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Cost of Air Pollution to Solar Energy Generation

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Abstract: — India intends to install 100 GW of solar energy by 2022. However, assessments of renewable energy resources do not adequately take into account the loss of solar energy caused by environmental variables such as air pollution. Here, we demonstrate that between 2001 and 2018, air pollution cost India 29 percent of its usable worldwide horizontal irradiance potential. Air pollution is thought to cause an average output loss of 12%, 26%, 33%, and 41% for the horizontal, fixed tilt, single axis, and dual axis trackers, respectively. This equals to yearly loss of 245 to 835 million US Dollars. The effective execution of the National Clean Air Program of India, coupled with total reduction of local emissions, would allow India to produce additional of 6 to 16 Terawatt Hours of energy per year from the existing infrastructure in 2018. This equates to a yearly economic gain of 325 to 845 million US Dollars, which is equal to the expenditures of executing these social initiatives. This reduction in air pollution will speed up India's progress toward attaining the objective of solar power generation with fewer installations.

Introduction

The adaptation of renewable energy is vital to prevent disastrous climate changes and fortifying long-term growth. In Accordance with the Paris Agreement, India agreed to reduce the intensity of emissions of Green House Gases by 33% to 35% from 2005 levels by 2030, as well as improving the percentage of energy resources that are not based on Fossil Fuels to

40% of total power generation by 2030. In recent years, among all renewable energy resources, Solar Energy has grown substantially. According to the International Renewable Energy Agency's (IRENA) 2019 study, India ranks sixth in total solar power capacity worldwide. Aerosols which are present in the air limit the solar light by scattering and absorbing the radiation. This is known as the "Atmospheric Attenuation Effect." Aerosols are also commonly deposited on panel surfaces, diminishing their Photo-Voltaic performance. The pollution in air is growing in East and South Asia, in contrast to the global switch from dark to bright induce by a decrease in aerosol loading. As a result, when new solar expansion projects are undertaken in countries for instance China and India, the impact of aerosols on the solar energy potential must be taken into account. Between the years 1960 and 2015, China lost 11% to 15% of its Photo-Voltaic potential, with aerosols accounting for a greater loss (21% to 34% in recent years). [7]

Between 2016 and 2017, research on urban haze in Delhi revealed an 11.5 percent reduction of solar irradiance over perfectly tilted silicon modules, which resulted in a 20 million US Dollar loss. By extrapolating inspections from an exploratory set up above northwestern India in a modelling framework, there was a loss in solar power of approximately 17 to 25 percent across the countries India, China, and the Arabian Peninsula. The Aerosol Soiling and Atmospheric Attenuation Effect equally contributed to this. In the same state of affairs, international research found out that the aerosols limit the output of power production by the solar panels by greater than 50 percent in the severely polluted regions like North India, North China, and Desert regions of the world. [7]

Despite the fact that all of these studies show that air pollution has a detrimental influence on solar power assets, precise financial assessments of advantages of meeting the target of a cleaner air on India’s solar power generation is still to be quantified. We describe the effects of air pollution on Solar Infrastructure that is set-up in India over 18 years (2001 to 2018), taking both attenuation and soiling effects into consideration. The net buildup of air particles on solar panels every day as a consequence of dry deposition and the natural rain clearance process is factored into our 'soiling impact' assessment. For the study period, we analyze radiation and aerosol data from Clouds and the Earth's Radiant Energy System (CERES) and Modern-Era Retrospective Analysis for Research and Applications, version 2 (MERRA-2). [5]

The calculation of how much more solar energy India might produce and the economic gains we could experience if some of the key regulations were properly followed and the amount of air pollution in the nation was successfully lowered is also calculated. Finally, we provide an alternative route made according to our remedial policy that will help India reach its 100 Giga Watt aim on schedule. The five regional electricity networks are examined in relation to all findings (North, South, West, East, and Center). [7]

