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A Charging Station Planning Study to Prepare for the Utilization of Electric Vehicles on University Campuses: The Case of Ondokuz Mayıs University

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Abstract

Electric vehicles (EVs) have gained significant interest as a cleaner and sustainable mode of transportation compared to fossil-fuel vehicles. Although its background goes beyond a century ago, the effects of global warming have increased the development and utilization of EVs. Similarly, serious investments are being made for the development and use of EVs for batteries and charging stations, and, R&D activities are being carried out in Türkiye. With the start of domestic e-Car utilization, it is expected that e-Cars will be used throughout Türkiye. Therefore, charging stations will be established to meet needs. For this scope, a design study has been conducted at Ondokuz Mayıs University Campus and the number of stations was determined to ensure the effective use of e-Cars at the campus. A field study was conducted on the current parking lots, their capacities, and average occupancy rates. Then, charging station recommendations were developed for each parking lot based on the distribution of EVs by correlating the parking lot capacities, occupancy rates, and distribution. With similar planning to be carried out on other university campuses, universities will be at the forefront of e-Car utilization and many studies can be conducted to solve the problems that will be identified.

Keywords: Electric cars, charging station, parking lot planning, vehicle utilization.

1. Introduction

Since their first appearance in the 18th century, vehicles have evolved into hundreds of different forms. According to available statistics, there are more than 1.5 billion wheeled vehicles in the world today, used in various sectors ranging from logistics, public transport and travel to the service sector [1]. As a result, vehicles have become very important in the global economy, both for saving time and for transporting people and goods. Although these vehicles save time and perform important services, they have a negative impact on the environment due to the harmful gases they emit as they have internal combustion engines [2,3].

in recent years due to the harmful gases emitted into the environment and the destruction of nature by humans [4,5]. According to the statistics of the US Environmental Protection Agency, 76% of the greenhouse gas emissions that cause global warming are CO2 emissions and 29% of these CO2 gas emissions are caused by the transport sector [1]. Due to this result and the fact that global warming is becoming more noticeable every day, global vehicle manufacturers have focused on developing vehicles that use green energy and have net-zero emissions instead of using vehicles that use fossil fuels [6,7].

In recent years, many fuel types have been developed and actively used in vehicles as an alternative to fossil fuels due to technological developments [8]. The most prominent of these are hydrogen-fuelled vehicles, plug-in hybrid vehicles and electric vehicles [9]. Hydrogen-fuelled vehicles (HFVs) move by burning hydrogen stored in cells, while electric vehicles (EVs) use electricity stored in batteries for energy. Although these two types are considered to be the most environmentally friendly new generation of vehicle engines, electric vehicles are more popular and preferred in today's conditions [10]. Looking at the history of the use of electric vehicles, it can be seen that they started to be used in the 1800s, but were not preferred at that time because the batteries could not match the range of internal combustion engines. At that time, the use of internal combustion engines was actually preferred due to a maximum range of 70 km and a speed limit of 40 km/h [11]. However, with the development of automotive and battery technology over the decades and the global warming that threatens the world in general every day, investment in electric vehicle technology and widespread use has increased. As a result of this positive discrimination in the development and use of electric vehicles, countries aiming to expand the use of these vehicles around the world have made this situation the main policy.

Electric vehicles, due to their operating characteristics, can provide significant benefits in many fields, especially environmental benefits by significantly reducing exhaust emissions [7, 12-14]. In order to make the use and operation of electric vehicles more effective and to fully reveal their positive effects, a large number of studies are being conducted worldwide. Most studies in this area focus on the widespread use of electric vehicles. Looking at the use of electric vehicles worldwide, it can be seen that three quarters of all new vehicles sold in 2021 will be electric vehicles [15]. On the other hand, it can be seen that this rate is quite low (2%) in the US in 2019 [15].

On the other hand, another important parameter for the widespread use of electric vehicles is charging facilities. The number of charging points has a very important role to play in increasing the use of electric vehicles. Studies on EV charging infrastructure have been carried out in many different countries. For example, according to a study conducted by [16] in China, access to charging stations in public places is shown to be the most important factor in people's adoption of EVs. According to another study conducted in the US, the lack of charging stations for EVs was identified as the most important barrier for society to adopt and use these vehicles [17]. In Norway, where the rate of EV use is quite high, [18] found that the availability of charging facilities is an important factor in consumers' decision making. In addition to charging station infrastructure, consumer expectations and behaviour, i.e., driver acceptance of these new vehicle types, are also highly influential in their diffusion. In the UK, [19] investigated the impact of incentives on electric vehicle (EV) sales using empirical evidence. In this context, [19] collected data on EV sales and incentives in the UK between 2011 and 2018 and analyzed the relationship between the variables. The results showed that incentives have a positive and significant impact on EV sales in the UK. In addition, the study found that the impact of incentives on EV sales varies across regions and income groups. Overall, the study suggests that government incentives can be an effective policy tool to encourage EV uptake, but their effectiveness may depend on the specific context and details of implementation.

In addition to charging infrastructure and consumer choice and behaviour, environmental factors play a very important role in the widespread use of electric vehicles. In this context, there have been many studies investigating the environmental benefits of electric vehicles compared to fossil-fuelled vehicles. [20] found that electric vehicles have a significantly lower carbon footprint than internal combustion vehicles. Another study compared electric vehicles with fossil-fuelled vehicles in China and found that electric vehicles play an important role in reducing air pollution compared to other vehicle types [21]. On the other hand, in a comprehensive study conducted in the European Union, [22] found that a switch to electric vehicles could reduce greenhouse gas emissions by almost 90% by 2050. The study found that although there are delays in implementation across Europe, the effect of the switch will bring vehicle-related greenhouse gas emissions close to net zero by the 2050s. The aim is to ensure the continuity of a habitable world by reducing air pollution factors to zero in a short time in a world where global warming is increasing day by day.

It is very important to plan systematic and operational preparations in advance in university campuses that will be pioneers in the use of electric vehicles in Türkiye. In this study, the required charging stations for fully electric vehicles for Ondokuz Mayıs University Kurupelit Campus (Central Campus) in Samsun, where major investments are being made in Smart City and Intelligent Transportation Systems (ITS), were designed according to the existing traffic density, parking capacity and density. In this context, the feasibility study determined how many charging stations should be placed in the existing car parks according to different percentages of electric vehicle use within the campus. In this respect, the study proposed a planning method that shows how the number of charging points will change depending on the use of electric vehicles on the campus and where they should be placed. By applying the method proposed in the study to other campuses, it is predicted that universities in Türkiye will be a pioneering example in the transition of universities to electric vehicles. In this way, universities will be able to observe the problems of the transition in advance and identify the problems that may occur in advance. Thus, they will be able to develop solutions to the identified problems in advance.

2. Current Situation in the e-Vehicle Market

2.1. Current situation in the world

Analyzing the available statistics on the number of electric vehicles, the cumulative number of electric vehicles in China reached 260 thousand by the end of 2019. Meanwhile, the total number of charging stations reached 65,000. Similarly, in Paris, London and Amsterdam, one of the leading cities in Europe, the cumulative number of electric vehicles reached 40 thousand and the number of charging stations reached 4 thousand, 6 thousand and 10 thousand respectively. In Oslo, the capital of Norway, which has the highest rate of electric vehicle use in the world, the number of electric vehicles reached 110,000 and the number of charging stations reached 5,000 [3]. In Los Angeles, the three largest electric vehicle markets in the world, this number has reached 200 thousand, 120 thousand in San Jose and 100 thousand in San Francisco. The number of charging stations was found to have reached 2 thousand in San Jose, 3 thousand in San Francisco and 5 thousand in Los Angeles [23].

