

# Detachable Geo-located Portable Batteries for Electric Vehicles

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## ABSTRACT

This intellectual property disclosure describes an approach to charge electric vehicles while the user is driving. This eliminates the wait time of charging and reduces the need for high-capacity batteries in vehicles, which are two of main problems within the electric vehicle charging infrastructure (EVCI) context. We achieve this is by having portable batteries distributed across a city that can be attached to the vehicle and dropped at any location once they are no longer needed. These batteries are geo-located through a GPS tracking locator and automatically recharged while idle by a solar panel located in the top of the battery.

### Author Keywords

Electric Vehicle; Portable Battery; Geo-located; Attachable; Detachable; Electric Vehicle Infrastructure; Wait Time

## INTRODUCTION

Two of the main challenges in the context of electric vehicle charging are the time required to charge the vehicle and battery capacity. Charging wait time typically ranges from 30 minutes to 8 hours and during this time the vehicle has to be parked and therefore cannot be used for transportation. Current approaches have focused on creating faster chargers to reduce wait time. This leads to much more expensive charging options, which include extra challenges such as the increased thickness and weight of the cable, increase heating, and power loss. Similarly, automotive companies have dedicated abundant resources to increase the battery capacity of their vehicles increasing the costs and weight of the battery.

The proposed solution is to create portable batteries which follow a similar behavior to public electric scooters. They are publicly available and distributed all over the city (Figure 1). They are usually located in the places more commonly used by users. Once an electric vehicle needs charging, the user searches a nearby portable battery (through an app), attaches it to the vehicle, and continues driving. The vehicle is charged while driving. Once the vehicle does not require further charging, the user can leave the portable battery wherever the user is located.

A typical scenario of usage for our proposed batteries is described in Figure 2 where an electric vehicle user is running out of charge in his battery and decides to use our proposed approach. For this, the user will go to our custom mobile phone app where the locations of nearby batteries are displayed (similar to how electric scooters and electric bicycles are displayed in similar apps). These descriptions will show the location, and the amount of charge in the battery. The user picks a battery and the app help the user navigate to the battery.

Once the user arrives to the battery location, the user attaches the battery to the electric vehicle and drives away (Figure 2 Middle), the vehicle will charge while the user is driving.

Finally, once the user is satisfied with the amount charged by the portable battery, the user can stop, detach the battery and drive away, the battery will recharge while it is idle (Figure 2 Right).

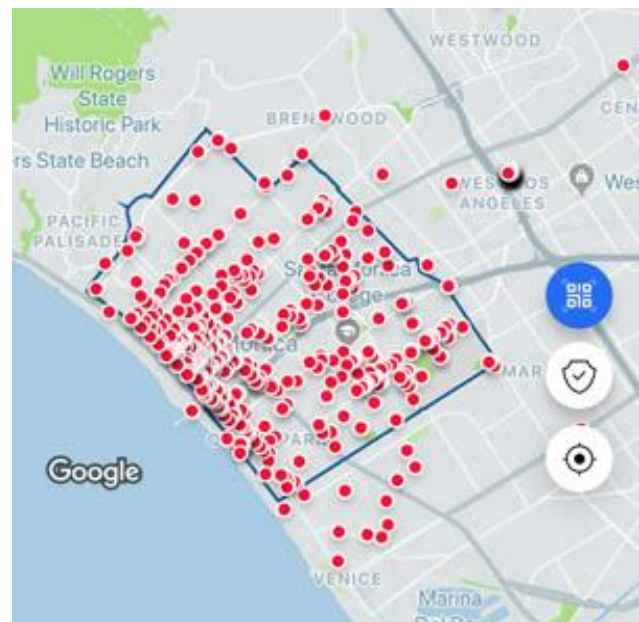
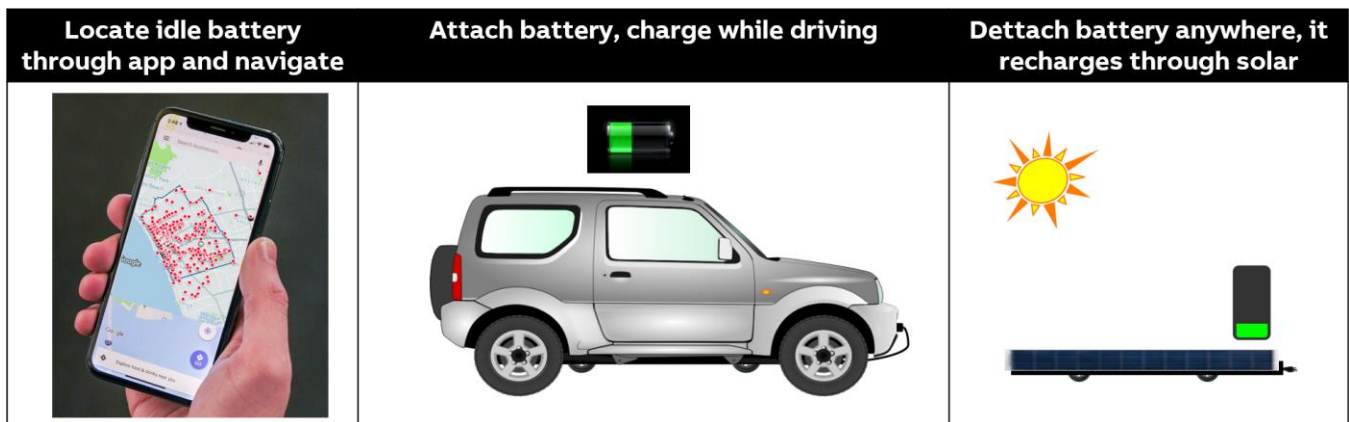


