For office use only
T1 ________________
T2 ________________
T3 ________________
T4 ________________

Team Control Number
93122

Problem Chosen
D

For office use only
F1 ________________
F2 ________________
F3 ________________
F4 ________________

2018

MCM/ICM

Summary Sheet

All-electric Vehicles are on the Way

The promotion of all-electric vehicles is an efficient measure in environmental protection. More and more countries positively respond to this move, including the US, Ireland, South Korea, etc. Our goal is to calculate the optimal number of charging stations needed in the United States and Ireland with the realization of electrification and to figure out the distribution of charging stations in urban, suburban and rural areas Also, we aim to identify key factors that advance the electrification. In order to boost this progress, a detailed timetable should be made. We are trying to solve these problems, promote electrification, decrease the use of fuel vehicles and protect natural environment.

When dealing with the optimal number of charging stations and its distribution, we establish an objective function model for minimum costs from two perspectives, one from car owners' charging costs and another from investment costs of charging station. We also formulate a multiple regression model with time trend items by analyzing the key factors affecting the process, such as the number of charging stations, the technical development battery and per capita GDP when making the schedule. This model then is optimized to obtain a function of the electrification rate and time, in order to get the final timetable.

According to the actual conditions in each country, we make reasonable assumptions about the parameters of the objective function model. Comparing with the actual situation, we find the calculated results correspond to the development of all-electric process. Our model is still available when it comes to different countries as long as we set respective parameters for them. For the timetable in Ireland, although our prediction is later than the Irish government had expected, we strongly believe that our conclusions are sensible, since it is closely related to the current status of the use of electric vehicles in Ireland.

Keywords: all-electric; objective function; multiple regression equation

CONTENTS

1.Introduction

Tesla Model3 makes the electric vehicles be more popular with people. Due to environmental issues, electric vehicles are replacing gas vehicles. The deployment of charging stations is of great significance during this vehicle revolution[1]. It is necessary to work out the optimal number of charging stations.

1.1 Restatement of the Problem

As environmental pollution is getting worse, people are eager to reduce the use of fossil fuels, including motor fuels. People are also becoming more and more aware of the necessary to protect the environment. Therefore, consumers are gradually choosing electric vehicles.

In any country, as the comprehensive promotion of electric vehicles is a long way, it is worth discussing how long it will take to complete the initial, intermediate and comprehensive development of electric vehicles in the future. In this issue of discussion, we need to analyze the use of electric vehicles. Especially, since in the technology-driven world, the use of electric vehicles is bound to be influenced by high and new technology, analyzing how these technologies affect the use of electric vehicles is crucial. In the process of turning to electric vehicles, people face two challenges, namely, the optimal number and location of charging stations. We need to set up a model to determine the optimal total number of charging stations and that in rural, suburban and urban areas. We should not only solve the problem of charging stations in the countries that have used electric vehicles but also solve the problem of national charging stations that have not yet started to use electric vehicles and even analyze the influence of the number and location of charging stations according to different geographical factors. We tried to set up a model to get the best possible number and location of charging stations, with the purpose of providing a reference for the country to protect the environment and promoting the use of electric vehicles in an all-round way.

1.2 Model/Literate Review

Ren Yulong [2] believes that it is feasible to establish the layout of charging stations based on time window constraints and a multi-objective optimization model determined by the optimal scale, based on the idea of dynamic traffic network. Under the time constraint, we set up a cost model to achieve the optimal goal of minimizing the cost of charging and the fund for charging stations. According to the regional economy, technology and the distribution of population, although different countries have different national situations, the model is still applicable.

Setting up a time planning model for Ireland to achieve an all-electric process, we built a multiple regression model with time-trend items to try to figure out the relationship between the rate of electric vehicles and time, based on a thorough analysis of the factors that affect the rate of electric vehicles in Ireland. Before calculating the rate of electric vehicles, we predict the factors such as the cost of batteries, per capita GDP in Ireland, and the number of charging stations, and get the time series of various factors. Finally, we solve the multiple regression equation, and we get the required time of the different rate of electric vehicles.

