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The Implementation of Battery Swapping Stations for the Electric Vehicles in Saudi Arabia (Study the Role of These Stations to Increase the Economic Indicators and comparing it with the Battery Charging Stations)

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Abstract:

The Kingdom of Saudi Arabia consume huge measure of vehicles fuel in a yearly way which hurt the monetary express, the worth of fuel utilization in Saudi Arabia, "petroleum and diesel", during the year 2019, including all areas, barring all, fuel utilization, added up to around 382 million barrels, contrasted with 377.2 million barrels in 2018, recorded at 100, 100 million barrels. Because of that it is liked to as be opposed to utilizing petroleum is to supplant it with Battery Swapping Stations.

Battery trading is another innovation permitting super-quick charging for electric vehicles, it permits Electric Vetches (EV) proprietors to supplant the released batteries with charged ones at the trade stations. At the point when the battery is released, the proprietor can transform it with a completely energized one. This will resolve the issue of setting up charging stations and furthermore diminish range uneasiness of drivers. Further, battery renting can assist EV proprietors with saving the expense of buying a battery. The assistance is less tedious and requires a couple of moments contrasted with charging at a battery station which could require hours. It additionally requires least framework. The principal objective of this undertaking is to sit a procedure that permits battery trading stations in Saudi Arabia to diminish the pointless abundance utilization and ascend with the monetary markers.

Keywords: Battery Swapping Station, Electric Vehicle, Charging, Fuel

1. Introduction

1.1 Motivations:

Saudi Arabia is a private vehicle arranged society and has one of the world's most noteworthy per capita fuel utilization in the transportation area. The nation is seeing a raising interest on its homegrown energy needs, and policymakers genuinely must devise approaches for the preservation of energy assets and decrease of GHGs outflows in the transportation area. Energy force in Saudi Arabia has set high records mirroring the development of the economy and the expanding request on fossil energy in homegrown use and weighty ventures activities. Energy force in the Kingdom was double the world normal in 2010 and with lopsided development between energy use and economy, this should ring the ringer for the Saudi government to take on a firecracker arrangement that reduce the expanding development of energy request domestics (EcoMENA). The pointers in Figure 1 exhibit the information for Saudi Arabia from 2011 to 2018. The normal incentive for Saudi Arabia during that period was 280.7 thousand barrels each day with at least 95.2 thousand barrels each day.

The most recent worth from 2018 is 534.92 thousand barrels each day. For correlation, the world normal in 2018 considering 191 nations is 136.55 thousand barrels each day (theglobaleconomy).

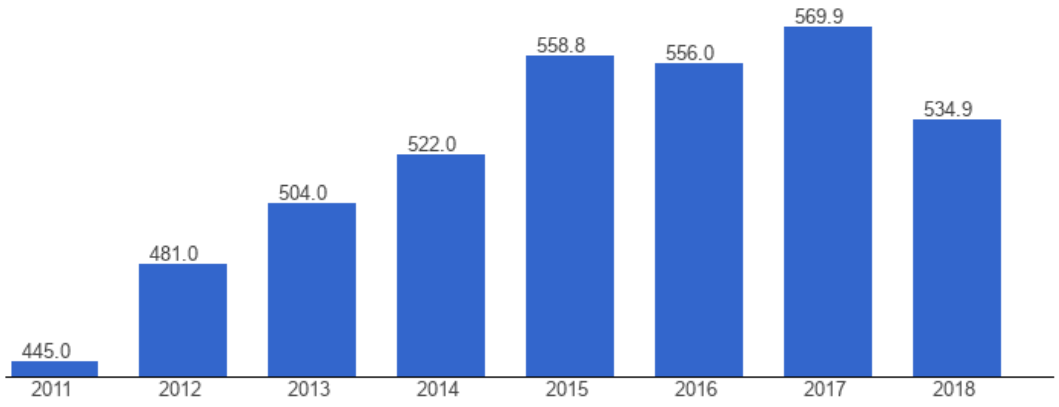

Figure (1) Gasoline consumption (thousand barrels per day) in Saudi Arabia 2011 - 2018

These quantities of fuel requests will influence the homegrown economy during the time in a damaged way, for that the battery trading station is the best substitute because of the saving of energy as well as expanding in monetary markers. Battery trading then again is a cycle to recharge the battery charge expected for an electric vehicle by trading a released battery with a completely energized one. Any rider or driver of an electric vehicle with a battery running out of charge can go to a battery trading station where the released battery of the EV is removed from the vehicle and traded with a completely energized battery of a similar setup. This strategy empowers battery trading as an assistant as opposed to selling the batteries as an item. As per the EV charging framework handbook, which was delivered by the NITI Aayog, a research organization of the Government of India (electricvehicles). There are two types of EV battery swapping stations Figure (***2***, which are:

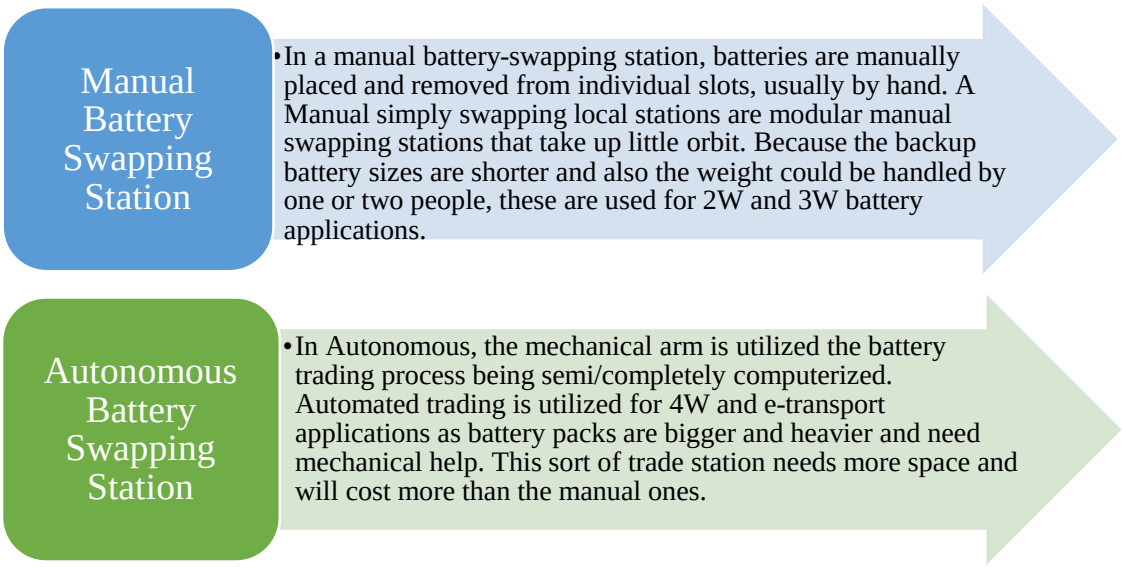

Figure (2) Types of Battery Swapping Stations

The possibility of a battery trading station in a wide reach is to help the monetary state particularly that the Kingdom of Saudi Arabia in activity of the vision of 2030 which center principally around maintainability of energy notwithstanding not relying upon fuel any longer.

Due to that the nation need something effective and Battery charging time is viewed as difficult for EV clients as this outcome in critical personal time for them, as the normal charging time for an EV battery is around four hours. If there should arise an occurrence of battery trading the client can just go to the trading station and trade their released battery with a completely energized one.

The vacation for this situation is only a couple of moments. It is particularly valuable for EV clients working in the traveler or products transportation area as it wipes out the apprehension about lengthy re-energizing times. Numerous makers are likewise searching for the option for charging stations, for example, battery trading. It is the best choice to re-energize your battery without anything to do trusting that the EV will charge. With the battery trading choices, the exhausted EV battery can be taken out from the vehicle and supplanted with a completely energized one inside couple of moments. Particularly nowadays there are a lot of electrical vehicles that go for a far distance to individuals as of late uses these vehicles to go far places. See Figure (***3***.

