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Study to Analyze and Assess Potential of High Solar Irradiation Regions in Lao PDR

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Abstract: *Developing countries have the potential to make a technological leapfrog to more efficient technology to meet their energy needs. Renewable energy like solar power can be setup anywhere with sufficient exposure to the sun, these countries also have pockets with extremely high potential for energy generation. Lao PDR studied under the studyhas a growing energy requirement due continued industrialization. As per our study there is great potential for a significant portion of the energy demand can be procured sustainably through the use of solar power plants, it is also possible for urbanized solar hotspots to be used though to a limited capacity with roof top installation. So the study aims at accessing the untapped solar potential of Lao PDR by analyzing the irradiation data obtained from NREL Geospatial Toolkit.*

Keywords: *Lao PDR, Photovoltaic, Solar Irradiation, SWERA Geospatial, Tilted Flat plate Irradiance*

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I. INTRODUCTION

Solar energy which are incident on the earth's surface, also called as insolation primarily depends on parameters like geographic location, earth and sun movements, tilt of the earth's rotational axis and atmospheric attenuation due to suspended particles. The intensity of insolation quantifies the solar resource potential or availability of a region [1]. The Solar Energy to electricity conversion can be carried out in broadly two ways i.e. Solar Photovoltaic (SPV) and Concentrated Solar Power (CSP). These systems utilize the radiations of wavelengths between 0.29 and 5.5 µm because the other part of the wavelength gets attenuated in other wave lengths due to absorption or scattering in the atmosphere.

Lao PDR is a nation which possesses hydro potential of hydro energy standing nearly at 26 GW. There are various policies, funds, investment and various programs are been implemented in order to enhance its process. The rapid investment is in renewable energy sector and the power production has ramped up from 2546.7 MW to 5806 MW in 2016.Currently there is only 700 kW solar power connected to the grid, 500 MW solar farm under study, 10 MW solar farm under construction. The solar potential in Lao PDR is much higher than what is being harnessed. The implementation of advanceand improved solar technologies for the production of the power using solar energy can aid Lao to achieve a significant and healthy solar, hydro and non-renewable energy mix [2]. Moreover, the regions currently unconnected to the main grid can produce electricity utilizing solar and hence improve the electrification or rural regions which currently stands at 94-95%.

II. OBJECTIVE

Main objectives of this study is to identify the solar hotspots in Lao PDR which have high irradiation of over 5 KWh/m^2using data obtained from NREL SWERA Toolkit utilizing Direct Normal Irradiance component [3]. Calculating the power production feasibility of the different solar energy harnessing technologies like SPV and CSP (Table 1).

III. METHODOLOGY

The solar radiation data for calculations, showing irradiation per year and generation potential can be directly accessed from the NREL site, using SWERA Geospatial Toolkit by putting setting at DNI moderate and inserting the location's coordinates. The data obtained consists of daily solar radiation, clearness index and air temperature [4]. Based on the data the daily solar radiation as per the (Fig. 1) most of the area in Laos receives irradiation of 3.5-4 KWh/m^2 per day but there are regions in the South as well which have irradiation over 5 KWh/m^2 per day which is considered to be apt for the production of power.

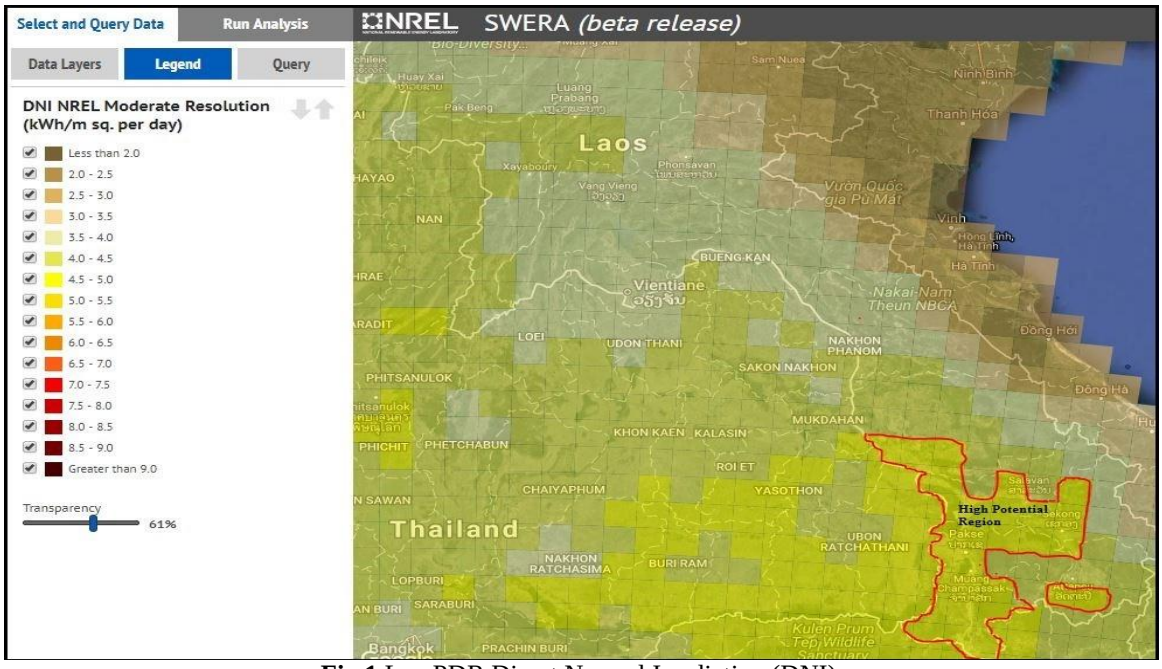

Fig.1 Lao PDR Direct Normal Irradiation (DNI)

