Energy+Environmental Economics

CPUC ZEV Rate Design Forum

Rate Structures Supporting Electrified Transit

08 June 2018

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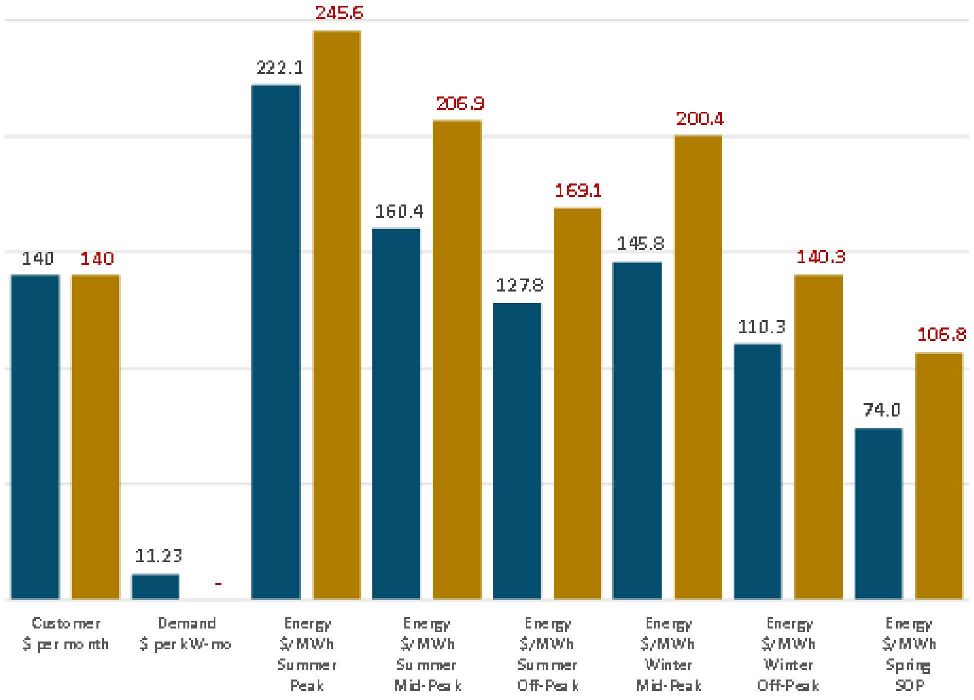
Overview

- Engaged by California Transit Association to examine electric rate structures that are most economic for electrified transit (mainly buses)
- Defined several "bookend" revenue-neutral rate structure scenarios for a medium-sized customer
- Data collected from CTA members to define key technical dimensions for buses, for example:
  - **Route profile**: **daytime** vs. **commuter**
  - **Charging location**: **overnight** vs. **two depot commuter**
  - **Charging**: **Un-managed** vs. **'Smart'**
  - **Buses per EVSE**: **Single** vs. **Multiple**

Key (preliminary!) conclusions

+ **The flexibility of each charging profile determines the extent to which a bus can respond to rate signals**
  - Flexibility is defined by route length, bus battery size, EVSE power and availability
+ **There is no single rate design that is optimal across all electric bus operations**
  - With certain charging profiles and smart charging technology, a rate with a demand charge can be the most economic structure
  - With other charging profiles, rates with no demand charges can be most economic
  - Implies that several rate options for electric transit could be offered
+ **'Smart' charging of buses (sequencing + ability to throttle power) leads to lower bills**

