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Design PV System for Any Building: a case between conventional solar cell and Nano Solar Cell

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Abstract

PV cells are the technology used to generate electricity from sunlight. Today PV companies are overborne by chip reliaced on crystalline Si but are hocked by lofty cost. Nanotechnology is globally abided as a key technique for technological and innovations remedy in all forks of the economy. In this work, a PV system is designed to congress its load requested, and this design is included both conventional PV system and Nano PV system. A collation between two types of the PV system is made from the number of system components and the cost. Finally, the cost of the Nano PV system is lower than that of conventional PV system for the same building (same load).

Keywords: MPPT controllers; Nano PV system; PV system design; PV system; Solar battery

I. INTRODUCTION

Solar energy is used to correspond to any type of loads (commercial & domestic) loads required. The cost and efficiency of the conventional PV cell made. From chip of crystalline Si cell is high or low respectively and so on correspond the type of loads. A collation between PV Nanosystem and PV system has appeared the last to be economy and loss costly [5].

The hindrance of familiar PV solar cell to bezel has been restricted by Nano cell [8]. PV cell is so expensive than traditional power generation in order to be widely used as domestic energy suppliers. In order to reduce the electrical energy cost, PC cell efficiency must increase. Recent research power proves that the silicon nanowire is excellent light absorber which will enhance the PV cell efficiency [17].

I.I Solar PV System

Electricity can be generating by a SPV system and supplies power from many sorts of instruments after saving the energy in a battery bank. A solar PV system furnishes power and energy from various sorts of appliances after enshrining the capacity in a battery bank [17]. SPV panel is the radix strain regardless of any system arranging. PV cells are the structure lumps of the panel [5; 15]. Different components are chosen for sight solitary needs, climate, site scene and expectation.

I.II Solar Ingredients

The operational and functional necessaries specify the ingredients to be adequate for the PV system. The logical parts of this system which are given in Figure 1, consist of PV cells, charge controller, battery bank, inverter and the specifies electrical loads [8; 2].

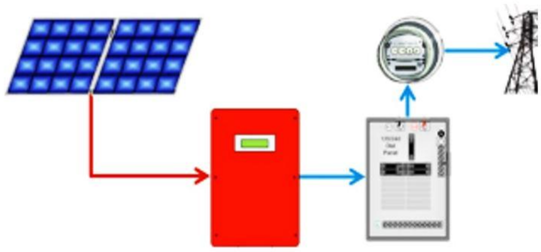

Figure 1. PV System

- PV cells: it diverts sunlight instant onerously to DC potential.

- Charge controller: it contains DC to DC controller and preventing battery overcharging in order to get the long battery life of the PV system.

- Battery bank: battery bank stores energy when excess energy coming out of the demand.

- Inverter: it converts DC/AC so that supply the AC load with electric power [28].

I.III Design of PV System

For the purpose of designing a PV system of a building, the following procedures are considered. The designing of the PV system based on the sorts of electrical load [19; 9; 18; 22].

Step 1:

Identification, the load till identifiable the overall electrical load request, maybe DC or AC loads and the numbers of operational hours for each, can be calculated by using formula 1.

Total load = (DC loads * number of operation hours per day) + (AC loads * number of operation hours per day)

(1)

Step 2: Battery Size Selection

In order to determine the batteries numbers, the formulas (2-4) is needed. Autonomy days are considered within this design, and during this time, the load comes upon the depth of discharge of the battery. The capacity of the battery in Ah is given in formula 2 [11].

$$\text{Battery bank capacity} = \frac{Avg.Wh\ per\ day\ of\ autonomy}{Battery\ voltage * depth\ of\ dish.} \quad (2)$$

No. of batteries in series or parallel connection is given in formula 3 & 4.

$$\text{No. of battery in series: } \frac{System\ Voltage}{Battery\ nomined\ voltage} \quad (3)$$

$$\text{No. of battery in parallel: } \frac{Battery\ bank\ in\ (Ah)}{Ah\ of\ battery} \quad (4)$$

Step 3: Selection of solar cell array.