China stands out as one of the world's largest markets for electric vehicle sales. Even surpassing the US, China alone sells 46% of all electric cars sold worldwide. In addition, around 43% of the electric cars produced in 2020 will be made by Chinese carmakers [24]. In Europe, electric vehicle sales are not as high as in the US and China. The main reason for this is that the EU's incentives for electric cars are not as effective as in the US and China (Fig. 1).

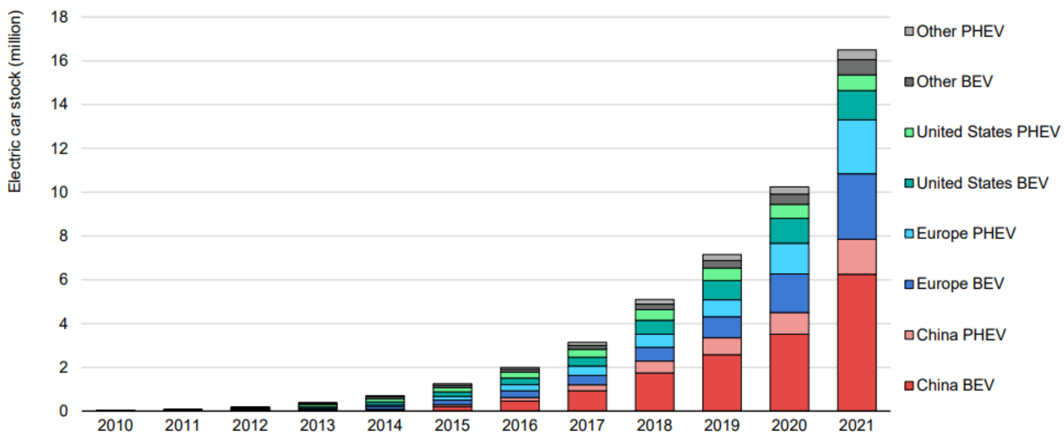

Fig. 1. The number of existing vehicles in the world in 2021 and the change by Years [24]

2.2. Current situation in Türkiye

According to the report prepared by TEHAD, the interest in electric cars in Türkiye is not at the desired level. Currently, the number of electric vehicles is around 6,500-7,000 (excluding hybrid vehicles). However, there has been a significant increase in electric car sales in recent years. For example, analysing the sales figures for the first six months of 2022, a total of 2413 electric vehicles were sold. This figure is significantly higher than the 894 units sold in the same period last year (Fig. 2). It is therefore expected that a total of more than 4,000 electric vehicles will be sold by the end of 2022. This figure represents an almost threefold increase (Fig. 2) [25].

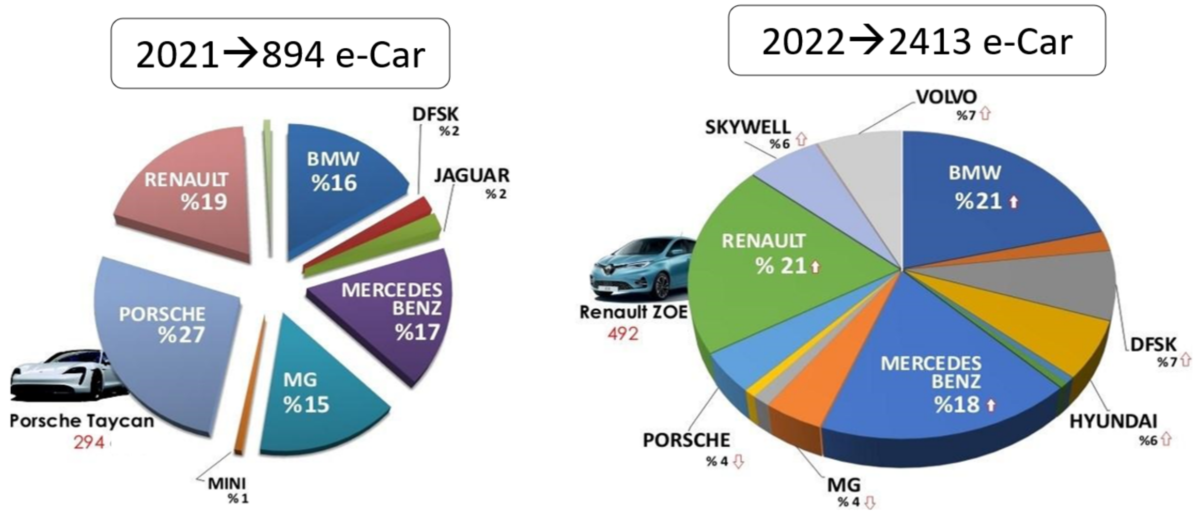

Fig. 2. Change in electric vehicle sales in Türkiye [25]

The domestic electric vehicle production and development process in Türkiye started with the production of solar-powered vehicles at METU in 2003. Later, the production of electric vehicles, which started in other universities, developed further with ITU receiving serious support from universities. In addition to universities, car companies have also started electric car production in Türkiye. For example, Renault produced the electric model 'Fluance' at its Bursa plant in 2011 and tested it in Europe for a long time. The Koç Group has also developed electric cars under the Ford "Focus" brand, but has not been able to start mass production due to infrastructure problems in Türkiye. Similarly, Toyota has also produced electric vehicles, but has not been able to start mass production due to infrastructure problems for the use of electric vehicles in Türkiye [25].

Nowadays, electric vehicles have started to be actively used in many countries of the world, especially in European countries, by establishing infrastructure systems and electric charging stations. In Türkiye, a large number of studies have been carried out in this field in recent years. As the market share in this field is quite high, the interest in this field is quite high. Studies in many areas such as batteries, charging stations, etc., especially for electric cars, minibuses and buses, are actively continuing (Fig. 3).

In 2017, a vision plan was announced to produce Türkiye's first domestic electric car. A year later, a consortium consisting of Anadolu Group (19%), BMC (19%), Kök Group (19%), Türkcell (19%), Zorlu Holding (19%) and TOBB (5%) was formed, resulting in the establishment of Türkiye's Automobile Initiative Group Industry and Trade Inc. on 25 June 2018. TOGG presented the SUV and sedan models of the domestic car at a press conference on 27 December 2019, and a factory was built in Gemlik as part of this production. The factory was opened on 29

October 2022 and mass production started with the first mass-produced vehicle coming off the line (Fig. 4).

Fig. 3. Sample images of some ongoing electric vehicle studies [25]

Fig. 4. Sample images of the domestic car TOGG SUV model and images of the vehicles planned to be produced [26]

In addition to the electric car, Türkiye's leading domestic bus manufacturers BMC, Otokar, Temsa, Karsan, Bozankaya and Akia have developed electric bus designs and started production. Many of these companies now offer their domestic buses for use in public transport in both domestic and international markets.

