# Turkey's Domestic Car TOGG in the Framework of New Trends in Electric Vehicles and Consumer Ethnocentrism

H. Nurgul Durmus Senyapar and Mehmet Rida Tur

***Abstract*— Rising energy demands, and technological requirements are causing the world to focus more and more on Electric Vehicles (EVs). Developing technologies for these needs accelerate the development of smart and sustainable transportation and builds smart cities of the future. In this context, Turkey's Automobile Enterprise Group, known as TOGG, was established in Turkey in 2018 with six partners and joined the EV market. In this study, new trends and emerging EV technologies such as wireless charging, smart power distribution, vehicle-to-home and vehicle-to-grid systems, connected vehicles, and autonomous driving for EVs are compared with TOGG technology; and its potential effects on the market are evaluated within the framework of consumer ethnocentrism. It also provides perspectives and recommendations for future smart transportation to serve as a guide for the future technological development and commercialization of EVs.**

*Index Terms*— **Turkey's Domestic and National Car, TOGG, Electric Vehicles, Battery Systems, Autonomous Operation, Intelligent Systems, Consumer Ethnocentrism.**

## I. INTRODUCTION

ADOPTION RATES of Electric Vehicles (EVs) are rising all around the globe because of a variety of favorable circumstances, including a reduction in the dependence on energy derived from fossil fuels, increased efficiency, and reduced levels of background noise [1]. In response to the global energy crisis, however, all attention has been focused on the electrification of transportation networks to produce EVs [2]. Up until relatively recently, the high costs involved in the development and purchase of EVs left both the consumer and the manufacturer uncertain about the future investment potential of original equipment manufacturers, and with it, customers. This uncertainty was compounded by the fact that EVs were not widely available. However, new companies have provided the automotive industry with a new perspective by rapidly developing new technologies, lowering the prices of batteries and other components of EVs, and opening the possibility of commercializing EVs that have appeal to a mass market. In addition, Original Equipment Manufacturers (OEMs) have been confronted with a significant rise in the level of technical complexity brought on by the proliferation of environmental rules and the growing demand from consumers for more vehicle connections. Over the last century, car manufacturers have become experts in the art of developing and producing cars powered by internal combustion engines. However, to keep up with the development of new technologies, the procedures and tools that are used to create new tools must also continue to advance. Now, there are still a substantial number of cars running throughout the globe that are powered by traditional Internal Combustion Engines (ICEs). These vehicles use a significant quantity of fossil fuels. Because of this, the electrification of automobiles is advancing at a fast pace. In general, pure battery, plug-in hybrid, and fuel cell EVs are the three categories that fall within the category of "green" EVs. Plug-in hybrid EVs are capable of being categorized as a transitional type because they continue to make use of fossil fuels and release pollutants [3]. Although fuel cell EVs offer several benefits, such as high energy efficiency, extended driving range, and rapid hydrogen filling, their technology and market are still not particularly widespread [4]. EVs that run only on the energy generated by their batteries are known as pure battery EVs. These cars emit no emissions whatsoever. Pure battery EVs currently hold much of the market share for EVs and have earned their place as mainstream models [5,6]. This is due to the ongoing development of new battery technologies, the rapid construction of charging facilities, and people's pursuit of low-carbon travel in recent years.

Despite significant advances in fundamental research on battery materials, drivetrains, and technical-level control strategies for EVs, consumers' initial assessment of EVs will

**H. NURGÜL DURMUŞ ŞENYAPAR**, is Gazi University Quality Coordinator, Ankara, Turkey, (e-mail: nurguld@gazi.edu.tr).

https://orcid.org/0000-0003-0927-1643

**MEHMET RIDA TUR**, is Electric and Energy Batman University, Batman Technical Sciences Vocational School Batman, Turkey, (e-mail: mrida.tur@batman.edu.tr).

https://orcid.org/0000-0001-5688-4624

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be extremely important. This is something that needs to be done for the successful commercialization of EVs in many developing countries. Research is progressing quickly in the areas of battery technologies [7-9], engine technologies [10,11], charging technologies [12], and power transmission systems [13,14].

The emergence and rapid development of the above-mentioned new technologies and their successful implementation in EVs have initiated a new revolution in the field of EVs. Even though previous analyses and summaries of EVs were extremely comprehensive and detailed, it is believed that the development of new technologies that can be used in EVs would grow the market and motivate more people to start using EVs. Within the framework of EV, the presentation of the new trend takes place in Part 2, and the presentation of typical technical advancements takes place in Part 3 by concentrating on representative instances of technology products developing in various nations. Following that will be a discussion on the new technological possibilities for TOGG, followed by a presentation of future potential and challenges. In conclusion, an investigation of the outcomes as well as projections for the future stages of TOGG's EV development is carried out. This research is very important for increasing TOGG's attractiveness to customers and promoting the growth and maturity of the market. A certain guiding experience and a leadership role for the future courses of EVs may be gained from the prosperous EV development experience that has been presented in this article for several example nations. As a result, this article presents some points of view and suggestions for the development of EVs in the smart cities of the future. In addition, smart cities are searching for innovative answers to various urban problems (environmental, social, and financial) that have surfaced because of the operation of the grid network, development, and fundamental circumstances (such as vehicles, waste, and energy). However, this cooperation is not always detectable, and it is necessary to conduct tests to identify the most significant benefit [15-17].

## II. ELECTRIC VEHICLES AND TREND TECHNOLOGIES

The purpose of the study is to show recent innovations that have emerged in the field of TOGG technology in comparison with other types of electric cars. Emerging technologies, such as wireless charging, smart power distribution, vehicle-to-grid (V2G) and vehicle-to-home (V2H) systems, and autonomous driving are also thoroughly discussed here, along with the obstacles and new possibilities that each present. Following what is shown in Fig. 1, the trend will be segmented into five subgroups that directly correlate to the five new trends.

### *A. Wireless Charging Feature*

If the induction charging system is in a magnetic resonance coupling state, excellent charging efficiency can still be guaranteed even if the transmit and receive coils are several feet apart [18,19]. This is because magnetic resonance coupling allows magnetic fields to be coupled in a way that is insensitive to distance. Using this approach, automobiles that are parked in garages or on the street may be effectively charged with 3-7 kW of electrical power across vast range lengths when the induction charging system has well-adjusted hardware components and is positioned at the ideal angle [20,21]. Fig. 2 displays a diagrammatic representation of a typical wireless charging system that is fixed.

