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A Network Model of Electric Vehicles Charging Station (EVCS) In Malaysia

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ABSTRACT

Electric vehicles (EVs) have been introduced over the past decade and have played a crucial role in reducing pollution in our country. This is evident as EVs utilize electric motors to propel, in contrast to regular petrol-based vehicles. The Malaysia Green Technology and Climate Change Corporation (MGTC), under the Ministry of Environment and Water (KASA), introduced the Electric Mobility Blueprint (EMB) in 2015, aiming to reduce the percentage of carbon monoxide gas by the year 2030. In response to the growing EV market, the ministry has expanded the capacity of electric vehicle charging stations (EVCS) nationwide. However, it should be noted that EVCS are primarily available in focused areas such as urban centers, shopping complexes, hotels, and along highways (R&R), as highlighted by the ministry. The objective of the study is to develop a network model for EVCS in Malaysia. This study aims to identify the locations of EVCS throughout Malaysia. These locations are gathered from online applications such as SETEL, JomCharge, ChargeSini, AgmoEV, ParkEasy, etc., and mapped on Google Maps to construct an EVCS network model in Malaysia. This model serves as a reference for companies or agencies interested in establishing new charging stations, based on specific criteria. Therefore, further investigation is necessary to determine potential locations for building EVCS sites, in accordance with the guidelines set by policymakers.

1. Introduction

In the contemporary era, significant advancements are evident in Malaysia, particularly within the electric vehicle (EV) sector. It is noteworthy that the EV industry is not a recent addition to the Malaysian landscape. Given the environmentally friendly nature of EVs, which can potentially mitigate air pollution and address various transportation challenges, there has been a notable surge in demand for these vehicles [1]. However, the demand for EVs in our country is not yet at the level seen in more technologically advanced nations abroad, such as Europe and the United States, which were pioneers in launching this industry. Nonetheless, Malaysia is not trailing behind in this significant sector, as the adoption of EVs presents an opportunity to decrease gasoline consumption. Moreover, the transition towards electric mobility in Malaysia promises benefits for both the environment and the economy [2].

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In a statement released by the Minister of Science, Technology, and Innovation in 2023, it was projected that EV adoption on Malaysian roads would reach 38% before 2024 [3]. So, Malaysia will also be one of the most advanced countries in this sector. According to the Deputy Minister of International Trade and Industry, Liew Chin Tong, in the last budget, the government granted full exemption from import duties, excess duties, and road taxes on locally installed or imported EVs in CBU (Completely Built-Up) [4]. In line with these incentives, more EV charging stations will be built throughout Malaysia, especially in the outlying areas. In the midst of the nation's automotive industry evolution, the Prime Minister underscored the imperative of establishing accessible charging stations (CSs), aligning with the National Energy Transition Roadmap 2023 objectives, which target 38% electric vehicle penetration by 2040 and 80% by 2050 [5].

Hence, in deploying CSs, stakeholders need to consider several key factors such as implementing specific monitoring system to address issues caused by internal combustion engine (ICE) vehicle users at these facilities, particularly in densely populated areas, areas with high rates of crime or vandalism, and popular destinations during weekends or holidays [6]. In addressing these concerns, this study endeavors to develop a network model for Electric Vehicle Charging Stations (EVCS) in Malaysia. Section 2 delineates the methodology utilized in this research, while Section 3 presents the research findings in detail. Finally, Section 4 offers concluding remarks on the study.

2. Methodology

Methodology means the methods and techniques for designing, collecting, and analysing data to produce evidence to support research. Methodology explains how a problem is investigated and why certain methods and techniques are used.

2.1 Google-Mapping

Google Maps was employed as the primary tool for coordinating the locations of electric vehicle charging stations across Malaysia. The data regarding the availability of EV charging locations was sourced from various applications including ChargeNGo, ParkEasy, Setel, JomCharge, GO TO u, PlugShare, and ChargeSini. Google Maps was selected due to its widespread usage and user-friendly interface, facilitating easy access to information. The EVCS mapping process is depicted in Figure 1.

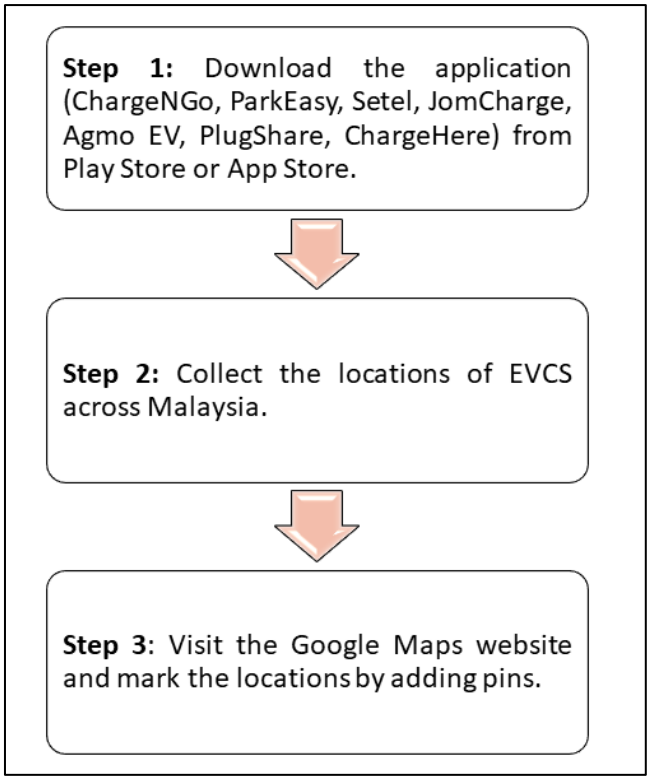

Fig. 1. EVCS Mapping Process

Here are the step-by-step instructions for pinning the locations of EVCS in Malaysia:

i. Locate the previously pinned location on the map that has been removed from the application and add it to the map, as illustrated in Figure 2.

