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A Prospective Study for Utilization of Alternative and Renewable Energies in Deployment of Highway Electrification and Its Importance

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ABSTRACT

Solar Photovoltaic (SPV) power plants have emerged as an essential component of a sustainable solution to produce electricity. This is because the need for renewable energy sources continues to rise. The broad deployment of Large-Scale Solar Photovoltaic (SPV) systems has certain obstacles, one of which is the restricted availability of land in urban and heavily inhabited regions. In this paper, the authors use MATLAB tool for the result simulation. This research paper is provide the new idea of charging of electric vehicle by using pantograph and in the pantograph electric supply is provided by renewable energy source. Pantograph is attached on electric vehicle and overhead line pole deployment on highway . electric supply is transferring from renewable energy source to overhead cable . Therefore, EVs with the inclusion of Electric Highway can charge the battery while moving and cut down on how long it takes for the vehicle to recharge. In this research paper we use overhead cable and calculate efficiency cable.

Keyword:- Solar charging station, MATLAB Simulation, highway distance , Overhead cable.

INTRODUCTION

The energy from the sun is converted into electricity using an SPV system. The SPV system includes the solar panel(s), Charge Controller (CCR) or inverter, battery bank(s), and any other electrical or mechanical devices[1-3]. In an off-grid system, the energy is stored in batteries, whereas in an on-grid or grid-tie system, the energy is supplied into the grid. Any SPV system would be useless without its inverter. The grid-tie inverter converts DC electricity into the necessary AC for injection into an existing power system[4]. In addition to these uses, inverters can also be found in wind and micro turbines, variable frequency drives, High Voltage Direct Current (HVDC) power transmissions, and uninterruptible power supplies[5].Designing an SPV power plant layout for a long and narrow space requires careful planning to maximize the available area for solar panel installation. As the world's energy consumption rises as a result of modern industrialization and population development, many investments in alternative energy solutions are being made to improve energy efficiency and power quality. Because there are various countries in tropical and temperate climates where direct isolation intensity can reach up to 1000W/m, photovoltaic energy is considered a key resource.

In comparison to standard roadways, the E-Highway is a completely different kind of highway. These kinds of roadways are built to give moving cars a high voltage supply. The first "e-highway" design is one with a designated lane on the highway with high-tension electric cables running the entire length of the road. The name "e- highways" refers to a range of highway configurations. As electric vehicles grow in popularity, they do have some drawbacks, such as the fact that they require longer charging times for their batteries and require larger batteries because they are heavier. Therefore, the main goal of the paper proposal is to fix these flaws. We are creating a workable model for it. The system employed in this model is comparable to the catenary system used in electric trains (in which current is obtained from the overhead transmission line with the aid of a pantograph and sent to the motor causing the vehicle to move).The trucks' sensors detect an electric contact line, which causes the truck to automatically lift its pantograph and make touch with If there is no such sensor, the driver must manually set the location using an electric line. The pantograph uses this energy to power electric motors and recharge batteries. The truck may run on batteries when there is no power line. E-highways' potential for zero emissions causes a decrease in CO_2 emissions.

LITERATURE REVIEW

This section provides an overview of the literature on the topic of a novel Solar Photovoltaic (SPV) power plant layout design for deployment in long and narrow spaces.

Chirwa et al., (2023)[21]evaluated the feasibility of installing solar PV floating systems over Zambia's current hydroelectric facilities. This study employs System Advisor Model (SAM) and modifies the inputs of the conventional photovoltaic performance model so that it can be used for Floating Solar Photovoltaics (FSPV). The results of this study would raise public awareness of solar photovoltaic systems on water, opening the door for potential government and private sector investments in the field.

Islam et al., (2023)[22]examined the feasibility and cost-effectiveness of installing a 10 MW floating solar PV system on UMP Lake. Estimates of energy output and losses were developed and calculated with the help of the PVsyst 7.3 program. It is estimated that the plant would generate 17,960 MWh of electricity per year at a levelized cost of USD 0.052/kWh. The initial investment of USD 8.94 million is expected to be recouped in 9.5 years of operation of the plant. It is estimated that the plant would prevent the release of 11,135.2 tons of CO_2 yearly.

Alarai et al., (2023)[23]analysed the performance of optimization based SPV power forecasting models based on weather circumstances using the cutting-edge Salp Swarm Algorithm (SSA) for its superior exploration and exploitation capabilities. Root Mean Square Error (RMSE), Mean Square Error (MSE), and Training Time (TT) are used to provide estimates about the effectiveness of the proposed optimization model. The RMSE and MSE values achieved with the suggested SSA technique are 1.45% and 2.12%, respectively, which are lower than the values obtained with previous algorithms.