2.3. Availability of car parks as charging stations

While there were around 2,500 electric vehicles in Türkiye at the end of 2017, the aim was to increase this number to 140,000 within four years. In addition, 14,000 commercial and 70,000 residential charging units were to be installed. However, these targets have not been met over the years. For 2022, the target has been set at 140,000 electric vehicles and 14,000 commercial charging units. With the existing infrastructure, 25 per cent of the 14,000 charging units should be DC fast charging units and the rest AC charging units. In addition, the number of residential charging units is expected to be around 70 thousand, but unfortunately these numbers have not been reached [27, 28]. Although there has been a significant increase in the number of electric vehicles in Türkiye in recent years, unfortunately it is far from the desired targets (Fig. 5).

Fig. 5. Location map of available charging stations in Türkiye [25]

There are currently around 4,000 charging stations in Türkiye. However, it is expected that the number of electric vehicles charging stations will reach tens of thousands in a short period of time after the Turkish domestic car TOGG starts mass production. With the launch of the TOGG domestic electric vehicle, many companies in Türkiye are expected to use electric vehicles in their fleets. Currently, Türkiye ranks last among the countries with charging stations in Europe, but this number is expected to increase very quickly with the TOGG Trugo developed for the domestic car TOGG [7]

When analysing the locations of electric vehicles in Türkiye in Fig. 5, it can be seen that the number of electric vehicles charging stations is quite insufficient. The most appropriate solution proposed to solve this problem is to use existing urban and intercity car parks as electric vehicle charging stations (Fig. 6). However, it is important to take traffic density into account when designing charging points and to install charging points accordingly. In the future, it is envisaged that all car parks will be fully used as charging stations. It is therefore very important and necessary to develop a new management system and to adapt the existing car parks to this system.

Fig. 6. Existing car parks as potential charging stations [29]

Placing charging stations only in existing indoor and outdoor car parks, and not analysing capacity utilisation and operational performance according to this new situation, may lead to long queues of vehicles and complexities at the entrance and exit of these car parks in the near future (Fig. 7).

Fig. 7. Queue formations which poorly designed and planned parking lots [30]

The following flow chart summarises the steps that need to be taken in order to avoid this problem in the pilot area (Fig. 8).

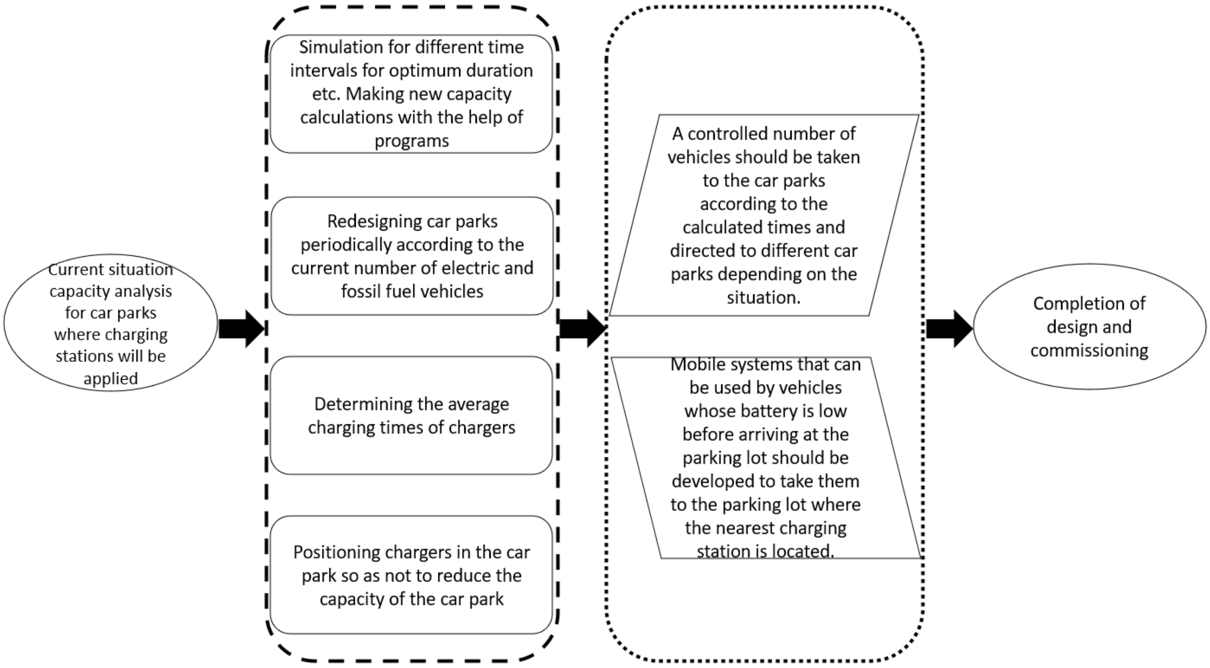

Fig. 8. Workflow plan for what to do in parking lot design for electric vehicles

3. Ensuring the Use of Zero Emission Vehicles in Omu Kurupelit Campus

3.1. Information about OMU campus

Ondokuz Mayıs University Kurupelit Campus covers an area of 10,000 hectares. There are many faculties, units and hospitals on the campus. Visuals of the campus are shown in Fig. 9.

Fig. 9. Image of OMÜ Kurupelit Campus [31]

The Kurupelit campus can be reached by tram, bus and minibus. Looking at the statistics for 2022, a total of 53201 students are studying at Ondokuz Mayıs University. 2524 academic staff and 3977 administrative staff support the education and training activities. In order to spread the use of zero-emission electric vehicles, which have become widespread in the world, in the central campus of OMU, it has been tried to make suggestions for the creation of infrastructure for the widespread use of electric vehicles according to the existing traffic parameters and parking facilities on the campus

3.2. Determining the amount of campus traffic

As part of the research, an attempt was made to determine the amount of existing traffic flow on the campus. To do this, the images from the security cameras at the main entrance and exit to the campus were analysed in a computer environment using a special coding language and image processing (Fig. 10).

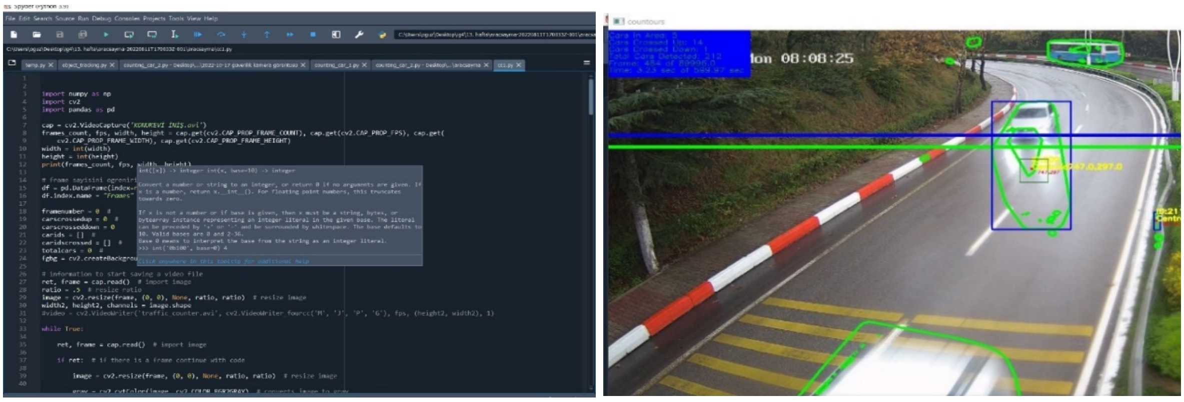

Fig. 10. Determination of traffic amount after analysis of camera images with image processing

At this stage, the most active period of vehicle mobility at the university was selected and the busiest periods were analysed as much as possible. Based on the data obtained from the image processing analysis in the computer environment, the current average daily traffic at the campus entrance was obtained according to vehicle-based time zones as shown in Table 1.

