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Solar panels and their implementation in the UBT campus

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Abstract. Every day more and more demand for electricity in our country are growing, to meet these requirements, avoiding the generation of electricity from coal, as the production of electricity from coal, damages the environment and our health, we must invest in production of electricity from renewable energy from wind, sunlight etc.
At pre-sent, energy from non-renewable resources such as fossil fuels or fissionable materials accounts for over 92% of the world energy usage. In addition, energy generation based on burning of fossil fuels has caused an increase in carbon dioxide (CO) and other gas emissions, leading to global warming. A switch from fossil fuels to renewable energy sources such as sun, wind or water has become one of the major challenges of the 21^{st} century.
My subject is about producing energy form photo-voltage. I have studied different technologies of photo-voltage, recent developments, increasing efficiency and cost differences between different technologies of photo-voltage. Also feed-in tariffs are discussed, the tariff which supports to increase investments in producing electricity from renewable energy and assist in the return of investment.

Keywords: Solar Panels, Feed in Tarrifs, Energy Efficiency

1. Introduction

Energy plays the most vital role in the economic growth, progress and development, poverty eradication, and security of any nation. Uninterrupted energy supply is a vital issue for all countries today. Future economic growth crucially depends on the long-term availability of energy from sources that are affordable, accessible, and environmentally friendly. Security, climate change, and public health are significantly dependent on the energy [1].
At present, 80% of our energy comes from fossil fuels such as coal, oil, and natural gas and only 2% from wind and solar combined. The world needs to change the kind of energy we use, even as we need more and more of it [1].
The energy that is produced from the fuels has caused environmental pollution and global warming. Environment pollution is influencing our health in many ways. Air pollution diseases include: (1) respiratory diseases, (2) gastric problems, (3) skin problems, (4) eye problems, (5) cardiac problems, and (6) others.
The renewable energies are energies that are earned from different resources than those that are used today (coal, oil). This kind of energy is clean and doesn't damage environment, this kind of energy derived from sunlight, wind, water etc . Economic development in the future depends on long-term sources of heat and these are membership affordable, accessible and environmentally friendly.

2. Solar Basics

2.1 Why solar energy is one of the key solutions to world energy demand

The sun is the most plentiful energy source for the earth. All wind, fossil fuel, hydro and biomass energy have their origins in sunlight. Solar energy falls on the surface of the earth at a rate of 120 pet watts, (1 pet watt = 1015 watt). This means all the solar energy received from the sun in one days can satisfied the whole world's demand for more than 20 years.

We are able to calculate the potential for each renewable energy source based on today's technology. Future advances in technology will lead to higher potential for each energy source. However, the worldwide demand for energy is expected to keep increasing at 5 percent each year. Solar energy is the only choice that can satisfy such a huge and steadily increasing demand [2].

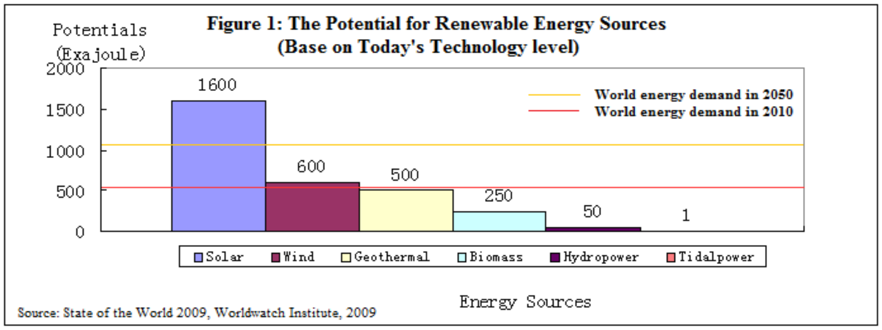

Figure 1. The Potential for Renewable energy Sources [2].

2.2 Solar Photovoltaic technologies

PV cell technologies are usually classified into three generations, depending on the basic material used and the level of commercial maturity:
First-generation PV systems (fully commercial) use the wafer-based crystalline silicon (c-Si) technology, either single crystalline (sc-Si) or multi-crystalline (mc-Si).
Second-generation PV systems (early market deployment) are based on thin-film PV technologies and generally include three main families:
1) amorphous (a-Si) and micromorph silicon (a-Si/μc-Si);
2) Cadmium-Telluride (CdTe);
3) Copper-Indium-Selenide (CIS) and Copper-Indium-Gallium-Diselenide (CIGS).
Third-generation PV systems include technologies, such as concentrating PV (CPV) that are still under demonstration or have not yet been widely commercialized, as well as novel concepts under development [5].

