TENTH CARNEGIE MELLON CONFERENCE ON THE ELECTRICITY INDUSTRY

Charging Demand Prediction of Electric Vehicles' Parking Lots Utilizing Auto-regressive Integrated Moving Average Model

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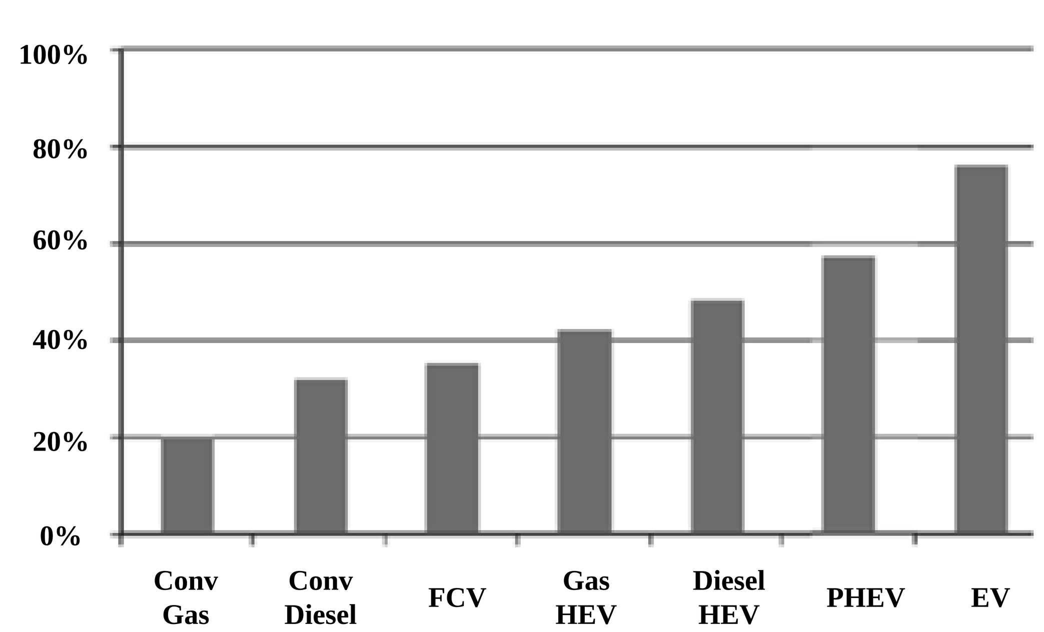
Summary

In recent years, increasing fossil fuel prices, environmental concerns and rising electricity demand motivate the power system to evolve toward the Smart Grid. Modern transportation is one of the key elements of future power system. In this context, utilization of electric vehicles (EV) should be taken into account in a systematic way to avoid unpredictable effects on power system. Additionally, an accurate and efficient demand forecasting method is required to perform a feasible scheduling in order to supply the predicted load sufficiently.
This study presents a probabilistic ARIMA-based forecaster method for the demand forecasting based on historical load data. In order to investigate the effectiveness of the method, the results have been evaluated for different scenarios and the effect of EV parking lots' charging demand on the electricity demand has been demonstrated.

Motivation

In recent years, the environmentally-friendly economy, rising fossil fuel prices and other incentives for independence from fuel price causes high penetration of EVs. Investigations implies that EV play a pivotal role in the modern transportation development because of its high efficiency in comparison with other vehicles' types such as plug-in hybrid electric vehicle (PHEV), diesel hybrid electric vehicle(HEV), gas HEV, fuel cell vehicles (FCV), conventional diesel and conventional gas.



A comparison between efficiency of vehicles

Problem Formulation

The following figures shows the optimization method and the Probabilistic parking lot model output respectively. The single vehicle charging demand calculation steps are:

