Innovative Financial Approaches for Procurement on Electric Buses in Sustainable Public Transportation Systems

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***Abstract*—Looking across the world an irresistible rise of electric vehicles is observed. The relevant infrastructure and industry sector are also developing rapidly. The advantages of electric vehicles thanks to the technological innovations which they have. However the most important disadvantage confronts is the purchasing costs. Their values have not reached the expected level yet. For this reason, electrical vehicle implementetions cannot be achieved in the public transportation, except some cities like Shenzen which is the one of the important city in China. Considering the points mentioned above, many applications are carried out in order to reveal different financial approaches in purchasing electric buses in public transportation systems in worldwide. In this study, purchase methods of electric busses with new business models especially in China, USA and Europe will be included. These methods are targeted to shed light on financial approaches, business model prediction and business analysis for the local governments that provide public transportation service in Turkey. The obtained approach results are expected to shed light on the electric bus route map in Turkey's public transportation systems**

Keywords-Electric buses, zero emission, public transportation systems, business model, financial approaches

I. INTRODUCTION

Public transportation systems in the world have the opportunity to significantly affect the quality of life of the populations they serve with the number of vehicles they have, their qualifications and passenger circulation capacities. Energy and environmental management is one of the strategic policies that are increasing in importance within the framework of sustainable municipality facilites for local governments and which includes many fields of activity. Operating approaches in this regard are related to many areas of daily life and are also important for the transportation perspective. In this regard, the emission values of buses used in public transportation services are among the important and priority issues that affect the selection concepts of buses, which are the main components of public transport with the rubber wheels. At this point, optimizing the existing system in terms of technological, economic and environmental aspects can often provide a more feasible and sustainable solution in order to provide a broad development in public transportation.

On the other hand, it is foreseen that the public transportation which the fastest integration area will be achieved by the accessible costs and sufficient technology maturity are reached in electric vehicles, [1]. Electric buses currently have already a large scale in this classification because today there is an electric bus concept in the portfolio of all bus manufacturers in the world, and there is a wide-ranging orientation towards electric buses, especially public transportation companies within the framework of delegations on zero-emission.

Public transportation sectors are developing and improving day by day so while at the same time the consumed energy levels are also increasing. Accordingly, the effective energy management system in public transportation to prevent major problems such as the increase in fuel unit prices in recent years, high emission factors and the recent increased operating costs of climate change, is considered both a solution and a fundamental requirement for our local governments.

Financial approaches introduced by this study is to help our local governments to acquire different approaches to the implementation of the sustainable public transportation systems in all around Turkey. So much so that Turkey's total CO_2 emissions in 2018 were 315 Mt, while in 2017 the transport-induced CO_2 emissions were calculated as 83 Mt [2].

In line with an environmentally sensitive public transportation system and the strategic goals of local governments, to make more citizens prefer public transportation instead of private vehicles; it is aimed by many local governments to encourage more efficient use of low-emission public transport with alternative fuel, thus to reduce energy costs and greenhouse gas emissions in transportation.

Energy demand for all electric vehicles in the world has reached 74 TWh, according to 2019 data; this value is expected to rise to 2,333 TWh in 2040. Again, the study, based on its predictions for 2040, states that the ratio of the amount of energy (electricity) required by electric vehicles on a country basis will correspond to 14% in Germany, 11% in the United States and 7.5% in China. On the other hand, although the number of electric vehicles in different segments is rapidly increasing, CO_2 emission rates of transportation are expected to rise to the highest level by

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2030 due to internal combustion engines [3]. By 2040, the direct CO_2 emission rates of electric vehicles (in public transportation, personal use, etc.) would only decrease to the levels in 2018; In this sense, it is stated that countries should be channeled to methods that provide more effective sanctions and solutions for the greenhouse gas emission problem caused by transportation.

In this context, local governments which are especially providing public transportation services, stand out a step forward in the use of electric buses. 1,568 electric buses are operated by related organizations in Europe according to 2017 data. This number comprises the 1.6% of the total bus fleet. There are also important incentive and support policies for electric buses across Europe [4]. Despite all this, when the literature and the conducted pilot studies are examined, it is stated that there are obstacles to the transition to electric bus operations in public transportation systems. The main approaches in the reports presented are that these elements are concentrated in the main axis of electric vehicle topology and battery technologies, public transportation operators and administrators, network and charging infrastructure systems. Similarly, limiting conditions are observed in terms of technological, financial and institutional structure.

On the other hand, the limitations on emissions and preventive systems in Europe from 2005 onwardsprovide speeding up the work on the subject. As of 2020, all buses to be purchased in Oslo are envisaged to use renewable energy fuels in accordance with the zero-emission standard. Similarly, there are reports that only zero-emission buses will be allowed to be purchased in Hamburg. Also in Stockholm, it is stated that the buses which allows renewable energy use comprises the 58% of its fleet, while this number will be projected to increase to 100 % by 2025 (including biodiesel) [5].