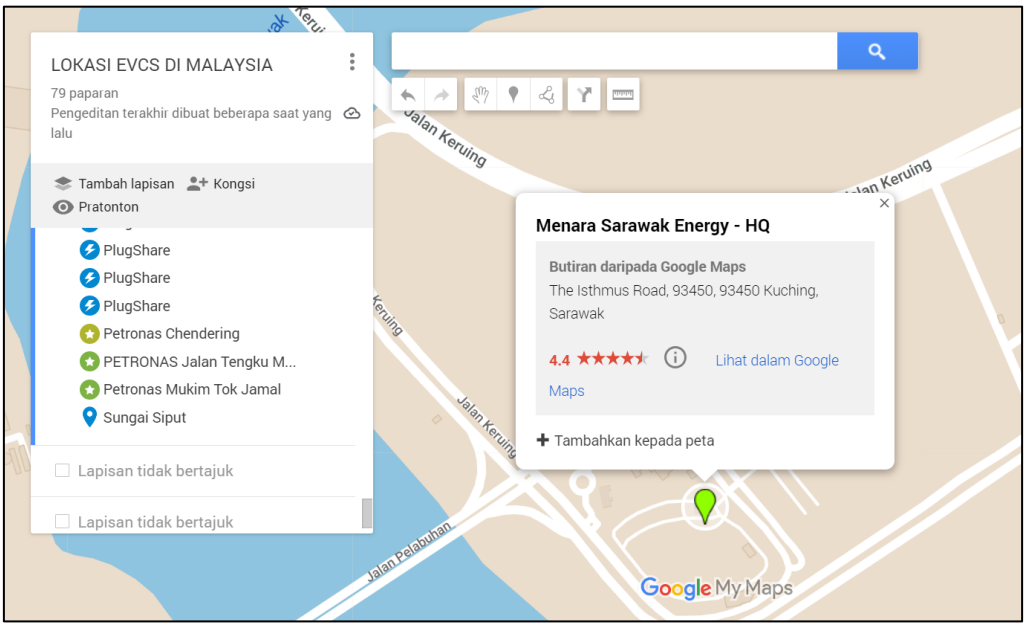

Fig. 2. Adding to map

ii. After locating the removed location, proceed by selecting the icon, color, and theme for the added EVCS on the map, as depicted in Figure 3.

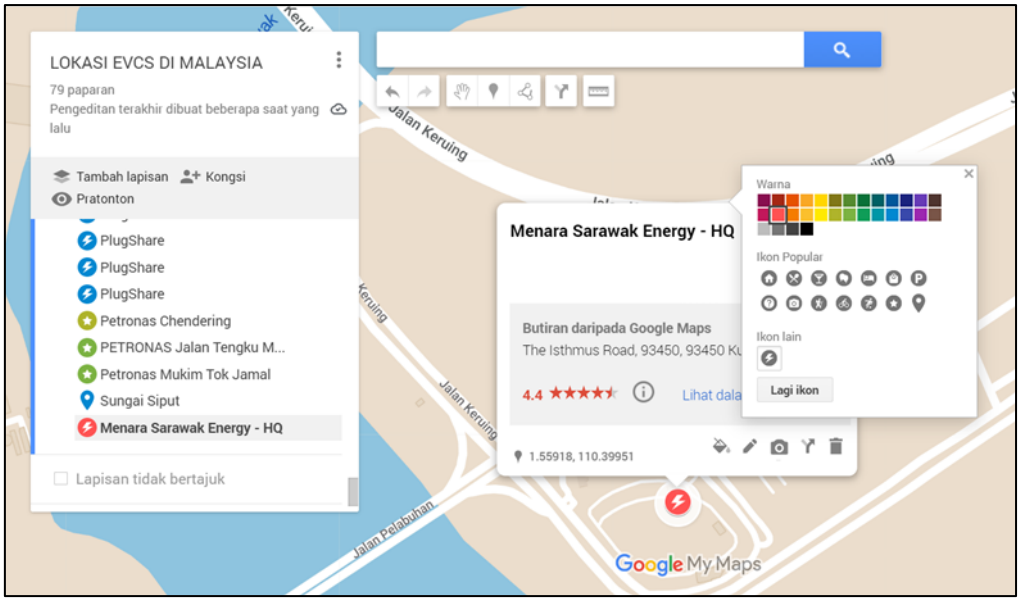

Fig. 3. Selection of icon, color and theme

iii. Finally, repeat steps (i) and (ii) for the subsequent locations.

3. Research Findings

As a result of this study, researchers found that not all oil pump stations in our country have charging stations for electric vehicles. Demand for electric vehicles has increased year after year, and even the Ministry of Investment, Trade, and Industry (MITI) has issued a statement that it will review the target of 10,000 EVCS to be operational by 2025 [7]. However, not all applications will be approved because the process is too numerous and requires approval from agencies such as the Energy Commission, local authorities, and others. There are various factors or criteria to be considered in the selection of the construction site of this EVCS.

