# MANAGED CHARGING AND BENEFICIAL VEHICLE-GRID INTEGRATION

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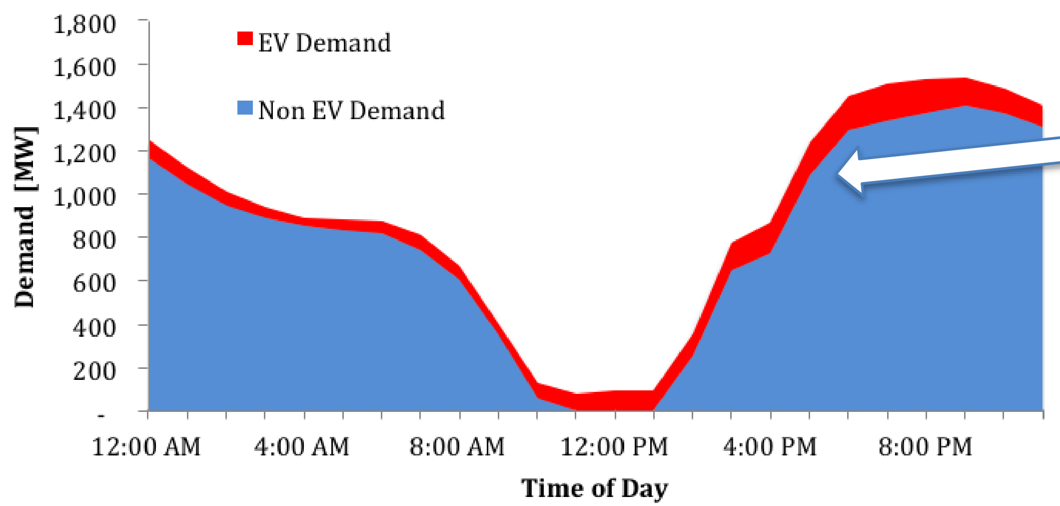
# MANAGED CHARGING

# WHAT IS MANAGED CHARGING?

- “Managed charging” simply means turning chargers on and off, or up and down, controlling the flow of power from the grid to the vehicle (“G2V”) to reduce costs and stress on the grid.
- *It is not* using vehicles to supply power back to the grid a la “Vehicle-to-grid (”V2G”) or to a home (“V2H”) or building (“V2B”)
  - (In the US, V2x really doesn’t exist yet beyond a few demonstration-scale programs.)
- *It is not* demand response

