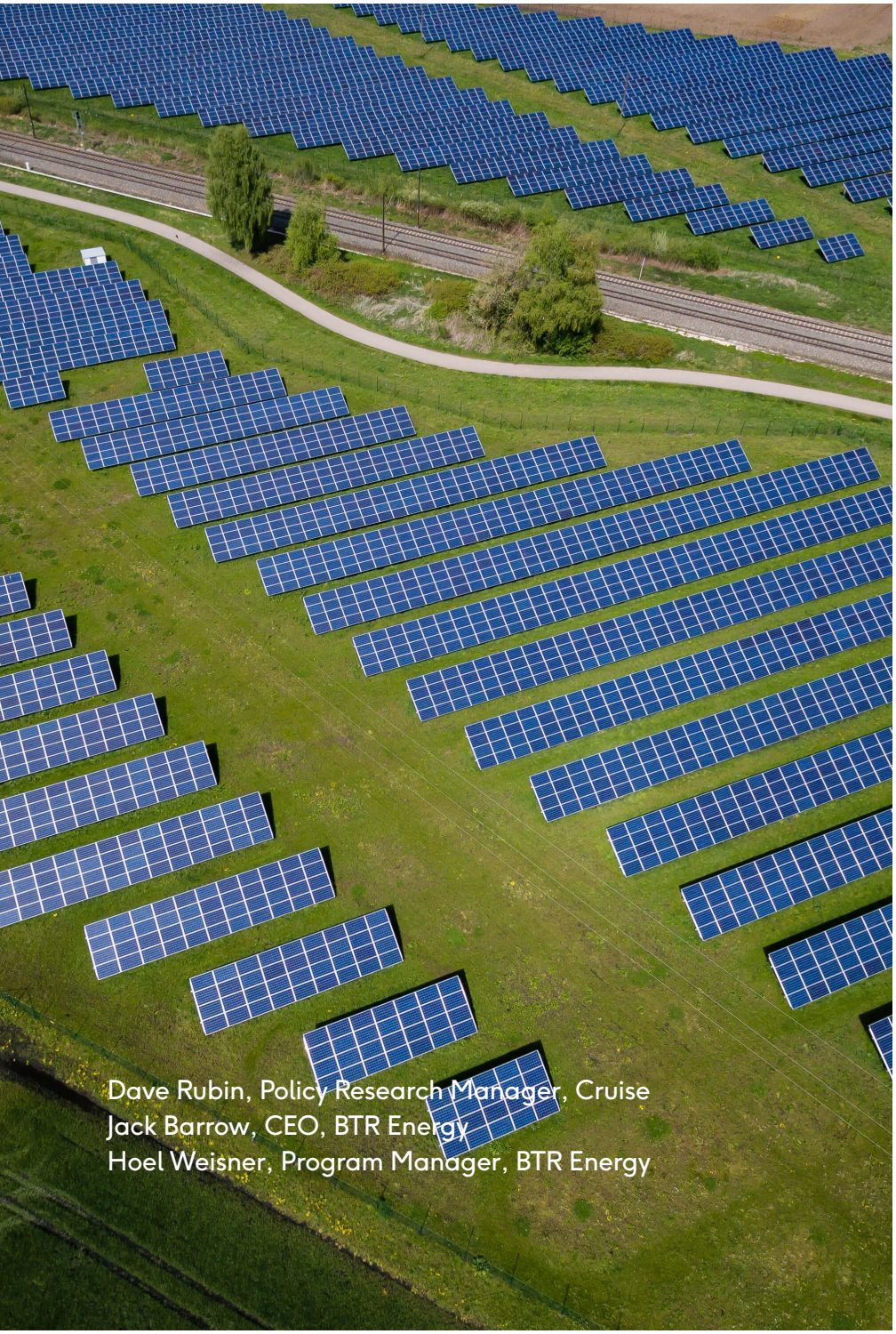
cruise

BTR ENERGY

Farm To Fleet

A Clean Energy Supply Chain for Autonomous, All-Electric Ridehailing



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Executive Summary

WE ARE PROUD TO ANNOUNCE FARM TO FLEET

California is in the midst of a massive effort to rapidly decarbonize its economy. Through strategies like Governor Newsom's Executive Order N-79-20 and policies like CARB's Clean Miles Standard, California is targeting transportation - its highest source of emissions - to mitigate climate change's worst impacts.

Cruise views our service as part of the solution. We are a shared, self-driving, all-electric vehicle company, with the goal of providing safer, more inclusive, and more sustainable transportation. In November 2019, Cruise went one step further, powering our California fleet with 100% renewable energy. Cruise is the first - and to-date only - autonomous vehicle developer to make that commitment.

But we realized that the charging of our fleet could create real financial benefits and economic opportunities for more communities today.

So Cruise partnered with BTR Energy ("BTR") to make our renewable commitment as impactful as possible. We spoke with renewable producers across California to find a way to purchase our renewable energy credits (RECs) directly from partners that shared our vision for a sustainable future. Those discussions revealed how Cruise could support the biggest driver behind the growth of California's renewable energy generation - the state's Central Valley.

We are proud to announce Farm to Fleet, Cruise's new initiative to intentionally purchase renewable energy directly from Californina's agricultural heartland to charge our self-driving electric vehicles, creating a pathway for farms generating on-site renewable power to participate in and financially benefit from transportation electrification. Through Farm to Fleet, Cruise is able to link our charging to solar energy generated by specific local businesses like Sundale Vineyards, a table grape vineyard outside of Tulare, and Moonlight Companies, a citrus and stone fruit grower in Reedley. Sundale Vineyards and Moonlight Companies are responsible for products Californians know and love, like Crimson seedless grapes and Cuties mandarins. These farms are now also in the business of powering all-electric autonomous vehicles.

But what is most exciting for Cruise is how these partnerships can scale over time. Cruise and BTR modeled how rapidly transitioning California's ridehail vehicles to EVs using deliberately sourced renewables could not only reduce emissions, but also directly support new revenue for solar producers - particularly in the Central Valley.

- Even under moderate VMT growth, an all-EV ridehailing fleet charged by renewables could reduce 5.5M metric tons of CO_2e per year by 2030 - **22% of the** total needed to reach California's targets under the California Global Warming Solutions Act of 2006 (AB 32) of reducing emissions 40 percent below 1990 levels.
- By 2035, REC revenue from EV ridehailing alone could exceed **$100M per year** for renewable producers - creating direct financial benefits for companies like Sundale and Moonlight.
- By 2040, all-renewable ridehailing in California could help avoid up to 13.5M metric tons of CO_2 per year - totaling the annual emissions of New Hampshire, or **the same impact as removing 2.9 million gas-powered cars off California streets.**

> **With Cruise, every electric mile we provide the public in California won't just clean the air. It will also help more Californians share in the economic opportunity of the electric revolution.**

Farm to Fleet

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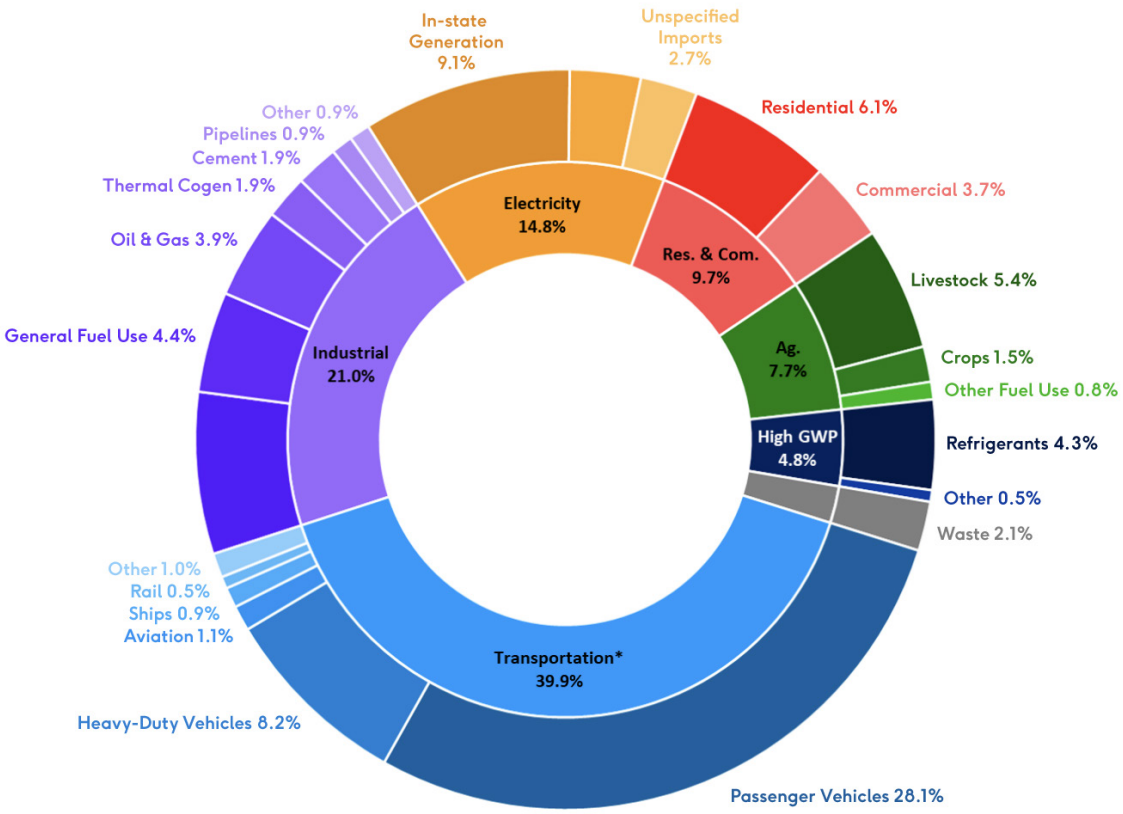
Transportation in California Today



Breakdown of 2018 California Emissions by Sector and Source - CARB

California is in the midst of a climate crisis. In 2020, wildfires burned over 4% of California - the worst season in the state's history. Orange skies covered the Bay Area, and fires raged from San Diego to the Oregon border. There is unequivocal evidence that the risk and severity of these wildfires stem from climate change, and that this climate change is driven in large part by carbon-powered transportation.

