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Shaping electric vehicle charging behaviours: lessons learned from California

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Executive summary

With action taken by industry and the public sector to fuel the uptake of electric vehicles (EVs), EV adoption has outpaced COP25 expectations.

Coming out of COP 26, automakers are pursing aggressive EV sales targets with significant research, development and capital investment. Many are planning to phase-out combustion engines entirely. Major corporate fleet operators, including Lyft and Leaseplan, have committed to fully electrifying their fleet by 2030. EV sales in major markets this year will surpass 5.5 million[1].

This rise in EVs brings greater demand for electricity, especially during peak hours. In response, large players like BP, Shell, Enel X, Siemens, ABB and GM have entered enter the EV charging arena, are targeting aggressive global deployment as many as 650,000 chargers by a single player by 2022.

Key participants – from government to utilities and car manufacturers – have a crucial role to play in delivering a smooth transition. In cooperation with other stakeholders, electric utilities need to ensure the electric grid can support this growth and enable access to a vast, distributed fleet of EV batteries to improve grid reliability and flexibility. Stakeholders also must work towards an equitable transition as they develop policies and roll out solutions.

With over one million electric vehicles and 40% of the US EV fleet, California is among the largest electric vehicle markets. With the second highest penetration per capita (21 EVs per 1,000 people in the world), California offers valuable learnings on both accelerating EV adoption and preparing to mitigate grid strain for other regions.

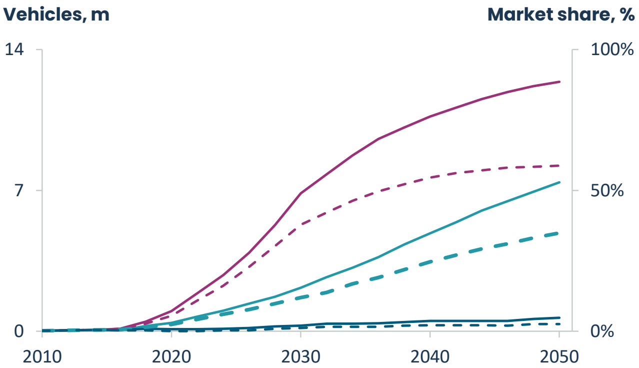
1. BloombergNEF; Marklines

The rise of EV adoption in the US will have substantial grid implications

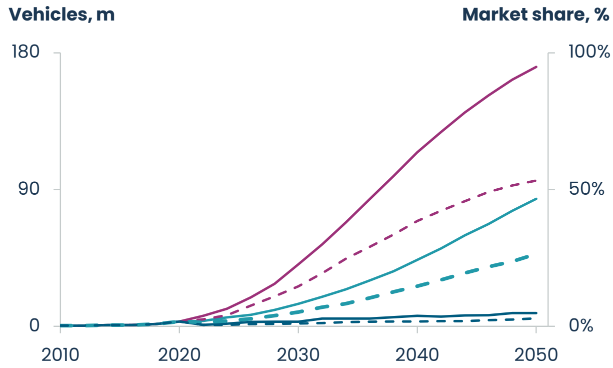
This past August, President Biden signed an executive order targeting 50% passenger EVs sold by 2030.

Assuming a high rate of adoption, the US will have a fleet of ~40 million electric vehicles by 2030, requiring 10% of the US's current generating capacity.

US new EV sales scenarios



US EV fleet size scenarios



EPRI low, medium, and high PEV market penetration scenarios, shown both as annual sales (at left) and total PEV fleet size (i.e., cumulative vehicles in service, at right).