Table 1. Average number of available vehicles by type for OMU Kurupelit campus

Time Interval	Vehicle Type					
	Passenger Car	Van	Bus	Truck	Lorry	Total
0-1	111	23	0	11	0	144
1-2	58	14	0	7	0	78
2-3	38	8	0	8	0	54
3-4	32	8	0	8	0	48
4-5	16	2	0	2	0	21
5-6	19	6	0	4	0	30
6-7	48	11	10	16	0	86
7-8	276	78	17	65	2	440
8-9	560	101	20	86	6	774
9-10	737	149	14	63	11	975
10-11	938	162	12	89	7	1208
11-12	1308	203	10	69	16	1606
12-13	1054	182	13	76	19	1345
13-14	813	111	15	75	8	1022
14-15	1179	168	12	82	15	1456
15-16	1490	226	12	86	22	1836
16-17	1936	334	15	94	33	2411
17-18	1065	191	20	80	16	1372
18-19	548	94	20	62	7	730
19-20	513	61	19	51	6	650
20-21	324	52	16	53	4	449
21-22	262	39	14	44	3	360
22-23	211	38	8	23	1	281
23-24	213	35	1	19	0	268
07-19	11904	2000	180	929	163	15176
06-22	13051	2163	239	1092	176	16720
06-00	13475	2235	248	1134	177	17269
00-00	13748	2297	248	1174	177	17644

The results shown in Fig. 11 are obtained by analysing the hourly distribution of the average daily traffic flow values obtained.

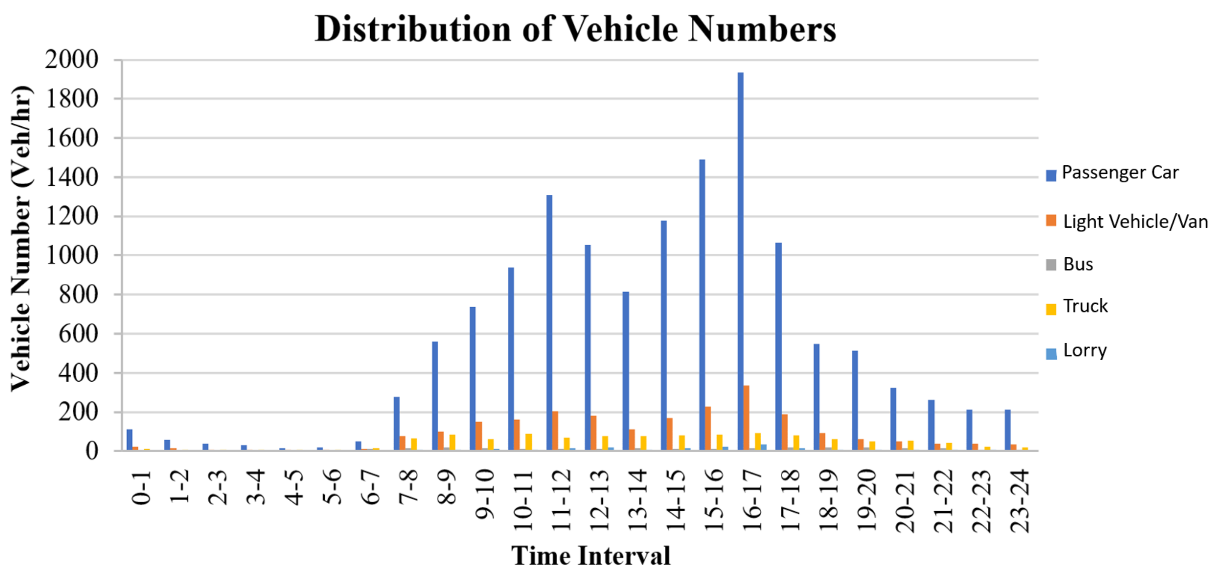

Fig. 11. Hourly distribution of current average traffic on campus by vehicle types

The distribution of the traffic on the campus according to certain time intervals and types of vehicles is shown in Fig 12.

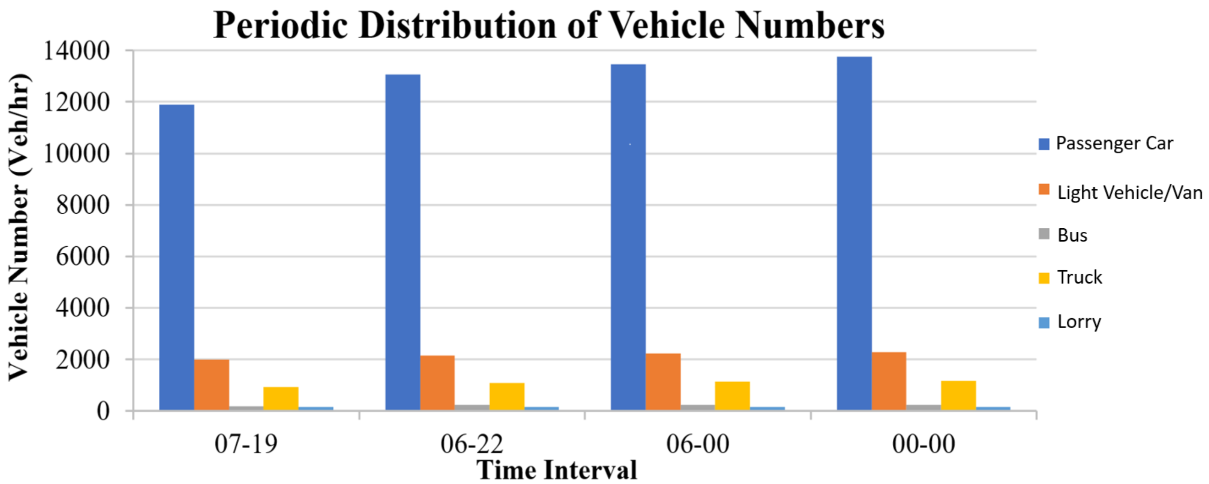

Fig. 12. Distribution of current average traffic on campus according to certain period intervals

An analysis of Figure 12 shows that most of the vehicles accessing the campus are distributed between 07:00 and 19:00. According to the average number of vehicles obtained, 15 thousand vehicles access the campus between these hours and 17 thousand vehicles on a daily basis.

3.3. Examination of the existing car parking capacity and parking lot usage on campus

In order to determine the existing car parking capacity and the average usage rate (average occupancy percentage) of these car parks on the Kurupelit campus, all actively used car parks on the campus were first mapped and grouped by number. The study of the capacity and use of the car parks included only the areas designed as car parks, not the street parking areas. The next step was to carry out field inspections to determine the capacity and average occupancy of all car parks, and to transfer and digitize the data obtained into the computer environment (Fig. 13).