The Malaysian Green Technology and Climate Change Corporation (MGTC) [8] under the Ministry of Environment and Water (KASA) has introduced the Electric Mobility Blueprint (EMB) in 2015 and expected the Low Carbon Blueprint in 2021 to 2030. Among the initiatives outlined under the blueprint is the setting of a national target of possibly 10,000 EV chargers operating by 2025 across Malaysia. As of July 26, 2022, MGTC has recorded the deployment of 816 EV charging stations at 406 selected locations in the country. Of this total, 651 units, or 92%, are AC type chargers (3.7 kilowatts – 22 kilowatts) while 56 units or 8% are DC type (30 kilowatt – 360 kilowatt). Therefore, the presence of CSs has played a vital role in the increasing adoption of EVs, reducing the range anxiety commonly experienced by EV users [9]. Figure 4 illustrates the integrated mapping designed to compare the locations of EVCS sourced from various applications.

Fig. 4. The locations of EVCS obtained from different applications

However, Table 1 displays the EVCS locations acquired from various applications.

Table 1
Number of EVCS in Malaysia [10]

State	Number of EV chargers	Number of EVCS location	List of EVCS locations
Selangor	270	143	Bukit Gasing (2), Lotus's Bukit Beruntung (3), KPJ Hospital Rawang (2-UM), Lotus Rawang (1), Eco Enclave Bukit Tinggi Bentong (2), Lotus Kuala Selangor (6), Starbuck Eco Grandeur (3), Izuwan Automobile Sdn. Bhd Tenaga Switchgear (TSG) Office (6), Sunway GIZA (LEVEL G) (4), Menara KPJ (CS), Majlis Daerah Sabak Bernam (1-UM), Eco Grandeur (3), Starbuck ECO Grandeur (3), Petronas Sg Buloh Lay-by (4), Lotus's Rawang (2), KPJ Hospital, Rawang (2), Lotus's Bukit Beruntung (3), D-One Motorspot (2), Kiara Bay Sales Gallery (2), Pejabat Pos Besar Shah Alam (2), SACC Mall (2), Masjid Sultan Salahuddin Abdul Aziz (2), WISMA MBSA 91), Starbuck Setia Alam (2), BMW Wheelcorp Premium Setia Alam 4S Centr (2), ECO Ardence (8), Setia Alam Welcome (1), AEON Mall Bukit Beruntung (2), SP Setia Corporate HQ (1), Setia City Convention Center (2), Audi Showroom Setia Alam (2), Menara Maybank (3), Sungai Wang Plaza (3), Aurora Place, Bukit Jalil (6), Petronas Grand Saga 3 (3), Danau Point (2),), Mini Cooper Skudai R&R Southbound (2), Lotus Mutiara Rini (3), Eco Business Park (2-UM), Sutera Mall (5), Volvo Pekin Auto (3-UM),
Wilayah Persekutuan Kuala Lumpur	250	85	Desa Damansara (2), Court 28 Residence (2), Taman Midah Cheras (2), Bandar Bukit Jalil (2), Taman Serangkai (2), Kampung Kerinchi (2-UM), Jln Professor D.U Azizi (4-UM),

			Bukit Damansara (2), Taman Segambut SPPK (2-UM, 1), Jalan Ipoh (2), Sentul (2), Jalan Dutamas 2 (2), Mont Kiara (2), Taman U Thant (2), D One Motorspot Sdn Bhd (2), Lotus's Tesco Kepong (3), BMW Millennium Welt KL North (2), The Maple Residence (4), MITEC KL (3-UM), Petronas Penchala Link (2), BMW Ingress Auto Damansara (2), The Nizra Building (3), Menara AIA (4), BMW Auto Bavaria KL (Occupied-3), Westart Motors Jln Tun Razak (3-UM), KLCC Convention Centre (3), Menara Maybank (3), Sungai Wang Plaza (3), Aurora Place, Bukit Jalil (6), Petronas Grand Saga 3 (3), Danau Point (2), Cyberview Resort and Spa (2), R&R Dengkil SB (2), Starbuck Rimbayu DT (2), AEON Bukit Tinggi (10), Bangunan SSASS (2), Pusat Akuatik Darul Ehsan (2), Petronas ELITE (2), SUNWAY GIZA (3), Tenaga Switchgear (3), Lavile KL (5)
Johor	77	42	BMW Millenium Welt Batu Pahat (1), Johor Premium Outlets (2), Mini Cooper Skudai R&R Southbound (2), Lotus Mutiara Rini (3), Eco Business Park (2-UM), Sutera Mall (5), Volvo Pekin Auto (3-UM), KPJ Bandar Dato' Onn Specialist Hospital (2-CS), Legoland Hotel (4), Aco HQ Johor Bharu (residence)(3), Palkom Motors JB (3), JBCC Komtar (2-UM), Zenith Lifestyle Mall (5), Wetex Parade (2), Starbuck Seri Austin (2), Palkon Motors (3), Pelangi Leisure Mall (3), Plaza Kelangi (3), JBCC Komtar (2), One Amber (5), Fulcrum (2), Urban Treasure (2), The Florence Residence (4), The Garden Residence (3), The Estuary (4), A Treasure Trove (2), Parc Botania (4), Jadescape (1)
Pulau Pinang	44	28	Starbuck Icon City (1), Iktikadraya Northen Bukit Mertajam (3), Starbuck Juru R&R (2) Petronas Juru Layby Arah Utara (2), BMW Tiang Siang Premium Auto Penang (3), Petronas BKE2 Butterworth bound (1), Quensbay Mall (2-UM), MBPP Relau Sports Complex (2), Tealive Bagan Ajam (3),Starbuck Tanjung Tokong (2), Hard Rock Hotel Penang (2), Central Square (2-UM), Hard Rock Hotel Penang (2), Entopia Penang Butterfly Farm (2), Shangri-La's Rasa Sayang Resort Penang (1), Gurney Plaza (1), Marriot Residence (4), Auto Bavaria Penang (1), Choo Plaza Georgetown Penang (1), Starbuck Island Glades (2), Udini Square Gelugor Penang (1), Suntech Power (1), Intel Penang PG15 (3)
Perak	25	16	Petronas Ulu Bernam Southbound (3), Behrang NB Layby (4), Xpark Sunway City Ipoh (2), Starbuck Sunway Tambut DT (2), Majlis Bandaraya Ipoh (1), Pejabat Pos Besar Ipoh (2), The Haven Resort Ipoh (2-UM), BMW Tiang Siang Premium Auto Ipoh (3), Petronas Sg. Perak Northbound (2), R&R Gunung Semanggol (2), O&G Hotel Parit Buntar (2-UM)
Kedah	30	16	Kulim Central (2), Starbuck Amanjaya DT (2), Amanjaya Specialist (1), Petronas Bandar Baru Ayer Hitam (7), Starbuck A lor Setar DT (2), Pejabat Pos Besar Alor Setar (2), BMW Lee Motors Alor Setar (2), Starbuck Changlun (2), Langkawi Fair Shopping Mall (3), Adya Hotel (1), Langkawi Hotel (1-UM), Langkawi Wildlife Park (2), Skycab Langkawi (3)
Sarawak	22	17	Roxy Beach Hotel Sematan (3), Wisma Sanyan (3), Sarawak Energy Sibu (2), The Spring Bintulu (3), Miri City Hall (4),

