NEPP
north european power perspectives

Results

June 2013

# Stochastic Model of Electricity Retailer Incorporating Aggregated Electric Vehicle Charging Uncertainty

**This paper is based on [1] which describes a proposed model of an electricity retailer considering a future scenario where controlled charging of an aggregate of electric vehicles (EV) becomes a viable option. The retailer plans for purchase of electricity from the spot market while hedging its risks in the financial market, specifically the forward market. In a planning environment where the retailer has to make decisions for purchase of forward contracts ahead of spot market clearing, it faces uncertainties from spot market prices and customer demand. A stochastic programming approach with a financial risk measure is used to take into consideration the uncertainties described. A case study using the model is performed, the results of which indicate that EV customers and the retailer would benefit monetarily with increasing penetration of electric vehicles. The studies consecutively show that this is also the case when increasing fraction of customers opting for variable price contracts.**

## Electricity Retailer

An electricity retailer acts as a middleman between the small/medium end-users and the electricity market. Within the Swedish context, the retailer purchases electricity from the Elspot physical market to supply its end-users while hedging its risks in the financial markets such as the futures, forward, options and contract-for-difference markets. A characteristic of the forward market is that the volume of electricity traded and its corresponding price is fixed and known well in advance. This gives a greater level of financial confidence to the retailer as opposed to its trading in the spot market where the electricity prices are volatile. At the time when the retailer is making its purchase plans in the forward market, the price of electricity in the spot market is relatively unknown with a high degree of uncertainty. Additionally, the volume of electricity to be traded during the corresponding time period is also uncertain. A retailer, in such a situation, has to weigh its options of trading in the forward market versus trading in the spot market for a future period in time. A stochastic modeling approach can be used to better characterize these uncertainties and make calculated judgments concerning the trading in the forward market.

## Retailer Planning Model

The aggregator model can be used to exploit the flexibility offered by the batteries of EVs by optimally scheduling the charging of EVs so as to minimize the total charging cost. As shown in Fig. 1, the EV demand is scheduled for every possible scenario of electricity price and conventional demand forecasted by the retailer. The generated scenarios can then be provided to the retailer planning model that maximizes the expected profit of the retailer to obtain the forward contract decisions and price setting for fixed price contracts with customers. A financial risk measure, such as conditional value-at-risk, may be used within the objective of the retailer planning model to control the risk of experiencing a low profit from the scenarios generated. More details of the model can be found in [1].