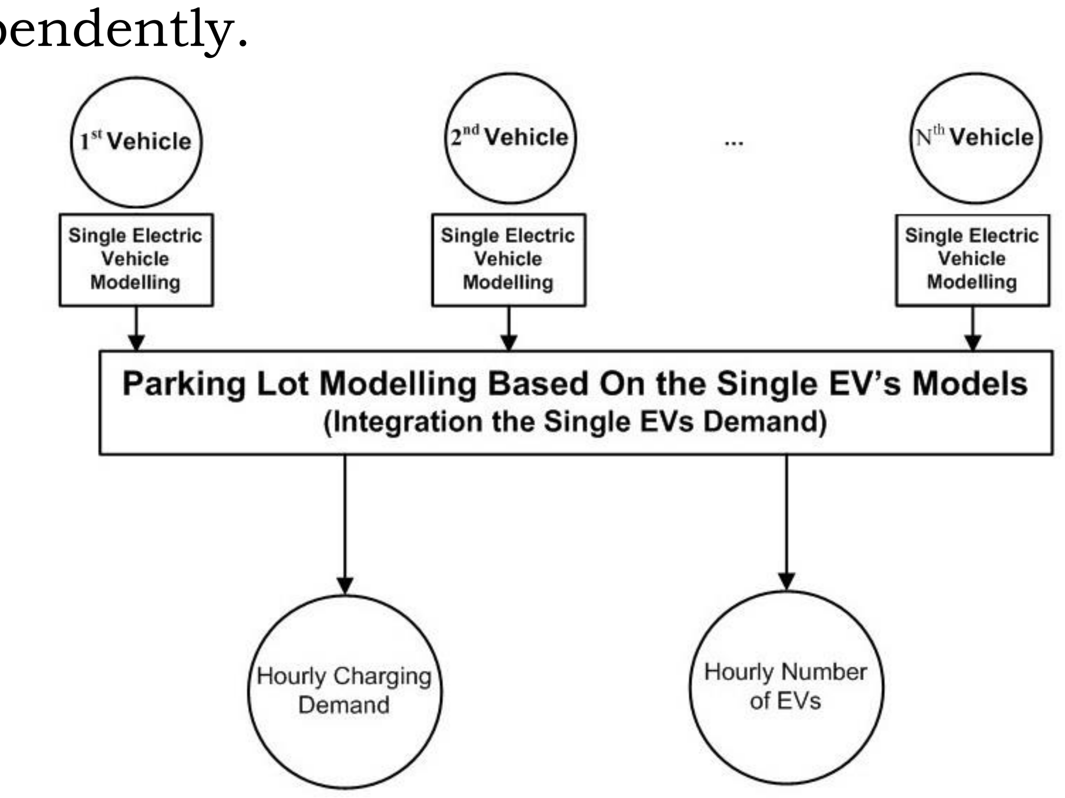
1) $M_d = e^{(\mu_{md} + \sigma_{md} .N)}$

2) $E_{demand} = \begin{cases} C_{bat}; & M_d = M_{dmax} \\ M_d E_m; & M_d < M_{dmax} \end{cases}$

3) $\begin{cases} t_{arrival} = \mu_{arrival} + \sigma_{arrival} .N_1 \\ t_{departure} = \mu_{departure} + \sigma_{departure} .N_2 \end{cases}$

4) $SOC_{final} = \mathbf{Min}\left\{ [SOC_{init} + \frac{E_{demand}}{C_{bat}}], [SOC_{init} + \frac{t_{duration} R_{ch}}{C_{bat}}] \right\}$

Utilizing the aforementioned steps, we run the model for all of the potential vehicles in the parking lot independently.



Parking Lot's Charging Demand and Number of Available Vehicles Based on Single EV model

Battery capacity, energy consumption rate, and market share of these vehicles are shown in the following table. An ARIMA-based forecaster is used to predict the parking lot's charging demand based on the generated probabilistic data.

EV parameters

EV class	C_{bat} (kWh)	E_m (kWh/mile)	η (%)
1	10	0.3790	20
2	12	0.4288	30
3	16	0.5740	30
4	21	0.8180	20

