ELECTRIC VEHICLE SOLAR SMART CHARGING BASED ON SOLAR IRRADIANCE FORECASTING

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Abstract:

The goal of this undergraduate thesis is to examine the effects of using photovoltaic (PV) power for electric vehicle (EV) charging near workplaces. In the situation under investigation, EV charging stations are connected to both photovoltaic systems and the power grid. the chosen model The aim of achieving constant power is the foundation for simulating various scenarios. By adjusting EV charging to a forecasted solar irradiation, you can communicate data with the grid. The MATLAB is used to implement the model. Because of this, several simulations for different input variables to model the anticipated PV, solar irradiance data are used. power production. To model the EVs' hourly electricity needs at the charging stations, driving distance data is used. Based on PV irradiance that differs from the forecast, a sensitivity analysis is performed. The results illustrate how much power the grid would require to be able to handle in the absence of a PV power system. Additionally, recommended sizes for PV power installations are provided. The recommendations vary depending on whether the goal is to achieve complete PV power coverage of charging demands or 100% self-consumption of PV generated electricity. PV power installations that are suitable for lowering peak grid power are recommended for various scenarios. The sensitivity analysis draws attention to discrepancies brought on by solar irradiance interference.

Introduction:

The Cross-Party Committee on Environmental Objectives presented the Swedish government with its final report on an air and climate strategy in June 2016. One recommendation in the report was for Sweden to cut domestic transportation sector emissions by 70% by 2030 compared to 2010 levels. In response to this, a collection of businesses, primarily in the energy industry, put up a document known as The Almedalen Manifesto. The manifesto advocated for investments in EVs and charging infrastructure and was addressed to the Swedish government. According to the manifesto, "electric car and charging infrastructure technology development has reached a stage where a large-scale introduction to the market is feasible." The Almedalen Manifesto's recommendations were meant to serve as a Sweden toward the ultimate objective of two million EVs by 2030. This objective considered necessary in order to achieve the necessary reduction in emissions.

Scope and Delimitations:

This study examines several EV charging simulators. There are simulations.

confined to managing parking lots associated with workplaces, located in Sweden. All EVs are considered to arrive in this model at 8 a.m. then stay there till five o'clock. The treatment of 24-hour charging is left to be studied in the future. The model is restricted to weekday simulations. Holidays and weekends are not considered. Solar irradiation and travel times to work were the two types of data used in this analysis. The simulations treat all of the EVs in the parking lot as a single system. The driving distances were compiled by Transport Analysis (2007), a government organisation in Sweden responsible for the analysis of transportation-related policies. It is not particularly typical of urban, suburban, or rural areas. irradiation from the sun.

The Power Grid:

A power producing unit is connected to various areas of the depending on its size. grid of power. The high-voltage grid typically has large power producers like nuclear and hydroelectric plants connected to it. Conversely, PV power systems are frequently directly connected to the distribution grid (Nordling 2016, 20). The permitted voltage changes on the electrical grid normally range from 5% to 10%. When increasing the amount of power generation provided to the distribution grid, certain constraints must be taken into account.

PV Power Generation in Sweden:

In Sweden, the percentage of PV power in overall electricity output is still quite low. The total quantity of electricity produced in 2015 was 158.6 TWh, of which 0.12 TWh (or around 0.08 percent) came from solar power. In contrast, Germany has 36.9 GWP of installed PV power in 2015. 7 percent of the domestic electricity demand was met that year by PV power output (Fraunhofer Institute for Solar Energy Systems 2016, 5). In Sweden, the number of PV systems being installed is rising. Each year from 2012 to 2014 saw a doubling of the installed PV power. A total of 47.4 MW P were installed in 2015, of which 45.8 MW P were linked to the grid. This was an increase of 30% from the previous year (Lindahl 2015, 5-6). Figure 1 displays the total amount of PV electricity installed in Sweden between 2010 and 2016. The total grid-connected PV power at the end of 2016 was 140 MWP, distributed over 10,000 PV power installations.

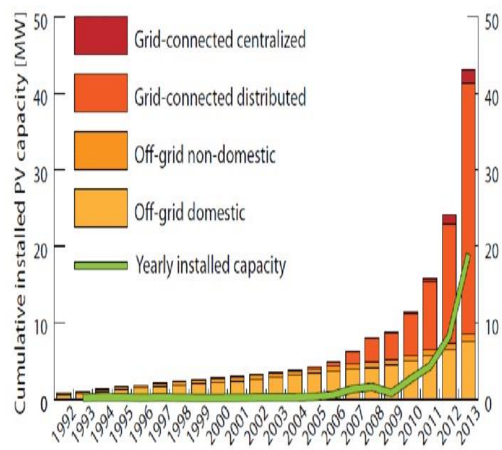

Fig. No. 1 Cumulative PV power installed

Flexible Power Usage and Smart Charging:

Flexible voltage control is needed on both the transmission and distribution grids to accommodate a rise in electrical generation connected to the low-voltage grid, such as solar power generation. If PV power generation surpasses 50% of the demand, inverters on the distribution side control voltages on the electrical grid. Germany now employs this method, which increases PV power generation by 40% without adding to the grid. Furthermore, the future electricity system would need flexible power consumption in addition to flexible power generation. On the local grid, high current loads can be avoided in this way. One approach to do this would be to change the price of electricity on an hourly basis. This would encourage more use of electricity during times of low pricing (Nordling 2016, 50-51). Flexible solutions can aid in reducing the grid loads brought on by charging currents when it comes to EV charging grid planning. To prevent the enormous loads that simultaneous EV charging places on distribution grids, there are two solutions that can be implemented. The initial choice is to lower charging powers. However, this eliminates the possibility of quick charging. The second choice is to give every EV a different start time. By scheduling either the full recharge process or certain portions of it during off-peak times, overlap can be minimised (Walker et al. 2016).

PV Power and Lenient EV Charging:

The battery of an EV is initially charged at a low power level when it is connected to a charging station. After some time, the power rises until it almost hits the battery's maximum tolerance. As the charging session draws to a close, the power drops and the battery charges only partially. This type of charging is gentle on the battery. Statistics gathered by Transport Analysis show that the bulk of travels to and from Swedish workplaces take place between the hours of 7 a.m. and 8 a.m. and 4 p.m. and 5 p.m. No matter what day of the year it is, on a cloudless day, the sun irradiance level rises starting at 8:00 a.m.

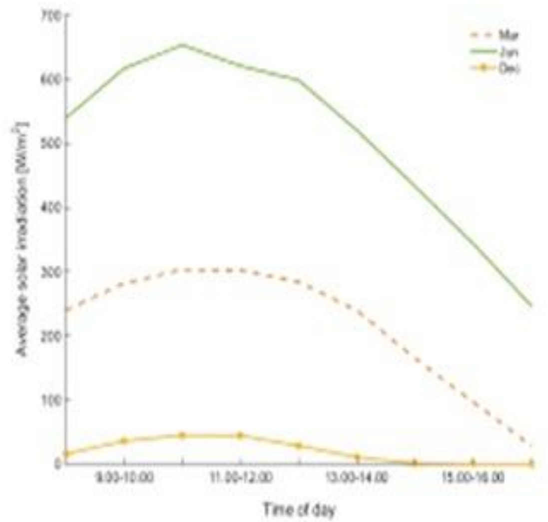

Fig. No. 2 Average solar irradiance per square meter during one workday in March, June and December respectively.

Self-Consumption:

PV power self-consumption is the act of directly using the electricity generated by PV power installations. Although PV power installations are often connected to the electrical grid, increasing self-consumption levels has a number of benefits. Cable losses are decreased when electricity is used on-site. Losses from solar systems positioned next to systems that use power equal to a 1 percent at most. This quantity pales in comparison to Swedish power grid losses, which in 2014 totaled 6.7% of the energ y produced. very high Consumption levels also result in a reduction in the quantity of electricity purchased from and sold to the grid, which has positive economic effects.

Methodology and Data:

All simulations and computations are performed using MATLAB. Driving distance information and solar irradiation data are input parameters for the main script. Then, in order to maximize self-consumption and minimize grid impact, it estimates the amount of power that should be given to the EVs and the energy grid, respectively, each hour.

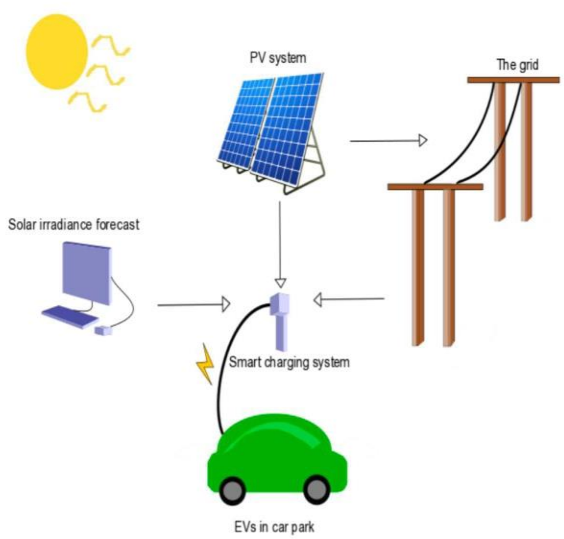

Fig. No. 3 A smart- charging system taking solar irradiance forecasts into account and registering the charge demand from the EVs

Solar Irradiance:

The ideal solar irradiation for PV power generation calculations is set at 1000 W/m2. Under typical test settings, this figure is typically used to calculate the nominal efficiencies for PV 10 modules. Data on horizontal sun irradiation with minute resolution for Norrkoping throughout a year were collected from the Swedish Meteorological and Hydrological Institute. These measurements are converted into average hourly solar irradiance, which is taken to be constant during the same month. From the data, the values corresponding to sun irradiance during business hours are taken.