			Miri Green Community (2), Permy Mall Miri (3), Sarawak Energy (2)
Pahang	20	10	Petronas Gambang Arah Barat (3), Petronas Gambang Arah Timur (2), Starbuck Kuantan Indera Mahkota DT (2), Proton Pesat CTM (2), TJM Cars Kuantan (1), Starbuck Teluk Cempedak (2), Petronas Peramu 2 (1), Villea Rompin Resort & Golf (3), Petronas Gambang Arah Barat (2) Zoo Teruntum Kuantan (1), BLH Econergy Kuantan (1)
Melaka	16	10	Ayer Keroh OBR Southbound (3), AEON Melaka Shoping Centre (4), Starbuck Kota Laksamana DT (2), Kings Green Hotel City Centre Melaka (2), Pejabat Pos Besar Melaka (1), Marvelux Hotel (4),
Negeri Sembilan	24	9	Bandar Baru Nilai (4), Sembayu Villa (2), BMW Millenium Welt Seremban (2), R&R Seremban Nourthbound (2), Pejabat Pos Besar Seremban (2), Petronas Jalan Sultan Azlan Shah JSAS (4), D'Tempat Country Club (2-UM), D'Wharf Hotel & Serviced Residence PD (6)
Sabah	16	14	Damai Lagoon Resort (1), SRS Automobile (3), BMW Regas Premium Auto Kucing (2), ICOM Square Gentari (2), PELITA The Isthmus (2), MIRI City Green Community Hub (1), Centre Point Mall Kota Kinabalu (2-UM), Regas Premium Sabah Sdn.Bhd (3),
Terengganu	13	10	Mydin Mall Gong Badak (1), Fajar Homestay Manir (2), Hotel Tanjong Vista (1), Primula Beach Resort (2), Genius Europe Auto (1), T&B Electron Paka R&R North (1), Kelab Golf Rekreasi Petronas (1-CS), Club Med Cheranting (1), Royal Chulan Cheranting Villa (1), Kemaman Kopitiam (2)
Kelantan	10	5	Petronas Kota Bharu (4), Starbuck Indera Mahkota (1), JW Guest House (1), Nissan Showroom (1), Only You Homestay (3)
Total	816	405	

According to a study from Farah *et al.,* [6], there are various parameters or criteria in the selection of EV charging station sites and initially, 52 criteria were selected based on the specific circumstances and geographical characteristics that exist in Malaysia. These criteria include society, economics, environment, technology, accessibility, and distance.

The presence of EVCSs that are listed on Google Maps suggests that the CS is more focused on urban areas, highways, hotels, and shopping. So, do the suburbs have no capacity to build the site of EV charging stations? Therefore, the purpose of this study is to give ideas or suggestions to other agencies or companies building EVCS in the new area. It is recommended that EVCS be established with a distance of at least 20 km between each location. This distance ensures that EVs, which typically have a range of 200-250 km on a full charge, can comfortably reach the next CS. This precautionary measure helps to mitigate range anxiety and ensures reliable access to charging infrastructure for EV users. The potential new location to be built is in Tanjung Malim. Tanjung Malim is an area that can be said to be out-of-city but it is known to many because of the existence of the Sultan Idris University of Education (UPSI). Table 2 presents potential locations for new EVCS, while Figures (5 – 14) depict the specific potential locations for new EVCS in each state.

Table 2
New potential locations of EVCS

State	New location of EVCS
Kedah	Kulim Central - Petronas Parit Panjang, Kuala Ketil (40.7 km)
Perak	Petronas Kuala Kubu Bahru - Petronas Kayangan Mukim Ulu Bernam Tanjung Malim (21.6 km)
Terengganu	Petronas Pak Sabah - Petronas Tok Jamal Kuala Berang (64.5 km)
Negeri Sembilan	Sembayu Villa - Petronas Simpang Durian (37.2 km)
Kelantan	Gentari Perdana Kota Bharu – Petronas Rantau Panjang (31.2 km)
Melaka	Petronas Sempang Ampat - Petronas Masjid Tanah (16.2 km)
Johor	Petronas Tangkak - Petronas Batu Anam (39.1 km)
Sabah	Petronas Pekan Beluran – Petronas Jalan Utara Sandakan (55.8 km)
Sarawak	Petro Station Daro - Petronas Dalat (59.8 km)
Perlis	Petronas Zhidatech Kangar - Petronas Jln Raja Syed Alwi (12.9 km)