Fig. 13. Collection of field data of parking lots

Table 2. The occupancy rate and capacity data of the car parks obtained by field observations

Location-Car Park No	Average Current Vehicle Number	Capacity (Vehicle)	Average Occupancy (%)
1- OMÜ Koleji Car Park	23	76	30.3
2- OMÜ Rektörlük Otopark-2	32	44	72.7
3- OMÜ Rektörlük Car Park-1	45	78	57.7
4- OMÜ AKM Car Park	72	85	84.7
5- OMÜ Hastanesi Car Park-5	185	235	78.7
6- OMÜ Tıp Fakültesi Car Park	23	24	95.8
7- OMÜ Hastanesi Car Park-6	27	29	93.1
8- OMÜ Hastanesi Kapalı Car Park-1	140	185	75.7
9- OMÜ Tıp Dekanlık Car Park	105	150	70.0
10- OMÜ Hastanesi Car Park-4	47	50	94.0
11- OMÜ Hastanesi Car Park-3	70	87	80.5
12- OMÜ Hastanesi Car Park-2	38	45	84.4
13- OMÜ Hastanesi Car Park-1	582	1200	48.5
14- OMÜ Hastanesi Car Park-9	49	114	43.0
15- OMÜ Hastanesi Car Park-8	38	44	86.4
16- OMÜ Veteriner Fakültesi Car Park-1	15	18	83.3
17- OMÜ Diş Hekimliği Car Park-1	122	158	77.2
18- OMÜ Diş Hekimliği Car Park-3	100	110	90.9
19- OMÜ Spor Bilimleri Fakültesi Car Park-1	5	16	31.3
20- OMÜ Tömer Otopark-2	16	34	47.1
21- OMÜ Spor Bilimleri Fakültesi Otopark-2	15	24	62.5
22- OMÜ Tömer Otopark-1	12	39	30.8
23- OMÜ Spor Bilimleri Fakültesi Otopark-3	61	84	72.6
24- OMÜ Spor Bilimleri Fakültesi Otopark-4	13	14	92.9
25- OMÜ Tömer Car Park-3	16	40	39.5
26- OMÜ Veteriner Fakültesi Car Park-2	47	62	75.8
27- OMÜ Hastanesi Car Park-10	43	35	122.9
28- OMÜ Hastanesi Car Park-7	59	65	90.8
29- OMÜ Hastanesi Kapalı Car Park-2	541	517	104.6
30- OMÜ Cami Car Park	6	56	10.7
31- OMÜ Diş Hekimliği Car Park-2	32	48	66.7
32- OMÜ İlahiyat Fakültesi Car Park	46	63	73.0
33- OMÜ UZEM Car Park	56	98	57.1
34- OMÜ KYK Yurdu Car Park	35	37	94.6
35- OMÜ İİBF Car Park	4	12	33.3
36- OMÜ Sağlık Bilimleri Fakültesi Car Park	70	88	79.6
37- OMÜ Merkez Kütüphane Car Park	12	96	12.5
38- OMÜ Ziraat Fakültesi Car Park	96	163	58.9
39- OMÜ Hayvan Hastanesi Car Parkları	34	53	64.2
40- OMÜ Eğitim Fakültesi Car Park	61	150	40.7
41- OMÜ Fen-Edebiyat Fakültesi Car Parkları	221	550	40.2
42- OMÜ Veteriner Car Park-3	43	60	72.1
43- OMÜ Yaşam Merkezi Car Park	43	70	61.4
44- OMÜ Mühendislik Fakültesi Car Parkları	130	224	58.0
45- OMÜ Teknopark Car Park	21	45	46.7
Total (∑)	3241	5436	Avg. 66.4

As part of the field observations and analysis, the car parks that can be used by electric vehicles on the Kurupelit campus were grouped (those close to each other were considered as a composite) and a total of 45 car parks were identified, as shown in Fig. 14. The capacity and average occupancy rates of these car parks are shown in Table 2.

Table 3. The order of the existing car parks according to their capacities, from the largest to the smallest

No for the Capacity	Car Park No- Location	Capacity (Veh.)	Average Occupancy (%)
1	13- OMÜ Hastanesi Car Park-1	1200	48,5
2	41- OMÜ Fen-Edebiyat Fakültesi Car Parks	550	40.2
3	29- OMÜ Hastanesi Kapalı Car Park-2	517	104.6
4	5- OMÜ Hastanesi Car Park-5	235	78.7
5	44- OMÜ Mühendislik Fakültesi Car Parks	224	58.0
6	8- OMÜ Hastanesi Kapalı Car Park-1	185	75.7
7	38- OMÜ Ziraat Fakültesi Car Park	163	58.9
8	17- OMÜ Diş Hekimliği Car Park-1	158	77.2
9	9- OMÜ Tıp Dekanlık Car Park	150	70.0
10	40- OMÜ Eğitim Fakültesi Car Park	150	40.7
11	14- OMÜ Hastanesi Car Park-9	114	43.0
12	18- OMÜ Diş Hekimliği Car Park-3	110	90.9
13	33- OMÜ UZEM Car Park	98	57.1
14	37- OMÜ Merkez Kütüphane Car Park	96	12.5
15	36- OMÜ Sağlık Bilimleri Fakültesi Car Park	88	79.5
16	11- OMÜ Hastanesi Car Park-3	87	80.5
17	4- OMÜ AKM Car Park	85	84.7
18	23- OMÜ Spor Bilimleri Fakültesi Car Park-3	84	72.6
19	3- OMÜ Rektörlük Car Park-1	78	57.7
20	1- OMÜ Koleji Car Park	76	30.3
21	43- OMÜ Yaşam Merkezi Car Park	70	61.4
22	28- OMÜ Hastanesi Car Park-7	65	90.8
23	32- OMÜ İlahiyat Fakültesi Car Park	63	73.0
24	26- OMÜ Veteriner Fakültesi Car Park-2	61	72.1
25	42- OMÜ Veteriner Car Park-3	62	75.8
26	30- OMÜ Cami Car Park	56	10.7
27	39- OMÜ Hayvan Hastanesi Car Parkları	53	64.2
28	10- OMÜ Hastanesi Car Park-4	50	94.0
29	31- OMÜ Diş Hekimliği Car Park-2	48	66.7
30	12- OMÜ Hastanesi Car Park-2	45	84.4
31	45- OMÜ Teknopark Car Park	45	46.7
32	2- OMÜ Rektörlük Car Park-2	44	72.7
33	15- OMÜ Hastanesi Car Park-8	40	40.0
34	25- OMÜ Tömer Car Park-3	44	86.4
35	22- OMÜ Tömer Car Park-1	39	30.8
36	34- OMÜ KYK Yurdu Car Park	37	94.6
37	27- OMÜ Hastanesi Car Park-10	35	122.9
38	20- OMÜ Tömer Car Park-2	34	47.1
39	7- OMÜ Hastanesi Car Park-6	29	93.1
40	6- OMÜ Tıp Fakültesi Car Park	24	95.8
41	21- OMÜ Spor Bilimleri Fakültesi Car Park-2	24	62.5
42	16- OMÜ Veteriner Fakültesi Car Park-1	18	83.3
43	19- OMÜ Spor Bilimleri Fakültesi Car Park-1	16	31.3
44	24- OMÜ Spor Bilimleri Fakültesi Car Park-4	14	92.9
45	35- OMÜ İİBF Car Park	12	33.3
Total (∑)		5436	Avg. 66.4

