# REDUCTION OF EV CHARGING COST THROUGH OPTIMAL SCHEDULING

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## 1. Introduction

Integrating EVs and EV charging stations into the electric grid may result in several issues, including an increase in the amount of electricity consumed by the grid, which could result in power outages or the need for costly grid upgrades. Hence, there is a need to optimize the charging infrastructure to improve the charging experience for EV owners and reduce the cost of charging stations for operators. We propose a scheduling algorithm to tackle this problem. Initially short-term load forecasting for the load demand on EV charging stations is carried out, which predicts the charging load of charging station for the next day. Furthermore, in addition to load forecasting, Monte Carlo simulations are executed to evaluate the power output of PV cells.

## 2. Methodology

**Short-Term Forecasting:**

Initially, short-term load forecasting for the load demand on EV charging stations is carried out, which predicts the load of a charging station for the next day. Also, Monte Carlo simulations are conducted to evaluate the power output of PV cells for each hour. Using the area of predicted energy demand, the count of vehicles is identified:

$$\boldsymbol{Total\ energy} > \sum_{vehicle\,=\,1}^{N} \boldsymbol{Energy_{vehicle}}$$

Finally, the data is synthesized which is used as input for scheduling

**Scheduling:**

1. Load the required input values, such as the arrival, departure time, energy required, PV tariff, Grid tariff, and Available PV power.
2. Then, the obtained input data is converted into five-minute slots.
3. Before identifying the minimum slots, the count of available charging stations is updated, and the suitable charging rate with charging time is identified.
4. Moreover, the charging cost for all slots between arrival and departure time is identified:

$$\boldsymbol{P_{req}(t) = R_{ch} - P_{pv}(t)}$$

$$\boldsymbol{C_{ch}(t) = R_{ch} \times Tariff}$$

$$\boldsymbol{Tariff} = \begin{cases} C_{grid}(t)\ \text{if}\ P_{req}(t) > 0\ \text{or}\ C_{pv} > C_{grid}(t) \\ C_{pv} \qquad\qquad\qquad\qquad otherwise \end{cases}$$

5. Later, slots are identified during which the total charging cost is minimum.
6. Finally, the vehicle is scheduled to charge during the identified slots.

