

## Study and analysis of electric vehicles adoption: a middle eastern country as a case study

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### Article Info

#### Article history:

Received Mar 23, 2023

Revised May 29, 2023

Accepted Jun 3, 2023

#### Keywords:

Adoption

Clean environment

Electric vehicles

Friendly environment vehicles

Hybrid electric vehicles

### ABSTRACT

Adaptation of hybrid electric vehicles (HEVs) and electric vehicles (EVs) is an important choice that has many positive environmental and economic impacts, where, it helps in reducing exhaust emission, participation in dropping down the amount of noise pollution, and improving the air quality. With these encouraging impacts as well as the reduction in the price of fuel consumption, electric vehicles become at the top of car industry. A study on electric vehicles and their impact on improving the quality of environment is the main motive of this research. Selected theories and factors related to the electric vehicles' adoption are investigated and analysed. The main factor that led to the spread of electric vehicles is the reliance on electric energy, so it is considered as zero emissions. But there is another effect, which is that these vehicles need continuous electric charging daily, which in turn needs to generate electricity, which leads to environmental pollution indirectly.

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## 1. INTRODUCTION

Recently, electric vehicles (EVs), which are driven by electric power, have been widely used [1]. Many applications have been designed to use the original delegation-based vehicle engine and use an electric motor, as a replacement [2]. This is the easiest technique to switch from petroleum to electricity [3]. In addition, the vehicle's components, and the engine is provided with the required power by several special batteries that store electricity [4]. It has the advantage of preserving the environment from pollution compared to traditional vehicles with internal combustion engines [5]. Electric vehicles starting with its actual development in 2009, were produced with short-range and heavy batteries, that are of high price [6], [7]. Innovation, therefore have focused on increasing the distance per the charging cycle as well as reducing the charging time [8], [9]. Several governments have begun to strongly encourage the adoption of this type of vehicles despite few complications related to them. Among such related problems are the need to ensure high enough supply voltage, as well as the fear of explosion of the vehicle when it collides due to heavy battery weight [10], [11].

By considering reports, that are recording a dramatic increase in the global market for electric vehicles [12], [13], one might likely to wonder if electric vehicles are a better choice than traditional vehicles. In fact, technologies that supporting EVs and batteries continue to evolve. Obstacles and impediments, such as high cost, limited range and performance efficiency, long charging time and scarcity of charging stations, are gradually fading [14], [15]. Furthermore, as EVs are having no emissions, they can be the dominant in the roads with the environment been better, and the air is kept clean [16], [17]. Rewards to this practice will be obtained through living in a clean environment and breathing fresh air, which contribute to overall human health and a low incidence

of disease worldwide. This will eventually mean less pressure on public health systems, and hospitals [18], [19]. Moreover, reducing emissions will preserve the ozone layer, reduce our carbon footprint, and help reducing the global warming [20], [21]. With all these positive impacts, electric vehicles are the future means of transport in cities and countries around the world that save money and make a big difference to the environment [22], [23].

In addition to the real demand of large volume of the market, the European anti-pollution regulations are contributing to the factors encouraging the adoption of electric vehicles [24], [25]. Electric vehicles have recently reached a level of autonomy and self-sufficiency, performance and price, that make them a perfectly effective and valid option for an increasing number of drivers. The requirements that have to be kept in consideration is that a connection point has to be made available in the garage, and to ensure that journeys are not exceeding 300 km between refills, especially if there are strong slopes in the path [26], [27]. The advanced technology that is adopted in manufacturing hybrid and electric vehicles is contributing to worldwide goal of reducing the carbon emissions levels [28], [29]. Studies and statistics are reporting that the adoption of plug-in electric vehicles in Los Angeles, for example, caused significantly lower carbon emission [30], [31]. It's worth mentioning, that applying new strategies to electric vehicles, such as intelligent control could be an important issue for electricity to be renewable generated [32], [33].

With all the given supporting factors, that are favouring the adoption of electric cars, resulting in clearly widespread use of these vehicles. Driven by the fact they do not need to use fuel, and being free of emissions, electric vehicles are a double-edged sword, where they require large electric charging energy leading to indirect environmental pollution. Literature is witnessing continuous studies and works related to electric vehicles and the factors affecting the tendency towards producing and adapting them.

Sierzchula [34], it was clarified that governments and private companies are responsible for the majority of purchases of electric vehicles worldwide. Fourteen companies that adopted electric vehicles, were considered in the study to determine the factors that have behind purchasing decisions. Additionally, the study concentrated on primary and secondary factors affecting the adaption of electrical cars, where, new technology was found to be the main factor affecting the adoption of electric vehicles.

Bockarjova and Steg [35], the results obtained from a large number of dutch drivers, are analysed. The theory of motivation for protection is found to be an applicable theory to completely model the adaption of electric vehicle using different indicators. It's further shown that all theoretical contexts are excellent predictors of various indicators. Adoption of electric vehicle are more interested when they perceived that the negative consequences of conventional vehicles were more severe and that electric vehicles would be expected to mitigate them. They found that environmental risks are greater when we predict indicators close to adoption; while security risks are more important for predicting distance adoption indicators.