State: Perak

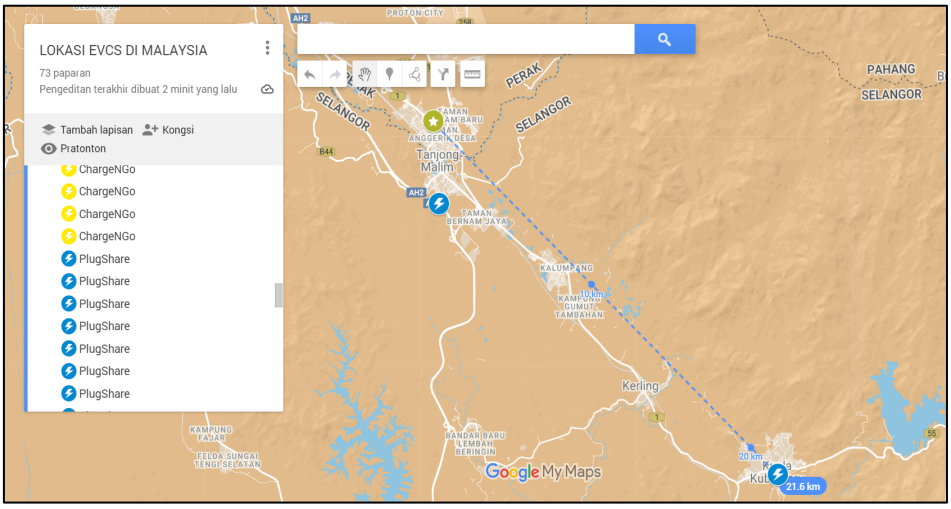

Fig. 5. Petronas Kuala Kubu Bahru - Petronas Kayangan Mukim Ulu Bernam Tanjung Malim (21.6 km)

State: Terengganu

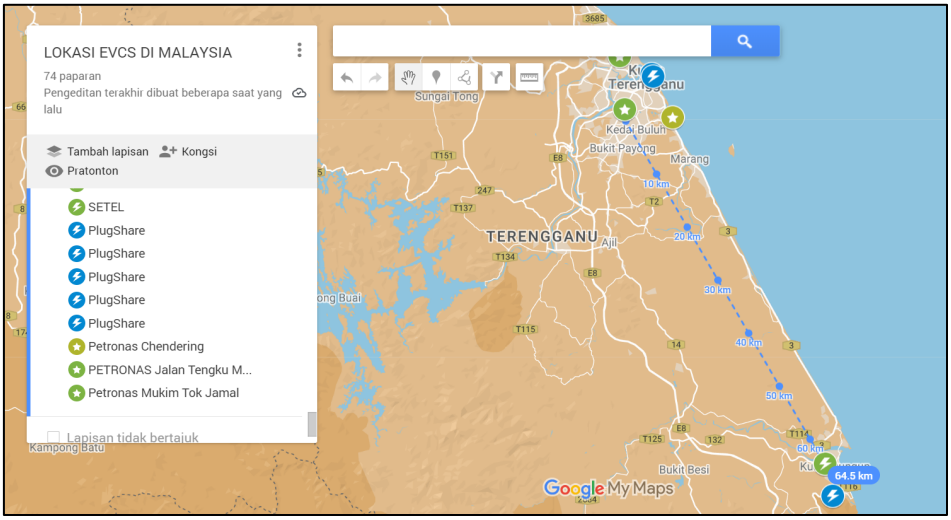

Fig. 6. Petronas Pak Sabah - Petronas Tok Jamal Kuala Berang (64.5 km)

State: Kedah

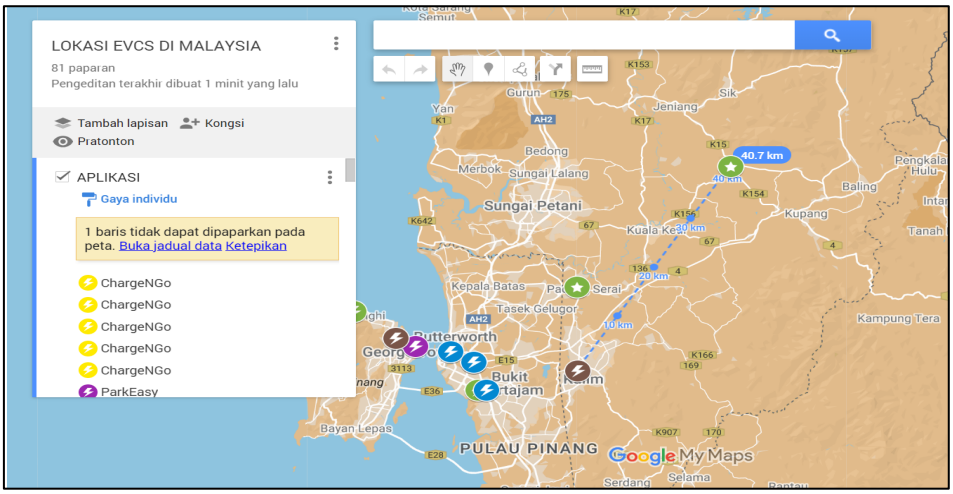

Fig. 7. Kulim Central - Petronas Parit Panjang, Kuala Ketil (40.7 km)

