EVs as Grid Resources & Plug Loads

CalPlug Fall Workshop

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xergyconsulting

About Xergy Consulting

Energy Efficiency

Research & strategy for state, national, & international policy and utility programs

Beneficial Electrification

Identify electrification opportunities that enable grid flexibility & reduce cost & emissions

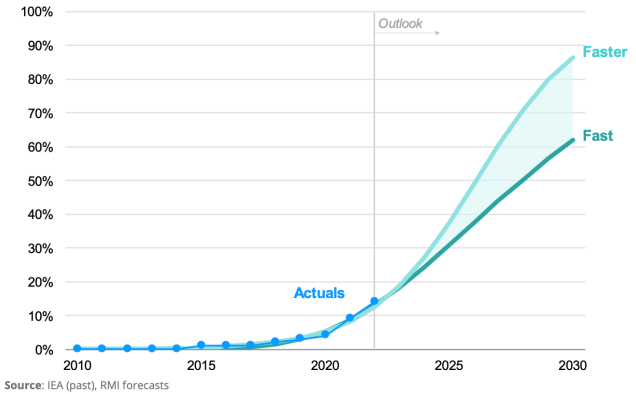
Technology Evaluation

Pilot design, M&V, & research to evaluate energy & demand savings of efficient & electrified end uses

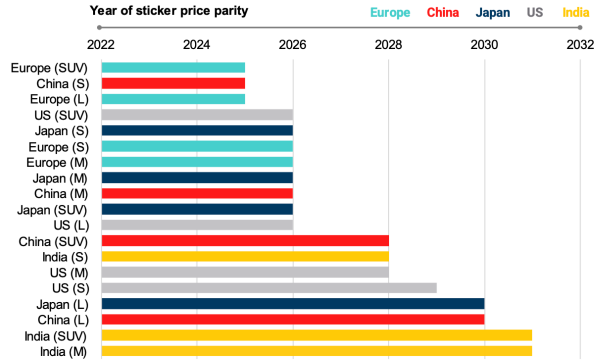
We are a mission-driven, woman-owned small business

EV fun facts

- EV market share increasing quickly
  - Biden Administration: 50% by 2030; CA + 17 states: 100% by 2035 or earlier
  - US sticker price parity ~2026 - 2029



Source: IEA (past), RMI forecasts

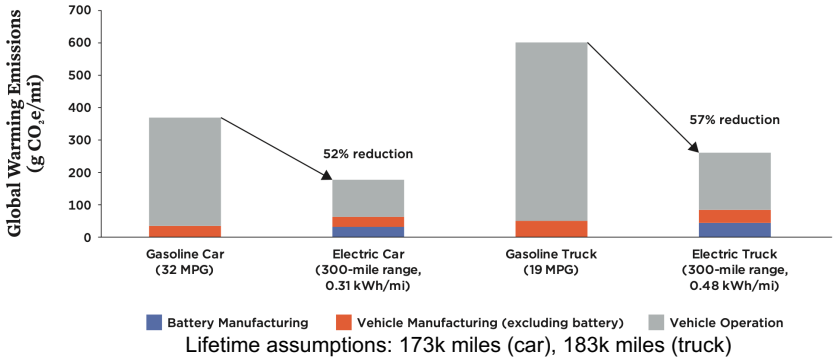


Source: BNEF. Note: S = small, M = medium, L = large, SUV = sports utility vehicle

Source: RMI (2023) X-change: Cars. The end of the ICE age

EV fun facts

- EV market growth increasing quickly
- Lifecycle impact: EVs lower than ICE vehicles
  - Majority impact during operation
  - Breakeven ~20k miles for passenger cars & trucks

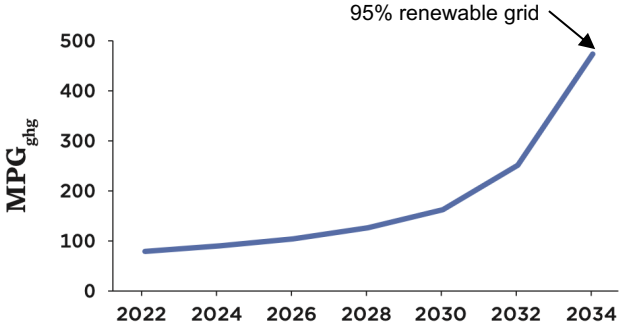


Lifetime assumptions: 173k miles (car), 183k miles (truck)