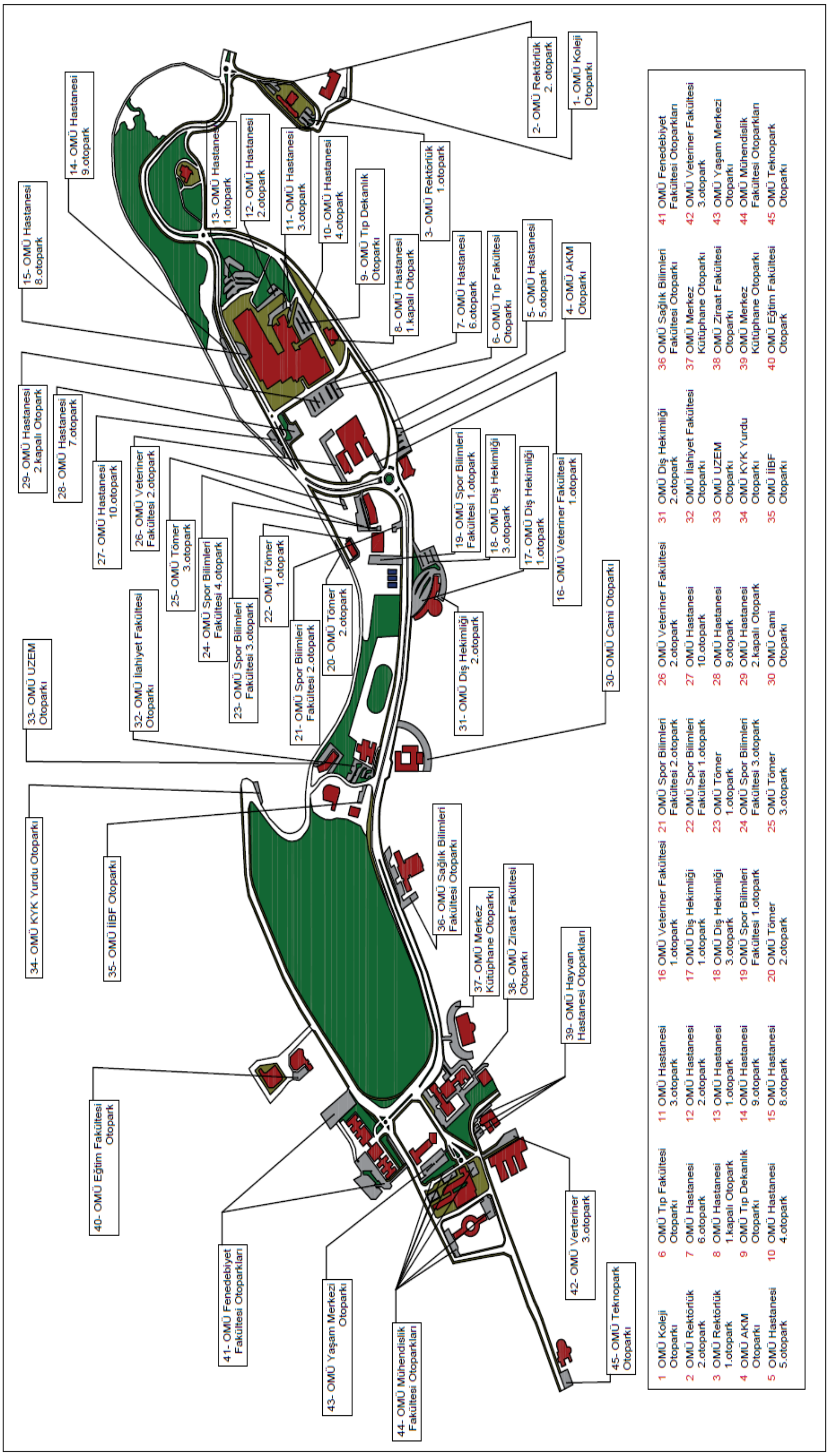

Fig. 14. Existing car parks on the OMU Kurupelit campus

From the car park capacity analysis, it was found that the average occupancy rate of the car parks within the university is 66.4%. To determine the location and number of EV charging points in the existing car parks, the existing car parks were ranked according to their capacity and occupancy rates, with priority given to those with the highest capacity (Table 3).

There are many important parameters in determining the number of charging stations, which is the most important issue in the use of electric vehicles. As it is known, electric cars, electric light commercial vehicles (pick-up trucks, minibuses and vans) and electric buses are the vehicles in the forefront, as they are at the beginning of the process of spreading electric vehicles today. Therefore, the number of charging stations in the OMU Kurupelit campus has been determined by taking these issues into consideration when making effective planning. Since the use of electric buses and the necessary work on charging stations is being carried out by Samsun Metropolitan Municipality in this planning, no planning work has been carried out for electric buses at the moment. In this study, a calculation was made and a proposal was developed for the location and number of charging stations for electric cars and electric light commercial vehicles (vans, minibuses and light commercial vehicles). In this context, it is very important to develop cost-effective proposals by carefully examining all parameters when determining the number of these expensive systems for the widespread use of electric vehicles. In the study, when determining the number of vehicles entering the campus (for two types), the total number of vehicles (13904) between 07:00 and 19:00, when the highest density is observed, was taken into account. In this context, the calculations

- Total number of vehicles on campus (day)

- Parking capacity (vehicle)

- Occupancy rate (%)

- Average number of vehicles in the car park

- Percentage availability of electric vehicles (1%, 5%, 10% and 25%)

- The total car parking capacity (vehicles) on campus was taken into account as a calculation parameter.

Taking all these parameters into account, the study calculated the number of charging stations according to different percentage scenarios, depending on the campus-specific situation, using the relationship given in Equation 1, and the results are shown in Table 4.

$$N_{CS} = \left[(EV\% \times N_{TV}) \times \frac{N_{EP}}{N_{TCP}}\right] * \left(\frac{N_{ACP}}{N_{EP}}\right) \quad (1)$$

Where N_{CS} is charging station number, $EV\%$ is e-Vehicle percentage (%1, %5, %10 ve %25), N_{TV} is total vehicle number in the campus for passenger car and light vehicles/vans, N_{EP} is examined car park capacity, N_{TCP} is total car park capacity in the campus and N_{ACP} is average vehicle numbers for the examined car park.

The distribution of the number of EV charging points recommended according to the number of EVs in the identified percentage scenarios by car parks is shown in detail in Fig. 15 (a-o). According to the results of the analyses, it is recommended to install the number of EV charging points shown in Fig. 15 (a-o) when the percentage of EVs specified in the scenarios is reached with the gradual diffusion of the domestic electric car TOGG.