Transportation is pivotal to achieving decarbonization in the state. It remains the largest source of greenhouse gases (GHGs) in California, and is responsible for roughly 40% of the state's total emissions, emitting roughly 170M metric tons (MMT) of carbon dioxide per year. As shown in the chart below from the California Air Resources Board's (CARB) report on Calilfornia's GHG emissions from 2000-2018, passenger vehicles - including cars, light duty trucks, and SUVs - make up two-thirds of this total.[1]

California's objective is to reduce the state's total GHG emissions (including transportation) from its current level to an ambitious target of 260 MMT CO2 per year by 2030 under AB 32, and achieve full carbon neutrality by 2045.[2,3] However, as shown below, current estimates show California is on track to miss its 2030 target by 15-45 MMT CO2 - critical to averting the worst impacts of global climate change.

[1]California Air Resources Board. "California Greenhouse Gas Emissions for 2000 to 2018 - Trends of Emissions and Other Indicators". 2020. https://ww3.arb.ca.gov/cc/inventory/pubs/reports/2000_2018/ghg_inventory_trends_00-18.pdf.
[2]Chris Busch and Robbie Orvis, "Insights from the California Energy Policy Simulator", Energy Innovation, January 2020, https://energyinnovation.org/wp-content/uploads/2020/01/Insights-from-the-California-Energy-Policy-Simulator.pdf.
[3]California's 2045 carbon neutrality goals were implemented under Executive Order B-55-18 by former Governor Brown in 2018: https://www.ca.gov/archive/gov39/wp-content/uploads/2018/09/9.10.18-Executive-Order.pdf.

And while these numbers and targets may seem abstract, the costs to human life of carbon emissions are real. A recent study from Harvard and Cambridge researchers shows that particulate matter (PM2.5) from fossil fuel emissions globally contributed to 8.7 million premature global deaths in 2018 - nearly 1 in 5.[4] Looking at the United States, one study found that transportation contributed to ~53,000 premature deaths alone, with over 5,700 of the ~20,000 premature deaths in California from PM2.5 due to pollution from gas and diesel vehicles.[5, 6]

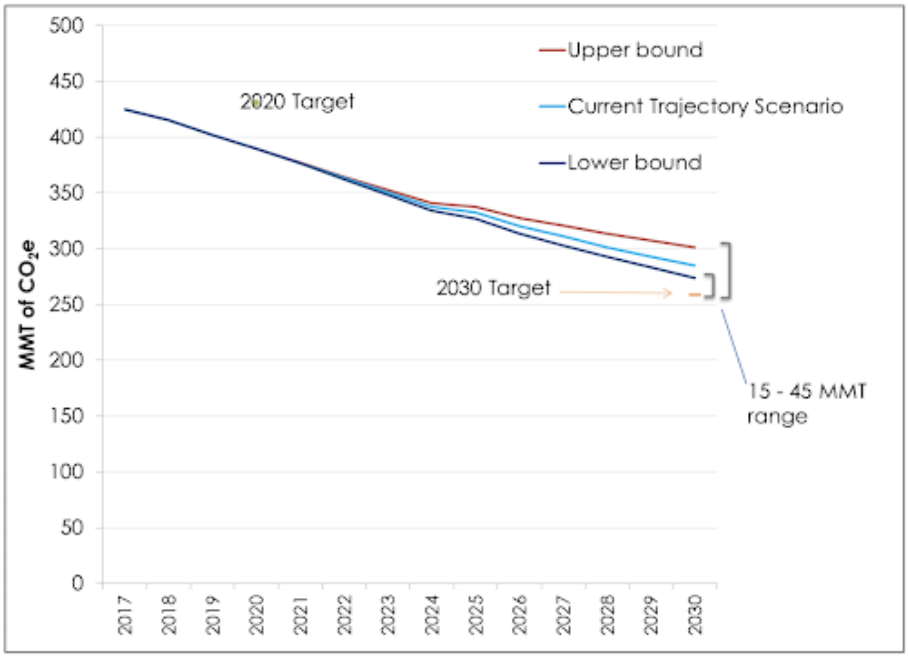
So when we talk about reducing emissions to combat climate change, passenger vehicles must be fundamental to any solution. To achieve California's vision for carbon neutrality by 2045, we must collectively advance policies that recognize light duty passenger vehicle emissions as a critical path.

Driving EV adoption within the passenger vehicle segment is of course critical to success. California leads the U.S. in terms of EV adoption, with roughly half of the nation's registered EVs. Electric powertrains are by design zero emission, and on average 67% cleaner than comparable internal combustion engine (ICE) vehicles, which on average emit three times their own weight in CO2 every year. Furthermore, the environmental benefits of EVs scale with the carbon intensity of the grid upon which they charge - in California, for example, an EV is five times cleaner than an ICE.

But EV adoption alone is not the only answer. "Number of EVs adopted" and "number of chargers installed" can be acceptable metrics for success, but are both fundamentally low resolution. The true emissions impact will be shaped by how many gasoline-driven miles are offset by the adoption or replacement of an EV. Buying an EV is one milestone, but its environmental impact only scales with how far it drives. And given that personally-owned vehicles have been shown to be parked 95% of their lifetime, utilization becomes a critical component of impact.[7]

Therefore, within the broader landscape of electrification, we need to not just accelerate EV adoption and fleet turnover, but also leverage concurrent modal shifts that present opportunities to amplify impact. As EVs reach market maturity, there are a variety of promising new duty cycles, business models, and use cases that have emerged. And while personal EVs will continue to play an important role in achieving our emissions targets, we need to also encourage and foster use cases that can convert the most amount of clean miles possible for the most people possible.

Figure ES-1. Emissions under Current Trajectory Scenario and varying assumptions



Source: California EPS

California Projected Emissions Reductions through 2030 Under Current Policy Landscape

[4] Vohra et al. "Global mortality from outdoor fine particle pollution generated by fossil fuel combustion: Results from GEOS-Chem". Environmental Research, Volume 195. April 2021. https://www.sciencedirect.com/science/article/abs/pii/S0013935121000487.
[5] Caiazzo et al. "Air pollution and early deaths in the United States. Part I: Quantifying the impact of major sectors in 2005". Atmospheric Environment, Volume 79, May 2013. https://www.coolgreenschools.com/wp-content/uploads/2015/07/US-air-pollution-paper.pdf.
[6] While this study used premature deaths in 2005, these numbers have remained consistent across studies throughout the years - ranging from 12,700 to 26,700. Wang et al. "Mortality burdens in California due to air pollution attributable to local and nonlocal emissions". Environment International, Volume 133, Part B. December 2019. https://www.sciencedirect.com/science/article/pii/S016041201932447X#b0030.
[7] Angie Schmitt, "It's True: The Typical Car Is Parked 95 Percent of the Time", StreetsBlog USA, March 10, 2016. https://usa.streetsblog.org/2016/03/10/its-true-the-typical-car-is-parked-95-percent-of-the-time/.

Enter ridesharing. Vehicles driving on transportation network company (TNC) platforms are an ideal use case for electrification. While TNCs only represent around ~1.2% of the total vehicle miles traveled (VMT) and ~640,000 vehicles in California, they can have an outsized impact on reducing emissions when electrified.[8] These vehicles often drive significantly higher miles than personally-owned vehicles and can reach a significant number of riders. Thus, when electric, TNCs are doubly effective as they offset trips and mileage that might otherwise be taken in gas-powered cars.[9]

Studies show that electrifying ridesharing can greatly reduce emissions. Researchers from the University of California at Davis found that electrifying one full-time rideshare vehicle in California has the same emissions reduction impact as three private EVs due to the volume of clean miles traveled.[10] Notably, ridesharing vehicles that are electric have significantly higher energy demand than personal EVs. That study found that while electric TNCs only make up 0.5% of total EVs in the state, they are responsible for 30% of the energy demanded by EVs at DC fast chargers. Meanwhile, another UC Davis study found that 40% of use of public DC fast chargers comes from electric TNC drivers - indicating a strong policy incentive to maximize these charging activities in a way that can achieve greater emissions reductions.[11]

So what does this tell us? EVs are certainly good for the environment. But shared electric vehicles, specifically those that can replace trips otherwise taken in gas-powered cars, are even more effective. And these electric TNCs - even in their very small number - are already having a notable impact in accelerating the public's ability to travel by clean, electric miles, regardless of EV ownership.