Wu *et al.* [36] showed that the usage of electric vehicles with respect to the indicators at that time was insignificant. One of the reasons for the modest adoption figures is that the massive acceptance of electric vehicles depends largely on the perception of electric vehicles by consumers. This work provides an overview of the factors and barriers to adopt plug-in electric vehicles, as well as they applied theoretical perspectives to understand consumer intentions and adoption behaviour with respect to electric vehicles. In addition, they identify gaps and limitations were also identified to highlighting the guide lines of the future works.

The extent to which plug-in electric vehicles (PEV) are more friendly environment, for most polluting species, than conventional cars in Texas, after taking into account energy emissions and the impacts of battery supply processes, is studied in [37]. The results indicated that PEVs in the current network can reduce GHG, NO<sub>x</sub>, PM<sub>10</sub> and CO emissions in urban areas, but generate high level of SO<sub>2</sub> emissions than existing light vehicles. As emission rates for conventional vehicles improve, it seems that electric grids must do the same improving of emission technologies.

An index to classify and identify the preparation of major cities in USA to adopt the electric vehicles, is presented in [38]. Preparation refers to sorting the cities in their order of supporting the adoption of electric vehicles, as evidenced by the presence of different types of policies, development of infrastructure, investments in PEV technology. They compared and sorted the cities of the states participating in the zero-emission vehicle program with the others, in order to understand the participation in this program has a significant impact on PEV preparation.

The sales of electric vehicles at different levels in Norway, is analysed in [39]. Authors of that work have further analysed the sales of EVs with the corresponding local demographics to determine the factors that led to a greater adoption of electric vehicles. It was contributed that access to vehicle charging infrastructure, was adjacent to the main cities, and that had the greatest power of sales growth. In addition, it was contributed that short-range vehicles were offered slightly more revenue than long-range vehicles.

Some effects in the adoption of the hybrid electric vehicle (HEV), were examined in [40]. This contrasted with most of the existing analyses, which focus on the analysis of factors related to socioeconomic and demographic. This article estimated the strength of neighbourhood effects in the adoption of HEV via application of special model, namely that the decision to adopt HEV of each consumer may be influenced by the decisions to

adopt HEV. They found that the adoption of HEV has significant effects. In addition, they applied time series analysis and showed that the historical adoption of HEV has a significant impact effect on future adoption.

The relationship between the presence of government incentives and the market share of electric vehicles, as well as other important socio-economic factors, is presented in [41]. This research relies on a cross-sectional analysis/time series, and the developed model is an aggregate binomial logic model, which provides an estimate division among conventional and electric vehicles from different US states between 2003 and 2011. The results showed that the price of electricity was negatively associated with the use of electric vehicles, while urban roads and incentives of government were positively correlated with the market share of state electric vehicles.

An analysis study covering non-adopters, potential adopters and early adopters of electric vehicles, is performed in [42]. The results of that study indicated that psychological and sociodemographic factors played an important role in predicting the adoption of EV. In addition, early users tend to live in areas with financial incentives for electric vehicles. They identified four potential adopter's groups of electric vehicles based on their assessment of the motivations for buying and not buying electric vehicles. Potential segments of adopters are differed in their sociodemographic and psychological characteristics, in addition to their political incentives. They discussed their findings to design effective marketing policies and marketing systems.

Vickers [43] mentioned that governmental incentives may be granted for people adopting electric vehicles. The concepts of these incentives include services that were applied to cover maintenance of electric vehicles. The operation of micro-networks, the exchange of energy, and the exchange of vehicles are among the service contexts. The research study analysed the types of services in each context by evaluating the most modern service provision approaches. The results offered an overview of the possibilities of harnessing the full economic potential of electric vehicles. For the adoption of electric vehicles to be increased, business models and technologies should be supported.

A questionnaire covering 482 participants to collect data about electric vehicles customers in Beijing, was conducted in [44]. The obtained results indicated that social acceptability of electric vehicles in the long term was affected with hazard-related attributes. The attributes of the resources have negative effects on their long-term acceptability and purchase intent. They found that the importance of attributes moderates the effect of hazard attributes and resources on adoption indicators. In addition, risk perception has positive effects on consumer adoption indicators, and government dependence and responsibility to protect the environment also influences the intention of consumer behaviour.

Zhai *et al.* [45] performed an online survey with respondents from a region identified as a potential leading market for electric vehicles, but has not yet reached a significant part of the electric vehicle market. The online survey tested the effect of two behaviour-based strategies on electric vehicle preferences: standards-based intervention and outstanding intervention. In order to identify the effect of treatment, they controlled the identity of the environment, the heterogeneity of key economic preferences and size. The obtained results indicated highlighting future cost savings greatly increases the probability of choosing electric vehicles.

A study on the best and optimal design of the location and charging capacity of electric vehicles is presented in [46]. Two mathematical models to obtain an optimal design that takes into account the balance between the choice of road and the waiting time for loading, was presented. The objective is to minimize the common costs of building facilities, travel and waiting times for drivers of electric vehicles. The upper-level model divided the facilities and their capacity, while the lower-level model characterized the balance behaviour of the driver's routes and the options of the loading facilities. They conducted a comprehensive experiment on three networks to evaluate the performance of the algorithms, the strength of the solutions, and to understand the possible expansion of the solution approach.