As of the current situation in Turkey, there are about 15,000 internal combustion motor (diesel and CNG) buses which are used in public transportation systems. Of these, only 118 electric buses in various features have been signed for contract, and only 84 electric buses for tenders have been delivered to the relevant local authorities. It is not known how many of the electric buses purchased by these local governments can be operated and used actively [1] [6].

The high initial purchase costs of electric buses, which have many advantages in terms of operating factors, make the transition from diesel or CNG to electric drive system very difficult for public transportation administrations with low financial power. So much so that even in cities with the most important bus fleets in our country, especially in Istanbul and Ankara, no electric buses are used yet [1] [6] [7]. At least, there is no regulation or incentive system in our country except for the recommendation of using electric buses in the public transportation system.

Based on 2019, there are about 4,000 electric buses in Europe, including electric buses with batteries, hybrid buses, trolleybuses and fuel cell buses, which operate in the urban public transport system. Given that about 400,000 electric buses are used globally, it can be said that the number of electric buses in Europe corresponds to a fairly small proportion [6].

The use of electric buses in fleets in public transport systems is getting widespread all over the world, but China's leadership in this area is undisputed. China, which started its activities with a budget of 140 M in the 10th Development Plan between 2002 and 2006, has a difficult point to reach all over the world today. Figure 1 includes the production quantities of electric bus manufacturers around the world.

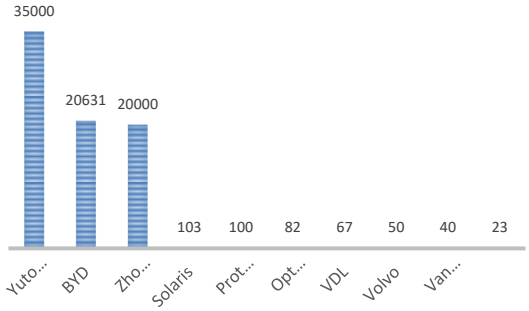


Figure 1. Total sales volumes of electric bus manufacturers around the world -2018 [8]

A total of 378 electric buses were launched in 2017 as part of an electric vehicle trend that is also rising rapidly in Europe. While VDL took the lead in the system with 100 electric buses supplied for the lines around Schiphol Airport, it was able to sell 107 electric buses in total in 2017. Solaris ranked second with sales of 57. According to 2018 data, electric buses are stated to correspond to 5% of the urban buses registered in Western Europe. The number of electric buses in Europe increased by 48% between 2017 and 2018, with a total of 562 battery powered electric buses included in the system. According to 2018 data in Europe, VDL is in first place with 87 electric bus sales and a market share of 15.5%; Solaris ranks second with a market share of 13.7% with 57 electric bus sales. Similarly, Volvo's sales of 7 electric buses in 2017, one of the other European electric bus manufacturers, increased to 36 in 2018; Irizar sold 22 electric buses in 2017 and 23 in 2018 [9].

Oslo's public transportation operator, Nobina, has become the first public transport operator in Europe to put into work China's BYD articulated electric buses. Since December 2017, 2 electric buses have been employed in Oslo for the testing processes related to the issue, while at the same time considering the goal of decarbonization of the bus fleet because election of the city as the 2019 European Green Capital, it is stated that all of the public transportation vehicles are targeted to be made emission-free within 10 years. For this purpose, among the operators that work in Oslo Unibuss has ordered 40 Vdl while Norgesbuss has ordered 17 Volvo electric buses**.** In addition, BYD, together with Alexander Dennis, produced electric buses for the British market and sold 77 electric busses with direct BYD brand in Europe within the framework of a different business model; With the joint venture of BYD - ADL, it sold 84 electric buses and reached 161 electric bus sales volumes registered in 2018.

Ultimately, when the 2018 electric bus market shares in Europe are analyzed, it is stated that VDL Bus & Coach

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takes the first place with a share of 15%, followed by Solaris with 14%, BYD with 11% and ADL with 9%. In Figure 2 below, the market distribution of European electric buses (battery-powered) is given on a brand basis for the change over the years [10].

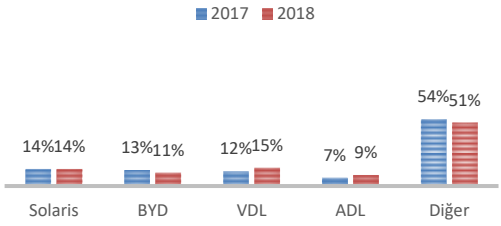


Figure 2. European Electric Bus (Full Electric) market distribution

II. Financial Approaches to Electric Bus Purchases

The electric buses, which are preferred for sustainable public transportation systems with zero emissions, need a completely new model and understanding of the business included a holistic approach. In fact, due to a number of restrictions which is especially related to electric buses, there are issues that are more disadvantageous than common diesel buses . These problems are especially valid for buses that are used in lines with long range or intensive working periods however sustainability of the projects can be achieved with electric buses that will be preferred in different concepts. In the example implemented at Amsterdam Schiphol Airport, electric buses operate 7/24 with a full-time shift. In this case, because of the system based on charging only in garages during the night will not be appropriate, the electric bus concept with fast charging system was preferred for the related line.