2.3 Overall cost reduction potentials for PV systems

Overall PV system costs are projected to continue to decline rapidly, although uncertainties exist at the moment regarding the markets growth in the short term. Short-term projections for the PV market are rapidly out of date given the rapid pace of developments. Longer term projections are likely to experience less volatility [5].

Table 4 Installed PV system cost projections for residential and utility-scale systems, 2010 to 2030 [3]

	2010	2015	2020	2030
Utility-scale				
EPIA (c-Si)	3 600		1 800	1 060 - 1 380
IEA (c-Si)	4 000*		1 800	1 200
Resdiential/Commercial				
IEA	5 000 - 6 000*		2 250 - 2 700	1 500 - 1 800
Solarbuzz (c-Si)	4 560	2 280 - 2 770		
Solarbuzz (thin film)	4 160	1 860 - 2 240		

Table 5. PV Technology – 10 Year Objectives [3]

Solar Europe Industry Initiative: PV technology roadmap for commercial technologies		**2007**	**2010**	**2015**	**2020**
Turnkey price large systems (€/Wp)*		5	2.5-3.5	2	1.5
PV electricity generation cost in Southern EU (€/kWh)**		0.30-0.60	0.14-0.20	0.10-0.17	0.07-0.12
Typical PV module efficiency range (%)	Crystalline silicon	13-18%	15-19%	16-21%	18-23%
	Thin Films	5-11%	6-12%	8-14%	10-16%
	Concentrators	20%	20-25%	25-30%	30-35%
Inverter lifetime (years)		10	15	20	>25
Module lifetime (years)		20-25	25-30	30-35	35-40
Energy payback time (years)		2-3	1-2	1	0.5
Cost of PV + small-scale storage (€/kWh) in Southern EU (grid-connected)***		-	0.35	0.22	<0.15

2.4 Factors affecting PV system cost reduction

The solar industry is constantly innovating in order to improve products efficiency and make Materials use more environmentally friendly. EPIA believes this can be achieved through:

- Technological innovation
- Production optimization
- Economies of scale
- Increased performance ratio of PV
- Extended lifetime of PV systems
- Development of standards and specifications

• **Technological innovation** - When PV modules are more efficient, they use less material (such as active layers, aluminum frames, glass and other substrates). This requires less energy for manufacturing and also lowers the balance of system (BOS) costs. With higher-efficiency modules, less surface area is needed.
• **Production optimization** - As companies scale-up production, they use more automation and larger line capacities. Production efficiency improvements enable the industry to reduce the costs of solar power modules.
• **Economies of scale** - As with all manufacturing industries, producing more products lowers the cost per unit.
Economies of scale can be achieved at the following supply and production stages:• Bulk buying of raw materials • Obtaining more favorable interest rates for financing • Efficient marketing.
• **Increased performance ratio of PV** -The cost per kWh is linked to PV system quality and reflected in its performance ratio. The lower the losses between the modules and the point at which the system feeds into the grid, the higher the performance ratio.
• **Extended lifetime of PV systems** - Extending the lifetime of a PV system increases overall electrical output and improves the cost per kWh. Most producers give module performance warranties for 25 years, and this is now considered the minimum lifetime for a PV module.
• **Development of standards and specifications**-The development of standards and consistent technical specifications helps manufacturers to work towards common goals. When widely accepted by the industry standards, they contribute to reduce costs in design, production and deployment. Standards also foster fair and transparent competition as all actors in the market must play by the same rules [3].

2.5 Photovoltaic system types

Photovoltaic systems can be generally divided into two basic groups:
1. Photovoltaic systems not connected to the network, stand-alone systems (off-grid)
2. Photovoltaic systems connected to public electricity network (on-grid) (1)

