CV0001 Civil Engineering & Sustainable Built Environment

**Needs for the Integration of Electric Vehicles in the Singaporean Context**

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# INTRODUCTION

# This report aims to research and discuss the prospects of adopting electric vehicles (EV) in the Singaporean context within the next 5-10 years time frame. It considers views from the economic, social, regulatory, and technological aspects and possible solutions. The research was done on relevant articles on EVs from electric vehicle journals from various countries, which were then analysed in terms of their relevance. Solutions were then proposed based on the approaches other countries took, which could work in Singapore and possible ideas with state-of-the-art technologies. Subsequently, these solutions were discussed with regards to their feasibility and their relation to researched literature. A conclusion was finally drawn on the overall implementation path of EVs in Singapore.

# LITERATURE REVIEW

# There are two possible innovation paths on integrating Electric Vehicles (EVs) into the energy system with high priority success factors: (1) resolve standardization challenges and modify existing regulations; (2) address energy management. Each of these innovation paths is to be done in four aspects: (1) socio-economic and regulatory frameworks; (2) enabling technologies; (3) market-ready products and services; (4) social and economic impacts (Wolf & Korzynietz, 2019). These paths would help solve problems such as charging infrastructure installations, car-to-energy supply communications, and financial incentives.

In Brazil, Li-ion battery technology's breakthroughs have prompted EV prices to go down in recent times; however, range anxiety still plays a crucial role in generating a dilemma amongst potential EV buyers. Vargas et al. (2020) suggested a possible alternative to the long charging time problem by adopting China's Nio battery swapping technology. Unfortunately, this technology was proved to be impractical in Brazil due to insufficient standardization.

Electric vehicles could rise to 50 million units in the next five years; hence, charging stations play a crucial role in ensuring this happens. It is estimated that $110 billion to $180 billion must be invested from 2020 to 2030 to support EV charging stations' global demand. Currently, EV charging stations in private residences in some countries like China, the US, UK, and the EU-27 are pretty ubiquitous, but they will be insufficient in the future; therefore, on-site commercial charging systems in buildings together with further adjustment on local electric-grid infrastructure will be needed for the next ten years to meet the demand (Hoover et al., 2021).

Fast-charging stations only constitute 5% - 10% of the total energy used by EVs in the US as they are mere substitutes to the dominant private chargers & general level 2 AC chargers (< 22 kW). Additionally, the highest energy transfer at fast chargers is recorded during the afternoon (11 a.m. – 3 p.m.), contrary to private and public normal speed chargers (Wolbertus & van den Hoed, 2020). Accordingly, charging stations are found less near EV owners' homes than highways (Smart & Salisbury, 2015).

At present, Thailand is one of ASEAN's EV hubs. As stated by Thananusak et al. (2020), this is achieved due to its strategies in advancing EV adoptions, mainly of which are expanding charging stations at key locations through partnership and tax exemptions as well as creating EV charging consortiums to enable data exchange to ensure operability. Furthermore, in 2018, through the National Energy Policy Commission, the country had proposed the Time of Use (TOU) rate to avoid peak demands during the day (9 a.m. - 10 p.m.). According to the National Energy Policy Board of Thailand, there are three operational phases to be surpassed to achieve the goals of the EV roadmap: (1) prepare EV usage for public transportation; (2) implement EV investment in personal transportation; (3) expand EV usage and infrastructure across the country.

# PROBLEM STATEMENT

# Singapore's 2030 Green Plan aims for a more sustainable future with fewer carbon emissions. Although electric vehicle (EV) prices have dropped (Baldwin, 2020), lack of range and charging point availability remains a turn-off for potential EV purchasers. With only less than 2,000 charging points and a low number of operating electric vehicles, in the meantime, Singapore is only crawling towards the electric utopia (Heng, 2021). Furthermore, it is still miles away from its 2030 Green Plan of operating 60,000 charging points nationwide.  Having said that, Singapore may not be able to reach its target of being carbon neutral by 2030 if charging infrastructure remains scarce and regulations remain ineffective.

# PROPOSED SOLUTIONS

## ASPECT 1: ENABLING TECHNOLOGIES

Charging time and the lack of widespread charging stations are arguably the main inhibitors of EV adoption in Singapore. One possible solution is battery swapping, having proven itself to be successful in China, led by the Chinese EV manufacturers: NIO and BAIC Beijing EV (BJEV) (Kane, 2020) with their standardized battery size in various kWh capacities (Ruffo, 2020). No cross-manufacturer standard has been set; however, it is intended for technical safety protocol purposes. During the purchase of their EVs, customers may opt for renting the battery monthly instead of buying the battery, saving about $10,000 per EV car purchase (Zhang, 2020).

Another key innovation is smart charging, opening the way for data exchange between EVs and grid operators which will be instrumental in optimizing energy use. Since the charging session requires identifying the EV driver (Virta, 2021), power suppliers can make use of the TOU rate to reduce peak demand.  Such a reduction in peak demand will lighten the energy infrastructure load, making electricity distribution more efficient and less costly.

## ASPECT 2: REGULATORY FRAMEWORKS

As of now, Singapore has made a standard that covers the technical requirements not only for charger installations but also their functional needs and safety (Energy Market Authority, 2021). Thus, the next step forwards should be setting new fuel economy standards and providing subsidies to boost the implementation of EVs. In Singapore, the Revised Carbon Emission-Based Vehicle Scheme (CEVS) has been introduced to impose surcharges or to grant rebates based on how clean the vehicles are (Land Transport Authority, 2021). This scheme could be expanded to grant rebates for EV vehicles based on their efficiency, i.e., the amount of range it can cover per kWh electricity. This would incentivise EV purchases and motivate companies to produce more efficient EVs.