As the electric bus industry develops, more and various financial options are expected to emerge. Different financing mechanisms should be evaluated by considering the electric buses has higher initial costs than combustion engine like diesel and CNG buses for all that the benefits of low operating costs of electric buses for the businesses carrying out public transportation services. As it is known, many of the electric buses used in various parts of the world in public transportation services are supplied with financial resources like international and local grants and self-financing loans, etc. However, it is not enough to change vehicles for replacing the public transport system. Also, reorganizing the bus depots where the charging systems are located and maintenance & repair activities are carried out; should be included in the cost analysis. For example, some bus operators in Shenzhen also preferred a different approach for electric buses; It was stated that by using the leasing method instead of purchasing the mentioned electric buses, especially the need for debt financing was reduced by gaining in initial investment costs. On the other hand, electric bus procurement methods should be researched and incentive mechanisms should be developed, based on new business models, which are compatible with new needs and which will include all stakeholders, especially local administrations, offering public transportation.

Transition from diesel and CNG buses used in public transportation systems to electric buses is very difficult for many operators. The additional costs incurred are tried to be alleviated with funds and various supports all over the world. Electric buses have 2 to 4 times higher initial purchase costs than conventional internal combustion engine diesel buses according to countries. Besides, a serious infrastructure investment is also required than the diesel bus concept. In addition, electric buses, which have a significant disadvantage due to the use of batteries, need to be replaced at least once during the entire life cycle (in order to meet the targeted performance conditions), which confronts public transport processors as an important additional cost to take up with [1][7].

It is known that there are some difficulties in the transition to the electric bus, especially on the basis of local administrations providing services in the public transportation sector all over the world. While these difficulties can be categorized technologically, financially and institutionally in the header, they are categorized as sub-headings based on vehicle / battery structure, network / charging infrastructure. Lack of operating information about electric buses. Also this issue is one of the vehicle and battery based technological constraints that make the transition to electric buses difficult. Advantages / disadvantages, achievable limits, weaknesses of vehicle designs are at the forefront of the technological constraints in this classification, while financially high initial costs and different financial solutions cannot be offered.Institutional constraints can be characterized by the fact that there are a large amount of internal combustion engine diesel and CNG vehicles in stock, and that battery and charge concepts for electric vehicles needs differences in their designs, and infrastructure requirements specific to these designs according to cities to be used.

One of the constraints determined in terms of public transportation operators is how public transportation companies should start the issue of electric buses on the basis of local administrations [11]. The fact that the current business models and vehicle purchase methods are not very common and flexible, these are also considered as financial weaknesses for public transport operators.When approached institutionally, it is seen that there is an increase in various negative perceptions, especially range concerns against electric buses, and not enough incentive / support policies.In addition, uncertainties about maintenance & repair, lack of experienced and sufficient workforce can be considered as important constraints.

Within the scope of the energy network and charging station, the fact that the existing energy infrastructures can not fulfill the capacity of power demand in the case of the introduction of electric buses, and insufficient standards and regulations also the failure to maintain the network stability are the primary constraints in this field.

Although electric buses are used in many parts of the world, it cannot be seen that they can be fully adapted to the fleets of cities except Shenzen and Zhengzhou cities of China (In these cities, fully electric buses are used). In Figure 3 general barriers of electric bus purchasing models

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are categorized. Nevertheless, in various regions of the world, especially in Europe, providing support and promote the use of pilot studies to achieve awareness and experience in performing electric buses.

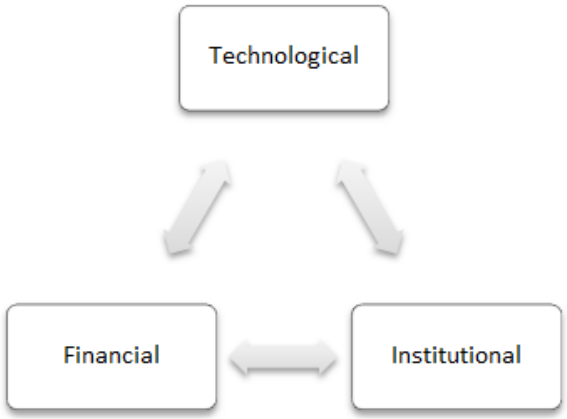


Figure 3. General Barriers of Electric Bus Purchasing Models

Although there are many domestic manufacturers in the field of electric buses in our country, it is thought that it still has not reached the expected stage like many other developing countries [1]. Nevertheless, the transition to electric buses in the public transportation service carried out by local administrations provides improved air quality, noise reduction for cities, reduction in total cost of ownership compared to traditional internal combustion engine buses, etc. Based on such topics, it attracts attention as a good option. In Figure 4 you can see basic electric bus tradespace components.



