Energy passivation of a building. The ICSTM building case study

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Abstract. The renewable energy sources are becoming more and more current in the energy supply of buildings, from residential buildings to institutional buildings. The renewable energy sources have proved to be a solution and an important element of the Romanian Energy System. We are starting from the idea of using the renewable sources to passivize a building, and we are relying on existing facilities in the Multidisciplinary Scientific and Technological Research Institute (ICSTM) from Valahia University of Targoviste (UVT) to produce the energy from its own sources. We are also considering the consumption data from previous year as well as the electric link to external power grid. This paper aims to propose new renewable energy units so that ICSTM become energetical independent. Currently, the ICSTM building consumes an amount of energy produced from renewable sources about three times less than that consumed from the external network. In order to determine the number of equipment, specifically CPV (concentrating photovoltaic) panels placed on trackers, it is desirable to create a 40% reserve above the installed power, taking in account the possible future development of the research laboratories.

1 Introduction

An energy-efficient construction is no more than a construction concept that can be reached and applied by anyone. [1]

Multidisciplinary Scientific and Technological Research Institute is part of the UVT, being built on an area with a ground footprint of 2240 m^2 and a total built area of 7250 m^2. The internal part of the building is formed by 35 laboratory spaces, 5 technological laboratories, 6 functional annexes, 7 administrative spaces and 4 dissemination spaces, with installations and equipment used for different activities of research. [2]

Multidisciplinary Scientific and Technological Research Institute is equipped with more sources which produce renewable energy: photovoltaic platform, wind platform, thermosolar platform.

All those sources cover only one part from necessary consumption for ICSTM, the other part is consumed from the National Energy System (SEN) network.

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2. The current state of the ICSTM supply with energy from renewable sources

The current ICSTM equipment consists of:
-The photovoltaic experimental platform which has an active surface of more 250 m^2, and the installed approximate power of 79,65 kWp;
-The wind experimental platform which has the installed approximate power of 25 kWp;
-The thermo-solar experimental platform which has the active surface of more 250 m^2, with an approximate capacity of 10000 litters.

2.1 The photovoltaic experimental platform

This platform is composed of many installations with different installed powers:
- *OnGrid installation,* which is located on the institute's terrace, it has PV panels with the orientation towards south and the inclination 45°. The installed power is 33.15 kWp. It is consisting of three type of panels: monocrystalline silicon panels, polycrystalline silicon panels and amorphous silicon panels. It is equipped with 6 inverters of SMA 5000TL-21kW type. [2]
- *OffGrid installation* located on the ICSTM terrace, it has PV panels with the orientation towards south and the inclination 30°. It has the installed power of 42.5 kWp and it is consisting of two types of PV panels, two types of invertors and 100 batteries.
- *The Off Grig installation of parasolar type.*

The ICSTM building is separated in three building bodies and the panels repartization had been made in the following way: the system in front of ICSTM consists of 120 photovoltaic panels of semi-transparent Altius AFP type.

PV of parasolar type consists of polycrystalline silicon panels with the 250 W nominal power.

- *The OffGrid installation of curtain type*. It consists of 51 Q.Cells Q.Pro-G3 BLK photovoltaic panels, polycrystalline silicon panels, 7 inverters of Victron Multiplus 5 kW, 2 inverters of Victron Multiplus 3 kW and 100 VRLA Gel Deep Cycle 220Ah and Victron VRLA Deep Cycle 220Ah batteries.
- *Fixed Tracker with 4kWp power*

The Tracker has two axes and the 25 m^2 surface. It consists of 15 Q.Cells Q.Pro-G3 BLK photovoltaic panels and 2 SMA SunnyBoy 2 kW inverters. The photovoltaic panels on the tracker are from polycrystalline silicon.