State: Negeri Sembilan

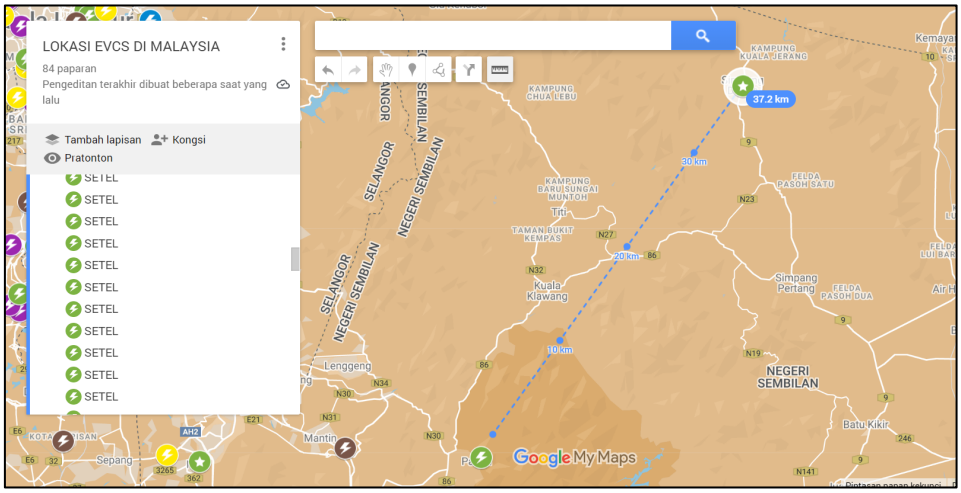

Fig. 8. Sembayu Villa - Petronas Simpang Durian (37.2 km)

State: Kelantan

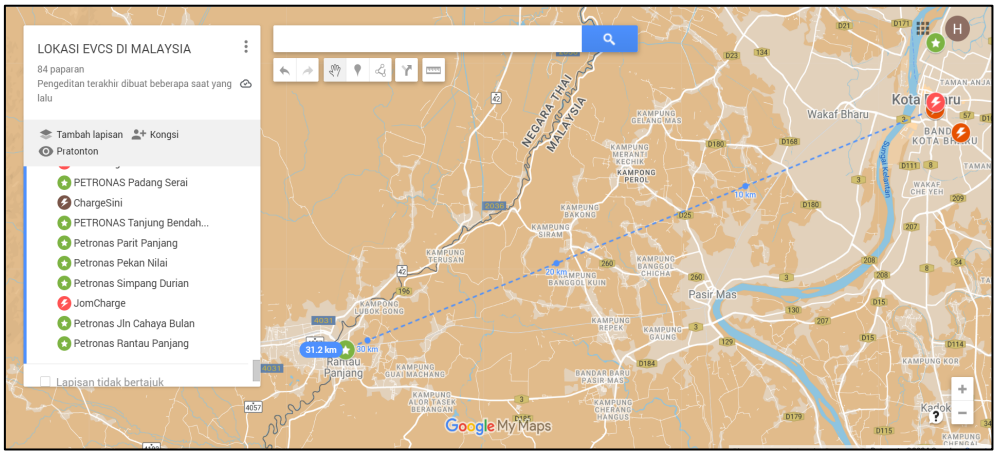

Fig. 9. Gentari Perdana Kota Bharu – Petronas Rantau Panjang (31.2 km)

State: Sabah

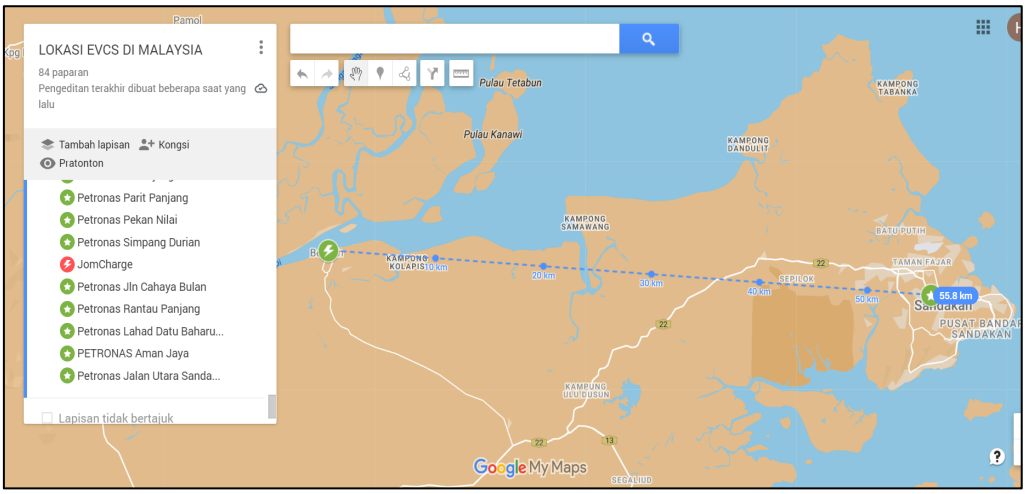

Fig. 10. Petronas Pekan Beluran – Petronas Jalan Utara Sandakan (55.8 km)