Figure 4. Electric bus tradespace components

In this context, the conversion of the existing internal combustion engine bus fleets of the cities to fully electric bus fleet should be analyzed accurately, and the appropriate systems and configurations should be determined, especially the operational planning of buses for the transition. It should be noted that the city-specific data used in electric bus application and operational operation issues may differ.
Local governments on public transportation businesses;

- Before determining the use of electric buses, they should consider the system as a whole (including the necessary infrastructure) and perform cost-benefit analyzes with the proper inputs,
- After awarding to use electric buses, pilot projects must be implemented first; the appropriate road map should be followed in terms of where, how to start and operate the works,
- Electric bus concept should evaluate as a whole with operational characteristics of existing electric buses in working condition, constraints, vehicle maintenance requirements and infrastructure elements that must be considered before preference of electric vehicles.

At the top of the many obstacles set out in the report on the use of electric buses in cities prepared by WRI; inadequate vehicle financing, traditional vehicle supply models and lack of stakeholder knowledge in electric bus operation were demonstrated [12]. In pilot projects where electric buses in 16 cities of Europe are integrated into existing systems; thanks to real-time applications, many issues have emerged, including space constraints of warehouses in bus garages, which have not been widely addressed in previous research, the effects of negative perceptions of public bus companies on electric buses, inadequate energy network infrastructure, and inefficiencies in energy planning.

As a result of the studies, it has been observed that the most important obstacle factor in the subject of electric bus is the scalability problem in large-scale projects.Despite the problems such as technological constraints, financing of business models and current network capacity in small-scale electric bus projects implemented in many cities, the system became operational, but when the project portfolio grew, it became clear that the number of vehicles increased.In this context, cities can ignore the disruptions to be experienced for small-scale electric bus projects, which are generally carried out in the first place, and have much more difficulty in large or full-scale electric bus project studies. Since it cannot be tolerated the disruption of the transportation service for any reason in the cities, it causes the projects to be perceived negatively in terms of system sustainability.The most striking example of this is that although it has a fleet of fully electric buses in Shenzen city of China, 350 diesel buses are kept ready for emergencies.

In this study, the aim of addressing the negative aspects of the electric bus programs is to ensure that the stakeholders are guided safely at the macro level planning works and to create an effective road map for transition to electric buses.

III. World's Largest Electric Bus Fleet and Shenzen Model

In the Electric Vehicle Outlook 2019 report, which was reported to have sold more than 2 million electric vehicles in the world in 2018, the sales of electric buses in 2040 will account for approximately 70% of the total electric vehicle sales; 57% of all passenger vehicle sales and 30% of the global passenger vehicle fleet are expected to be electric [12].

The most important resource that sets an example for these predictions is Shenzhen city of China.Before starting the use of electric buses in Shenzhen (before 2012); Although the number of diesel buses constitutes 0.5% of the total number of vehicles in the city, it is stated in various reports that the emissions of buses constitute 20% of the total transportation emissions because buses operate longer than private vehicles.This also directs assessments that the

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use of electric buses is an important benefit in preventing air pollution caused by exhaust emissions [13].

With the 16,359 electric buses announced at the end of 2017, the city of Shenzen was able to use fully electric buses in the public transportation system in the world; Thus, it became the city with the world's first 100% and largest electric bus fleet. There are many studies and analysis in the literature on how to overcome obstacles such as the major breakthrough in Shenzen - high costs for electric buses, lack of charging station / energy infrastructure and more. Figure 5 in below shows the change of electric bus usage by year in Shenzhen, China.

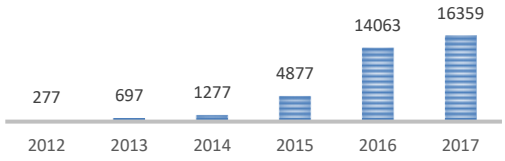


Figure 5. Shenzen City's electric bus fleet replacement by years

In this great transformation carried out in Shenzhen in the studies examined, a consensus was reached that the 4 main factors detailed below were effective.

A. National and Local Subsidies

The use of electric buses in public transportation systems in China is supported by various subsidies by the central government.Within the framework of this major transformation in Shenzhen, it provided public transportation companies with an average of $ 90,000 to $ 150,000 per electric bus.For many Chinese cities, especially Shenzhen, policy incentives such as national and local subsidies play a major role in closing the cost gap between electric buses and traditional diesel buses.It is stated that these subsidies, which were provided to Shenzhen until 2016, amounted to more than half of the purchase cost for a 12-meter electric bus [14].

