Electric Vehicle Charging as a Distributed Energy Resource

An eLab Collaboration with RAP, SDG&E and RMI

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Rocky Mountain Institute

Carbon War Room

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A Dynamic Grid Resource

Controlled charging of electric vehicles (G2V, not V2G) can deliver many benefits:

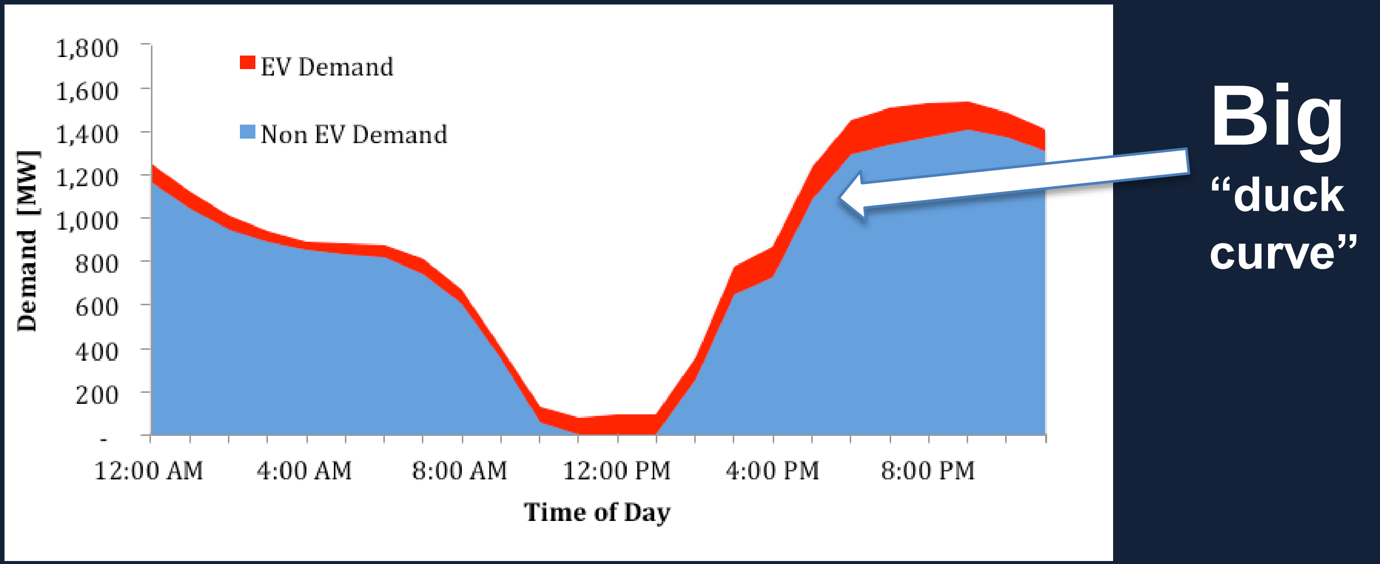
- Optimize existing grid assets and extend their useful life
- Avoid new investment in grid infrastructure
- Supply ancillary services, such as frequency regulation and power factor correction.
- Absorb excess wind and solar generation
- Reduce emissions
- Reduce electricity and transportation costs
- Reduce petroleum consumption