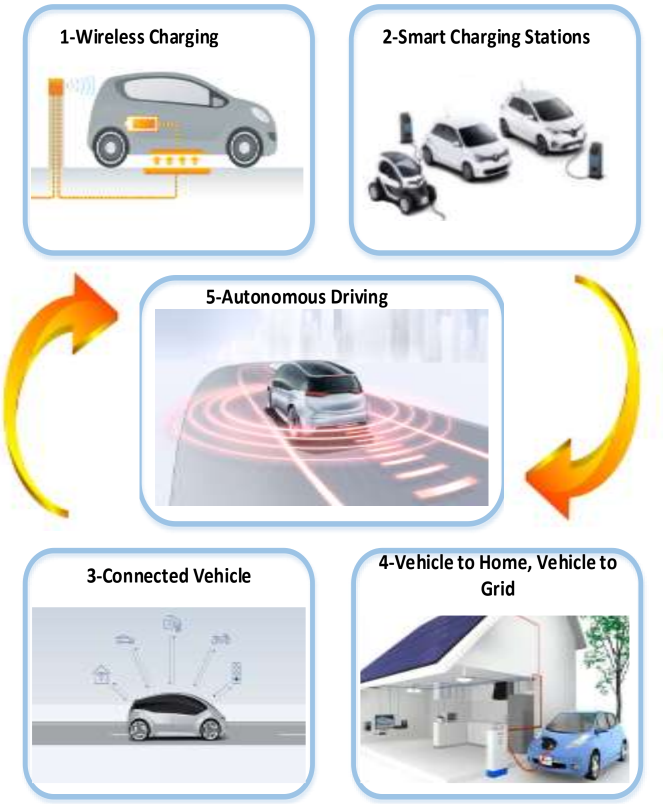


Fig. 1. Structure and highlights of this review

Traditional methods of charging have their place, but wireless charging offers many advantages over them, including increased adaptability, longevity, and dependability. It is also more convenient for automobile drivers. These stations not only prevent irreparable damage and corrosion to charging connectors caused by frequent dropping and plugging, but they also provide safe charging in potentially hazardous scenarios, such as explosive gas stations where electric sparks are prohibited [23,24]. In addition, these stations prevent irreparable damage and corrosion to charging connectors caused by frequent dropping and plugging. From the year 2020 until the year 2025, it is anticipated that the worldwide market for EV wireless charging will rise at a compound annual growth rate of 49.38% [25]. Another key component that will continue to drive the market is the sustained growth of rapid EV chargers, which is expected to reach a size of over $7 billion in 2025. Using predetermined electromagnetic coils buried under the road, the advanced dynamic charging idea intends to continually charge EVs when they are stopped at a signal or even while they are moving. Figure 2 explains the concept of the "smart city" of the future, which is envisioned to include a well-established wireless charging infrastructure.

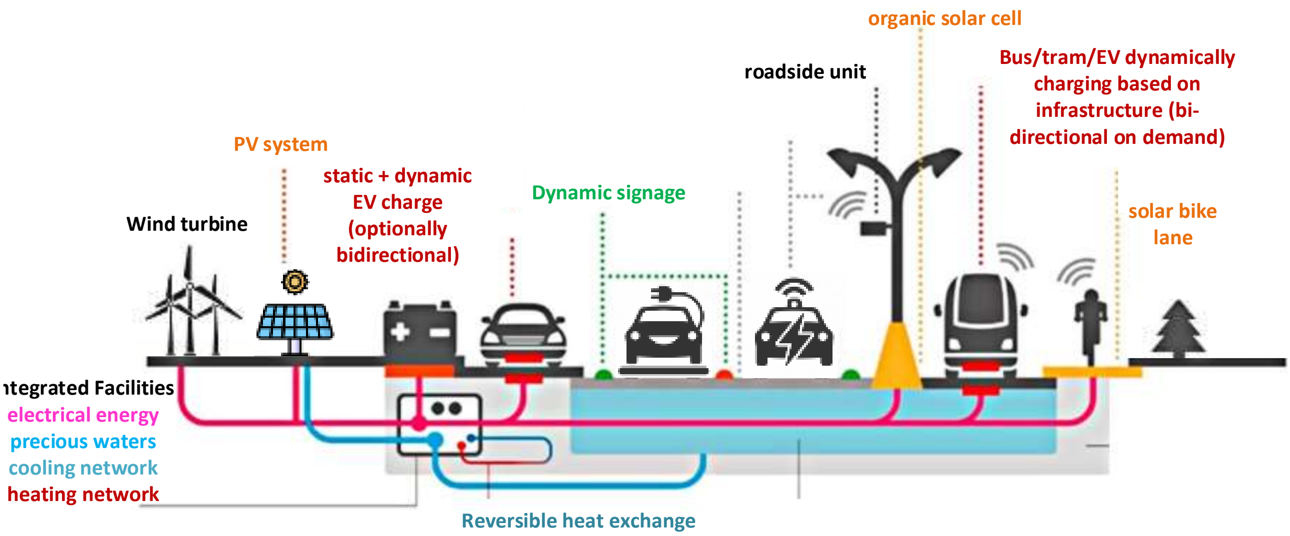


Fig. 2 Fixed wireless charging [22].

TABLE I
SUMMARY OF CHALLENGES AND OPPORTUNITIES OF WIRELESS CHARGING IMPLEMENTATION IN EVS [26].

| Challenges | Opportunities |
|---|---|
| Misalignment tolerance of charger | Application and development of new materials |
| Timing of high-speed power transfer | Extended range and battery life on EVs |
| Multiple vehicles charging per transmitter | Developing autonomous driving |
| Charger life and durability under real conditions network effect | Renewable energy storage |
| Grid effect | Frequency control in grid connection |
| High cost of infrastructure construction and large-scale deployment | Cost reduction for EVs |
| Interoperability between multiple manufacturers | Cost reduction and environmental benefits |
| Benefits | |
| Universal standards | |
| Fast charging | |

### B. *Smart Power Distribution Technologies*

The efficient distribution of electricity allows for the charging of additional EVs without requiring significant infrastructure improvements. Instead of adding extra physical electrical capacity, the power distribution system may dynamically divide the available power among additional electric vehicle chargers to allow for the charging of a greater number of EVs [27-29]. Figure 3 uses a typical system to highlight the benefits that may be gained by implementing intelligent power distribution. Drivers want information on charging that is communicated openly and honestly, including up-to-date details on the availability of charging stations and the rates charged during peak and off-peak hours. Drivers will have access to sophisticated EV charging management options thanks to a back-end charging centralized control and management system that is comprehensive [30]. These solutions will include demand-side response intelligent energy management.

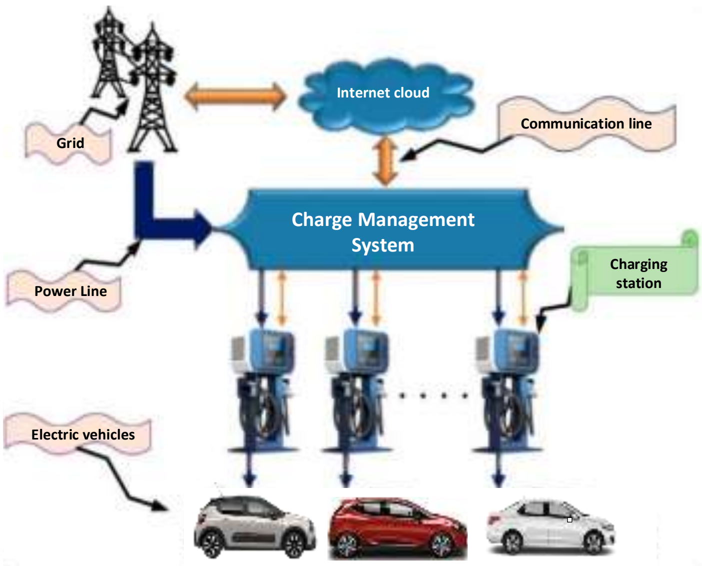


Fig. 3. Schematic diagram of smart power distribution [31].