Rangaraju et al., (2023)[24]developed a unique Strengthen Gaussian Distribution-centric Deep Long Short-Term Memory (SGD-DLSTM) approach for predicting Solar Power Generation (SPG) with deviation analysis.The next step involves calculating the Mean Absolute Error (MAE), MSE, and RMSE to evaluate the divergence between the actual and projected results. Therefore, it was determined via experimental evaluation that the suggested model outperforms the state-of-the-art works.

Manoj et al., (2021)[25]conducted an experimental analysis of GMPV, FPV, and SPV systems' functionality. Three separate PV system prototypes with data-gathering devices are created for GMPV, FPV, and SPV installation techniques. Simultaneous performance evaluation and experimental testing are conducted in natural settings. The study's findings include measures of meteorological and electrical phenomena. According to the numbers, FPV is more efficient than both GMPV and SPV.

Dahmoun et al., (2021)[26]examined data collected by the Supervisory Control and Data Acquisition (SCADA) system to assess the efficiency of one of the world's biggest solar PV projects (23.92 MWp) in the El Bayadh region of Algeria. There are several metrics used for this purpose, including the performance ratio, the yield factor, and the capacity utilization factor. This initiative's findings show that the anticipated data received from the PV system and SolarGIS tools closely matches the actual data gathered from the PV plant output. Furthermore, the study shows that there is a high connection (0.91) between the module temperature and the performance ratio.

Mamatha et al., (2021)[27]assessed the FSPV module's performance in terms of its PV and I-V characteristics using data from actual weather conditions in the year 2020.In addition, the PV system was used to analyze and compare the technical performance of GSPV and FSPV with the same rating at the projected 5MWp plant at the Srisailam reservoir in A.P., India. Compared to Ground-mounted Solar Photovoltaics (GSPV), the cooling effect of the proposed floating SPV system could prevent a total of 111.09 million liters of water per year.

Kumar et al., (2021)[28]suggested a Grey Wolf Optimizer-Based Bridge-Linked Total Cross-Tied (GWO-BLTCT) configuration. Fill factor, performance ratio, power augmentation, and power loss are used to evaluate the proposed topology's performance to those of conventional and hybrid topologies such as series-parallel, total cross-tied, BLTCT, and SuDoKu-BLTCT. The suggested GWO-BLTCT has the lowest power loss and highest fill factor, making it the most efficient of the available topologies. It also has the best average power improvement (23.75%) and performance ratio (70.02%).

OBJECTIVE

A Novel Concept of charging lane on a highway is also proposed to be investigated. The solar photovoltaic plant can provide the power supply over the entire span of the highway and hence can provide support to a novel electric vehicle charging system. In this system, it is proposed to designate a separate line for charging where an electric vehicle can travel with a pantograph arrangement to charge while moving. Once a requisite state of charge is achieved, the vehicle can leave the charging lane and move on to other lines. This provides a scenario where the entry location of the electric load is not fixed as well as the load is moving over the length of the line. In the present work, it is proposed to study the system.

METHOD

It would need a tremendous amount of room to set up a charging station with the capacity to charge 60 vehicles, from which the energy for 20 trucks would be reserved through a micro inverter. w, if at a rectangular layout, we can see that there is not a huge disparity between the width and length of the space required, however, in the case of a thin rectangle design, the length is comparatively quite high in contrast to the breadth. Therefore, in the event of a regular rectangular layout, it is extremely difficult to locate a spot that has such enormous dimensions, particularly when the SPV power plant is constructed between towns on roadways. The most feasible way to generate such a large quantity of electricity while using the space available on the road is to utilize pathways without harming the nature or agriculture of such regions, or to provide lay-bys without being connected to the electric grid. Additionally, no additional infrastructure would need to be created as the solar module would just be set up on the already pathway. The SPV power plant is typically installed in a very long and narrow area, such as a footpath, so the solar modules are designed in a long and narrow rectangular layout by decreasing the size of the cell module to maximize the amount of available space.

Calculations

The following part contains a calculation for the required amount of energy and space, as well as a comparison of the dimensions of a regular rectangular layout versus a long narrow rectangular layout.

a) Determine the required number of modules for generating 6000-watt energy for charging 60 trucks.