It is observed that these supports and subsidies are not continued as of the period reached. The new point of view is that the subsidies are no longer necessary to make electric buses cost-competitive with diesel buses.According to a study by the World Bank and Global Environment Agency, the total cost of ownership of electric buses in Shenzhen in 2016 was $ 375,457; however, the total cost of ownership of a diesel bus has been calculated as $ 342,855.As a result, although the initial purchase costs are higher for electric buses in Shenzhen; The approach is demonstrated that the operating and maintenance costs of electric buses are significantly lower than those of diesel buses, and that the gap is decreasing day by day according to the total cost-benefit analysis conducted [15].

B. Rental Method

Some bus operators in Shenzhen also have preferred a different approach for electric buses; by using the vehicle rental method instead of buying, it is aimed to provide achievement especially for the initial investment costs. It is stated that this situation especially reduces the need for debt financing.

This method can be defined as a kind of leasing used in the public transportation business. With the method of renting electric buses, it provides flexibility to the capitals that municipalities should allocate in this regard and offers investment opportunities in other areas. This situation also allows the private sector to undertake financial and technological risks. In the model, it is possible forthe public transportation company to rent direct electric buses, but it can also be carried out alternatively through private enterprises. It is based on the principle that private enterprises offer the public transportation system with a certain number of lines or vehicles as an operator on behalf of the local enterprise. The difference here is that the buses used are electric. In fact, this method, which includes traditional internal combustion vehicles like diesel buses, is preferred especially in England, while it is carried out with electric buses in new format. In comparison with internal conbustion engine buses, operational savings obtained by electric buses are directed to the payments to be made by the said local administration or public transportation operator to relevant institution providing financial opportunities with the scope of this service. Thanks to the strong lease contracts established with this model, it is observed that a service purchase is provided according to the performance requrements of cities, while most of the operational risk is shifted to the operators or bus suppliers according to the chosen method. The side that is qualified as a supplier is responsible forthe maintenance and sometimes operation of buses, often at a fixed cost during the contract. Most of the leases of the available electric bus (including battery) are encountered in studies where the public transport operators continue for a maximum of 1-2 years to pilot the operation for the bus, but long-term leasing is also considered an option. This is a relatively new approach; this model, which is made with electric buses, is used in the relevant transportation authorities in Warsaw and New York besides Shenzhen.

On the other hand, there are models where only the battery is rented under the title of rental in electric buses. In this financing mechanism, a model is operated by public transportation operators on the fact that battery costs cannot be included in the initial purchase costs for electric buses, considering that the average cost of electric buses is 40% to 60%, based on the structure used for electric buses, its effectiveness comes to the fore. In the model, battery packs of electric buses are rented separately after the vehicle purchase and usually from the electric bus manufacturer; here the public transport operator can make monthly or annual payments for the use of the battery.In this case, it is aimed to reduce the difference in the current initial purchase costs of electric buses according to diesel and CNG buses, while reducing the investment costs.

It is also stated that within the scope of these models, municipalities received tax-based incentives as well as loans and grants from their governments on a national basis to support the purchase and operation of electric buses. Also in this context, besides Shenzhen, it is stated that an agreement was signed with the national government in Copenhagen on behalf of the local administration to give operators offering

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public transportation services Access to low interest loans for electric bus purchases; the warranty period is benefited by reducing the period from 6 years to 10-12 years [16].

For these leasing concepts used abroad, the general opinion obtained by public transportation operators is that financial leasing business models are dependent on grants and funds, and in this sense, widespread and sustainability can be made possible with these funds and incentives.

Another application example of this model(a purchase model based method by purchasing the bus itself and renting the batteries in the bus) was made between the local transportation operator Park City and the electric bus manufacturer Proterra, which serves the ski resort in Utah. In the mentioned model, in 2017, a grant of $4.4 million was purchased for the buying of 6 electric buses. It is based on the Project that Park City Transit has electric buses (excluding battery), charging insfrastructure and garages; the owners of the batteries to be used in buses are Proterra and leased by Park City Transit; in addition, the Proterra provide the necessary services to the batteries [17].

The sanother application is a work based on the partnership of GenerateCapital and BYD to provide a wider variety of lease arrangements. BYD Motors and GenerateCapital pioneered a new rental program to accelerate the adoption of electric buses. With the joint venture established for this purpose, new approaches heve been adopted to complete the lifetime of the batteries used in electric buses. It is stated that this joint venture is designed to reduce the preliminary costs in the installation of electric bus fleets in the USA and to expand their use [18].