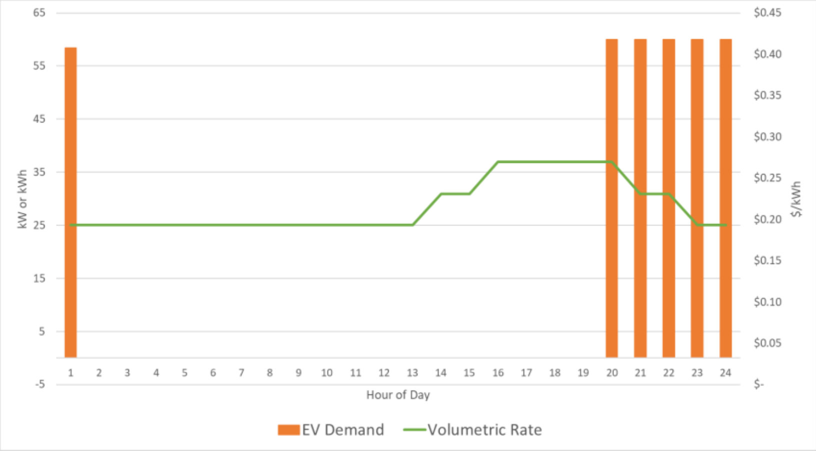
Rate Scenario #1: No Demand Charge

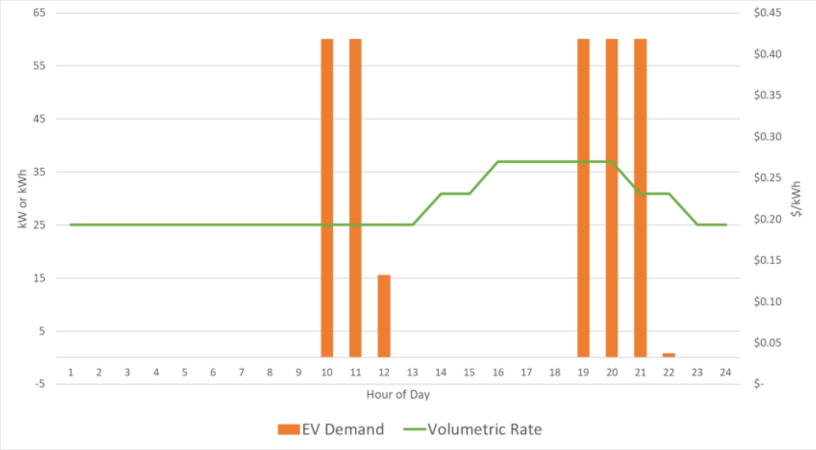


- **Default rate structure (blue bars)**
  - Demand charge ($/kW-mo max monthly)
  - Seasonal and TOU energy ($/kWh)
- **Rate Scenario #1 (gold bars)**
  - No demand charge
  - Transmission & distribution costs collected in seasonal and TOU energy rates

Unmanaged Charging
Single Bus, Summer Day

60 kW EVSE, 350 kWh bus battery

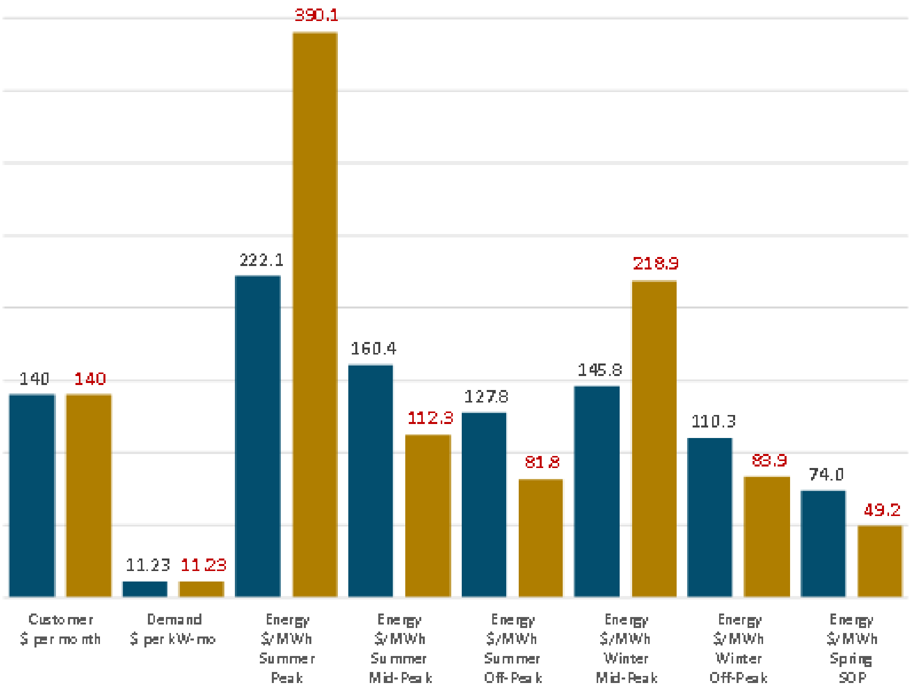




- **Daytime Route**
  - Drives 170 miles
    - 6 am to 8pm
  - Charges overnight
- **Commuter Route**
  - Operates morning and evening but not midday
  - Charges midday and overnight (two depots)