2.2 The wind experimental platform

The wind experimental platform has the wind installations with turbines which have vertical axis or horizontal axis: the OnGrid installation; the MagLev installation; the SmallWind installation.
- *20 kWp OnGrig installation* on the ground has: one Aeolos HAWT wind turbine with 10 kW power and horizontal axis, 24m monopole; the Aeolos VAWT wind turbine with 10 kW and vertical axis, 260 rpm, 18m monopole; two ABB Wind inverters 15kW.
- *MagLev installation*. It is a wind turbine which function on the principle of magnetic levitation [3], it has vertical axis and is located on ICSTM terrace with 3 kWp power.
- *2 kWp SmallWind installation* has: one Aeolos HAWT wind turbine with 1 kW power, horizontal; one Aeolos HAWT wind turbine with 1 kW power, vertical.

2.3. The thermo-solar experimental platform

The thermo-solar experimental platform from ICSTM includes: the thermo-solar installation for heat input; the thermo-solar installation for domestic hot water.

- *26 kWp Thermo-solar installation* for heat input includes: 12 Westech SP-S58/1800A-20 EHPT thermo-solar panels with vacuum tube; 5 Alfa-Bit Beta 58/1800-12 thermo-solar panels; 10 Tesy SP 07 250 ASL flat-plate thermo-solar panels; Taconova Tacosol Circ ZR High efficiency pumping stations; Ferroli Ecounit 1000-2WB heat exchanger and storage boilers.
- *thermo-solar installation* for domestic hot water by 600 liters which includes: two SunSystem boilers of 300 litres -a thermosiphon system with flat catheters.

3 The own produced energy and total consumption of energy from ICSTM

Calculation were made for one calendar year considering the energy consumed from the produced energy by ICSTM's own equipment from and the energy consumed from national network and the cost for that moment.

Total energy produced by the photovoltaic platform in the studied period is 112417.22 kWh, it shown in the figure 1, the total produced energy by the wind platform is 21600.58 kWh, it shown in the figure 2, and the total produced energy by the thermo-solar platform is 21252.20 kWh.

Energy consumption in the same period from SEN was: the consumption of electrical energy 239908.4 kWh; the consumption of natural gas 259008.32 kWh, so a total consumption 498916.72 kWh shown in the figure 3, this value represents an annual daily average of approximatively 59.95 kWh. The value payed to supplier was 35470.60 EURO.