Figure 1. Location of portable batteries distributed around a city in high transit locations



**Figure 1. Sample of usage of the detachable portable batteries 1. Users locate the battery and navigate to it. 2. Attach the battery and drive. 3. Once the battery is full, detach the battery and drive away**

This idea is beneficial in several key aspects:

1) Eliminating wait time: The user does not need to wait while it is charging. This tackles one of the main concerns of electric vehicle charging. Given that the vehicle is charging while driving, wait time is virtually eliminated. This enables a whole new market of vehicles that can work 24 hours a day without having to stop for charging. Similarly, it tackles the problems of fast charging, given that fast charging won't be necessary since wait time is no longer an issue.

2) Convenience: Similar to electric scooters, these portable batteries do not need to be returned to any particular location. Once the vehicle no longer requires charging, the car can leave the portable battery wherever it is located. Also similar to electric scooters, these portable batteries are located all over cities and therefore finding them is as easy as opening an app telling the user information about the batteries nearby

(location, capacity, how much charge each of them has remaining, and how much do you have to pay for it).

3) Sustainable business model: Charging the portable batteries can follow a similar business model to the electric scooters where the company recruits homeowners near high transit areas who charge the portable batteries in their homes and get paid for it. That way the company does not have to worry about charging all the batteries themselves, but only charging batteries located in remote areas.

An alternative way to charge the batteries could also be to have an integrated solar panel in the battery, so that it can recharge over time without the company having to charge the battery themselves

4) Applications for the future: These portable batteries are easily adaptable to the foreseen future of electric mobility. When self-driving vehicles become a reality, these vehicles can search for the batteries in a completely autonomous way and can be attached to the vehicle also autonomously without the human having to intervene in any meaningful way.

5) 24-hour vehicle usage: Service vehicles (such as taxis, delivery trucks, and buses), where the human drivers rotate but the vehicle never stops moving are now enabled in the EV context. Currently, service vehicles pay outstandingly high prices in fast charging to avoid stopping. Stopping would be completely eliminated by these portable batteries since the user can just pick a battery, charge while driving, and drop it at any location. Similarly, in the foreseeable future where a portion of the population won't own vehicles, but just call them when needed, these vehicles that are used 24-hours a day will be enabled by this technology due to these portable batteries allowing EVs to run 24 hours a day without stopping to recharge.

