-High Efficiency Motors (HEM)*

### What is a High Efficiency Motor?

A high efficiency motor produces the same shaft output power (kW), but uses less input power (kW) than a standard motor. High efficiency motors must have a nominal full load efficiency that meet or exceed the high efficient motor standards (NEMA) or IEC. Most High Efficiency Motors are in general three phase squirrel cage induction motors

### How is a High Efficiency Motor different than a standard motor?

| Watts Loss Area | **Efficiency Improvements** |
|---|---|
| 1. Iron | Use of thinner gauge, lower loss core steel reduced eddy current losses. Longer core adds more steel to the design, which reduces losses due to lower operation flux densities. |
| 2. Stator $I^2R$ | Use of more copper and larger conductors increases cross sectional area of stator windings. This lower resistance (R) of the windings and reduces losses due to current flow (I). |
| 3. Rotor $I^2R$ | Use of larger rotor conductor bars increases size of cross section, lowering conductor resistance (R) and losses due to current flow (I). |
| 4. Friction & Windage | Use of low fan design reduces losses due to air movement. |

### How much does High efficiency motors cost?

Generally they average 15-30% more than standard motors.

### What is the efficiency of High Efficiency Motors?

High efficiency motors is 2-8% more efficient than standard motor. The difference is higher for smaller sizes and less for larger sizes.

### When is right time to consider buying High efficiency motors?

- During new construction
- Instead of motors that are part of the inefficient drive system
- When purchasing equipment package, such as compressors, HVAC system and pumps
- **when making major modifications to facilities or processes.**
- Instead of rewinding burnt standard motors

- To replace undersized or overloaded motors
- Starting an energy management program

To replace an existing standard (conventional) motor if the payback period is less than (5) years, this would be applicable under the following conditions:

1- high rating motors
2-high output operating load percentage
3- annual operating hours >3000
4-cost of kWh is high (like the situation in Palestine)

## Benefits and advantages of High Efficiency Motors

- They cost less to operate due to their high efficiency
- They will run cooler due to lower losses.
- Because of cooler operations the motors can work in higher ambient temperatures without requiring extra cooling.
- The motor life time of high efficiency motor is high because of its cooler operation
- Insulation life is up to four times longer
- High efficiency motors are also more rugged than standard motors, tolerating greater fluctuations in applied voltage, voltage imbalance and overload
- Higher power factor
- High efficiency motors are more reliable and need less maintenance, which is an extra saving also less maintenance, means fewer force outages.
- They are friendlier to the environment as they produce lower noise level because of low magnetic saturation and smaller fan.
- Using High efficiency motors reduces the peak demand, which means less generation and less $CO_2$ emissions.