2.Assumptions

1.All charging stations are funded and run by a charging company. We do not take account into competition among charging stations;

2.The model and specifications of each electric vehicle are the same;

3.Electric vehicles can be regarded as particles, driving at the same speed of v to maintain a uniform linear motion;

4.Each electric vehicle will run out of electricity power when they arrive at the charging station and it takes 24 hours(destination charging)or 30 minutes to charge(super charging);

5.Electric vehicles waiting for the charging does not consume electricity;

6.The management costs of destination charging and super charging are the same;

7. Each charging pile can only be used by one vehicle at a time;

8. Each electric vehicle is charged once a day on average.

3.Notations

Notations	Descriptions
TC	Total social cost.
$C_{company}$	The cost of Charging company.
C_{person}	The cost of consumers.
m	The number of charging stations.
i	The charging station i.
α_1	Unit construction cost of destination charging pile.
α_2	Unit construction cost of supercharging pile.
n_{dc}	Number of destination charging piles.
n_{sc}	Number of supercharging piles.
β_m	Management cost conversion factor.
ω	Average life of charging piles.
p_1	Unit cost of charging for users.
Q_i	The average daily need of charging of Charging station i.
Z_i	Number of vehicles at charging station i.
q_i	The average need of charging of electric vehicles.
Er	The rate of electric vehicles.
P_{sc}	The probability that owners want to use a supercharging pile.
P_{dc}	The probability that owners want to use destination charging piles.
y_i	Per capita GDP at charging station i.

4.Cost Model

4.1 Feasibility analysis of a complete switch to all-electric in the US

To talk about the United States electric car, certainly, Tesla company can't be ignored. As a complete mass transit alternative to traditional transport consuming fossil fuels, electric vehicles are still the only realistic choice. Tesla's electric car seen everywhere has entered the lives of Americans, whether it is in the streets of big cities, or away from the downtown highway. Is it possible for electric vehicles to be applied completely in America, especially for Tesla?

As can be seen from Figure 4.1.1, the total sales volume of electric vehicles in the United States from 2013 to 2017 has been increasing year by year except 2015 with the market share of Tesla in the United States increasing(Figure 4.1.2), indicating that the life style of the United States gradually becomes all-electric. It is reported that 2018 Tesla market share is expected to reach 50%. Whether the goal is achievable depends on if Tesla can solve the bottleneck problem.

