NAVIGATING UNCERTAINTY IN EV ADOPTION

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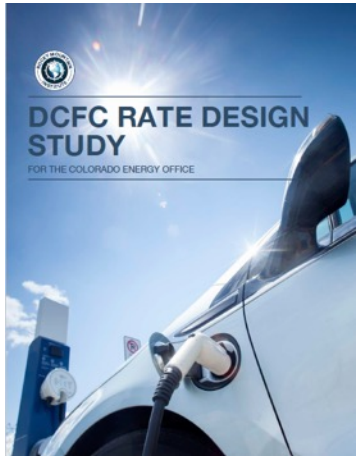
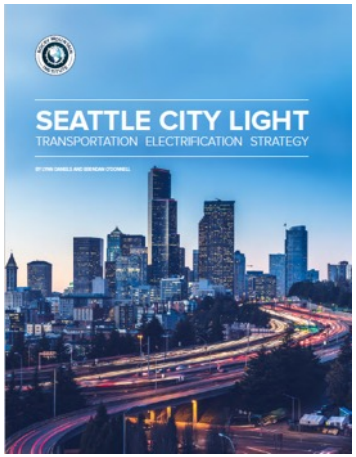
Oregon Global Warming Commission webinar – October 25, 2019

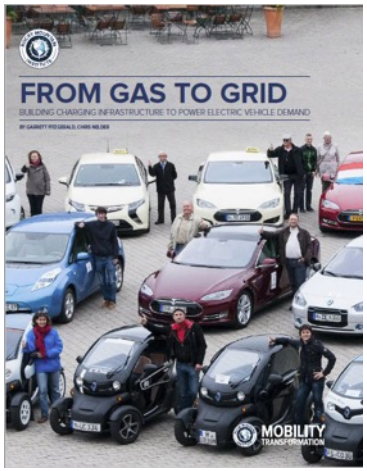
RMI EV-GRID REPORTS



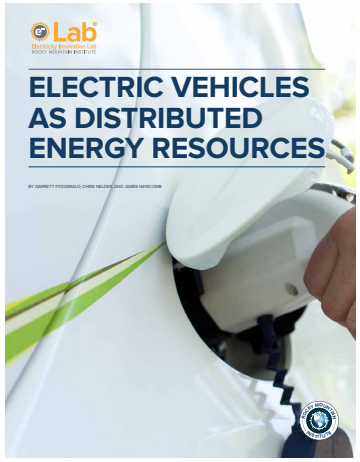
***DCFC Rate Design Study* (Sept 2019)**



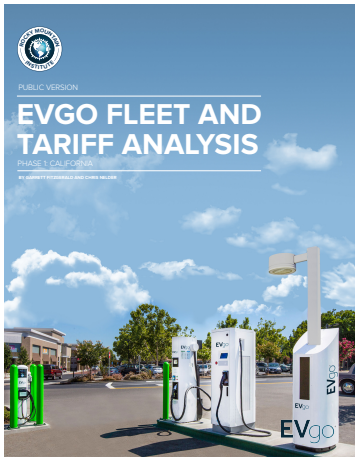
Seattle City Light TE Strategy (Aug 2019)



***From Gas to Grid* (October 2017)**



***Electric Vehicles as Distributed Energy Resources* (June 2016)**



***EVgo Fleet and Tariff Analysis* (March 2017)**

RMI EV-GRID ADVISING

New York Power Authority

- Helped develop Transportation Electrification Strategy
- Supported NYPA in planning "EVolve NY" - A network of 400 150-kW DCFC across the state
- Advising on rate design (demand charge relief) and utility make-ready investments
- Developing a charging-as-a-service strategy for NY transit bus fleets

Seattle City Light

- Helped develop Transportation Electrification Strategy
- Gap analysis of charging infrastructure and identifying where City Light could address un-met needs
- Forecast loads for medium- and heavy-duty EVs (buses, delivery trucks, Class 8 trucking) and evaluate against system hosting capacity