The integration of secondary batteries and renewable energy sources into the electrical grid is developing into an advanced smart power distribution technology that makes it easier to deploy quick electric vehicle chargers. The capacity of the electrical grid may be increased by re-feeding surplus power output from secondary batteries and renewable energy sources, such as green energy generators. Secondary batteries, which serve as energy buffers, can provide electricity in times of crisis, such as when the grid is overloaded or severed [32].

Table 2 provides a concise summary of the potential and difficulties that lie ahead in the development of intelligent power distribution for EVs.

TABLE II
A SUMMARY OF THE POTENTIAL AND PROBLEMS ASSOCIATED WITH THE IMPLEMENTATION OF SMART POWER DISTRIBUTION FOR EVS [33].

| Challenges | Opportunities |
|---|---|
| Market Framework | New market models enabling active and reactive EV distribution service systems such as load shifting, peak shaving, valley filling, voltage regulation, and distribution system level reactive power control. |
| Economic aspects | Economic considerations, including benefits analysis for all stakeholders and possible compensation strategies for service providers. |
| Battery corruption | Integration of battery degradation costs with changes in charge/discharge strategies. |

## C. *Vehicle Connection Technologies*

The connectivity technologies operate together seamlessly with three different networks: the in-car network, the V2G network, and the mobile internet in the vehicle itself. It is a massive, distributed communication system for V2X interaction that incorporates X, and it is also known by its acronym, IoV, which stands for the "Internet of Vehicles". Vehicle connections offer a multifunctional network that supports intelligent transportation management, intelligent dynamic information services, and intelligent driving control [34]. This comprehensive scenario for the implementation of the Internet of Things (IoT) in the Intelligent Transportation System (ITS) is provided by the Internet of Things (IoT) in the Intelligent Transportation System (ITS). Certain communication protocol standards, such as the IEEE 80211p WAVE standard or cellular data protocols [35], are adhered to throughout the process of exchanging information. Interfaces to WiFi or cellular networks (GSM, HSDPA, LTE, or 5G are projected to be built on a significant scale) and other short-range communication technologies are often included in typical car connection systems [36]. The Global Vehicle Identification (GVI) terminal is without a doubt the technology component that is essential to the connectivity of vehicles and serves as the communication gateway [37]. It allows the vehicle to have global locating and tracking capabilities, as well as a worldwide network connection, thanks to its integrated information sensors, network communication module, and Global Online Identification (sometimes known as an "online license plate") [38].

Table 3 provides a summary of the difficulties that may arise and the possibilities that may present themselves throughout the development of Connected Vehicles (CVs) technologies for EAs in the future.

TABLE III
SUMMARY OF CHALLENGES AND OPPORTUNITIES IN IMPLEMENTING CVS IN EAS [39].

| Challenges | Opportunities |
|---|---|
| CV interoperability | Blockchain integration with CVs |
| CV reliability | Improving the reliability, flexibility, safety, security, and privacy of CVs |
| Efficient wireless resource allocation in CVs | Implementation and development of artificial intelligence (AI) and machine learning techniques in CVs |

## D. *V2H and V2G Technologies*

While the V2H system makes it possible to utilize the energy that has already been stored in the EV to power a home, the V2G system makes it possible to sell the electricity that has already been stored in the EVs to the grid and charge the EV by buying electricity from the grid [40]. Software for managing the battery, hardware to handle the transfer of power in both directions and communication modules to provide two-way dialogue between the vehicle terminal and the grid operator are the primary components of V2H and V2G systems [41]. Intelligent algorithms keep a constant watch on the working condition of the grid to assess in real-time whether a vehicle is now able to purchase or sell energy from the grid and whether or not a vehicle is qualified to reach the applicable agreement.

In 2013, an example project (Fig. 4) was presented to link EVs, solar power production, and individual consumers via the use of a smart grid and home information management system [42,43]. By using the V2G technology, it was able to communicate the following findings to the public [44-46]:

- Significantly increased energy self-sufficiency, which resulted in an improvement in participants' zero-emission energy autonomy (from 34% to 65%)
- The frequency of energy exchanges between participants and the grid has been significantly reduced (45%)
- The utilization efficiency of electrical energy storage capacity has reached 93%
- Energy loss from conversion during the process of storing energy in DC batteries and recovering power from them is 80%
- Battery capacity consumption for powering EVs has reached 80%
- Battery capacity consumption for two years of use was negligible (6~7%) [47,48].

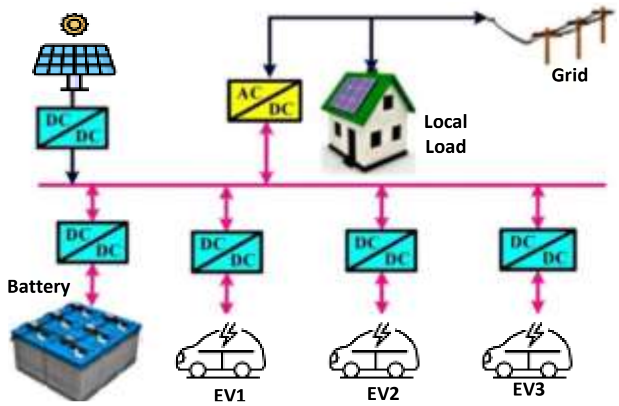


Fig. 4 Representative V2G and V2H systems in different countries [49,50].

The challenges and opportunities in the future development of V2G and V2H technologies for EVs are summarized in Table 4.

TABLE IV
SUMMARY OF THE CHALLENGES AND OPPORTUNITIES OF V2G AND V2H FOR EAS [51]

| Challenges | Opportunities |
|---|---|
| Battery corruption | Integration of battery degradation costs with change in charge/discharge strategies |
| Cyber attacks | New technologies that increase the resilience of V2G and V2H systems against cyber-physical attacks and new security standards |
| Time delay | Wide bandwidth communication channels such as LAN and WAN networks |
| Stability issues | Development of robust controllers |

### *E. Autonomous Driving*

The Society of Automotive Engineers offers the most widely accepted definition of autonomous driving. Autonomous driving may be broken down into different levels, each corresponding to a different amount of automation. Realizing the potential of autonomous driving will need sophisticated technology across a wide range of fields; and sense will be essential to achieving this goal. These standards define six levels of driving automation, which are “No Automation”, “Driver Assistance”, “Partial Automation”, “Conditional Automation”, “High Automation”, and “Full Automation” [52-54]. “No Automation” is the lowest level of driving automation, and “Full Automation” is the highest level of driving automation.

Wheel speed odometry relies on a rotary encoder to keep track of the rotation of the wheel and estimate the change in position in relation to where it began [55]. However, the wheels do not always have a complete rolling motion to the ground, and they are susceptible to slipping when the driver makes rapid speed changes or while traveling on flat roads. The unrecorded drift will result in cumulative inaccuracies, and as a result, the dependability of odometry will steadily decline over time. It is important to note that visual odometry is not restricted to the form of the movement on the ground since it tries to estimate the vehicle’s location and velocity by analysing the movement of the picture from frame to frame (Figure 5), therefore, it is not limited to the shape of the movement on the ground [56]. The challenges and opportunities in the future development of autonomous driving in EVs are summarized in Table 5.