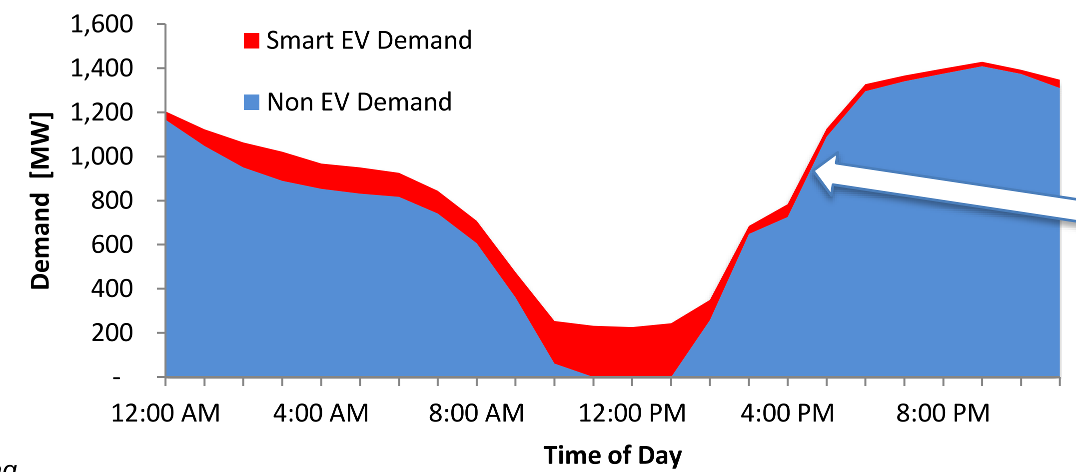
# MANAGED CHARGING: LOAD SHIFTING

- Projected HECO demand with 23% EV penetration with uncontrolled EV charging




**Big "duck curve"**

- Projected HECO demand with 23% EV penetration with managed EV charging




**Smaller "duck curve"**

# MANAGED CHARGING BENEFITS

**Managed charging can:**

- Shift load flexibly in *time* and *space*
- Encourage charging when power cheap and clean, and avoid charging when power is expensive and dirty
- Fill in the valleys and avoid the peaks to create a more uniform system load profile

**A more uniform system load profile helps grid operators:**

- Obtain higher load factors
- Optimize the use of their existing resources
- Avoid having to invest in new peak generation capacity
- Integrate more wind and solar onto their systems by matching a variable load with a variable supply
- Reduce costs to benefit all ratepayers, *even those who don't drive.*

# MANAGED CHARGING STRATEGIES

**“Passive” methods**

- Encourage beneficial charging behaviors primarily **through price signals** (e.g., TOU) and alerts
- Price signals can be fixed (or seasonal), or dynamic (varying hourly)

**“Active” methods**

- Charging aggregators (including automakers) or utilities can **directly control** chargers or vehicles.

# MANAGED CHARGING STRATEGIES

**Customer-controlled**

- Customer sets vehicle or charger to charge when prices are low
- Customer manually responds to a “flex your power” alert when grid is stressed, preferably for compensation
- Low participation rate, low effect, positive customer experience

**Aggregator-controlled**

- A charging aggregator controls many vehicles dynamically in response to utility signals and tariffs, within customer’s parameters
- High participation rate, high effect, positive customer experience

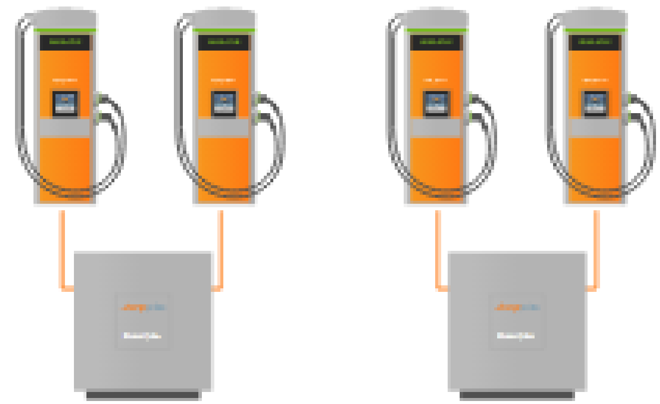
**Utility-controlled**

- Utility directly controls vehicle chargers as needed, with or without customer compensation
- High participation rate, high effect, negative customer experience

**→ All managed charging strategies require dwell time.**

# DIFFERENT RATES FOR DIFFERENT USE-CASES


For Level 1 & 2 chargers, (mainly residential and workplace charging at 8 hours or more), a conventional Time of Use (ToU) rate design to encourage **managed charging is appropriate**.



For DCFC (50-350+ kW), a more sophisticated rate design is needed, which minimizes the role of demand charges until the market matures.

- The load is "spiky" and unpredictable.
- Managed charging requires expensive redundant storage
- The DCFC use-case is **not conducive to managed charging**.

# RATE DESIGN FOR "PASSIVE" MANAGED CHARGING

- Charging should be **profitable** so that it is sustainable.
- Charging should always be **cheaper than gasoline** (typically **$0.29/kWh, or ~$0.09/mile, or less**).
- Level 2 charging should be considerably **cheaper than DC fast charging.**
- EV chargers should be on **dedicated tariffs** and on **separate meters**, preferably the meter built into the charging station.
- Tariffs should offer an opportunity to **earn credit for providing grid services** through **managed charging**.