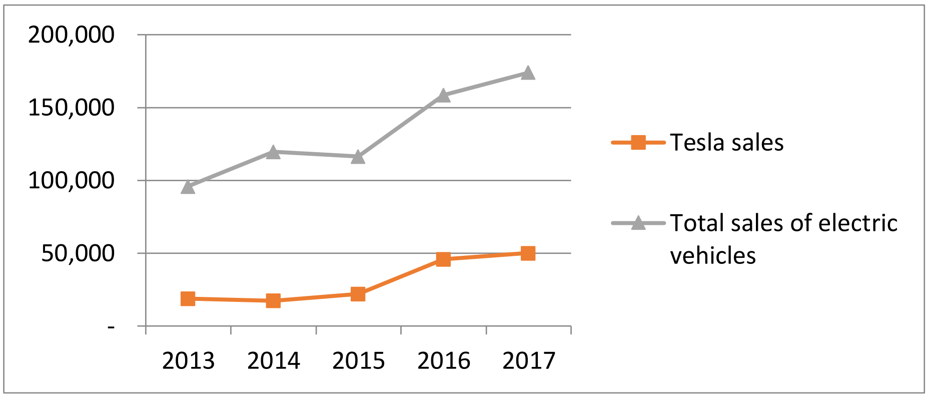

Figure 4.1.1US electric car sales from 2013 to 2017

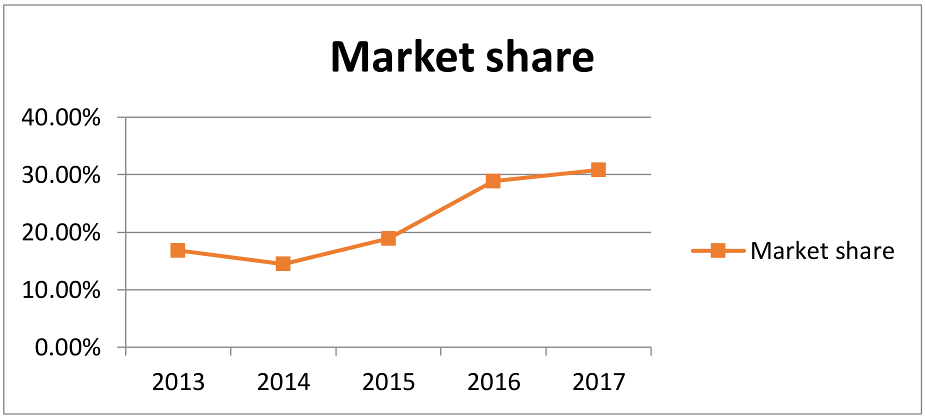

Figure 4.1.2 Tesla market share from 2013 to 2017

Figure 4.1.3 shows that the production capacity in 2015 and 2016 can keep up with the sales but the production capacity in 2017 is lower than the sales volume mainly due to the fact that a part of the production capacity of Tesla is for the production of the Model 3 Series. Thus, the other production can't keep up. The new Model 3 is popular with the public. There are huge orders, but the output leaves much to be desired. The priority for Tesla is to increase the production of the new model, Model 3, for which Tesla announced the acquisition of Perbix, an automated machine manufacturer.

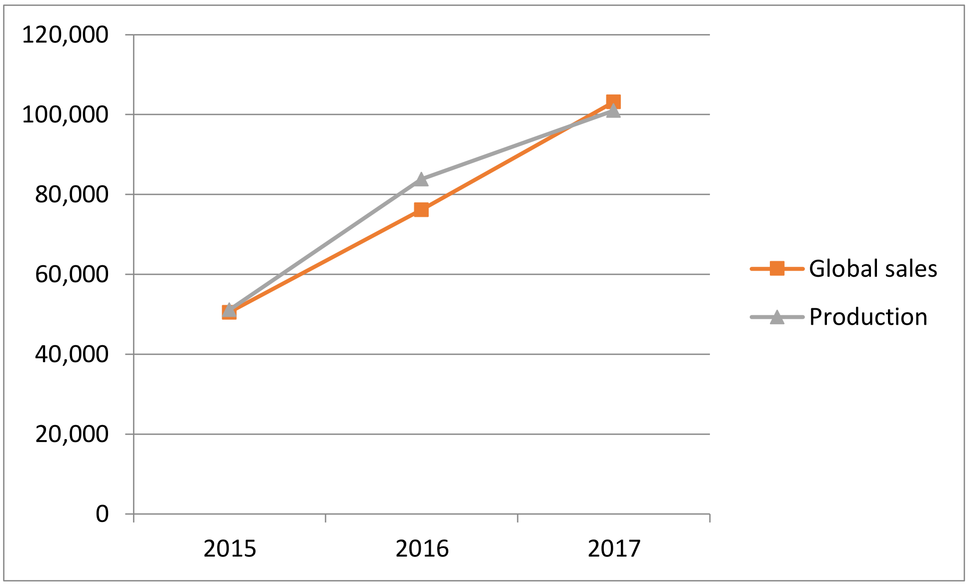

Figure 4.1.3 Tesla's global sales and capacity

Therefore, we think it possible for the United States to be fully electrified. Whether Tesla dominates the electric vehicle market depends on whether Tesla can solve the production bottleneck of Model 3.

