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:
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Project Acronym	University building
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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 life in 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 have taken 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, Hisham Hijjawi 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

Hisham Hijjawi 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

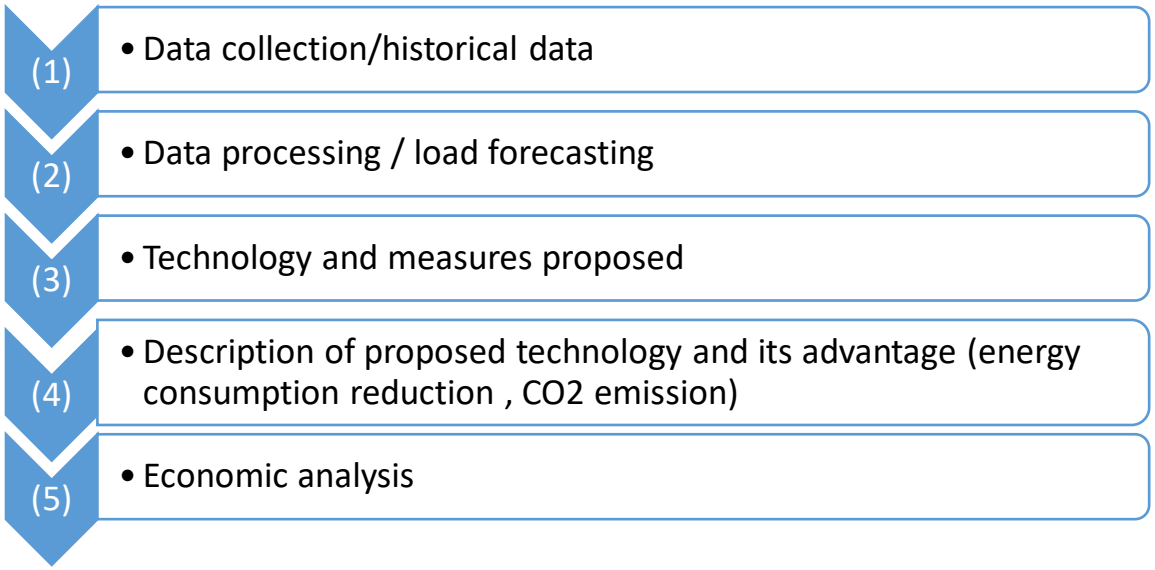
In 1996, the Faculty of Agriculture was moved to the Khadouri Campus in Tulkarem, northwest of Nablus. The Faculty's new site is one of the most beautiful landscapes in Palestine, as it is located only 14 km from the Mediterranean Sea. The campus' area is about 164 dunums and it houses a cow shed, chicken 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:



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.