The Sizing of the array must meet the average value of (Ah request per day) required with the nominal operating voltage. Average Ah per day can be obtained by [3; 12; 10; 23; 25]:

$$\text{Avg. Ah per day} = \frac{Avg.taken\ from\ battery\ per\ day}{battery\ efficiency} \quad (5)$$

The peak amperes value of the array is calculated by this formula.

$$\text{Peak amperes of array} = \frac{Battery\ avg.Ah\ per\ day}{Peak\ sunshine\ hours\ per\ day} \quad (6)$$

No. of the module that connected in series and parallel is given below:

$$\text{Module connected in series} = \frac{Battery\ banl\ voltage}{Nominal\ module\ voltage} \quad (7)$$

$$\text{Module connected in parallel} = \frac{Array\ peak\ per\ day}{Peak\ ampere\ per\ day} \quad (8)$$

Step 4: Array Inclination Selection.

PV module must be faced the north in the southern hemisphere and south in the northern hemisphere. In the installation, PV array must be steady at an angle depending on the latitude of the place, so that it is necessary to subtract or to add 10o angle at various latitude [16]. The till the angle of the PV array is depicted in table 1 [13; 7].

Table 1. PV array tilt angle

Latitude (Avg.)	Tilt angle
9	15
(10-20)	Latitude + 5
(21-45)	Latitude + 10
(46-65)	Latitude + 15
(66-75)	80

II. MATERIALS AND METHODS

The materials and methods used in this work are illustrated as follow:

II.I System Description

The suggested location is a building that sited at university college Dublin (6º 02/ W 52º 59/ N), Ireland. The irradiation data is got at Dublin airport weather station. Average universal disposed to irradiation received by the PV array is (1000W/m^2) and the power of this building is 53.625KW, and the power needed for Delhi technological university is 5700W. The system design calculations are made by a visual basic program [6]. System details ate given in table 2.

II.II Economic Cost Method

The approaching that taken in this work supposes the interchange the PV system mixed with the national grid. The time required to recompense for the overall (renewable) primary energy needed through PV system life cycle [6]. Financial analysis is achieved to find the effect of various potential renewable energy based on conventional PV system and Nano PV system per year [20].

Payback time (year) = cost system (6)/annual saving or profits.

The electricity cost (LCoE) self-result from the system. It performs the ratio of overall lifetime costs of generated electricity to the overall estimated electric energy offspring in terms of the present value [4]. The method of LC_oE is [20],

$$\text{LCoE} = \frac{\sum[(I_t + M_t)\ (1+r)^{-t}]}{\sum[E_t\ (1+r)^{-t}\ ]} \quad (9)$$

II.III Experimental Details

The manufacturing specifications of the materials are illustrated as follow:

II.III.I Silicon Nanowire synthesis

PV nano-crystalline Silicon boron-doped substrate with the resistivity of (3-10 Ω.cm) and orientation value (100) is put as the basic material. The P-Si wafer thickness is approximately 360μm. The samples used for the synthesis of Si nanowire and solar processing is cut from an area equal (1 cm^2) [21].

Firstly, the substrates are cleaning ultrasonically in ethanol and acetone during 5min; after that, they rinsed in DO-water and dried with N2. In order to obtain on vertically aligned Si nanowires with requires length [24].

The next step after cleaning the substrates is dipping then in an aqueous $AgNo_3/HF/H_2O$ solution with the ratio of 4:34:162 for 3 min, at room temperature.

The chemical reaction process can be reprinted by these equations:

$$Ag^+ + e^- \rightarrow Ag \quad (10)$$

$Si + 6F^- \rightarrow SiF_6^{2-} + 4e^-$ (11)

II.III.II Fabrication of Solar cell

In order to obtain solar cell samples, a Schottky structure, as depicted in Figure 2, is used.