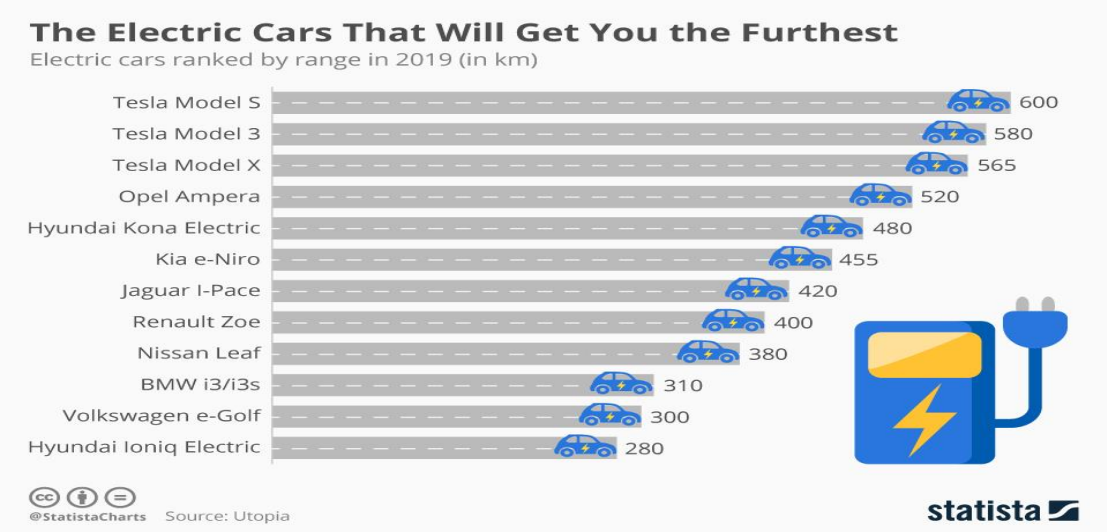

Figure (3) the Electric Cars That Will Get You the Furthest

electric vehicle pushed by electric engines and utilizations electrical energy put away in batteries dissimilar to vehicle with ignition motors electrical vehicle doesn't create exhaust gases during activity this by itself makes electrical vehicle more harmless to the ecosystem than vehicle portion should be created from sustainable sources eg from wind sun oriented hydroelectric or biogas power plants by consolidating different drive types the general productivity of the vehicle can be improved and fuel utilization can be diminished thus in view of that individuals need likewise while they go far spots to take to them the fill of the vehicle maturing and what amount of time it will require the normal charging a customary vehicle battery with a commonplace charge amp of around 4-8 amperes will take around 10-24 hours to charge it completely to support your battery enough to have the option to turn over the motor it would take around 2-4 hours.

This shows that battery trading is greatly improved, because of when somebody need to go far distances, The additional battery will be there and can supplant it effectively without a colossal measure of time and exertion that can cause an issue either to the actual driver or the vehicle, so the activity is agreeable and in addition to that there are various contrasts between battery trading and battery charging station (afdc.energy). As it demonstrated in

Table ***(1***).

Comparing Materials	Time	Reliability	Predictability of battery lifetime	Cost
Battery Swapping Station	10 minutes to Swap batteries	High reliability	Accurate	Low initial cost
Battery Charging Station	30 minutes to 8 hours to charge batteries	Less reliability	Not Accurate	High initial cost

Table (1) Compression between Battery Swapping Station and Battery Charging Station

in addition to providing another more pleasant economic state a vehicle swapping station there might be another option that replenish the source of energy of evs than battery bank right away manually swap exhausted charges for fully loaded battery systems of theory the filling station or cell firm should own all of these rechargeable batteries with the electric vehicles (EVs) motorist acting as a cell borrower its depleted batteries will be replenished either at the service station or at a central location the technique of battery switching is also referred to as physical refueling or mechanical recharging so it requires manual substitution and battery charging. these electric vehicle charging stations combine the advantages of both slow and high recharging gently recharging EVs batteries during the off hours as swiftly replenishing cars in such a short period of time the battery pack switching operation may be completed in a couple of moments using automated gear which is exactly applicable to the existing refueling technique on traditional automobiles (sciencedirect.).

1.2. Research Objectives

- Construct a Battery Swapping Stations to match the Kingdom vision 2030 in Saudi Arabia.
- Investigate how to accurate design strategies and energy-efficient batteries systems to improve the economic performance and reduce energy consumption.
- Develop an energy management indicator which considers the features of battery swapping stations, including batteries, energy storage systems, and the option of exchanging power with the grid.
- Investigate how to reduce the fuel, petrol consumptions for vehicles needs and achieve a high-performance while maintaining healthy indoor environments.

1.3. Report Outline

A next is said to be the rest of the report: Following chapter 2 examines potential solutions related research offered in this project, while Chapter 3 provides a quick explanation of the technique and mathematical equations which show that with an electric vehicle charging station in terms of improving economic and environmental conditions.

2. Background and Literature Review

2.1 Battery Swapping Station

Lately, because of the undeniably critical deficiency of non-sustainable assets, like oil and coal, inordinate utilization, and the resulting climate contamination, electric vehicles (EVs) stand out enough to be noticed and become inclined toward as a kind of clean energy vehicle (Yabe, 2012) . The central point of contention for the compelling activity of EVs is energy renewal. It is realized that there are two primary ways of tackling this issue: EV charging and battery trading (Zhang X. a., 2016) (Zhang C. a., 2016) . By and large, EV charging requires a long charging process. Hitherto, because of strategy and cash limitations, the charging stations, charging heaps, and other charging foundations are not broadly conveyed. The previously mentioned reasons make it plausible that EV clients will be compelled to pause and stand by, which brings about holding up anxiety. In expansion, EV clients compromise between the leftover battery energy, the area dissemination of charging offices,

and their itinerary items, which effectively brings about range tension (Shao, A mobile battery swapping service for electric vehicles based on a battery swapping van, 2017) (Franke, 2012) .

Subsequently, more analysts and EV administrators are directing their concentration toward battery trading (Jamian, 2014) (Rogowsky, 6) . Battery trading can give another completely energized battery, which doesn't need draining the energy of the old battery. Range uneasiness is facilitated, and somewhat boundless mileage is acquired. Since battery trading just requires a couple of moments, holding up tension is essentially facilitated (Shao, A mobile battery swapping service for electric vehicles based on a battery swapping van, 2017).

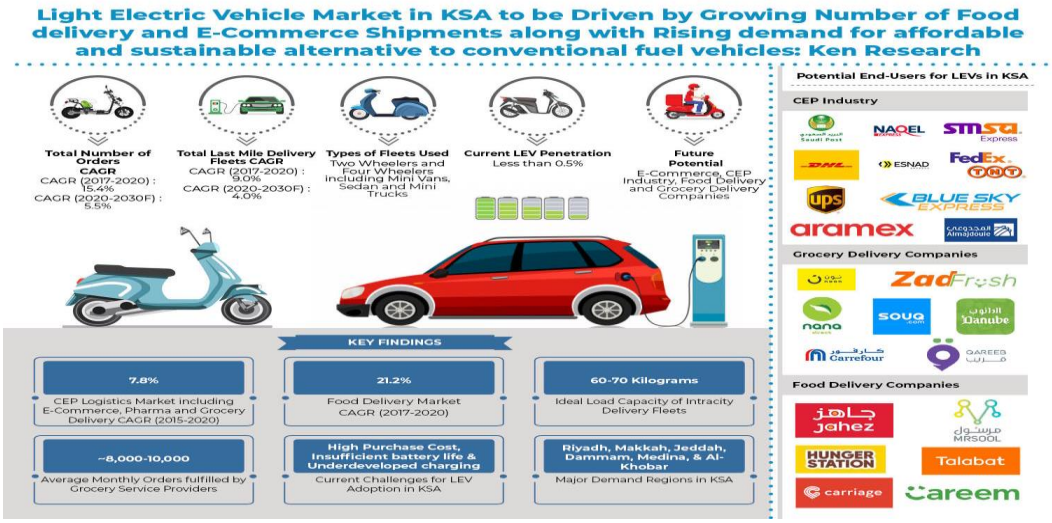

Figure (4) future potential of Light Electric Vehicle industry in KSA.