On the basis of DNI data the crude values of the irradiation varies from 7.5 KWh/m^2 per day in the month of January to lowest of 2.7 KWh/m^2 per day in extremely wet seasons of July-August. But the average value stands at a value of 4.65 KWh/m^2 per day approximately. This sums up to the yearly average of 1700 KWh/m^2 per year.

The average value of Tilted Flat Plate irradiation input in the southern region of Lao PDR is 5.20 KWh/m^2 per day. This leads to a yearly output of 1900 KWh/m^2. Hence the average input per day or G_{av} = 5.20 KWh/m^2 per day. On the basis of data from Solar Potential Resource Tool of the NREL maps suggests that the area where PV installation could be carried out with the yearly average of 5-5.5 KWh/m^2 per day is yieldable over an area of 5,196 km^2 (Table 1.).

TABLE1. Land Area by the Resource Class

Resource Class	Area
3.5 – 4 KWh/m^2/day	226 km^2
4 – 4.5 KWh/m^2/day	11,551 km^2
4.5 – 5 KWh/m^2/day	12,409 km^2
5 – 5.5 KWh/m^2/day	5,196 km^2

Table 1: Solar Irradiance of Southern Region of Lao PDR

Cities	Tilted Flat Plate Latitude Tilt Irradiance (KWh/m2 day^{-1})	Earth Skin Temperature (degree C)
Ban Sim	5.06	24.6
LaoNgam	5.06	24.6
Pakse	5.25	25.79
Lahanam	5.14	24.99
Saoavan	5.06	24.6
Sekong	5.06	24.6
Ban Sating	5.06	24.6
Thateng	5.06	24.6
Munag Chapmassak	5.31	26.58
Paksong	5.06	24.6
Ban Tom	5.06	24.6
Soukhouma	5.31	26.58
Nakasong	5.31	26.58
Ban Chom	5.23	24.01
Phouvong	5.25	25.58
Sanamxai	5.25	25.58
Xe Pian National Park	5.25	25.58
Navieng	5.25	25.79
Nathon	5.06	24.6
Napong	5.25	25.79

Beng	5.25	25.79
Ban Khoun Kham	5.25	25.79
Phontong	5.25	25.79
Nong Du	5.25	25.79
Venu Kham	5.44	26.87
Thakho	5.43	27.24

The annual energy demand in the southern region of Lao PDR is 531 GWh with maximum demand of 148 MW [5]. So the average daily load demand or E_L = 1,454,794 KWh day^{-1}. The total rating, area and number of PV modules needed for the whole system is calculated. The total PV module area required for the system is as follows:

$$PV_{area} = \frac{E_L}{G_{av} \times T_{cf} \times \eta_{pv} \times \eta_B \times \eta_{inv.}} \quad (1)$$

E_L =1,454,794 KWh day^{-1}(average daily load demand)
G_{av} = 5.20 KWh/m^2 per day (average solar input per day)
T_{CF} =0.578 (temp.Coefficient factor)
η_{pv}= 20% (PV efficiency)
η_B= 80% (battery efficiency)
η_{inv} = 95% (inverter efficiency)

$$PV_{area} = \frac{1454794}{5.2 \times 0.578 \times 0.2 \times 0.8 \times 0.95} = 3.184 \text{ km}^2 \quad (2)$$

As per the calculations, the potential total distance over which PV plates should be installed is nearly 3.184 km^2 to meet the power demand of South Lao

IV. RESULTS AND CONCLUSION

The required area to be covered by solar PV plates is 3.184 km^2 and the total area in the north which receives the solar irradiation of 5 – 5.5 KWh/m^2/day is nearly 5,196 km^2 (Table 1.). This potential area is 1631 times of the required area. Hence the installation of the solar PV panels is feasible and plausible.

The solar potential available in the south of Laos could help the country to escalate the rural electrification level to 100% by electrifying the regions which are not connected to the national grid. This will further improve the renewable energy mix of the nation and boost its hydro power trade to the neighboring nations like Vietnam and Thailand. The thrust in R&D could help in improving the efficiency of PV panels and lower the cost of generation of electricity. The use of solar also lowers the GHG emissions which are much lesser than even hydro power plants. Hence the investment in w3solar power would dual purpose of achieving a greener, low carbon economy and electrification of remote, rural belt of Lao under-connected to the national grid.

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