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Ample, Inc Comments on Zero-emission Vehicle Infrastructure Plan (ZIP)

Additional submitted attachment is included below.

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California Energy Commission
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Project Title: Zero Emission Vehicle Infrastructure Barriers and Opportunities

Ample, Inc. Comments on Zero-emission Vehicle Infrastructure Plan (ZIP)

AMPLE, Inc. appreciates the opportunity to provide comments to the California Energy Commission regarding its Zero-Emission Vehicle Infrastructure Plan (ZIP). Ample, Inc. is a San Francisco-based company that is in the process of deploying a battery swap-based energy delivery service for electric vehicles. It is Ample's intention to install and maintain a significant network of battery swap stations within the state of California, throughout the United States and internationally. Ample's modular battery swapping is a cost-effective means of transitioning drivers without access to overnight EV charging to electric vehicles. The CEC has requested feedback on its ZIP Plan. This response will address a number of the areas covered in the ZIP Workshop of January 20, 2022.

The CEC is engaged in a broad sweep of initiatives aimed at promoting the decarbonization of California's mobility system. However, two key variables that will ultimately determine whether electric vehicles are in fact able to serve the needs of a vast majority of Californians are largely omitted from the Commission's analysis: time and cost premiums associated with public charging as compared to gasoline. Much of the relevant data on these variables is closely held by EV charging companies, and as a result remains opaque and confusing to consumers, policymakers and researchers. But what is overwhelmingly clear is that public charging is significantly more expensive than gasoline and that the time required for public charging is prohibitive for many use cases – especially use cases relevant for low income and working Californians. While the EV activist and policy community's intense focus on delivering environmental justice is laudable, asking low-income residents to rely on charging networks that are both slow and expensive is not a solution. Promoting "environmental justice" by telling low-income MUD dwellers, street parkers and TNC drivers to rely on slow, expensive public charging rather than fast and comparatively cheap gasoline is rather like telling a citizenry starved for bread that they should instead eat cake. It's feasible in concept, but impractical and likely to provoke an intensely negative response.

Many of CEC's plans implicitly underestimate the infrastructure challenges of electrifying the state's mobility system. At the same time, they do not fully account for important and powerful technological solutions to the aforementioned challenges. For instance, the two most populous countries in the world (China and India) have both announced that they intend to develop national battery swapping standards. Indeed, battery swapping is already playing an important role repowering electric vehicles in China, which is by far the world's largest electric vehicle market. Currently, battery swapping is implicitly omitted from CEC's ZIP planning process.

Unless CEC addresses this gap in its infrastructure plans, California will lag behind the world in both deployment and equity. This response explains a number of perspectives on battery swapping and modular battery swapping, including the following areas:

- Perspectives on why modular battery swapping is an important tool for achieving electrification
- How battery swapping infrastructure can be used to economically integrate renewables
- Battery swapping as a solution to the challenges of fleet electrification
- Why battery swapping will be necessary to support the state's equity and environmental justice goals

Modular battery swap as a solution to California's ZEV infrastructure challenges

The fundamental concept of battery swapping solves a number of issues inherent to the "charging only" model of EV infrastructure deployment. Allowing batteries to charge external to the vehicle results in cascading benefits. To understand all of the benefits of modular battery swap, it is useful to examine it from a number of different perspectives, including: user/driver, grid, EVSE operator, environmental, infrastructure buildout and a resource-use.

Driver perspective
From a driver perspective, modular battery swap allows refueling in a fraction of the amount of time fast chargers require. Modular battery swap allows people who street park, park in urban garages, travel long distances, and can't afford installation of expensive EV charging infrastructure at home or in fleet applications to own and operate EVs. Because modular batter swap trickle charges batteries it also significantly extends the life of EV batteries.

The grid
Modular battery swap strengthens the grid by evening out demand and providing flexible energy storage for renewables – a result of the ancillary battery banks that are core components of the system. By absorbing renewables when they are plentiful and dispensing them quickly via swap when and where they are needed, modular battery swap fills a critical gap in our energy infrastructure. Swap systems can also curtail energy consumption when desirable, feed energy back into the grid when demand peaks and provide frequency balancing grid services.

EVSE operator
Modular battery swap is profitable. Because modular swap stations allow for higher capacity factors, they can service roughly 10X as many vehicles as an equivalently powered fast charger does today. This means swap stations can absorb electrical demand charges and profitably refuel electric cars.