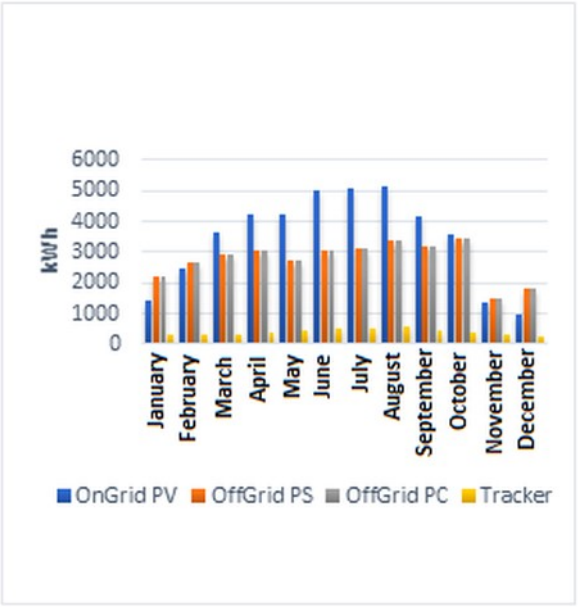

Fig. 1. The total produced energy by the photovoltaic platform

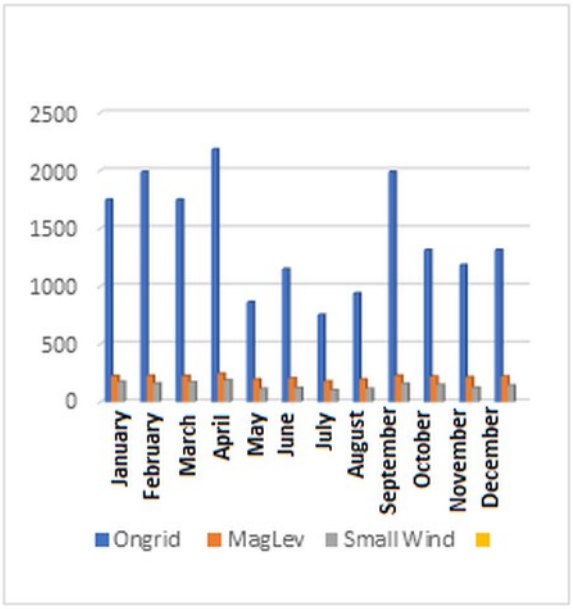

Fig. 2. The total produced energy by the wind platform

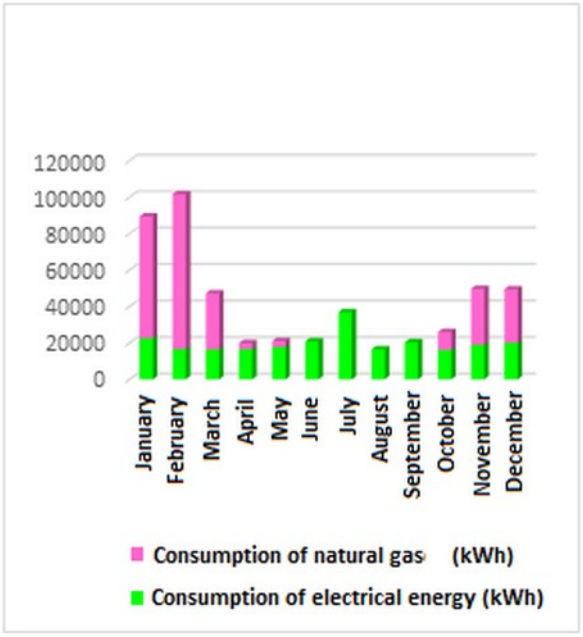

Fig. 3. The total consumption of energy from SEN

We find that the absorption of energy from the national network is about three times higher than the production of the developed energy with the currently own equipment as shown in figure 4.

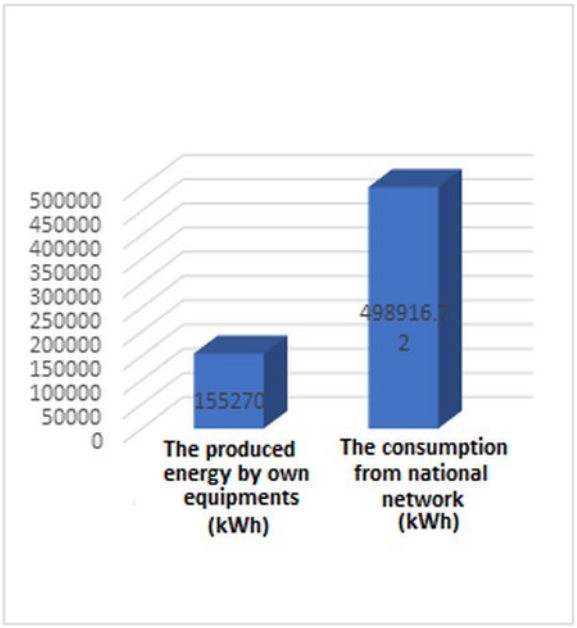

Fig. 4. The total energy (from national network and produced with own equipment)

4 Proposal for the ICSTM building power supply only with energy from own renewable sources

The purpose is to fully feed the ICSTM building whit renewable energy produced from own sources, because the amount of bills paid to the energy provider rises to very high values.

To cover all the energy consumption that ICSTM currently has but taking into account the possible development of ICSTM laboratories or the failure of current sources of renewable energy we need to consider a 40% surplus. This means that the necessary energy from renewable sources will increase to approximatively 689483.408 kWh a year. Thus, the annual daily average needed will be around 80 kWh.

Solution we propose to achieve the autonomy of ICSTM building is: installing ten systems of *concentrating photovoltaic panels* (CPV) Tracker type with two axes of 12.00 kWp.

Trackers will be located near ICSTM building, figure 5, on same line whit the existing tracker on the right of the alley and other six on the left of the alley, between the alley and the Greek Amphitheatre, parallel whit the ICSTM building.