EV vehicles — EV market share

Scenarios: Low — Medium — High

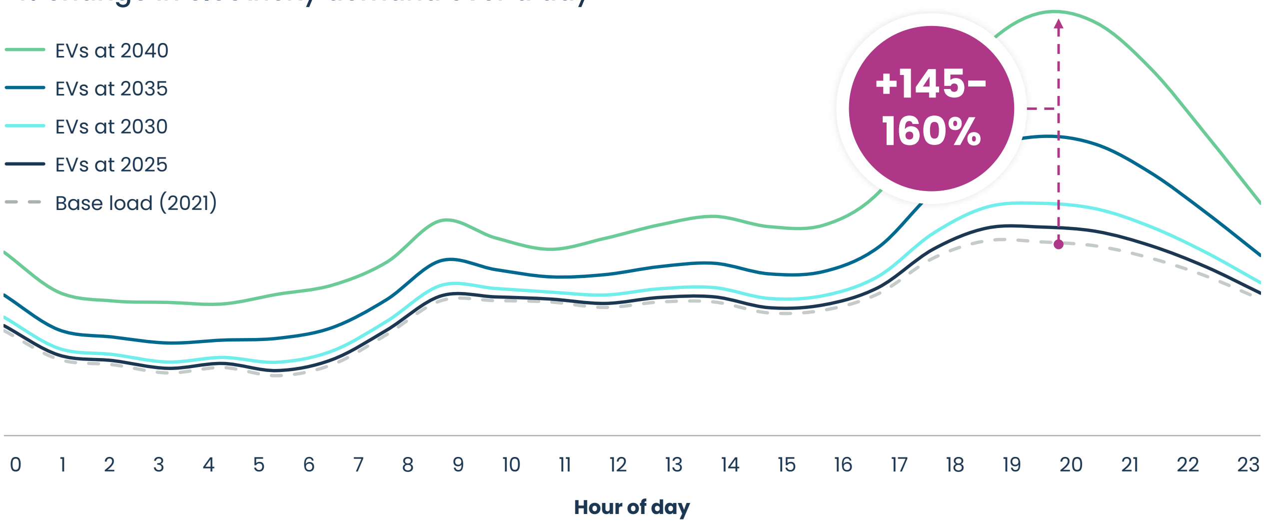
Solid lines correspond to number of vehicles (left axes) and dotted lines correspond to sales shares (right axes). While both annual and cumulative sales estimates in all three scenarios are projected from actual sales data through 2016, as is shown in Figure 2, the actual sales from 2016 to 2018 are included for comparison.

Source: *Grid Integration Tech Team and Integrated Systems Analysis Tech Team: Summary Report on EVs at Scale and the U.S. Electric Power System,* U.S. DRIVE, November 2019

Drivers typically charge their vehicles after their commute home when electricity demand is high (typically between 4-9pm). If not managed, peak demand from electric vehicles could be as much as 145-160% higher than current peak demand by 2040.

Network peak demand impact from EV uptake in USA*

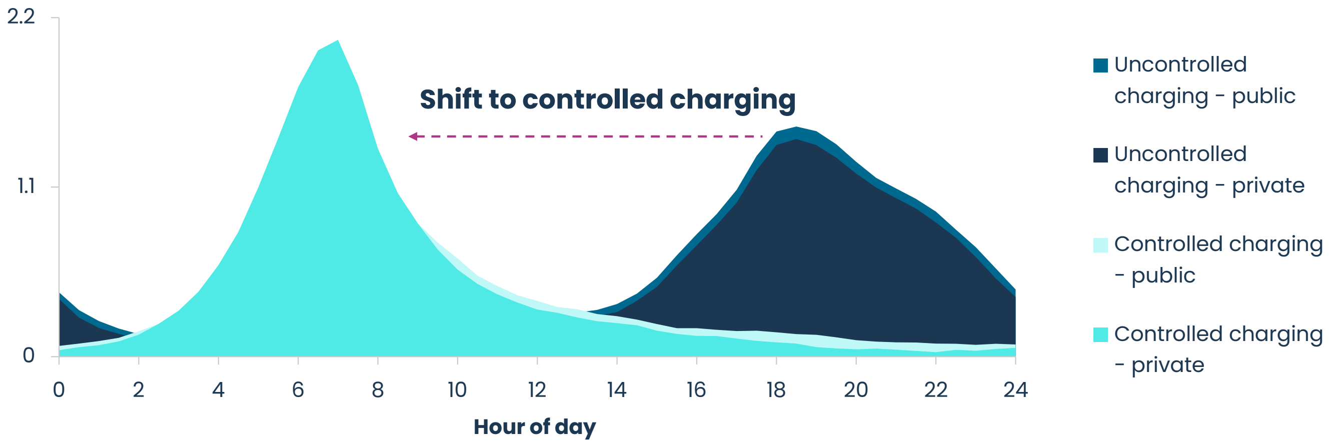
*% change in electricity demand over a day



Source: Partners in Performance analysis

Incentivising drivers to charge during a lower demand period (e.g. early morning) could offer major savings and improved resilience

Typical weekday



Source: *Grid Integration Tech Team and Integrated Systems Analysis Tech Team: Summary Report on EVs at Scale and the U.S. Electric Power System,* U.S. DRIVE, November 2019

California dreamin': learning from an earlier adopter

Over the last decade or so, California has utilised a variety of policy and economic levers to drive EV growth. It leverages the size of its economy and influence to enact stronger policies like energy efficiency standards, recognising that manufacturers will often use established standards nationwide.

