Energy+Environmental Economics

Infrastructure and Operational Considerations for BEV Electric Rate Structures

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Background

- **E3 was engaged by California Transit Association (CTA) to conduct an analysis of electric rate structures that are most economic for electrified transit**
  - Focus on operations and economics of electric buses
- **Key learnings from this study deal with the impact of infrastructure and operations in determining optimal BEV electric rate structures**
  - Current and future technology, operations and electricity grid conditions

Key Questions

- Which electric rate structures are best for today's and tomorrow's e-buses?
- Does un-managed versus Smart charging impact this outcome?
- What is the impact of increased bus battery size?
- What is the impact of increased EVSE size?

Analysis Steps

1. **Develop "Charging Profiles"**
   - Hourly annual bus operations: determines how buses charge
2. **Create candidate rate designs for evaluation**
   - Range of energy and demand charge structures
   - ~4 pm to ~9 pm on-peak, ~ 9 am to ~ 3 pm off-peak
   - Each rate structure is "revenue neutral"
3. **Calculate annual electricity bills for each Charging Profile and candidate rate design**
4. **Rank electricity bills for each Charging Profile**

Current & Future e-buses

+ **Today's e-bus**
  - 500 kWh battery with 60 kW EVSE
  - BYD's current best-in-class is 500 kWh, New Flyer is 545 kWh, Proterra is 660 kWh
+ **Tomorrow's e-bus**
  - 1,000 kWh battery with 500 kW EVSE
+ **Both**
  - 30% minimum SOC at all times

Charging Profiles

+ Non-commuter

- 150 and 230 miles per day

+ Commuter

- 150 miles per day

+ Both

- Single depot and two-depot charging locations
- 5- and 7-day schedules
- Unmanaged charging: each bus charges immediately upon depot arrival and charges as quickly as possible
- Smart charging: bus charging can be staggered, delayed and throttled to minimize monthly bills

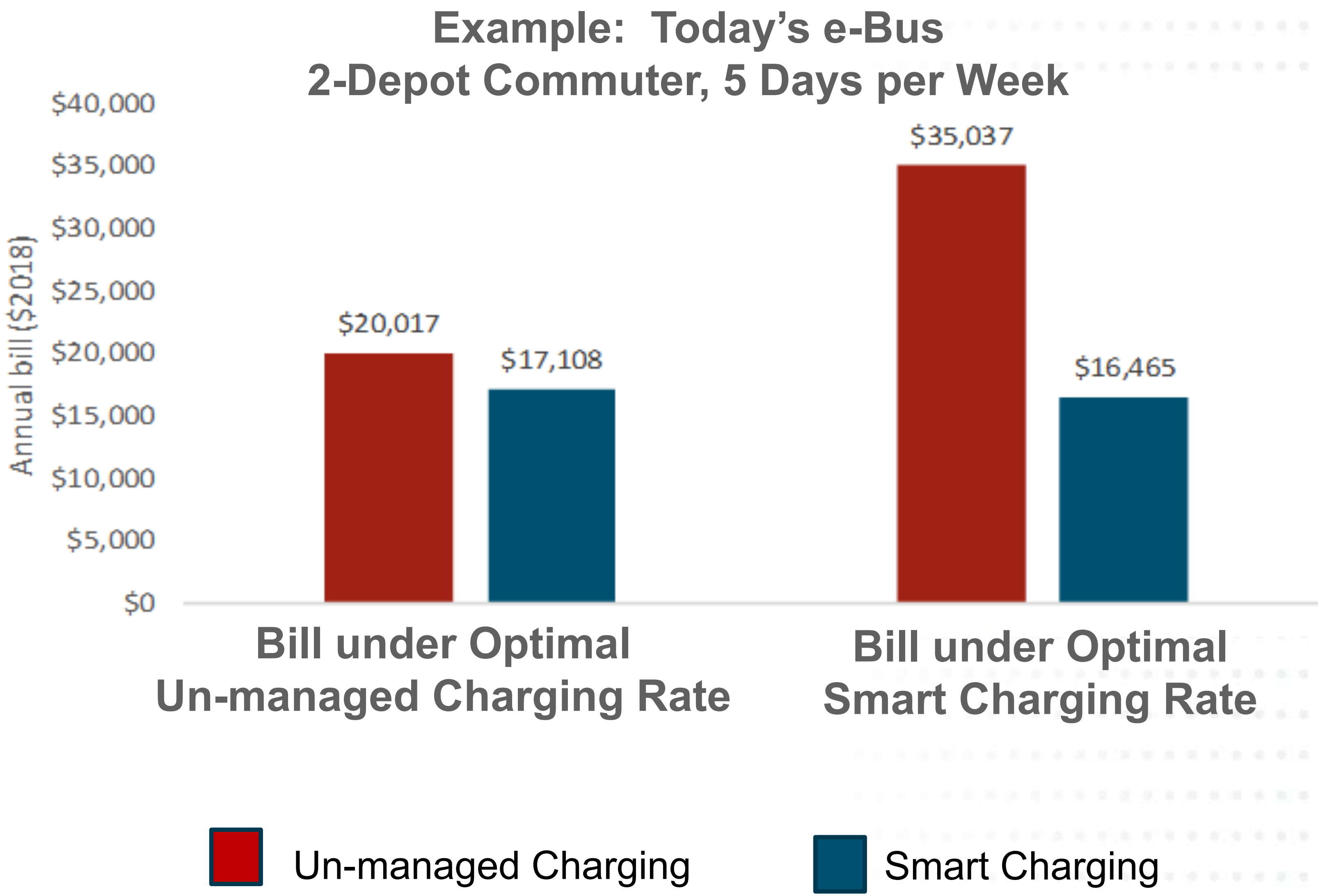
Best Rate Design for Unmanaged Charging

- **For today's and tomorrow's bus under un-managed charging:**
  - No demand charge
  - Flatter TOU ratios (lower on-peak, higher off-peak)
    - A fully flat rate structure would yield the most economic results, however this is unlikely from a regulatory perspective

Best Rate Design for Smart Charging

- **For today’s and tomorrow’s bus with Smart charging:**
  - More volatile “peakier” TOU rates or real-time price signal for energy charges
  - “Peakier” time-differentiated demand charges
    - For smaller customers, a non-time differentiated demand charge at roughly today’s levels

Smart Charging Reduces Bills



Impact of Increased EVSE capacity

- Under un-managed charging, if rates have a demand charge then adding charging capacity will increase electricity bills
- Under Smart charging, increasing EVSE capacity can decrease bills by increasing the charging flexibility

Impact of Increased e-bus Battery

- We estimate value of up to about $5 per kWh of additional e-bus battery storage
- The more charging-constrained the facility is, the more beneficial a larger e-bus battery is
- In cases where charging is already flexible, benefit of a larger battery is negligible

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Thank you!

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