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To: **California Air Resources Board**

Date: **January 15, 2024**

Re: **Workshop on Amendments to Advanced Clean Cars II Regulations**

Introduction

Ample strongly supports the California Air Resources Board's Advanced Clean Cars II goal of achieving 100% zero-emission vehicle sales for the light duty segment by 2035. The purpose of this memo is to provide context on emerging techno-economic opportunities associated with battery swapping and batteries-as-a-service (BaaS) business models. Both are burgeoning trends within the international EV industry and both will be critical to achieving long term climate and clean air goals. Battery swapping is particularly relevant to the challenges of fleet electrification. It is much faster than conventional charging and reduces up-front cost for fleet purchasers.

The organization of this memo is as follows:

1. Policy and regulatory background on battery swapping.
2. Background on Ample and modular battery swapping.
3. A request that CARB implement policies that are technology neutral and do not (explicitly or implicitly) disadvantage battery swapping.
4. A request that CARB provide consumers with information about charging times

Policy and regulatory background on battery swapping in electric vehicles

The consumer EV industry is little more than a decade old. At its inception, a debate on optimal EV architecture contemplated two separate technology pathways: tethered charging (represented by Tesla and Nissan) and battery swapping (represented by Renault and Better Place). Early EV policy included frameworks supporting both approaches and many policymakers considered each pathway to be equally likely. However, over the late 2000s and early 2010s a number of policy and market developments nudged the industry toward a tethered charging model for EV deployment. The first of these was the bankruptcy of the battery swapping company Better Place. This was paired with the success of Tesla – which was saved from bankruptcy by a large loan from the U.S. Department of Energy Advanced Technology Vehicle Manufacturing loan program. But there were additional factors. For instance, early EV purchases were highly concentrated among affluent early adopters. These individuals tended to place a premium on performance (e.g. 0-60 times) and, conveniently, most had access to home charging. As a result, almost all EVs sold in the United States relied on tethered charging (e.g.

Image 1: Ample swapping stations are designed to accommodate a wide range of vehicles.

plugging in an electrical charging cable in order to transfer electrons). Slow charge times and high EV costs meant that EVs were primarily accessible to high-income individuals who could reliably charge at home. In America, EVs still represent a relatively small proportion of automotive sales and they are primarily owned and operated by affluent individuals.

But battery swapping is making a comeback in the world's largest EV markets. America accounts for only about 10% of global EV sales.[1] Whereas China accounts for 57% of global EV sales and the EU 27%. China and Europe have already pushed past the market for early adopters. (In China more than a third of new vehicle sales are electric.) Because of this, China and Europe have begun deploying a variety of next generation EV charging technologies. One of the most important is battery swapping, which allows drivers to change out an empty battery for a fully charged one in minutes. This approach is fast, low-friction and reduces strain on the grid compared to fast charging. In China, the sales of battery swapping electric vehicles are growing quickly. There are more than half a million battery swap-enabled EVs on Chinese roads. China also has at least 3000 battery swapping stations for light duty electric vehicles and many more for heavy duty electric vehicles. These battery swapping stations can fully charge many dozens or even hundreds of EVs a day, whereas today's charging stations are generally limited to single digits.

As America's EV market matures, its reliance on battery swapping will increase – especially for fleet vehicles and EV drivers without access to overnight charging. In anticipation of this, there are some unique business model and technology considerations that California must consider so as not to inhibit growth of the EV market.

[1] Canalysis, Global EV sales up 63% in H1 2022, with 57% of vehicles sold in Mainland China (August 11, 2022) https://www.canalys.com/newsroom/global-ev-sales-h1-2022

Background on Ample and modular battery swapping

Ample provides modular battery swapping services to fleet customers. The company manufactures all of the major components used in its battery swapping system in our five research and manufacturing facilities in the Bay Area. Ample's Brisbane, CA battery module manufacturing plant is supported by a $14.7 million grant from the California Energy Commission, awarded on May 10, 2023. In December of 2023, Stellantis (the parent company of Chrysler, Jeep, Fiat and several other brands) announced that it would partner with Ample to sell swappable versions of its EVs, beginning with the Fiat 500e. This followed the 2023 announcement by Mitsubishi Fuso (a Daimler Trucks subsidiary) that it would utilize battery swapping in its eCanter electric medium duty truck.