The energy required to fully charge one truck = P_0

Total power needed = $(P_t) = n \times P_0$

The number of trucks that required to be charged = n

The typical amount of power that is generated by a single cell = (E_C)

No of cells in one module = N

Then power generated by one module (E_m) = $E_C \times N$

No of module needed to generate P_t amount power= $\frac{P_t}{E_m}$

Example,

Let the amount of power needed to charge a single truck = 100kw

So, for charging 40 trucks we need to generate = 100×40 = 4000kw of power,

Further, we need to store reserve energy for charging 20 trucks i.e.,

20×100=2000kw of power is stored in the microinverter.

Micro inverters are utilized because they are more costly than regular inverters but have higher energy efficiency and allow the panels to function independently.

Thus, the SPV power plant's total output should be equivalent to the electricity needed to charge 60 vehicles = 40,000 + 20,000 = 6,000 kilowatts.

Let the average energy provided by a single cell = 3w

If 1 module = 36 cell,

Then power generated by one module= 36× 3 =108

No. of modules needed to generate 6000kw is:

$= \frac{6000000}{108} = 55{,}555.55 \approx 55{,}556$ modules

b) Space is needed to place the total modules.

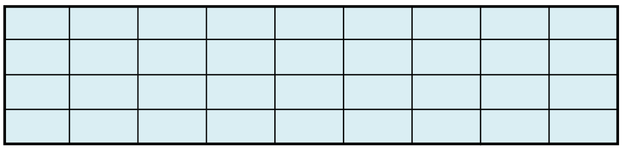


Figure 1: Cell arrangement in module

The given cell size be = S_C

No. of cells in one module =N

Size of one module = $(S_M) = (S_C) \times (N)$

Space needed by (M) modules = (M)× (S_M)

Example

Let, the given cell size be = S_C = (15cm×15cm) = 0.15m×0.15m =0.0225m^2,

No of cells in one module =N = 36

Size of one module = $(S_M) = (S_C) \times (N)$ = 36×0.0225 = 0.81m^2

The space needed by (M) modules = (M) × (S_M) = 55556 × 0.81= 45000.36 m^2 = 0.045Km^2

c) Dimensions Required for Normal Rectangular Design

In this instance, they would be using the conventional rectangle layout.

Therefore, to maximize the available space, the measurements should be selected in such a way that there is not a significant imbalance between the length and width.

Then, to cover 45000.36 m^2 of the area a rough dimension of (226m × 200m) could be taken.

Where, length = 226 m

breadth = 200 m

Then, Area covered = length × breadth = 226×200 = 45200m^2

MATLAB SIMULATION

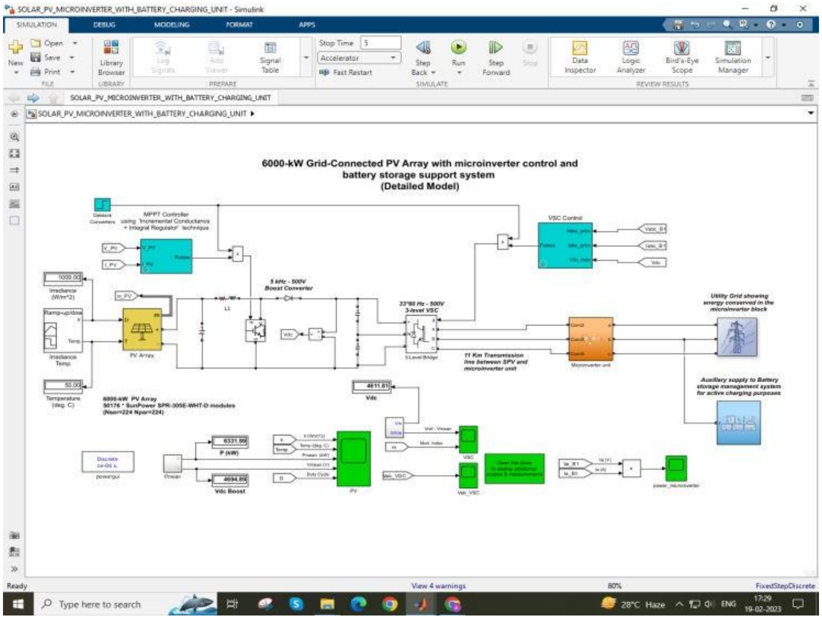
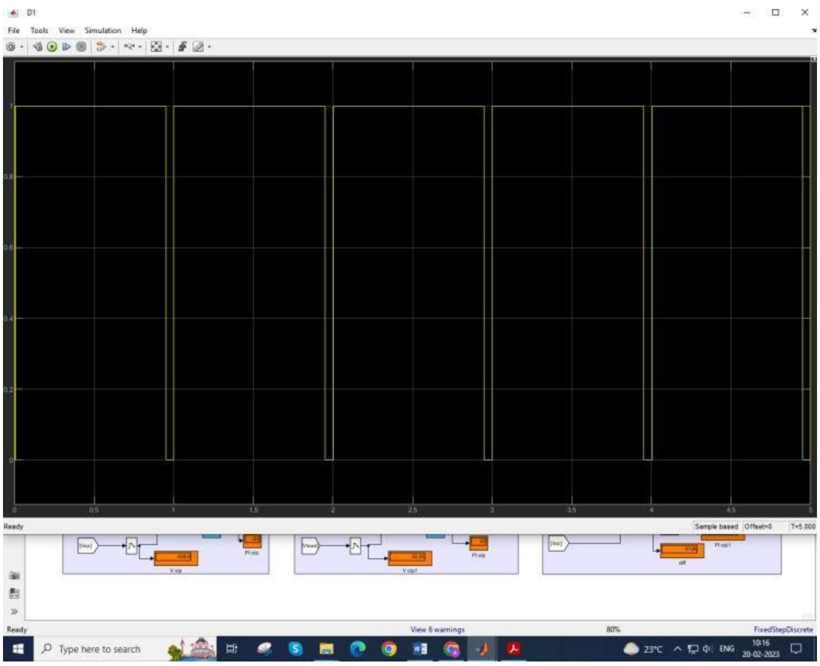