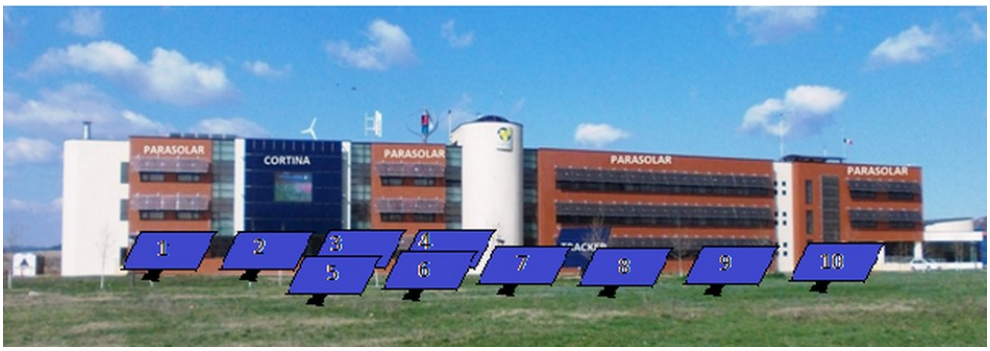

Fig 5. The location of the trackers

4.1 The equipment chosen

➢ *Concentrating photovoltaic panels* (CPV) were chosen because these have the efficiency of 27.2% against the usual panels which have efficiency around 15%. These panels behave well in small but unshaded spaces in tracker systems. [4]

Panels chosen are Concentrix Solar 75 Wp CX-75 CPV Multi-junction, nominal capacity 75 Wp, voltage MPP 135 V, current MPP 0.55A, short circuit current 0.64 A, output circuit voltage 150 V, maximum voltage 1000 V, length 828 mm, width 428 mm, weight 9.5 kg.

➢ *Tracker – because the concentrating photovoltaic panels* (CPV) have smaller sizes than classic ones, and the tracker offers a more space than the existing one, approximatively 70.6 m^2, we will used 198 panels a single tracker. The nominal power is 8000 – 12000 Wp, the elevation angle is from 10º to 90º and the rotation angle Est-West of maximum 300º.

➢ *Inverter* –5 inverters SolarMax 20C type will be used, with recommended PV power 24000 W, Max. DC input voltage 900 V, Max. DC input current 48 A, AC nominal power 20000 W, maximum AC output power 20000 W, weight 275 kg.

➢ *Batteries* – To ensure the storage of produced energy by the ten trackers (1980 panels) is takes 4 modules of 40 batteries are needed which together give:

$$40 \text{ batteries} \times 480 \text{ V} \times 260 \text{ A} = 124.8 \text{ kW} \quad (1)$$

Batteries will be Battery Rolls Solar 4000 - S260 type with the nominal capacity of 200Ah / C 20 – 266 Ah/ C 100, voltage 12 V. [5]

➢ *Regulator – the type chosen is REGULATOR* VICTRON ENERGY BLUESOLAR MPPT 150/60 – TR with the characteristics: auto-selector system voltage/battery 12/24/36/48 V, power of photovoltaic panels 12V-860W / 24V-1720W / 48V-3440W, the maximum voltage for photovoltaic panels 150 V when the temperatures is low / maximum 145 to start and normal operating, maximum charge current 60 A, maximum efficiency 98% and the operating temperature -30/+60ºC.

➢ *PV electric cable* – 500 m

On a tracker with the chosen dimension are necessary 198 CPV panels and we obtain for each formed system 10 kWh. Given that we need 10 such systems, the total cost for the panels is 135229.79 EURO.

Table 1. The total costs on the investment.

Equipment	Number of equipment	Price (EURO)
Concentrix Solar 75Wp CX-75 CPV Multi-junction	1980	135229.79
Invertor - SolarMax - SolarMax 20C	5	7420.22
Battery Rolls Solar 4000 - S260	160 (4 modules)	48935.90
Tracker	10	122340.50
PV electric cable	500 m	590.00
REGULATOR VICTRON ENERGY BLUESOLAR MPPT 150/60 – TR	10	5000
Set cables/box connections/fuses/connectors		1900.00
The workmanship		17021.30
The total cost		**338469.90 EURO**

4.2 The amortization of the costs

The total cost of purchasing the sources used to obtain ICSTM energy passivation, is 338470 EURO. Regarding the values of the bills in one year, which ICSTM payed – 35470.563 EURO, we can approximate the amortization time for the investment costs.