4.2 Cost Modeling

Two aspects of the cost need to be considered in the charging station cost model, one is the consumption of owners, another is the construction costs and management costs of the charging company. The cost using the charging pile for owners includes the charging fee at the charging station i every year, the cost of the electric vehicle driving to the charging station and the time of waiting for charging. Taking a year as research time, we set up the following function:

$$\mathrm{TC} = \sum_{i=1}^{m} (C_{company} + C_{person}) \tag{1}$$

Annual construction costs and management costs of charging company are expressed as follows. According to straight-line depreciation method, charging pile cost can be allocated to each year on average:

$$C_{company} = C_{construction} + C_{management} \quad (2)$$

$$C_{construction} = (\alpha_1 * n_{dc} + \alpha_2 * n_{sc}) * \frac{1}{\omega} \quad (3)$$

$$C_{management} = \beta_m * (n_{dc} + n_{sc}) \quad (4)$$

The charging fee at the charging station i every year:

$$C_{1i} = p_1 * Q_i * 365 \quad (5)$$

$$Q_i = Z_i * Er * q_i * (P_{sc} + P_{dc}) \quad (6)$$

The cost of the electric car driving to the charging station and the waiting time for the charging:

$$C_{2i} = p_1 * Q_i * \frac{L_i}{24v} * 365 + \frac{y_i}{365 * 24} * T \quad (7)$$

$$\mathrm{T} = \frac{L_i}{v} + t_i \quad (8)$$

Among them, the waiting time value is replaced by the local per capita GDP. Suppose the owners' waiting time obeys the distribution of cypress,

$t_i = f(n_{sci}\ , n_{dci}\ , q_i\ , Er, Z_i);$

L_i:The average distance between demand charging points and charging stations for electric vehicles;

v: Electric vehicles travel at the speed of v at a constant speed;

y_i: Per capita GDP at charging station i;

T : The total time consisting of the time of electric vehicle from the demand point to the charging station and the waiting time for charging;

t : The average waiting time for electric vehicles;

We divide the United States into three large service areas, urban, suburban, and rural areas respectively. The re-divided cost model can be simplified to:

$$\mathrm{TC} = \frac{(\omega * \beta_m + \alpha_1) * n_{dc} + (\omega * \beta_m + \alpha_2) * n_{sc}}{\omega} + \sum_{i=1}^{3} [p_1 * Z_i * Er * q * (P_{sc} + P_{DC}) * 365 * \left(1 + \frac{L_i}{24v}\right) + \frac{y_i}{365 * 24} * (\frac{L_i}{v} + t_i)] \quad (9)$$

Where,

i=1,2,3 stand for urban, suburban, and rural areas respectively;

4.3 Results of the Calculation

Based on the cost model we set up, we get the optimal number of charging piles at the lowest cost. The objective function:

$$\text{MinTC} \tag{10}$$

$$\text{s.t.} \quad t_i = f(n_{sci}, n_{dci}, q_i, Er, Z_i)$$

$$t_i = \frac{t_{sci} * n_{sc} + t_{dci} * n_{dc}}{n_{sc} + n_{dc}} \tag{11}$$

Waiting time obeys Poisson distribution:

$$t_{sci} = \frac{(\frac{Z_{\mathbf{i}} * E_r * P_{sc}}{48})^{n_{sc}} * \frac{Z_{\mathbf{i}} * E_r * P_{sc}}{48 * \mathrm{n_{sc}}}}{n_{sc}!\,(1 - \frac{Z_{\mathbf{i}} * E_r}{48 * \mathrm{n_{sc}}})^2} * P_{sc0} \tag{12}$$

$$P_{sc0} = \left[\sum_{\mathrm{k}=0}^{n_{sc}-1} \frac{1}{n_{sc}!} * \left(\frac{Z_{\mathbf{i}} * E_r * P_{sc}}{48}\right)^k + \frac{k}{n_{sc}!} * \frac{1}{1 - \frac{Z_{\mathbf{i}} * E_r * P_{sc}}{48 * \mathrm{n_{sc}}}} * \left(\frac{Z_{\mathbf{i}} * E_r * P_{sc}}{48}\right)^{\mathrm{n_{sc}}}\right]^{-1} \tag{13}$$