State: Sarawak

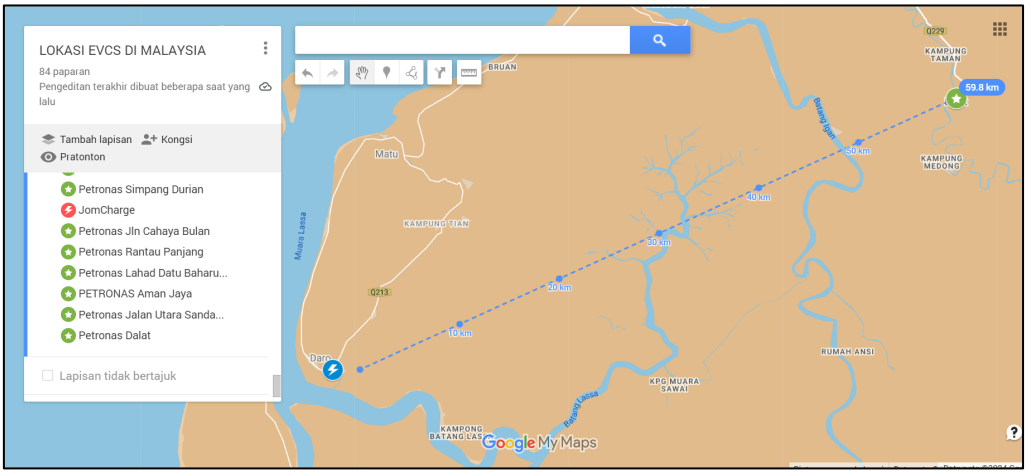

Fig. 11. Petro Station Daro - Petronas Dalat (59.8 km)

State: Johor

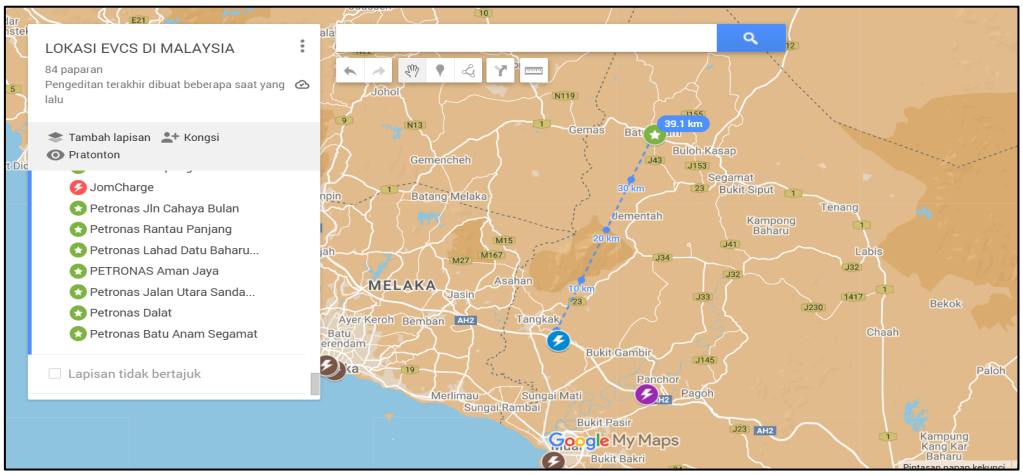

Fig. 12. Petronas Tangkak - Petronas Batu Anam (39.1 km)

State: Melaka

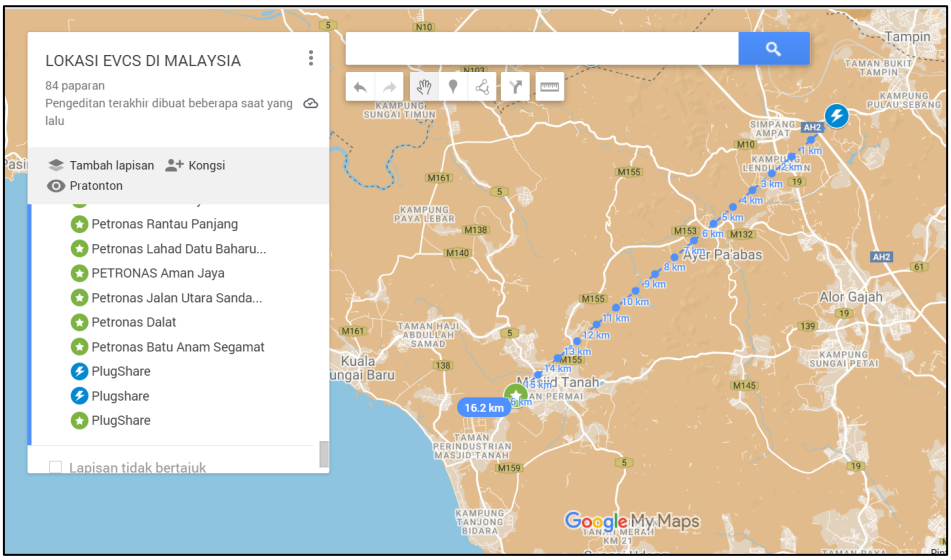

Fig. 13. Petronas Sempang Ampat - Petronas Masjid Tanah (16.2 km)

State: Perlis

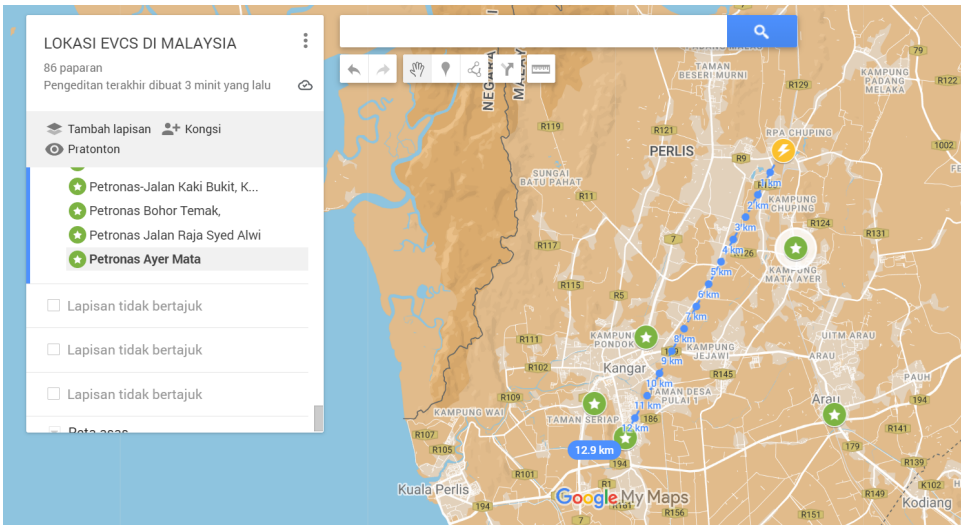

Fig. 14. Petronas Zhidatech Kangar - Petronas Jln Raja Syed Alwi (12.9 km)