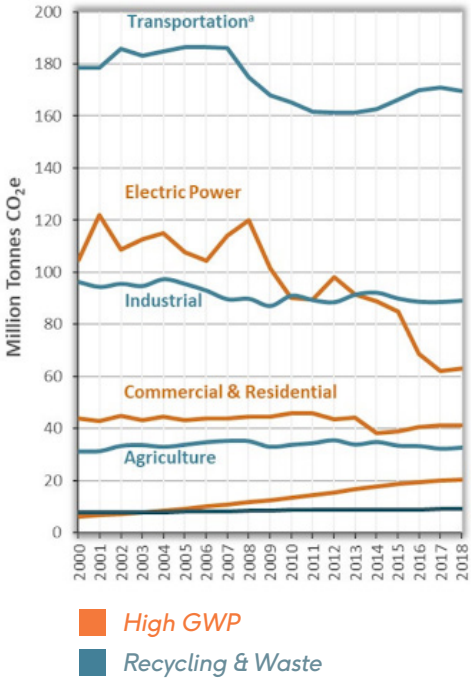
Cognizant of the benefits of these use cases for emissions reduction, the California Air Resources Board (CARB) is (as of the time of this writing) in the final stages of drafting the Clean Miles Standard. This state-wide program would require TNCs to decrease the emissions per mile of vehicles on their platform through a combination of increased fuel efficiency (via EV adoption), increased vehicle occupancy, and investment in first-last mile connectivity like biking and walking infrastructure - all as a means to reduce the carbon intensity of transportation.[12] The most logical policy evolution then would be to charge these ridesharing vehicles with fully renewable electricity. But with an estimated 640,000 TNC drivers across California each managing their own refueling, it would be nearly impossible to coordinate such a feat.[13]

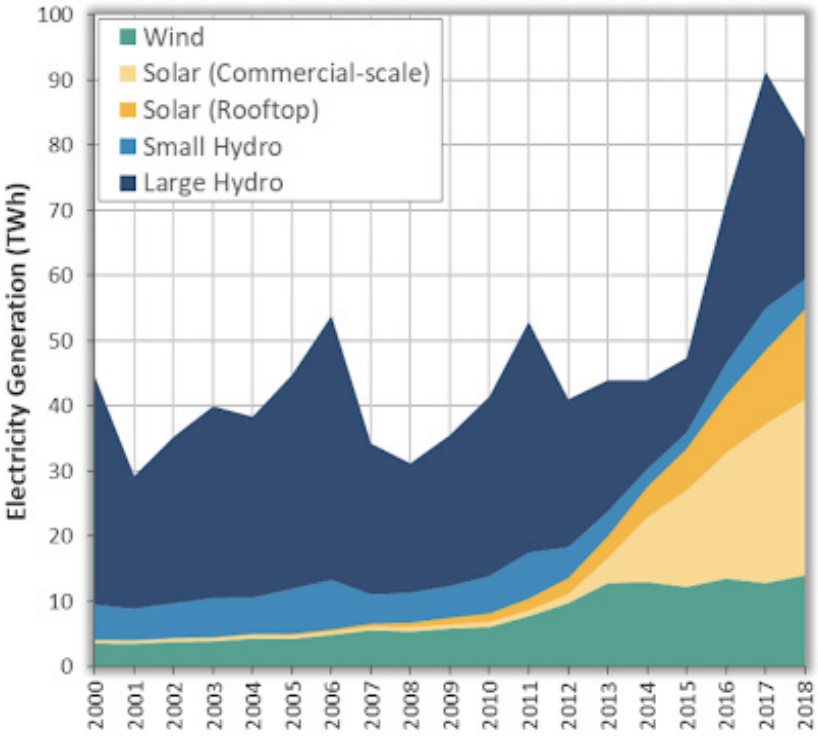
[8]CARB, "SB 1014 - Clean Miles Standard 2018 Base Year Emissions Inventory", December 2019, https://ww2.arb.ca.gov/sites/default/files/2019-12/SB%201014%20-%20Base%20year%20Emissions%20Inventory_December_2019.pdf.
[9]Rocky Mountain Institute. "Racing to Accelerate EV Adoption: Decarbonizing Transportation with Ridehailing". 2021. https://rmi.org/insight/accelerating-the-electric-vehicle-transition.
[10]Alan Jenn. "Emissions Benefits of Electric Vehicles in Uber and Lyft Services". National Center for Sustainable Transportation. August 2019. https://escholarship.org/uc/item/15s1h1kn.
[11]Kelly Fleming and Mollie D'Agostino. "Policy Pathways to TNC Electrification in California". UC Davis Policy Institute for Energy, Environment, and the Economy. May 2020. https://escholarship.org/content/qt9zx112v2/qt9zx112v2_noSplash_6d4550f2968fed62de5bfb79f5bd6747.pdf?t=qaixwi.
[12]CARB. "Draft Regulation Order - Clean Miles Standard". November 2020. https://ww2.arb.ca.gov/sites/default/files/2020-11/CMS%20Draft%20Regulation%20Order.pdf.
[13]Ibid.

Renewable Power Generation in California's Agricultural Heartland

The electric power sector, meanwhile, tells a different tale. Transportation emissions have generally remained unchanged (and even risen) over the last decade, with the exception of the COVID-19 pandemic over the last year. Yet as shown in the chart from CARB, while transportation remains stubbornly high in terms of the state's CO2e emissions, the electric power sector has made tremendous strides in reducing GHG.

This success is in large part due to California's regulatory landscape. The Renewable Portfolio Standard (RPS) requires that utilities procure an incrementally higher share of renewable energy as a portion of base load up to 60% of total energy by 2030.



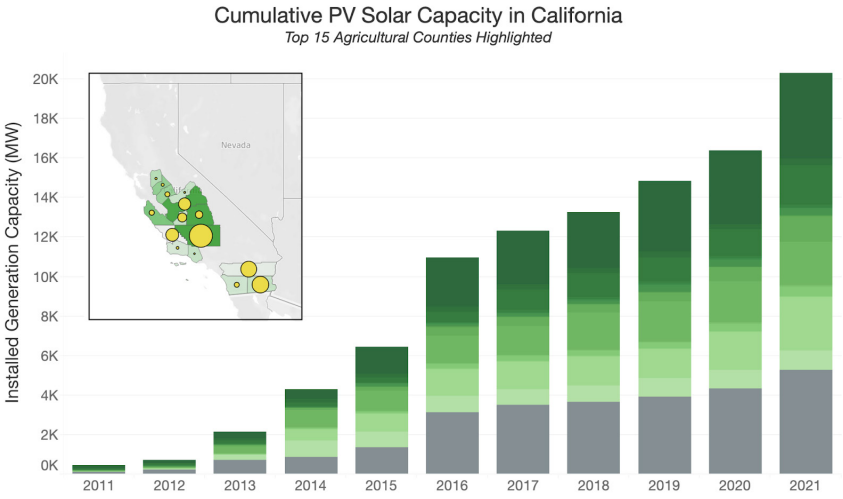


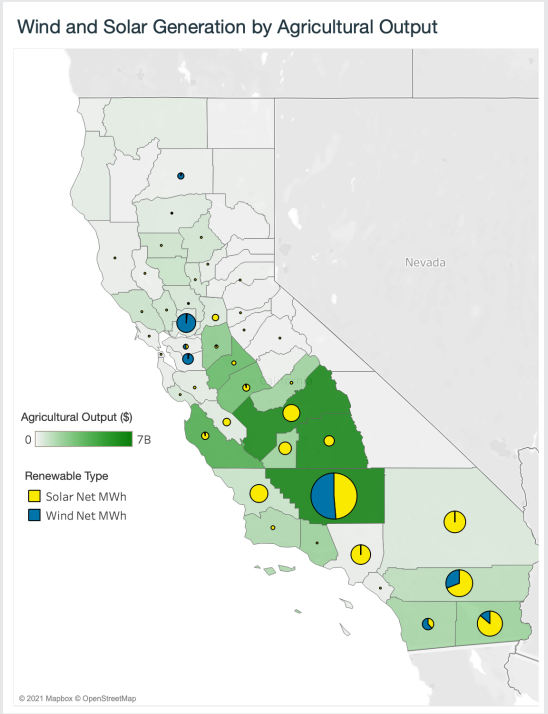
By increasing renewable requirements, RPS provides energy generators additional value through the creation of Renewable Energy Credits (RECs) - another financial incentive to decarbonize California's electricity generation. RECs are separate financial instruments representing one megawatt hour (MWh) of renewable energy generation. Created alongside the corresponding renewable power itself, the RECs can be bought and sold based on market values, and "retired" by an entity to represent the consumption of renewable power.

[14]Ibid.
[15]California State Legislature. "Senate Bill 100 - California Renewables Portfolio Standard Program: emissions of greenhouse gases". California Legislative Information. September 10, 2018. https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180SB100.

While renewables represent roughly 32% of the electricity on California's grid, solar has grown tremendously in both total output, as well as share of generation. As shown in the chart above, from 2011 to 2018, "in-state solar generation saw significant growth as rooftop photovoltaic solar generation increased eight-fold, and total solar generation (commercial-scale plus rooftop solar) increased by a factor of 15 during that period". Indeed, there was a 14% year-over-year growth in solar production from 2017 to 2018 alone.