Similarly,

$$t_{dci} = \frac{(Z_{\mathbf{i}} * E_r * P_{dc})^{n_{dc}} * \frac{Z_{\mathbf{i}} * E_r * P_{dc}}{\mathrm{n_{dc}}}}{n_{dc}!\,(1 - \frac{Z_{\mathbf{i}} * E_r}{\mathrm{n_{dc}}})^2} * P_{dc0} \tag{14}$$

$$P_{dc0} = \left[\sum_{\mathrm{k}=0}^{n_{dc}-1} \frac{1}{n_{dc}!} * (Z_{\mathbf{i}} * E_r * P_{dc})^k + \frac{k}{n_{dc}!} * \frac{1}{1 - \frac{Z_{\mathbf{i}} * E_r * P_{dc}}{\mathrm{n_{dc}}}} * (Z_{\mathbf{i}} * E_r * P_{dc})^{\mathrm{n_{dc}}}\right]^{-1} \tag{15}$$

Where,

t_{sci}:Waiting time for supercharging pile

t_{dci}:Waiting time for destination charging pile

Electric vehicles using supercharging pile charging 30 minutes can run 170km. Taking account into the full electric charge after the charging pile supporting services must keep pace, the distance between charging stations should not exceed 170km. Since the population distribution, traffic flow and economic level are different in urban, suburban, and rural areas, the distance between charging stations is not the same. The distance between the electric vehicle owner charging demand point and the nearest charging station is random(but not exceed 170km). We use Monte Carlo simulation method[11] to find the average distance, including $L_1/L_2/L_3$(Figure 4.3.1).

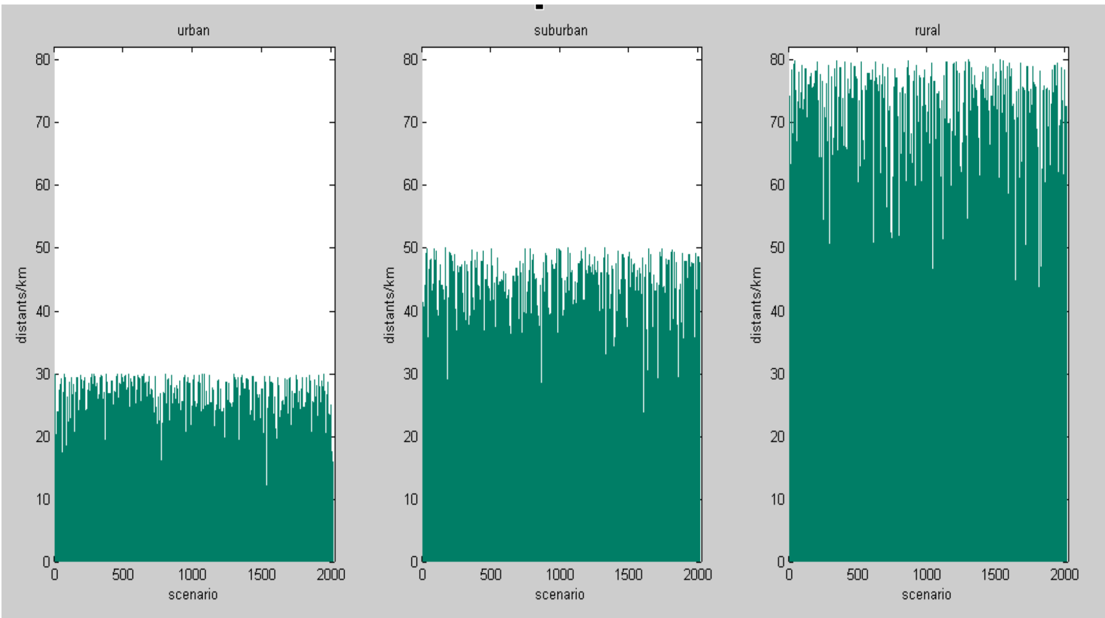

Figure 4.3.1 The simulation of average distance of urban, suburban, rural demand point to the charging station

According to Tesla's characteristics, we assume that the average battery capacity of electric vehicles in 70~90kw·h was evenly distributed. We use Monte Carlo simulation method to calculate the daily charging demand expectations(Figure 4.3.2).