For example, Petronas Kayangan Mukim Ulu Bernam Tanjung Malim has the potential to build an EVCS because it is in the middle of the path to the Slim River and to Rawang. It is 20 kilometers away from Petronas Kuala Kubu Bharu. The 20 km distance is considered because the main purpose is to multiply these EVCS in the outskirts. Additionally, one of the other criteria for why these EV charging stations should be built near the oil pump station is because hybrid vehicles also require petrol products. However, in the article by Farah *et.al.,* [6] it is stated that the charging stations built nearby are inappropriate because they lead to a waste of resources. The investigators disagree with this statement because there will be no waste if there is a request.

In this year of 2024, our society has been wise in choosing a Go Green vehicle. In fact, it is the area of Tanjung Malim and there is a famous automotive factory called PROTON. PROTON is on the verge of developing EVs and will be the first manufacturer of electric cars in Malaysia by 2025 [11]. Not only that, Proton Holding Bhd's (PROTON) will partner with China's Zhejiang Geely Holding Group

Co. Ltd (GEELY) in expanding the production of EVs in Malaysia. Among the new technologies listed are smart connectivity systems, voice activation systems, polymer fuel tanks, luxurious interior packaging, and so on. Proton's Deputy Chief Executive Officer, Roslan Abdullah, argues that the merger of GEELY's expertise in Proton can develop benefits in many aspects such as EV technology and expertise [12].

Furthermore, there is potential for Petronas Tok Jamal in Kuala Berang, Terengganu, to be developed as an EVCS location. This is because the researchers' plotting of Google Maps revealed that the Terengganu area had a lower distribution of EVCS. According to SETEL, Petronas Pak Sabah has an EV charging station in Kuala Dungun. This PETRONAS is located 64.5 kilometres away from Petronas Tok Jamal. This is a considerable distance that might be used for the construction of a new EVCS site. Residents of Terengganu who live or work in other states will be able to return to Terengganu with careful planning if this PETRONAS is converted into an EVCS. The manufacturer has established an estimated driving distance for each EV. The government and the EV manufacturer have established an estimated driving distance for each model. Still, because it tracks our driving habits, this number is unpredictable. EVCS should be installed in locations with lower EVCS distribution since the overall range of electric vehicles is constrained.

Enhancing EVCS networks in Malaysia requires a multi-faceted approach that includes expanding infrastructure, standardizing protocols, offering incentives, fostering partnerships, promoting education and awareness, driving innovation, and implementing supportive regulations [13]. By prioritizing these strategies, Malaysia can pave the way for a more sustainable transportation future powered by electric vehicles. Embracing these initiatives will not only reduce carbon emissions and dependency on fossil fuels but also spur economic growth and technological advancements in the transportation sector [14]. Hence, the EV sector has considerable potential for driving economic growth in the future [15]. The challenge of charging station placement involves identifying the optimal locations within the transportation network to minimize any impact on the operational efficiency of the distribution network [16]. With a collaborative effort from both public and private sectors, Malaysia can create a robust and comprehensive EVCS network that supports the widespread adoption of EVs and contributes to a cleaner and more efficient transportation ecosystem [1][13].

4. Conclusion

On the whole, researchers found that EV charging stations in the country are increasing due to high demand for electric vehicles. Through this study, researchers have included all EVCS locations in Malaysia in a single map to make it easier for users to plan travel and charging. Despite this, users can continue to make bookings in applications like SETEL, ChargeNGo, JomCharge, Chargesini, Go-To-U, Agmo EV, and more. The use of these electric vehicles must be passed on to all communities because of the many benefits it has to us. Even the United States (USA) at the beginning of 2017 recorded the best achievement in sales of these electric vehicles [17]. As a developing country, governments should follow the footsteps of advanced countries such as the United States, Japan, Korea, and others in increasing the production of these electric vehicles. Indirectly, the country's economy will also grow and make the environment and the air of our country better. Therefore, researchers have also made a little search and plan to add EV charging stations in Malaysia especially in the outlying areas and in the East Coast area. There are some potential new locations to be used as the site of a new EV charging station. In fact, the researchers have also pointed out some of the appropriate criteria in the construction of new EVCS.

Malaysia intends to construct more electric vehicle charging stations (EVCS) by 2030, per the plans outlined in the Electric Mobility Blueprint 2021–2030. The countrywide adoption of electric vehicles is encouraged, and the growth of the electric vehicle sector is supported. The development of EVCS infrastructure in Malaysia has been committed to by the government, pertinent agencies, and private companies. Plans to increase the number of CSs in public areas like retail malls, office buildings, and residential neighbourhoods are part of this. In fact, this program is a part of the attempts to promote the use of environmentally friendly cars and lessen air pollution. It is envisaged that having more EVCS will boost consumer confidence in switching to electric cars and guarantee convenient access to charging. As a result, we can anticipate that Malaysia will continue to make progress toward 2030 and beyond in the development of EVCS. So, this study is very important and the manufacturers of EVs should focus on the shortcomings of the vehicles and improve them for the future use.

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