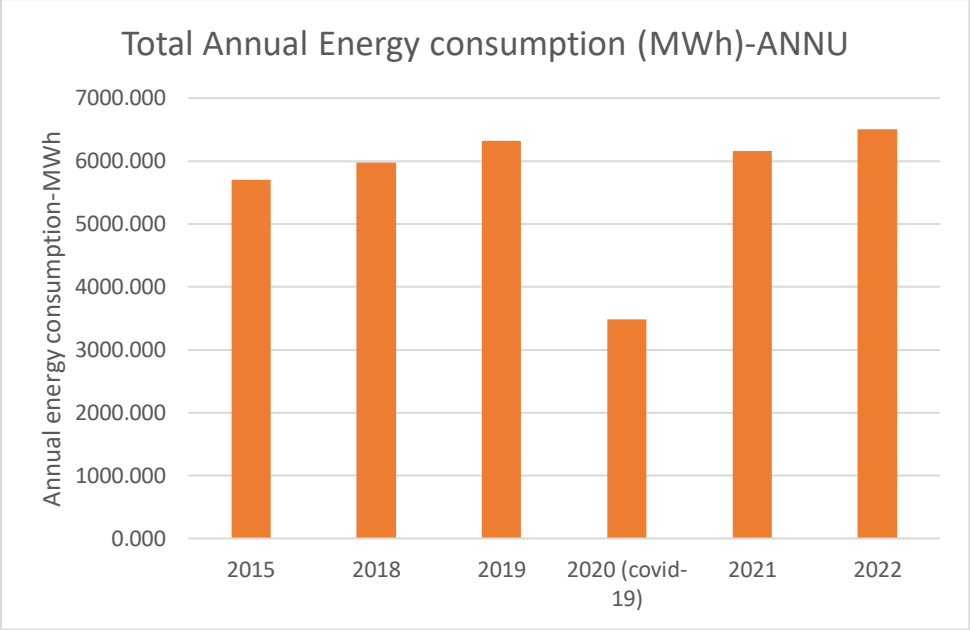


Fig. 1: electricity consumption in ANNU buildings for recent 5 years

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

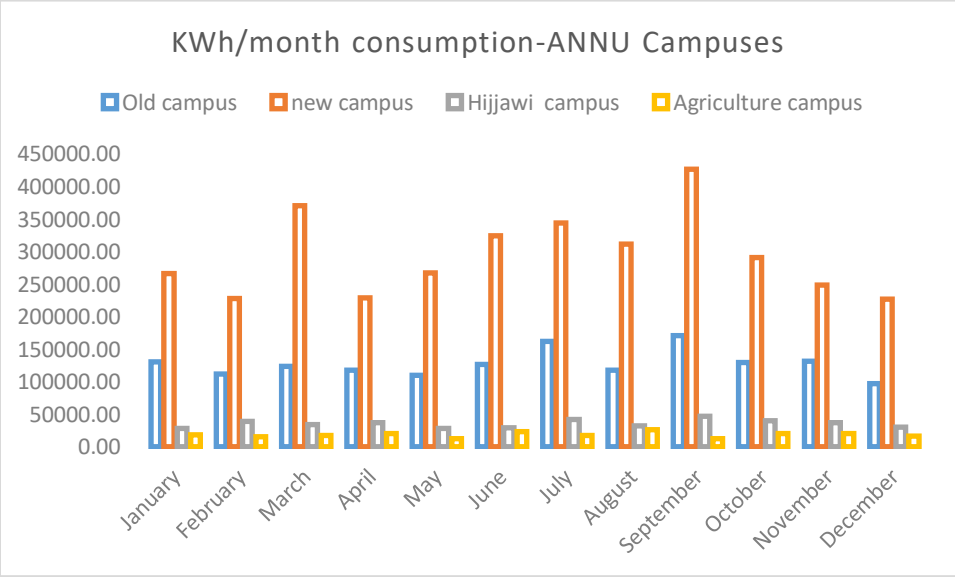


Fig.2 monthly energy consumption in ANNU campuses

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 Faculty of Engineering and IT Building	2 Faculty of Science Building	3 medicine faculty Building	4 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 Faculty of sport Building	6 new campus library Building	7 Korean Palestinian IT Institute of excellence Building	8 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		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,	

	W/m2K, the windows are double glazing with a total overall U-value of 2.5 W/m2K		the windows are double glazing with a total overall U-value of 3.1 W/m2K	
Energy consumption kWh/m2/year	67.49	38.23	79.78	49.06

New campus	9	10	11
	Scientific centre Building	An-Najah Child institute Building	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: Hisham Hijjawi College & Tulkarem campus buildings stock energy data

	Hisham Hijjawi campus	Tulkarem campus
	Vocational college	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).

