Optimization of Photovoltaic Plant

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***Abstract*—**In this paper, we have to design and optimization of large scale solar photovoltaic plant of 1 MW and it minimized LCOP .It is not widely seen that large scale plant use any mechanical tracking system ,although there are some discussed in.In this project we also do new things in this thesis like creation of cost variable including series solar panel cost ,parallel solar panel cost and series parallel solar panel cost .In this paper we design the cost function of 1 MW solar photovoltaic plant which is termed as fitness function ,and to operate this cost function with the help of genetic algorithm section in global optimization tool box in matlab to obtain the desirable solution so after operating the algorithm we get the optimize value of cost function of 1MW solar photovoltaic plant .

Keywords-*LCOP (Levelized cost of production)*

I. INTRODUCTION

Photovoltaic Plant :-It is kind of solar park and large scale plant where system is designed for supply merchant solar power into the electricity grid.. SPV power plant consists of SPV modules in arrays (total wattage being 1 kW or more), re-chargeable battery bank, power conditioning unit (inverter & charge controller) etc. When sunlight falls on the SPV module, DC current is produced, which is stored in a battery bank. The inverter converts the DC current from the battery into AC current which, in turn, is used for operating various loads, such as, lights, fans or other electrical appliances in the building, subject to the total load (watts) being restricted to the capacity of the module (Wp).

mathematical model of SPV was presented and showing the effects of shunt resistance on the performance of the panel. In , designsofvarious types photovoltaic (PV) components were discussed with two case studies. A new control technique of a cascade multi-level inverter for minimization of shading effect and showing a degradation of DC bus capacitors was presented . Inverters that have the capability of eliminating harmonics for large

The output of any SPV system depends upon solar irradiance and temperature. A conventionally lumped diode model of a cell is popular for simulating the behavior with irradiance and temperature, but, more accurately, in , a model of solar cells with distributed diode has been investigated and compared with a one-diode lumped diode model. In , a thin-film solar cell is presented under different spectrums of insolation. Xiao and Xu reviewed high-efficiency solar cell materials, devices, and physics for last 20 years. The architecture of plants such as series parallel (SP) and total-cross-tide (TCT) is presented in for minimization of shading effects on plant performance. With under-shading, multiple peaks methods, the maximum power point might be trapped in local maxima, which reduces the plant are present in the power voltage curve of the panel; whereas, with conventional MPPToutput. In [19], a neural network-based technique (radial basis function– artificial neural network [RBF-ANN]) was presented that performs maximum power point (MPP)—even in non-uniform conditions. Several large-scale SPV plants and case studies have been presented in . One of the major challenges in SPV systems is the optimization of plant size to improve the overall performance of the plant. In , the optimum technique to connect renewable energy sources with the grid using the Solver platform has been presented. An analytic hierarchy process (AHP) was performed on decision making of PV modules for very large-scale SPV systems in .

The optimization with different variables and economic analysis is presented in . A mathematical procedure for modeling SPV in a TCT configuration with rectangular (*N* rows with *M* modules each) and non-rectangular arrangements operating in uniform and mismatching conditions is presented in . Non-uniform irradiance on modules has significant effects, resulting in heating borders deactivation . The output of the function of irradiance and how to increase the radiation on panels using mechanical tracking systems is discussed in . In the design of large-scale SPVs, the cost and output power are compromised and to minimize levelized cost of production

(LCOP). It is not widely seen that large scale plants use any mechanical tracking systems, although there are some, as discussed in . The economic analysis including net present value (NPV), internal return rate, and payback period of large scale plants and methods to design optimum SPV plants based on genetic algorithms (GAs) is presented in . This article presents a method to design a large-scale SPV plant which includes a detailed analysis of the components. Different optimization techniques, such as GA, graywolf optimization (GWO),antlion optimization (ALO), and multi-verse optimizers (MVOs) are used for LCOP. The Monte-Carlo simulation, based on the economic analysis of plants, has been carried out to provide information about the NPV and internal rate of return (IRR). The selection of different components, such as transformers and inverters, has been discussed. This article is divided into the following sections: the model of SPV plants, optimization algorithms, and design of SPV, economic analysis, results, and discussion.