RMI EV-GRID ADVISING

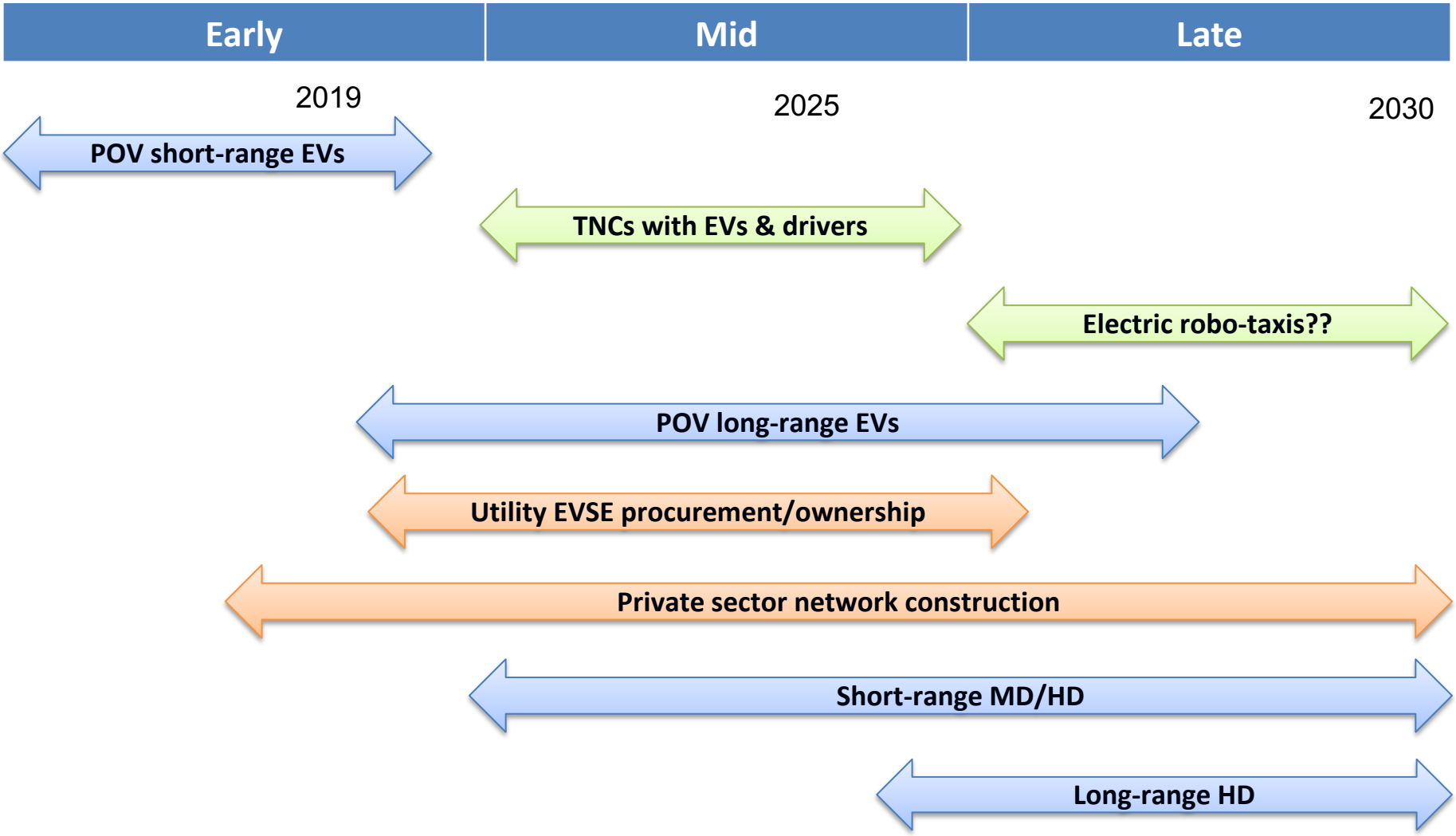
GOVERNMENT OF BERMUDA

- Developing plan to transition old fleet of diesel buses to new fleet of electric buses
- Working with local utility to provide power using local renewables
- Advising on rate design