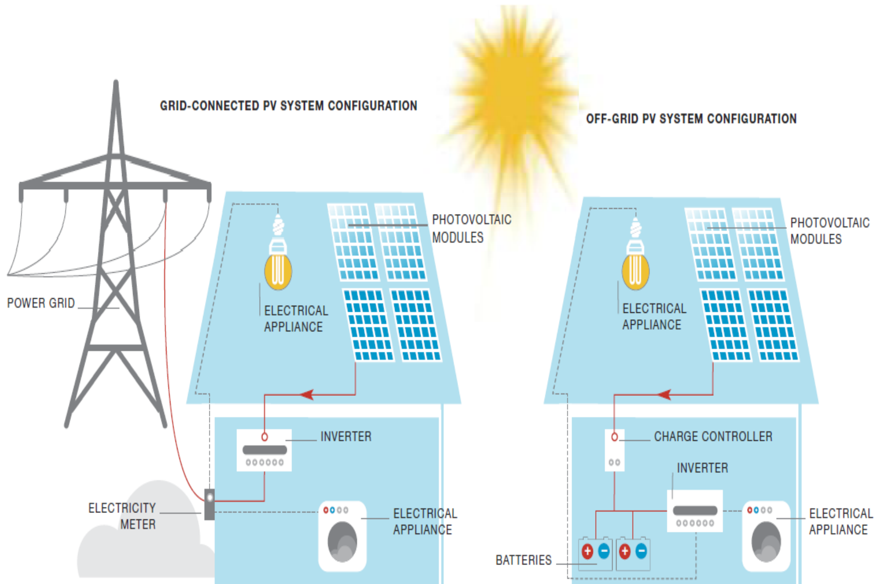

Figure 2 Different Configurations of Solar Power Systems (1).

2.6 Public awareness Feed-in Tariffs: Key driver of solar success

Feed-in Tariff (FiT) scheme that guarantees a price for all renewable electricity that is fed into the grid.
• Have the right to feed solar electricity into the public grid
• Receive a premium tariff per generated kWh that reflects the benefits of solar electricity compared to electricity generated from fossil fuels or nuclear power
• Receive the premium tariff over a fixed period of time.
• Costs are paid by utility companies and distributed to all consumers. This ensures the non-dependence of the government budgets.
• FiTs drive cost reductions.
• FiT encourage high-quality systems. Tariffs reward people who generate solar electricity, but not those who just install a system. It then makes sense for owners to keep their output high over the lifetime of the system (1).

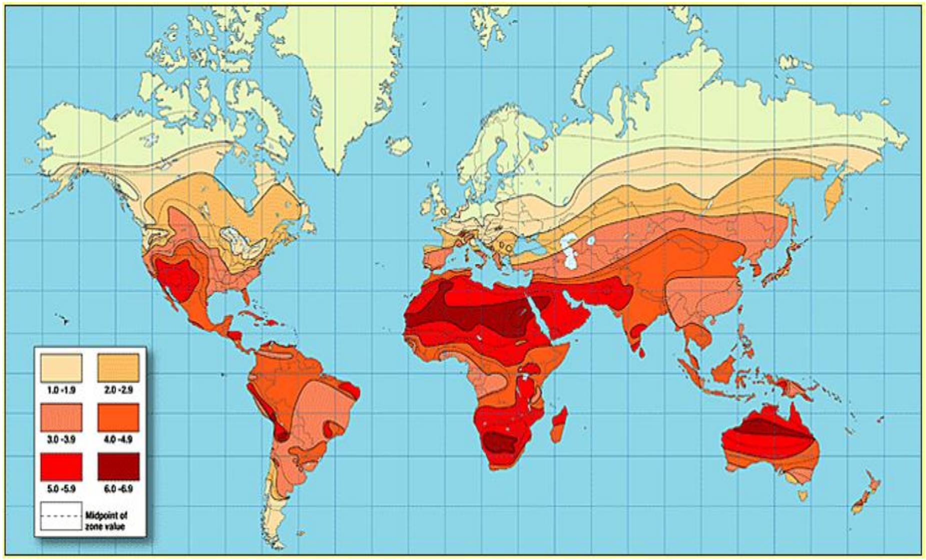

Figure 3 World solar radiation map: Expected number of full sun-hours you can expect in different locations. 1 sun-hour equals 1 kWh per square meter per day (1).

2.7 Total installed PV capacity

The global installed PV capacity has increased in ten years from 1.8 GW in 2000 to 67.4 GW at the end of 2011, a growth rate of 44% per year (1).