C. Optimized Charging System and Line Planning

The operation of a fleet installed from electric buses differs significantly from the operation of fleets installed from diesel buses. It is stated that due to shorter driving distances (depending on batttery capacities and compared to diesel buses) and long-term charging requirements (may vary depending on the preferred charging concept), the use of 100% more electric buses in the first place is required. This large number of vehicle supplies brings additional costs for operation and maintenance. It is stated that the operation management of buses has been optimized forthis situation in Shenzhen and these additional costs have been almost completely eliminated [19]. It is stated that the concept, which provides 250 km range with 5-hour depot charge in Shenzhen, and thus the sustainability of a full-time operation along the suitable line which the relevant bus is responsible is adopted. For this model, mainly electric bus battery and charging system concept is preferred.In addition, bus operators cooperated with network energy infrastructure providers (electric distribution company) in order to equip most of the bus routes with charging infrastructure to ensure that the service does not interfere with recharging, and 1 charging station has been set up for every 3 buses at present. These stations are made available for the use of other private electric vehicles other than public transportation and an opportunity is provided to improve their financial performance. Moreover, as with all international market conditions, a model is operated in bus operators where battery charging cycles are provided at the terminals, which are fully charged at low unit price (night tariff) and where necessary, require additional range with intermediate charges during the busy travel times and optimum operating cycles of electric buses.

D. Provide Lifetime Warranty for Batteries Used in Electric Buses

In electric buses, the need for battery replacement is frequently encountered in the early stages of electric vehicles, especially when technological maturation is not sufficiently achieved. Similarly, it leads to additional lifetime costs that increase with mechanical failures. Normally, bus operators have to cover all these costs in traditional purchasing methods.

In Shenzhen, bus manufacturers provide lifetime warranties for batteries used in electric buses, as bus operators requested this in their contracts during this procurement phase. Bus manufacturers took this risk on bus operators to manage financial risks. On the other hand, the battery warranty process included in this model eliminates the disadvantage of the continuous development of battery technology for operators [20].

Considering the aforementioned issues, it is seen that with the large-scale business experience of Shenzhen, it is possible to transform the existing conventional engine bus fleets of cities into electric buses by a sustainable cost. In addition, unlike the methods used in Shenzhen, other business models especially for electric bus supply are given below.

Another business model put forward for the use of electric buses in local public transportation enterprises is the common procurement method. This model is based on the provision of buses by 2 or more public transport operators simultaneously and under the same conditions. This method increases the purchasing power of the enterprises by making use of the classical scale economy. For example, several public transport operators in the Los Angeles are have collaborated with the State of California to maximize economies of scale by developing a state-wide joint procurement program. A similar approach has been adopted in Washington State [21].

In procurement approaches for electric vehicles, designing flexible business models for the developing industry ecosystem; preparing the ground suitable for benefiting from resources and intersectoral partnerships is very important. While the results to be obtained from a unique business model perspective create added value for all stakeholders, especially the industrial players, it is expected to provide policy predictions for decision making mechanisms [22].

In the following, unlike buses, comprehensive business models of applicationsbased on electric vehicle concept and charging infrastructures in the normal passenger vehicle category are given.It is seen that different approaches, such as fast charging systems, battery swapping technology and structures that can be integrated with renewable energy systems, are taken into consideration in the business models of this sample project, and are generally carried out in the

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energy distribution company in that region where the project is realized.Within the scope of the cost-benefit analysis, modeling topics are also included in smart business model infrastructures, battery, initial investment cost analysis, reducing the electricity costs required for the energy needs of users, changing user habits, creating financial effective costs for long range.

1) Sample work 1

In the first of these business models, BYD, the world's leading electric vehicle manufacturer, collaborated with SouthernPowerGrid, the city's electricity distribution company, as part of a pilot Project for fast charging infrastructure and services in Shenzhen,China. In this context, a system based on the principle of deploying charging stations near the users' home after the purchase of electric vehicles is modeled. On the other hand, the works carried out with this joint venture have been used in the taxi stand of public transportation in Shenzhen; currently, 60% of the taxis have been electrified. It is also stated that in 2022, it is aimed to be composed of all electric vehicles in taxis, as in electric buses.

2) Sample work 2

This technology-oriented business model, the main element in the electric vehicles is to replace the batteries with a pre-charged battery instead of being filled when needed. The model, in which the user is offered the option of renting instead of purchasing the battery, is validated for the HAIMAbranded electric vehicle model produced by WanxiangGroup.

Within the framework of this business model, users are offered 2 different options. In the first, vehicles are rented without batteries; the battery is rented to the consumer on a monthly/annual basis, provided that the energy cost used by the electricity distribution company of the region is included. Thanks to this battery rental service offered for approximately 330 € per month and modular and fast battery replacement developed for vehicles within this scope, the system is implemented according to the principle of replacing the empty battery with the battery charged in the relevant centers without the need for filling. Another option in this model is based on the purchase of electric vehicles. During the first 3 years or 60,000 km following the purchase process, the opportunity to benefit from free battery usage and replacement is given to users. It is stated that with this model, it is aimed to create a standard electric vehicle battery replacement concept that provides a sustainable and fast system and to encourage the use of electric vehicles by directing consumer behavior fort he electric vehicle model included in this concept. In addition, it is aimed to significantly reduce the additional cost incurred(initial purchase) and usage cost; on the other hand, it is stated that smart charging infrastructure elements come to the fore .