# SPECIAL CONSIDERATIONS FOR RESIDENTIAL CHARGING

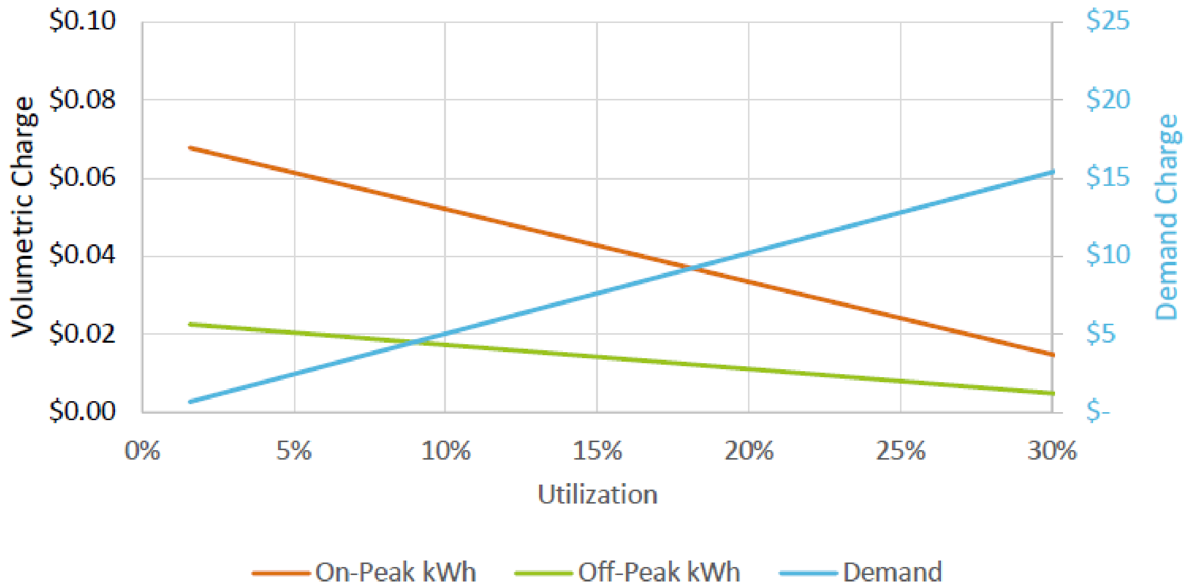
- Level 1 charging is lowest-cost, lowest-impact way to charge and needs no special support or load control.
- Level 2 charging is easier for utilities to support than DCFC and should be encouraged with residential programs to offer favorable TOU rates and incentives/subsidies for installing L2 chargers.
- Level 2 charging with rooftop solar, distributed battery storage and residential load management systems is ideal and offers:
  - the most system flexibility
  - the lowest utility *system* cost long-term
  - a path to microgrid topologies

# RATE DESIGN FOR DCFC

- **DC fast charging is mostly a market failure** due to poor rate design.
- Conventional utility rates with **demand charges can kill the business case** and are not suitable. On public DCFC with low utilization rates, demand charges can be as much as **80-90%** of a monthly bill.
- Public **DCFC are critical** to achieving our transportation electrification aims.
- New, **DCFC-specific rates are needed** while the market is young and charger utilization rates are low.
- **DCFC** operators will always want to manage their own charging and be **hostile to "active" charge management** because their entire use-case is the *fastest charge in the least time, right now*.