An assessment of the facilities registered to generate RECs as part of the RPS shows some impressive figures. Of all of the wind and solar generation capacity installed in California, 28.1% and 32.3% respectively are installed in Central Valley counties. California counties with high agricultural productivity outside the Central Valley similarly correlate with significantly higher annual generation of solar and wind power, as shown in the map., Looking at the top 10 agricultural counties in California, those numbers are even higher - hosting 59.4% of the state's total solar facilities and 59.9% of its wind generation facilities. In fact, data from the California Energy Commission (CEC) shows that those 10 counties with the highest agricultural output generate more than half of the state's solar power.





And this trend appears unlikely to slow.

The growth of installed renewable generation in California's Central Valley and other agricultural centers has been impressive - particularly in solar power. As shown in this graph of WREGIS-registered PV projects, California's PV solar capacity has increased more than 130 fold over the past 10 years, with the state's top 15 agricultural counties (represented in green) accounting for 74% of that total.

California's Central Valley is poised to remain instrumental in fostering a more renewable and sustainable grid.

[16]CEC, "2019 Total System Electric Generation", https://www.energy.ca.gov/data-reports/energy-almanac/california-electricity-data/2019-total-system-electric-generation.
[17]Ibid, page 11.
[18]Database of REC generators as part of the RPS was sourced from WREGIS website: https://rps.energy.ca.gov/Pages/Search/SearchApplications.aspx./ For this calculation, "solar" refers to PV generation. Solar thermal capacity remains a relatively small share of total installed solar capacity.
[19]Imported wind energy excluded from analysis. CEC, "Total Wind Production by County", Electricity from Wind Energy Statistics and Data, 2019 Annual Totals. https://ww2.energy.ca.gov/almanac/renewables_data/wind/index_cms.php.
[20]Imported solar energy excluded from analysis. CEC, "Solar PV and Solar Thermal Electricity Production by County", California Solar Energy Statistics and Data, 2019 Annual Totals. https://ww2.energy.ca.gov/almanac/renewables_data/solar/index_cms.php.
[21]Top ten counties for agricultural output include Kern, Tulare, Fresno, Monterey, Stanislaus, Merced, San Joaquin, Ventura, Kings, and Imperial. California Department of Food and Agriculture, "California County Agricultural Commissioners' Reports Crop Year 2016-2017", December 28, 2018. https://www.cdfa.ca.gov/Statistics/pdfs/2017cropyearcactb00.pdf.

Cruise and Our Commitment to a Cleaner California

The subsequent challenge then lies in how to couple these trends - greater electrification of California's vehicle stock, whether by choice, incentive, or requirement, particularly in ridesharing, and supporting the surging growth in renewable power generation in California's agricultural heartland, chiefly from solar. We believe we've unlocked that opportunity.

Cruise is an all-electric self-driving technology company with a mission to build the world's most advanced autonomous vehicles (AVs) to safely connect people to the places, things and experiences they care about. And critical to our vision for safer, more inclusive, and more sustainable transportation is our all-electric fleet. Since our founding in 2013, Cruise has been committed to testing and operating our self-driving technology only on EVs. We were proud to carry that vision forward in partnership with General Motors, starting in 2016, when Cruise began testing exclusively with the Chevrolet Bolt vehicle platform, and into the future with the announcement of the Cruise Origin in January 2020.[22]

Yet we recognized that there was more that could be done to achieve our environmental goals.

Collective action is a major hurdle for fully renewable-powered ridesharing as it exists today. Even with the relatively few electric TNC vehicles on the road in California (estimated to be only roughly 0.8% of TNC VMT in 2018), arranging for all of those drivers to take advantage of fully renewable electricity rates - either at home or only at facilities committed to renewables - would be a logistical morass.

In contrast, Cruise's current charging infrastructure is fully-owned and operated, using a centralized charging hub model. This allows for a number of benefits: co-location of vehicle maintenance, higher utilization, and optimized battery charging.[23] A shared AV can also serve a much broader segment of the population, and be used more efficiently than personal vehicles. Research from the University of Texas at Austin shows that a shared AV can replace up to 11 conventional, personally-owned vehicles and still serve the needs of those riders' travel patterns.[24] This central management affords another benefit: fleet-wide energy procurement. In contrast to the decentralized nature of TNCs which makes a coordinated renewables strategy difficult to implement, Cruise's owned-and-operated model allows us to make company-wide energy decisions that can impact our entire fleet instantaneously.

And we have done just that. Starting in December 2019, Cruise began charging our California fleet with 100% renewable energy, utilizing the Low Carbon Fuel Standard's "Zero Carbon Intensity Pathway".[25] Working through BTR, Cruise is sourcing RECs from across California to fill this need, powering our vehicles in a sustainable way. In 2020 alone, Cruise drove over 770,000 fully autonomous miles in California - Each powered by renewable energy through our partnership with BTR in sourcing RECs. This means that every mile we provide the public in California is not only electric, but also truly zero emission.

Cruise is the first - and to date only - AV developer to take the step of charging its fleet with renewable electricity.

The Origin will be the cornerstone of Cruise's future shared, all-electric, self-driving service.

[22]Cruise. "Introducing the Cruise Origin". https://www.getcruise.com/origin.
[23]Dr. Ken Ferguson. "Charging Into a Greener Future: Optimizing Battery Life in Cruise's All-Electric, Autonomous Fleet". Cruise. July 6, 2020. https://medium.com/cruise/charging-into-a-greener-future-optimizing-battery-life-in-cruises-all-electric-autonomous-fleet-2314810e1e98.
[24]Kara Kockelman and Daniel Fagnant. "The Travel And Environmental Implications Of Shared Autonomous Vehicles, Using Agent-based Model Scenarios". Transportation Research Part C. 2014. https://www.caee.utexas.edu/prof/kockelman/public_html/TRB14SAVenergy_emissions.pdf.
[25]Tracy Cheung. "Cruise Becomes First Self-Driving Company to Power Vehicles With 100% Renewable Energy". Cruise. April 22, 2020. https://medium.com/cruise/cruise-becomes-first-self-driving-company-to-power-vehicles-with-100-renewable-energy-3c7a7974590c.

Farm to Fleet - Cruise's Clean Energy Supply Chain

But we didn't stop there. While Cruise's all-electric, all-renewable, and shared AVs will provide the public with access to zero-emission transportation, we began to brainstorm ways in which we could expand the benefits of our fleet to more communities today - not just those in cities most likely to experience Cruise's service first. Cruise realized our centralized AV charging management enabled purchasing of renewable power in a way that directly benefits those driving decarbonization in California's Central Valley. Increasing the share of clean miles traveled isn't just an opportunity to reduce emissions - as a fleet operator with considerable charging needs, we recognized this was a chance to be intentional with our power sourcing, creating a clean energy supply chain from farmers in the Central Valley to our chargers in San Francisco - from Farm to Fleet.

So, starting in Spring 2021, Cruise began sourcing our renewable energy credits directly from farms in California's Central Valley that generate their own solar power on-site.

Working closely with BTR, Cruise was able to launch solar power partnerships with the same farms and communities driving the clean energy revolution in California's Central Valley. This allowed Cruise to intentionally and directly source our solar RECs from partners like Sundale Vineyards, a third-generation table and wine grape farm outside Tulare, and Moonlight, a family-owned fruit orchard near Fresno.[26,27]

Moonlight Companies is a family-owned farming company in the heart of California's San Joaquin Valley, the breadbasket of the state's agricultural base. Started in 1918 by the Tavlan family, Moonlight and its companies grow a number of fruits across vineyards, orchards, and groves, including peaches, nectarines, plums, pluots, apricots, table grapes, oranges, lemons, and mandarins. While all their fruit is hand-picked from predominantly along the Kings River, Moonlight has invested in state-of-the-art facilities and technologies that allow it to efficiently, quickly, and sustainably get its fruit to market. Moonlight is also leading in its investment in renewable power, including a combined 3.9 megawatts (MW) of installed fixed and tilt solar arrays as well as two Tesla Powerpacks. These solar arrays generate the RECs that Cruise purchases to maintain our renewable commitments. Moonlight is also exploring programs to electrify its agricultural equipment.

Through this initiative, every mile that Cruise drives in CA goes to directly generating economic opportunity and supplemental income for farmers, creating a tangible link between California's agricultural sector and Cruise - even as our AVs charge hundreds of miles away.

[26]Sundale Vineyards. http://www.sundalevineyards.com/.
[24]Moonlight Companies. http://www.moonlightcompanies.com/.

Morning light shines off solar panels at Sundale's vineyard in Tulare.

Farm to Fleet will not only help bridge the rural-urban divide in California, it will also expand how we understand the benefits and impact of autonomous electrification across the state. More than 34% of the RECs Cruise used in 2020 were generated by agricultural businesses. By 2022, 100% will come from Moonlight and Sundale.

We believe that Cruise's centralized EV AV ridesharing fleet is a fundamental differentiator for California's sustainable transportation goals - particularly given our ability to offer 100% renewable-powered transportation to those who may never own an EV or have access to a charger. And via Farm to Fleet, we have now unlocked the ability to scale that value to California's farmers and agricultural sector, even while pre-commercial. As noted above, coordinated action amongst personal EV owners or even TNCs to achieve fully-renewable charging would be extremely challenging. In contrast, Cruise's owned and operated infrastructure provided the opportunity to make these commitments fleet-wide, bridging the financial benefits of EV adoption to California's farmers in a concerted and meaningful way.