Battery Swapping Stations Generally, as a suburbanite instrument, an EV is the primary method of everyday transportation. An EV is utilized to drive to work in the first part of the day and return home around evening time, with infrequent utilizations for heading to buy dinner and different objections during the day. During the pinnacle drive hours, energy utilization is moderately high, and thusly, the battery trading request is high. Accordingly, to just recharge the completely energized battery stockpiling utilizing the battery coordinated operations framework might be insufficient on account of the restricted limit of the completely energized battery stockpiling in the battery trading station. To ensure battery recharging and mitigate the transportation strain of the battery planned operations framework, a viable arrangement is to send a battery charging framework at the battery trading station. This battery charging framework is simply used to charge the batteries that are traded out and it isn't available to EV clients.

This further develops the completely energized battery stockpiling as well as assumes a significant part in adjusting the top burden in the brilliant matrix.

Now, the battery trading station has two methodologies for recharging its battery stockpiling: from a battery accusing the industrial facility of a battery coordinated factors framework and from its own battery charging framework. Likewise, the battery trading station has two principle capacities: to give a battery trading administration to the EV clients straightforwardly and to renew the completely energized batteries for the battery trading van to give a battery trading administration to the EV clients indirectly (Shao, A mobile battery swapping service for electric vehicles based on a battery swapping van, 2017) . Tesla revealed a method for switching power packs into hybrid cars among us patented products 10513247B2.

A frame with a base and a rack for holding the battery pack, as well as a hoist for raising and lowering the frame, are included in this system. On the frame are also two sets of four air bearings apiece. The first pair is on top of the frame and allows for relative movement between the frame and the lift, while the second set is on the bottom side of the frame and allows for relative movement between the frame and the battery pack. The rack can also be moved in relation to the frame's base. A car travels over a ramp supported by pillars and parks as near to the battery pack lift mechanism as possible for swapping to take place. The use of vehicle guides aids in optimum positioning. This is crucial to the procedure's success. Through the use of pressure springs, the frame is then matched towards the driver's charging station. A fixed-to-the-frame modification of such alignments pin further includes adequate coordination among the car and the switching gear. "Co - ordination" occurs when the perceived where the gear contacts its rear fenders of the vehicle's power bank but each of the engine power mechanisms the nut runners positioned just on gear are exactly aligned also with specific bolts that secure its power pack to the car body. Fastener patterns, or connection or hole shapes specific for car models, are frequently included to configure engine power devices. Consequently, for overtighten a power pack, enough pressure was provided utilizing bolt rollers. For aid in the unfastening operation, each unit is shifted at minimum diagonally. It's worth noting how aligning all the screws in the very same way can streamline the process of fastening and unstrapping the car batteries. Finally, each unattached load was moved off another shelf and lowered/removed again from surface of the car.

It may be difficult to precisely park a massive EV adjacent toward the power exchange machine. The distance is believed to be around 400 meters. (sciencedirect.)

2.1.1 Battery Charging Factory:

The majority most rechargeable batteries were centralized-charged in a quick charge factory before being dispatched to battery switching stations through the battery logistics system. Some battery switching vans may be able to acquire completely charged battery replenishment at the battery charging factory on occasion. The centralized charging procedure demands a considerable quantity and electric power; therefore, renewable energies are an ideal solution to share part of energy load to balance the peak energy load in a smart grid and may be handle depending upon the request of the demanding of the swapping batteries. See Figure (***5***.

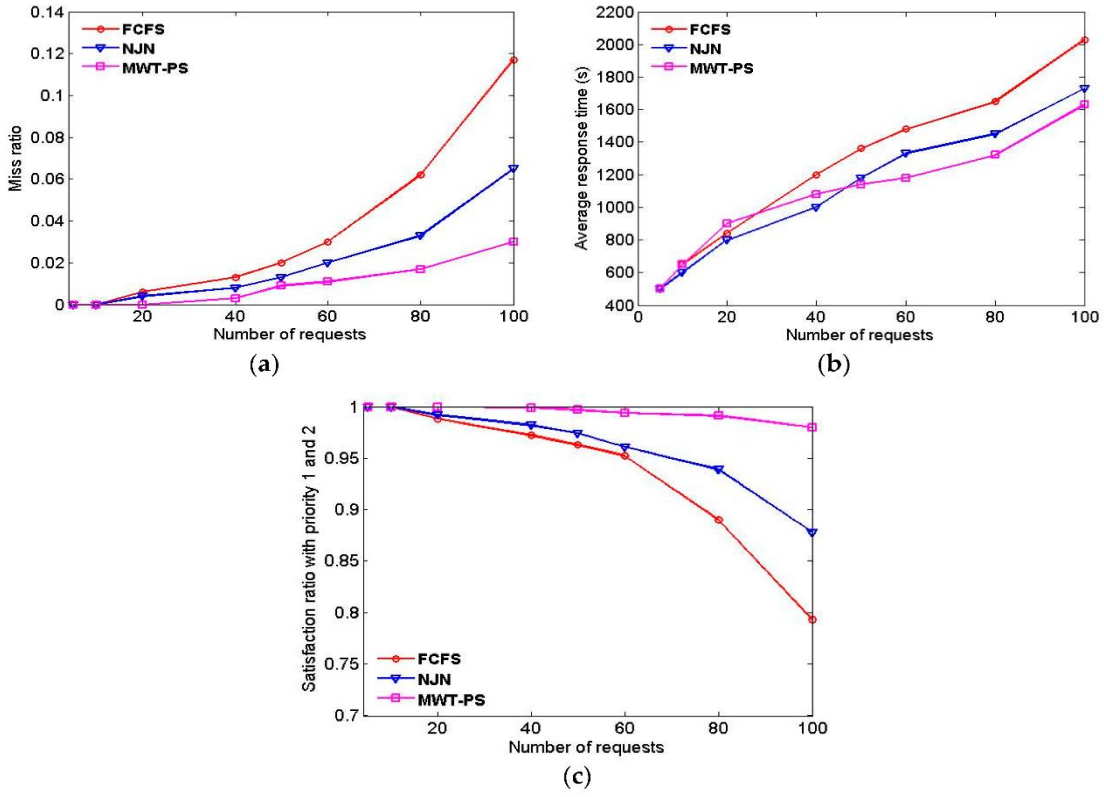

Figure (5) Performance evaluation of battery swapping with respect to number of requests.

what's more from the battery charging industrial facility administrators perspective of organization the potential power assets can save an extensive expense of buying energy from the savvy lattice and increment the activity pay since they don't have to buy energy from the brilliant

network assuming that the energy given by sustainable power assets is adequate (Shao, A mobile battery swapping service for electric vehicles based on a battery swapping van, 2017) .