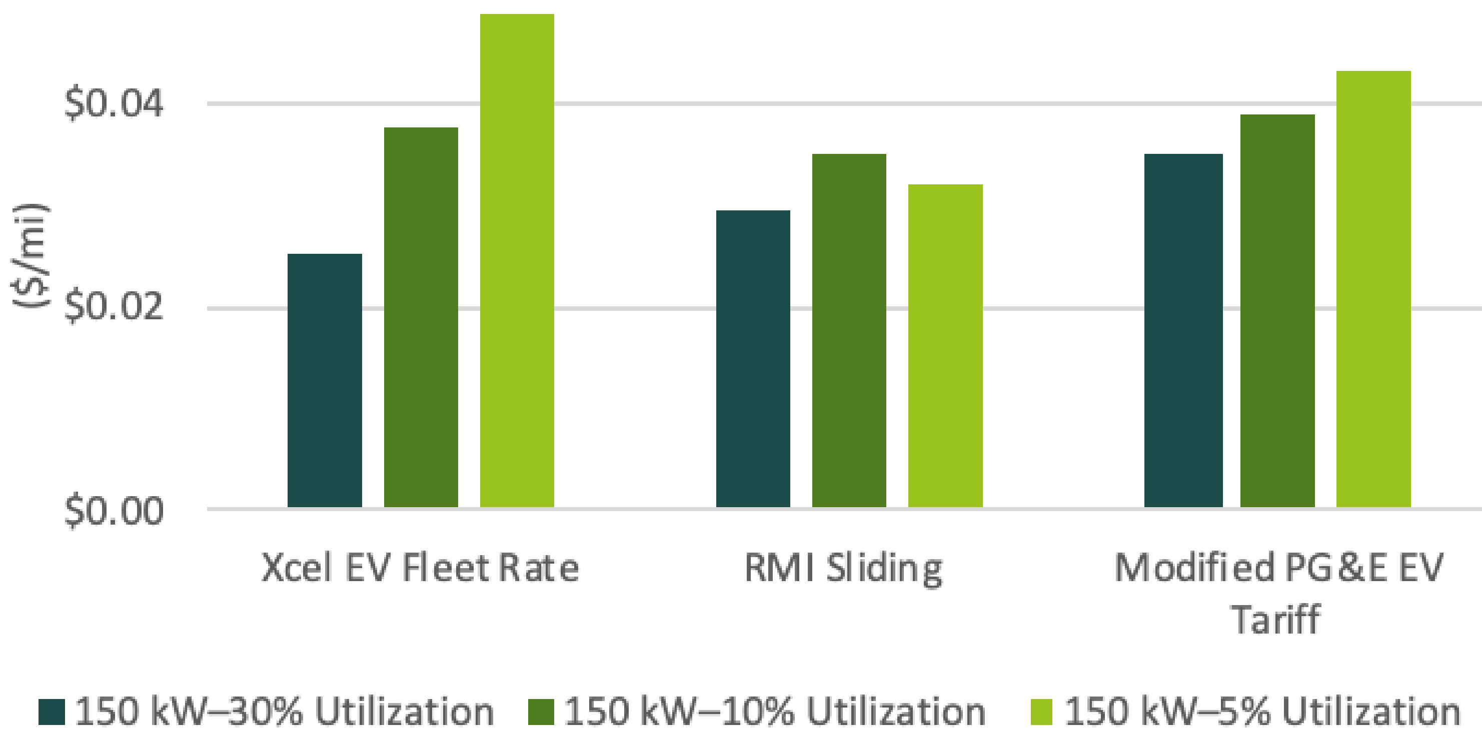
# DCFC RATE DESIGNS COMPARED
# RMI'S PROPOSAL

- Charges scale *as a function of utilization rates*.
- Fixed monthly charge: $34.40/mo.
- Two-tier ToU rate:
  - On-peak (9 am – 9 pm) Decreases from $0.068 to $0.007
  - Off-peak (9 pm – 9 am) Decreases from $0.022 to $0.002
- Demand charge: Increases from $0.677 to $17.622/kW



# DCFC RATE DESIGNS COMPARED
## PUBLIC 150 KW DCFC

RMI tariff produces the *most consistent cost per mile* and the cheapest cost at 5% and 10% utilizations