Spotlight - Sundale

The Kinosians began farming in California in the 1930s outside Tulare, where they grew Thompson and Emperor table and wine grapes. After six decades of harvests, the Kinosians started Sundale Vineyards in 1995 and are a leader in both California's grape industry and sustainable agriculture. Beginning in the late 2000s, Sundale began installing solar panels to power their cold storage facilities. As of 2021, Sundale had installed 2.0 megawatts (MW) of solar power capacity that generates the RECs that Cruise uses to power its fleet. Sundale is also a leader in sustainable water use, using 100% drip irrigation and low volume sprayers to more efficiently water its crops. Today, Sundale grows an estimated 4 million boxes of grapes grown every season, and is still owned by the Kinosian family.

Farm to Fleet - Scaling Into the Future

While the unification of two of California's most iconic industries - agricultural and innovation - via Cruise's Farm to Fleet is ground breaking in and of itself, what is most exciting is how an initiative like Farm to Fleet can expand into the future. While the RECs that Cruise buys provide a direct financial benefit to California's agricultural communities now, Farm to Fleet's true impact comes at scale. To understand the full-scope of potential benefits, Cruise worked with BTR to model and forecast the following outcomes from Farm to Fleet:

- **How much could all-electric ridesharing reduce California transport emissions by sourcing zero-emission RECs from the state's Central Valley,**
- **How much financial benefit could be generated for Central Valley farms by intentionally sourcing RECs from these suppliers**

The outcomes of this model show that 1) renewable-powered, all-electric ridehailing can dramatically reduce emissions, delivering outsized gains in reducing the state's transportation emissions, and 2) deliberate and intentional procurement of these renewables can generate significant revenue for farms.[28]

Modeling Assumptions

To understand how Farm to Fleet could work at scale, Cruise and BTR explored three key variables for how the state's transportation landscape can evolve in the years ahead - VMT growth or reduction across the state's entire vehicle fleet, ridehailing's share of total VMT within California, and share of EV adoption within California's ridehailing fleet. Additional assumptions included California's reducing grid carbon intensity and price forecasts on REC generation and supply.

VMT Data for California

Key to this study is how California's total VMT will change over the coming years as both the population and economy grow, as well as how the state will implement policies to meet its future mobility needs and reduce greenhouse gas emissions. Current VMT data were obtained from the latest edition of Caltrans' annual Road Data book, totaling roughly 347.2B miles in 2018.[29] Projections for future VMT change come from the Caltrans Clean Transportation Plan 2050, where they present the following projections:[30]

- **Unchecked growth in VMT as population and the economy continue to grow and driving remains the dominant form of transportation. This results in a medium to high growth scenario of +13% to +35% over 30 years.**
- **A best-case scenario that results from full implementation of the Caltrans Clean Transportation Plan leads to an aggressive reduction in VMT of -27%.**

[28]"Ridehailing" in the context of this analysis is intended to capture both traditional TNCs as well as other charter-party carriers (TCPs), such as Cruise's autonomous ridehailing service, as defined by the CPUC.[24]Moonlight Companies. http://www.moonlightcompanies.com/.
[29]Caltrans, "2018 Road Data," December 2020, https://dot.ca.gov/programs/research-innovation-system-information/highway-performance-monitoring-system.
[30]Caltrans, "California Transportation Plan 2050," February 2021, https://dot.ca.gov/programs/transportation-planning/state-planning/california-transportation-plan.

Ridehailing Share of VMT

Forecasted ridehailing VMT growth in this analysis comes primarily from the BNEF EV Outlook, which shows shares of ridehailing VMT climbing as high as 12% through 2035.[31] Supporting this is a report by transportation consulting and research firm Fehr & Peers that estimates the San Francisco and Los Angeles metro areas account for nearly 65% of all California VMT. Furthermore, ridehail's share of VMT in these markets is already as high as 13% in core urban counties.[32] To capture these diverse inputs, this analysis modeled ridehail VMT growth of 15% (high) and 5% (low) by 2035, and used a sigmoid function to show accelerated growth until the target year and then slowing growth thereafter.

EV Adoption in California's Ridehailing Fleet

The modeled rate of EV adoption in California's ridehailing fleet is based on a synthesis of reports and policy goals. These include a roadmap laid out by the city of San Francisco and researchers,[33,34] policy visions for Los Angeles by the Transportation Electrification Partnership,[35] estimates by the California Public Utilities Commission, the Clean Miles Standard,[37] as well as commitments by TNCs themselves.[38] As such, EV adoption is modeled under two separate rollout plans - an aggressive goal (but one most cited by industry and regulators) of reaching 100% of EVs in the ridehailing fleet by 2030 (as outlined in the state's proposed Clean Miles Standard), and a more conservative goal of reaching 100% by 2035. Notably, ridehailing EVs in this analysis are modeled as generating no upstream carbon emissions from charging, given the assumption they would charge using RECs.

Other Assumptions - California Fleet MPGe, California Grid Carbon Intensity, and REC Forecasts

To better understand both avoided emissions and annual REC revenue for farmers, Cruise and BTR also forecasted California's increased fleet fuel efficiency, projected grid carbon intensity, as well as future REC prices based on historic market price indexing.

Cruise and BTR developed a scaled increasing fuel efficiency metric for California's blended light duty fleet. This represents a counterfactual to compare avoided emissions from the penetration of ridehailing as share of VMT and the electrification of those vehicles. Given the complexity of modeling a multivariate analysis for increased light duty vehicle fuel efficiency and fleet turnover alongside ridehailing, total fleet efficiency was estimated at 31.1 MPGe, as established in the Clean Miles Standard's Base Inventory Report.[39] This scales to 60 MPGe by 2050, representing a mixed light duty fleet of ICE vehicles and EVs. Forecasted grid intensity allowed a comparison between total emissions from gas-powered ridehailing and by grid-equivalent electricity as more renewables are brought online. Sources used for these projections were CARB's Lookup Table Pathways on fuelstock,[40] CEC's 2019 Integrated Energy Policy Report on forecasted energy mix,[41] and CEC research on decarbonization and renewables.[42]

[31]BloombergNEF, "Electric Vehicle Outlook 2020," June 2020, https://bnef.turtl.co/story/evo-2020/page/1?teaser=yes.
[32]Fehr & Peers, "Estimated TNC Share of VMT in Six US Metropolitan Regions," August 2019, https://issuu.com/fehrandpeers/docs/tnc_vmt_findings_memo_08.06.2019.
[33]San Francisco Municipal Transportation Agency, "Proposed Electric Vehicle Roadmap for San Francisco," The Mayor's Electric Vehicle Working Group, June 2019, https://www.sfmta.com/sites/default/files/reports-and-documents/2019/07/evroadmap_final_june2019.pdf.
[34]Hsu et al., "City charging infrastructure needs to reach 100% electric vehicles: The case of San Francisco," International Council on Clean Transportation, October 2020, https://theicct.org/publications/sf-ev-charging-infra-oct2020.
[35]Los Angeles Clean Tech Incubator (LACI), "Zero Emissions 2028 Roadmap", Transportation Electrification Partnership, October 4, 2018, https://roadmap.laci.org/wp-content/uploads/2018/10/LACI-ROADMAP-V7-HI-FI-1-100418.T6H-Web-READY.pdf.
[36]S. R. George, "Electrifying the Ride Sourcing Sector," CPUC, April 2018, https://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/About_Us/Organization/Divisions/Policy_and_Planning/PPD_Work/PPD_Work_Products_(2014_forward)/Electrifying%20the%20Ride%20Sourcing%20Sector.pdf,
[37]Ibid.
[38]Uber and Lyft have both made commitments to go all-electric by 2030.
[39]Blended light duty fleet efficiency for California is lower today than the 31.1 MPGe of California's ridehailing fleet, indicating that these findings may actually be slightly conservative in the early years. As a result, the scenarios have slightly lower initial LDV fleet emissions totals than that modeled by CARB in its California Greenhouse Gas Inventory Report for 2018.
[40]CARB, "CA-GREET3.0 Lookup Table Pathways - Technical Support Documentation", August 13, 2018, https://ww2.arb.ca.gov/sites/default/files/classic/fuels/lcfs/ca-greet/lut-doc.pdf.
[41]CEC, "2019 Integrated Energy Policy Report", February 20, 2020, https://efiling.energy.ca.gov/getdocument.aspx?tn=232922.
[42]Mahone et al., "Deep Decarbonization in a High Renewables Future: Updated results from the California PATHWAYS model", Energy and Environmental Economics, prepared for the CEC, May 2018, https://www.ethree.com/wp-content/uploads/2018/05/E3_2050Pathways_Draft_FullDeck_20180522.pdf.

REC price and supply forecasts were modeled with REC price data from Karbone Inc. ("Karbone"), a New York-based financial services firm specializing in energy markets. BTR and Karbone collaborated to forecast price fluctuations through 2035 and establish different REC price scenarios used in the model.