Source: Union of Concerned Scientists (2022) Driving Cleaner

EV fun facts

- EV market growth increasing quickly
- EV lifecycle impact is lower than ICE vehicle impact
- EV impact decreases as grid incorporates more renewables



Source: Union of Concerned Scientists (2022) Driving Cleaner

EVs are pretty great, getting better, and need to improve

- EVs are grid resources, help integrate renewables
  - As flexible loads
  - As storage
- EVs as plug loads
  - Current efficiency
  - Improvement opportunities

EVs as flexible loads

EVs are flexible loads

- Flexible loads can shift operation to use renewable generation
  - Electricity use and service are decoupled (water heater, home battery, EV)
  - User doesn't require service in real time (washer, dryer)
- EVs spend most of their time not driving
  - Average passenger EV: less than 40 miles per day


Image credit: Rheem

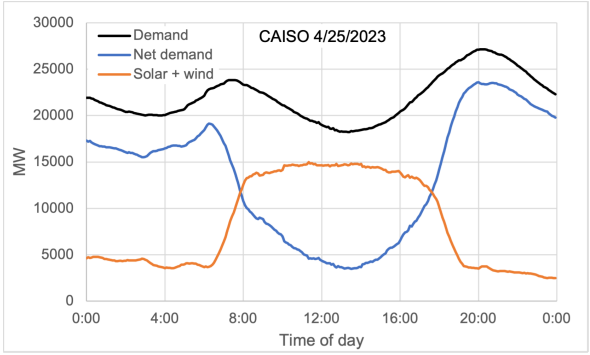

Image credit: LG

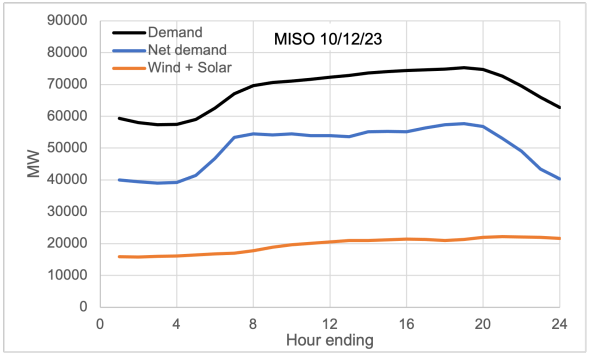

Image credit: Kia


Image credit: Samsung

Managing EV load to improve renewable generation integration

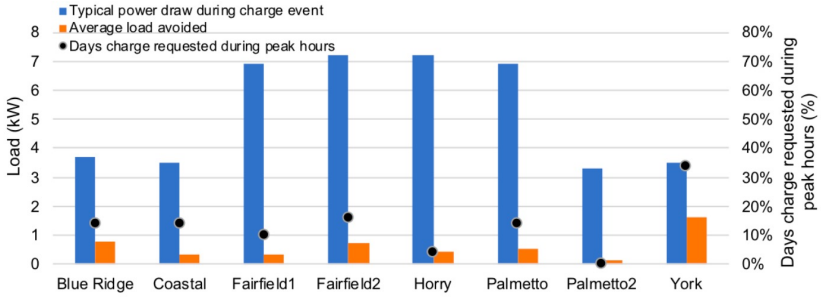
- Strategies
  - Match demand to supply (time-of-use rates)
  - Curtail during demand peaks (demand response)
  - Frequency regulation
  - Manage load for to avoid infrastructure overload





Predicting & leveraging charging demand

- Characterize EV charging load shape
  - Number of EVs, per-vehicle demand
- Build chargers where EVs are when renewables are available
- EVs need to be plugged in to be valuable



Source: NRECA (2020) EVSE Load Control Case Studies

Image credit: Luminous Energy

EVs as storage

EV batteries can power other loads

- Vehicle to grid (V2G), vehicle to building (V2B)
- Strategies:
  - Load shifting, energy arbitrage
  - Backup power
  - Frequency regulation
- Requires bidirectional equipment
- Vehicles
  - Passenger EVs
  - Buses, other medium- and heavy-duty
  - Fleets