With regards to subsidies, the government could invite established EV firms to bid for their designs on novel technologies, e.g., swappable-batteries, along with their cost-benefit analysis. The contract winner(s) would sign an agreement with state-owned electricity distributors to ease communication between the vehicles and the grid, then commence their envisioned EV plan with the help of government subsidies and tax incentives.

## ASPECT 3: MARKET-READY PRODUCTS AND SERVICES

According to LTA (2018), the bus has the highest ridership compared to other public transports; hence, moving towards bus electromobility by increasing electric bus fleets will be a more sensible option to do. Currently, Singapore has only less than 100 electric buses in operation, with high costs being the main challenge. This could be mitigated by planning retrofits for charging systems, implementing TOU rates, and dealing more with the energy management system instead of the site's electrical capacity.

Besides electric buses, well-distributed charging stations are also needed. Hoover et al. (2021) mentioned that across China, the US, UK, and the EU-27, the total charge-point units needed by 2025 is estimated to be 22 million to 27 million, and a total of 55 million units will be needed by 2030.  Hence, placing charging systems on commercial areas in Singapore, such as malls and office buildings, would be very strategic to meet charging stations' demand ten years down the road.

## ASPECT 4: SOCIO-ECONOMIC IMPACTS

To mitigate the major impacts of transition towards EVs, Singapore may refer to Thailand's policies which allow non-EV companies to apply for licenses in order to obtain investment benefits from the Board of Investment, such as tax exemptions for a period of time or zero import duty (Thananusak et al., 2020). Nevertheless, the government should also monitor that the funding is strictly used for further research and operational EV development purposes.

Such funding can also be used to facilitate training of the workforces transitioning from non-EV to EV industries. Currently, giant oil companies like Chevron, Shell, and Statoil ASA are making efforts to change their business models towards electromobility accommodation, in particular, charging stations expansion (Lambert, 2019; Shieber 2021) and investing in large operators of EV charging networks like ChargePoint Inc (Shell Acquisition, 2017); hence, workforce training will be needed. For further details regarding the workforce training, Singapore may want to refer to California's Employment Training Panel (ETP), which is a government-sponsored in-house training program, or American River College, which offers a pre-apprenticeship certificate in the future energy sector (Chandler, 2016). Such in-house training programs can then be integrated with the current SGUnited Traineeship Program.

# DISCUSSION

To pursue the 2030 Green Plan, the Singapore government may be keen on passing regulations and making contracts with one of China's EV giants to impose a standardized battery-swapping design specification, mechanism, and safety codes for different vehicle classifications. As of now, battery swapping technology is still a brand-new technology with numerous implementation challenges yet to be solved, for instance, land resource limitation, high cost of infrastructure, and gradual market penetration. It is of utmost importance to have one or more fixed government-approved standard designs for battery swapping models by implementing an exclusive contract bidding as mentioned in the "Regulatory Frameworks" section of our solution. This standardization will not only break down complex standards to simpler ones, but also boost each candidate to expand their charging infrastructure across the country.

Nevertheless, there are other factors that the government team must consider besides technical consensus: safety, cost, and social influence. Such examinations may require a prolonged period of time to perform. According to the "History of Singapore" (2018), the study to decide on adding MRT to the public transportation system took ten years from conceptualization to approval. When such a long period of time is needed, there is a possibility that better battery range and price, coupled with faster charging time, may cause battery-swapping technology just to be an idea of the past.

The importance of an integrated smart charging system for fast & conventional chargers must also be stressed as it plays a crucial role in energy management. One way energy intake may be regulated better is by having the electric supplier and charging station providers rely on technologies, such as EV identification and smart meter gateways. Furthermore, tangible energy intake data provided by the smart system will help the government to persuade necessary changes in charging habits in order to ease the strain on power consumption. It is also expected that EVs will be able to reverse-charge to the power grid in succeeding generations.

Apart from the technical limitations circulating the integration of EV to Singapore, the social and economic impact of the implementation plays a crucial role in considerations as well. Major key players in the economy - companies such as oil and automotive - whose market depends on traditional gasoline automotive, might need some time and financial support from the government in changing their business models during the transition.

In view of the workforce perspective, skills and work patterns for both non-EV and EV companies will significantly differ. Consequently, the transitioning industry workers ought to be equipped with relevant skills required by the EV industry through training programs funded by the government. Such training programs can be easily integrated into the current SGUnited Traineeship programme, making it more likely to succeed.

To put everything into perspective, it is worth examining the conversion process of the entire Singapore public busses into electric models. As the current bus system has already matured, a transition to electric fleets will undoubtedly present some problems mentioned in the previous sections of the discussion. On the one hand, there will be major transformations of charging stations, service centers, spare parts, and maintenance facilities. On the other hand, there is the fact that an estimation of $110 billion to $180 billion must be invested from 2020 to 2030 to support the global demand for EV charging stations, including on-site commercial charging stations.

Despite these challenges, electric buses still should be implemented first, as buses make up the largest portion of public transportation ridership in Singapore. Moreover, the bus system has relatively fixed routes and charging patterns, which allows for easier implementation of TOU and smart charging systems. 

# CONCLUSION

A complete transition to cleaner-energy vehicles would be a remarkable feat for Singapore. Some challenges remain on the horizon, such as insufficient charging infrastructure, long charging time, and numerous socio-economic side effects for such transition. Regardless, we remain optimistic in technological breakthroughs, namely swappable batteries, smart charging, and strategic energy management planning. These innovations coupled with effective regulatory frameworks will eventually catalyse electromobility penetration, reducing any disruptive impacts we will surely encounter in the process.

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