# DCFC LOAD MANAGEMENT STRATEGIES

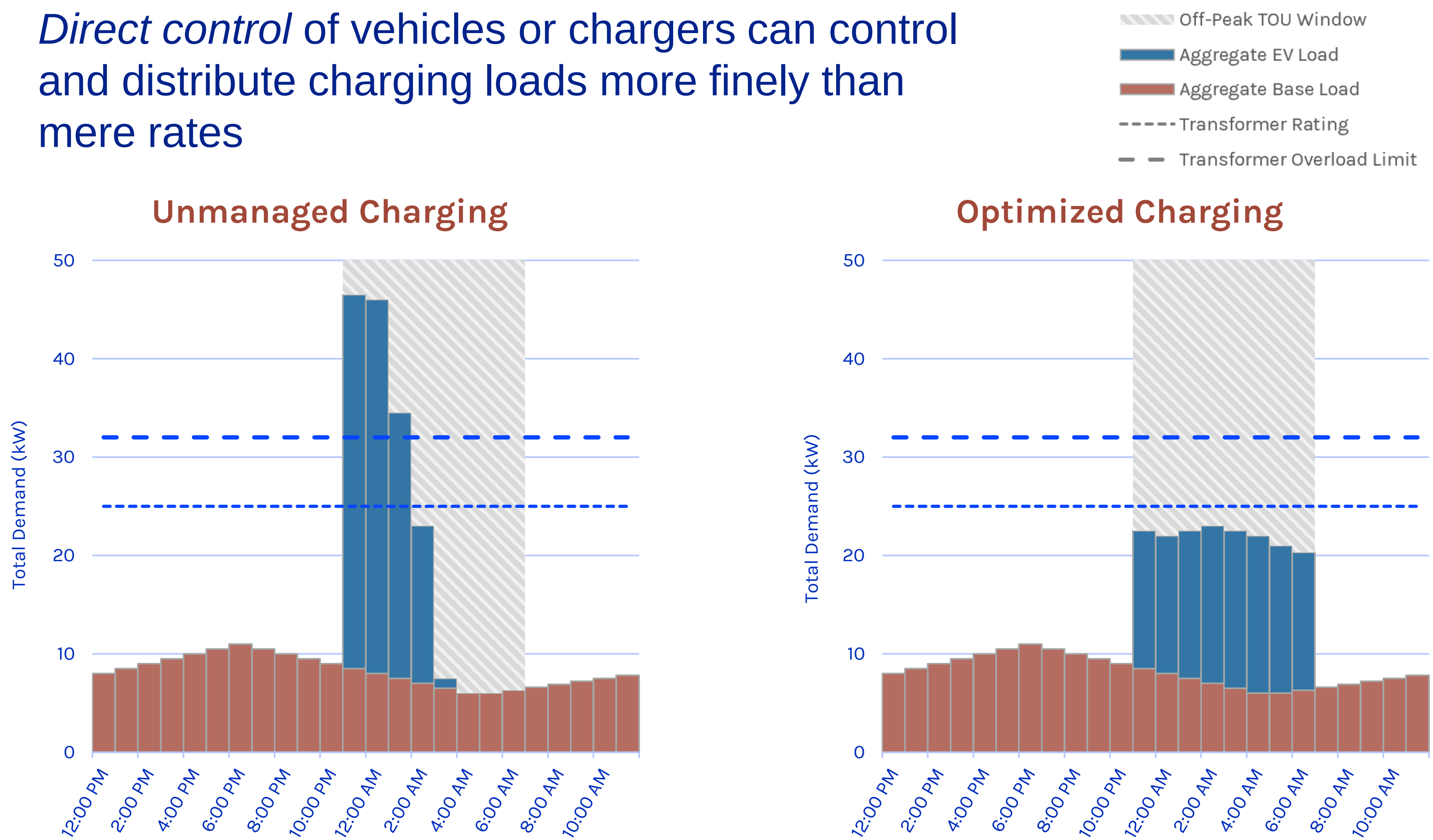
DCFC networks (like Electrify America and EVgo) are often unable to get favorable utility rates without punitive demand charges, leaving them with few choices:

- Only deploy where utilization rates are high and revenue is strong
  - (Do not deploy in underserved communities)
- Deploy with expensive and redundant battery storage and control systems that allow them to manage their own load and avoid triggering demand charges
  - (High storage costs will limit use of this strategy)

→ Smart, proactive engagement with DCFC operators to offer favorable tariffs, sites with significant distribution system capacity or proximity to substations, and co-investment can help attract them.