Table 4. The number of e-charging stations recommended for car parks according to the percentage distribution of the number of e-vehicles in traffic (1%, 5%, 10% and 25%)

No for the Capacity	Car Park No- Location	Capacity (Veh.)	Average Occupancy (%)	Total Number of Charging Stations for Electric Vehicle Percentage			
				1%	5%	10%	25%
1	13- OMÜ Hastanesi Car Park-1	1200	48.5	15	74	149	372
2	41- OMÜ Fen-Edebiyat Fakültesi Car Parkları	550	40.2	6	28	57	141
3	29- OMÜ Hastanesi Kapalı Car Park-2	517	104.6	14	69	138	346
4	5- OMÜ Hastanesi Car Park-5	235	78.7	5	24	47	118
5	44- OMÜ Mühendislik Fakültesi Car Park	224	58.0	3	17	33	83
6	8- OMÜ Hastanesi Kapalı Car Park-1	185	75.7	4	18	36	90
7	38- OMÜ Ziraat Fakültesi Car Park	163	58.9	2	12	25	61
8	17- OMÜ Diş Hekimliği Car Park-1	158	77.2	3	16	31	78
9	9- OMÜ Tıp Dekanlık Car Park	150	70.0	3	13	27	67
10	40- OMÜ Eğitim Fakültesi Car Park	150	40.7	2	8	16	39
11	14- OMÜ Hastanesi Car Park-9	114	43.0	1	6	13	31
12	18- OMÜ Diş Hekimliği Car Park-3	110	90.9	3	13	26	64
13	33- OMÜ UZEM Car Park	98	57.1	1	7	14	36
14	37- OMÜ Merkez Kütüphane Car Park	96	12.5	0	2	3	8
15	36- OMÜ Sağlık Bilimleri Fakültesi Car Park	88	79.5	2	9	18	45
16	11- OMÜ Hastanesi Car Park-3	87	80.5	2	9	18	45
17	4- OMÜ AKM Car Park	85	84.7	2	9	18	46
18	23- OMÜ Spor Bilimleri Fakültesi Car Park-3	84	72.6	2	8	16	39
19	3- OMÜ Rektörlük Car Park-1	78	57.7	1	6	12	29
20	1- OMÜ Koleji Car Park	76	30.3	1	3	6	15
21	43- OMÜ Yaşam Merkezi Car Park	70	61.4	1	5	11	27
22	28- OMÜ Hastanesi Car Park-7	65	90.8	2	8	15	38
23	32- OMÜ İlahiyat Fakültesi Car Park	63	73.0	1	6	12	29
24	26- OMÜ Veteriner Fakültesi Car Park-2	61	72.1	1	6	11	28
25	42- OMÜ Veteriner Car Park-3	62	75.8	1	6	12	30
26	30- OMÜ Cami Car Park	56	10.7	0	1	2	4
27	39- OMÜ Hayvan Hastanesi Car Parkları	53	64.2	1	4	9	22
28	10- OMÜ Hastanesi Car Park-4	50	94.0	1	6	12	30
29	31- OMÜ Diş Hekimliği Car Park-2	48	66.7	1	4	8	20
30	12- OMÜ Hastanesi Car Park-2	45	84.4	1	5	10	24
31	45- OMÜ Teknopark Car Park	45	46.7	1	3	5	13
32	2- OMÜ Rektörlük Car Park-2	44	72.7	1	4	8	20
33	15- OMÜ Hastanesi Car Park-8	44	86.4	1	5	10	24
34	25- OMÜ Tömer Car Park-3	40	40.0	0	3	5	13
35	22- OMÜ Tömer Car Park-1	39	30.8	0	2	3	8
36	34- OMÜ KYK Yurdu Car Park	37	94.6	1	4	9	22
37	27- OMÜ Hastanesi Car Park-10	35	122.9	1	5	11	27
38	20- OMÜ Tömer Car Park-2	34	47.1	0	2	4	10
39	7- OMÜ Hastanesi Car Park-6	29	93.1	1	3	7	17
40	6- OMÜ Tıp Fakültesi Car Park	24	95.8	1	3	6	15
41	21- OMÜ Spor Bilimleri Fakültesi Car Park-2	24	62.5	0	2	4	10
42	16- OMÜ Veteriner Fakültesi Car Park-1	18	83.3	0	2	4	10
43	19- OMÜ Spor Bilimleri Fakültesi Car Park-1	16	31.3	0	1	1	3
44	24- OMÜ Spor Bilimleri Fakültesi Car Park-4	14	92.9	0	2	3	8
45	35- OMÜ İİBF Car Park	12	33.3	0	1	1	3
Total (∑)		5436	Avg. 66.4	88	442	884	2210