VARIOUS OTHER ENTITIES

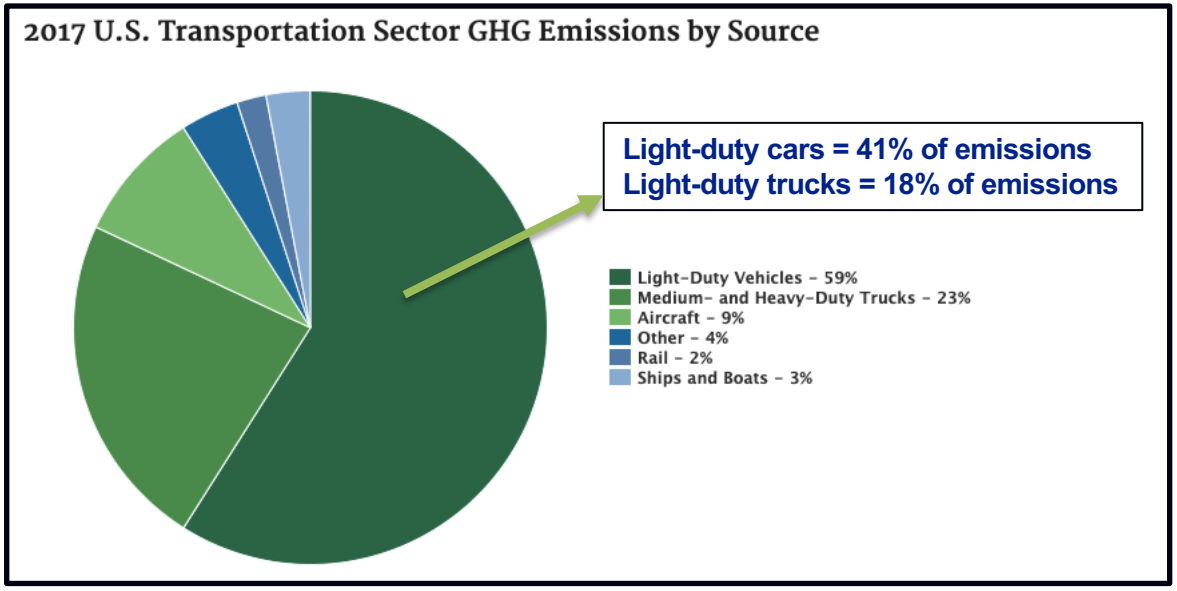
- Transportation Electrification Strategy
- Fleet transitioning guidance
- Rate design analysis & advice
- Standards and protocols
- Best practices for system design (REV West)
- Cost analysis & mitigation
- Regulatory advice
- Load forecasting

TRANSPORTATION ELECTRIFICATION: WHAT'S ON THE HORIZON?



- Our work with **Seattle City Light** (SCL) took a closer look at light-, medium-, and heavy-duty segments and how they could impact SCL's grid…

LIGHT DUTY VEHICLES ARE BIGGEST SOURCE OF TRANSPORTATION EMISSIONS, BUT BARRIERS LIMIT NEAR-TERM ADOPTION



Vehicle availability is biggest barrier

- Personal vehicle sales for LD trucks, crossovers, and SUVs are growing
- 45% of US personal vehicle sales are crossovers and SUVs

- No electric or hybrid light-duty trucks
- Few electric crossovers or SUV models available, all at significant price premium

- Of the 59% of emissions from LDVs, 22% is addressable today

Charging infrastructure, consumer decision-making limit market size

- ~20% of US residents live in multi-unit apartment complexes
- Significant market for EVs but without a solution for providing charging infrastructure access