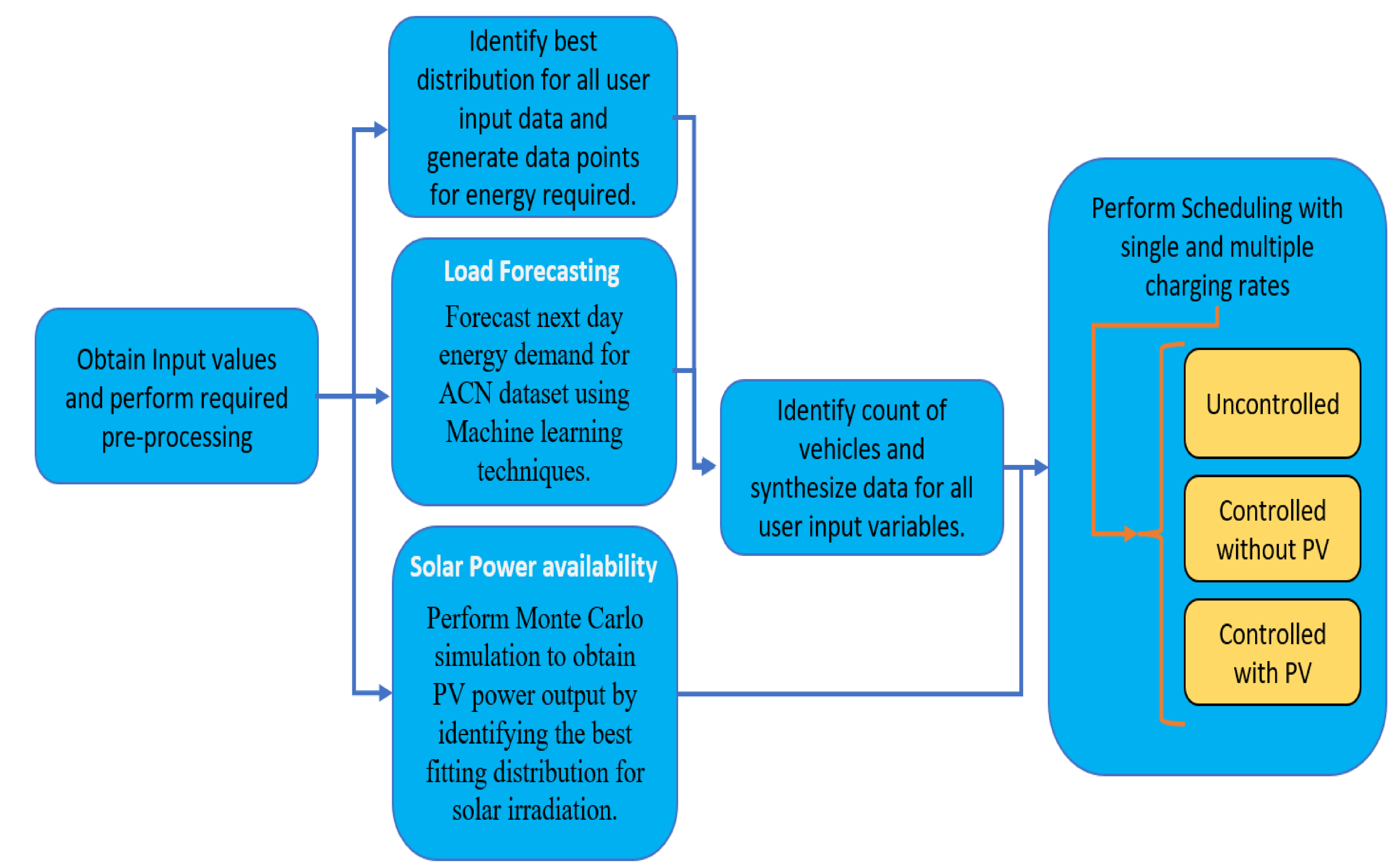


**Figure 1.** Flow Chart.

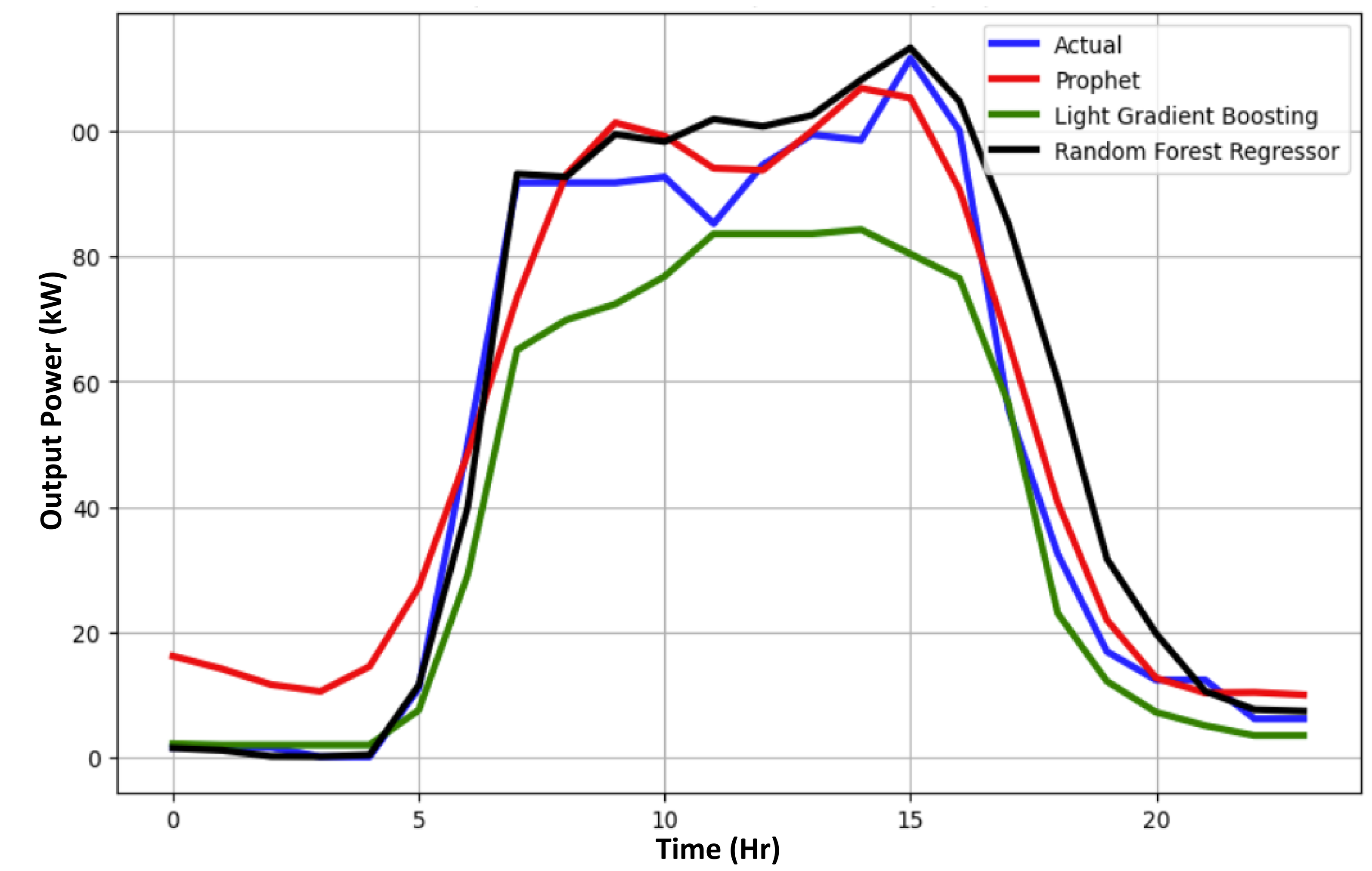


**Figure 2.** Forecasting of Energy Demand

## 3. Results

**Forecasting:**

| Model | MAE | RMSE |
|---|---|---|
| Random Forest Regressor | 6.45 | 10.35 |
| Prophet | 7.68 | 15.54 |
| Light Gradient Boosting | 10.17 | 13.85 |

**Table 1.** Performance metrics.

**Scheduling:**

| Type | Single Charging rate | Multiple Charging rate |
|---|---|---|
| Uncontrolled | $137.26 | $164.79 |
| Controlled without PV | $124.08 | $127.71 |
| Controlled with PV | $113.20 | $121.21 |