Load-shaping for grid optimization

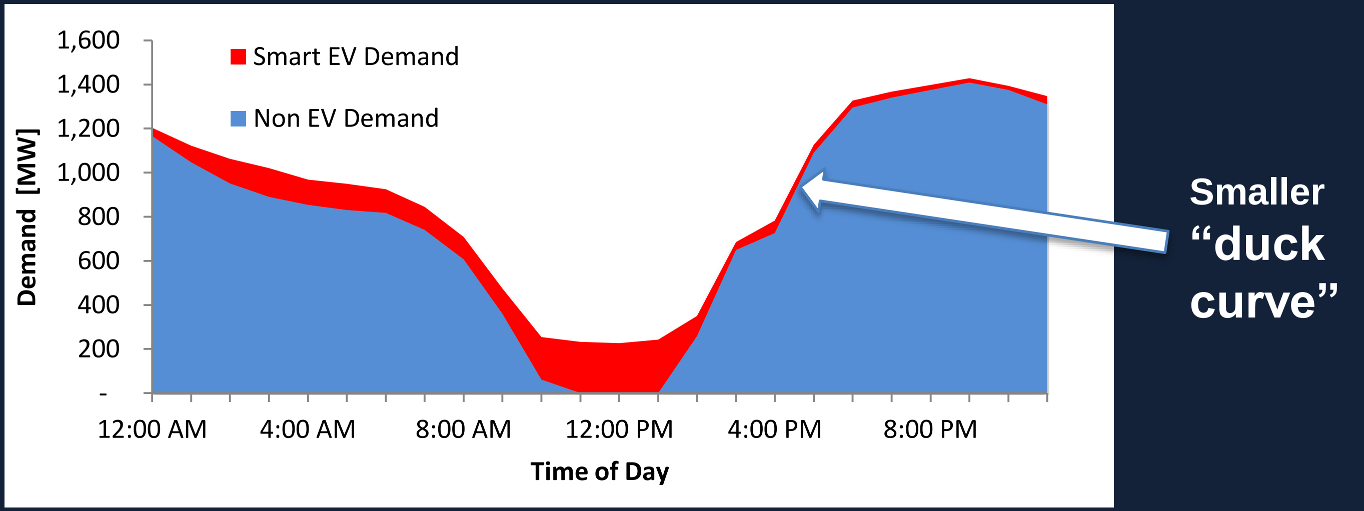
Use EV charging to fill in the valleys and avoid the peaks of the load profile

- **Carrot**: Advanced tariff design (Time of Use rates, dynamic real-time pricing) creates incentives to charge when grid power costs are lowest
- **Stick**: Charging stations can be controlled by utilities and charging station aggregators

Pressed Duck



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



Projected HECO demand with 23% EV penetration and optimized charging

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Advanced Utility Services

Controlled charging can deliver many grid benefits

DEMAND RESPONSE

G2V demand response:

- Turns off chargers at times of peak load
- Can combine vehicles and stationary storage to cut demand by 100 kW (BMW pilot)
- Can avoid capacity investment
- Can help customers avoid demand charges

POWER QUALITY

Groups of vehicles can bid demand response into “ancillary services” markets:

- Frequency control
- Voltage control
- Transition generation
- Power factor correction (SDG&E, Shell, Company X pilot)
- Ramp rate reduction

MOBILITY AS A SERVICE

- Many EVs at a single “charging hub”: Low cost, easy to manage, more demand response
- Rented, not owned
- High-density, high-use (18+ hours/day)
- Being tested by: Tesla, NRG, Greenlots, Charge Point

Reduce Emissions

ELECTRIC VEHICLES CAN REDUCE NET EMISSIONS EVEN ON COAL-FIRED POWER GRIDS COMPARED TO CONVENTIONAL VEHICLES

NET EV EMISSIONS FROM THE POWER GRID AND FROM FUEL COMBUSTION IN A CONVENTIONAL VEHICLE VARIES BY GENERATION MIX, THE CHANGING MIX OVER TIME, AND THE TIME OF DAY THAT VEHICLES RECHARGE

BEST POLICY FOR REDUCING EMISSIONS IS TO INCREASE RENEWABLE ENERGY ON THE GRID WHILE DEPLOYING EVS AND WORKPLACE CHARGING STATIONS

Absorb excess wind and solar generation

- **End curtailment:** When wind and solar are producing more power than the grid can use, EVs can absorb the excess
- **Enable more renewable deployment:** “the deployment of PHEVs results in vastly increased use of wind.” (NREL, 2006)
- **Make variable renewables dispatchable:** By absorbing wind and solar when it’s producing, then calling on the EV storage instead of calling on grid generators.