- And this is a fragmented market where economics are important, but decisions are often driven by comfort, convenience, familiarity, lifestyle fit, and peer comparison

➢ For the electric grid, LDV load will be distributed (though hot spots can lead to localized distribution grid constraints).
➢ For Seattle City Light, we found (1) their grid could absorb new LDV load even in our most aggressive adoption forecasts and (2) they should develop programs specifically for EV customers, to accelerate adoption

MEDIUM- AND HEAVY-DUTY VEHICLES ALSO FACE VEHICLE AVAILABILITY CHALLENGES, BUT COULD LEAPFROG LDV ADOPTION

MD/HD Segment	# of EV Models Available Today	# of OEMs "Producing"	Projected 2019 Global Sales
Delivery MD trucks and vans	19	13	12250
Other MDT	6	6	
Heavy-Duty Trucks	0 for long-haul, 5 short-haul	0 long-haul (12 announced), 3 short-haul	3500
School Buses	12	8	200
Transit Buses	43	14	120000

Demand for EV MD/HD is growing, but supply is constrained

- OEM focus has been on electric buses
- US lags far behind China
- City policies, mandates are driving transit agencies to electrify bus fleets

- Production bottleneck for medium-duty, active OEMs are startups
- National fleet investments (UPS, Fedex, Amazon) are driving manufacturing scale

Adoption will be driven by economics

- Fleet will transition to electric if economics are proven, operational changes are minimal
- Electric buses, delivery vehicles near parity with diesel in the US

- Infrastructure costs, utility demand charges make or break economics over vehicle lifetime
- Few utility investments yet: PG&E and SCE have combined $579 million on infrastructure for MD/HD vehicles

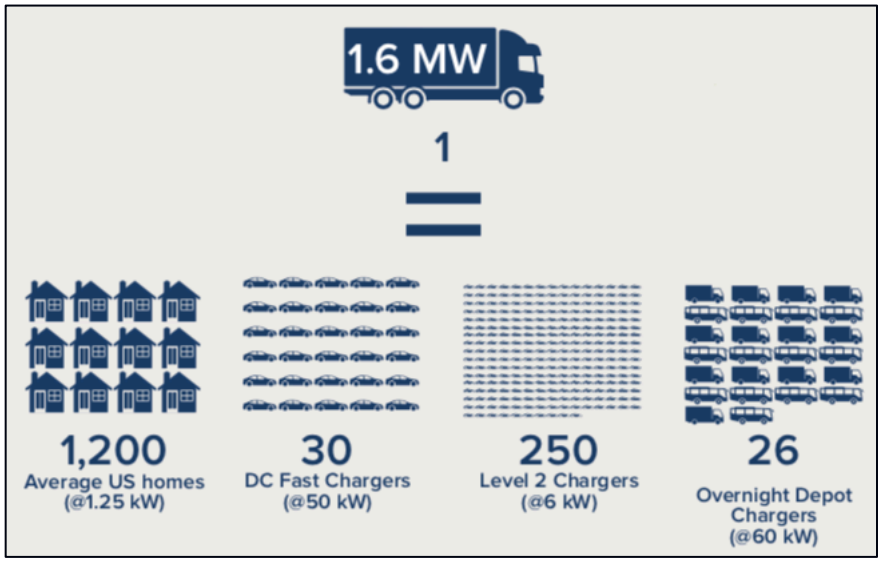
NACFE Guidance Report: Electric Trucks, Where They Make Sense

BUT, MEDIUM- AND HEAVY-DUTY VEHICLES POSE A UNIQUE CHALLENGE FOR UTILITIES AND THE ELECTRIC GRID

By 2025, depots for MD/bus fleets will be here:

- Sites will likely require system impacts study
  - 200 delivery vehicles could draw 4-12 MW
  - 200 buses could draw 10-30 MW
- Early planning can help with site selection and planning, to avoid large grid upgrade costs

➢ New electric loads of this size could cause grid constraints. We recommended that Seattle City Light take a proactive approach, engage with fleet customers, and support planning *today*.