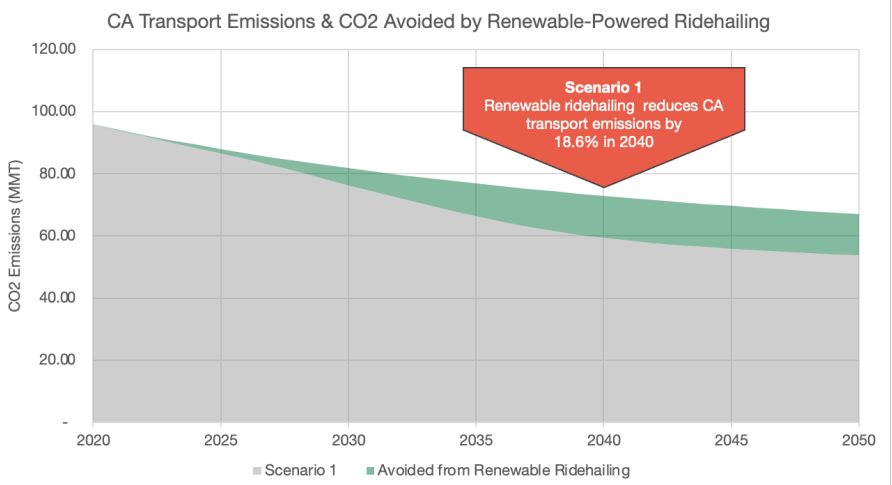
Analysis

Cruise and BTR explored how these two outcomes (emissions reduction and REC revenue for farms) can scale through three modeled scenarios, each offering different visions for the future of California's transportation.

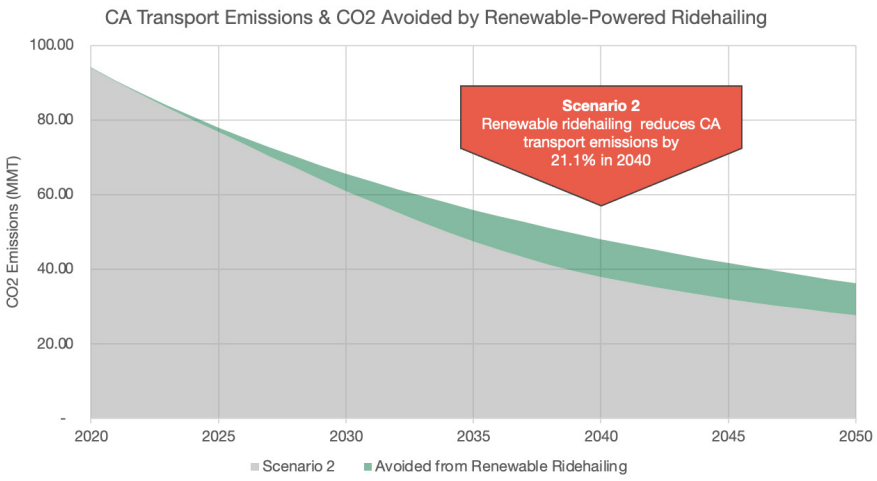
	California VMT Growth	TNC Share of Transportation	TNC EV Adoption
Scenario 1	Mid	High	Fast
	13%	15% by 2035	100% by 2030
Scenario 2	Low	High	Fast
	-27%	15% by 2035	100% by 2030
Scenario 3	High	Low	Slow
	35%	5% by 2035	100% by 2035

Scenario 1: Base Case of Steady VMT, Fast Growth in Ridehailing, and Rapid EV Adoption

The first scenario represents a hypothetical future where policy visions like the California Clean Transportation Plan 2050 (CTP50) are relatively successful. VMT grows proportionally with the mid-growth scenario in CTP50, rising to 13% higher statewide by 2050. The rise in VMT also drives greater growth in ridehailing, particularly as affordable autonomous service becomes more available, with ridehailing rising to 15% of total VMT by 2035. Meanwhile, ridehailing companies press forward with full transition of their fleets, achieving full EV adoption by 2030.



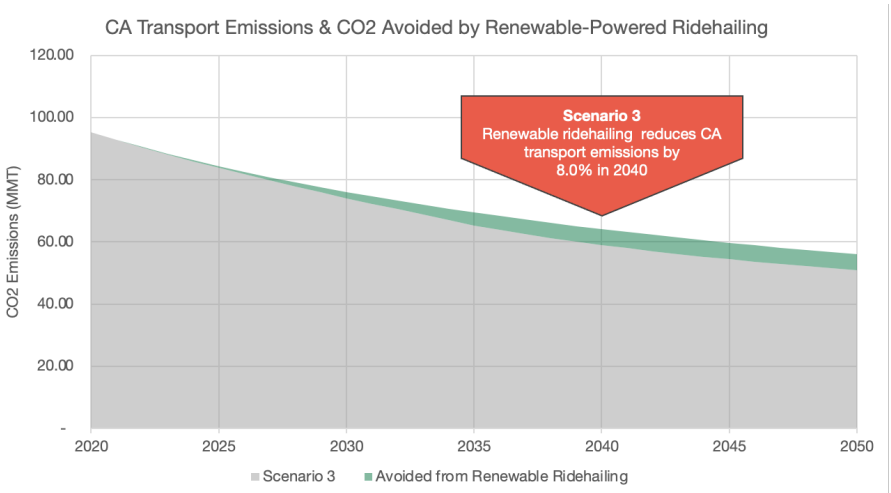
Scenario 2: Best Case of Reduced VMT, Fast Growth in Ridehailing, and Rapid EV Adoption



The second scenario is more optimistic. California's policy initiatives around multimodal transit, biking, and walking significantly cut VMT by 27% through 2050. Meanwhile, affordable autonomous ridehailing proliferates (as in scenario 1) as an attractive alternative to personal vehicle ownership, with total share of travel reaching 15% by 2035. Lastly, electrification policies are successful, with 100% turnover in California's ridehailing fleet by 2030. In this case, avoided emissions eventually plateau and then fall as Californians spend less time in cars, as shown in the first chart below.

Scenario 3: Worst Case of High VMT, Slow Growth in Ridehailing, and Slowed EV Adoption

The third scenario represents a darker picture. California fails to achieve its ambitious VMT reduction targets laid out in CTP50. Instead, VMT grows statewide by 35% over the next 30 years, with population and economic growth driving greater vehicle travel, while lingering concerns around COVID-19 discourage a rapid return to public transit. Ridehailing vehicles remain a relatively small proportion of total state transportation (rising to 6% of all VMT by 2035). Lastly, EV adoption within ridehailing fleets is slower in the second scenario. California is unable to accelerate electrification, and complete turnover of ridehailing vehicles isn't achieved until 2035.



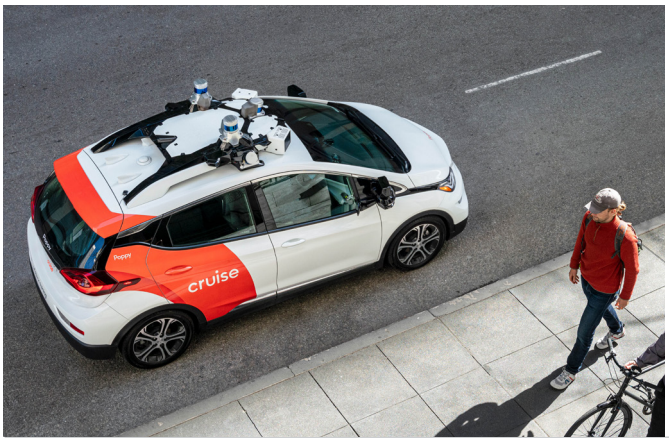
Results

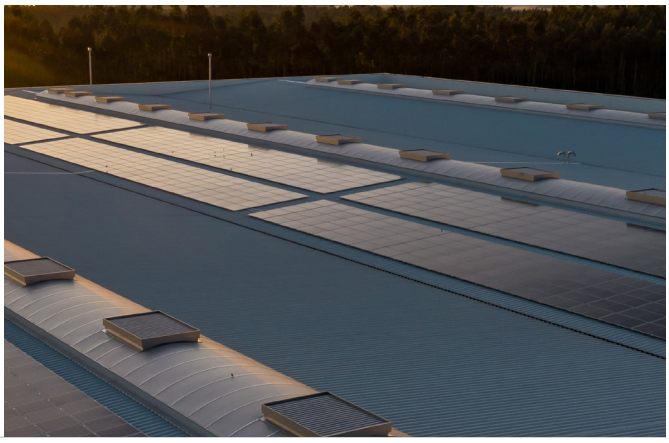
Cruise and BTR modeled these three scenarios using the assumptions above for VMT growth, ridehailing's share of VMT, and EV adoption within the ridehailing fleet to generate results for total avoided emissions and annual revenue for California's farmers supplying RECs.

Avoided Ridehailing Emissions versus No EV Adoption

One of the clearest benefits of zero emission, 100% renewable ridesharing is rapid reduction of transport emissions. As shown below, each scenario leads to tangible progress in achieving California's goals of reducing total emissions to 260 MMT CO2 by 2030 - 40% below 1990 levels as defined under SB 32.[43] Despite current efforts, California is on track to miss its 2030 targets by ~25MMT. By 2030, scenario 1 could **reduce California's emissions by 5.5 MMT CO2 annually, achieving 22% of the remaining gap under SB 32**.[44] Similarly, scenario 2 and 3 could achieve a 19% and 7.8% reduction respectively.