3) Sample work 3

In the business model developed by Tesla, which is the most popular company in the field of electric vehicles, a small part of the energy is provided at the free fast charging stations that provide the necessary energy supply for the electric vehicles, while the panels producing electricity from solar energy provided. While this business model stands out with a focus on high-tech vehicle production and sales; it is stated that it aims to have people own electric vehicles and to change their consumer attitudes towards electric vehicles by directing their usage habits [25].

4) Sample Work 4

And the last business model, it is aimed to completely remove the financial risks of electric vehicle users; thanks to the two-component payment system, a different concept is introduced. In the model introduced, costs are transferred from user to Autolib (company), including vehicle purchase, battery and required energy. Thus, the operation is carried out on the basis of taking the majority of the risks related to electric vehicle technology, market development and infrastructure over the user. All elements within the framework of this business model are provided by Autolib and its subsidiaries. Thus a significant reduction in financial investment cost is envisaged. In fact, the model is basically based on preventing all these risks from focusing on the user and distributing the risks among ecosystem players [26].

IV. Electric Buses in Public Transportation System in Turkey

The energy and the environment management for local government which gains importance in the field of sustainable municipality comprehension day by day and consists of many activities is one of the strategic policy. The activity approach in this issue is both related to the many area of the life and is also important for the transportation perspective. In this context, public transportation system in Turkey is managed directly or/and indirectly by the local government in each city. It is considered that the public transportation activities managed by the appointed units should be kept under certain standards and managed under a single centralized policy within the framework of energy and environmental strategies independently in terms of different priorities and targets.

The electric vehicle project introduced recently in our country and prototype produced by TOGG along with including in "Support and arrangements will be made to expand the use of domestic electric buses in urban and intercity transportation' in yhe 385.5 of 11th Development Plan of the Presidency depict that importance in the field of electric vehicles in the national policy [23].

The 23 tenders have been carried out considering infrastructurer requirements for electric buses, public transportation administrations for vehicle procurement/projects and related participation since 2019 in Turkey. While the 7 of these tenders was cancelled because of various reasons, the 16 of them was resulted in the contracts. Finally, the 8 pieces of the electric bus procurement tender the administration can successfully realize was organized. When considering the tenders that are dependent on the existing contract in the public transportation system, while the 118 pieces of the electric bus are expected to be ready to usage, the 84 pieces of the electric bus have been delivered to the municipalities in Turkey since 2019. However, it is not known how many of

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them are used actively. In this context, the usage of electric buses were firstly carried out by Eskişehir Tepebaşı Municipality in Turkey. Tepebaşı Municipality, a district of Eskişehir, purchased 4 pieces of the electric bus along with the project of the European Union that participates in. Only social service as well as public transportation is provided to Eskişehir Tepebaşı municipality with the 10.7 meter long electric buses. Then, Izmir Metropolitan Municipality established Turkey's first electric bus fleet consisting of 20 pieces of the electric bus with the 12 meter long. Also firstly, it was taken a step 100% zero emission public transportation in Turkey by providing the integration with solar energy system. Both the first trolley bus fleet and the biggest electric buses fleet with 24 metter, biarticulated, 22 electric buses (trolleybuses) were established to use in Turkey's public transportation via 22 pieces of the trolley bus buying from Malatya Metropolitan Municipality. Likewise, Konya Metropolitan Municipality have started to use 4 pieces of the electric bus with the 10.7 meter long in the public transportation. Manisa Metropolitan Municipality has 22 pieces of the electric bus consisting of 20 pieces with 18 meter long and 2 pieces with 24 meter long, 24 meter long ones are the longest electric buses with energy storage system in Turkey. While Elazig Metropolitan Municipality has 15 pieces of the electric bus fleet where the first 18 meter long single articulated electric buses, Kayseri Metropolitan Municipality has totally 18 pieces of the electric bus fleet which of 10 pieces with 18 meter long single bellows electric buses and 8 pieces with 24 meter long double articulated electric buses. In addition to this, although Sanliurfa Metropolitan Municipality have signed a contract including the purchase of 10 pieces of the trolley bus with 24 meter long, the buses cannot be operated in the system. Finally, Ankara Metropolitan Municipality published a pres release about purchasing 3 pieces of the electric bus and using them in Ankara public transportation system with the scope of the protocol signed with the General Directorate of Electric Gas and Bus with Renewable Energy General Directorate in 2019 [1][6].