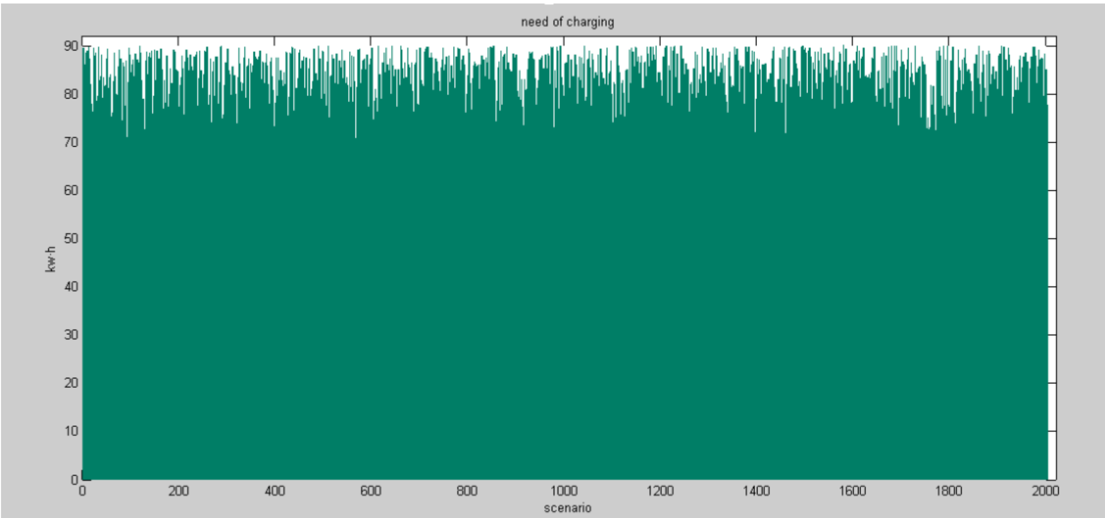

Figure 4.3.2 Average vehicle daily charging demand power

Some parameters are as shown in the table:

v(km/h)	y_1(dollar)	y_2(dollar)	y_3(dollar)	β_m(dollar)
80	91,098.00	36,264.00	4,092.00	500,000.00
α_1(dollar)	α_2(dollar)	ω(yrs)	Z(EVcars)	Er(%)
100,000.00	200,000.00	10	247,418,000	100

Table 4.3.1 parameters value

Studying the data in 2016, the car news website, Autonews[3]reported that, the latest survey from the University of Michigan Transportation Institute had found that, in 2016, American owned 0.766 cars on average and the average family owned 1.968 cars. The numerical indicator reached a new level since 2009. In 2016, with a population of 323 million people in the United States, there were 247,418,000 vehicles in the nation. Surfing the website of the US Bureau of Statistics, we can find the data of urban, suburban and rural population. We can estimate the car ownership of the three and calculate Z_i.

We assume that the size of urban, suburban and rural charging stations are the same. There are six charging piles in each charging station in our strategy. In line with the existing charging station configuration[9],the number of destination charging piles is about twice that of supercharging piles. We assume that $n_{dc} = 2n_{sc}$.

In summary, when the rate of electric vehicles is 100%, the optimal number of charging stations we calculate is 204,000.

The result is presented in the following table(Unit: thousand).

	Urban area	Suburb	Rural area	Total
Charging station	100.1	66.7	37.1	204
Charging pile	600.6	400.4	222.9	1224
Rate	49.07%	32.72%	18.21%	100%

Table 4.3.2 the optimal number of charging stations

At present, there are about 180,000 gas stations in the United States. The construction of gas stations are limited by various factors. However, the construction of charging stations is subject to fewer restrictions. The number of charging stations we calculated is still reasonable.

5. Applicability

5.1 Application in Ireland

Ireland has a natural and beautiful environment, not only pursuing economic development but also environmentally-friendly development. Transport minister Shane Ross previously announced that they will get out of fuel-powered vehicles by 2050. It creates huge space for the Irish electric vehicles market to develop and also contributes to all-electric progress. We believe that Ireland is able to migrate away from gasoline and diesel vehicles to all electric cars. Therefore we choose Ireland as the research object.