The Model Principle:

The model is designed to meet daily charging requirements, achieve consistent power exchange with the electrical grid, and match hourly charging powers and PV power generation. Each day's driving distance for each EV is chosen at random, so each day of the simulated year's charging demand for the parking lot is different. The quantity of installed PV electricity determines the degree of self-sufficiency. All PV energy generated is provided directly to the EVs if the total daily PV energy generation equals the daily demand for the parking lot. If the total PV energy production is insufficient to meet the daily demand for parking, the difference is filled by the power grid, which is equally divided throughout the whole workday. If the daily PV energy production is more than the demand for parking spaces, the surplus power is sent to the electricity grid and distributed as equally as feasible. Depending on whether the hourly PV energy generation is more or lower than the mean excess energy generation in this scenario, when the PV system creates excess energy, the power exchange with the electricity grid varies each hour.

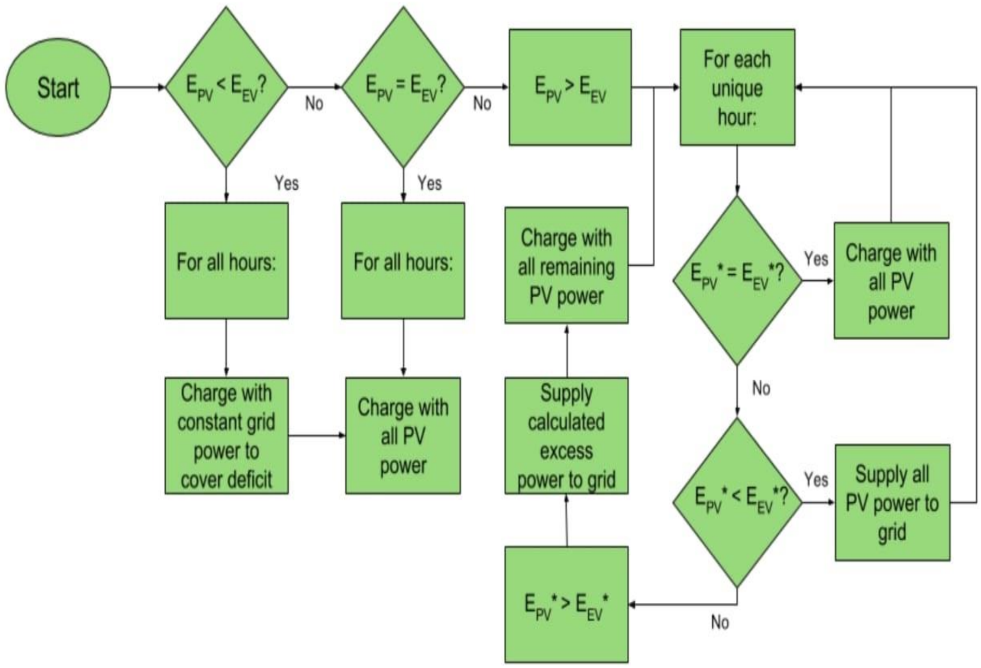

Fig. No. 4 Flowchart for Electric Vehicle Solar Smart Charging Based On Solar Irradiance Forecasting

Sensitivity Analysis:

A rough prediction of solar irradiation served as the foundation for the simulations shown in the previous section. In other words, it is assumed that it is possible to calculate with absolute precision the amount of PV energy that will be produced throughout the day. However, the sun irradiation cannot be guaranteed in practise. The actual irradiance will differ from the forecast for the majority of the hours. Two scenarios with varying sun irradiation are examined in this section. The simulations use solar irradiation that is 50 and 150 percent, respectively, below forecast levels.

Conclusion:

The model developed in MATLAB is assumed to be implemented as a system that modifies EV charging for all outcomes and conclusions. The combinations of 50, 100, or 200 EVs and 0, 20, 100, 200, or 300 KWP installed PV power are the only ones allowed in the simulation scenarios. However, more simulations are run in order to identify PV installations suitable for 100% self-consumption. For some PV power setups, the self-consumption levels can only stay at 100%. If maintaining 100% self-consumption is the goal, the maximum installed PV power permitted is roughly 693 W P per EV.

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