# "ACTIVE" MANAGED CHARGING

*Direct control* of vehicles or chargers can control and distribute charging loads more finely than mere rates



# “ACTIVE” MANAGED CHARGING TECHNIQUES

**Aggregators control chargers**

- Don’t control L1 or DCFC
- L2 chargers must be networked to be controllable, but many are not.
- Charger manufacturers have no common control language or API, so controlling many chargers of disparate makes is difficult at best.
- “Smart chargers” with control systems can be expensive and very slow to deploy.
- So far, independent aggregators who control chargers have generally gained very modest market penetration before getting acquired by a larger entity (usually a utility).

# "ACTIVE" MANAGED CHARGING TECHNIQUES

**Manufacturers like OVGIP control vehicles through on-board telematics**

- Automakers' approach (Open Vehicle-Grid Integration Platform, "OVGIP") is still just a pilot project started in Oct 2021.
- Partners include 1 utility (Xcel Energy), 4 automakers (BMW, Ford, GM and Honda) and 1 platform operator (Sumitomo Electric)

**Aggregators like WeaveGrid control vehicles through on-board telematics**

- Independent software layer works across multiple platforms
- Charger-agnostic, uses vehicles' native telematics systems.
- Actively manages the vehicles' charging systems based on battery SOC, utility tariffs & price forecasts, resource availability including generator curtailments, etc.
- "Driver first" approach is unobtrusive, considers customer needs
- Offers utilities load control and awareness, automated system optimization, & better customer adoption.

# BENEFITS BEYOND MANAGED CHARGING?

**Demand response (DR)**

- Requires interruptibility, which is generally a feature of “active” managed charging techniques only.
- Only a few pilot projects in the US (e.g., BMW / PG&E project)

**Ancillary services (A/S)**

- Generally sold to ISOs/RTOs, which requires scale (typically >100 kW).
- Therefore, ability to provide DR or A/S implies control of hundreds or thousands of vehicles on demand.
- The A/S market is very thin (easily saturated) and already has many participants. No clear edge for EV chargers to play in it.

**Is there significant value in DR or A/S with EVs?**

- Unclear. Maybe through blockchain-based transaction platforms.
- The value of DR & A/S can be realized only when there are hundreds or thousands of EVs *actively charging and participating.*

# LOAD CONSIDERATIONS

# LOAD CONSIDERATIONS FOR LIGHT-DUTY VEHICLES

**Home charging is dominant now, but will not be in the future, as...**

- EV range grows and more vehicles can go 200+ miles on a charge
- adoption moves from wealthier single-family home residents to apartment dwellers without dedicated parking
- public charging networks expand.

**Public chargers are mostly fast with high power requirements**

- 150 DCFC is the standard now
- Charging power levels up to 350kW will be available at every station
- DCFC sites are expensive. $1m per site not unusual.
- Again: DCFC charging is not conducive to managed charging without redundant & expensive storage on site.

# LOAD CONSIDERATIONS FOR MEDIUM- AND HEAVY-DUTY VEHICLES

**Charging depot loads will be significant.** Beyond 50-150 kW DCFC stations for LDV, will need to fund & recover costs for **2 MW** loads at public charging depots and **20 MW** loads at truck stops.

**Long-haul HD trucks** will be the last to electrify:

- Early stage technology, with first models appearing this year
- Will require build-out of national network of "mega"-chargers
- **Significant grid upgrades will be required to handle ~40 MW loads in small rural communities.**
- Possible disparate impact in rural communities along freight routes.