FedEx chanje

FedEx acquires 1000 Chanje electric delivery vehicles

amazon RIVIAN

Amazon orders 100,000 Electric delivery vans from startup Rivian, on-the-road by 2024

ups WORKHORSE

UPS buys 1000 electric vans from Workhorse

Electric long-haul HD trucks a ~decade away:

- Technology at concept/prototype stage
- Will require build-out of national network of "mega"-chargers

➢ When HD electrification happens, significant grid upgrades will be required to handle load at sites. Possible disparate impact in rural communities along freight routes.

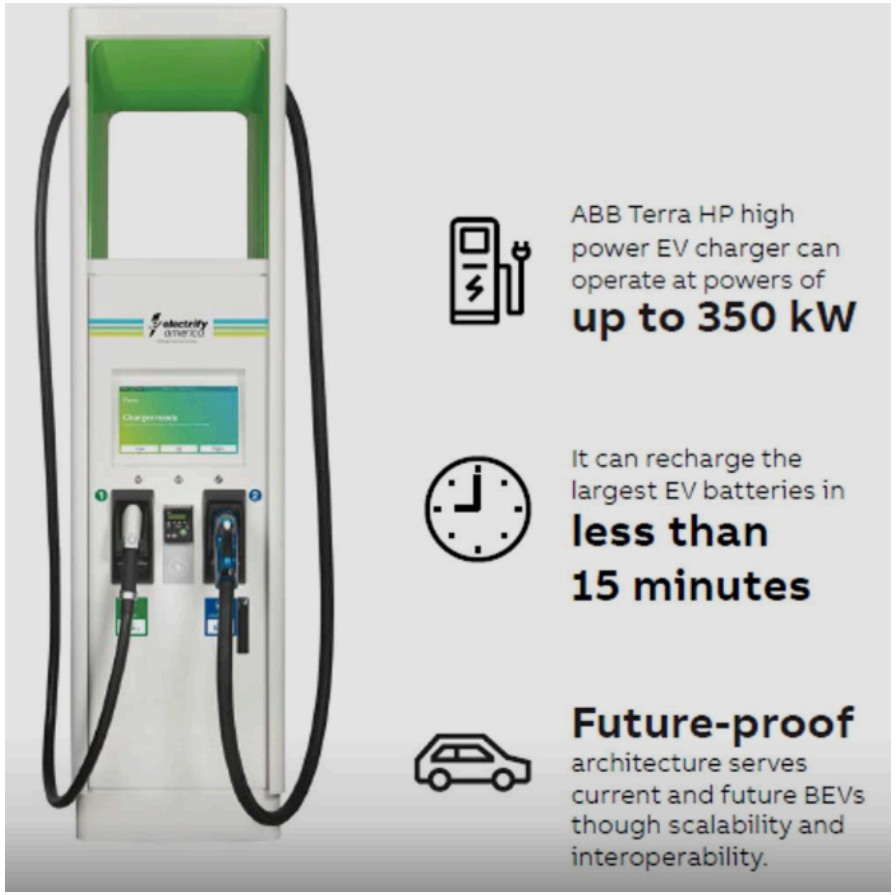
➢ Talk to fleets *today*, keep talking to them about plans to transition to electric.

CHARGING INFRASTRUCTURE: TODAY AND TOMORROW

Everything is changing…

- Today: 7 kW home charging, 50 kW fast chargers
- Tomorrow: Commitments for 150 kW fast chargers, up to 350 kW
- Retail built up around chargers like gas station? “Mega”-chargers at truck stops?