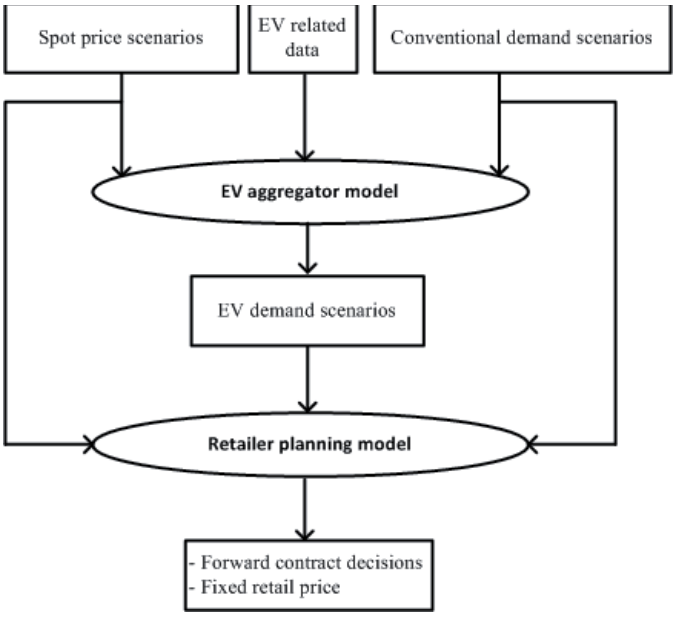


*Figure 1: The retailer's planning framework*

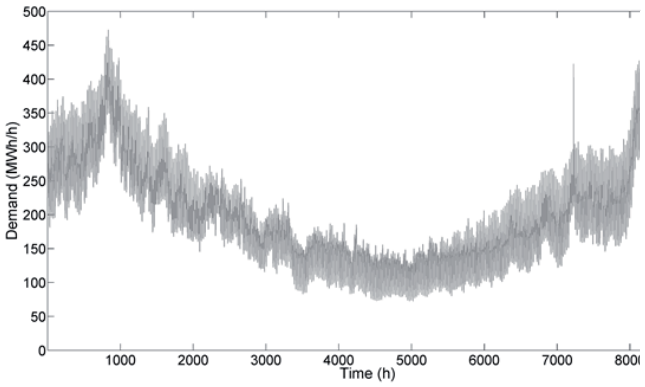


*Figure 2: Estimated conventional demand*

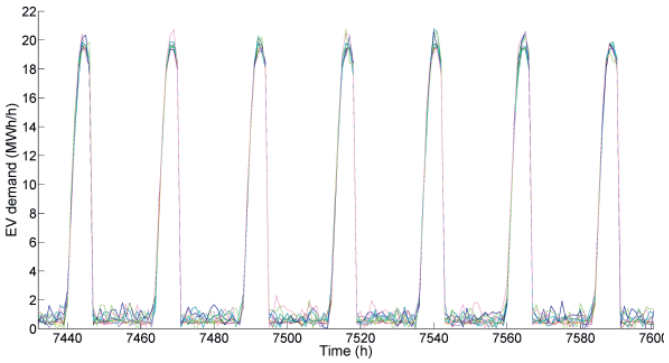


*Figure 3: EV demand scenarios*

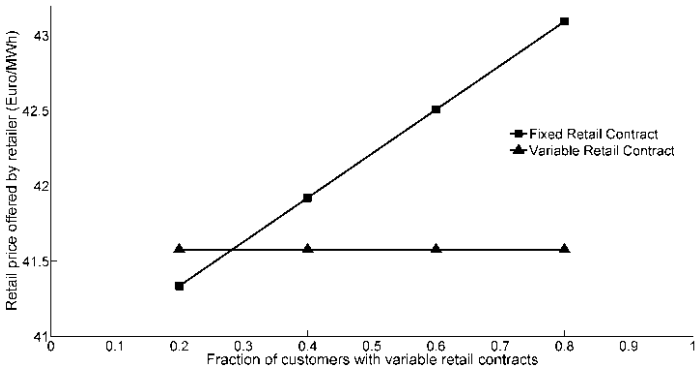


*Figure 4: Retail price offered by the retailer*

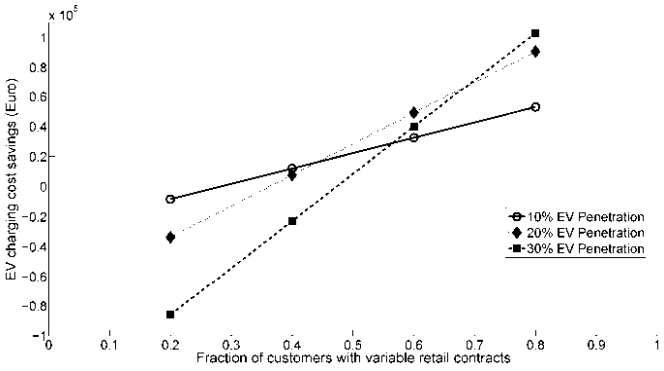


*Figure 5: Total cost savings by EV customers*

## Case Study and Results

A case study was performed with the EV aggregator and retailer planning models. One year price data from Elspot along with the conventional demand level served by a typical retailer in Sweden was used as shown in Fig. 2. Scenarios were generated from the input data and the scheduled EV demand was obtained from the EV aggregator model as shown in Fig. 3. The total demand and electricity price scenarios were then provided to the retailer model to obtain the forward contracting decisions to be made by the retailer. It was observed that the retailer plans a greater volume of purchase from the forward contract when risk averse.

From the customer perspective, it can be seen from Fig. 4 that the fixed price contract customers would pay more for a unit volume of electrical energy when a greater share of customers served by the retailer have opted for variable retail contracts. In Fig. 5, the cost savings is calculated as the difference between the costs incurred by EV owners in case they entered into a fixed retail contract and the costs incurred by them in case they entered a variable retail contract. For a lower fraction of customers with variable retail contract, it can be seen that the EV owners would end up paying more by entering into a variable retail contract as opposed to a case when the majority of the retailer's customers have entered into a variable contract. It is interesting to note that this is advantageous to both the retailer and the EV customers because, with variable price contracts, the EV owners would transfer less financial risk to the retailer while attaining additional savings. At the same time, it can be noted that the profits of the retailer would relatively increase with increasing number of its customers opting for a variable price contract. Additionally, at higher variable price contract ratios, these savings would be increased with increasing levels of EV penetration in the system.

## Concluding remarks

- The electricity price to be paid by fixed price contract customers was found to increase with increasing fraction of customers opting for variable price contracts.
- Total cost savings for EV customers was found to increase with EV penetration and increasing number of customers signing variable price contracts with the retailer as opposed to fixed price contracts. Such an arrangement would also aid the retailer as the retailer's expected profit was found to increase with a greater share of customers opting for variable price contracts.

**References:**

*[1] P. Balram, L. A. Tuan, L. Bertling Tjernberg, " Stochastic Programming Based Model of an Electricity Retailer Considering Uncertainty Associated with Electric Vehicle Charging," International Conference on European Energy Market (EEM), 28-31 May 2013, Stockholm, Sweden.*

For further information:
Pavan Balram, Le Anh Tuan, Lina Bertling Tjernberg Division of Electric Power Engineering, Chalmers University of Technology