2.1.2. Electric Vehicles in Saudi Arabia:

Saudi Arabia anticipates inner flammable motors (ICE) vehicles to make up most vehicles driven in the Kingdom for the following 15-20 years. The Middle East/North Africa (MENA) district is developing at an expected 36% with Saudi Arabia as the main local market. Saudi Arabia represented practically 52% of the vehicles sold in the Gulf Cooperation Council (GCC) and 35% in the MENA district in 2020. Absolute vehicles sold in Saudi Arabia in 2019 and 2020 were 556,000 and 436,000, individually. Deals are projected to arrive at 543,000 units by 2025 with electric vehicles (EVs) making up just 32,000 units. In spite of worldwide patterns and approaches supporting EVs, Saudi Arabia anticipates interior flammable motors (ICE) vehicles to make up most vehicles driven in the Kingdom for the following 15-20 years, as indicated by nearby industry specialists. Toyota controls 30% of the Saudi market followed by Hyundai and KIA by 26% and Renault-Nissan-Mitsubishi by 9%. General Motors, Ford, and Fiat Chrysler Automobiles make up the excess offer. It is guage that 62,000 EV units would be sold in the GCC locale and very nearly 91,000 EVs in the MENA district by 2025. Regardless, there are just four get-together plants for business vehicles, and these have a low volume yield. As per the Kingdom's vision 2030 objectives, the National Industrial Development Center (NIDC) intends to draw in 3-4 Original Equipment Manufacturers across the ICE and EV esteem chain, determined to deliver 300,000 vehicles every year with a 40% nearby substance by 2030. NIDC gives motivations to empower industrialization through credits, charge impetuses, and levy exceptions. Vehicle bodyboards, wheel parts, tires, seats, fuel siphons, safety belts, back pointer light covers, headlights, guards, and motor covers are popular and present market section or extension open doors for t U.S. organizations looking for joint endeavor associations in the Kingdom. Subsequently, will guarantee greater improvement as the Figure (*6*) bellow shows.

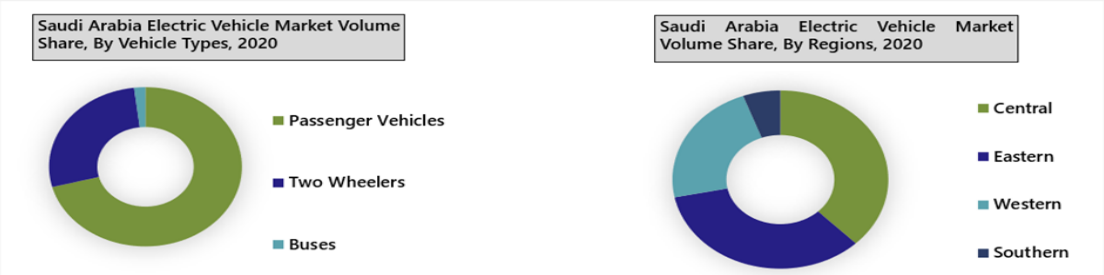

Figure (6) Saudi Arabia Electric Vehicle Volume Share Market 2020

Inside vehicle types, traveler vehicles gained over 60% of the portion of the overall industry as far as income. They are projected to show huge development during the figure time frame inferable from the developing populace that proposes a drawn-out potential in the electric vehicle fragment ascribed to the rising discretionary cashflow of families and lower emanations targets set by the public authority. The nation has chosen to control GHG outflow by 130 million metric huge loads of CO2 comparable by 2030 under the Paris objective and INDC. Which moreover will have a few monetary impacts additionally in various loads or places like:

1- Business Side Potential for EVs in KSA dispatch express bundle administrations (CEP) Industry:

Homegrown express messenger overwhelms the market and is relied upon to enroll income development at a CAGR of 4.4% and development in shipments at a CAGR of 8.6% during the determined year 2020-2030. CEP Shipments incorporate E-Commerce, Pharma, and Grocery conveyances. The express organizations, for example, UPS, DHL, and Saudi Post utilize four-wheelers especially little vans, to convey bundles/bundles in Saudi Arabia. Internet business conveyance vans generally make 45-50 conveyances in a day, with a normal outing length of 100 km in Tier 1 urban communities and 50 km in Tier 2/3 urban communities. During forecast, the messenger express bundle administrations in Saidi Arabia will increment. Look to Figure (*7*).

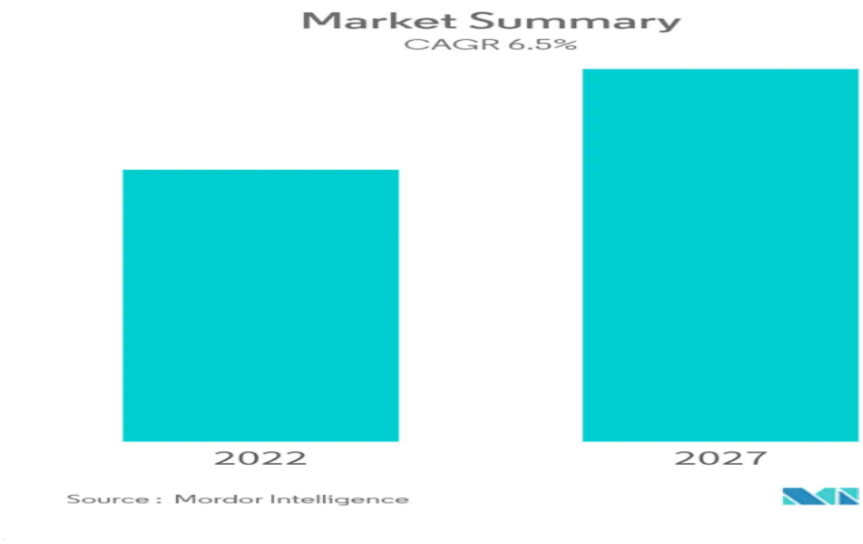

Figure (7) SAUDI ARABIA COURIER, EXPRESS- GROWTH (2022 - 2027).

Central parts in this classification incorporate Saudi Post, Raquel Express, SMSA Express, DHL, Aramex, and UPS. As of now, LEVs don't guarantee a high reception potential ascribed to both a significant expense uniqueness and an absence of a vehicle. In any case, little organization EVs might acquire force soon, given their lower fuel and support costs. They are likewise less reliant upon charging foundation, since their power necessities are lower, and they are bound to come in models that permit battery trading.

2- Business Side Potential for EVs in Grocery Delivery Industry:

The business is at an early stage enlisting a twofold digit development rate between 30-40% in income terms. Online basic food item infiltration as far as clients are relied upon to increment from 3.7% in 2019 to 20% by 2025 owing change in client inclination from disconnected to online shopping for food. Espattiaaly that this side turns out to be an ever-increasing number of products and the most recent two years it became gigantic trying for different business sectors.See Figure (*8*).

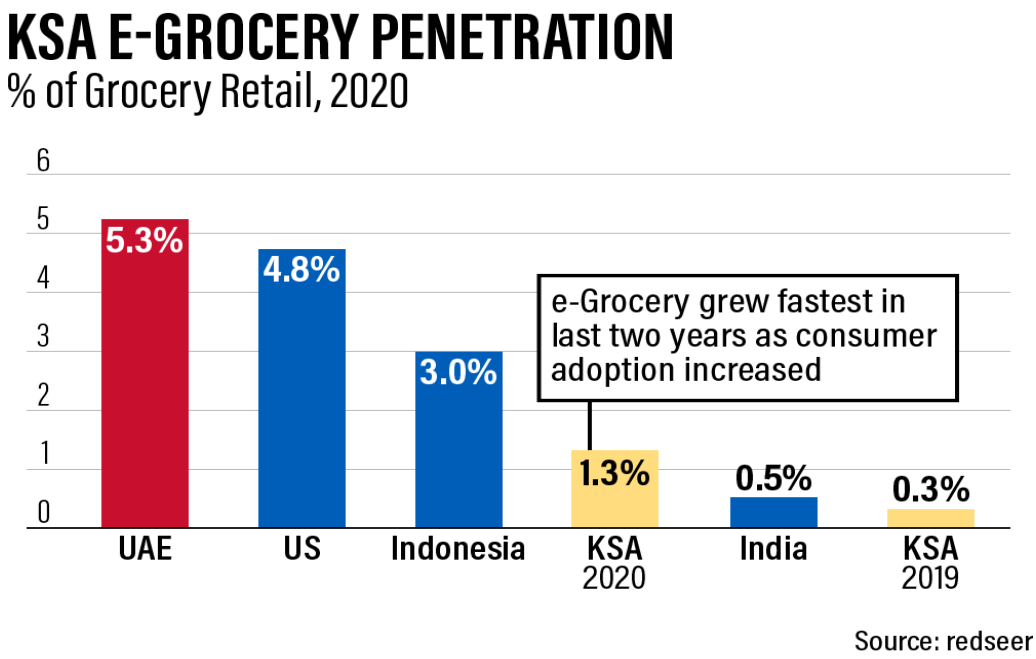

Figure (8) Saudi Arabia Grocery grew Penetration

Basic food item organizations, for example, Danube and Carrefour have their own in-house armada while others normally cooperate with outsider administrators to satisfy client orders.