OPTIMIZATIONMETHODS:-There are different optimization techniques, these are:

GENETIC ALGORITHM

Genetic algorithm is global optimization technique, which means that they converge to the global solution rather than to a local solution.

In GA technique we get a global solution so it is advantage of GA. However, this dissimilarity becomes ambiguous when working with multi objective optimization, which frequently entails a set of solution points. Mathematically, a single global solution to a multi objective problem does not exist if not the utopia point happens to be possible.

Genetic algorithm freely parallel biological growth and are based on Darwin's theory of natural selection. The detailed workings of the algorithms involve the talking of microbiology and, in rising new possible solutions, copy genetic operations. A population represents a group of potential solution points. A generation represents an algorithmic iteration. A genetic material chromosome is comparable to a propose point, and a gene is comparable to a component of the design vector.

MODEL OF SPV PLANTS

SPVMODULE

The proposed method for optimization of plant size has been performed based on 2011 data of National Renewable Energy Laboratory (NREL) . The model of small scale SPV systems is discussed in . The voltage and current relationship is an important equation because it provides the information about the non-linear nature of the system. The voltage and currents are the functions of solar irradiance and temperatures.

Equations (1)–(4) represent the relationship of radiation and temperature to maximum Power:

Isc= [I_{sc},ST C + Ki (Tc− 25°C)] ∗G/1000……1

Voc= [V_{oc},ST C + Kv(Tc−25^{0}C] 25°C)……2

Pmax = Voc IscFF………………………………3

Tc= Ta +$\frac{\text{NCOT} - 20^\circ\text{C}}{800\ \text{W/m}^2}$*G…………………4

where

Voc is open-circuit voltage,

Isc is short-circuit current,

Pmax is maximum power produced by each module,

FF is form factor,

Isc, ST C is short-circuit current at nominal condition,

Voc, ST C is open-circuit voltage at nominal condition,

G is solar irradiance,

Tc is cell temperature,

Ta is ambient temperature,

Kv is temperature coefficient of open-circuit voltage,

Ki is temperature coefficient of current,

NCOT is nominal operating cell temperature.

COMPONENTS ARRANGMENT

The number of panels arranged in series (*Ns*) formation can be well determined according to the rating of modules and inverters. The expressions are given as Eqs. (5) and (6):

Nsmin= roundup(Vimin/Vmpp)………………………………..(5)

Nsmax= rounddown(Vimax/Vocmax)……………………… (6)

where *Vi*min, *Vmpp*are the minimum voltage across the inverter and MPP voltage of the module, and *Vi*max and *Voc*max are the maximum voltage across the inverter and open-circuit voltage of a panel, respectively. The number of parallel strings of the module (*Nsp*) to be installed with each inverter depending upon the rating of the module and the inverter. Each module has its own current rating that's why one limiting factor is the current rating of the inverter, and the other factor is the number of modules connected in the series. *Nsp* is the number of parallel connected string modules, each having an *Ns* module in a series to each inverter, as in distributed inverter mode.

Equation (7) gives the limits of Nsp*:*

Nsp=min[floor(Pmin÷NsPmax),floor(Iinv÷Impp)]…………… ………………………… (7) where *Pinv* is the power rating of the inverter, and *Iinv* and *Impp* are the current ratings of the inverter and MPP current of the panel. Thus, the number of modules connected to each inverter is *Nspinv = Ns ∗Nsp*. Many numbers of inverters can be determined using the above expression and by determining the total number of modules arranged in a plant. The total number of modules used in the plant can be expressed as *Nmodule= Pplant÷Pmax,* whereas *Pplant*is the rating of the SPV plant. The number of inverters to be employed in the SPV system is expressed as in equation…………………… ……………………………………………………………(8)

Ninv=Nspinv if remainder is 0

Else

(Nmodule÷Nspinv)+1………………………………………… …………………………8

Where *Ninv*, *Nmodule* are the number of inverters and modules in the plant. The power output by each individual module depends on a number of factors, such as shading effect due to nearby structures and due to the module itself on other modules. The effects of shading can be minimized by designing the plant in an optimum way and by deciding the site of the plant. Internal shading can be brought down to zero by optimally choosing the distance between the rows of panels. The rerating factor of the module due to shading and dirt can be included in module power expression as Eq. (9):