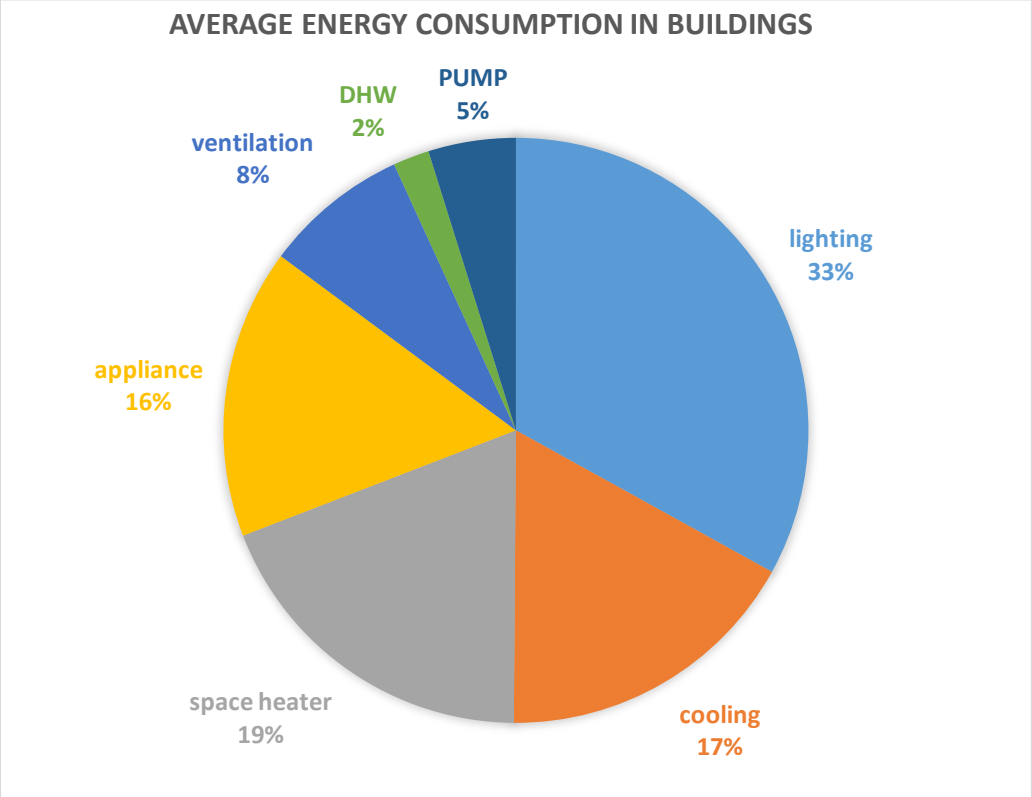


Fig.3 Energy Consumption pattern in ANNU campuses

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).