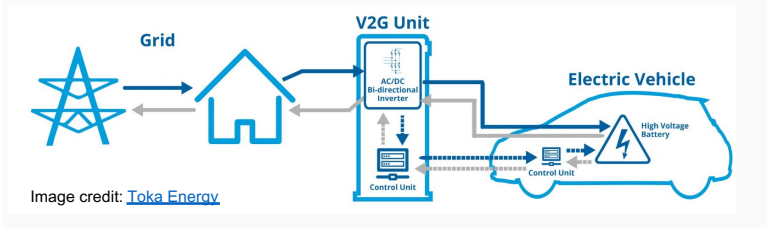


Image credit: Toka Energy

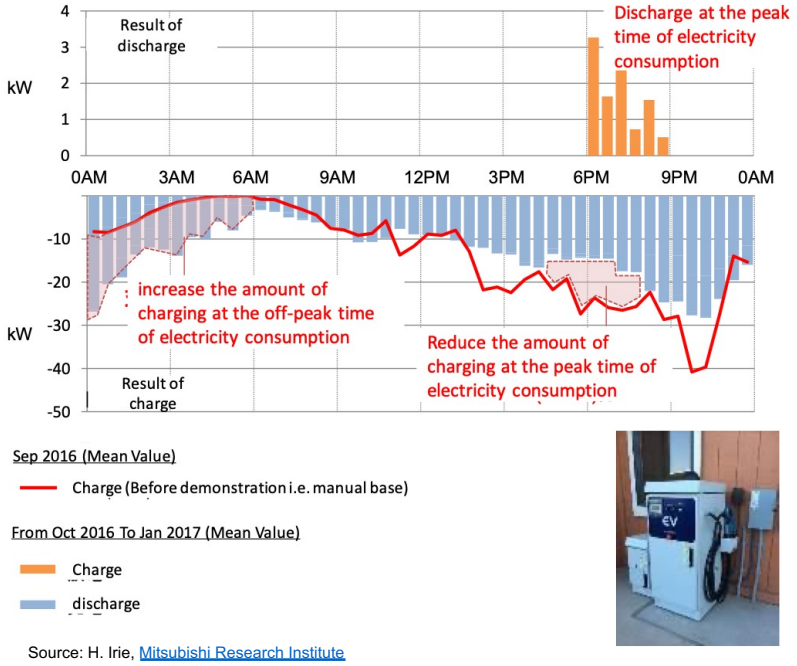

Image credit: Sunrun

V2B and V2G implementation: early stages

- Technology is available to do it
- Challenges
  - Infrastructure: connection to building or grid
  - Standards: communication, safety, security
  - Battery degradation: cycles, depth of charge & discharge
  - Economics: Value to EV owners & utility, comparison to other load management strategies
- Identify use cases that provide the best value
  - Value depends on many factors: location, type of vehicle, strategy
  - Lots of ongoing pilots and research

JumpSmart Maui Pilot

- Early V2G pilot: 2015-2017
- 80 Nissan Leafs
- Bidirectional chargers at homes
  - Discharge during evening peak
  - Charge during overnight wind generation
- Discharge limited to 30 minutes @1 kW/vehicle



Source: H. Irie, Mitsubishi Research Institute

Cajon Valley Union School District & SDG&E school bus pilot

- Six bidirectional DC fast chargers
- Seven electric school buses
- Discharge capacity: 24 – 45 kW/bus
- Participating in SDG&E's Emergency Load Reduction Program: $2/kWh
- Challenges
  - Charger reliability
  - Initial cost
  - Incentives for discharging

Photo courtesy of Cajon Valley Union School District

Source: Electric School Bus Initiative

Leverage EV mobility

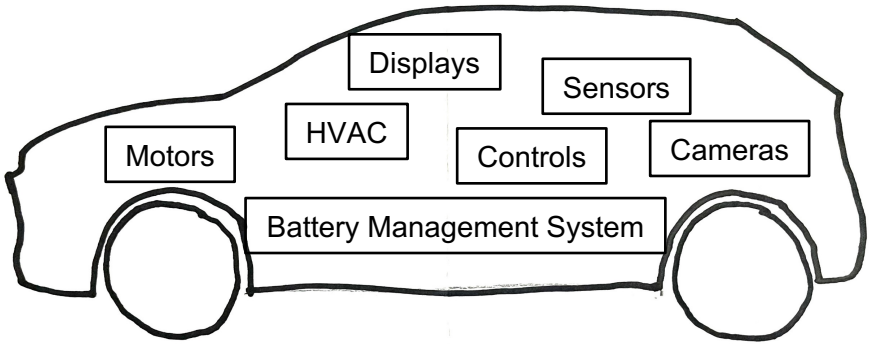
- Resiliency: school bus to power critical buildings during grid outages