+ Rate Scenario #1 is most economic for both routes

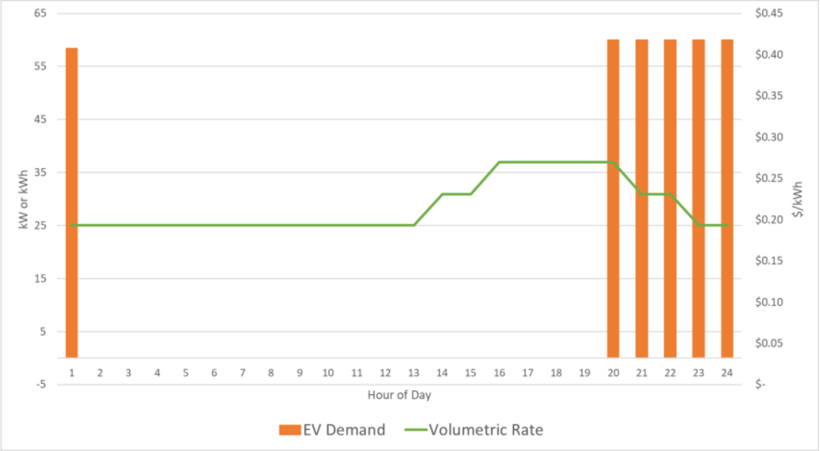
Rate Scenario #2
Demand Charge + High Onpeak Energy



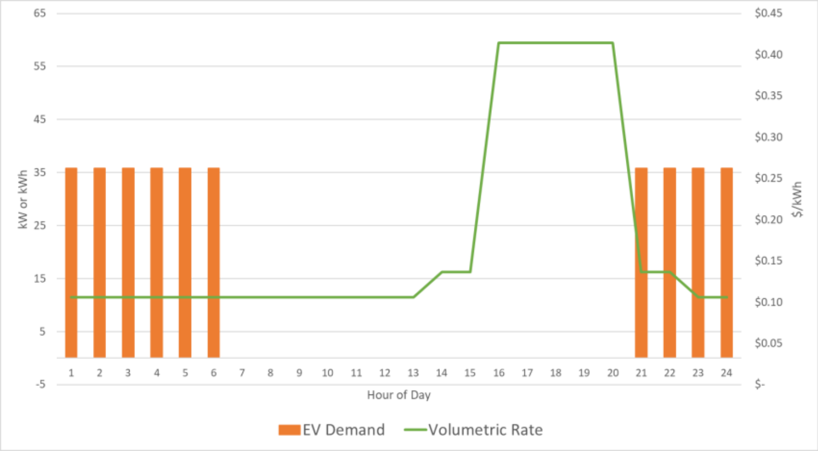
+ **Default rate structure (blue bars)**
  - Demand charge (maximum monthly)
  - Seasonal and TOU energy
+ **Rate Scenario #2 (gold bars)**
  - No change to demand charge
  - TOU energy rates
  - Distribution costs collected in energy only during Summer on-peak and Winter mid-peak periods