Timeline for Zero Emission Vehicle (ZEV) adoption in California

2007
EV rebates & 1st tax credit through 2015

2012
Gov Brown Executive Order to target 1.5M ZEVs by 2025

2015
AB1236 re: EV charging infrastructure ordinances - streamlining permitting for residential and non-residential EV charging stations

2021
- CA reached 1M EVs sold
- CA's largest export now EVs with three-dozen companies producing
- State budget included: Light-duty ZEV adoption - $1.2B; ZEV and infrastructure mfg $407M
- Currently: CVRP $750-4,500 rebates and charging infrastructure via PACE. Utility rebates from $800-1,500
- New Energy efficiency standards incentivising all-electric construction with solar and electric panels that can handle EVs
- Transportation Electrification Framework (TEF) decison in progress to accelerate EV infrastructure and support equitable transition

2022
CEC's three-year plan to meet charging port goal begins

2025
- Goal: 1.5 million ZEVs on CA roads
- Goal to install 250,000 EV charging ports (incl.10,000 DC ports and 200 hydrogen-fueling stations)

2030
- Goal: half of USA sales are ZEVs via Biden
- Goal: 5 million EVs on CA roads
- Goal: install additional 900,000 EV charging ports

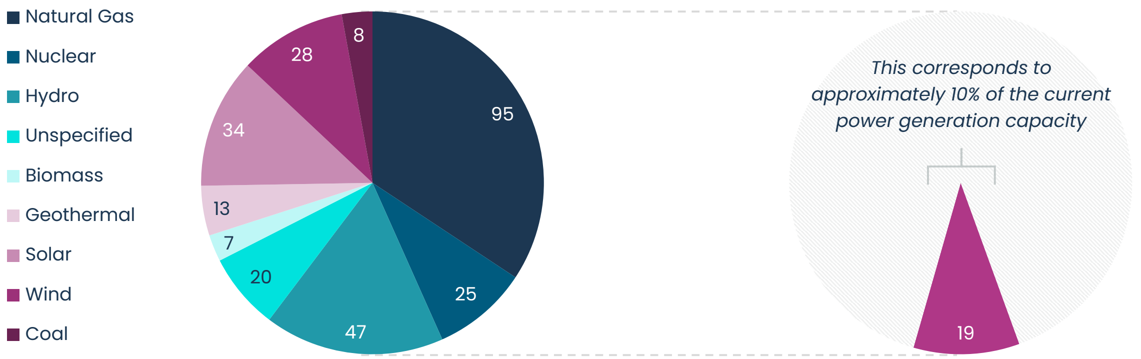
2035
Goal: all new CA passenger vehicle sales are ZEVs

2045
Goal: CA carbon neutral economy

In California, projected energy consumption by EVs is expected to reach 10% of the state's generating capacity by 2030

California Power Mix – 2019, TWh

Projected Californian EV consumption – 2030



Source: *2019 Total System Electric Generation*, California Energy Commission; *Grid Integration Tech Team and Integrated Systems Analysis Tech Team: Summary Report on EVs at Scale and the U.S. Electric Power System*, U.S. DRIVE, November 2019

California has anticipated grid strain and benefits from a growing fleet of EV batteries

With anticipated increased demand on the grid during peak hours, California has been enacting policy decisions through regulatory bodies like the California Public Utilities Commission (CPUC), and utilities have implemented a variety of demand shaping levers to benefit rate payers.