Table 2. The amortization of the investment costs.

Initial Investment - 338470 EURO			
The produced energy on year - 698.483 MWh			
The year	**The produced energy MWh**	**The amortization of the investment (RON)/(EURO)**	**The remaining amortized value (RON)/(EURO)**
1	698.483	35470.563	302999.2
2	691.498	35470.563	267528.7
3	684.583	35470.563	232058.2
4	677.737	35470.563	196587.6
5	670.959	35470.563	161177
6	664.249	35470.563	125656
7	657.606	35470.563	90175.9
8	651.030	35470.563	54705.3
9	644.520	35470.563	19234.75

10	638.075	19234.75	0
11	631.694		0
12	625.377		0
13	619.123		0
14	612.932		0
15	606.803		0
16	600.735		0
17	594.727		0
18	588.780		0
19	582.892		0
20	577.063		0
21	571.293		0
22	565.580		0
23	559.924		0
24	554.325		0
25	548.782		0
Total	**15518.70**		

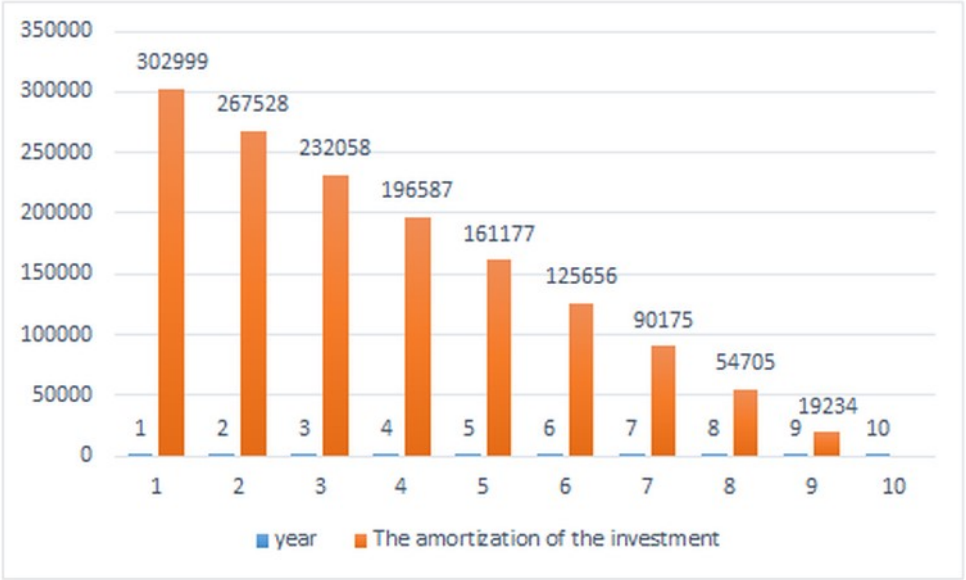

Fig. 6. The amortization of the investment

The amortization of the investment is made in 9 years and 7 months, and the lifetime of the equipment in 25 years, table 2, figure 6.

5 Conclusions

The ICSTM building is now partially powered from renewable sources and partially from national network (SEN) of energy. The quantity of energy produced from renewable sources is about three times less than the energy consumed from the national network.

The study drawn for the ICSTM building to became autonomous in terms of energy consumption shows that this is possible if we add to the current renewable sources, some others renewable sources.

The best solution resulted after several atempts, is the use of 1980 CPV panels mounted on 10 trackers with 10 charge regulators for 4 banks which contain each 40 batteries and 5 inverters – 24 kW toghether with necessary materials for instalation.

When we determined the number of equipment, a 40% reserve over the required power to install for the future development of the research laboratories was considered.

By comparing the cost of the investment with the value of the energy bills, it was found that the investment is depreciated within 9 years and 7 months, the lifetime of the equipment being 25 years.

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