Fig 2 simulation of 6000KW Grid connected pv array withmicro inverter with battery storage support system

RESULT



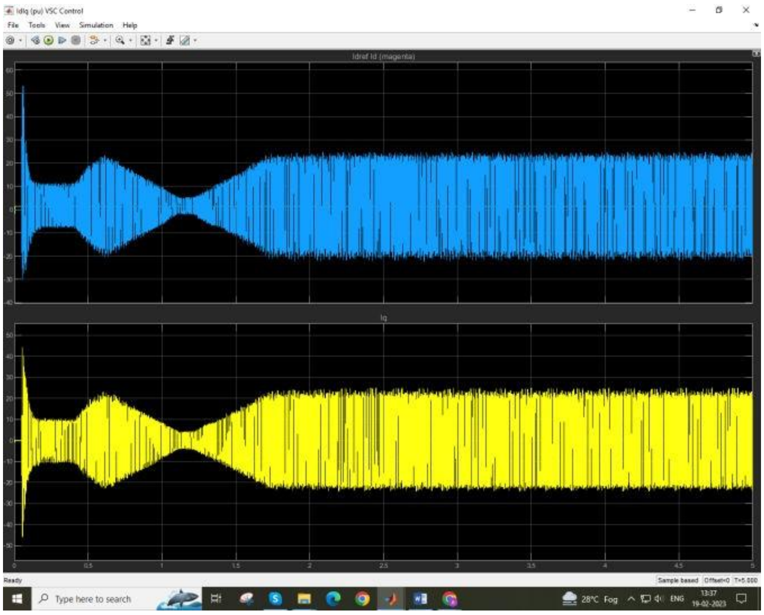


Fig 3 Output of grid connected system

Efficiency of cable
A cable's efficiency is measured by how well it can carry electricity or communications while reducing waste. Cables are ubiquitous because of their usefulness in so many different contexts, including power transfer, data transmission, and more. There will always be some power or signal loss as it passes via any cable, so keep that in mind. In this fourth diagram, we see that as cable length increases, its efficiency decreases. Figure 3 shows that the efficiency value increases to 0.9989 for the longer distance of 11 km.

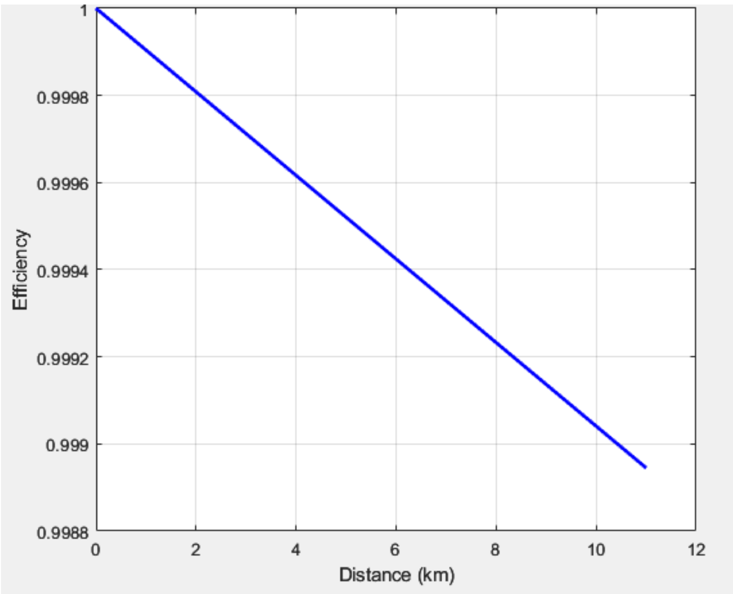


Figure 4 Efficiency of cable.