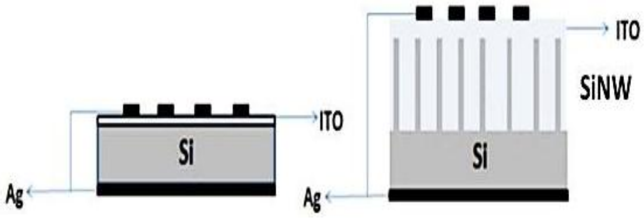

Figure 2. Schematic diagram Schottky solar cell with and without nanowires.

Broad back metal contact is made by Ag sputtering on the rear side of the substrates (Si & Si nanowires) then, annealed them at 120 ºC, to build the ohmic contact. The annealing temperature is sufficient to mutate the Ag contact on nano-crystalline Si substrate to an ohmic one. Schottky contact front side is made by sputtering of IID as a transparent conductive layer. Figure 3 represents the function of IID as suitable to form. Schottky contact on P-Si surface. [26].

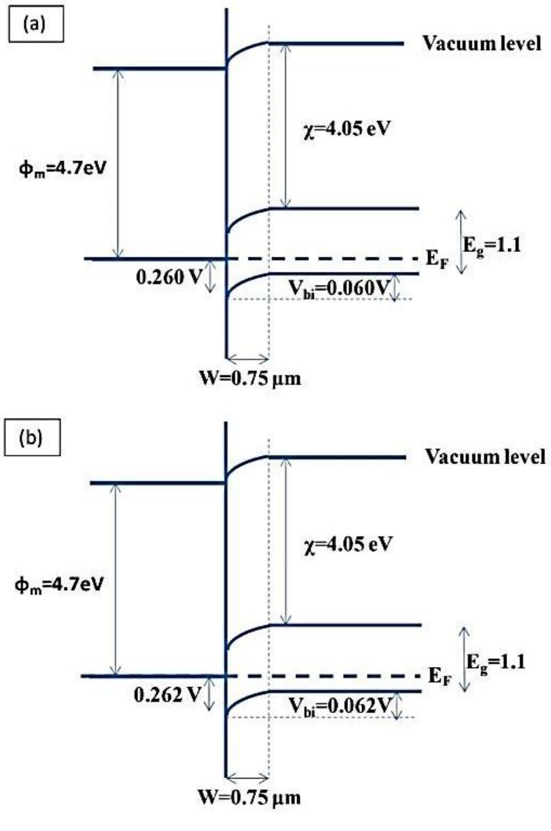

Figure 3 Band energy diagrams (a) Si (b) Nanowires/Si substrates

II.III.III Characterization Methods

Morphology of nanowire Si sample is tested by scanning electron microscopic (SEM) MIRA3 TESCAN model. Assaying of synthesis nanowire chemical composition is done by x-ray. The processed samples are characterized by current-voltage (I-V) technique are light and dark conditions [1]. A standard light (AM 1.5) is used for measuring the properties of the solar cell [27].

II.III.IV Theoretical Aspects

(I-V) solar curves represent the superposition theorem of these curves in light and dark clauses. The shifting (I-V) curve down into the fourth quadrant is happed due to light incident, and the power will extracting from the diode [14]. The diode law is:

$$I = Io\ [\exp\ (\frac{qV}{nkT}) - 1] - IL \quad (12)$$

Where,

I_o: Saturation current in the dark.

V: Voltage at diode terminals.

The efficiency (η) of the solar cell can be determined like the fraction of the incident electrical power that will be converted to electricity as given:

$$Pmax. = V_{oc}\ I_{sc}\ FF \quad (13)$$

$$\eta = \frac{V_{or} \cdot I_{sc}\ FF}{P_{in}} \quad (14)$$

Where,

FF: Fill factor of (I-V) curve.

$$FF = \frac{V_{MP} \cdot I_{MP}}{V_{oc} \cdot I_{sc}} \quad (15)$$

V_{oc}: Open-circuit voltage.

I_{sc}: Sort-circuit current.

II.III.V Designing of PV System

The higher education of building (university college Dublin) [17] & Delhi technological university deem as a case study, are well-known buildings the total hourly load of university college Dublin & Delhi technological university are 53625Wh and 5700Wh respectively as shown in table 2.