6) Feasibility: Most of the business model proposed for these portable batteries has already been demonstrated successful by public electric scooters. However, acknowledging the differences and how these are also feasible makes the idea stronger. One of the main differences is the capacity of the battery. A common electric vehicle has a battery capacity of 15 to 40 kWh. A portable battery to fully charge these vehicles would weigh between 80 to 200 kg. A portable battery of this weight can be attached to a vehicle without significantly decreasing its mobility.

7) Optimized positioning: Given that these portable batteries are picked and dropped wherever is most convenient for the battery users, they become naturally positioned in the places most frequented by its users. This implies that with no additional effort, the batteries will be positioned in the places where they are needed the most, therefore increasing the likelihood of being further used and increasing convenience for their users.

## IMPLEMENTATION

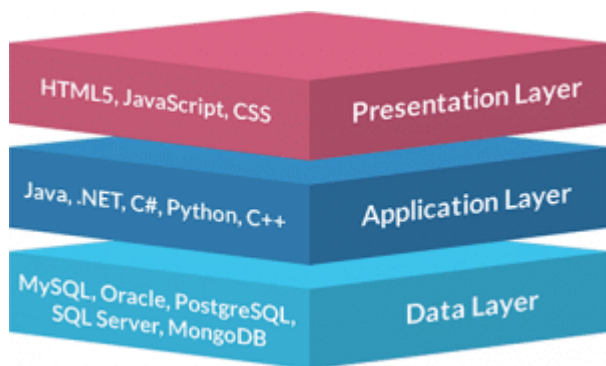
The implementation of this idea can be seen as two-fold: Software side and hardware side. The software side includes the software app that guides drivers to available batteries and

contains the knowledge regarding where the batteries are located, capacity, and how much charge is left. The hardware side details the battery, the solar panel, and the attachment mechanism.

The software side will follow a three-tier architecture (Figure 3) where the bottom layer describes the database layer containing the information regarding the current state of the batteries including location coordinates, charge status and capacity. This can be achieved using relational databases such as MySQL, Oracle or SQL Server. These can be constantly updated using SOA (Service-Oriented Architecture).

The middle layer describes the business logic tier where most of the computations are executed (navigation for the user, recommendations to which battery to select, etc.) using object oriented open source languages such as Java and Python.

Finally, the top layer describes how this information is presented to the user. We will use different technologies depending on the devices being targeted. For example, HTML5, JavaScript and CSS for a desktop view or frameworks like Flutter or Ionic for mobile devices



**Figure 3. Three tier application describing the architecture of the app being used**

The hardware side consists of a 15 to 40 kWh capacity battery, which weights between 80 to 200 kg. It includes a solar panel to recharge while it is idle, and an attachment mechanism to attach to the vehicle.

There is a variety of solar panels that can be used, for example, Hyundai's PERL monocrystalline solar cells are a good option given its low cost. These range from 1.63 square meters (17.62 square feet) to 2.22 square meters (23.95 square feet). This solar panel will be attached to the battery becoming an alternate source of charge while the battery is idle.

Finally, the attachment mechanism initially is thought as a rolling base which can be attached to the vehicle and roll behind the vehicle while driving (similar to a trailer). This

mechanism can be further improved into more elegant options (discussed in the Future Modifications section).

## PRINCIPAL APPLICATIONS

The principal application of the portable batteries is targeting the use case where the EV user prefers not to wait for the vehicle to charge. In this scenario, the user can simply open the app describing where the nearest available portable battery is located (including the battery's capacity, how much charge it has left, and the price for charging). Drive to it, attach it, and drive while charging.

## PROBLEMS ADDRESSED

There are two main problems this invention is overcoming:

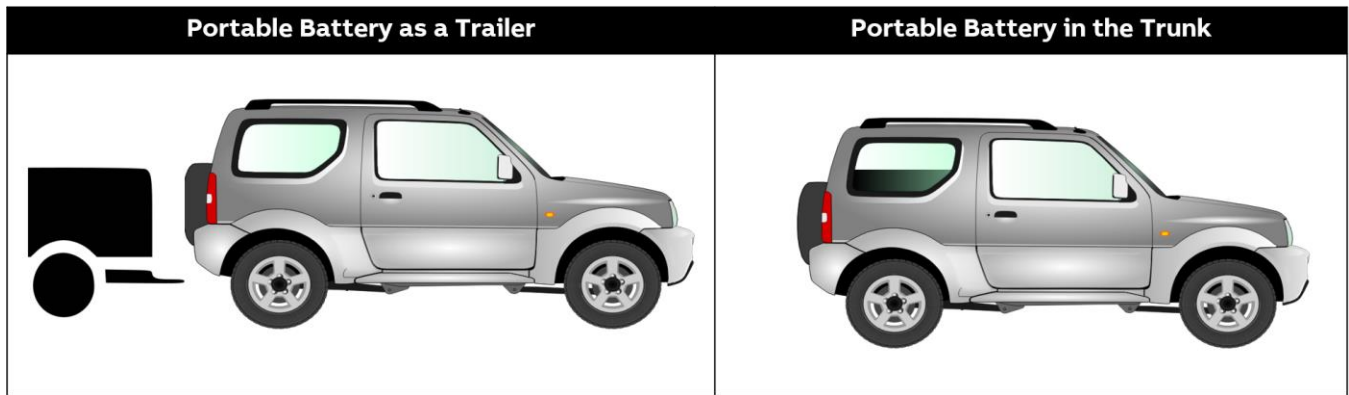
1) Wait time in EV charging: One of the main problems in our current EV charging context is the time users have to wait for their vehicles to be charged. This is also one of the problems to which companies are paying more attention. EV companies have dedicated a lot of attention and resources to solving wait time by creating faster chargers which become every time more expensive and include added complications such as added cable weight, heating, etc. Portable batteries will completely eliminate charging wait time given that the vehicle charges while the user is driving.

2) Battery capacity: The other main problem current EV charging deals with is reduced battery capacity. Similarly, automotive companies have dedicated extensive efforts in increasing the capacity of the batteries deployed in electric vehicles leading to increased costs and weight. The proposed invention reduces the need for high capacity batteries given the pervasive approach to positioning batteries in highly used locations. These batteries are easily available, therefore even if a vehicle's battery is low capacity, the user can just find a near-by battery and use it to charge their car while driving, reducing the need for higher capacity batteries and reducing range anxiety.

## FUTURE MODIFICATIONS

There are several main aspects of the portable batteries that can change in the future:

1) User/battery interaction: Currently the vision is to have an app where human users can log in to learn about information from the portable batteries (location, capacity, how much power is left) to be able to drive to the battery. In a future where self-driving vehicles are more common, this communication and responsibility to find a battery will be delegated to the self-driving vehicle. No longer will the human have to locate and drive to the battery, but the vehicle will interact with the system to find the best battery to attach.



**Figure 4. Alternatives mechanisms to attach the portable battery to the electric vehicle. Left: portable battery as a trailer. Right: Portable battery within the vehicle.**

2) The attachment mechanism: There are several possible ways the attachment can be envisioned. One possibility is to have these portable batteries in a rolling base which can be attached to the vehicle and roll behind the vehicle while driving (Figure 4 Left). Other options can be to attach it to the bottom of the car; therefore, it won't be visible and would be more elegant, or place it inside the car (Figure 4 Right).

3) Charging the battery: The initial idea to charge the batteries is to follow the model used by electric scooters where the company recruits homeowners near high traffic areas and pays them to charge the batteries in their house. An alternative (or additional) way to charge the batteries could be to include a solar panel in the batteries so that they recharge using solar power when idle.

### COMPARISSON TO STATE OF THE ART

There have been similar approaches proposed in the past. For example, the battery swap proposed by Better Place [1] where the idea is to swap the entire drained battery for a fully charged battery at designated battery swapping stations. Different from this, our approach does not require expensive swapping stations and batteries are located throughout cities.

Similarly, approaches have been proposed where the electric battery of a hybrid vehicle is charged by a combustion engine [2,3,4,5,6]. In these cases, vehicles are still dependent on gas to charge the battery while driving and there is an increased cost of maintenance given the two co-existing systems in the car.

Finally, there have been other approaches suggested as portable battery mechanisms for electric vehicles [7] but these are for jump starting the vehicle only, and not to charge the battery while the car is running as proposed by our approach.

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