**Table 2.** Cost involved in different analysis.

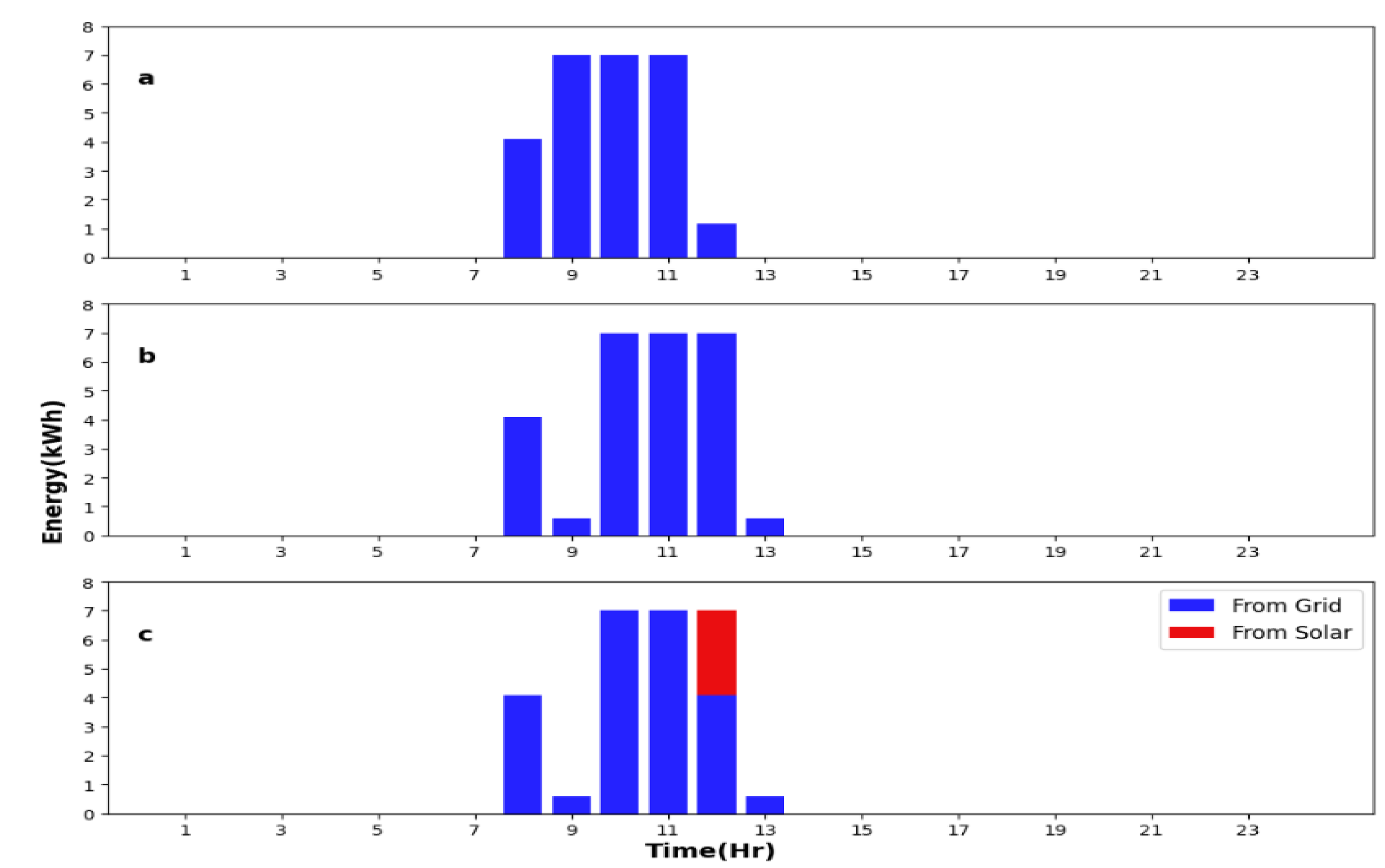


**Figure 3.** Energy delivered with multiple charging rate (a) Uncontrolled charging (b) Controlled charging without PV power (c) Controlled charging with PV power.

## 4. Conclusions

An optimal scheduling algorithm is proposed to charge EV's with single and multiple charging rates. From the proposed algorithm we can:

- Optimally charge the vehicles and minimize the charging cost
- Reduce the burden on the grid
- Use a renewable source as input to reduce the charging cost and contribute to the development of a more sustainable transportation system.

## 5. Implications

1. Lower overall energy and cost savings, which paves the way for smart cities.
2. Charge scheduling systems can assist policy makers in planning future investments in charging infrastructure by providing valuable data on when and where EV drivers need charging infrastructure.
3. Charge scheduling systems can reduce costs and affect competition between different stations in the marketplace.

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