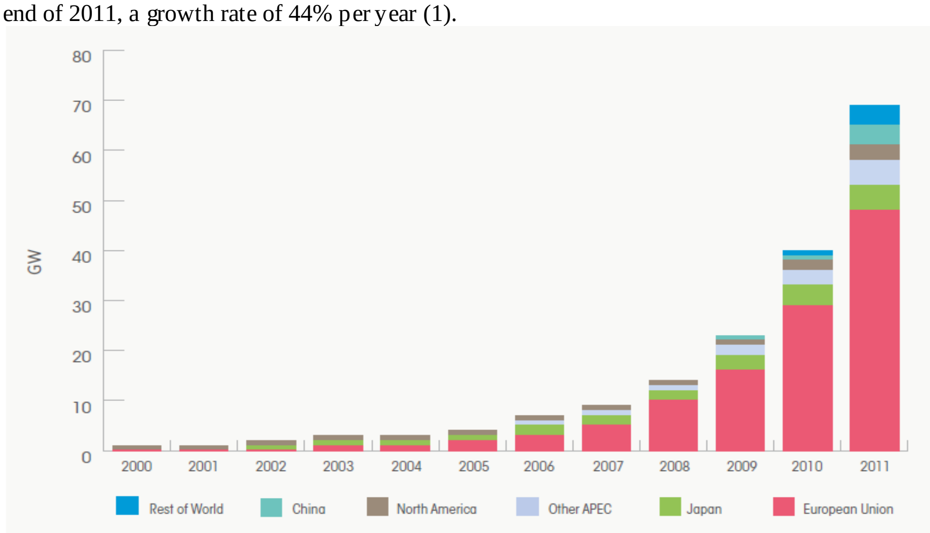

Figure 4 Evolution of global cumulative installed capacity, 2000-2011 (1).

3. Implementation of solar panel in campus of UBT

The geographical position of Lipjan

Latitude 42.5 and in degree N 42° 30' 0"longitude 21.11 and in degree E 21° 7' 0.012"

Table 1 Monthly averaged clear sky and daylight hours (1).

Monthly Averaged Insolation Incident On A Horizontal Surface (kWh/m^2/day)

Lat 42.5 Lon 21.11	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
22-year Average	1.69	2.49	3.47	4.22	5.15	6.10	6.28	5.53	4.13	2.77	1.70	1.34

Monthly Averaged Clear Sky Insolation Incident On A Horizontal Surface (kWh/m^2/day)

Lat 42.5 Lon 21.11	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
22-year Average	2.74	3.91	5.46	6.85	7.47	8.02	7.69	6.70	5.52	4.09	2.84	2.33	5.30

Monthly Averaged Daylight Hours (hours)

Lat 42.5 Lon 21.11	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average	9.46	10.6	11.9	13.3	14.6	15.2	14.9	13.8	12.5	11.1	9.81	9.15

3.1 Determining how many kW photo-voltage systems must be to meet the needs of campus of UBT

Table 2 We have the data about spending on campus of UBT during 2014, except the month 9 and 7 are supposed because i didn't have the bills.

Average kW spend in a day=31485kW/356(days)=88kW

Month	Expenses in kW in months	Amounts in euros
1	3199	370
2	1837	183.5
3	2523	261
4	2278	160
5	2285	185
6	1775	142
7	1107	92
8	1107	92
9	3321	440
10	3321	440
11	4494	572
12	3738	494
	31485	3431.5

The average cost of kW in 2014 kW=3431.5€/31485kW=0.109€/kW

November is the most spending 4494kW for 30 days (November 2014)
5 weekend days (Sundays)
25 working days
All Sundays in campus of UBT costs are external and internal lighting, security cameras, and computer. Costs are around 4kWh.
It means
24(h) x 4kW=64kW during one Sunday
5 Sundays
5 x 64 kW= 320 kW
4494kW-320kW=4174 kW total expenses for 25 working days.
Active period for 25 days are 08:00 - 18:00 10h active
Passive period for 25 days are 18:00 - 08:00 14h passive
14 (h) x 25 (days) x 4kW=1400kW Total expenses of kW for passive hours for 25 days
4174kW-1400kW=2774kW total expenses of kW for active hours for 25 days
Expenses for active hours are lecture halls, amphitheater, cafeteria, security cameras, hall of IT.
Number of active hours for 25 days are 25 x 10h=250h

Average cost per kW for active hours=2774kW/250h=11kW/h
It means that the photo-voltage system must be the 12 kW