Managed vs Unmanaged Charging
Single Bus, Daytime Route, Summer Day

Unmanaged



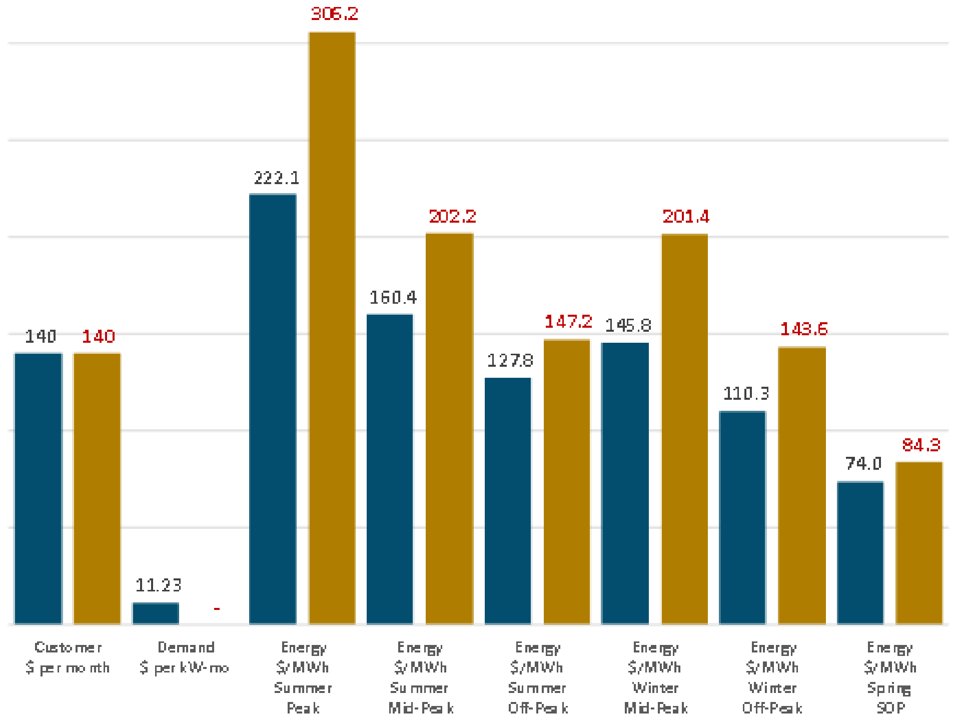
Managed



60 kW EVSE, 350 kWh bus battery

+ **Daytime Route can charge over a 10-hour period making rate structure #2 more economic**
  - 10-hour charging period reduces the demand charge impact
  - Rate design reduces energy rates during mid- and off-peak hours
  - Daytime route charges during mid- and off-peak periods when energy charges are lower, further improving economics

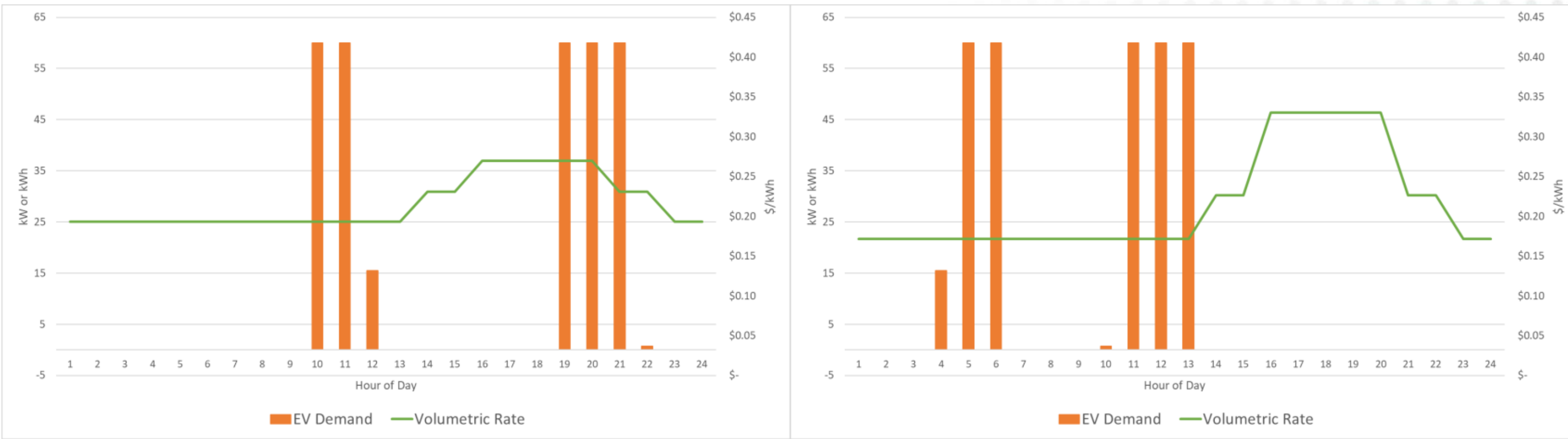
Rate Scenario #3
No Demand Charge + "Peakier" Energy