New ways of operating the network to improve the integration of electric vehicles by avoiding additional network reinforcements, was presented in [47]. Authors of this published work proposed a new fast-charging station topology for electric vehicles based on a multi-terminal DC link arrangement via applied the same power electronic devices. Terminals are connected to different feeder so that the electric vehicle's load can be shared between the secondary substations upstream. The experimental results were validated in a reduced system that mimics the main characteristics of a real BT distribution system. The proposed solution can be considered as a catalyst for electronic mobility due to minimizing the impact of billing and maximizing the use of current assets.

After this section, section 2 is presenting a comparative analysis, where a table is constructed with a number of factors adopted in the surveyed works and studies, such as; the theories used, and the adoption context. A case study is presented in section 3, where the Jordanian electric vehicle market is studied and analysed to project the scope of adoption of electric vehicles in a middle eastern country. The conclusions of the paper are shown in section 4.

## 2. METHOD

Considering the literature work and studies presented in previous sections, Table 1 is made to summarize this literature into a number of factors, namely; Authors and year of publication, adoption context, theories used,

participants/organization, environment/actors, technology, and pollution reduction. In this table, the adoption of new technology for hybrid and electric vehicles that are considered zero-emissions vehicles, are shown. Some theories and factors are selected related to adaption of electric vehicles. In addition to this, there other factors that are mentioned in literature such as; barriers against consumer adoption, the distribution of charging station management system, and roles and policies. This set of factors are not considered in Table 1. Moreover, many recent research papers are emphasizing the analysing of factors affecting the adoption of hybrid and electric vehicles, while other works are focusing on both pros and cons of using HEVs and EVs and their effects on the consumers.

Table 1. Selected theories and factors related to the adoption of electric vehicles

Author(s)/ year of publication	Adoption context	Theories used	Participants/ organization	Environmen/ actors	Technology	Pollution reduction
Sierzchula (2014) [34]	Significant factors for organizations that extended their EV fleets	test group is designed to represent population	fourteen companies that adopted electric vehicles	Consumers	qualitative case study	Zero Emission
Bockarjova and Steg (2014) [35]	collective and individual concerns predict different pointers of adoption	Protection inspiration theory predict pro-environmental behavior	Dutch drivers	Consumers	Descriptive statistics of variables (dependent and independent)	Zero Emission
Wu <i>et al.</i> (2015) [36]	Adoption of EV depend on perception of electric vehicles by consumers	barriers against consumer adopting plug-in EVs,	General	Consumers	Review approach	Zero Emission
Nichols <i>et al.</i> (2015) [37]	PEV are more friendly environment, to make PEV adoption easier and more affordable	Life-Cycle Analysis	Texas-USA	Industry	Electric vehicle emissions model	Zero Emission
Clark-Sutton <i>et al.</i> (2016) [38]	effects of many of the incentives on per capita EV sales	statistical test of difference in means	major cities in USA	Consumers	investments in plug-in electric vehicles (PEV) technology	Zero Emission
Mersky <i>et al.</i> (2016) [39]	the decisions to adopt HEV	Government incentives can be used to improve adoption factors	Main cities in Norway	Industry	Regression methods	Zero Emission
Liu <i>et al.</i> (2017) [40]	Growing number of electric vehicles in USA	focus on the analysis of factors related to socioeconomic and demographic	spatial units across the state of Ohio	Consumers	applied time series analysis	Zero Emission
Soltani-Sobh (2017) [41]	Using psychological and sociodemographic factors	Developed binomial logit share model	Diverse U.S. states from 2003 to 2011	Industry	cross-sectional/time-series (panel) analysis.	Zero Emission
Priessner <i>et al.</i> (2018) [42]	design of effective policy schemes and marketing measures	design of effective policy schemes and marketing measures	representative survey of Austrian citizens	Industry and government	Using cluster analysis	Zero Emission
Vickers (2017) [43]	policy measures to accelerate the adoption of EV	economic incentives to ownership in terms of EV services	identify the operation of micro-networks	Government	technology requirements and operational management decisions	Zero Emission
Liu <i>et al.</i> (2019) [44]	The targeted participants are potential car consumers	A five-point Likert scale	city smog risk	Consumers	protection action decision model	Zero Emission
Zhai <i>et al.</i> (2021) [45]	shift in electric vehicle adoption	conducted an online survey	Ministry of transport-Italy	Industry	tested the effect of two behavior-based strategies	Zero Emission
Chen <i>et al.</i> (2020) [46]	location and charging capacity of EV	balance between the choice of road and the waiting time	comprehensive experiment on three networks	Consumers	Estimation of average logarithmic waiting time	Zero Emission
Kuki <i>et al.</i> (2011) [47]	charging station management system	new fast-charging station topology	Laboratory testing platform	Industry	multi-terminal DC link	OK

**3. RESULTS AND DISCUSSION**

Among the biggest environmental issues reported nowadays on earth, are the emissions of greenhouse gases as well as the global climate change. Many countries are dealing with these issues by implementing policies for making a transition to zero-emission vehicles, such as electric vehicles. Moreover, automobile industries have responded to global movements by changing the orientation of car production from internal combustion engine-based to other environmentally friendly vehicles. Jordan is considered as one of the pioneers in adopting electric vehicles in the Middle East, therefore it is considered as a suitable case study. Related data are obtained from to Jordan free zones investors authority market covering six years from 2014 to 2019, where a year before dealing with hybrid vehicles was surveyed to the year in which the Coronavirus appeared.