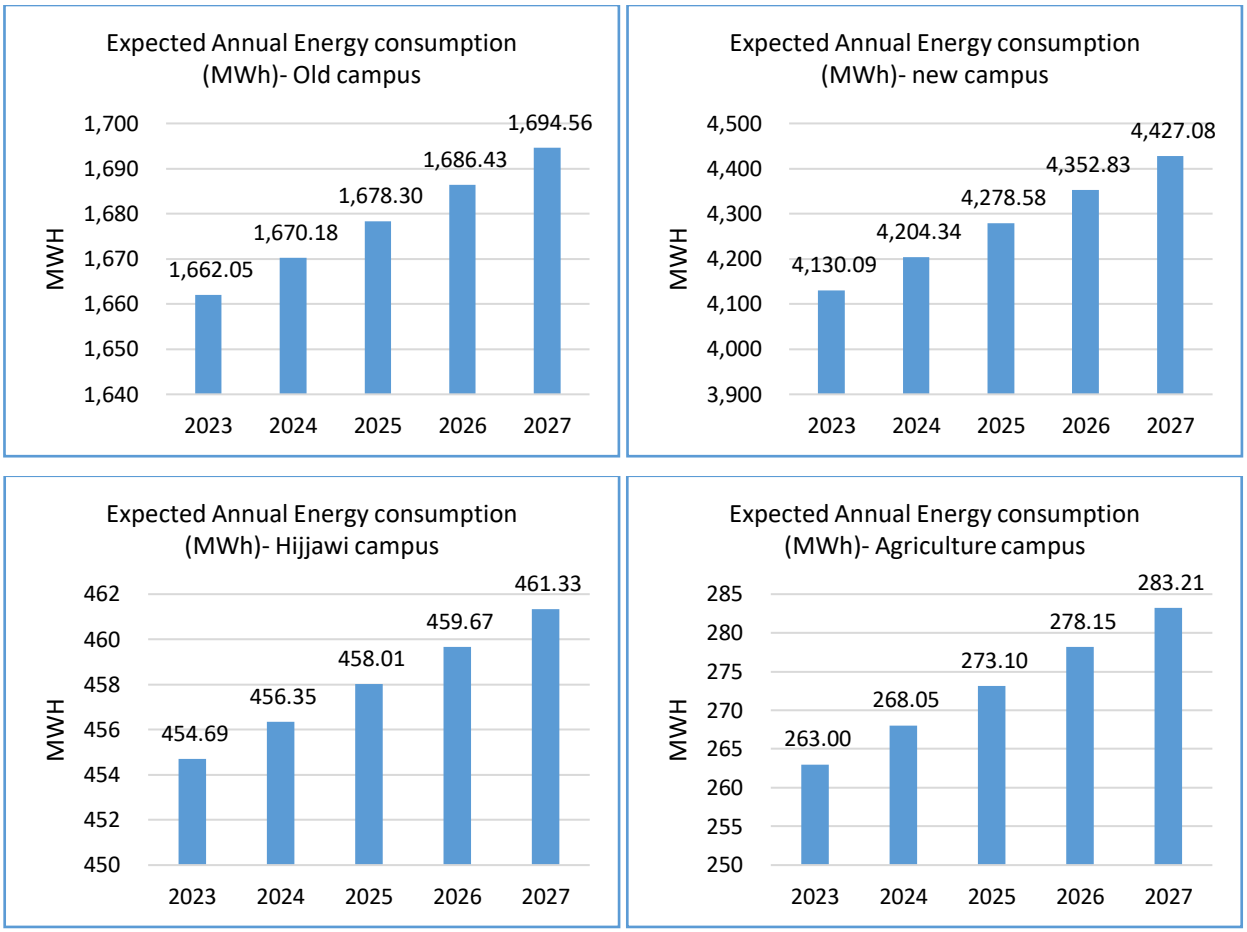


Fig.4 Expected Annual Energy consumption (MWh)- ANNU Campuses

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 while they are switched off or in standby mode (consuming electricity at a cost but not doing any work), which called vampire loads, as follow:

- Electronics appliances (computer, printer, etc.) are still ON even though they are turned off.
- Appliances on STANBY MODE are draining power even though they are not doing 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 Meter

Thermometer

Digital Multimeter

Fig.5 Measurements 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 lamps with highly 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 kWp hijawi 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 = 77.8 kWp 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 CO2 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

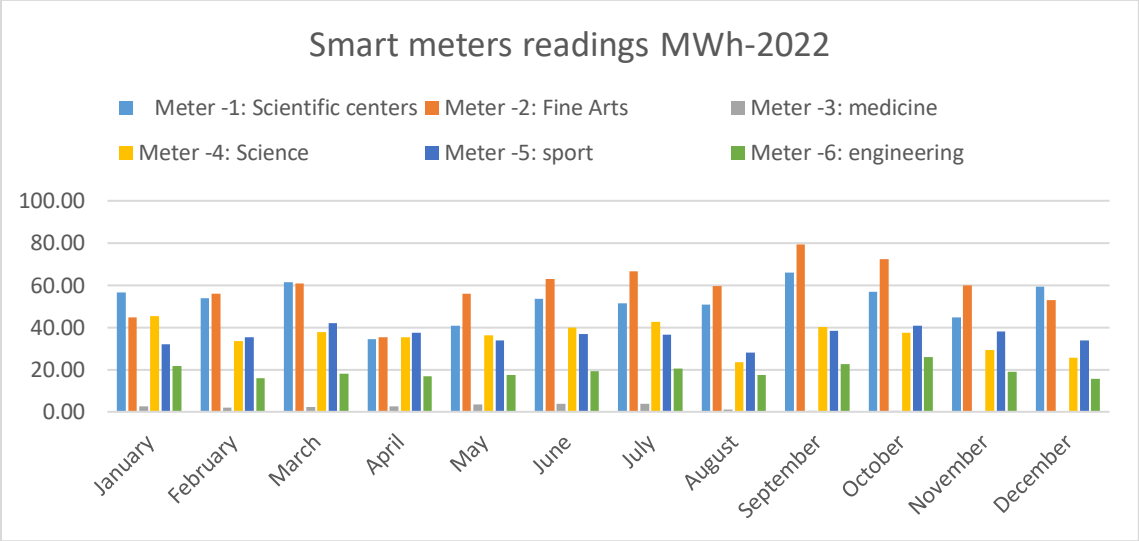


Fig.6 implemented Smart meter results

- 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 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 CO2 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 Co2 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