- **Electrify America** commitment to install DC Fast EV charging stations, with charging power levels up to 350kW available at every station, capable of adding 20 miles of range per minute to a vehicle.
- UK’s electricity operator **National Grid**: home charging will not be the dominant way to charge electric vehicles (EVs) in the future as long-range EVs are manufactured



KEY QUESTIONS

Policy questions

- What's your objective (cars, emissions, better mobility)?
- What role will your agency play?
- How should you support goals of governor/mayor/city leaders?
- What's your utility and charging network engagement strategy?

Big picture questions

- How many EVs will there be by 2020? 2025? 2035?
- When should we start building chargers?
- Will wireless induction chargers replace wired chargers?
- Will AVs take over?
- Will SAEVs replace POVs (and when)?

Charging network questions

- Who should own and operate chargers?
- Who will put up the capital to build chargers?
- What kind of chargers do you need for a multi-unit dwelling, and in what configuration?
- How can we provide electric mobility access to all, including non-drivers?
- How many chargers do we need per EV, what kind (fast/slow), and where (on/off street)?
- Urban core chargers for POVs or eHubs for SAEVs?
- How do you balance the need for Level 2 in public space (e.g., curbside) and the potential for SAEV giving it back?

KEY ISSUES

1. **DC fast charging is mostly a market failure** we will have to correct to achieve our transportation electrification aims.
2. This problem almost certainly requires **a rate design cure**.
3. **Charging depot loads will be significant.** In addition to today's 50-150 kW DCFC loads, let's have a view toward funding & recovering costs for 2+ MW loads at public charging depots, 5-10+ MW loads at transit bus barns and 20+ MW loads at truck stops.
4. **Utility investment is necessary.**
5. **Fleet electrification entails a steep and treacherous learning curve.** Most fleet managers are unfamiliar with charging equipment, operational aspects of managing charging, financial impacts of charging and maintaining electric fleets, etc. Horror stories abound.

HOW TO GET READY

Utilities:

- Develop appropriate EV-only time-varying tariffs that encourage managed charging.
- Make a plan to accommodate DCFC charging depot loads of 1 MW or more in town and 3+ MW loads on interstates, including an assessment of where the grid has excess capacity and where it is constrained.
- Plan for dispersed low-energy loads today (to accommodate personally owned vehicles) and concentrated high-energy loads tomorrow (to accommodate fleets of robo-taxis, delivery vans, etc.).

Regulators: Have a clear position on charging infrastructure ownership and cost recovery. Charging infrastructure will figure in future IRPs.

DOTs and elected officials: Advance planning for EV charging infrastructure is essential to obtaining the optimal outcome. It should be under way now.