3.2 Determination of the position of solar panels

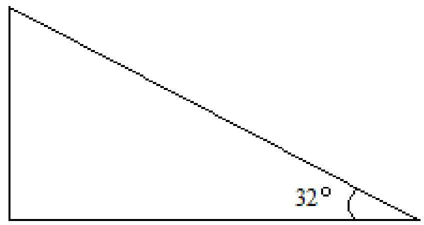

Figure 5 The position of solar panel in campus UBT should be 32 °(1).
Annual optimum angle (rounded to the nearest integer) according to the European Commission database.
Source: http://re.jrc.ec.europa.eu/pvgis/apps4/pvest.php#

3.3 The orientation solar panel

Optimum orientation of the solar collector is the one from the South to the Northern Hemisphere. While the angle against the horizontal plane for which the monthly average radiation is maximal it is called the optimal angle

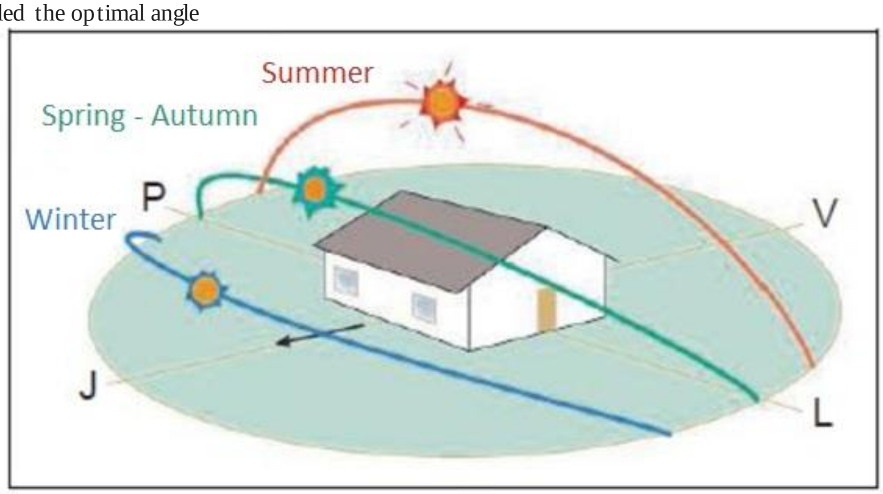

Figure 6 Positions of the sun during seasons of the year (1).

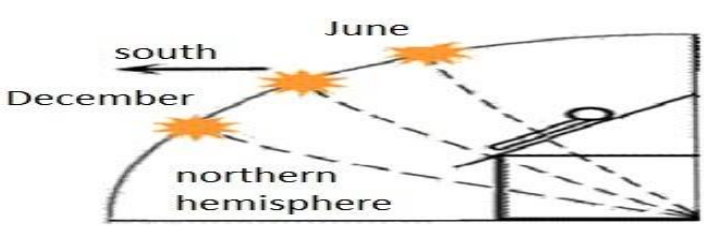

Figure 7 The orientation of the solar collector in the Northern Hemisphere (1).