Image credit: Holy Cross Energy via NRECA

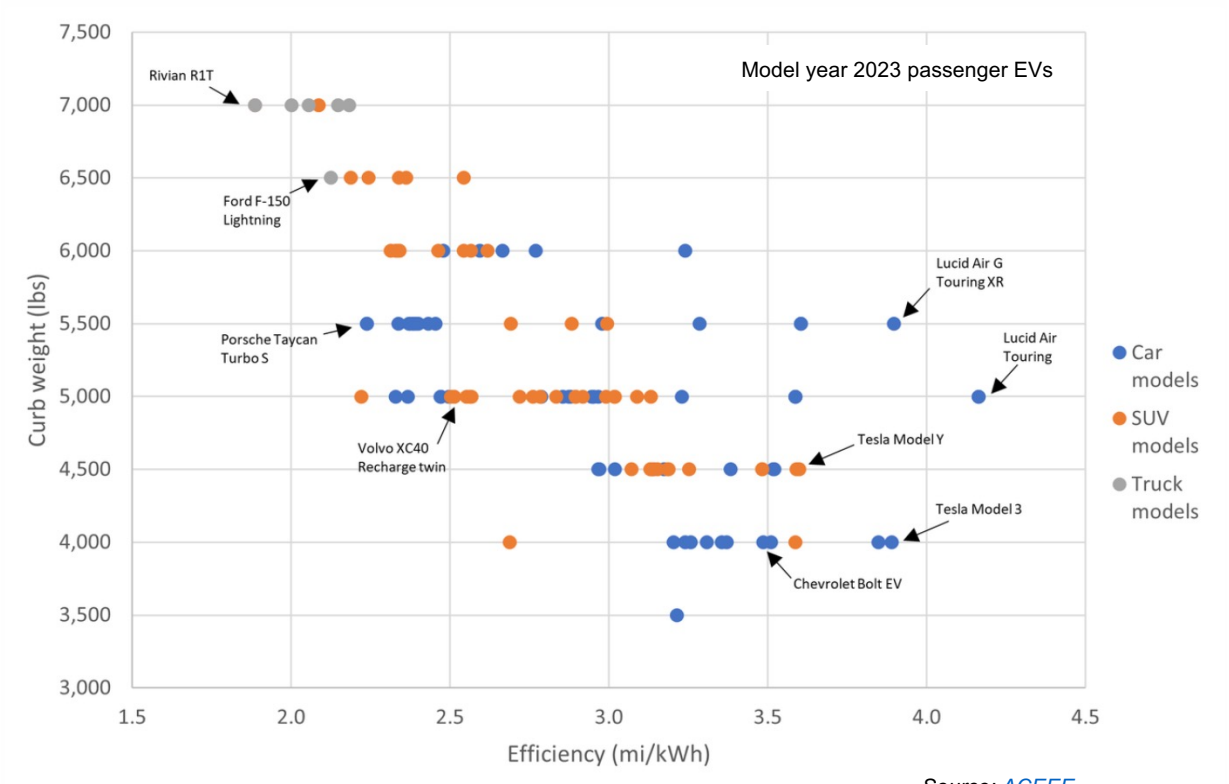
EVs as plug loads

EVs are (complex) plug loads

- System of plug loads
- Operation modes
  - Drive (Active)
  - Charging, maintenance
  - Park (Low Power Mode)