Riyadh, Medina, and Makkah are perceived as areas with the most extreme interest and supply of online staple administrations where LEVs could be at first sent. and Makkah have been identified as places with the greatest demand for and supply of online grocery services, where LEVs could be deployed first. Providers can save expenses and gain a competitive edge in the industry by growing the in-house delivery capacity or partnering utilizing vehicle industry players on a contractual basis. Princess Straight, Zadfresh, Danube, Qareeb, and Carrefour are all major players in this market.

3- Business Side Potential for EVs in Food Delivery Industry:

For the past few years, the online meal delivery business in Saudi Arabia has seen remarkable expansion. During the forecaster year, the industry is predicted to rise by 7.2 percent in sales while satisfying over 200 million orders. Through the selling of solid infrastructure solutions and appealing commission rates for restaurants, aggregator platforms such as Hungrstation, Careem, and Jahez have expanded throughout the kingdom.

The businesses use a pay-per-delivery model, in which freelancers who possess a car or a two-wheeler are hired and compensated based on the number of orders they deliver. Hungerstation, interpreted, Careem, Jahez, and Mrsool are all significant players in this market. And for possible deployment for battery storage for EVs, partnerships with restaurants, malls, real estate developers, and other commercial hubs should be considered. Popular markets and pick-up stations for food and beverages are perfect charging / swapping hubs for keeping an EV fleet ready for both last-mile products and food delivery. The market for online grocery purchase and delivery in Saudi Arabia were estimated at Usd 511.21 million in 2020, and it is expected to increase at a 10.05 percent CAGR from 2021 to 2026. Even after the pandemic threat in 2020, the market continued to rise steadily. During the next five years, global Saudi Arabian food and accommodation business are likely to be driven by digitalization and the advent more innovative internet platforms. This same comfort of saving time is a major component with in huge trend of Saudi Arabia's mobile nutrition purchasing as well as transportation market. The new gen lives a stressful schedule, and comfort of time saved becomes a large determinant and in rise of Saudi Arabia's internet food shopping as well as shipment business . See Figure (9) .

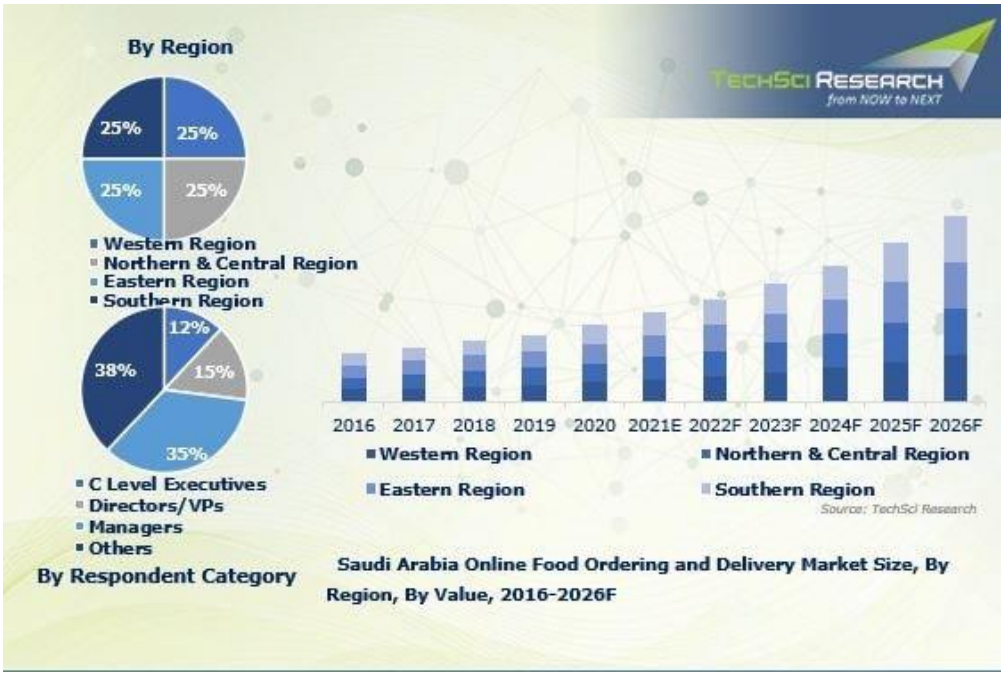

Figure (9) Saudi Arabia Food ordering and Deliver Market size by region, by value 2016-2026.

From the above figure, the utilizing of Evs will be expensive and longer an ideal opportunity to accuse yet of swa[[ing battery method it will be more productive.

The internet-based food conveyance administrations offer more prominent accommodation to the clients as the clients can rearrange through a few cafés, food things, and various cooking styles at a solitary touchpoint, sitting in their home, office, or some other spot of comfort. Also, the clients can get top to bottom data with respect to their food, can analyze the food and value choices, access criticism from past purchasers, profit different limited-time plans/offers, track the conveyance individual, make installment through different choices like web-based installment, e-wallet installment, Cash on Delivery (CoD), and appreciate different advantages through web-based food requesting. In particular, the internet-based food conveyance administrations empower the clients to appreciate bother-free food, assisting them with saving time and energy, which goes about as a significant driver for the market. Saudi Arabia's internet-based food requesting and conveyance market is sectioned by activity type, source, installment, and district. In light of activity type, the market is bifurcated into food aggregators and cafés.

Food aggregators drove the market in 2020 and the pattern is probably going to go on until 2026 because of accommodation and a wide scope of choices to look over.

2.2. Existing of battery swapping station:

The general production of electric is still reliant on road projects. Include the installation of battery storage, as well as identifying a terminal and recharging your charge in less time. All-electric vehicles (EVs), and also hybrid electric vehicles (HEVs) and connector hybrids, have seen a surge in popularity. Electric vehicles lessen society's dependence on oil and its impact to global warming. They're fun to drive, as per some. Nevertheless, public projects still are required for widespread adoption of evs. Those include installation of charging stations, and also finding a car charger and lessening recharge time.(O'shea, 2016) .

As per Goldman Sachs Research, engines recorded only for than 3% all international car purchases during 2016. Around 2025, rechargeable autos would represent in about 20% of all vehicles sold. Electric car market is growing from 2.6 million to 17 million in 10 years if 85 million light vehicles are produced each year.