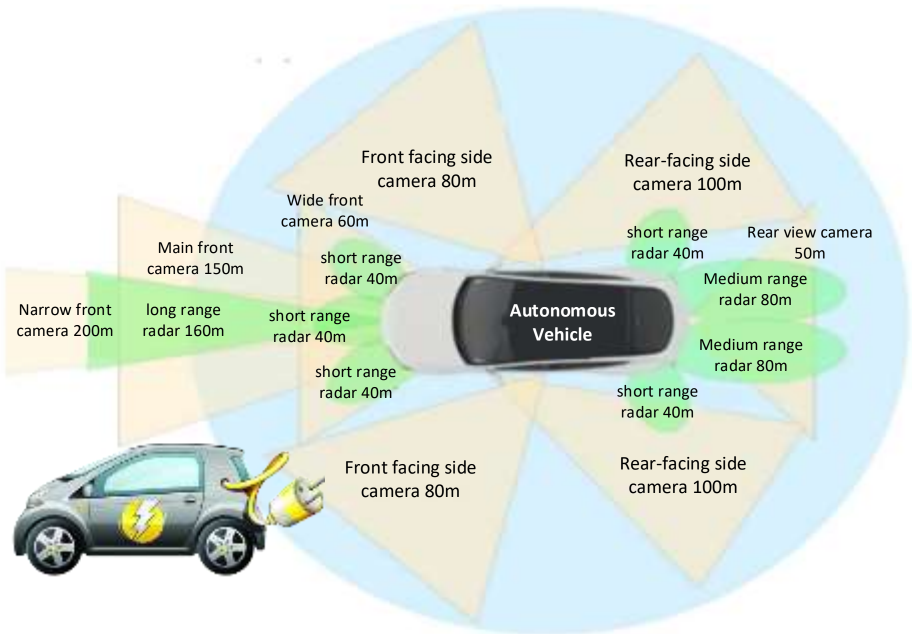


Fig. 5 Locations and scope of sensors installed in an autonomous vehicle [57]

 

TABLE V
SUMMARY OF CHALLENGES AND OPPORTUNITIES OF AUTONOMOUS DRIVING IMPLEMENTATION IN EVS [58,59].

| **Challenges** | **Opportunities** |
|---|---|
| Limited physics-based models | Data-based models and hybrid models |
| Lack of controller for arbitrary situations | Fully viable methods for numerical control design that can accommodate uncertainties and discover approximately optimal or even viable solutions under real-time operational constraints. |
| Decision-making algorithms in autonomous vehicles, from powertrain control loops to autonomous driving functionality | Development of large V2X systems and learning-based components |
| Providing high reliability, low cost, and complexity | Enhanced resilience to sensor and actuator failures, communication interruptions, and cyberattacks |
| Concerning the positioning of autonomous vehicles, there is a lot of uncertainty about what levels of automation will be brought to public roads and when. | Construction of new physical and cyber infrastructure |

## III. ELECTRIC VEHICLES AND TOGG TECHNOLOGY: EXPECTATIONS

### *A. Domestic and National Automobile TOGG*

Although attempts were made to produce domestically branded automobiles in Turkey in the 1960s, mass production could not be started. On November 2, 2017, Turkey's Automobile Joint Venture Group Promotion Meeting was held at the Presidential Complex. With the protocol signed, Anadolu Group, under the coordination of the Ministry of Science, Industry, and Technology and the Union of Chambers and Commodity Exchanges of Turkey (TOBB), established Turkey's Automobile Enterprise Group to produce the TOGG along with BMC, Kök Group, Turkcell and Zorlu Holding. The prototype of TOGG appeared on August 5, 2019. In 2017, Turkey's Automobile Initiative Group (TOGG) was launched as a domestic and national car. Prototypes of the domestic branded car were produced under the name of Turkey's Automobile and its presentation was made on 27 December 2019. TOGG made its world brand launch at CES 2022. Attending CES, held in Las Vegas, USA, between 5-7 January 2022, with its vision car, TOGG announced its innovations to the world public at a press conference. It is planned to produce 1 million vehicles in 5 different segments by 2030.

The automotive sector leads the way in Turkey's exports. With the expansion of TOGG, it is expected that Turkey will produce one million vehicles in five distinct models by the year 2030. Additionally, it is anticipated that 93 percent of TOGG's supply will be completed, with 78 percent of the supply coming from Turkey and 22 percent coming from countries in Europe and Asia. According to the country's Minister of Industry and Technology, Turkey has gathered more than $126 million to finance innovation and regional development, and it plans to acquire 30.000 cars by the year 2035. It is anticipated that the electric automobile would reach a yearly production rate of 175.000 units.

Turkish Electric Vehicles (TEV) became the first vehicle whose intellectual property rights belong to a Turkish company. TEV is expected to contribute to the Turkish economy with a USD 7.5 billion decrease in the current account deficit and an increase of USD 50 billion in GDP (TOGG Investment Office, 2020. Within the scope of this discussion, it has been determined that the TOGG battery company, which is anticipated to begin production in 2023, will be responsible for the annual manufacture of 20 GWh worth of lithium-ion batteries. With this capacity, it will be possible for Turkey to create batteries that are enough for an annual average of 250-300 thousand electric automobiles, which would avoid the country from having to import batteries that cost billions of dollars. In this regard, it is thought that meeting the demand for minerals such as lithium, nickel, manganese, and graphene, which are utilized in the creation of batteries, using indigenous resources would become an issue of considerable significance [60].

### *B. TOGG in the International Market*

The European market was ahead of the Chinese market in terms of registrations for new Plug-in Hybrid (PHEV) and Battery Electric (BEV) passenger vehicles when we conducted our most recent check at the beginning of 2022. The market in the United States was lagging that in the other two main areas. Now, the picture is a little different, demonstrating once again how dynamic EV sales still are, and for the first half of 2022, the market in China has caught up with the market in Europe. The registration of BEVs accounts for 19% of all new passenger cars, while PHEVs account for an additional 5%. A market share that is eight percentage points more than it was the year before and four times larger than it will be in 2020 is what China has accomplished in terms of market share. Because of this, China has already surpassed the 20% EV share objective outlined in the 14th Five-Year Plan Energy Conservation and Emission Reduction Work Plan, two years earlier than the 2025 deadline that was originally set shown in Figure 6 [61].