Ample's swapping system repowers EVs faster than conventional DC fast-charging at a price lower than gasoline. Ample has deployed a fleet of swap-enabled Nissan Leafs and Kia Niro EVs in the San Francisco Bay Area in partnership with Uber and the rideshare rental car company Sally. The company is currently adding more swapping stations and swap-enabled EVs in the Bay Area, and is in the process of expanding into additional US, European and Asian markets (notably Spain and Japan).

Like many providers of battery swapping services worldwide, Ample provides EV repowering services on a "pay-as-you-go" basis (BaaS). Drivers pay a monthly fee to use the swapping service and Ample's batteries, plus a per-mile charge. Because drivers do not buy the battery, up front costs are significantly reduced. Drivers can also right-size an EV's battery for a specific duty cycle (increasing or decreasing the range as desired) which enables more efficient utilization of battery stocks. Because fast swapping reduces the charging anxiety associated with running out of energy, fleets can opt for smaller, shorter-range batteries.

Currently, Ample's major customers are rideshare and last mile delivery fleets. Ample's modular battery swapping service is an ideal solution for fleets as it resolves two critical obstacles: 1) lengthy recharging times and 2) costly infrastructure. Ample's BaaS system can repower an EV much faster than conventional DC fast charging, it works for a wide variety of OEMs and models, and is ideal for fleet drivers who do not have a place to charge an EV overnight.

The mechanics of the Ample modular EV battery swap system

Ample's platform consists of three major components (swapping stations; vehicle plates; vehicle trays; and battery modules) that form the basis of a drop-in replacement for OEM EV battery packs and enable faster, more affordable repowering than DC fast-charging.

Battery Module: Battery modules contain EV battery cells connected serially or in parallel. Ample's battery modules can be stacked and arranged into various form factors (shapes) in order to fit into different vehicle chassis. Battery modules are arranged into a holding tray which serves two functions: 1) It secures the batteries and 2) it provides a latching mechanism which

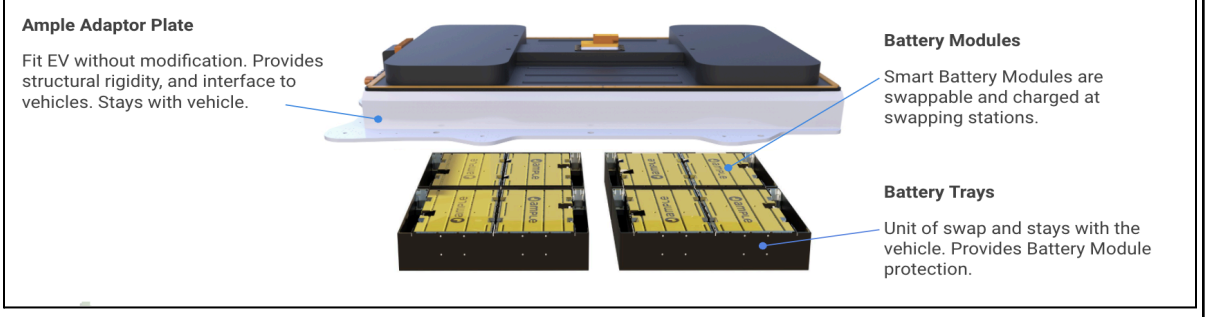

Image 2: Ample's vehicle integration kit has three major components: adaptor plate, battery trays and battery modules.

fastens the batteries securely to the vehicle adaptor plate.

Adaptor Plate: Ample's adaptor plate is the same size and shape as the OEM battery pack, with the same mechanical, electrical, and data interfaces. A plate typically holds four trays, but this can be adjusted depending on the size of the vehicle, the geometry of the undercarriage and the shape of the OEM battery pack. Each Ample-enabled vehicle will have one plate installed where a fixed battery pack would otherwise be located.

Swapping Station: The battery swap station utilizes an array of interconnected robots and electronics to safely and efficiently remove discharged modular battery packs from a vehicle, replace them with fully charged modular battery packs, and recharge the discharged battery packs.

The process of swapping is initiated by raising the vehicle via a lift embedded in the floor of the Ample swapping station. After the vehicle is raised, Ample's swapping robot positions itself underneath a tray and sends an electronic handshake to the vehicle instructing it to release the adjacent tray. The tray is unlocked by means of latching mechanisms that are internal to the tray (and thus protected from debris, inclement weather and under-vehicle impacts). The robot then delivers that tray to a swapping bay where a robot removes discharged batteries and replaces them with charged batteries. Discharged battery modules are racked for charging and subsequent swapping. This process is repeated until every tray within a vehicle has been swapped delivering a full charge to the vehicle.