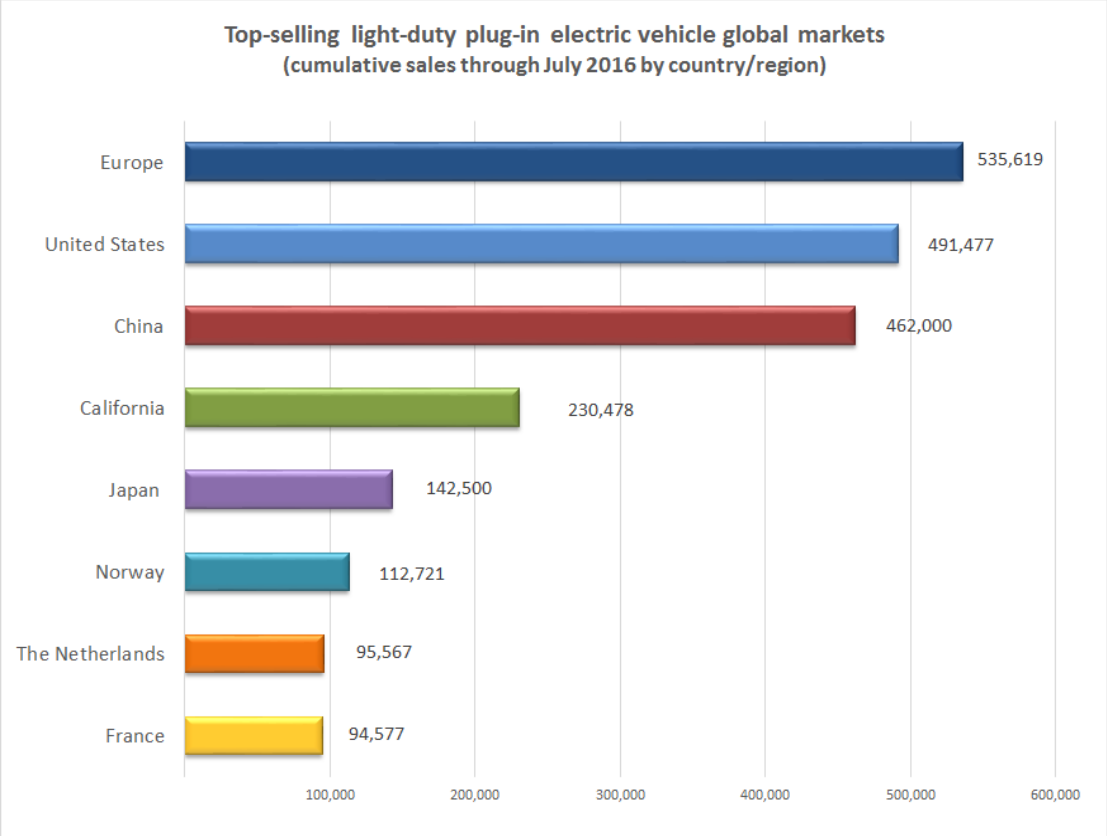

Figure (10) Top PEV global markets 2016

1- Battery Swapping Stations in China:

EV behemoths in China are all on board on super capacitor. A Chinese startup Nio (their packs are manufactured either by Chinese energy behemoth CATL) isolates overall cost of both the charger as from car's sales price. People who buy the Nio ES8, ES6, or EC6 models without the need for a battery can now lease one rather than, thanks to the new 'Battery as a Service' offer. Throughout China, Nio has 143 rechargeable batteries terminals so motorists may swap used car batteries with fully loaded ones. The BaaS is currently available in 64 Chinese cities, and Nio claiming to have done around 800,000 power exchanges. Nio was creating a new rechargeable batteries unit each week in China, as according to Li, and plans to install 300 additional stations next year. (Hampel, 2021).

Figure 11 A CGTN reporter is filming the process of battery-swapping in a NIO battery-swap station in Beijing, China, August 3, 2020. Wang Tianyu/CGTN

2- battery Swapping Stations in USA:

Ample, based in San Francisco, is introduced battery technology battery switching towards the United States. Before debuting with 5 exchanging locations with in Bay Area, this business was in lockdown mode over 7 years. Ample's initial consumers are Über workers in the area. The idea isn't brand new. Following raising $850 million in funding, Nicer Place created a electric car and batteries exchange firm, but still it went into bankruptcy in 2013. In 2013, Tesla also demonstrated charge switching, and only opened one unit for a year.

Vehicle owners, as per Elon Musk, aren't interested. For China, battery changing is already commonplace. Nio, an electric vehicle manufacturer, wants to expand its system for switching station through 500 this year, including stations opening in Norway as part of its European expansion. (Pettitt, 2021) .

Figure (12) a modular battery architecture that allows for any EV to use Ample's stations (Source: Ample)

Ample's technology has two major components:

- A completely independent trading station that eliminates exhausted battery modules from the vehicle and replaces them with completely energized ones. The exhausted battery modules are then put on racks where they are re-energized.
- An modular storage design that enables any ev to use Ample's fast chargers. The batteries are constructed from lego-like pieces which can fit any vehicle, independent the size or design. The entire process takes less than 10 minutes.(Emilio, 2021) .

Figure (13) Ample Station (Source: Ample)

2.3.1. Pros of Battery Swapping:

There are four fundamental obstructions with regards to mass EV reception, to be specific, the high forthcoming expense, range tension, long charging time and nonattendance of the solid steady

framework. How about we perceive how battery trading can assist with beating these detours and proposition different benefits too (Battery Swapping - A Pragmatic Complement to EV Charging, 2019) :

1. Decrease in EV Acquisition cost

- The battery represents 40-half of the absolute expense of an Electric vehicle. On account of a trade framework, we can isolate the vehicle business from the energy business. the responsibility for batteries might lie with the BSS and not with the vehicle proprietor. In this manner, the battery turns into a variable expense, decreasing the securing cost drastically.

2. Disposing of Long Charging Time

- AC charging and, surprisingly, quick DC charging times are horrendously lengthy when contrasted with refueling an ICE vehicle. This is particularly valid for business vehicles with high use rates where time spent in re-energizing the batteries straightforwardly converts into lost time out and about and lower compensation for the driver. Battery trading gives a choice that is pretty much as quick as refueling an ordinary vehicle.

3. Easing Range Anxiety

- a broad organization of bss can actually display a limitless reach to electric vehicles accordingly facilitating range anxiety

4. Identical Infrastructure-

- A massive resting area is needed for a power outlet. However, because battery trading is quick (as little as 3 minutes), only a small amount of area is required to set up charging terminals again for cells, and no elaborate public infrastructure is expected.

5. Longer Battery Life

- Quick filling, and also billing at high temperatures, leads the power to degrade over time. Slow recharging in a contained way is being used to improve the battery life of traded units.

6. Framework Load Management

- Battery charging timetable can be figured out how to take into consideration greatest changing to be done at evening or during off-top hours. As trading stations will have many charged batteries at all times, there likewise exists a chance for the BSS to give capacity to the framework during top burden hours.

7. Battery Recycling and Disposal

- Coordinated trading tasks take into account orderly removal and reusing of spent batteries.

2.3.2. Challenges with Battery Swapping:

Charger switching entails a combination of technology and commercial obstacles. Force people to look at the key concerns with carrying out a Battery Swapping plan:

1. Normalization of Battery Packs	2. Unwavering quality of Leased Battery Pack	3. Monetarily Viable Business Model
• Battery loads that accompany different Electric Vehicles are not normalized. Most automakers safeguard the plan and data about their battery packs as their center innovation. For a huge scope trading activity, interoperability between battery packs will be required that can be accomplished by normalization. Nonetheless, simultaneously normalization of the battery stashes takes from automakers' opportunity of the plan and may confine development in the field.	• It will be a test to guarantee the EV driver/proprietor that the battery pack being placed into their vehicle is solid and works couple with their vehicle.	• In India, we have yet to see a successful proof of concept for running a swapping station. Tesla and Better Place have both tried their hands on a global scale, yet both have failed. Gogoro, which began selling scooters with swappable batteries in Taiwan in 2015 and has already moved to Japan, France, and Germany, is one successful example. Every day, Gogoro riders swap 86,000 batteries all around the world.