Table 2. A load of building studding

Building	Load (W)
University College Dublin	53625
Delhi technological university	5700

Table 3 Providers the data of conventional PV module and Nano PV module.

Table 3. Ratings of two PV modules

Conventional PV module		Nano PV module	
Peak power	170W	Peak power	170W
Peak power voltage	31.7A	Peak power voltage	27.8W
Peak power current	3.8A	Peak power current	4.3A
Open circuit voltage	43.6V	Open circuit voltage	41.1V
Short circuit current	8.1A	Short circuit current	5.1A
Max system volt.	600V	Max system volt.	1500V
Series fuse rating	15A	Series fuse rating	25A

Table 4 providers the data of solar battery.

Table 4. Ratings of solar battery

Battery specifications	Value
Voltage	12V
Ampere hours	200Ah
Depth of discharge	0.8
Efficiency	0.9

III. RESULTS AND DISCUSSION

The number and cost of all components used in the conventional PV system (University College Dublin) are given in Figure 4.

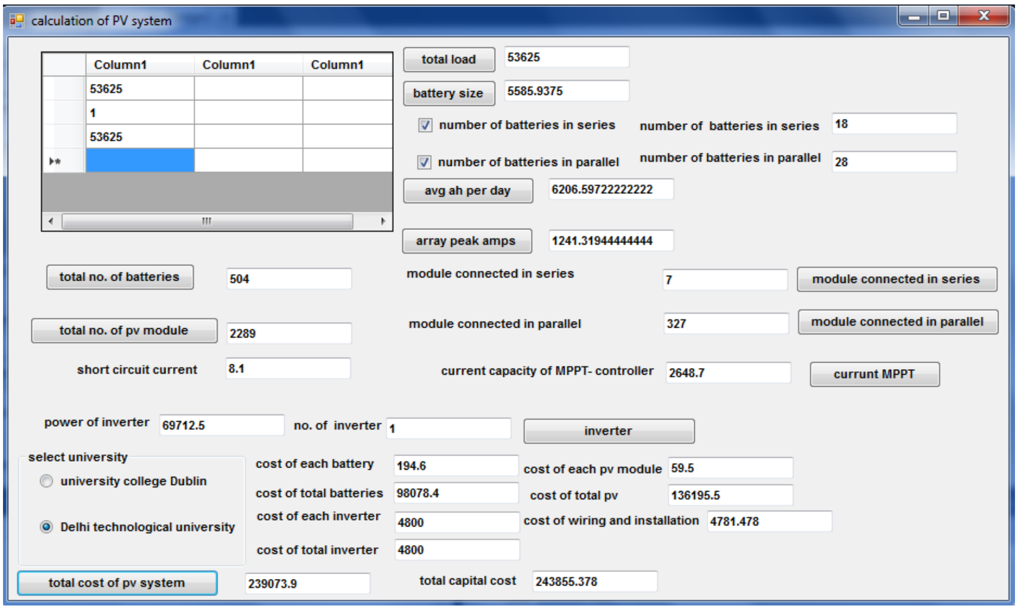

Figure 4. Conversational PV system of university College Dublin (number & cost)

Total=53625W (each inverter has capacity 70KW).
Cost of each inverter=4800$.
Cost of each PV panel=59.5$.
Cost of battery=194.6$.
The result:
Total no. of batteries=504.
Total no. of PV module=2289.
Over the cost of PV system=239073.9$.
Total capital cost=243855.378$
The number and cost of each and all components used in the nano PV system (University College Dublin) are given in Figure 5.