A wide range of EV efficiency



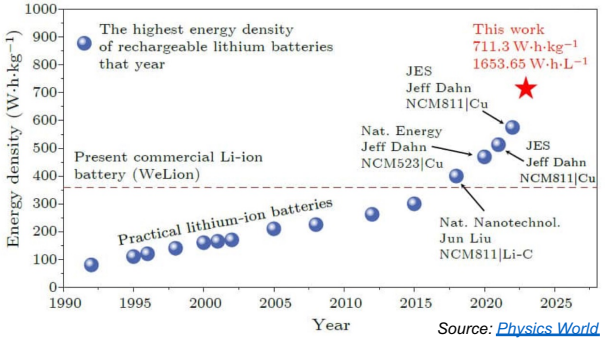
Source: ACEEE

Efficiency improvement opportunities

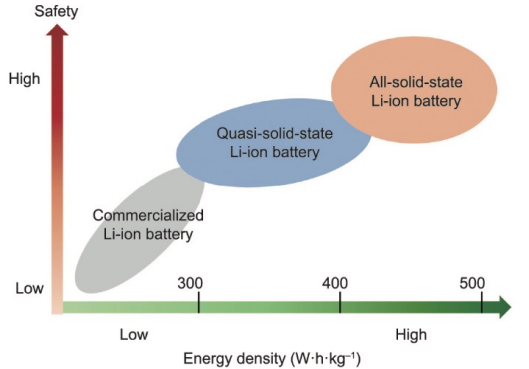
- Improve aerodynamics

Efficiency improvement opportunities

- Improve aerodynamics
- Reduce vehicle weight
  - Battery pack capacity
  - Improving energy density (Li-ion, other chemistries)



Source: Physics World



Source: Wang & Sun (2023)

Efficiency improvement opportunities

- Improve aerodynamics
- Reduce vehicle weight
- Efficient battery charging systems

Image credit: Enphase

Wired, Level 2
4 - 19 kW
Efficiency: 83 – 94%

Wired, DCFC
50 – 350+ kW
Efficiency: 90 – 95%

Image credit: Efficiency Maine

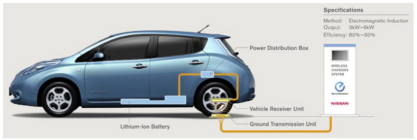
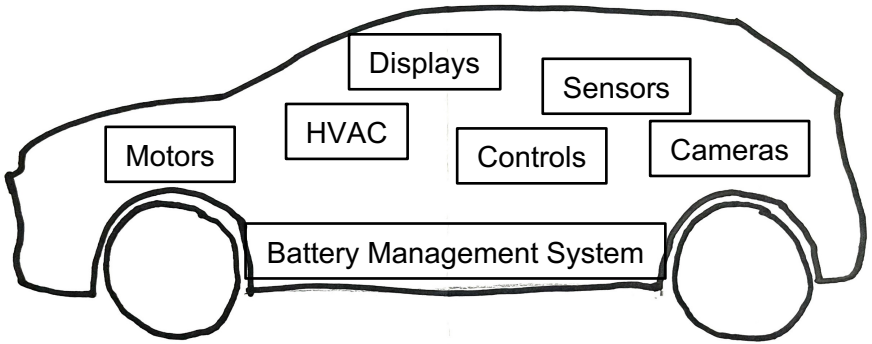


Image credit: Nissan

Wireless
1 – 180+ kW
Efficiency: 80 – 90%
(prototypes up to 97%)

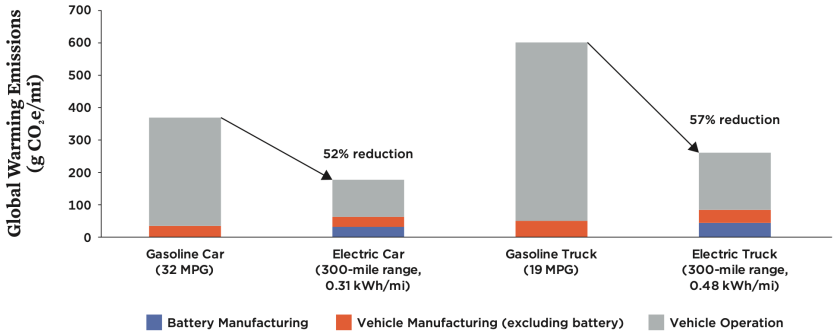
Efficiency improvement opportunities

- Improve aerodynamics
- Reduce vehicle weight
- Efficient battery charging & management
- Efficient motors & HVAC
- Power management



Adopting EVs is not the end point

- EVs are an improvement over ICE vehicles but **efficiency still matters**
- More efficient EVs
  - Reduce renewable generation needs
  - Provide grid infrastructure benefits: lower strain/congestion reduces need for improvements
  - Smaller battery packs = constrained mineral resources go farther
  - Lighter vehicles = less tire & road wear = less impact on waterways and ecosystems



Source: Union of Concerned Scientists

Closing thoughts

EVs are pretty great, getting better, and need to improve

- EVs benefit the grid, cost less, reduce emissions
- Load flexibility improves renewable generation integration
- We still have work to do
  - Leverage EV load management and batteries for the best value
  - Improve EV efficiency to reduce generation and transmission investments, spread resources, and reduce impact

Thank you

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