- **Default rate structure (blue bars)**
  - Demand charge (maximum monthly)
  - Seasonal and TOU energy
- **Rate Scenario #3 (gold bars)**
  - No demand charge
  - Transmission and distribution costs collected in TOU energy rates
  - "Peakier" TOU energy ratios

“Smart” vs Unmanaged Charging
Single Bus, Commuter Route, Summer Day

Unmanaged | **Managed**

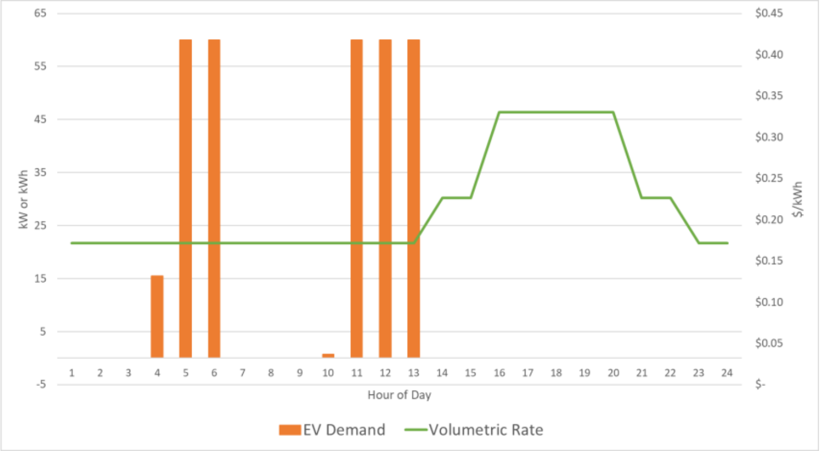


60 kW EVSE, 350 kWh bus battery

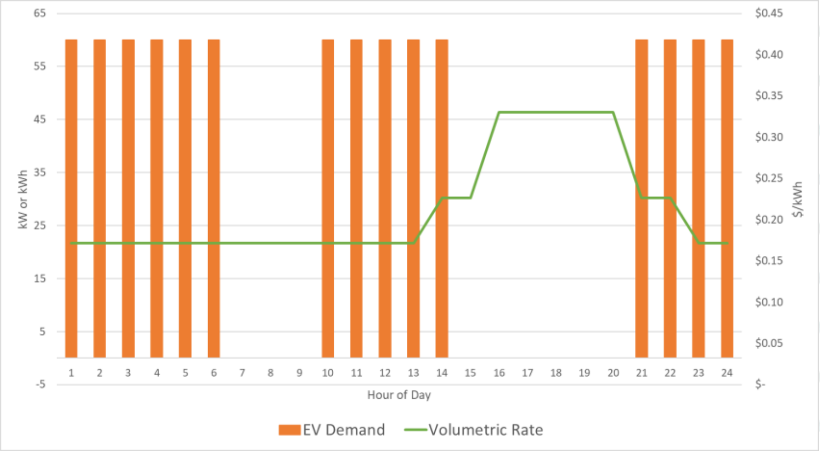
- **Commuter Route can charge twice for short periods, yielding best economics under Rate #3**
  - “Peakier” design reduces energy rates during off-peak hours
  - Managed charging enables all charging to occur during off-peak periods with low energy charges

"Smart" Charging
Single vs Multiple Commuter Buses

Single Bus



3 Buses



+ **Under "smart" scenario, single & multiple Commuter buses can avoid charging during on-peak periods**
  - No demand charge
  - Managed charging enables all charging to occur during mid- and off-peak periods
+ **Rate structure #3 remains most economic for this route**

No Single Rate Design is Optimal

	1 Bus Unmanaged charging	1 Bus Smart charging	3 Buses Smart charging
Daytime One Depot	Rate #1	Rate #2	n/a
Commuter Two Depots	Rate #1	Rate #3	Rate #3

- **The flexibility of each charging profile determines the extent to which a bus can respond to rate signals**
- **There is no single rate design that is optimal across all electric bus operations**
  - Implies that several rate options for electric transit could be offered
- **Advances in 'Smart' charging technologies could unlock other economic rate designs**