**Fleet managers need help**

- A steep and treacherous learning curve.
- Horror stories abound.
- **Utility outreach is essential** to sense future MHD loads, and to help fleet managers plan infrastructure.

# LOAD REQUIREMENTS ON DISTRIBUTION SYSTEMS

<table>
<tr><th>Large new loads</th><th>Can require</th></tr>
<tr><td>Residential Level 2 chargers (2.9 – 9.6 kW)<br>• Each EV is like adding a new house</td><td>• Distribution transformer upgrades</td></tr>
<tr><td>Workplace Level 2 chargers (7.7 – 16.9 kW)<br>• Up to ~1 MW</td><td>• Distribution transformer upgrades<br>• Feeders<br>• Service panel upgrades</td></tr>
<tr><td>Public high-speed (DCFC) charging depots<br>• 50 kW – 2 MW<br>• Most new public DCFC are 150 kW</td><td>• Distribution transformer upgrades<br>• Feeders<br>• Service panel upgrades<br>• Make-ready</td></tr>
<tr><td>Transit bus barns, fleet vehicle yards<br>• 5 – 30+ MW</td><td rowspan="2">• Distribution transformer upgrades<br>• Feeders<br>• Service panel upgrades<br>• Make-ready</td></tr>
<tr><td>Interstate truck stops<br>• 20 – 40 MW</td></tr>
</table>

# LOAD CAPACITY PLANNING

1. Calculate load by use-case
2. Understand operational constraints and availability for curtailment/DR

| Use-case | Power Level (kW) | # per site | # sites | Total load | Flex? |
|---|---|---|---|---|---|
| Residential L1 | 1 | | | 1 kw | |
| Residential L2 incl. MUDs | 2.9 – 9.6 | | | 8 – 150 kW? | |
| Workplace & public L2 | 7.7 – 16.9 | | | < 1 MW | |
| Public DCFC depots | 50 – 150 | | | < 2 MW | |
| Transit bus barns | 50 – 150 | | | 5 – 30+ MW | |
| Fleet vehicle yards | 50 – 350 | | | < 5 MW | |
| Interstate truck stops | 150 – 1,700 | | | 20 – 40 MW | |

# UTILITY OWNERSHIP OF CHARGING INFRASTRUCTURE

*Jurisdictions vary in their views on utility ownership of charging infrastructure.*

- Utility investment in **“make-ready”** infrastructure is probably okay everywhere, BUT…
- Utility incentives to invest in make-ready should be **performance-based**
- Utility investment in charging stations (not just make-ready) should focus on installations that are **unlikely to interest private sector** companies, like low-income multi-unit dwellings
- While the sector is young, test multiple models via **pilot projects**.

# UTILITY STRATEGIES FOR BENEFICIAL VEHICLE-GRID INTEGRATION

- Offer favorable ToU rates for Level 2 (residential & workplace) chargers, and rates with minimal demand charges for DCFC.
- Work with aggregators to control loads where price signals alone are inadequate.
- Invest in “make-ready” infrastructure to reduce the private sector’s costs for deploying chargers. Make utility investments performance-based.
- Build utility-owned charging stations only where private sector companies would not, like low-income multi-unit dwellings.
- Help fleets prepare to electrify. Reach out to major fleets and charging networks, cut red tape, and provide low-cost interconnection processes with dedicated support. Offer information on distribution system capacity and any costs associated with needed system upgrades.

# PARTING THOUGHTS

- Transportation electrification is a rapidly changing space, full of uncertainty
- Potentially large loads are on the way, so develop serious system expansion plans to “future-proof” sites and minimize capital expenditures.
- Model early and often, challenge assumptions and be ready to abandon them. What works somewhere else may not be best for you.
- Support microgrid-based system expansion with incentives to combine EV chargers, rooftop solar & distributed batteries for maximal system resilience.