Timeline of the policies and actions in place to reduce grid strain caused by EVs

Key Demand response DERs and Net metering Time of use V2H/V2G

2006
- $262M **demand response** programme budget enacted by CPUC
- **Demand response** programmes in place for largest CA utilities that remain in various forms today

2013

Initial **net metering (NEM)** decision

2014

Collaborative development of the 2014 California **Vehicle-Grid Integration (VGI)** Roadmap

2015

CPUC decision on **Time Of Use (TOU) rates**

2016

CPUC decision on **net metering (NEM) 2.0** (provided compelling benefits for solar, required all residential solar customers be on **TOU rates**)

2017
- **Net metering** in effect in 2017
- CPUC Decision broadly defines **demand response** as reductions, increases, or shifts in electricity consumption by customers in response to their economic signals or reliability signals
- Initial phase of PG&E and BMW **V2G pilot programme** wrapped up

2019 *(-22)*

Phased **TOU rate** implementation by utilities

2020
- CPUC decision creating a framework for **vehicle-grid integration**
- Southern California Edison (SCE) announced plans for a **V2G demonstration project**

2021
- State budget includes: **Long duration energy storage** - $735M; State funding for a new **microgrid incentive programme** - $200M
- 3 major CA utilities have **demand response** programmes, **TOU rate structures**
- **Net metering 3.0** decision expected in December 2021 or early 2022
- PG&E and BMW announced expansion of **V2G pilot**

Collaboration across key parties is critical to the ongoing success of policy development and implementation. The California Energy Commission is currently leading efforts to update the state's roadmap to integrate electric vehicle charging needs with the needs of the electrical grid. The Energy Commission's partners include the California Independent System Operator, the California Public Utilities Commission (CPUC), California Air Resources Board (CARB) and other stakeholders.

Emerging demand shaping levers to better match electricity supply and demand

Various degrees of behaviour, technology and service maturity shape EV charging demand. A customer's ability and willingness to utilise various demand shaping levers determines their charging maturity.

The major demand shaping levers, at various stages in development, in California are: Time of Use (TOU) rates, demand response programmes, vehicle-to-home (V2H) and vehicle-to-grid (V2G) programmes, and distributed energy resources (DERs) paired with charging stations. These levers can be deployed across customer types from residential to Commercial and Industrial.

Bringing residential and commercial customers up the maturity curve results in improved electricity supply and demand matching

0% — Not ready for change

High upfront EV cost and range anxiety dominate thinking

20% — Disengaged and charges without regard to cost

- ToU incentives have no impact on behaviour
- Fast-charges or uses 240v wall socket

40% — Adjusts charging behaviours to achieve savings

- Peak pricing influences time of charging
- Learning to play the economics

60% — Extracts some V2H benefit under personal control

- Adopted V2H as a home energy backup
- Allows discharge for personal use at peak

80% — Releases control to access more savings

- Allows third party control of battery in scenarios where pricing is too high to ignore
- Allows discharge to grid for payment

100% — Invests in energy solutions to complement EV

- Allows full third party control of battery
- Has coupled EV with solar and/or storage

Manual

Customer managed TOU, Demand Response (DR)

Vehicle-to-Home/Business (V2H/ V2B)

Third-party managed TOU, DR

Vehicle-to-Grid (V2G)

Private generation/ storage (DERs)

Time of Use (TOU) rates

All three major California investor-owned utilities (IOUs) offer TOU plan options which encourage EV owners to charge their vehicle at lower-cost times. The initial 2018 pilots included more than 500,000 consumers and over 90% of initial participants continue to use a TOU rate.

These utilities emphasise that customers would pay less than the equivalent of $2 a gallon of gas when charging during off-peak times (current California gas prices at the time of writing this are as high as $5.50 per gallon). Some existing plans disaggregate energy use for EVs using a separate meter allowing customers and utilities to have a more granular view of energy usage.

Utility and EV TOU plan	# pricing periods	Weekday peak vs off-peak price ratio (summer, range across pricing periods)	Notes
PG&E EV2-A	4	2.05 – 2.63	Three different pricing tiers across four time periods
PG&E EVB	4	2.07 – 3.73	View EV energy use with separate meter
SCE TOU-D-PRIME	2	2.52	Tool to select plan, text reminders about peak
SDG&E EV TOU 5	3	3.44 – 6.22	$16 monthly service fee offsets the ratio
SDG&E EV TOU 2	3	1.63 – 2.82	
SDG&E EV TOU	3	1.63 – 2.82	View EV energy use with separate meter

What is needed to ensure TOU rates curb grid strain?