Pmodule = Pmax*D*S1*S2 ………………………………………. non optimized sized plant Pmax*D…………………..………for optimized sized plant……………..…………9

Where*S*1 is shading due to nearby structures and *S*2 is shading due to the panel itself. *D* is the derating factor, mainly due to dirt, and *Pmodule*is the power produced by each panel. The total energy generated by the module during its lifetime is expressed as Eq.(10):

Emodule =Ƞmpp Ƞinv ∑ ∑ ∑ Pmodule Δt…………………………………………………10(a)

Espv=Nmodule Emodule………..…………………………………………… ……………10(b)

where *Emodule* is the energy produced by the module throughout its life; *ESPV* is the total energy produced by the plant in its lifetime; and *ηmpp, ηinv* are the efficiencies of the MPPT model inbuilt in the inverter and section of the inverter, respectively. *t*is the simulation time interval, *d* is the day, *y* is the year, and *t* is the time during day. The selection of inverters for SPV systems depends upon several aspects, such as MPPT enabling feature, string sizing factor, etc. The inverter's AC side usually is at 415 to 600 *Vac*, and that is a step up by a transformer; hence, the selection criteria of transformers have also become an important factor in the designing of large-scale power plants. The size of the transformer is usually determined by the PV plant's peak power rating, but a largely unpredictable power injection on the main grid is obtained if a too large rated power is selected, leading to grid instabilities. This will lead to regular shutdowns of the plant, and the conventional power plant will need to inject the remaining power requirement. If a small rating of transformers is used, then the optimization will be a difficult task and the system will become too complex, and it becomes even more complex with energy storage concepts. The optimization of the transformers in SPV includes initial cost, cost of energy wasted during overload, efficiency, and grid instability .The initial cost of transformer is provided according to the market value, and the overload energy waste can be estimated using loss of production power probability (LPPP) index. This approach is adopted from the loss of power supply probability (LPSP) technique used

LPPP $=\sum_{k=1}^{n} LPP(K) / \sum_{K=1}^{N} Pi(k)\Delta t$………………………… .11(a)

Ew=$\sum_{k=1}^{n} Pi(k)\Delta t LPP(K)$……………………………… ……...11(b)

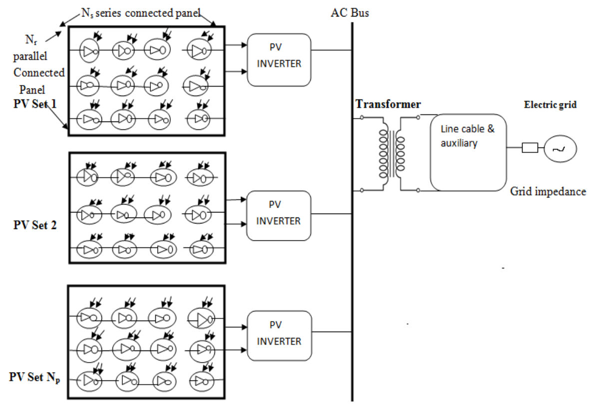


Fig 3.1 Model of SPV plant

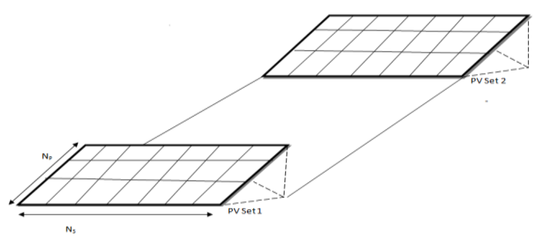
COST OF PLANT:

The cost of the plant is expressed in (12) and (13):
Cplant=NmoduleCmodule+NinvCinvt+A∗Carea+Cinst,…(12)
Cinvt=Cinv……………………………………………….(13)
where *Cmodule* is the cost of each module; *Cinvt* includes the inverter, (*Cinv*) the filter, and (*Cf*) costs; and *Carea* is the cost of installation area (per m^2). *Cinst* includes the cost of the mounting structure, cables and hardware, junction boxes and distribution boxes, lighting arresters, earthing kits, PVC pipes and accessories, and supervisory control and data acquisition (SCADA) software for monitoring, design, erection, transformers, and taxes. The module and inverter parameters are also provided .The maintenance and total cost of the plant throughout its life is presentedwithEqs.(14)and(15).