In the following Figures 1-6, trade statistics of different vehicles are illustrated for the adopted six years (i.e. 2014-2019). In the figures, numbers of vehicles per months of the corresponding year, are shown. Sales in the local market of conventional vehicles (CV), HEV, and electric vehicles (EV), are shown together with number of exported vehicles. Figure 1, is showing the statistic of vehicles entered and exported of Jordanian market in 2014. This statistic shows that all the sales are focusing more on CV, and there is no mention of HEV and EV vehicles in this year because there is no adoption yet of these new cars.

In Figure 2, a summary of vehicle sales during 2015, is presented. The Figure is showing the first appearance of hybrid vehicles in the Jordanian market. In December of that year, it is noted that the sales of hybrid electric vehicles have become approximately half the sales of conventional vehicles.

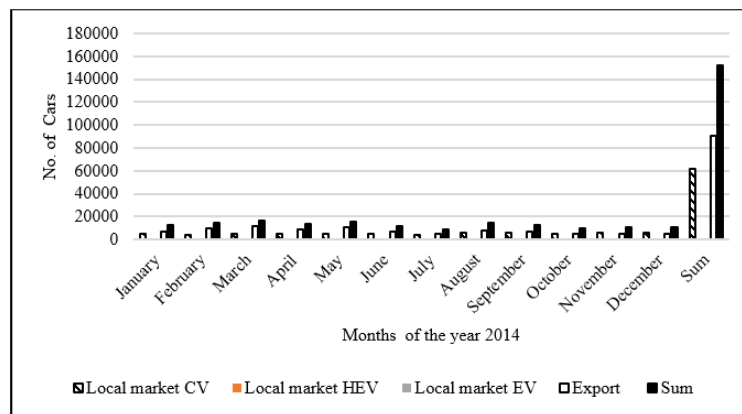


Figure 1. Trade statistics of different vehicles in the Jordanian market 2014

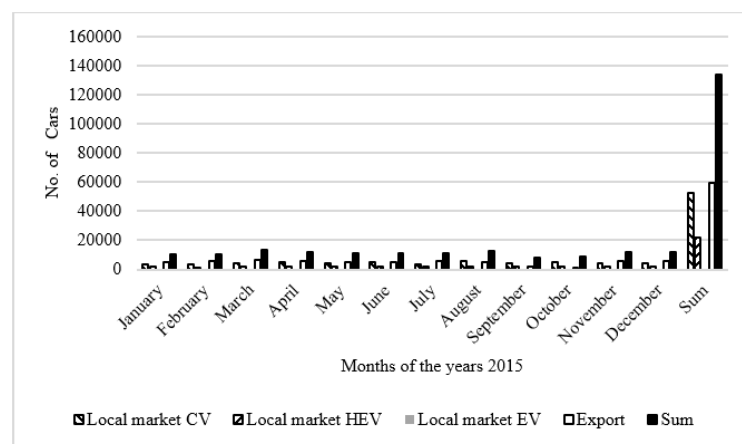


Figure 2. Trade statistics of different vehicles in the Jordanian market 2015

In Figure 3 however, statistics of vehicle sales during 2016, is illustrated. A slight increase in the sales of hybrid vehicles in the Jordanian market can be noticed. Compared with December of the preceding year, the sales of hybrid electric vehicles have become close to sales of conventional vehicles for the same month of this considered year (i.e December 2016).

Figure 4 is presenting statistics for the sales of vehicle during 2017. Significant increase of hybrid vehicles in the Jordanian market, can be noticed. The increase in sales of hybrid vehicles is evident starting from June, and sales gradually increase until it has reached five times the sales of traditional vehicles in December 2017. In addition, the total number of sales of HEVs vehicles is more than that of the CVs.

Evolution of vehicle sales during the year 2018, is illustrated in Figure 5. A noticeable incident shown in this figure, is that the sales of hybrid vehicles have a sharp decline, reaching approximately to zero in the months of February and March. The reason for the significant decay in the sales of hybrid vehicles is due to the fees and taxes added to the trade of these vehicles. On the other hand, abolition of fees and taxes on the import of electric vehicles is behind the significant increase in the sales of these cars.