→ Limit available pricing periods and the length of the peak period to five hours or less

→ Create a large enough price differential between peak and off-peak pricing to incentivise off-peak charging

→ Educate customers about the benefits of off-peak charging.

Demand response (DR) programmes

Demand response programmes are the most mature of the levers, with policies and funding dating back to 2006. These originally compensated customers for reducing energy consumption in response to a signal, but have since been revamped to allow third party programmes and broaden the definition to include "reductions, increases, or shifts in electricity consumption by customers in response to their economic signals or reliability signals." By broadening the definition, customers are now able to increase electricity usage when the grid has excess renewable generation available from solar or wind.

All three major IOUs offer demand response programmes, however these programmes have declined recently. This probably arises with the challenges of accurately measuring the programmes' impacts and customers having access to the necessary technology.

To make demand response programmes more accessible, utilities have incentivised the installation of DR-enabling technologies and embraced third-party programmes to manage thermostats, water heaters and EVs in response to TOU rates. However, questions remain about the effectiveness of these programmes and how to they can be improved.

Vehicle-to-home/business (V2H/B) and vehicle-to-grid (V2G) programmes

California stakeholders have long recognised the value of having a fleet of EV batteries to shape demand via V2H and V2G.

This was recognised with the collaborative development of the 2014 California Vehicle-Grid Integration (VGI) Roadmap, then followed by the CPUC decision on net metering in 2016. The CPUC has since created the vehicle-grid integration framework, including the use of EVs to power buildings during wildfire-related public safety power shut-offs.

With the advancement of VGI technology and increasing desire for grid flexibility, California stakeholders recognise the need to update the earlier roadmap to incorporate open standards, realise value for stakeholders, commercialise earlier research investments and maintain their leadership in advanced technology development. California is also examining how it can shape policy to fit VGI into its framework while meeting its 2025 target of 1.5M ZEVs on the road.

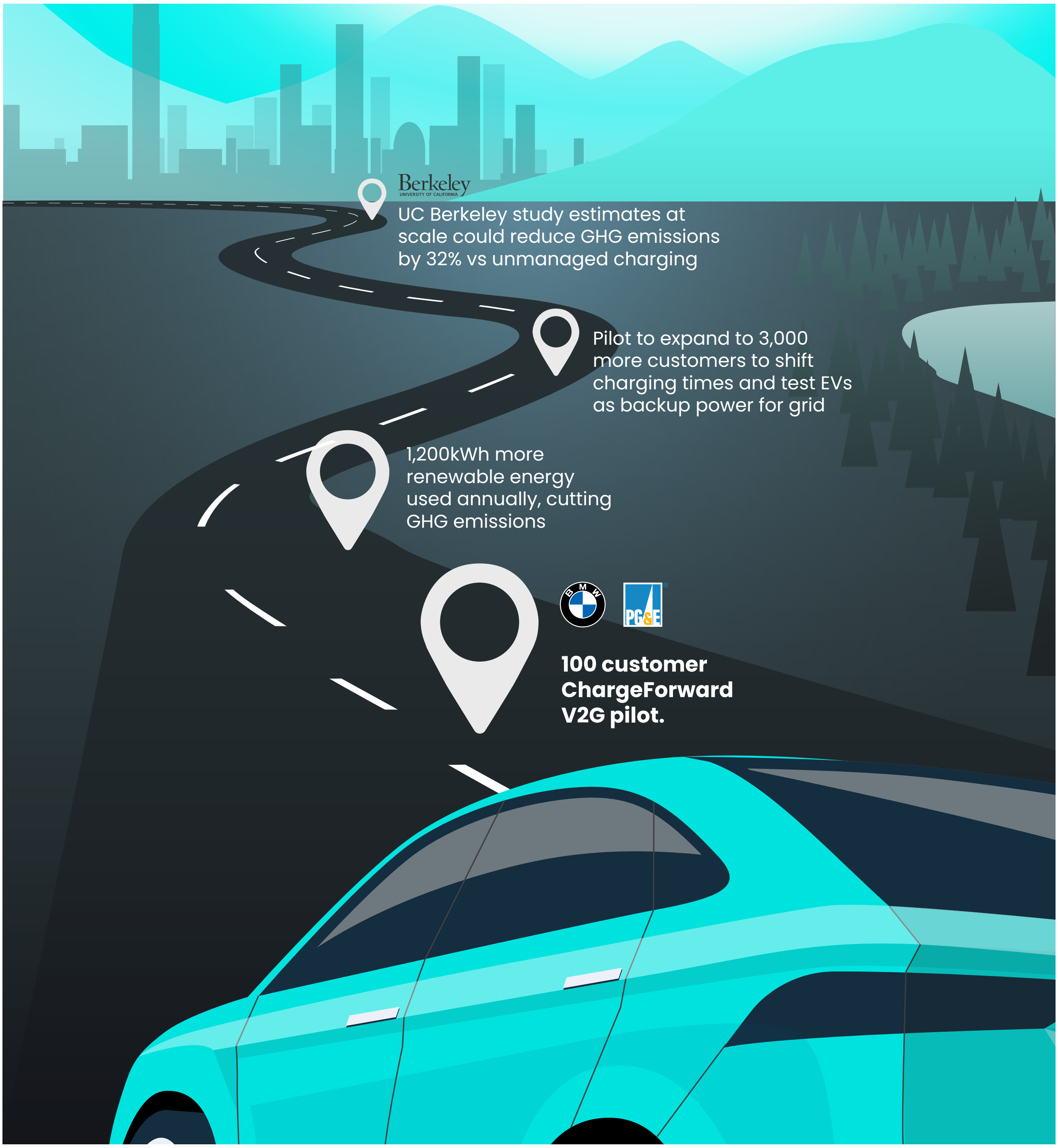
While many EVs on the road today do not have the required technology to take advantage of V2H or V2G, automakers are now incorporating the necessary bi-directional hardware to make V2H/B and V2G a reality. For example, Ford recently released the F150 Lightning with Intelligent Backup Power and Nissan is trialling its V2G technology.