Many key assumptions underlying California regulations, which explicitly assume tethered charging, do not apply to battery swapping electric vehicles. It will be important for California to pursue technology neutral rules that do not needlessly bias fleet electrification against battery

swapping. Some key considerations that should impact the development of California's ZEV Market Development Strategy are enumerated below.

CARB should ensure that Advanced Clean Cars II Regulations are technology and business model neutral, and do not (explicitly or implicitly) disadvantage battery swapping

We urge CARB to ensure that regulations and rules governing funding opportunities are implemented in a technology-neutral manner. Technology-neutral rules would put battery swapping on a level playing field with conventional EV charging. Part of this involves not imposing standards designed for tethered charging onto battery swapping stations. One example is charging connector type (battery swapping stations do not use CHAdeMO, CCS, or NACS connectors). Accordingly, CARB should exempt battery swapping from standards for tethered charging.

Limiting funding opportunities to certain types of charging connectors or requiring certain power levels can have the practical impact of excluding battery swapping. Again, EVs do not plug in and swapping stations may require significantly less power while delivering energy at much higher speeds than a DC fast charger.

Some regulations designed to protect consumers from the inconveniences of public EV charging are not currently relevant to battery swapping. For example, starting in 2026 the Advanced Clean Cars II regulation requires a 200-mile minimum range for all ZEVs. For battery swapping vehicles, this requirement is unnecessary as vehicles can be repowered in minutes and provide a user experience comparable to filling up at a gas station. This regulation is, in fact, counterproductive from an environmental perspective. Excessively large batteries waste critical materials and the manufacture of these batteries is environmentally destructive and carbon intensive. Unnecessarily large batteries also increase vehicle weight, making EVs a danger to pedestrians and other drivers. We see these rules requiring excessive range as both unnecessary and self-defeating within the context of battery swapping. Sophisticated fleet customers should have the choice to opt for light, low-cost, range-flexible EVs that are capable of fast swapping.

In summary, overly prescriptive regulations, rules and requirements penalize and disadvantage new technologies that have the potential to improve upon incumbent technologies.

CARB should update Advanced Clean Cars II Regulations to require that OEMs provide consumers with information on how long it takes for a 100% charge or swap

CARB is considering new consumer-facing vehicle labels that inform consumers of charging times for EVs. These labels would be similar to fuel economy window stickers. They would allow Californians to make better informed decisions on which EV to purchase or lease. Ample

strongly supports state efforts to inform consumers how long it takes to charge to 100% at a typical public charger.

Today, most EV marketing focuses on how quickly an EV can charge to 80% at a state-of-the-art high capacity charger, in ideal weather conditions. These numbers misrepresent the realities of owning and charging an EV. Only government regulation can ensure that consumers get accurate information about EV repowering times. Because many drivers do not have access to home charging, they are fully reliant on public charging. Providing them with accurate charging times will improve their EV adoption experience.

The time it takes to repower an EV can be more relevant to the real world experience of driving an EV than overall range (only 5% of car trips in the US are more than 30 miles).[2] Today, drivers gravitate towards EVs with longer range because charging is both slow and inconvenient. Drivers should be given the freedom to opt for an EV with a shorter range, and ultra fast charging or battery swapping.

Conclusion

Conservatively, it is safe to assume that fewer than 1% of vehicle miles traveled in the U.S. are currently electrified. California leads the nation in electrification policies and EV market share. But as California looks toward the future of electrification, it is imperative that the state consider market trends in China and other countries that are further along in the transition to zero emissions.

Well-designed policies will avoid command and control-style technology requirements in favor of performance-based requirements and technology-neutral criteria. California has a proud history of driving innovation in the auto industry through its strong clean air policies. But in order to complete the transition to zero emission vehicles, the State must continue to innovate. Fully decarbonizing California's mobility ecosystem will require a diverse range of technologies and business models.

[2] The obsession with EV range is all wrong, Shannon Osaka, The Washington Post (July 7, 2023) https://www.washingtonpost.com/climate-solutions/2023/07/07/ev-range-anxiety-battery-myth/