2.4.1. Impact of Battery Swapping Stations in Power Grid

Public Grid in Saudi Arabia consider an auxiliary of the Saudi Electricity Company, has said that the power matrix covers all pieces of the Kingdom of Saudi Arabia to serve its endorsers more

than 13,000 urban areas and towns, focusing on its nonstop undertakings to foster transmission organizations to upgrade the assistance and arrive at all supporters as indicated by best global norms. Energy in Saudi Arabia includes petrol and flammable gas creation, utilization, commodities, and power creation. Saudi Arabia is the world's driving oil maker and exporter. Saudi Arabia's economy is petrol-based; oil represents 90% of the nation's commodities and almost 75% of government income. Towards the finish of 1998, the power area set out upon a significant rebuilding program. One of its points was to accomplish economical execution. In spite of the fact that headway has been made, outstanding difficulties, incorporate appeal development, low age limit save edges, wasteful energy use, nonappearance of season of-utilization rate changes, and the requirement for huge capital speculations to subsidize extension. Momentum practical arrangements, especially those reassuring energy preservation, prompted top burden reserve funds of in excess of 871 MW in 2001, basically due to a joint effort between the Ministry of Water and Electricity and the Saudi Electricity Company. Arrangements and projects are being produced for public mindfulness, energy guideline and regulation, and energy data and programming. In the event that energy preservation is fruitful, requests can be diminished by 5-10%. This is comparable to 3-6 GW of extra limit, which addresses a potential $1.5-3.0 billion saving north of 20 years.

Regularly, interest in energy productivity is 1% of utility deals incomes, which for a nation like Saudi Arabia could be $15-60 million yearly. If by some stroke of good luck reserve funds on cooling are thought of, the profit from the venture is identical to 400-500 MW creating a limit saving of up to $0.25 billion. See Figure (*14*).

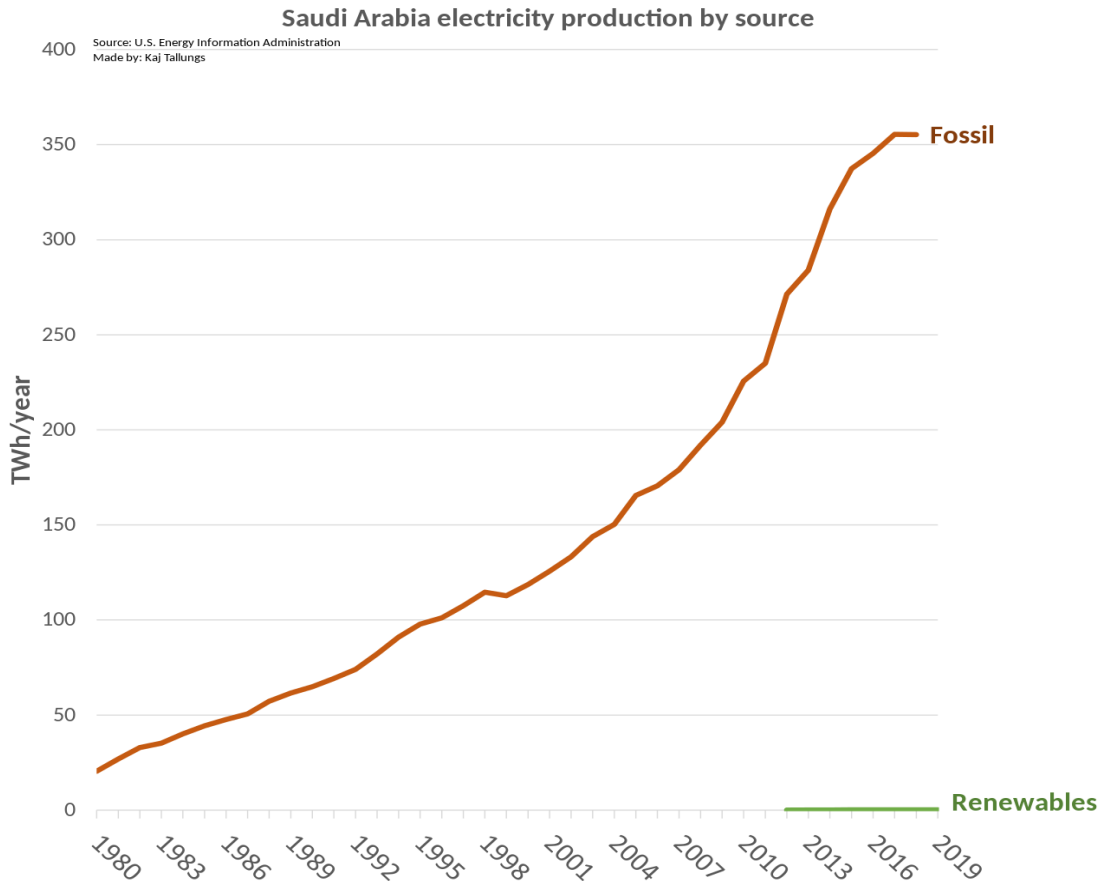

Figure (14) the consumption of Fossil Fuel in Saudi Arabia

As shown in the chart above, after the 2030 vision, Kingdoom has changed its strategy to focus on resiliency, sustainability, but, most importantly, renewables so that the country does not rely on pertoluim as its main source of power. As a result, the grid of Saudi Arabia's Kingdoom can handle the additional station demand. An ev car efficiency can be measured in kwh of electricity (kWh) every 100 kilometers. The price (is usd per kWh) and the performance of a car (how much power was utilized for go hundred miles) should be known in order to compute the fuel savings of an EV. The cost per mile is around $0.04 if power is $0.13 per kWh and the car uses 33 kWh to drive 100 miles. Recharging an EV with a 200 nautical miles trip (assuming a totally exhausted 66 kWh pack) may cost around $9 if power costs $0.13 per kilowatt-hour.

To evaluate the expenses of refuelling conventional and plug-in vehicle models. This battery swapping process might happen in a variety of ways. (company). See Figure (*15*).

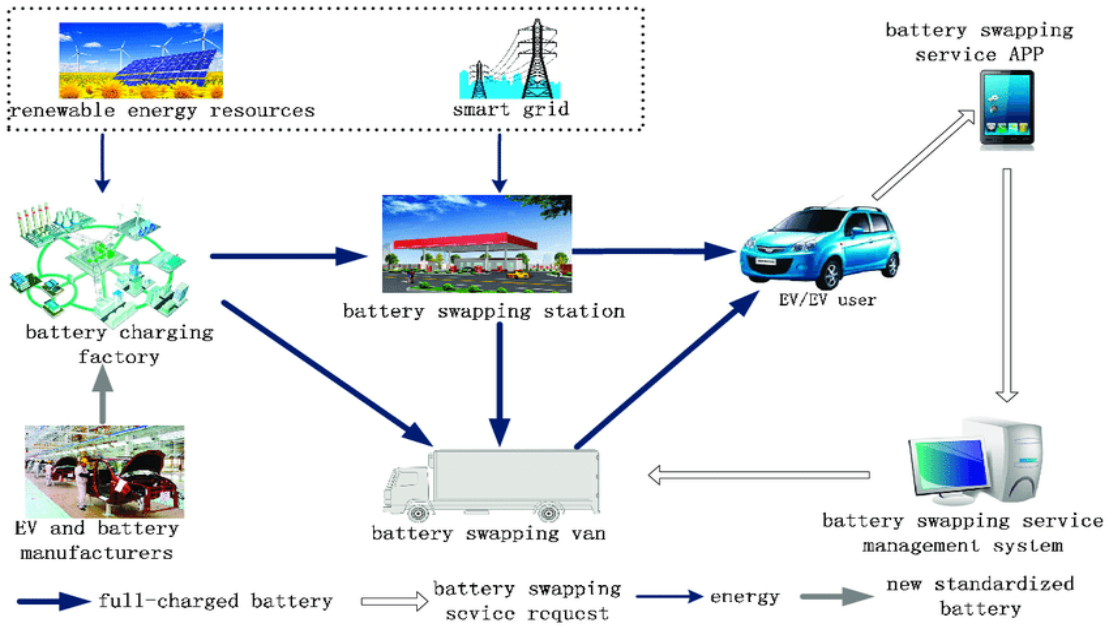

Figure (15) Several Ways of battery Swapping

the swapping additionally can happen by utilization of a battery trading van carries an unmistakable change to the EV battery trading the elements of every member and the jobs they played will be subsequently different to diminish the effect of these progressions and give a viable and proficient EV cell trading administration the capacity and job of every still up in the air particularly their changes the course of battery creation stuffing transportation stockpiling and trading and correspondence are portrayed the connection between every member (researchgate).