Beyond 2030, those impacts grow even further. By 2040, scenario 1 could yield an annual reduction of transportation emissions of 13.5 MMT CO2, totaling the **annual emissions of New Hampshire in 2017, or the same as taking 2.9 million gas-powered cars off the road in California**.[45]

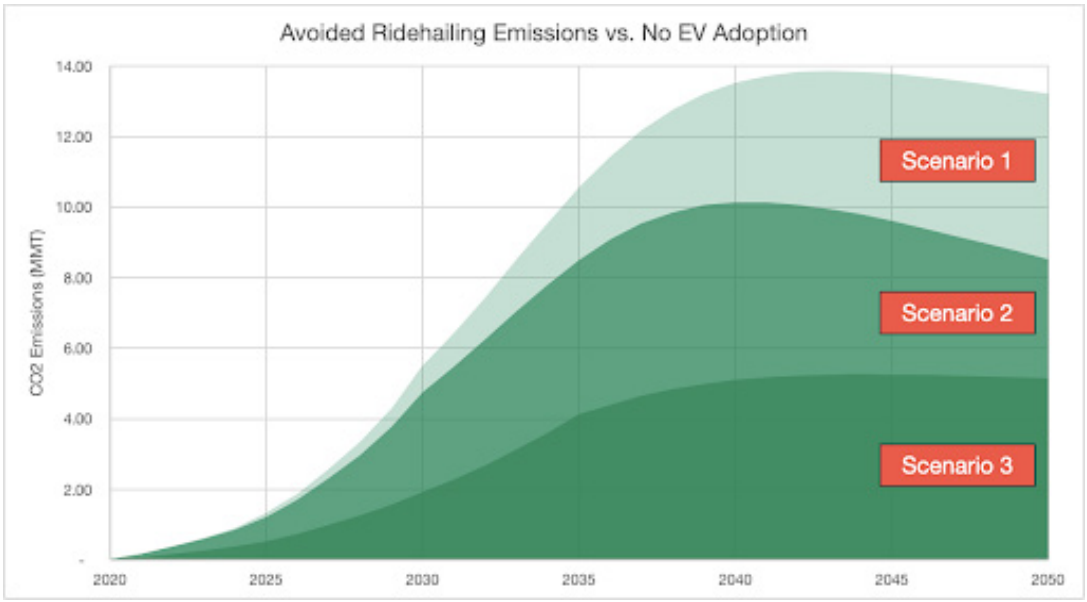




[43]Ibid.
[44]While counterintuitive, scenario 1 produces the greatest impacts on SB 32 targets as total VMT is higher than scenario 2, providing more opportunities to reduce total transportation emissions.
[45]U.S. Energy Information Administration, "New Hampshire - Environment", State Profile and Energy Estimates, April 15, 2021, https://www.eia.gov/state/data.php?sid=NH#Environment.

Farm to Fleet - Scaling Into the Future

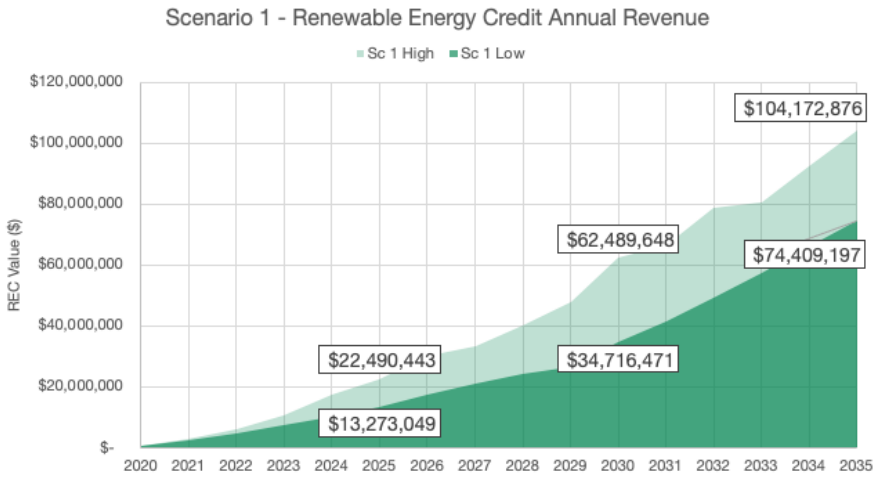
When compared against expected declines in total transportation emissions, all scenarios show notable reductions in emissions. The charts below show California's modeled transportation emissions under the three scenarios, based on forecasted VMT and blended fleet fuel efficiency. The green section represents avoided emissions based on 100% renewable EV ridehailing, similar to Cruise's service. Under the "base case" scenario, renewable ridehailing alone could reduce the state's transportation emissions by 18.6% by 2040. Scenario 2, modeling the best case outcomes for EV ridehailing and VMT, show an even more impressive 21.1% reduction. Even under the worst case scenario where VMT grows precipitously and ridehailing electrification is slow, transportation emissions still drop by 8%.



Annual Revenue Projections for REC-Generating Farms

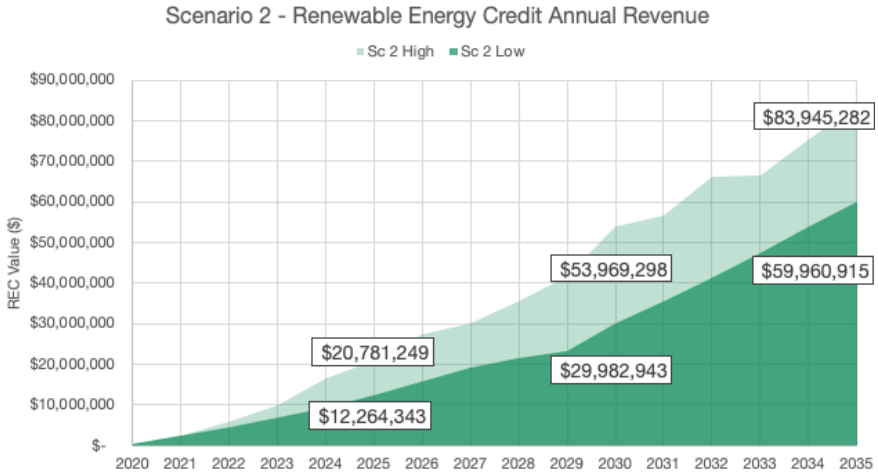
Beyond the emissions benefits of Farm to Fleet, pairing the charging of electric ridehailing vehicles with RECs from California's solar-producing farms also creates sizable revenue opportunities over time. To model forecasted revenue, Cruise and BTR calculated the amount of energy needed to charge California's all-electric ridehailing fleet in each scenario, and projected revenue based on high and low REC price scenarios.[46] The graphs below lay out results in detail.

Scenario 1 - steady VMT growth with rapid ridehailing and EV adoption - saw the greatest economic opportunities for California's farms. Initial revenues ranged from $13.3M to $22.5M in 2025, but rapidly scaled to $74.5M -$104.2M by 2035 - gains that could go directly to REC-producing farms like Moonlight and Sundale through Farm to Fleet.

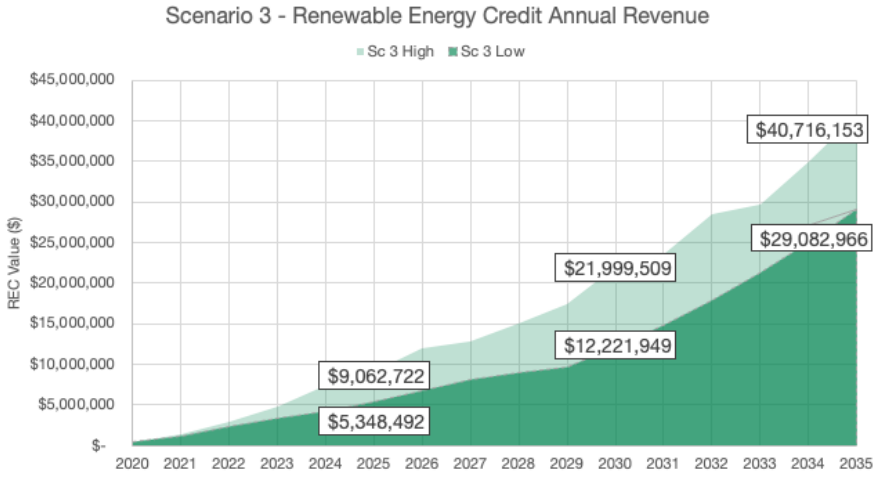


[46]To approximate the blended mix of the MPGe fuel efficiency of California's EV fleet, Cruise and BTR catalogued 2019 battery EV sales from Argonne National Laboratory statistics to determine total percent of sales, and layered in EPA-certified MPGe data. This blended fleet composition provided a representative sample of total weighted fuel efficiency and associated energy demand per VMT by an "average" California EV.

Scenario 2 - representing the best case of reduced VMT and rapid ridehailing and EV adoption - saw similarly impressive financial gains for Californian farms generating RECs. Initial revenue projections mirror scenario 1, but scale to between $60M and $83.9M by 2035. The relatively lower long-term forecasts stem from the 27% reduction in VMT compared to the 2020 base year.



Scenario 3 - representing the worst case of rapidly increasing VMT with minimal growth in ridehailing and EV adoption - saw the least financial benefits for REC-generating farms. 2025 projections were less than half of scenarios 1 and 2, with 2035 estimates between $29.1M and $40.7M in REC revenue per year.