3.4 Solar system 12 kW and the connection scheme

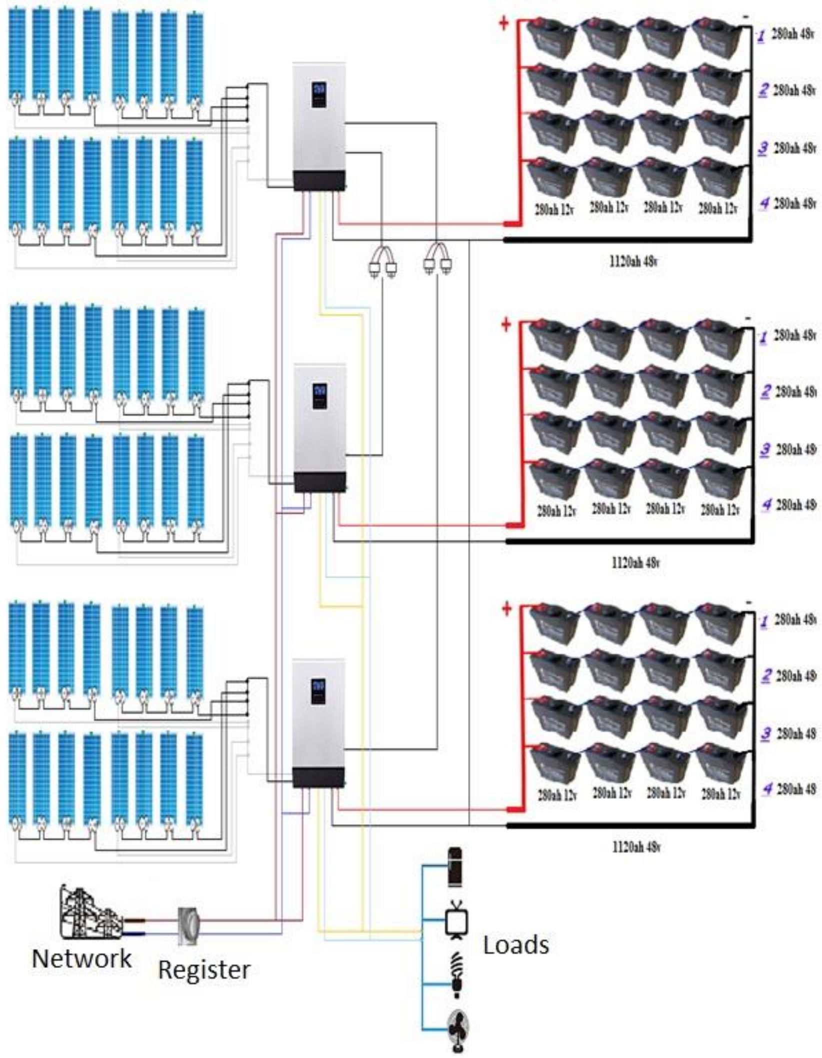

Figure 8 Scheme of connection of photo-voltage system 12 kW battery 12v 280ah membership type and 3 4kW 48V-type inventor PIP 4048MS linked in parallel with 12V 250W solar panels.

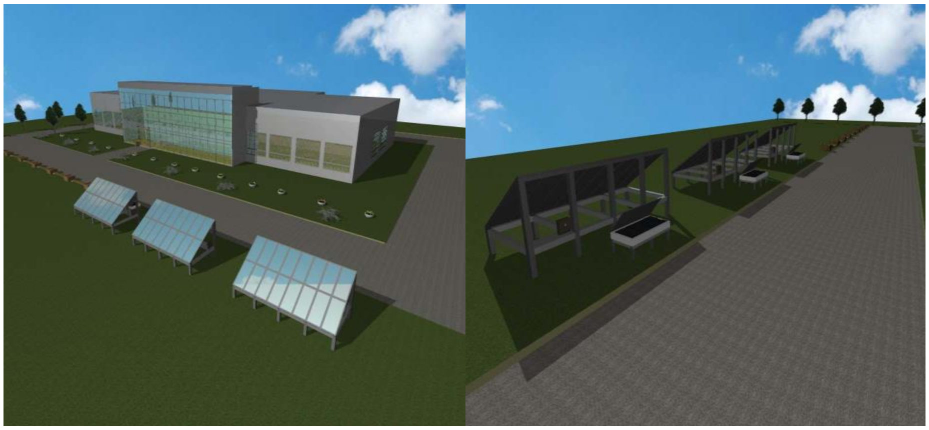

Figure 9 Someviews of solar panels designed with ArchiCAD how it would seem if they were implemented in the UBT Campus.

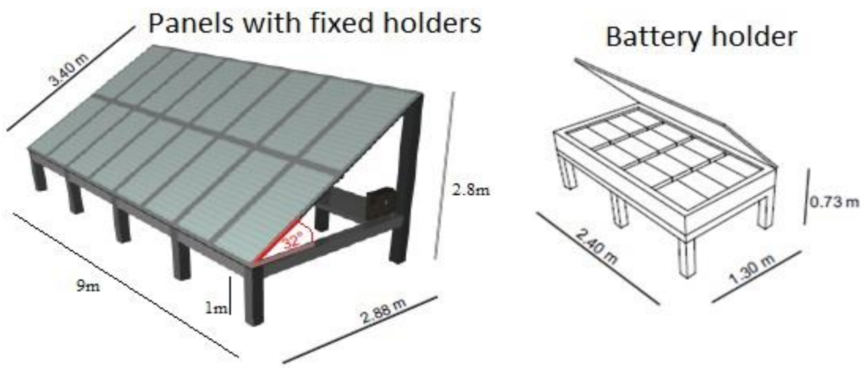

Figure 10 The dimensions of fixture holders of solar panels and the battery holder designed with ArchiCAD.