Number of variable of cost function	**3**
Ns	**15**
Np	**89*5**
Nr	**1**
Lower bound	**13118**
Upper bound	**174102**
Optimize value of objective function(LOCP)	**9.066697490027229**

CM = (Nmodule Mmodule + Ninv Minvt) (1 + g)*/ (d-g) …………………………………… (.14)

Total cost = Cplant+ CM……………………………(15)



Interconnection of module in PV set

The *Mmodule* and *Minvt* are the maintenance costs of the module and inverter, respectively, which are chosen to 1.5% of their installation cost in simulation process, and *d*, *g* are annual discounts and inflection rates.

3.4 OPTIMIZATION ALGORITHMS

In the proposed article, many optimization techniques are taken into consideration, and the variables for optimization are *Ns*, *Np*, and *Nr*. The function for optimization is to minimize LCOP and is as follows:

Min {LCOP} = m

RESULT

After Running program on **Global Optimization Tool Box** using function Genetic Function we get the following result:-

PV module, BP sx150s
Distributed inverter ABB, 250kWp PVS-800-57-0520 kW

Table No.: Plant parameters specification

Voc	43.75 V	Efficiency MPPT	99%
Isc	4.75 V	Efficiency inverter	96%
Vm	34.5 V	Rating	250KW
Im	4.25 A	*Vi*min	450V
Pmax	150W	*Vi*max	750V
NCOT	47±2^{0}C	Current rating	600A

6. CONCLUSION

. In this project we have designed and optimization of large scale photovoltaic plant of 1 MW of photovoltaic plant and it minimized levelized cost of production. In this project we design the cost function of 1 MW solar photovoltaic plant which is termed as fitness function, and to operate this cost function with the help of genetic algorithm section in global optimization tool box in Matlab to obtain the desirable solution. So after operating the algorithm we get the optimize value of cost function of 1 MW solar photovoltaic plant.

REFERENCES

[1] Shah, R., Mithulananthan, N., Bansal, R. C., and Ramachandaramurthy, V. K., "***A review of key power system stability challenges for large-scale PV integration***," Renew. Sustain. Energy Rev., Vol. 41, pp. 1423–1436, 2015

[2] Zobaa, A. F., and Bansal, R. C. (Eds.), ***"Photovoltaic systems," 4in Handbook of Renewable Energy Technology***, Singapore: World Scientific Publishers, Chap. 9, pp. 205–224, January2011.

[3] Shah, R., Mithulananthan, N., Lee, K. Y., and Bansal, R. C., "***Wide-area measurement signal-based stabilizer for large-scale photovoltaic plants with high variability and uncertainty***," IET Renew. Power Gener., Vol. 7, No. 6, pp. 614–622, 2013.

[4] Kumar, V., Shrivastava, R. L., and Untawale, S. P., "***Solar energy: Review of potential green and clean energy for coastal and offshore applications***," Int. Conf. Water Res. Coastal Ocean Eng., Aquat. Proc., Vol. 4, pp. 473–480, 2015.

[5] Shah, R., Mithulananthan, N., and Bansal, R. C., ***"Oscillatory stability*** analysis with high penetrations of large-scale photovoltaic generation," Energy Convers. Manag., Vol. 66, pp. 420–429, 2013.

[6] Shah, R., Mithulananthan, N., and Bansal, R.C., "***Damping performance analysis of BESS, ultracapacitor and shunt capacitor with large-scale PV plants***," Appl. Energy, Vol. 96, pp. 235–244, 2012.

[7] Sharma, N. K., Tiwari, P. K., and Sood, Y. R., "***Solar energy in India: Strategies, policies, perspectives and future potential***," Renew. Sustain. Energy Rev., Vol. 16, No. 1, pp. 933–941, 2012.