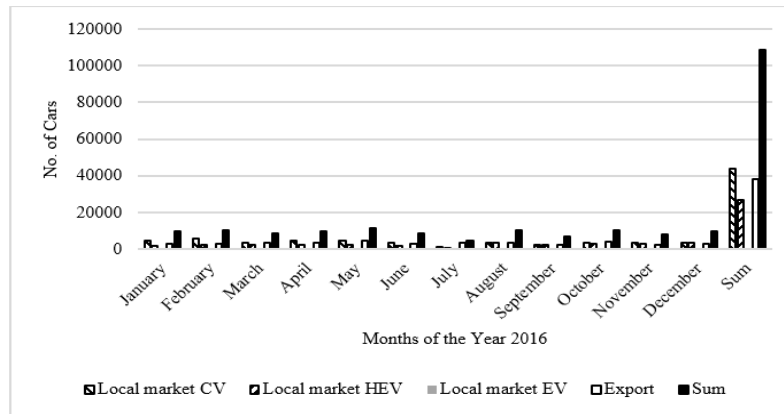


Figure 3. Trade statistics of different vehicles in the Jordanian market 2016

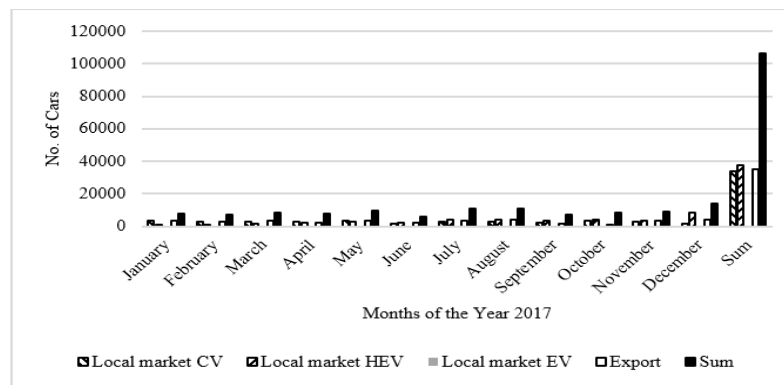


Figure 4. Trade statistics of different vehicles in the Jordanian market 2017

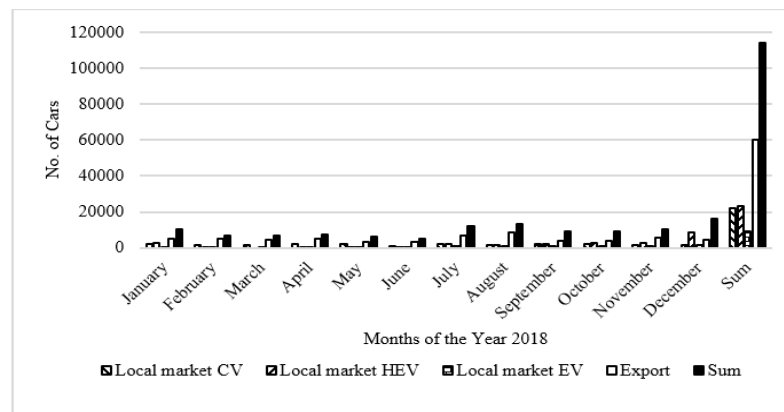


Figure 5. Trade statistics of different vehicles in the Jordanian market 2018

Figure 6, demonstrates the sales of vehicles during the year 2019. In which the sale of EVs has approximately reached to zero in May and June. The reason for the significant decline in these two months is justified by the slight increase in the fees and taxes. The year 2019 is the year of the car sales setback (and in the rest of the business), as a result of the spread of the Coronavirus pandemic, and this has continued until 2020.

In addition to the presented statistics, and their analysis, the electric vehicle market in Jordan continue in expansion, where reports of the Jordan free zone investor commission (JFZIC) have stated a trade of 18,641 gasoline vehicles, 10,055 diesel vehicles, 18,039 hybrid vehicles and 5,083 electric vehicles, during the year 2021. The year 2022, on the other hand, noticed a trade of about 56,000 vehicles, with almost 180 per cent increase related to electric cars. The worldwide increase in carbon emission, and the rising levels of air pollution, as well as the global move of adopting renewable energy sources, is another factor contributing to the development of the market. This market has projected a growth at compound annual growth rate (CAGR) of 34.0% during 2019-25. The Jordanian government is also working to strengthen the electric vehicle charging infrastructure in co-operation with the private companies.

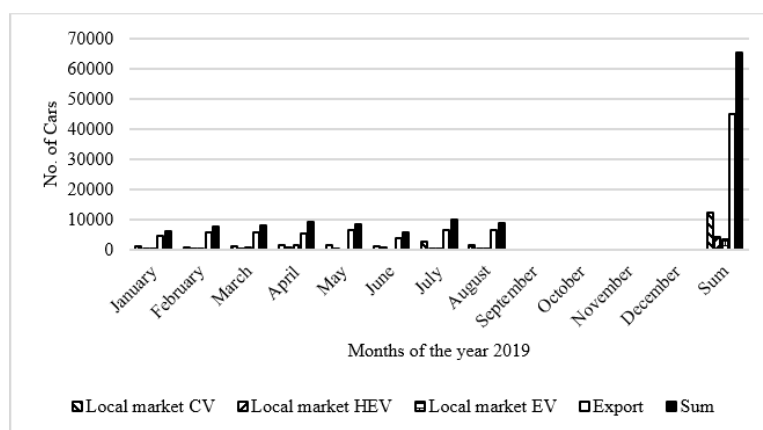


Figure 6. Trade statistics of different vehicles in the Jordanian market 2019

#### 4. CONCLUSION

The emergence of electric vehicles was decades before the emergence of internal combustion vehicles, where the first successful electric car was built in the U.S. around 1885 by William Morrison. Ten years later, Thomas Edison has his own electric car, followed by Henry Ford presenting the mass-produced Model T. Electric vehicles, however did not make their way well for several reasons, including cost, speed, and ease of refuelling. Now the matter has turned somewhat, for many reasons, the most important of which is the preservation of the environment.

