Economic impact of EVs in the Brazilian electrical distribution networks

Code: 12.040

Flávio T. Mariotto, Luiz C. P. Silva, Yuri G. Pinto, Fernanda C. L. Trindade
Objectives

Evaluation of the economic impacts of the massive use of electric vehicles resulting from the mitigation of technical impacts in the Brazilian networks distributors
Introduction

- New demand for electric energy to the Electric Vehicles (VEs)
  (i) Battery Electric Vehicles (BEV)
  (ii) Plugins Hybrid Electric Vehicles (PHEV)
- Predominance of charge in home or work environment
- Long charging time will affect the load curve.
- Change the operating conditions of the distribution network
  (i) decrease in voltage magnitude
  (ii) increased voltage unbalance
  (iii) overload of conductors and transformers
- Investments to reinforcing infrastructure to mitigate technical impacts
Methodology

- Adhesion of VEs
- Grouping by distributor
- EE daily demand
- Apparent penetration of VEs
- Violations simulation in the distribution network
- Investment projection and financial evaluation

BEV and PHEV
Adhesion of VEs

Financial Factors
• Tax Benefits
• Cost of use

Non-Financial Benefits

Attenuators
• Autonomy
• Absence of public chargers

TCO

Potential Market Segmentation

Mercado Total de Veículos

Total vehicles sales

BEV Fleet

BEV Sales

Bass - BEV

Scraping

PHEV Fleet

PHEV Sales

Bass - PHEV

Scraping

ICE Fleet

ICE Sales

Scraping

System Dynamics

GDP
Demand growth

Prices

BEV
VHEP
VHE
ICE
Tendencies
Adhesion of VEs

Projection of fleet of plugins VEs
- In 2030: 7.7 millions (14% of light vehicles fleet of)
Grouping by distributor

Relevant Cities

Criteria grouping based on GDP, GDP per capita, HDI and population.

- 10% of Brazilian cities (556 cities)
- 77% of the light vehicles fleet
- 87% of the electricity distributors

Distribution of VEs in the Relevant Cities

- Actually – Adhesion proportionally to actual VEs fleet
- After 2024 – Adhesion proportionally to actual light fleet
Electric energy daily demand

São Paulo State

Daily Km in 2016: 39.6 km
Grow tx: 0.4 km/year

Km by vehicle age (City SP)

Vehicle efficiency (km/kWh or km/l)

Cetesb 2015

ANP (Ref 2014)

Fuel consumption by city (Gas and ethanol)

Fleet by city, vehicle type and fuel

Tendency of daily km in the Relevant Cities

Projection of daily energy demanded by VEs in kwh in the Relevant Cities

BEV
PHVE

Daily average in 2030 to BEVs: 56 km

• Sindipeças - (Frota circ. 2015)
• Denatran - frota-2014

Fuel consumption by city

Sindipeças - (Frota circ. 2015)
Denatran - frota-2014
Apparent penetration of VEs

Balances differences in energy demand of plugins vehicles

\[ P_{Ap} = P_{VHEP} \times \left( \frac{D_{VEB} - D_{VEBmt}}{D_{ref}} \right) + P_{VEB} \times \left( \frac{D_{VHEP} - D_{VHEPmt}}{D_{ref}} \right) \]

\( D_{ref} = \) Daily reference charge

= 10.7 kWh
Monte Carlo simulation of 25,000 secondary networks

BEVs penetration of 10%, 20% and 30%

200 random scenarios per network

(i) Position of the charging stations

(ii) Initial time of each recharge from 6:00 p.m. to 9:00 p.m.

(iii) Variable charging duration based on:

• biphasic chargers with power of 3.3 Kw

• daily reference charge of 10.7 kWh (daily average of 50 km)

• probability density with log-normal curve

(iv) Load flow calculation for 24 hours
Distribution Network Violations

Main violations types

- Magnitude of tension: 78.8%
- Voltage imbalance: 11.1%
- Conductor overload: 9.5%
- Transformer overload: 0.6%

Mitigated Network Percentages

- Conductors
- Transformers

Voltage magnitude violation occurs in almost 80% of the affected networks
Distribution Network Violations

Frequency of investments to enhance conductors

10% penetration of BEVs
Network with violation: 12718
Investment projection and financial evaluation

Monte Carlo simulation

Apparent penetration of VEs

Percentage of networks with violations

Investment per network with violation

Technical losses:
- Reference distributor
- Other distributors

Qualitative assessment of networks

Investments by network

Reference distributor
- Num. networks
- Num. consumers

Investments by consumer

Annual investment and remuneration
Results

Projection of investments in planning cycles

Reference distributor

All distributor in Relevant Cities

Marginal investments (to those normally made by distributors)
Results

Amount of investments until 2030 to all Relevant Cities

Investments frequency

- **Average R$ 55.1 millions**
- **From R$ 31 to 77 millions**
- **70% probability**
- **Standard deviation / mean: 46%**

- **Average per consumer of R$ 1.71**
- **From R$ 0.95 to R$ 2.38**
- **70% probability**

Investment range ( Millions R$)
Results

**Economic assumptions**

<table>
<thead>
<tr>
<th>Item</th>
<th>Valor</th>
</tr>
</thead>
<tbody>
<tr>
<td>WACC regulatory (after tax)</td>
<td>8.09%</td>
</tr>
<tr>
<td>Discount Rate (yearly)</td>
<td>5.85%</td>
</tr>
<tr>
<td>Investment cost (yearly)</td>
<td>8.09%</td>
</tr>
<tr>
<td>Average network depreciation (years)</td>
<td>28</td>
</tr>
<tr>
<td>Prudence index</td>
<td>100%</td>
</tr>
<tr>
<td>Incoming tax (IR + CSLL)</td>
<td>34%</td>
</tr>
</tbody>
</table>

**Amount of regulatory revenues up to 2030**
From R$ 30 million to 60 million

**Net Present Value (NPV) in 2030**
From $ 2 million to 6 million
ROI = 12%

**Financing approach**
Wide dispersion of investments (28 times) (VEs penetration and networks characteristics)
Response to the displacement time of the VE charge

• Encouraged for consumers to charge VEs out of peak hours
• Survey of consumers with EVs in California*
  • 62% use a special PEV rate
  • (when available from the distributor)

Reduction of investment from 60% to 70%

* EV Consumer Survey Dashboard

"Only includes responses from those who answered "Yes" to the question: 'Does your electric utility offer special rates for residential electric vehicle (EV) charging?"
## Conclusions

### Low impact in the short term
- By 2030 the estimated investment amount is from R$ 0.95 to R$ 2.38 per consumer
- Strong investment reduction triggered by off-peak VEs charge

### Planning
- New energy demand
- Methods of prediction and mitigation of impacts in the distribution network
- Availability of capital for investments

### Regulation
- Review of prudence criteria for investments defined by the regulator
- Incentives to charge out-of-peak hours (Smart Charge)
Acknowledgments

• Aneel Research project

PD-0063-0060/2013

Technical and Commercial Insertion of Electric Vehicles in Business Fleets of the Metropolitan Region of Campinas

CPFL Paulista
CPqD
UNICAMP (University of Campinas)