Environmental
Modular battery swap allows EV batteries to fill up with zero carbon energy when renewable energy is plentiful and dispense that energy quickly when it is needed. Counterintuitively, a modular battery swap system utilizes fewer batteries in aggregate (this is not true for standard battery swap). This is because a modular battery swap system can dynamically adjust the amount of battery storage dispensed to a vehicle depending on the driver's needs. For example, a fleet vehicle may only require 30 miles of range most days, while occasionally traveling much farther. A modular battery swap system can meet that daily demand with a smaller battery pack (by utilizing fewer battery modules) then add additional battery modules for longer trips on demand.

Infrastructure deployment
Modular battery swap allows for rapid, economical deployment of charging infrastructure. This is because modular battery swap stations do not require construction. They can be assembled, onsite, in a matter of days because they are largely prefabricated. Infrastructure sufficient to cover a medium-sized city can be deployed within the space of weeks and easily scaled thereafter.

Resource efficiency
Modular battery swap stations allow for extremely high throughput (similar to a gasoline station) for a much smaller geographic footprint and lower system cost than chargers. Each station requires only two parking spots. Because modular battery swap has the capacity to charge continuously, a less powerful grid connection can charge more batteries (ergo vehicles). Modular battery swap also allows for variable battery pack capacity and more intensive

duty cycles for electric vehicles (because of faster refueling). These last two characteristics improve the economics of electrifying fleets and, even more importantly, reduce embedded GHG emissions and resource consumption.

The electric grid: challenges and opportunities

Given that decarbonization and clean air are foundational goals of CEC's Electric Vehicle and Charging Infrastructure program, it is important to examine the impact of different repowering approaches on the grid and renewables integration. Battery swapping is a cost-effective means of building out the storage capacity required to decarbonize the grid. Conversely, the costs of integrating electric vehicle charging systems into the U.S. grid without battery swapping are astonishing. The Boston Consulting Group (BCG) pegs the cost of upgrading the grid for electric vehicles through 2030 at between $1,700-$5,800 per car.[1] Assuming annual auto sales of 1.7 million units in California, a 100% EV sales scenario would equate to between $2.9 billion to almost $10 billion in grid system upgrades annually. Further, BCG's analysis shows that higher numbers of EV sales will result in higher (not lower) per vehicle grid integration costs.

A significant portion of this cost can be offset by grid storage assets in the form of battery swap stations. By separating the process of charging from the action of transferring energy into an electric vehicle, battery swap stations allow for better managed, more constant and more efficient utilization of existing grid assets as compared to charging. The potential for improving the integration of renewable energy is particularly important. Significant static storage capacity combined with battery swapping allows the electrical system to capture the energy from intermittent low carbon energy sources (e.g. wind and solar) when available and to dispense that energy quickly when it is needed.

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EV fleet charging

Fleet electrification poses a variety of challenges. Ample urges the CEC to adopt a stance of technology neutrality in its discussions of fleet electrification infrastructure. It is important to remember that fleets that utilize zero emissions electric vehicles are investing private funds into capital that will provide two important public goods: clean air and reduced GHG emissions. From that perspective, the CEC should not only seek to encourage fleet electrification, but *to prioritize high-intensity utilization of electric vehicles by fleets*. The benefits of high-intensity fleet electrification extend beyond the immediate community. Indeed, establishing sustainable business models for fleet electrification will have cascading national and international benefits.

However, both the logistics and economics of fleet charging are extremely challenging within a fleet context. In the case of a level 2 system, the mere act of charging renders the entire fleet unusable for a large portion of the vehicles' potential duty cycle (as they need to be stationary and plugged in). Further, commercial-grade L2 chargers cost many thousands of dollars to install and the simultaneous draw from many L2 chargers would generally require costly upgrades to a facility's electrical system and lead to significant "demand charges" associated with higher sustained electrical demand. In the case of high-power charging, the high cost of infrastructure and associated demand charges pose similar or greater hurdles. But there are other cost and logistical obstacles as well. To charges in under an hour, an EV cannot be charged to full capacity (ie. it can only be charged to ~80%). This results in systemic excess deployment of costly and resource-intensive batteries. Even charging a vehicle up to 80% requires fleet operators engage in an expensive game of musical chairs, reshuffling vehicles every 30-60 minutes. This is not

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[1] Sahoo, Anshuman, et al. "The Costs of Revving Up the Grid for Electric Vehicles." United States - EN, United States - EN, 8 Jan. 2021, www.bcg.com/en-us/publications/2019/costs-revving-up-the-grid-for-electric-vehicles.

only labor-intensive (thus costly); it is extremely impractical. Such an operational structure further disadvantages EVs from a cost and utility standpoint.

