Transportation Electrification
A Disruptive Technology and Potential Emerging BPS Reliability Risk

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United Nations – October 2023
Oscillatory Instability
(Poor Load Modeling)

Fault-Induced Delayed Voltage Recovery

Malin 500-kV Bus Voltage, August 4 2000 Alberta separation
Wood Mackenzie projects passenger and commercial EVs in the US to grow to:
- 69.4 million and 3.14 million respectively by 2035
- 178.3 million and 5.76 million respectively by 2050
EIA Projections from NetZero Roadmap

- Electric car sales (million)
  - 2010: 5
  - 2015: 10
  - 2023: 15

- Solar PV capacity additions (GW)
  - 2010: 5
  - 2015: 240
  - 2023: 360

Note: 2023 values are estimated
How Fast Is the Switch to Electric Cars?
19 countries have reached the 5% tipping point—then everything changes

12-month moving average

EV share of new vehicles (BEV)

If the US follows the trend, a quarter of new cars would be fully electric in 2025

Years after crossing 5% threshold

Sources: BloombergNEF; Bloomberg Intelligence; ACEA; CATARC; OFV; New Zealand Ministry of Transport
Figure 4.3: The Statewide Aggregated Electricity Load for a Typical Weekday

Source: California Energy Commission and NREL
• Electric Highways:
  - Fast charging needs
  - Converting fueling stations into EV charging hubs
  - Many highways near large transmission
  - 3-20+ MW loads tapped off transmission

• Electric Fleets:
  - Buses, delivery vehicles, service vehicles, etc.
  - Smaller in MW size, but much more common
  - Significant aggregate load at distribution or even transmission

Source: National Grid
• **Rapid or unexpected changes in load consumption**
  - Time of use rates, “panic charging”, impacts to system frequency/voltage and overall load patterns

• **Ramping needs to manage critical charging hours**
  - Charging hours anti-correlated with solar PV profile, V2G support for variability

• **Constant power loads**
  - Slow and steady degradation of stability margins, wide-area oscillation problems, grid unfriendly

• **Fault ride-through performance**
  - Similar to solar, unexpected/unstudied response from thousands of EVs could be problematic, recovery matters

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**EV Impacts to the Bulk Power System**

Source: CEC
• System restoration and blackstart plans
  ▪ Unexpected load steps during blackstart
  ▪ Capabilities during large voltage/frequency swings

• Participation in DER Aggregation
  ▪ EV smart charging as DER (FERC definition)
  ▪ V2G as DER (NERC definition)
  ▪ EVs part of DER Aggregators (FERC 2222)
  ▪ Displacement of BPS generation and possible essential reliability services

• Other possible impacts
  ▪ Power quality, harmonic, control interactions
How do electric vehicle chargers behave *during grid disturbances*?
Driving Innovation: EV Modeling for Future Industry Reliability Studies

Understanding

• Beta test and approve model
• Provide EV performance guidance
• Roll out model to industry broadly
• Provide study guidance

Models

• Provide EV performance guidance

Studies
How EV Charging Load Behaves...
...Affects the Dynamic Performance of the Bulk Power System
Joint Partnership to Convene Key Stakeholders

• Cross-industry collaboration to establish recommended practices for “grid-friendly EV charging loads” during grid disturbances
  ▪ Coordination with utility industry, EV and EV supply equipment manufacturers, vendors, etc.
• Step towards joint collaboration
• Longer-term solution: Society of Automotive Engineers
Questions and Answers

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