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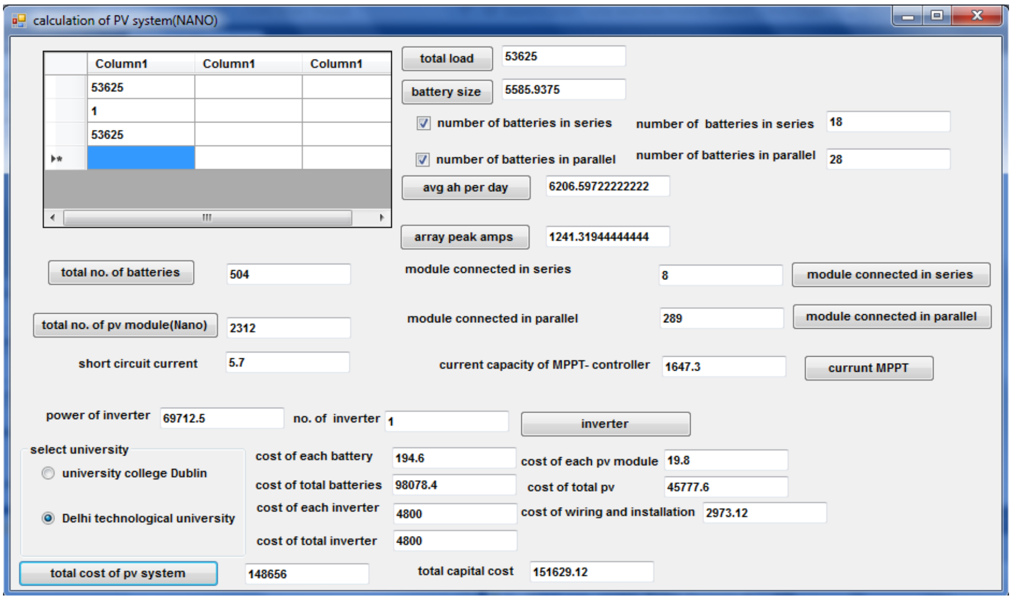

Figure 5. Nano PV system of University College Dublin (number & cost)

Total=53625W (each inverter has capacity 70KW).
Cost of each inverter=4800$.
Cost of each PV panel (Nano solar)=19.8$.
Cost of battery=194.6$.
The result:
Total no. of batteries=504
Total no. of PV module=2312
Over the cost of PV system=148656$
Total capital cost=151629.12$
The number and cost of all components used in the conventional PV system (Delhi Technological University) are given in Figure 6.

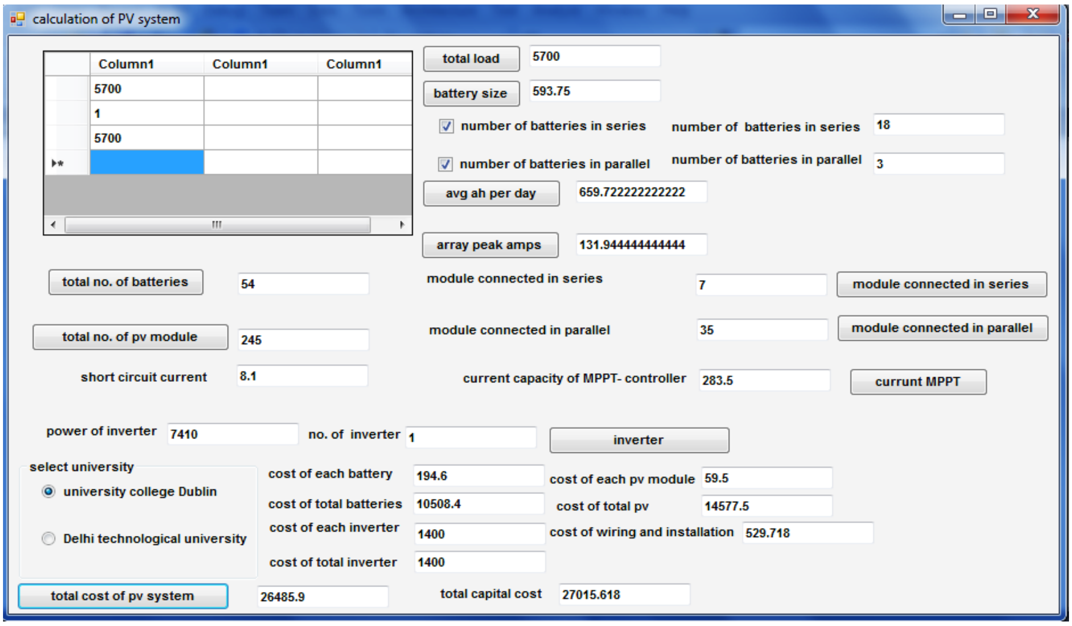

Figure 6. Conventional PV system of Delhi Technological University (number & cost)