I. LITERATURE REVIEW

India has a goal set for installation of Hundred Giga Watt of solar infrastructure by 2022. However, the loss in the production of solar energy production because of the ecological aspects such as pollution in the air is not adequately taken into account in the assessment of energy resource that are renewable. It is shown here that between 2001 and 2018, India lost 29 percent of its usable global horizontal irradiance capability due to the pollution in the air. The average output loss suffered by solar power systems equipped with horizontal, fixed tilt,

single axis, and double axis trackers because of the pollution in air is estimated to be 12 percent, 26 percent, 33 percent, and 41 percent, respectively, amounting to a depletion of 245 to 835 million US Dollars per year. The successful implementation of the NCAP, as well as 100 percent reduction of household emissions through the provision of fuel which is cleaner to use for domestic use and rural electrification, would allow India to generate a surplus of 5.99 to 16 Terawatt Hours of electricity every year from the already installed solar power capacity in 2018. When this is converted to a form of benefit in terms of finance comes out to be of 325 to 845 million US Dollars, which is equal to the cost of implementing social programs being talked about. Reducing air pollution would thus speed up India's advancement toward meeting the solar energy production target India has set and that too with fewer installation capacity which will therefore avoid any further costing for solar energy infrastructure expansion. In this project, we hope to create a tool that will allow investors, researchers, and government officials to

estimate the cost of air pollution to solar power generation. India has set a goal of hundred Giga Watt of solar installation capacity by 2022. However, solar energy loss due to ecological aspects such as pollution in the air is not adequately taken into account in renewable energy resource assessments. The annual economic loss is in the range 245 to 835 million US Dollars, allowing India to generate a surplus of Six to 16 Terawatt Hours of electricity.[7]

II. DATA AND METHODOLOGY

In this study, the CERES (CERES Science Team 2017) version 4.1 synoptic grid of NASA shortwave down flows (0.3 to 5 micrometer) over the Indian region (6 to 38°N, 65°N) (SYN1deg) Process the data. – 98? E) for five regional grids from 2001 to 2018. We use three ground-based data sets with different temporal resolutions to evaluate the CERES data. This takes in account the statistics from Indian Meteorological Department (IMD) at eight stations in 2016, four stations from 2014 to 2018 and monthly and annual averages got from Global Energy Balance Archive (GEBA) for 2001 to 2009 at 11 centers. The 8-day combination of IMD stations (N =2281) showed a Mean Absolute Bias Error (MABE) of 20.91 W m-2 and a Mean Squared Error (RMSE) of 28.03 W m- in good concurrence with CERES (R 2 of 0.79).
Analysis using single IMD station also shows strong uniformity, only leaving out Shillong (R2 of 0.45), which has a complex topography on the NE power grid. Study of data from 4 BSRN centers (3249 center days) shows that there is a good agreement (R2: 0.67, MABE: 2436 W m-2, RMSE:
39.36 W m-2). Monthly as well as yearly averaged evaluations of the 11 GEBA centers show strong agreement (R: 0.89, MABE: 9.81 W m-2, RMSE: 12.53 W m-2). [4][5][6]
Our analysis is consistent with previous studies using CERES and additional ground center surveys. This comprehensive assessment of CERES with 1 local (IMD) dataset and 2 international (BSRN and GEBA) datasets over the study tenure in the Indian Territory demonstrates reliability of the CERES SYN1deg statistics for future studies.
In addition, Multi-Angle Implementation of Atmospheric Correction Algorithm (MAIAC) - This product has superior performance than the old MODIS applications and has a rougher resolution over all. To convert the MAIAC AOD to PM2.5, (a particulate Matter which has a size smaller than or equal to two and a half micrometers) a dynamic measuring component procured from MERRA-2 dataset was used to convert the Central Pollution Standards Administration of India Committee (CPCB) is being coordinated. The class monitors 2 Environ resolution Latvian data is depicted in SI- Datasets. [4][6]