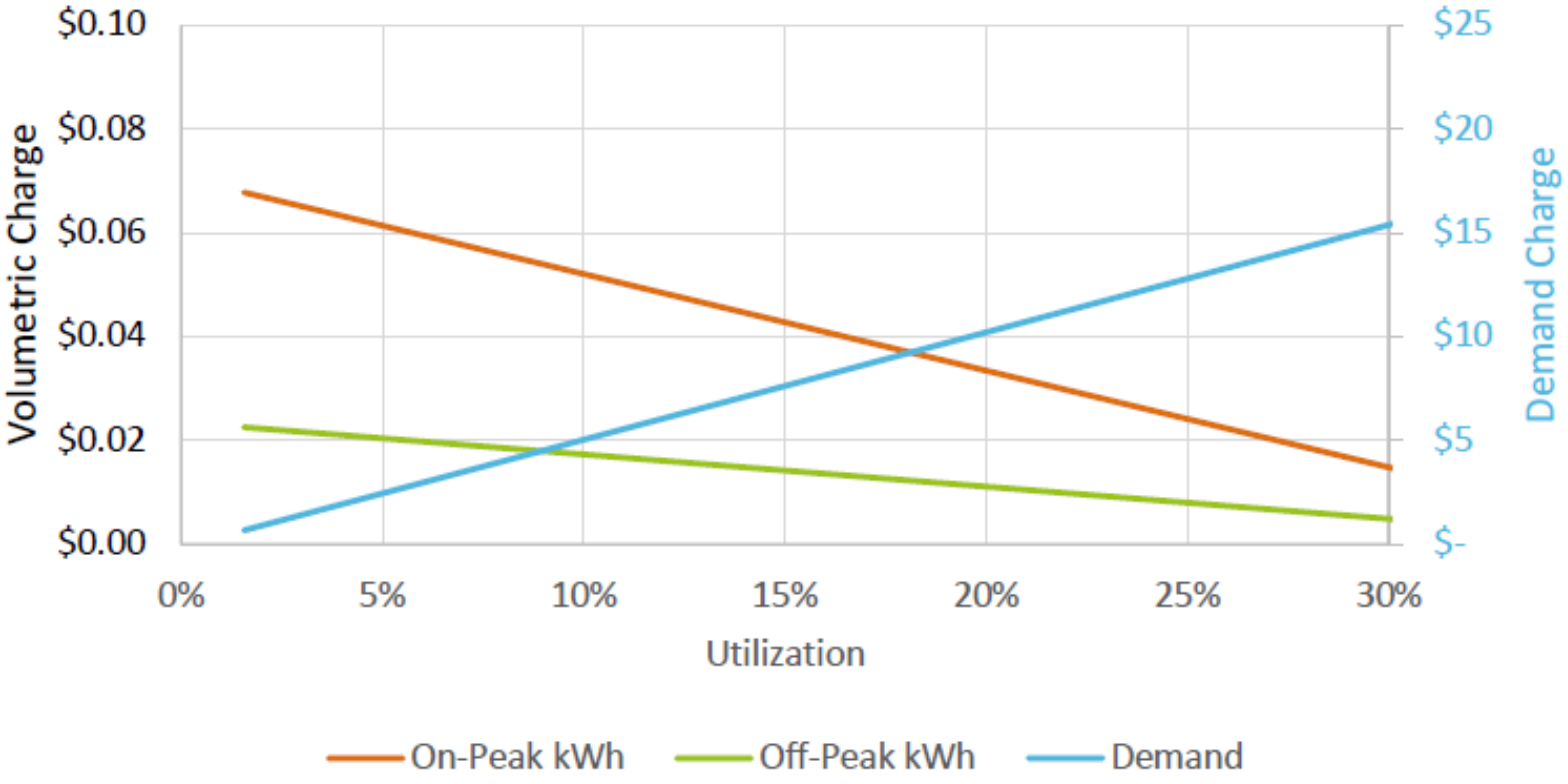
CHARGING INFRASTRUCTURE OWNERSHIP

- In our federalist republic, **there are no "one size fits all"** approaches to charging infrastructure ownership. Every state must decide for itself how to proceed.
- Utility investment in **"make-ready"** infrastructure is probably okay everywhere, BUT…
- Incentives for utilities to invest should be **performance-based**, AND…
- Incentives should **encourage utility investment** in installations that are **unlikely to interest private sector** companies, like low-income multi-unit dwellings, AND…
- States & regulators would be wise to test multiple models via **pilot projects**.

RATE DESIGN OBJECTIVES

- Charging should be **profitable** so that it is sustainable. But **demand charges make this impossible** when utilization rates are low.
- 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.
- Ideally, utilities could leverage distributed energy resource management systems (DERMS) to **promote a more efficient use** of existing grid infrastructure by offering varying rates, or interconnection costs, or levels of cost sharing for make-ready by location.

RMI'S RATE DESIGN FOR 100+ KW DCFC



TO SUM IT UP: EVERYTHING IS CHANGING

- Transportation electrification is a rapidly changing space, full of uncertainty
- Potentially large loads on the way, plan ahead to minimize capital expenditures
- But when? Lots of forecasts, they're all wrong
- So → model early and often, challenge assumptions and be ready to abandon them
- Develop programs/rates for EV customers today
- Be ready for accelerated adoption tomorrow

Thank you!

Transforming global energy use to create a clean, prosperous, and secure low-carbon future.