Total=5700W (each inverter has capacity 8KW).
Cost of each inverter=1400$.

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Cost of each PV panel=59.5$.

Cost of battery=194.6$.

The result:

Total no. of batteries=54.

Total no. of PV module=245.

Over the cost of PV system=26485.9$.

Total capital cost=27015.618$

The number and cost of each and all components used in the Nano PV system (Delhi Technological University) are given in Figure 7.

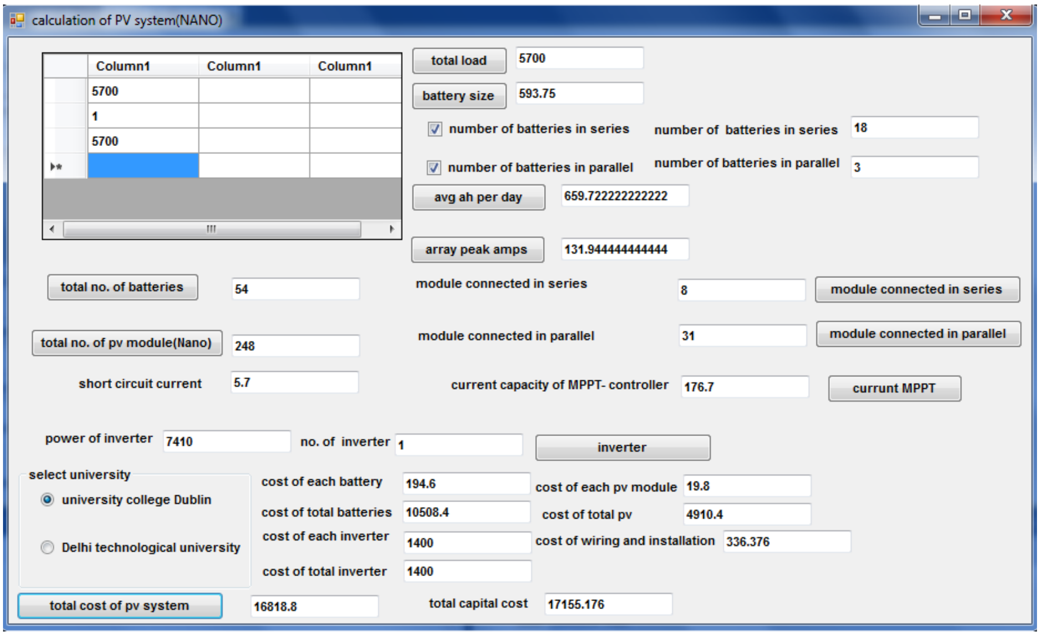

Figure 7. Conventional PV system of Delhi Technological University (number & cost)

Total=5700W (each inverter has capacity 8KW).

Cost of each inverter=1400$,

Cost of each PV panel (Nano solar) =19.8$,

Cost of battery=194.6$.

The result:

Total no. of batteries=54.

Total no. of PV module=248.

Over the cost of PV system=16818.8$.

Total capital cost=17155.176$.

The procedures of determining the PV system components and calculating the cost of each component and the total system is given in Figure 8.