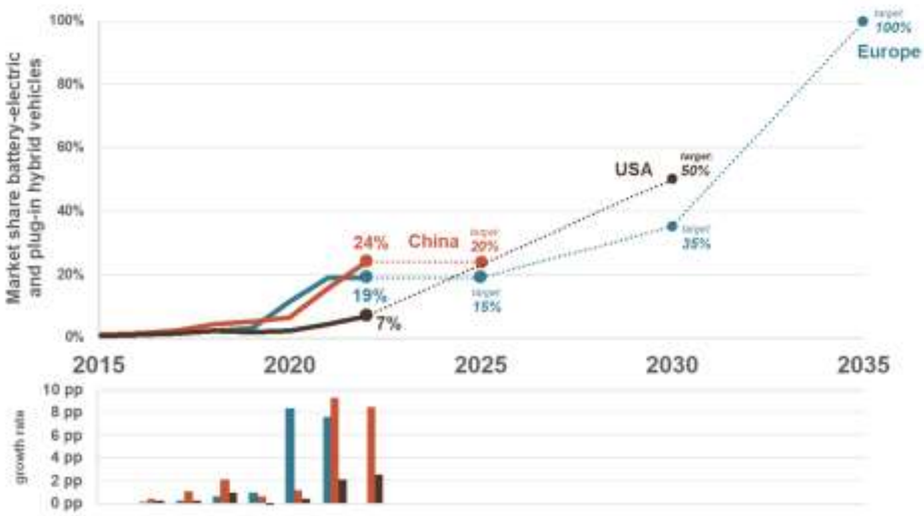


Fig. 6. Market growth rate in EVs

In this context, “Europe” refers to the European Economic Area, and the region presently holds the second-place spot with a 10% proportion of BEVs and a 9% share of PHEVs. As a direct consequence of European CO2 rules for new automobiles establishing an average goal of 95 grams per kilometers (g/km) for 2020/21, automakers have almost tripled the market share of electric cars in only one year, particularly in 2020. This trend is expected to continue. However, after successfully meeting their CO2 objectives for 2020/21 without incurring penalties, it seems that car makers’ enthusiasm for EV sales has diminished to some degree. The 2025 standard is the next regulatory goal mark; nevertheless, this standard is not significant enough to have a significant influence on the portfolio plans of manufacturers. The market seems to be growing at a pace of zero percent so far in 2022, although tax benefits for EVs are now beginning to decrease in certain European nations. In addition, there are huge waiting lists for electric cars because of persistent supply constraints.

After falling farther and further behind for a time, the market in the United States had the highest growth rate among the three primary areas during the first half of 2022. During this period, Battery EVs made up 5.5% of all new passenger automobiles, while Plug-in Hybrid EVs made up 1.4%. Sales of light trucks in the United States represent a market share that is three times bigger than it was in 2020, even though it is still lower than in China and Europe. The aim of 50 percent sales of EVs by the year 2030 which was established by the President continues to serve as the leading regulatory signal in the United States.

With the expansion of TOGG, it is expected that Turkey will produce one million vehicles in five distinct models by the year 2030. Additionally, it is anticipated that 93 percent of TOGG’s supply will be completed, with 78 percent of the supply coming from Turkey and 22 percent coming from countries in Europe and Asia. According to the country’s Minister of Industry and Technology, Turkey has gathered more than $126 million to finance innovation and regional development, and it plans to acquire 30.000 cars by the year 2035. It is anticipated that the electric automobile would reach a yearly production rate of 175.000 units.

In a summary, although the European Union’s aim of having 100% all-electric cars on the road by 2035 is unquestionably the worldwide standard, the area does not have a relevant intermediate target, especially during the years leading up to 2029. As a consequence of this, sales of EVs in Europe will remain flat, mirroring the trend that we saw in the first half of 2022. The new energy vehicle authorization in China, on the other hand, seems to apply ongoing pressure on EV sales; nevertheless, the country’s sales goal for the year 2025 has already been fulfilled, and long-term objectives are still not accessible. It seems that the planned Electric Vehicle objective in the United States is backed by improved light commercial vehicle greenhouse gas emissions requirements for the 2023-2026 model years, making it the most advanced target for EVs anywhere in the world for the timeframe 2030. TOGG engineers will reveal the electric vehicle platform that they have built as their unique work and will patent it. The platform, which will provide a structure for maximum efficiency, comfort, durability, and safety, will see a fixed investment of over 22 billion TL ($3.21 billion), and the factory will start mass production in 2022 with an annual capacity of 175.000 units [59]. The platform will provide a structure for maximum efficiency, comfort, durability, and safety; the investment in the platform will be over 22 billion TL.

### *C. Trend Technologies and TOGG Hardware*

Established in 2018, Turkey's Automobile Initiative Group has become the company that produces electric cars in Turkey, and in 2023 it will introduce 20,000 first vehicles from the T10X series to its users. The T10X series can reach 20%-80% occupancy rate in a very short time such as 28 minutes and travel 523 kilometers. The 4-wheel drive AWD model reaches 100 kilometers in 4.8 seconds with 320 kW double engine power, the rear-wheel drive RWD model reaches 100 kilometers in 7.4 seconds with 1660 kW single engine power, the models' torque is 700 Nm and 350 Nm, respectively. produced. [62]. This function is known as regenerative braking and is familiar to many who have used Tesla vehicles.

When the brake is used, kinetic energy is released, which is then captured by the alternator, where it is transformed into electrical energy and stored once again. This technique has the potential to increase the range of a typical domestic automobile by up to twenty percent. It reaches 400 horsepower in variants that include all-wheel drive, and it can go from 0 to 100 kilometers per hour in 4.8 seconds. The homegrown vehicle, which has a 200-horsepower engine and drives the rear wheels, can go from 0 to 100 kilometers per hour in 7.6 seconds. The domestic automobile, which is powered by lithium-ion batteries, offers two alternative possibilities for its range; more than 300 kilometers or more than 500 kilometers [63].

Users will benefit tremendously from the vehicle's quick-charging technology, which enables the vehicle to achieve a full charge in only thirty minutes. At the same time, the domestic automobile, which can get updates over the internet, is equipped with third-level autonomous driving technology. This is made possible by the car's sophisticated driving assistance systems. We came upon a feature in Tesla's automobiles that allowed for an upgrade to be performed via the internet. In the context of the domestic vehicle, the Internet of Things (IoT) was accorded a significant amount of importance. The intelligent energy solutions offered by TOGG provide users with complete control over the charging process and emphasize the user experience before, during, and after the charging process. Users can enjoy the most effective and convenient experience possible, free from the burden of worrying about battery life or travel distance. All users of EVs will benefit from these solutions since they provide alternatives for ecologically responsible, intelligent driving as well as charging their vehicles. TOGG can stand out from its competitors on a worldwide scale because of its Use Case Mobility methodology and the ecosystem it has developed on this foundation.

Figure 7 provides detailed information on EVs that are manufactured by a variety of companies and are reasonably priced [63]. Additionally, the projected amount of time necessary to charge the car from 0% to 80% capacity according to a variety of charging techniques is included in the figure. In this case, the voltage for the first stage of charging is similar to 110-120 V, the voltage for the second stage of charging is 220-240 V, and the voltage for the third stage of charging, also known as DC Fast Charge (DCFC), is 200-800 V. The amount of charge in an Electric Vehicle's battery is directly proportional to the vehicle's driving range. However, depending on the make and model, the range of the battery drops to between 200 and 400 kilometers after traveling 100 kilometers in certain vehicles. On the other hand, the majority of currently available EA models in China can go farther than 400 kilometers. On the other hand, the TOGG was developed for a range of between 300 and 500 kilometers.