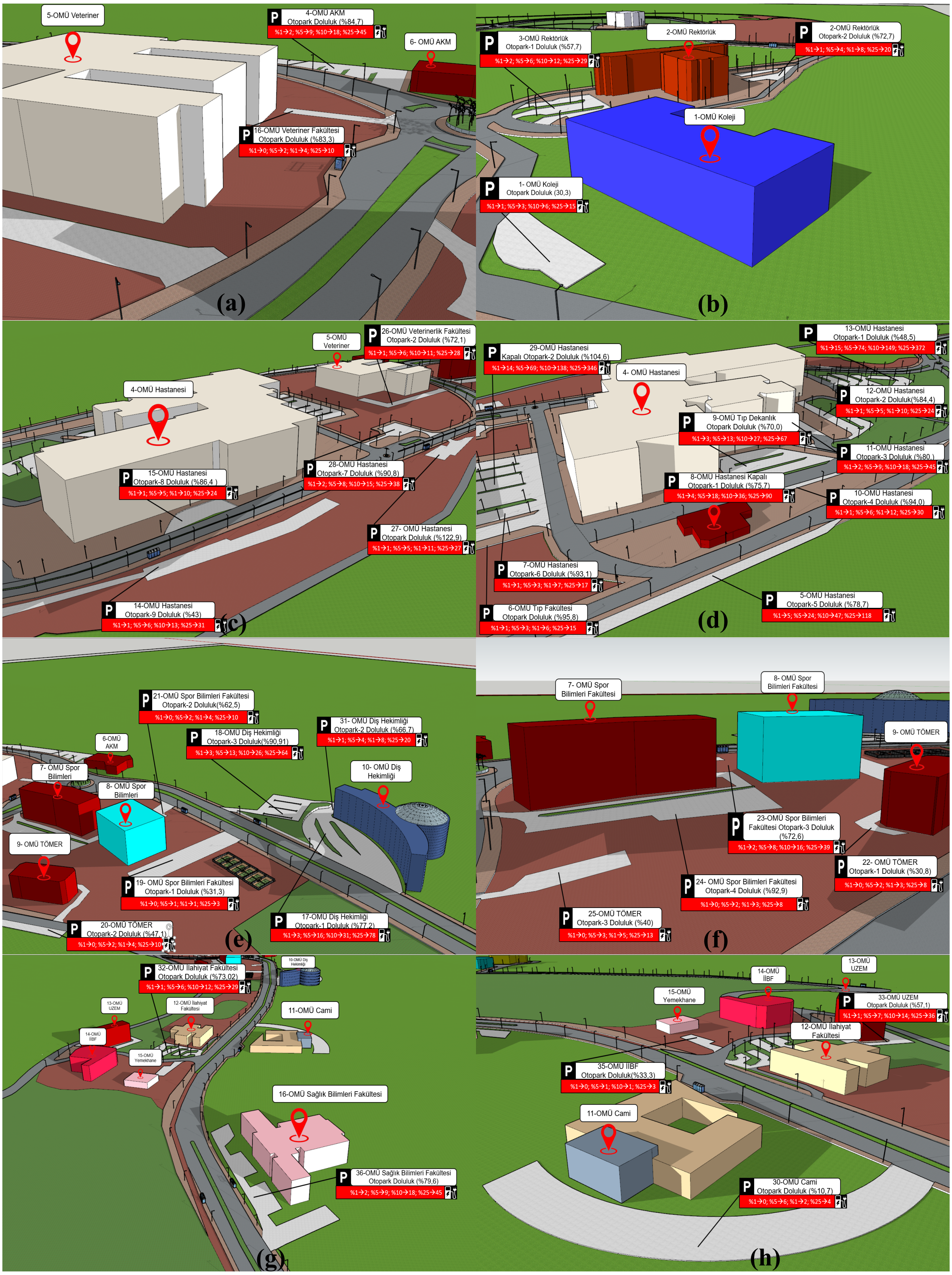
5-OMÜ Veteriner
4-OMÜ AKM Otopark Doluluk (%84,7)
6- OMÜ AKM
16-OMÜ Veteriner Fakültesi Otopark Doluluk (%83,3)
(a)
3-OMÜ Rektörlük Otopark-1 Doluluk (%57,7)
2-OMÜ Rektörlük
2-OMÜ Rektörlük Otopark-2 Doluluk (%72,7)
1-OMÜ Koleji
1- OMÜ Koleji Otopark Doluluk (30,3)
(b)
5-OMÜ Veteriner
26-OMÜ Veterinerlik Fakültesi Otopark-2 Doluluk (%72,1)
4-OMÜ Hastanesi
15-OMÜ Hastanesi Otopark-8 Doluluk (%86,4)
28-OMÜ Hastanesi Otopark-7 Doluluk (%90,8)
27- OMÜ Hastanesi Otopark Doluluk (%122,9)
14-OMÜ Hastanesi Otopark-9 Doluluk (%43)
(c)
13-OMÜ Hastanesi Otopark-1 Doluluk (%48,5)
29-OMÜ Hastanesi Kapalı Otopark-2 Doluluk (%104,6)
4- OMÜ Hastanesi
12-OMÜ Hastanesi Otopark-2 Doluluk(%84,4)
9-OMÜ Tıp Dekanlık Otopark Doluluk (%70,0)
11-OMÜ Hastanesi Otopark-3 Doluluk (%80)
8-OMÜ Hastanesi Kapalı Otopark-1 Doluluk (%75,7)
10-OMÜ Hastanesi Otopark-4 Doluluk (%94,0)
7-OMÜ Hastanesi Otopark-6 Doluluk (%93,1)
6-OMÜ Tıp Fakültesi Otopark Doluluk (%95,8)
5-OMÜ Hastanesi Otopark-5 Doluluk (%78,7)
(d)
21-OMÜ Spor Bilimleri Fakültesi Otopark-2 Doluluk(%62,5)
6-OMÜ AKM
18-OMÜ Diş Hekimliği Otopark-3 Doluluk(%90,91)
31- OMÜ Diş Hekimliği Otopark-2 Doluluk (%66,7)
7- OMÜ Spor Bilimleri
8- OMÜ Spor Bilimleri
10- OMÜ Diş Hekimliği
9- OMÜ TÖMER
19- OMÜ Spor Bilimleri Fakültesi Otopark-1 Doluluk (%31,3)
20-OMÜ TÖMER Otopark-2 Doluluk (%47,1)
17-OMÜ Diş Hekimliği Otopark-1 Doluluk (%77,2)
(e)
7- OMÜ Spor Bilimleri Fakültesi
8- OMÜ Spor Bilimleri Fakültesi
9- OMÜ TÖMER
23-OMÜ Spor Bilimleri Fakültesi Otopark-3 Doluluk (%72,6)
22- OMÜ TÖMER Otopark-1 Doluluk (%30,8)
24- OMÜ Spor Bilimleri Fakültesi Otopark-4 Doluluk (%92,9)
25-OMÜ TÖMER Otopark-3 Doluluk (%40)
(f)
32-OMÜ İlahiyat Fakültesi Otopark Doluluk (%73,02)
11-OMÜ Cami
16-OMÜ Sağlık Bilimleri Fakültesi
36-OMÜ Sağlık Bilimleri Fakültesi Otopark Doluluk (%79,6)
(g)
14-OMÜ İİBF
13-OMÜ UZEM
15-OMÜ Yemekhane
33-OMÜ UZEM Otopark Doluluk (%57,1)
12-OMÜ İlahiyat Fakültesi
35-OMÜ İİBF Otopark Doluluk(%33,3)
11-OMÜ Cami
30-OMÜ Cami Otopark Doluluk (%10,7)
(h)

Fig. 15. Distribution of charging stations in car parks obtained as a result of calculations according to e-vehicle percentage scenarios (a-o)

4. Conclusion and Recommendations

Ongoing research around the world shows that technological research for the development of electric vehicles and incentives for their widespread use are continuing at the usual pace, and efforts are being made for the effective use of electric vehicles on all roads. At present, the main obstacle to the preference of electric vehicles in Türkiye is the lack of sufficient charging (e-charging) stations to ensure fast charging of vehicles. This study examines the current number of active vehicles on campus and proposes electric vehicle charging stations (in terms of location and number) in the campus car parks according to electric vehicle percentage scenarios. Thus, this study will be a guideline for the use of e-charging stations within the central campus of Ondokuz Mayıs University in 2023 and beyond, when the use of electric vehicles will become more widespread in our country with the domestic e-vehicle "TOGG". OMU Kurupelit campus will be a pioneer campus in the use of electric vehicles with the implementation of the proposed locations and number of charging stations when the identified scenarios are realised. All charging stations proposed in this study are designed for fast charging (~20-45 min) instead of slow charging (~8 hours) in the campus where vehicle and parking mobility is intense. There are large transformers and sub-centres within the OMU central campus and it is envisaged that this situation will work effectively even if the vehicles consume high current electricity. Again, before installing charging stations, it is necessary to evaluate the issue in terms of electrical power and transformer capacity, assuming that vehicles can charge at the same time.

The study believes that the steps to be taken for the use of electric vehicles on campus and their charging needs will bring the importance and use of electric vehicles to the forefront of our country's 2023 visions and will further increase the demand for the domestic electric car (TOGG), which will enter the production phase. The ability to charge their EVs on campus, especially for academics, administrative staff, students and guests who spend most of their day on the university campus, will be an incentive for them to use EVs and for OMU to become a green campus university. It is expected that universities will be able to take an active role in the use and operation of electric vehicles when similar studies are carried out in other university campuses.

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Notations

N_{CS} Charging station number
$EV\%$ e-Vehicle percentage (%1, %5, %10 ve %25)
N_{TV} Total vehicle number in the campus for passenger car and light vehicles/vans
N_{EP} Examined car park capacity
N_{TCP} Total car park capacity in the campus
N_{ACP} Average vehicle numbers for the examined car park

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