Discussion

These projections detail three very different worlds for the future of California's transportation. Policies like the Clean Miles Standard have established clear expectations for how ridehailing can lead electrification of the state's transportation sector. Powering those EVs with renewable power is the next logical step in increasing the sustainability of the state's transportation sector. With appropriate policy and industry coordination, the ridehailing sector can have an outsized impact in driving down California's transportation emissions, directly helping the state achieve environmental goals like AB 32. But without concerted efforts from industry and policymakers, California could miss a critical opportunity to achieve the emissions benefits of all-EV, all-renewable ridehailing.

As more ridehailing becomes electric, there are tremendous opportunities to manage charging to create real financial benefits for more communities, such as California's agricultural sector. The possible benefits for California farmers, even at a small scale, are notable - particularly for a region that is so pivotal to the U.S. food supply. While the Central Valley has less than 1% of total U.S. farmland, it produces 25% of the nation's food, including 40% of total U.S. fruit and nut production.[47] Initiatives like Farm to Fleet can bridge the divide between California's cities and the Central Valley, creating real revenue opportunities for the very same businesses and communities leading decarbonization in California.

Farm to Fleet is also a roadmap for how Cruise can replicate these positive-sum initiatives across the U.S. As more states explore policies similar to the Renewable Portfolio Standard and Low Carbon Fuel Standard to achieve emissions goals, Farm to Fleet can be a model to bridge America's urban and rural regions through partnership, financial opportunity, and sustainable business practices.

[47]U.S. Geological Survey, "California's Central Valley - Valley Facts", https://ca.water.usgs.gov/projects/central-valley/about-central-valley.html.

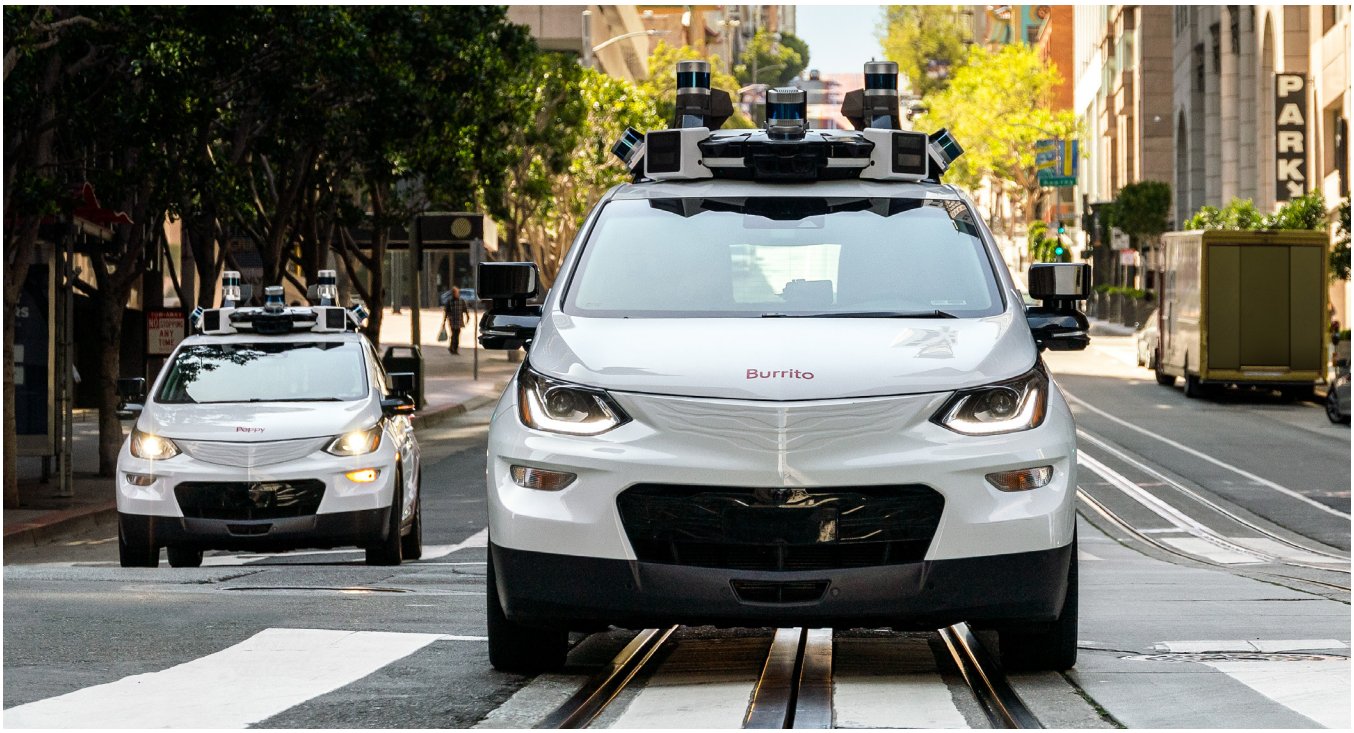
Farm to Fleet - Scaling Into the Future

Looking ahead, Cruise is exploring future analysis into how Farm to Fleet can also help improve public health by reducing criterion air pollution and PM2.5 emitted from gas-powered transportation. While rapid electrification of ridehailing will help achieve climate change goals, there are also tremendous synergies between the growing share of renewable power in the Central Valley and the offsetting of gas-powered miles with all-renewable ridehailing in California's urban regions. Local air pollution from gas-powered transportation in California's cities (and the Bay Area in particular) is a well-known contributor to the worsening smog seen in the Central Valley, and has been shown to cause pulmonary diseases, childhood asthma, and other health conditions.[48] With poverty and race correlated with increased exposure to PM2.5 in California (in large part from gas-powered transportation), there is a strong transportation equity and environmental justice imperative from Farm to Fleet, as well.[49]

Conclusion

California is in the midst of a dramatic shift towards greater electrification - particularly with an emphasis on high mileage use cases like ridesharing. These vehicles not only help rapidly scale EV adoption and infrastructure, but also provide access to clean miles for members of the public that may never own an EV or have access to a charger. Central management of these vehicles, such as with Cruise's autonomous fleet, also presents an opportunity to enact fleet-wide charging policies that can completely eliminate emissions. At the same time, California's Central Valley and other agricultural regions are playing an outsized role in driving a cleaner and more sustainable grid - with roughly 75% of California's solar installations in the last 10 years occurring in its 15 top agricultural counties.

Cruise's innovative Farm to Fleet initiative is an opportunity to capture these two trends in a manner that can rapidly reduce transportation emissions in cities while simultaneously generating real economic opportunities for California's farmers leading the adoption of clean, renewable energy - even as these vehicles charge hundreds of miles away. Cruise is incredibly proud of our initial efforts with Moonlight, Sundale, and BTR. As we work to deliver a greener, more sustainable future, creative approaches to electrification like Farm to Fleet are critical to maximize the benefits of the clean energy revolution. Building on these commitments, we look forward to future opportunities that allow us to collectively expand and grow our understanding of how electrification can create economic opportunity for more people, communities, and businesses, and truly drive us towards a future where sustainable transportation benefits all.



[48]Brendan Borrell, "California's Fertile Valley is Awash in Air Pollution", Mother Jones, December 10, 2018, https://www.motherjones.com/environment/2018/12/californias-fertile-valley-is-awash-in-air-pollution/.
[49]David Reichmuth, "Inequitable Exposure to Air Pollution from Vehicles in California", Union of Concerned Scientists, January 28, 2019, https://www.ucsusa.org/resources/inequitable-exposure-air-pollution-vehicles-california-2019.

About the Authors

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David is the Policy Research Manager for Cruise. As part of Cruise's Government Affairs team, Dave leads Cruise's engagement with research centers, universities, think tanks, and community advocates to explore the ways in which autonomous, electric, and shared mobility can improve today's transportation system.

Prior to working with Cruise, Dave served as a strategic advisory and management consultant in Washington, DC, supporting U.S. multinationals in the transportation, energy, and aerospace industries to navigate political risk and cultivate new market expansion opportunities. Dave has a passion for the future of transportation and how technology and policy can drive positive sum outcomes.

Jack Barrow

Jackis a co-founder and the Chief Executive Officer of BTR Energy. BTR's mission is to build the infrastructure that enables electric vehicles to interact with renewable electricity suppliers and electricity markets generally. In his role, Jack manages the development and implementation of BTR's corporate strategy, principal level client and regulator engagement, capital raises, and investor relations.

Prior to BTR, Jack was a founding partner of the management consulting company CEB's (acquired by Gartner, NYSE: IT) corporate venture fund. He believes new and innovative collaborations between the transportation and energy industries will accelerate the decarbonization of both.

Hoël Wiesner

Hoël is a Program Manager with BTR Energy. Hoël oversees BTR's participation in the California Low Carbon Fuel Standard program and works closely with the Company's product team to develop intuitive and informative solutions for clients. Hoël also helps BTR forecast, understand, and manage market changes that provide new opportunities to maximize the benefits of electric vehicle adoption in California and beyond.

Prior to joining BTR, Hoël worked as an analyst in the energy industry in New York and in the Mid-Atlantic. A lifelong interest in renewable energy motivates him to seek out the hard problems facing the industry as it pivots towards a greener path.

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