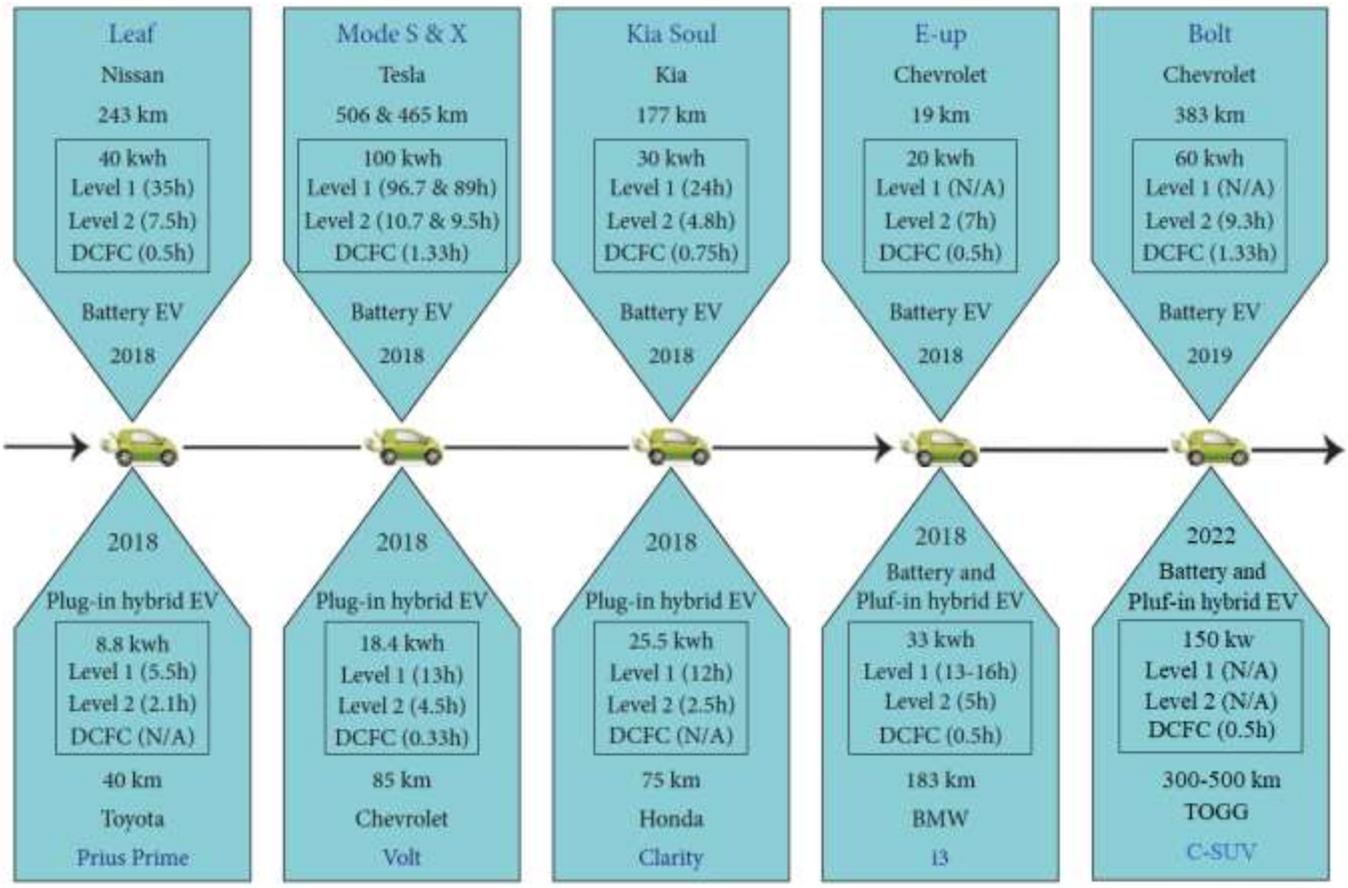

Fig. 7. Comparison of some EVs Produced in the Last 5 Years

The TOGG C-SUV has real-time data on automobiles as well as an intelligent production network that is the Internet of Things compatible. In addition to this, its battery range is sufficient to compete with that of gasoline-powered rivals. When it comes to the design of the battery and the electronic power unit, significant progress has been made. Producing 160 kW / 218 HP and 350 Nm of torque, the T10X RWD (rear drive) will have ranges of 314 and 523 kilometers with two different battery options. While the 52.4 kWh battery option of the rear-wheel drive T10X offers 16.7 kWh/100 km (WLTP) energy consumption, the 88.5 kWh battery option has a consumption value of 16.9 kWh/100 km.

### *D. TOGG Expectations*

With its national automobile, the TOGG, Turkey demonstrates that it is not unconcerned by the pace of technological advancement taking place elsewhere in the globe. Electric automobiles, which have recently become more commonplace in many nations, are among the most significant instruments that will be used to meld the world of the future. The most recent action that Turkey has made is related to this sector. TOGG will offer a variety of models, including domestic SUV, sedan, and hatchback versions of its vehicles. The TOGG automobile, which will likely be an electric vehicle when it is constructed, is notable due to the qualities it has. TOGG was conceived to be outfitted with cutting-edge technology, making it a potential contender to be one of the automobiles of the future that has remarkable characteristics. The C-SUV is slated to become the first vehicle of its kind to be manufactured under the TOGG brand. The Mercedes-Benz C-Class is the model that is most popularly purchased in Turkey, which is why this is the case. The capability of maintaining an internet connection at all times is the element of the TOGG domestic automobile that stands out as the most significant and useful characteristic. It is anticipated that the car would take 28 minutes to get an 80 percent charge once the charge has been started. The TOGG is a one-of-a-kind automobile that is of the newest generation and distinguishes out due to the advanced technology it has. The battery of the long-range TOGG may be recharged in a relatively short amount of time.

Surprisingly, the TOGG national automobile comes with two distinct engine choices since this is one of its many impressive qualities. The vehicle's acceleration from 0 to 100 kilometers per hour takes 7.6 seconds with the first engine choice, which produces 200 horsepower; the vehicle's acceleration from 0 to 100 kilometers per hour with the second engine option, which produces 400 horsepower, takes 4.8 seconds. Both sorts of engines have the potential to be quicker than many other cars that are now operating on Turkey's congested roadways when seen from a broader perspective. Despite this, the maximum speed that the domestic automobile TOGG is capable of reaching is limited to 180 kilometers per hour (another characteristic that stands out), which was done to make driving in traffic safer. The electric TOGG automobile includes several characteristics, including autonomous driving and a chassis that can be customized. In addition, TOGG, which is anticipated to give the domestic and international markets additional momentum because of its cutting-edge technological characteristics, is another significant development that is anticipated to pollute the air less as a consequence of its capacity to produce zero emissions.

In a study that was prepared by using the interview method, various topics such as the first reactions of the participants with the exploratory feature of TOGG, which features of the vehicles they emphasized in their evaluations, price estimates/expectations, purchase intentions, and brand name suggestions were examined [63]. The characteristics of TOGG, both in terms of its design and its implementation, have been discussed in the previous section. In general, the fact that the cars are electric, the ease with which they can be recharged, the technological components, the level of safety, and the range that they can travel on a single charge are among the technical factors that are stressed in the assessments. Notable aspects include the capacity of the cars' batteries, the current charging state of the vehicles, and the infrastructure associated with the charging stations.

When the assessments that were produced by the research are looked at, it can be observed that TOGG is intelligent, autonomous, and has other similar characteristics. It has been noted that the emphases do not seem to have a significant impact on the individuals who were interviewed. Only three of the people who were interviewed highlighted the importance of being intellectual or independent. However, just like in comparisons and explanations with other models in the same category, the TOGG C-SUV is equipped with high-tech batteries that will provide a range of 300 to 500 kilometers with a battery that can compete with alternatives to gasoline, as well as an intelligent production network system that is compatible with the Internet of Things.