The intensive use of conventional vehicles causes carbon dioxide emissions and pollutes the environment. Therefore, to reduce this pollution, it is important to control these emissions by adopting electric vehicles recognized as zero emission vehicles. Increasing of electric vehicles penetration will be so affective in decreasing the demand of energy consumption. Although some of the emissions are generated by hybrid vehicles, there are also emissions from electric vehicles, which depend in particular on the sources used to make their own batteries which needs continuous charging.

The spread of the Coronavirus pandemic in 2019 led to the suspension of all businesses, including vehicle sales of all kinds. The Jordanian vehicles market (sales of vehicles) is studied between 2014 up to 2019, in which the sales of hybrid and electric vehicles are affected by many factors related to consumer (cost and new technology), government (fees and taxes), environment (regulations and laws), organization (charging and repairing). Recently, sales of both HEVs and EVs are increased gradually compared to CVs.

#### REFERENCES

- [1] A. Ensslen, P. Ringler, L. Dörr, P. Jochem, F. Zimmermann, and W. Fichtner, "Examining an innovative electric vehicle charging tariff to incentivize customers' provision of load flexibilities," *Energy Research and Social Science*, vol. 42, pp. 112–126, Aug. 2018, doi: 10.1016/j.erss.2018.02.013.
- [2] R. P. Brooker and N. Qin, "Identification of potential locations of electric vehicle supply equipment," *Journal of Power Sources*, vol. 299, pp. 76–84, Dec. 2015, doi: 10.1016/j.jpowsour.2015.08.097.
- [3] F. Koyanagi and R. Yokoyama, "A priority order solution of EV recharger installation by domain division approach," in *45th International Universities Power Engineering Conference UPEC 2010*, pp. 1–8, 2010.