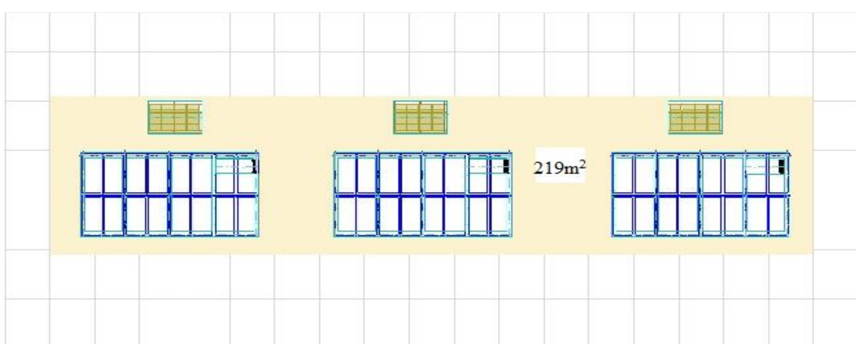

Figure 11 Required space for setting up this solar system of 12kW is 219m2, designed byArchiCAD.

3.5 The cost of this system

Inventor solar system connected parallel 3 * 60A MPPT 4kw charger costs around 2,200 Euro.
Poly-crystal solar panel 250W 12V 10 pieces cost about 1600euro and of 48pc around 8000euro.
Solar Battery 12v 280ah WINNER brand costing around 280 Euros and for 48 batteries costs 48 x 260 = 12000euro.
Holders of panels are static and battery holders are static. These cost around 1500euro holders.

Maintenance
The system will be operated at least 25 years. During the operation, the system should be 1 time changing batteries. observing the trend of reduction costs of battery technology and by then should be implemented the feed-in tariffs in our country. This will reduce the time of return of investment. The system would not need more than 32 batteries. Until then the battery should cost per piece 150 euro. 32 x 150 €= 4800€. Additional maintenance panels must be cleaned in winter when the snow is on panels and dust must be clean in summer time, because it will reduce the efficiency of panels.
Total costs:
3 inventor 2200euro
48 Pc panels 8000euro
48 Pc batteries 12000euro
Holders 1500 euro
Changing batteries 4800euro
Total cost =2200+8000+12000+1500+4800=28500 euro
The cost for 2015 in May costs 28500 Euros approximately, if this investment is made in the coming years then system would cost cheaper and would reduce time of return of investment and dimensions of batteries, panels, Inventor differ depending on producers.
Remark: All data were obtained from the website www.ebay.com to May 2015 prices of equipment. Factors that impact on the price of the system photo-voltage (changes) are: Movements of the US dollar, the price of raw material for producing solar panels, developing technology of solar panels, different prices between different producers, developing of battery technology, battery prices, prices of Inventor, the different prices on different capacities for solar systems etc.

3.6 Return of investment

By knowing the costs in campus of UBT that are around 3431.5 € in 2014. The return of investment. Based on data in NASA see Table 3. Lipjan has average of 5.3 hours of clear skies per day.
Production of electricity from 12kW solar system
12 kW x 5.3h = 63.6kWh for 365 days
63.6kWh x 365 (days)=23214kWh
Multiply with the average cost of kW 0.109 /kW that UBT has paid
23214kWh x 0.109€/kW =2530.3 euro

$$\text{Return of Investment} = \frac{\text{Total cost of investment}}{\text{Production in a year of solar panels}} = \frac{28500€}{2530.3€} = 11 \text{ years}$$

Conclusion

Based on research institutes in the years ahead, we will have more developed technology of photo-voltage and cheaper cost of them , reducing cost will help increase the competitiveness, which helps in increasing the efficiency of panels, reducing prices of solar panels, reducing prices of raw materials , technology development of batteries, reducing prices of batteries and increasing their lifetime, with increased efficiency of panels and batteries we will have smaller dimensions of panels and batteries. Also, smaller dimensions of panels and batteries have less materials being used to produce them. All these help in increasing investment in energy production of photo-voltage.
Based on research that were done in the past decade, we have had rapid developing technology of photo-voltage and cost of them reduced drastically,, which has helped in increasing investment in energy producing by photo-voltages. In our country, if we want to increase investments in energy producing photo - voltages. State should create favorable conditions; one of them will be removing customs for photo-voltages systems, state must do law for feed-in tariff, which will be a deal between distributor and supplier of renewable energies, which would help in return on investment more quickly and would encourage investments in energy producing photo-voltage. This will make better environment to live, electrical energy more and will help to reduce pollution of environment.

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