There are a number of fleet focused sectors in which these problems are likely to come to the fore. One is ride share – which poses some of the biggest challenges for electrification but also some of the biggest opportunities for emissions reduction on a per vehicle basis. Until recently, Ample was the only company renting EVs to TNC drivers in the Bay Area. As of Summer 2021, Sally also rents EVs to Uber drivers using Ample's modular battery swapping system to repower their vehicles. Recently non-battery swap-based entrants are also attempting to enter the San Francisco market. Generally speaking, the high cost and lengthy charge times associated with electric vehicles mean that neither drivers nor fleet companies can afford to use EVs in high-intensity applications like ride share unless those vehicles are battery swap enabled. (Demand from the taxi/ride share sector was one of the forces that led to the rise of battery swapping in China.) Assuming one hour a day of EV charging (which is, in fact, a very generous assumption) a rideshare driver would sacrifice roughly $5000 of income annually simply due to charging time. With per mile equivalent costs between $4.60 to almost $10/gal – or roughly twice the retail price of gasoline in California – most fast chargers are not only slow, but expensive. Conservatively estimated, the time plus energy cost penalty for drivers who transition from gasoline to public charging infrastructure would be around $9,000 annually. If vehicles are charged at a fleet depot, all the aforementioned challenges are simply transferred to the fleet operator.

Battery swapping solves many of the logistical, costs and energy challenges associated with fleet charging. We ask the CEC to thoughtfully consider how to craft policy that does not inadvertently exclude battery swapping going forward as many of its solicitations have in the past.

Equity and environmental justice goals

More than half of American vehicles lack access to an overnight charging point and CEC has consistently overestimated the ability of DC fast charging and public L2 charging to support drivers without access to home charging. The inadequacy of public charging as a solution is demonstrated vividly by the experience of China – the world's largest EV market. Today, China accounts for over 80% of DC fast charging stations installed globally. Yet despite this robust charging network, over the last two years China has undergone a major policy shift to prioritize the deployment of battery swap-enabled electric vehicles and battery swap stations. Publicly announced additions for battery swapping facilities in China will be capable of repowering over 80 million vehicles a week by the year 2025.

Yet CEC has largely disregarded battery swapping. Battery swapping is a particularly powerful solution to provide repowering services to vehicles of multi-unit dwellings (MUDs) residents, rural communities and street parkers. For these constituencies battery swapping allows for many of the same operational benefits as gasoline or hydrogen but at a lower cost of infrastructure and with better interoperability with traditional EV charging infrastructure.

At 59 cents a kilowatt hour (a standard price for public EV charging in California) the cost of refueling a Nissan Leaf is equivalent to a Prius driver paying about $8.40 a gallon. These exorbitant costs and charge times are not sustainable or equitable for Californians that lack access to at-home charging.

Conclusion

The purpose of the ZIP is to support CEC decision-making by documenting state plans and supporting public discussion of how to meet California's zero emission vehicle goals. State investments will be directed to increase equity and accelerate development of repowering infrastructure. The ZIP will be a high-level view of California strategy document designed to ensure sufficient infrastructure development. Within this context, Ample would like to urge CEC not to act as a mere agent of incumbent industry solutions that have not yet scaled and are unlikely to solve the challenges of decarbonization.

The ZIP should focus on overarching goals of transportation electrification, which are clean air and reducing the threat of climate change. Technology neutral policies to encourage clean miles driven, rather than particular types of infrastructure will best serve these goals. For example, 250,000 electric vehicle chargers installed will not necessarily reduce carbon pollution if slow charging times or the high cost of DC fast charging results in extremely low utilization.

Battery swapping can help California meet its decarbonization goals because it is as convenient as refueling at a gas station, and costs less than gasoline or DC fast charging. In its final ZIP and ZEV Market Development Strategy, CEC should explicitly acknowledge the role that battery swapping will play in repowering ZEV vehicles in the state and globally. This will help ensure that policymakers do not inadvertently close off new solutions.