V. Discussion and Conclusion

Transition to electric buses for local administrations that provide public transportation in our country is not only a transformation of vehicle concepts, but also takes over as an attractive option, which improves air quality for cities and reduces traffic based noise, transportation based gren house gase missions and operating costs (compared to traditional internal combustion engine buses). However, purchasing cost of electric buses compared to diesel and CNG buses with the same quality is quite high causes the biggest obstacle to sustainable public transportation service.

In this context, analysing the transition of existing internal combustion engine buses into electric buses accurately and determining optimum system and configuration of vehicles especially operational planning of buses are the important issues. In this study, the approaches to be followed during the transition to the electric bus concept for our local governments are presented. Considering the business models at issue in public transportation with rubber wheeled systems especially for Ankara and Istanbul is significant to lead the way to the electric bus concept, which will be mandatory to use on the 100% zero emission sustainable public transport in the near future. From these business models, purchasing the electric bus without battery that leasing method based on the perspective in paying the batteries with operating gains depending on the years and methods based on the creation of economies of scale by two or more public transport authorities with the scope of the joint venture can be preferred. On the other hand, this issue can be possible by using methods that based on long-term contracts considering by our local governments and allow it to be carried out on condition that completely commissioning of the public transportation with certainlines and/ or a certain number of buses, by using external public transport operators. It should be taken into consideration that this public transportation service should be provided by electric buses and in cases where it should be mandatory in the contract to be made.

References

[1] Topal, O. (2019). Türkiye'de Elektrikli Otobüsler. İstanbul: Efe Akademi

[2] International Energy Agency Data Bank, Source: IEA CO2 Emissions from Fuel Combustion https://www.iea.org/subscribe-to-data-services/CO2-emissions-statistics

[3] Bloomberg New Energy Fianace Global Electric Vehicle Oulook 2019 Report

[4] Sustaniable Bus Editorial Staff (2021), Genoa targets a full electric public transport fleet by 2025. New e-bus delivery by Rampini, Sustaniable Bus Magazine

[5] The Future of Mobility Is At Our Doorstep, McKinsey&Company 2019

[6] Topal, O. Türkiye Toplu Ulaşım Sisteminde Elektrikli Otobüsler. Avrupa Bilim ve Teknoloji Dergisi, (15), 155-167.

[7] Topal, O. (2017, April). Electric bus concept against to diesel and CNG bus for public transport operations. In 2017 5th International Istanbul Smart Grid and Cities Congress and Fair (ICSG) (pp. 105-109). IEEE.

[8] Editorial Staff Sustaniable Buses (2021), European e-bus market grows 22% in 2020 despite pandemic. Sustaniable Bus Magazine

[9] CME Solution

[10] Topal, O . (2020). Elektrikli Otobüslerde Kullanılan Şarj Hızlı Şarj Sistemleri . Avrupa Bilim ve Teknoloji Dergisi , (20) , 93-100 . DOI: 10.31590/ejosat.750221

[11] Elektrikli Otobüsler için Yerel Yönetimlere Tavsiyeler- Orhan TOPAL 2020

[12] Bloomberg New Energy Fianace Global Electric Vehicle Oulook 2019 Report

[13] Shenzhen Urban Transport Planning & Design Institute Co. Ltd.

[14] How to Enable Electric Bus Adoption in Cities Worldwide, World Research Institue 2019

[15] Worl Bank and Global Enviroment Agency

[16] Scheurer, J. (2013, December). Measuring Copenhagen's public transport accessibility and network performance in a European context. In Proceedings from the Annual Transport Conference at Aalborg University (Vol.20,No. 1).

[17] Liu, Z., Song, Z., & He, Y. (2019). Economic Analysis of On-Route Fast Charging for Battery Electric Buses: Case Study in Utah. Transportation Research Record, 2673(5), 119-130.

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[18] Liu, D. (2019). The US Electric Bus Transition: An Analysis of Funding and Financing Mechanisms (Doctoral thesis, Duke University).

[19] Lin, Y., Zhang, K., Shen, Z. J. M., & Miao, L. (2019). Charging Network Planning for Electric Bus Cities: A Case Study of Shenzhen, China. Sustainability, 11(17), 4713.

[20] Shenzhen Urban Transport Planning and Design Institute. 2017. New Energy Bus Operation Report Framework (Phase report). World Bank-GEF "Big City Tobacco Workshop Congestion and - Carbon Reduction" Project

[21] Markle L., Maximum acceleration in ZEV policy: e4 meeting highlighted collaboration, LAEDC, 2021

[22] Competing and Co-existing Business Models for Electric Vehicles: Lessons from International Case Studies Claire Weiller, Amy Shang, Andy Neely, Yongjiang Shi - This paper is forthcoming in the International Journal of Automotive Technology and Management January 2015

[23] "11th Development Plan" Republic of Turkey

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