Estimation Of Economic Burden

Convert the aerosol impact (profit or loss) on the production of solar energy into direct monetized value. Radiation loss or gain is assumed to be linearly proportional to power generation loss/gain, ignoring factors like loss of transmission, power conversion loss, and loss because of the other component inherent complexities and inefficiencies. In the same way, we assess the benefits of implementing the policy options above. All the calculations take into account the latest GJ 2018 to 2019 total solar installed capacity (28 Gigawatts and 39 Terawatts Hour per year). A standard price of

0.052 dollars each unit (per kilowatt-hour) electricity consumed nationwide is considered. In addition, we used the plant power generation data from the Central Authority of the Ministry of Power to investigate the effects of aerosol pollution on solar power production. Study using SI Methodology in a complete flow chart of the research plan is shown below. [3]

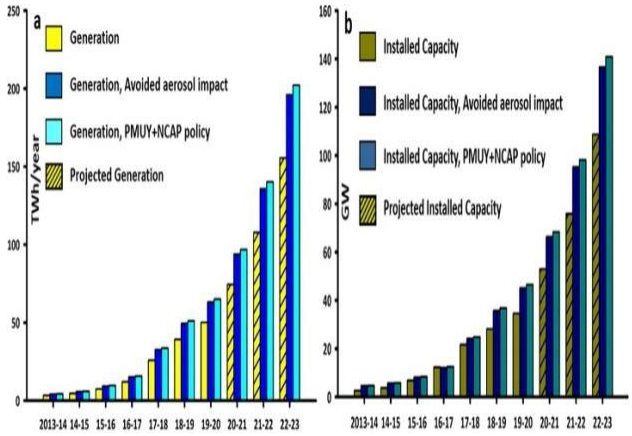

Fig.1. Shows Successful Implementation of National Clean Air Policy and growth in solar power generation, over the years 2013 to 2023. X- axis shows year wise division while Y-axis shows solar power generated annually.

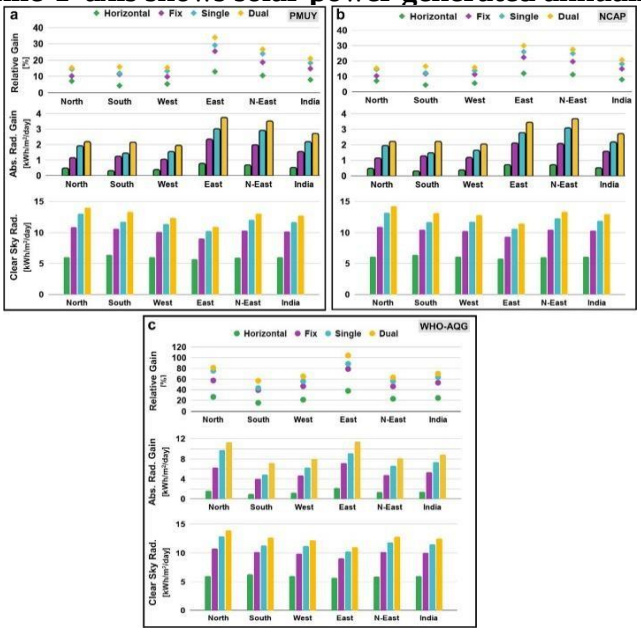

Fig.2. Bar plot of solar electricity generation and cumulative solar installed capacity over the Indian regions from the FY 2013-14 to 2022-23. (a) Actual solar electricity generat n (in T h yr^{-1}) form the FY 2013 to 14 to 2019-20 (in yellow) and estimated

IoW production from Financial Year 2020 to 2021 to Financial Year 2022 to 2023 (yellow with hatch). (b) Actual total solar installed capacity (in Gigawatts) from the Financial Year