Utilities like PG&E, SCE, and SDG&E are leading the charge in developing V2G pilots

The three major IOUs are working together with each utility piloting different VGI concepts. By working collaboratively, they are able to utilise resources more effectively to accelerate development of their collective knowledge.

For instance, SCE announced plans for a V2G demonstration project in 2020. The programme, designed to show customers that they lower their bills in exchange for supplying energy from their cars, uses passenger vehicles and buses to charge and discharge power to the grid. They are also reviewing the possibility of standardising equipment for grid connection. In addition, SCE has proposed three further pilots to explore V2G technology, pricing and customer engagement tools and analytics bundles.

Meanwhile, PG&E is collaborating on its ChargeForward V2G pilot programme with BMW:



Distributed energy resources (DERs), typically solar and battery storage, paired with charging stations

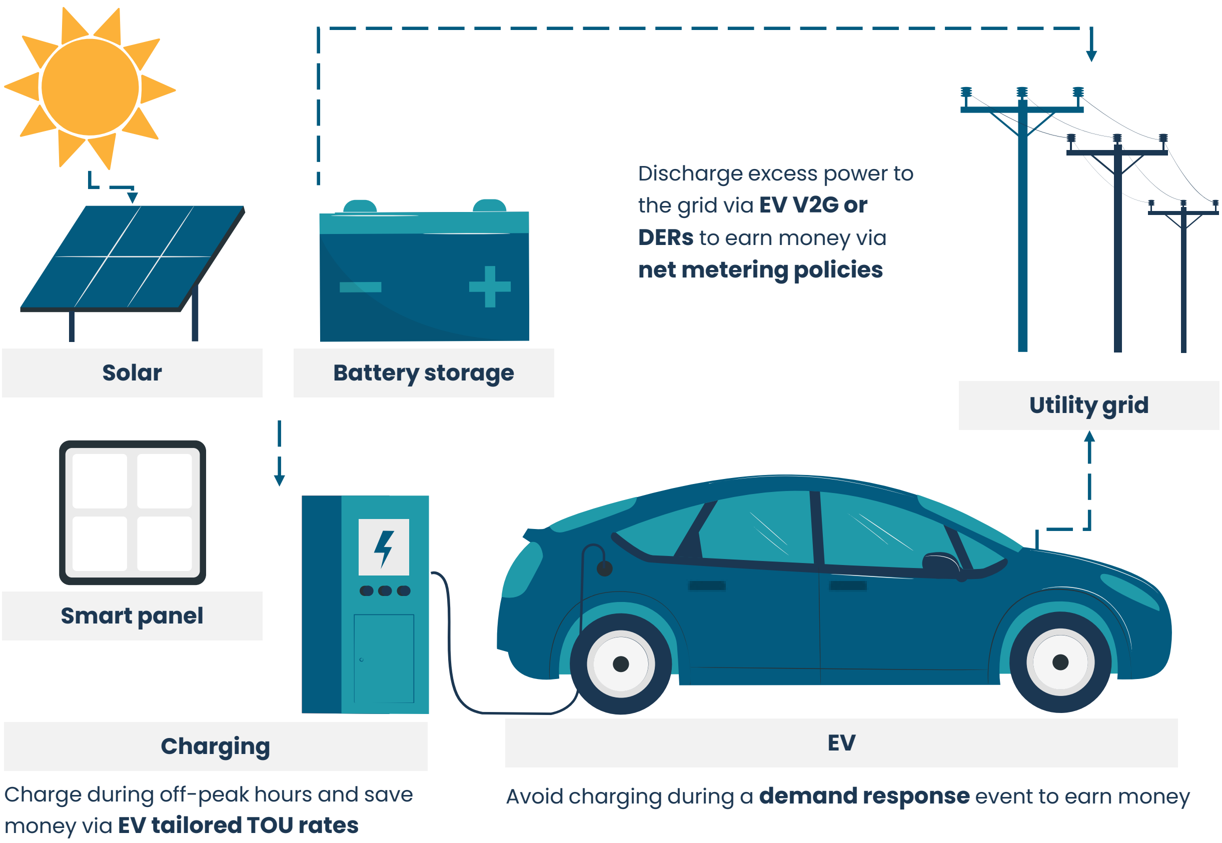
Pairing solar and battery storage with charging infrastructure is in its infancy but has the potential to meaningfully flatten peak demand, save costs and improve grid flexibility.

Behind-the-meter solar and storage in California are expected to increase 260% and 770% respectively between 2019 and 2030[2] and will be utilised in a variety of use cases. The net metering (NEM) 2.0 policies were established to help fuel adoption and create an energy sharing economy. With a decision expected soon on net metering 3.0, the economics of providing power back to the grid may be negatively affected.

It is yet to be seen how policies will further shape stakeholder investment and government, private business, and individual behaviour.

Santa Cruz County offers an early example. They are using ENGIE's Storage solutions to reduce the impact of EV charging on building's electricity demand for the county and expect to save $190,000 over 10 years. The ENGIE Storage system monitors the system continuously, enabling the county to view savings and flatten of peak demand through the GridSynergy portal. The county will also generate additional revenue through PG&E's Excess Supply Programme by charging during periods of excess supply on the grid.