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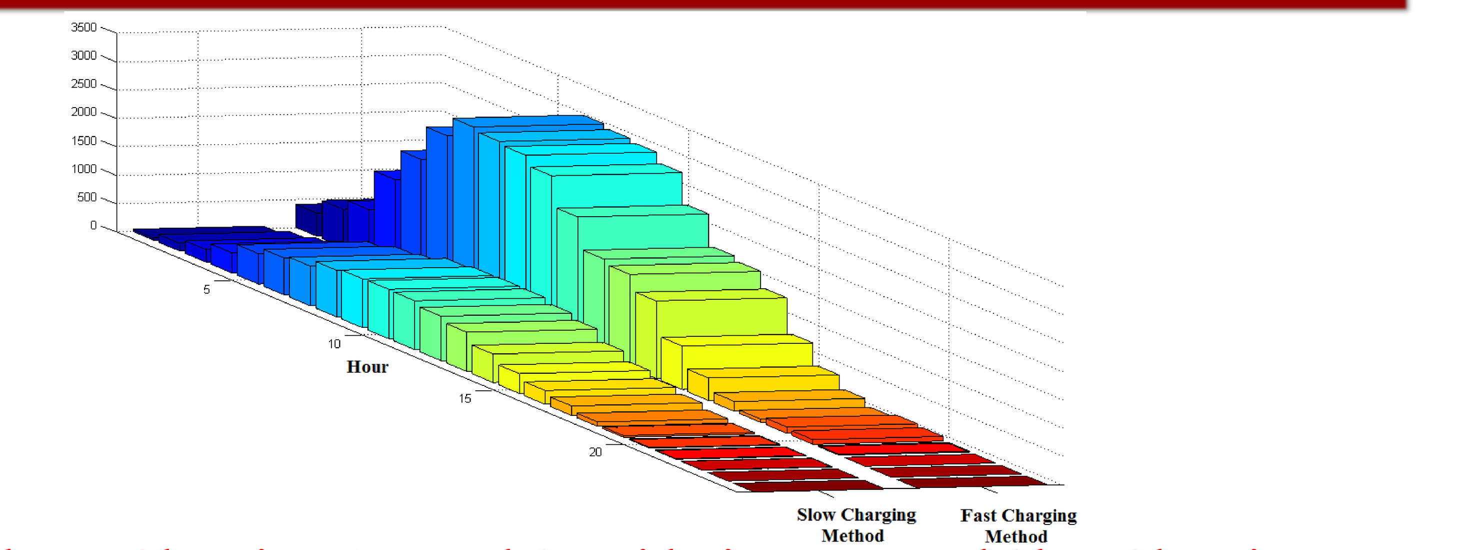
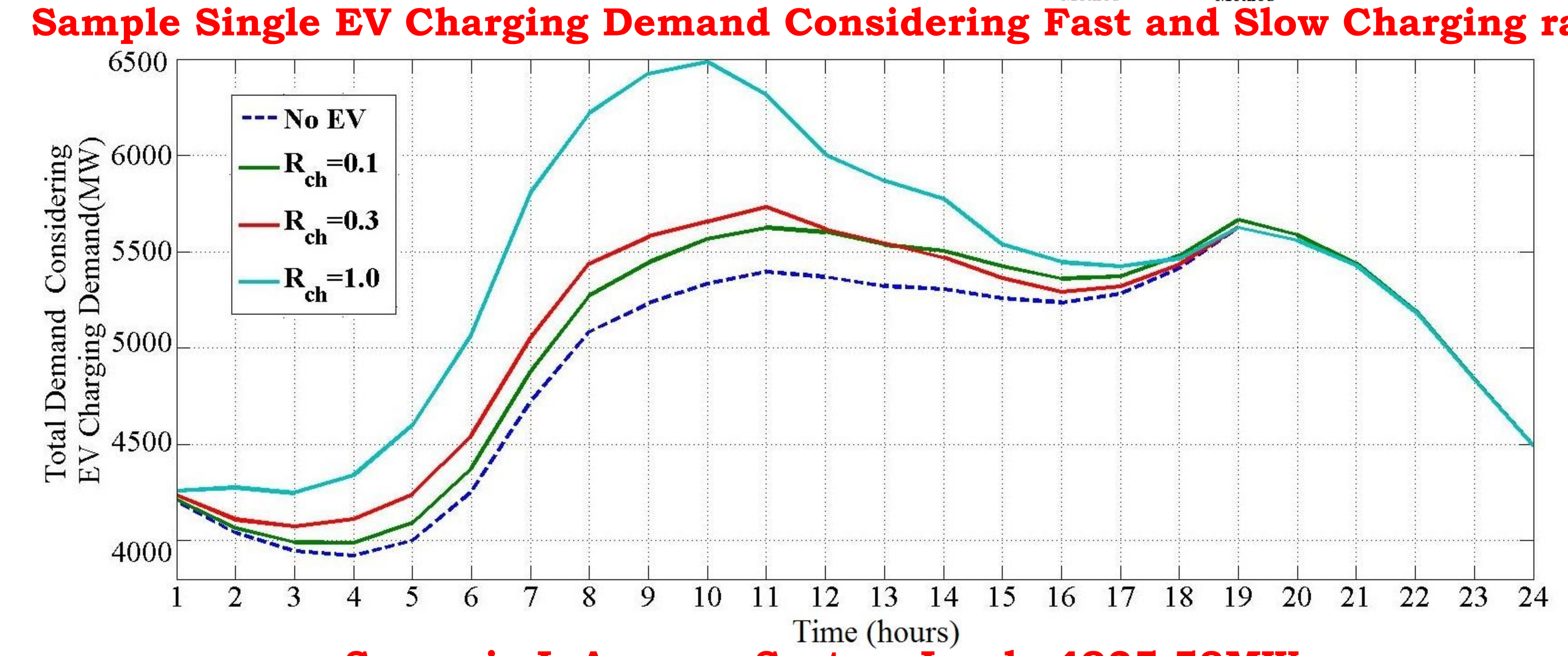
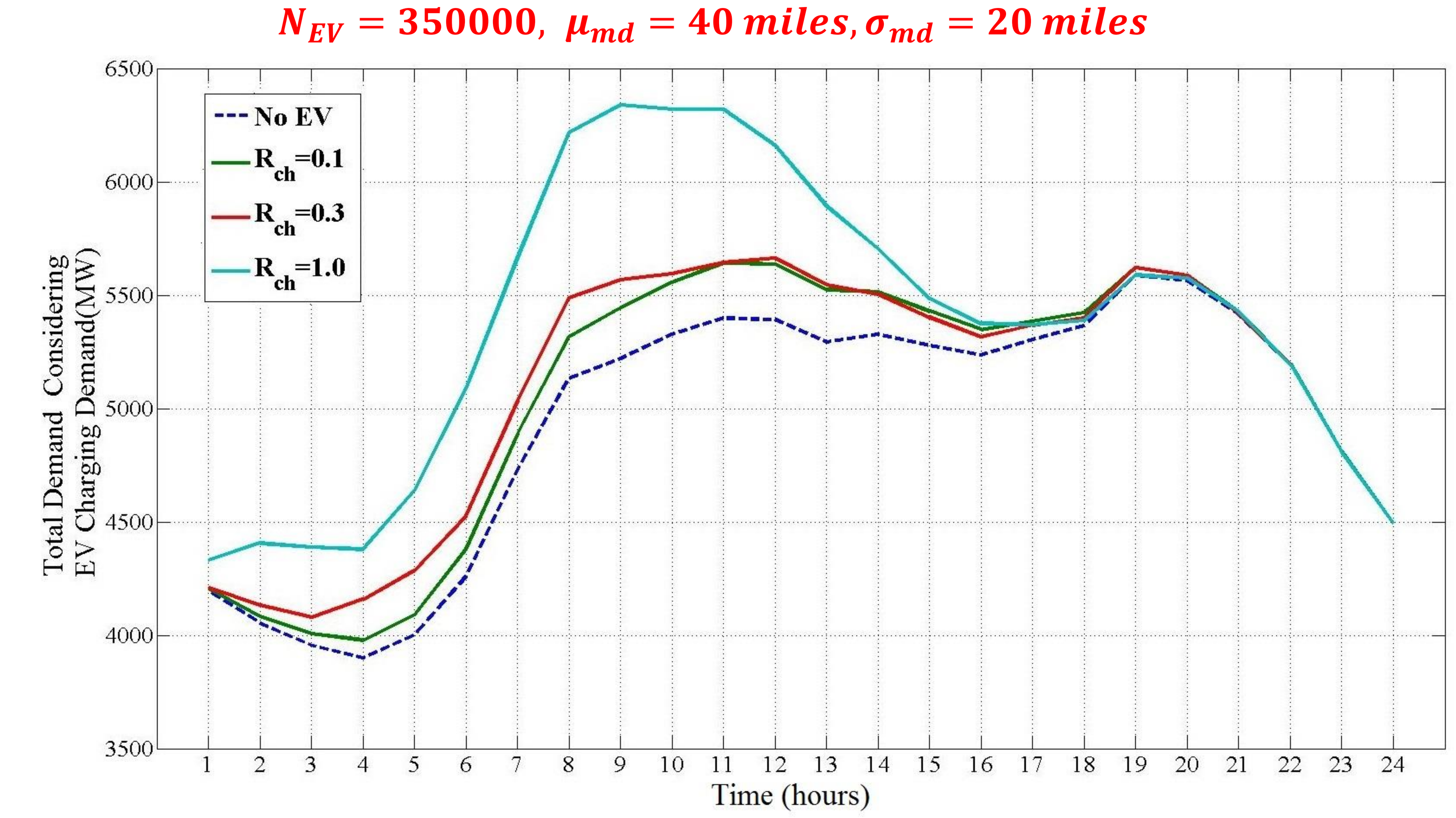
Simulation Results



Sample Single EV Charging Demand Considering Fast and Slow Charging rates



Scenario I: Average System Load= 4935.58MW, $N_{EV} = 350000$, $\mu_{md} = 40\ miles, \sigma_{md} = 20\ miles$



Scenario II: Average System Load= 4935.58MW, $N_{EV} = 350000$, $\mu_{md} = 80\ miles, \sigma_{md} = 30\ miles$

Conclusions

- We propose an approach to predict the charging demand considering large-scale utilization of electric vehicles.
- We evaluate the effect of charging rate and probabilistic driven distance on the total electricity demand.

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