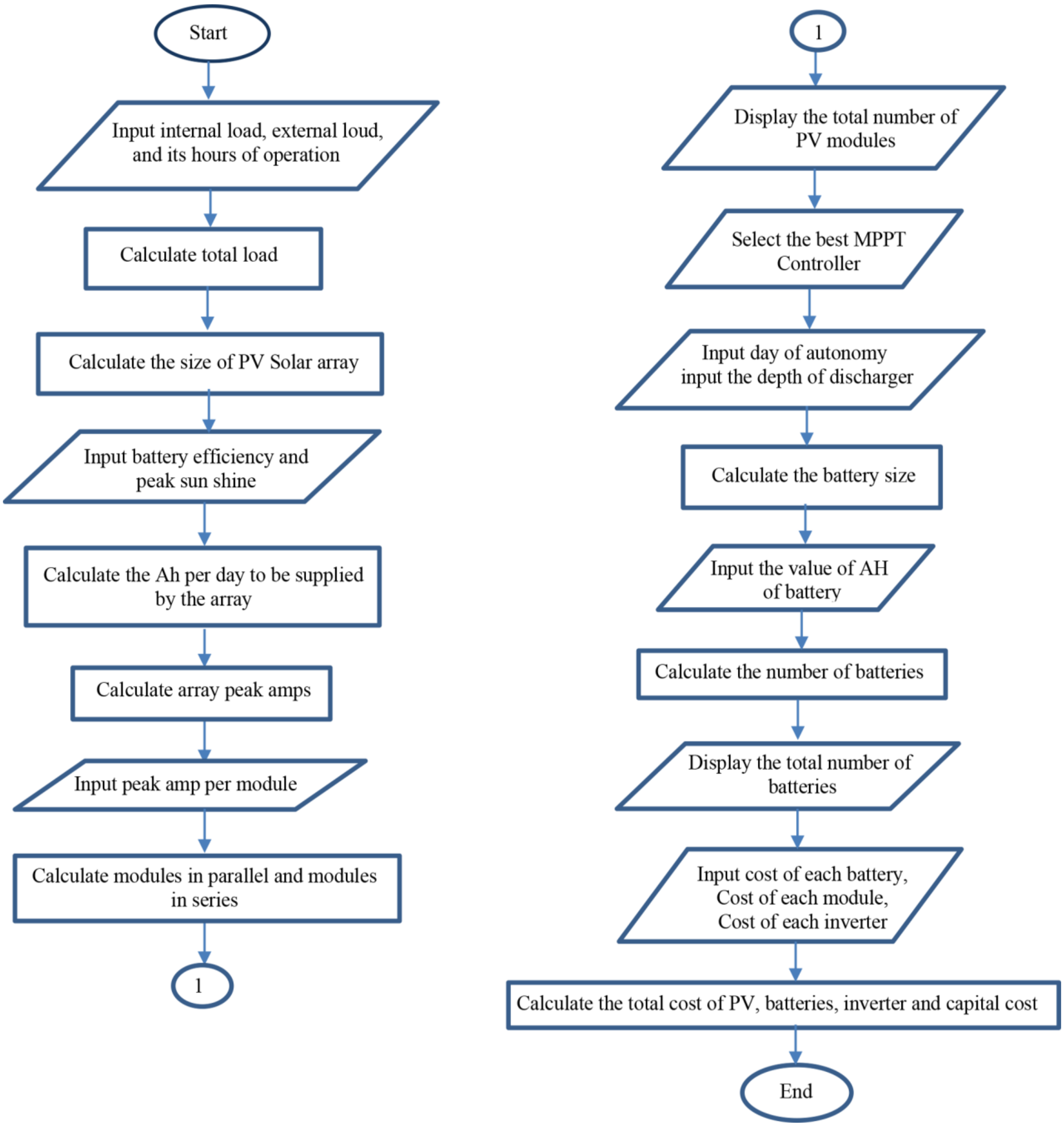

Figure 8. Flow chart represents the designing of the PV system.

IV. CONCLUSIONS

The designed program is suitable for all conventional and Nano PV system. The components of both conventional and Nano PV system can be determined by giving the total load only for any PV, battery and inverter type. Nano solar PV system that designed for University College Dublin and Delhi Technological University building is more economical as compared with the conventional solar PV system. The cost of Nano PV system is less than that of the conventional PV system.

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