During the interviews, 78 people made clear mention of quality, and 52 of those people stated that they believed the tool to be of good quality. Emphasizing the quality of the participants in their evaluations, during the interviews. Some of these 51 individuals discussed quality by assessing it in conjunction with the design. The brand has a significant edge in the worldwide rivalry over electric cars because of the Use Case Mobility strategy that the vehicle takes, as well as the ecosystem that TOGG has built around it. The participants said that the price of the automobiles on the market would determine whether they would make a purchase, although 40.2% of them expressed a willingness to buy.

At the introduction ceremony, the release dates for all the models were disclosed. The TOGG Xcoupe has taken the position of the hatchback, which is likely going to be introduced the following year. It is anticipated that the next model will be introduced in the year 2026.

TABLE VI
TOGG VEHICLE TYPE AND TURKEY RELEASE DATES

| Model | Vehicle type | Introduction date | Turkey release date | European release date | Motor |
|---|---|---|---|---|---|
| **TOGG SUV** | C-segment SUV | 27 Dec 019 | July 2023 | 2024 3. quarter | Electric |
| **TOGG Sedan** | C-segment Sedan | 27 Dec 2019 | 2025 1-2. quarter | – | Electric |
| **TOGG Xcoupe** | C-segment Xcoupe | 29 Oct 2022 | After 2026 | – | Electric |
| **TOGG Kompakt SUV** | B-segment SUV | Waiting | by 2030 | – | Electric |
| **TOGG MPV** | – | Waiting | by 2030 | – | Electric |

## IV. CONSUMER ETHNOCENTRISM IN PURCHASE DECISIONS

### A. *Consumer Ethnocentrism and Electric Vehicles*

As a result of their irreparable damage to the environment, rising greenhouse gas emissions are identified as a significant issue for economies around the globe. The transportation industry has a considerable effect on the situation. Considering the decline of fossil fuels, EVs are viewed as a key answer. While EV adoption is increasing rapidly, particularly in developing nations, a lack of supportive regulations, infrastructure, consumer knowledge, economic incentives, and cheap prices, among other factors, has a direct impact [64].

In Turkey, for instance, the current share of EVs and hybrids accounted for 0.3% of all registered vehicles by 2020 [65]. Therefore, far more effort is required to achieve the target level of EV adoption. Promoting home brands is another strategy to accelerate the adoption of EVs, as patriotism is emerging as a significant factor in influencing consumer behaviour in nations with high levels of nationalism as well as in more expensive product categories [66]. It is anticipated that it will be adopted as a domestic vehicle after the TOGG and that this adoption rate will increase. Consumer Ethnocentrism (CE) is more likely to affect local purchases of expensive product categories, particularly vehicles because they have a greater economic impact [67-69]

The EV sector is a growing market, and EVs appear to be relatively new to the automobile industry, particularly in developing nations. While many companies on the market produce their own EVs, CE has also been linked to the purchase intentions of EVs in nations with high levels of nationalism. In China, for instance, a positive association was established between CE and Chinese consumers' willingness to purchase Chinese EVs. In a second study with a sample of Chinese consumers, they found comparable outcomes [70-72]. CE, a highly sought-after consumer behavior predictor, has also been disregarded in EV adoption research, except for a few studies, while many nations have had to implement regulations to promote EV adoption on a national scale and a few automakers are developing their own EVs.

Extensive research has demonstrated that consumers' personality traits, attitudes, and features influence their adoption of EVs [73,74], as well as their instrumental/functional perceptions of EV properties and pro-environmental behaviors [75-77]. In EV adoption research, the authors focused on the idea of Consumer Innovativeness (CI) in terms of personality characteristics, disposition/perceptions, and actual behavior, as EVs are viewed as a novel transportation technology [78]. While environmental behavior influences are largely regarded as a factor in EV adoption, consumer innovation appears to be a far less common component. In addition, there is a lack of a holistic picture of consumer-product interaction [79]. Previous research on the Turkish sample has demonstrated that, on average, Turkish consumers exhibit high-to-moderate ethnocentrism [80-82]

Thus, the ethnocentric approach can be utilized to sell TEVs and promote domestic adoption. We believed that CE could therefore influence EV's purchase intentions. This study aims to contribute to the literature on EV adoption by determining if and to what extent CE and CI influence TEV buying intentions. As TEV is the first EV with a Turkish-branded electric vehicle, we hypothesize that these two primary concepts are likely to affect the adoption of EVs in Turkey [83].

In the literature, EV types are categorized as Battery Electric Vehicles (BEVs), Plug-in Hybrid Electric Vehicles (PHEVs), and Hybrid Electric Vehicles (HEVs). PHEVs and HEVs are EVs with two engines; an internal combustion engine and an electric motor supplied by batteries and the BEV has a single electric motor that is powered by a battery. The TEVs evaluated in this study are battery-powered electric cars. It is referred to as TEV since it is the first electric vehicle produced and manufactured in Turkey. However, the car industry dominates Turkey's exports. Thus, TEV became the first vehicle for which a Turkish corporation owned intellectual property rights. TEV is anticipated to contribute to the Turkish economy by reducing the current account deficit by USD 7.5 billion and increasing GDP by USD 50 billion.

In December 2019, the first two TEV prototypes, a C-SUV, and a Sedan were displayed. It will be distributed by the TOGG. Additionally, TOGG will produce five distinct models by 2030. TOGG is a coalition of four local enterprises, with TOBB (Turkish Union of Chambers and Commodity Exchanges) serving as the coordinator [64]. Long before the introduction of TEVs, it was discovered that perceived hazards had a negative impact on a potential domestic automotive brand's purchase intention, whereas product image had a positive impact [84]. Since TEV is a novel product, few studies have been conducted on it. In the qualitative analysis, 44.6% of respondents deemed the first two prototypes of the TEV to be successful, while 24.1% deemed it to be moderately successful due to its lack of market presence [85]. In addition, the participants emphasized the TEV's functional characteristics (electricity, rapid charging) and its overall design. In another study, CI and CE explain TEV purchasing intent significantly [86].

### *B. Consumer Ethnocentrism in Purchase Decisions and TOGG*

Increasing greenhouse gas emissions are defined as an important problem for economies around the world due to their irreversible damage to the environment. The impact of the transportation sector on the problem is quite remarkable. As fossil energy sources are also declining, EVs are seen as an important solution. While the adoption of EVs is growing rapidly, especially in developing countries, there is a lack of favorable policies, lack of infrastructure, consumer awareness, economic incentives, affordable prices, etc.

For example, in Turkey, as of 2020, the current share of EVs and hybrid cars only accounts for 0.3% of all registered cars in the country. Therefore, much more effort is required to drive EV adoption to the desired level. Another way to increase the adoption of EVs is to promote domestic brands, as the idea of patriotism is emerging as an important factor for influencing consumer behavior in countries with high nationalism as well as in more expensive product categories. It is estimated that TOGG will increase this rate as a domestic automobile. CE is more likely to influence local purchases for expensive product categories, especially automobiles, as they contribute more to the economy. In addition, empirically, it was found that CE explained more variance ($R2=0.3$) in the purchasing behavior of automobile owners than computer owners ($R2=0.1$) in comparison to two product categories, automobile, and computer. This relationship has also been empirically confirmed in the Malaysian context. Therefore, CE can be an important determinant of domestic vehicle purchase intentions.