Demand shaping levers can work in concert to reduce grid strain while creating an energy sharing economy



Benefits

- → Reduce customer costs
- → Improve grid reliability
- → Reduce grid capex costs with at scale coordination

2. *California PUC unveils draft plan for 'forward-thinking' distributed energy policy*, Utility Dive, July 27, 2021

Conclusion

While EV adoption technology and policies are in their infancy, important progress is being made.

Ultimately, technology availability combined with a willingness to test and learn business models that foster an energy sharing economy can create a more flexible, reliable and affordable grid.

Developing a clear perspective, having a seat at the table, and collaborating with other stakeholders to shape policies, roadmaps, and execution is critical to success. It is also important to develop partnerships to test and learn various demand shaping levers, rapidly iterating until a scalable solution is determined.

Key questions to ask as an organisation

How prepared is your organisation for the transition to electric vehicles and how will it affect the electric grid?

- → Do you understand what drives customer adoption of the demand shaping levers in your territory?
- → Does your organisation have the team and capabilities in place to take advantage of this transition?
- → Do you have partnerships and collaboration models to adapt to the changing environment quickly enough?

About the author

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Sarah is an experienced executive and advisor, partnering with a wide range of businesses to address the most pressing strategic and operational opportunities. As a partner in the Energy Transition practice, Sarah is focused on collaborating with clients to meet their emission reduction goals and ensure sustained results.