- [4] O. Van Vliet, A. S. Brouwer, T. Kuramochi, M. Van Den Broek, and A. Faaij, "Energy use, cost and CO<sub>2</sub> emissions of electric cars," *Journal of Power Sources*, vol. 196, no. 4, pp. 2298–2310, Feb. 2011, doi: 10.1016/j.jpowsour.2010.09.119.
- [5] L. Wang *et al.*, "Monitoring-based HVAC commissioning of an existing office building for energy efficiency," *Applied Energy*, vol. 102, pp. 1382–1390, Feb. 2013, doi: 10.1016/j.apenergy.2012.09.005.
- [6] H. Huo, Q. Zhang, K. He, Z. Yao, and M. Wang, "Vehicle-use intensity in China: current status and future trend," *Energy Policy*, vol. 43, pp. 6–16, Apr. 2012, doi: 10.1016/j.enpol.2011.09.019.
- [7] G. Zhou, X. Ou, and X. Zhang, "Development of electric vehicles use in China: a study from the perspective of life-cycle energy consumption and greenhouse gas emissions," *Energy Policy*, vol. 59, pp. 875–884, Aug. 2013, doi: 10.1016/j.enpol.2013.04.057.
- [8] M. Neameh, S. D. Salisbury, G. A. Hill, P. T. Blythe, D. R. Scofield, and J. E. Francfort, "Analysing the usage and evidencing the importance of fast chargers for the adoption of battery electric vehicles," *Energy Policy*, vol. 108, pp. 474–486, Sep. 2017, doi: 10.1016/j.enpol.2017.06.033.
- [9] R. T. Doucette and M. D. McCulloch, "Modeling the CO<sub>2</sub> emissions from battery electric vehicles given the power generation mixes of different countries," *Energy Policy*, vol. 39, no. 2, pp. 803–811, Feb. 2011, doi: 10.1016/j.enpol.2010.10.054.
- [10] X. Cen, H. K. Lo, L. Li, and E. Lee, "Modeling electric vehicles adoption for urban commute trips," *Transportation Research Part B: Methodological*, vol. 117, pp. 431–454, Nov. 2018, doi: 10.1016/j.trb.2018.09.003.
- [11] J. E. Kang and W. Recker, "Strategic hydrogen refueling station locations with scheduling and routing considerations of individual vehicles," *Transportation Science*, vol. 49, no. 4, pp. 767–783, Nov. 2015, doi: 10.1287/trsc.2014.0519.
- [12] M. K. Hidrue and G. R. Parsons, "Is there a near-term market for vehicle-to-grid electric vehicles?," *Applied Energy*, vol. 151, pp. 67–76, Aug. 2015, doi: 10.1016/j.apenergy.2015.04.051.
- [13] J. Krumm, "How people use their vehicles: statistics from the 2009 National household travel survey," Apr. 2012, doi: 10.4271/2012-01-0489.
- [14] X. Zhang, X. Bai, and H. Zhong, "Electric vehicle adoption in license plate-controlled big cities: Evidence from Beijing," *Journal of Cleaner Production*, vol. 202, pp. 191–196, Nov. 2018, doi: 10.1016/j.jclepro.2018.07.265.
- [15] R. Wang, "Shaping urban transport policies in China: Will copying foreign policies work?," *Transport Policy*, vol. 17, no. 3, pp. 147–152, May 2010, doi: 10.1016/j.tranpol.2010.01.001.
- [16] J. Yang, Y. Liu, P. Qin, and A. A. Liu, "A review of Beijing's vehicle registration lottery: short-term effects on vehicle growth and fuel consumption," *Energy Policy*, vol. 75, pp. 157–166, Dec. 2014, doi: 10.1016/j.enpol.2014.05.055.
- [17] I. Pavić, T. Capuder, and I. Kuzle, "Value of flexible electric vehicles in providing spinning reserve services," *Applied Energy*, vol. 157, pp. 60–74, Nov. 2015, doi: 10.1016/j.apenergy.2015.07.070.
- [18] M. Achtnicht, G. Bühler, and C. Hermeling, "The impact of fuel availability on demand for alternative-fuel vehicles," *Transportation Research Part D: Transport and Environment*, vol. 17, no. 3, pp. 262–269, May 2012, doi: 10.1016/j.trd.2011.12.005.
- [19] J. Shin, J. Hong, G. Jeong, and J. Lee, "Impact of electric vehicles on existing car usage: a mixed multiple discrete-continuous extreme value model approach," *Transportation Research Part D: Transport and Environment*, vol. 17, no. 2, pp. 138–144, Mar. 2012, doi: 10.1016/j.trd.2011.10.004.
- [20] A. F. Jensen, E. Cherchi, and J. de Dios Ortúzar, "A long panel survey to elicit variation in preferences and attitudes in the choice of electric vehicles," *Transportation*, vol. 41, no. 5, pp. 973–993, Apr. 2014, doi: 10.1007/s11116-014-9517-6.
- [21] V. Oikonomou *et al.*, "Linking least-cost energy system costs models with MCA: an assessment of the EU renewable energy targets and supporting policies," *Energy Policy*, vol. 39, no. 5, pp. 2786–2799, May 2011, doi: 10.1016/j.enpol.2011.02.050.
- [22] M. Wang, J. Han, J. B. Dunn, H. Cai, and A. Elgowainy, "Well-to-wheels energy use and greenhouse gas emissions of ethanol from corn, sugarcane and cellulosic biomass for US use," *Efficiency and Sustainability in Biofuel Production: Environmental and Land-Use Research*, vol. 7, no. 4, pp. 249–280, Dec. 2015, doi: 10.1088/1748-9326/7/4/045905.
- [23] J. Dong and Z. Lin, "Within-day recharge of plug-in hybrid electric vehicles: Energy impact of public charging infrastructure," *Transportation Research Part D: Transport and Environment*, vol. 17, no. 5, pp. 405–412, Jul. 2012, doi: 10.1016/j.trd.2012.04.003.
- [24] K. S. Kurani, T. Turrentine, and D. Sperling, "Testing electric vehicle demand in 'hybrid households' using a reflexive survey," *Transportation Research Part D: Transport and Environment*, vol. 1, no. 2, pp. 131–150, Dec. 1996, doi: 10.1016/S1361-9209(96)00007-7.
- [25] M. K. Hidrue, G. R. Parsons, W. Kempton, and M. P. Gardner, "Willingness to pay for electric vehicles and their attributes," *Resource and Energy Economics*, vol. 33, no. 3, pp. 686–705, Sep. 2011, doi: 10.1016/j.reseneeco.2011.02.002.
- [26] T. T. Taefi, J. Kreutzfeldt, T. Held, and A. Fink, "Supporting the adoption of electric vehicles in urban road freight transport – A multi-criteria analysis of policy measures in Germany," *Transportation Research Part A: Policy and Practice*, vol. 91, pp. 61–79, Sep. 2016, doi: 10.1016/j.tra.2016.06.003.
- [27] B. K. Sovacool, "A transition to plug-in hybrid electric vehicles (PHEVs): Why public health professionals must care," *Journal of Epidemiology and Community Health*, vol. 64, no. 3, pp. 185–187, Mar. 2010, doi: 10.1136/jech.2009.090746.
- [28] A. Jenn, K. Springel, and A. R. Gopal, "Effectiveness of electric vehicle incentives in the United States," *Energy Policy*, vol. 119, pp. 349–356, Aug. 2018, doi: 10.1016/j.enpol.2018.04.065.
- [29] G. Hill, M. Bell, and P. Blythe, "Quantifying a cellular automata simulation of electric vehicles," *Physica A: Statistical Mechanics and its Applications*, vol. 416, pp. 421–429, Dec. 2014, doi: 10.1016/j.physa.2014.08.007.
- [30] A. Ajanovic, "Promoting environmentally benign electric vehicles," *Energy Procedia*, vol. 57, pp. 807–816, 2014, doi: 10.1016/j.egypro.2014.10.289.
- [31] M. Alló and M. L. Loureiro, "Estimating a meta-damage regression model for large accidental oil spills," *Ecological Economics*, vol. 86, pp. 167–175, Feb. 2013, doi: 10.1016/j.ecolecon.2012.11.007.
- [32] J. D. Kim and M. Rahimi, "Future energy loads for a large-scale adoption of electric vehicles in the city of Los Angeles: Impacts on greenhouse gas (GHG) emissions," *Energy Policy*, vol. 73, pp. 620–630, Oct. 2014, doi: 10.1016/j.enpol.2014.06.004.
- [33] L. Göransson, S. Karlsson, and F. Johnsson, "Integration of plug-in hybrid electric vehicles in a regional wind-thermal power system," *Energy Policy*, vol. 38, no. 10, pp. 5482–5492, Oct. 2010, doi: 10.1016/j.enpol.2010.04.001.
- [34] W. Sierzechula, "Factors influencing fleet manager adoption of electric vehicles," *Transportation Research Part D: Transport and Environment*, vol. 31, pp. 126–134, Aug. 2014, doi: 10.1016/j.trd.2014.05.022.
- [35] M. Bockarjova and L. Steg, "Can protection motivation theory predict pro-environmental behavior? Explaining the adoption of electric vehicles in the Netherlands," *Global Environmental Change*, vol. 28, no. 1, pp. 276–288, Sep. 2014, doi: 10.1016/j.gloenvcha.2014.06.010.
- [36] X. Wu, D. Freese, A. Cabrera, and W. A. Kitch, "Electric vehicles' energy consumption measurement and estimation," *Transportation Research Part D: Transport and Environment*, vol. 34, pp. 52–67, Jan. 2015, doi: 10.1016/j.trd.2014.10.007.
- [37] B. G. Nichols, K. M. Kockelman, and M. Reiter, "Air quality impacts of electric vehicle adoption in Texas," *Transportation Research Part D: Transport and Environment*, vol. 34, pp. 208–218, Jan. 2015, doi: 10.1016/j.trd.2014.10.016.