Power loss in cable.
The dissipation of electrical power as heat over a cable's length is known as "power loss" due to distance. A greater amount of energy is lost due to the cable's increased resistance as its length grows. Some of the electrical energy is dissipated as heat owing to the resistance of the conductive substance in the cable. Engineers can increase the voltage, utilize more efficient cables, and install bigger conductors to reduce power loss. When constructing power transmission systems, it is crucial to consider power loss and voltage drop across distances to maintain maximum performance and efficiency. Power loss due to cable is shown numerically. Power loss is shown in Figure 10 to be 0.004 kilowatts at 2kilometers, and 0.025 kilowatts at 11kilometres.

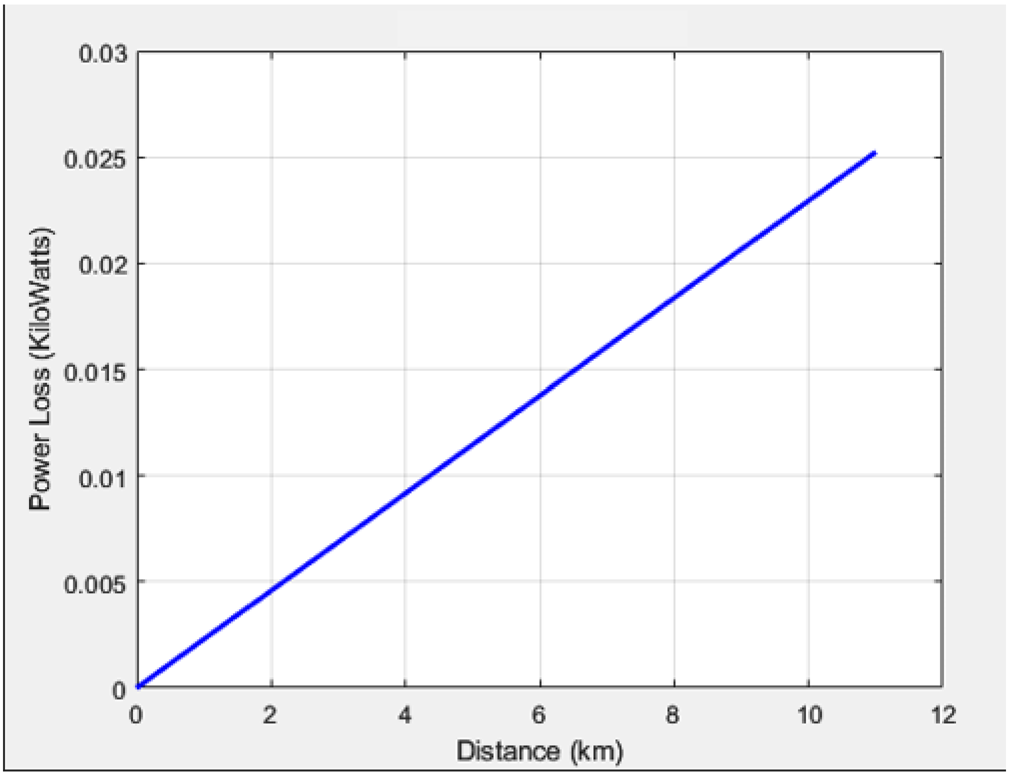


Figure 5 Power loss in the cable

CONCULUSION

An innovative Solar Photovoltaic (SPV) power plant layout design that is optimized for deployment in long and narrow locations is a viable method for effectively harvesting the sun's energy. This cutting-edge design takes use of linear areas that are not being put to their full potential, such as those along highways, roofs, or walls, and optimizes the ability to collect solar energy. This design guarantees that the solar panels get ideal sunshine exposure throughout the day by placing them in a linear pattern; as a result, the total energy production efficiency is improved. In this paper, the authors use MATLAB tool for the result simulation. The experimental finding demonstrates that at 0 km, efficiency is greatest. Its power out-feed efficiency is 80.52%, while its power transmission efficiency is 94.72%.

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