2013 to 2014 - 2019 to 2020 (in dark yellow) and projected cumulative capacity from Financial Year 2020 to 2021- Financial Year 2022 to 2023 (dark yellow with hatch). Each generation bar in (a) is grouped into 3 bars

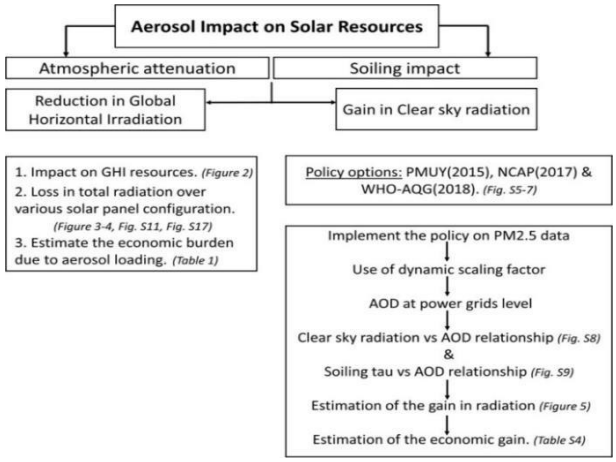

Fig.3. This figure shows process flow of calculating the economic burden estimation.

III. CONCLUSION

India's solar power potential and its loss due to aerosols impurities has been increasing with the increase in use of Solar Energy. In India, air pollution is a major issue. As Indians, we not only recognize the situation directly, but also the long- term consequences for our children and grandchildren. As a result, we aimed to tackle this challenge by tackling another, similar problem with a huge commercial use case. According to our study, assuming the present trend of installation and policies to lessen the pollution in air that are followed, India's solar energy target can be realized on time, if not before. In this study, we solely look at the direct influence of aerosols on solar energy. According to climatic research, cloud lifespan rises with increased aerosol loading. It proposes that lowering pollution in the air would also reduce obscureness, therefore increasing the power generation from the solar infrastructures even more. Moreover, dirty clouds prevent rains and other forms of precipitation. As a result, if pollution is decreased, the precipitation will increase which may out turn in wet scavenging and even more decrease in the aerosols that are present in the air and atmosphere, hence improving the solar power production. This aspect, however, must be quantified in a modelling structure capable of addressing aerosol and cloud interaction. As a result, we can say that in India, the real benefit of reducing the pollution in air can be way more beneficial than what it is reported in this observation. Our results will end up helping regulators, institutors, and venture capitalists better estimate solar power resources and ease up the solar infra growth in over the next few years in the Indian subcontinent. Because air pollution reduction measures are predicted to deliver modest advantages to Solar Photo Voltaic production, particularly in direct radiation based Concentrated Solar Plants, the Government of India must crease its investment in the country's Concentrated Solar Plant installation facility. The economic advantage of lowering air pollution in terms of surplus solar power generation, according to our findings, is comparable to the present implementation cost of significant air pollution removal initiatives. This is in addition to the significant benefits to health of an individual that are expected from reduced air pollution exposure. As a result, when conducting a cost to benefit examination of any plans that focus in the reduction or removal of air pollution in India, the estimation of solar assets should be included. Although PMUY has helped increase the supply of clean fuel in India, a number of issues inhibit long

term usage of clean fuel. In the same way, the clean air action plans recommended under the NCAP for various undeveloped cities lack prioritization based on economical and simple implementation. In order to enjoy the most benefits, India needs to overcome these practical challenges and assure appropriate policy enactment.

Our analysis shows that actions to reduce air pollution have a high prospective to boost the production of solar energy in India. As a result, the aim of new strategies to control individual aerosol types can be evaluated in the upcoming times. The increased use of various solar powered gadgets like lanterns that get charged from solar energy, heaters working on solar energy, cookers that take power from the sun, and other products that don't have carbon in them, as well as the efficient generation of solar energy, would greatly decrease the overdependence on coal for power generation that India has currently. And so, this would help reduce air pollution across the country. [1][3]

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