- [38] K. Clark-Sutton, S. Siddiki, S. Carley, C. Wanner, J. Rupp, and J. D. Graham, "Plug-in electric vehicle readiness: Rating cities in the United States," *Electricity Journal*, vol. 29, no. 1, pp. 30–40, Jan. 2016, doi: 10.1016/j.tej.2015.12.006.
- [39] A. C. Mersky, F. Sprei, C. Samaras, and Z. S. Qian, "Effectiveness of incentives on electric vehicle adoption in Norway," *Transportation Research Part D: Transport and Environment*, vol. 46, pp. 56–68, Jul. 2016, doi: 10.1016/j.trd.2016.03.011.
- [40] X. Liu, M. C. Roberts, and R. Sioshansi, "Spatial effects on hybrid electric vehicle adoption," *Transportation Research Part D: Transport and Environment*, vol. 52, pp. 85–97, May 2017, doi: 10.1016/j.trd.2017.02.014.
- [41] A. Soltani-Sobh, K. Heaslip, A. Stevanovic, R. Bosworth, and D. Radivojevic, "Analysis of the electric vehicles adoption over the United States," *Transportation Research Procedia*, vol. 22, pp. 203–212, 2017, doi: 10.1016/j.trpro.2017.03.027.
- [42] A. Priessner, R. Sposato, and N. Hampl, "Predictors of electric vehicle adoption: An analysis of potential electric vehicle drivers in Austria," *Energy Policy*, vol. 122, pp. 701–714, Nov. 2018, doi: 10.1016/j.enpol.2018.07.058.
- [43] N. J. Vickers, "Animal communication: when i'm calling you, will you answer too?," *Current Biology*, vol. 27, no. 14, pp. R713–R715, Jul. 2017, doi: 10.1016/j.cub.2017.05.064.
- [44] Y. Liu, Z. Ouyang, and P. Cheng, "Predicting consumers' adoption of electric vehicles during the city smog crisis: An application of the protective action decision model," *Journal of Environmental Psychology*, vol. 64, pp. 30–38, 2019, doi: 10.1016/j.jenvp.2019.04.013.
- [45] Q. Zhai, H. Rahardjo, A. Satyanaga, Y. Zhu, G. Dai, and X. Zhao, "Estimation of wetting hydraulic conductivity function for unsaturated sandy soil," *Engineering Geology*, vol. 285, p. 106034, May 2021, doi: 10.1016/j.enggeo.2021.106034.
- [46] R. Chen, X. Qian, L. Miao, and S. V. Ukkusuri, "Optimal charging facility location and capacity for electric vehicles considering route choice and charging time equilibrium," *Computers and Operations Research*, vol. 113, p. 104776, Jan. 2020, doi: 10.1016/j.cor.2019.104776.
- [47] Á. Kuki, L. Nagy, M. Zsuga, and S. Kéki, "Fast identification of phthalic acid esters in poly (vinyl chloride) samples by direct analysis in real time (DART) tandem mass spectrometry," *International Journal of Mass Spectrometry*, vol. 303, no. 2–3, pp. 225–228, Jun. 2011, doi: 10.1016/j.ijms.2011.02.011.

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