2.4.2 The Electric Vehicle Storage Battery

whereas gas-powered vehicles obtain stocked energy gasoline or diesel an electric automobile gets its hydropower from a significant number of batteries ev batteries go through release patterns while driving and charging patterns whenever the vehicle was connected the amount of charge that cell may hold is influenced by continuing the cycle throughout time this reduces the distance and time required to charge across each excursion the majority of manufacturers offer a five- to eight-year warranty on their batteries regardless it is expected that such a fully electric cell can last 10 to 20 years before something needs to be change the way it works is stonishingly simple it consists of a cell connected to at least one electric engine that drives the wheels.

whenever you press the gas pedal the car in a flash feeds capacity to the engine which bit by bit consumes the energy put away in the batteries electric engines likewise fill in as generators so when you take your foot off the choke the car starts to dial back by changing over its forward movement back into power this happens all the more firmly assuming you hit the brakes this regenerative slowing down recuperates energy that would somehow be lost putting away it in the battery again thus working on the vehicles reach. See Figure (*16* bellow demonstrates the efficiency also if Electric Vehicle batteries

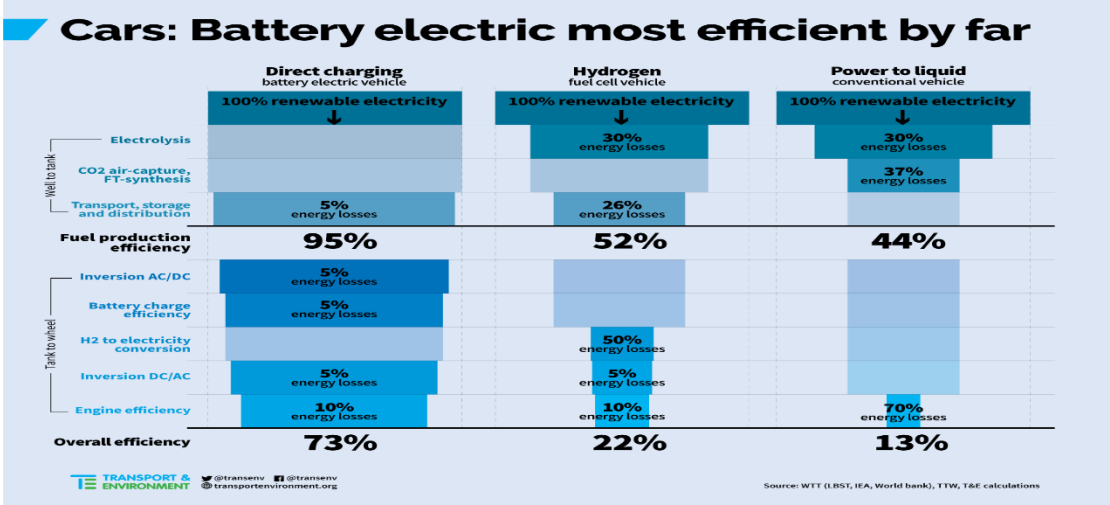

Figure (16) Batter electric most efficient types

the accompanying graph clearly shows that the cell productivity of electric car is high than greatest type of these cell however is a lithium-particle li-particle battery is a type of battery that is used in electric car and a variety of other devices they feature a thicker energy layer than traditional lead-corrosive or nickel-cadmium cell as a result battery manufacturers will be able to conserve space reducing the overall size of the battery pack lithium is also the lightest metal on the planet lithium-particle li-particle cell in any event do not contain lithium metal instead they contain particles if youre wondering what a particle is its an iota or an atom with an electric charge caused by the loss or gain of at least one electron lithium-particle cell are likewise more secure than numerous other options and battery makers should guarantee that wellbeing measures are set up to safeguard customers in the improbable case of a battery disappointment for example makers furnish electric car with charging shields to safeguard the cell during rehashed quick charging meetings in a brief timeframe.(edfenergy).

3. Mathematical Optimization Model of Battery Swapping Stations

3.1. Introduction

Including Battery Swapping Stations in distribution grids can offer a wide range of benefits to the power grid, such as peak reduction, congestion relief and capacity deferral. This chapter presents a mathematical optimization model for battery swapping stations, considering interrelationships among battery swapping, Storage of the battery vehicles, and the utility.

3.2. Mathematical Optimization Model

An optimization mathematical model is developed with an objective of minimizing the total cost of the battery swapping stations, as follows

$$Min\ Cost^{P\&O} \qquad \text{Equation 1}$$

Where $Cost^{P\&O}$ represents the operational planning cost of the battery swapping stations, that includes the cost of buying power from the grid, peak demand charge, and net of the revenue from selling power to the gird.

The following constraints apply:

Energy Management Constraints of battery swapping stations

- *Energy Management Constraints*

Power Given and Taken by battery swapping stations: This constraint ensures that the power given and taken should be within the energy management balance of the battery swapping stations.

$$\gamma_z^{storage\ of\ battery} P_{z,h}^{storage\ of\ battery} + P_{z,h}^{-ABESS} + P_{z,h}^{-ADR} + P_{z,h}^{-MG} = P_{z,h}^{+ABESS} + P_{z,h}^{+ADR} + P_{z,h}^{+MG} \qquad Equation\ 2$$

The BESS power charging and discharging should be within the BESS power limit, given by:

$$P_{z,h}^{+\,ABESS} \leq P_{size}^{BESS} \quad \forall z \in N, \forall k \qquad \textit{Equation 3}$$

$$P_{z,h}^{-\,ABESS} \leq P_{size}^{BESS} \quad \forall z \in N, \forall h \qquad \textit{Equation 4}$$

- Constrains of Power Conversion:

$$P_{z,h}^{storage} \leq P^{Inv^{storage}} \quad \forall z \ \forall h \qquad \textit{Equation 5}$$

$$P_{z,h}^{-\,ABESS} \leq P^{Inv^{BESS}} \quad \forall z \ \forall h \qquad \textit{Equation 6}$$

$$P_{z,h}^{+\,ABESS} \leq P^{Inv^{BESS}} \quad \forall z \ \forall h \qquad \textit{Equation 7}$$

- Coordination of Distributed Energy Resources: The following constraints ensure that the charging and discharging of the BESS, and power given and taken by the battery swapping stations, do not occur at the same time, as follows:

$$P_{h,y}^{+ABESS} P_{h,y}^{=-ABESS} = 0 \quad \forall z \, \forall h \qquad \textit{Equation 8}$$

$$P_{h,y}^{+SH} P_{h,y}^{-SH} = 0 \quad \forall z \, \forall h \qquad \textit{Equation 9}$$

- State of Charge of the BESS:

$$SOC_{z,h+1} = SOC_{z,h} + \left(P_{z,h}^{+ABESS}\eta^{in} - \frac{P_{z,h}^{-ABESS}}{\eta^{out}}\right)\Delta t. \quad \forall z\,, \forall h \qquad \textit{Equation 10}$$

$$0.2\gamma_z^{SH} E^{BESS} n_z^{SH} \leq SOC_{z,h} \leq \gamma_z^{SH} E^{BESS} n_z^{SH} \quad \forall z\,, \forall h \qquad \textit{Equation 11}$$

4. Summary

In this chapter, a mathematical optimization model was developed for operations planning of the battery swapping station that includes vehicle storages batteries, BESS, and the option of exchanging power with the grid that within the network limitations.

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