The EV industry is a growing market. EVs seem relatively new to the automotive industry, especially in developing countries. While many brands in the market create their own EVs, EV purchase intentions in countries with high nationalism are also associated with CE. In China, for example, a positive correlation was found between CE and the purchase intentions of Chinese EVs among Chinese consumers. Similar results were obtained in another study on a sample of Chinese consumers. CE, a widely sought-after determinant of consumer behavior, has also been neglected in EV adoption research, apart from a few studies, while many countries have had to develop policies to promote EV adoption on a national basis, and a few auto brands are creating their own EVs.

Extensive research has also shown that consumers' personality traits, perceptions, and characteristics have an impact on EV adoption and instrumental/functional perceptions of EV attributes and pro-environmental behaviors. Since EV is interpreted as a new technology in transportation, the authors paid attention to the concept of Consumer Innovativeness (CI) in terms of personality traits, disposition/perceptions, or realized behavior in EV adoption research. While pro-environmental behavioral influences are widely accepted factors, it seems quite rare that consumer innovativeness is taken as a determinant in EV adoption. Also, a comprehensive view of the consumer-product relationship is lacking.

This means that the ethnocentric emphasis can be used to market TEV and drive domestic adoption. Therefore, we thought that CE might influence EV purchase intentions. In short, this study aims to contribute to the EV adoption literature by assessing whether and to what extent TEV purchase intentions are affected by CE and CI. We suggest that these two main concepts are likely to influence the adoption of EVs in the Turkish case, as TEV is the first EV with a Turkish-branded Electric Vehicle.

It has been determined that long before the emergence of TEV, perceived risks negatively affect the purchase intention of a possible domestic automobile brand, while product image positively affects it. Since it is a new product, limited research on TEV has been found. In the qualitative study, 44.6% of respondents thought that the first two prototypes of TEV were successful, while 24.1% thought it was somewhat successful because it has not yet been seen on the market. In addition, the participants highlighted some of the functional features of the TEV (electricity, fast charging) as well as its overall design.

## V. CONCLUSIONS

It is anticipated that advancements in the development of electric automobiles as well as contributions to the total sources and facilities of renewable energy would result in an improvement in the reputation of electric cars in the worldwide market. In this sense, additional technological advancements such as appropriate and reasonable pricing rules, smart cities, robust adaptive frameworks, business structures, policy, $CO2$ emission reduction, mitigation, and measurement of the impact on the environment, health, and electricity grid are essential.

This research provides an overview of the many components that make up the process of developing electric automobiles. The TOGG market comparison and emerging technologies are investigated once the fundamentals of EVs and the widespread acceptance of these vehicles have been included. To prepare future experts to grasp the solutions that need to be implemented, known electric vehicle approach guidelines and the various components that make up those guides have been extensively evaluated. In addition, several components of the pre-existing framework that were used to set up TOGG communication and EA sharing networks were investigated and compared. These components included aspects of the framework's characteristics, such as its benefits and drawbacks, consistency, control and coordination strength, and strengths.

Pure battery EVs have emerged as the most popular choice on the market among the many different types of electric vehicle models owing to the modern technology and user-friendly characteristics that they provide. This research looks at some of the most common and significant technologies that are becoming available for EVs, such as wireless charging, intelligent power distribution, V2G and V2H systems, connected vehicles, and autonomous driving. This investigation focuses on the characteristics that define TOGG vehicles, including autonomous control and long-range plucking-aided storage technologies. These characteristics are described.

In October of 2022, an assessment was carried out to see whether the TOGG tool, which had been taken from the band, would be able to live up to the requirements. It has been decided that the vehicle is built for a range of between 300 and 500 kilometers on a single charge using lithium-ion batteries, and the anticipated criteria are that the batteries must be able to charge to 80% in less than thirty minutes. The development of sophisticated technology across a wide range of fields is required to bring fully autonomous driving to the TOGG vehicle. The domestic vehicle, which is equipped with sophisticated driver assistance systems and can get software updates from the internet, is meant to be ready for the technologies required for level 3 autonomous driving.

TOGG, especially in the context of consumer ethnocentrism, should be considered a positive initiative that will enable the adoption of EVs in the market and increase their sales, thus contributing to the country's economy and reducing the environmental pollution. For the vehicle to make a good entry into the sector and ensure its permanence, it should be developed by protecting the technology that can compete with rival imported goods, and the ethnocentric approaches of the consumers should be evaluated as a positive motivating factor in the marketing and sales processes. When supported by legal regulations and economic incentives, Turkey's domestic and national vehicle TOGG has the potential to become an important player in the electric vehicle industry. As a result, Turkey's automobile will always take its place in the internet with its connected infrastructure and will not need a different device to connect to the internet. The car will be in communication with all smart city infrastructure, electrical grid, devices, houses and buildings and will turn into a thinking assistant for its user in many different areas of life. In the coming years, especially with the spread of 5G technology, the connected automobile will become the center of smart life, and new services that will arise within the mobility ecosystem will provide a different mobility experience that adds value and facilitates the lives of users.

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## BIOGRAPHIES

**HAFIZE NURGUL DURMUS SENYAPAR** In 2005, she obtained her master's degree in communication studies from Ankara University in Ankara, Turkey. In 2012, she earned her doctorate from Gazi University with a dissertation on critical discourse analysis. She completed her undergraduate education in the departments of business and communication and is currently pursuing a third undergraduate degree in health management. As a necessary prerequisite for health, she continues her research on environmental sustainability and the social elements of green energy. She conducts multidisciplinary research to provide a new perspective on topics such as the health co-benefits of renewable energy resources, consumer approaches, incentive mechanisms for economic and social support of green energy transformation, and consumer attitudes and intentions against new and environmentally friendly technologies. She teaches Management and Organization, Quality and Strategic Management, Health Communication, and Social Psychology at Gazi University. At Gazi University, she serves as an assistant quality coordinator.

**MEHMET RIDA TUR** (M'05–SM'10–Ph.D'18) B.S. He received his Master's degree from Marmara University, Istanbul, Turkey in electrical engineering in 2005 and in electrical and electronics engineering from Fırat University, Institute of Science and Technology in 2008. He received his PhD degree from Yıldız Technical University in 2018 with his thesis on Power Systems. He worked as an Instructor at Mardin Artuklu University Technical Programs from 2010 to 2019. From 2010 to 2019, he held various positions in Artuklu University Electricity and Energy Departments, especially as the Head of the Department. Since 2019, he has been appointed to the Department of Electricity and Energy at Batman University and is still working as an Associate Professor and Head of the Department. He has many books, one of which is the co-author of Electric Energy in Turkey (Seta, 1st edition, 2017). He has close to one hundred publications and has worked in power engineering on many different aspects of his career, due to his interest in applying economic analysis and quality methods in power systems. The focus of his career has been public service delivery systems. He is a member of the International Conference on Renewable Energy Research and IEEE Applications committee. His main areas of interest are protection-reliability, power systems quality, power systems economics, renewable energy systems and smart grids.