California has:

- The most EVs on the road of any state: 200,000
- The most ambitious EV deployment target: 1.5 million zero-emission vehicles on California roads by 2025
- The most experience in EV pilots and advanced tariff design

LESSONS LEARNED: California's Experience

The EV Project: SDG&E experimental tariff design

TOU rates are effective at shifting charging to off-peak hours. Without TOU rates, drivers plug in when they get home, exacerbating the duck curve

SDG&E has bid aggregated EV fleet vehicles as demand response into CAISO energy and ancillary services market

PG&E pilot with BMW bids 94 vehicles & stationary storage into demand response market

New SDG&E program will feature hourly dynamic prices posted a day ahead; drivers can use smartphone app to charge during lowest-cost hours

SUMMARY

If we integrate EVs proactively and intelligently, we can:

- minimize new investment in grid infrastructure
- optimize existing grid assets and extend their useful life
- enable greater integration of variable renewables (wind and solar PV) without needing new gas generation for dispatchable capacity, while reducing curtailment of renewable production
- improve energy security
- reduce electricity and transportation costs
- reduce petroleum consumption
- reduce emissions of CO2 and conventional air pollutants
- provide multiplier benefits from increased money circulating in the community
- supply ancillary services to the grid, such as frequency regulation and power factor correction

If we integrate EVs reactively and badly, it will:

- shorten the life of grid infrastructure components
- require greater investment in gas-fired peak and flexible capacity
- make the grid less efficient
- make the grid less stable and reliable
- increase the unit costs of electricity for all consumers
- inhibit the integration of variable renewables, and increase curtailment of renewable generation when supply exceeds demand
- increase grid power emissions

Thank you

Questions?

Extra slides

The EV Project

- Largest deployment and evaluation project of electric drive and charging infrastructure to date
- 12,000 Level 2 chargers, 100 Level 3 chargers, 125 million miles, 4 million charging events in 10 states & D.C.

LESSONS LEARNED: The EV Project / SDG&E

Drivers plug in when they get home, but delay charging to the cheapest off-peak hours of a TOU tariff

Charging behavior can be influenced during the first months, then it gets harder

The larger the price differential between TOU rate intervals, the more shifting of charging.

A 6:1 ratio between on-peak and off-peak periods is enough to shift 90% of charging to off-peak periods

Requisites include:

- Good rate structures
- Charger control technology
- Telemetry between charger/PV and utility
- Second meter

California's next objective:

Deploy enough charging stations to support 1 million EVs by 2020

LESSONS LEARNED: California's Experience

SDG&E

Will deploy, own and operate 3,500 charging stations at 350 sites including MUDs

SCE

Will provide "make ready" locations for 1,500 charging stations at workplaces, campuses, recreational areas and MUDs, to be owned & operated by 3rd parties

PG&E

[pending pilot]

Proposes to deploy and rate-base 7,500 Level 2 and 100 Level 3 charging stations including 20% MUDs with optional 3rd party participation

Recommendations for REGULATORS

- Create incentives, tariffs, and market opportunities to accelerate the deployment of EVs and charging infrastructure
- Open wholesale markets to EVs as demand response, enable bi-directional dispatch and service regulation
- Support using EVs to maximize renewable generation and flatten load profile
- Create performance-based incentives for high utilization of chargers and use of EVs to optimize existing grid assets and avoid new investment
- Remove regulatory uncertainty
- Streamline distribution interconnection procedures and improve business opportunity for third party development, ownership, and operation of charging infrastructure

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Recommendations for UTILITIES

- Develop awareness of where and how EV charging will affect distribution system
- Deploy AMI, telemetry systems, and possibly control systems
- Offer well-formed TOU rates or other dynamic pricing to shift charging toward low-cost, off-peak hours
- Support aggregators and public/workplace charger deployment, whether owned by the utility or by a third party
- Guide placement of workplace & public chargers and charging hubs to reduce installation costs and absorb wind/solar production
- Educate customers about the lower cost of owning EVs, their rate options, how to save money, and their options for installing and operating charging equipment

Recommendations for

PRIVATE SECTOR

- **Vehicle OEMs and dealers**: Work with utilities & aggregators to expand the EV market, encourage well-formed TOU rates, and develop flexible & responsive charging control systems
- **Charging station aggregators**: Work with utilities to site charging depots for maximum benefit and lowest cost; convey the value of demand response to regulators, utilities, and customers
- **Building owners:** Work with utilities, aggregators, and customers to identify & install chargers at high-value, low-cost public sites
- **All**: Support dynamic tariffs; implement two-way communication/control systems; educate customers; support open source & common standards & interfaces