We have collected some of the data and information about Ireland, which can be applied in Cost Model. When the full evolution to electric vehicles is completed in Ireland(no transition time required),we can figure out the optimal number of charging stations. The result is showed as follows(Unit: PCS).

	Urban area	Suburban	Rural area	Total
Charging station	5834	4066	6100	16000
Charging pile	35003	24395	36602	96000
Rate	36.46%	25.41%	38.13%	100%

Table 5.1.1 the optimal number of charging stations

In the model of Ireland, in our opinions, the key factor is per capita GDP. In other words, the economy has played a decisive role.

5.2 Investment Suggestions

Ireland currently has about 1,600 gas stations and 1,000 charging stations. The country has 2,500,000 vehicles, but the rate of electric vehicles is less than 1%, which means that the charging station can not be fully utilized. If we restart the deployment of charging stations, we suggest the government should build up charging stations both in urban and rural areas because the number of vehicles in urban and that in rural areas in Ireland are similar. Based on the current situation, we can attract the masses to purchase electric vehicles by implementing preferential policies and mobilization efforts. When the rate of electric vehicles reaches a certain level, the country should focus on the construction of charging stations.

5.3 Timeline Model

The survey shows that, 86% of Irish office workers are within 50 kilometers of their work place. The mileage of electric vehicles could meet their needs. Taking account into the factors of environment and economy, the potential of Ireland's electric vehicle market is huge. It is only a matter of time before Ireland becomes fully electrified. By analyzing the influencing factors of the process of all-electric vehicles, such as per capita GDP, the number of charging stations and battery cost, we build a model of the relationship between the rate of electric vehicles and time.

5.3.1 Timeline Modeling

The price of electric vehicles and the convenience of charging are considered firstly by people when buying electric vehicles. The price of electric vehicles is mainly affected by the cost of battery and the number of charging stations affects the convenience of charging. Similarly, people's income and the development of the national economy will have an impact on the process of all-electric vehicles. We build a timeline model:

$$\begin{aligned}\text{rate} = {} & \alpha_1 \log(cost) + \alpha_2 log^2(cost) + \alpha_3 \log(pgdp) + \alpha_4 log^2(\text{pgdp}) \\ & + \alpha_5 \log(\text{char}) + \alpha_6 T + \beta \qquad (15)\end{aligned}$$

where,

rate:the rate of all-electric vehicles in Ireland(%)

cost:the cost of battery

pgdp: Per capita GDP in Ireland

char: The number of charging stations in Ireland

T: Time(based on quarter, T)

5.3.2 Results of the Calculation

Using Eviews for linear regression fitting, the result is as follows:

Variable	Coefficient	Variable	Coefficient
C	9.14 (4.8421)**	log^2(pgdp)	-0.3 (6.19223) **
log($cost$)	-6.18 (-9.0514)***	$log^2(cost)$	0.37 (8.2231)***
log($char$)	0.2 (5.8404)***	T	0.02 (4.9870)***
log($pgdp$)	5.09 (14.4379)***		

Table 5.3.2.1The result of linear regression fitting

Then,

$$\text{rate} = -6.18\log(cost) + 0.37log^2(cost) + 5.09\log(pgdp) - 0.3log^2(\text{pgdp}) + 0.2\log(\text{char}) + 0.02T + 9.14 \qquad (16)$$

Before calculating the rate of electric vehicles, we first predict the situation of the cost of battery, per capita GDP, and the number of charging stations over time. The linear regression equation is as follows:

$$\log(cost) = -0.05T + 6.43 \qquad (17)$$

$$\log(pgdp) = 0.02T + 10.8 \qquad (18)$$

$$\log(char) = 0.11T + 5 \qquad (19)$$

Substitute equation (17)、(18)、(19) into (16):

$$\text{rate} = 0.00078T^2 + 0.15\text{T} + 6.28 \qquad (20)$$

When the rate of electric vehicles is 30%,50%,100% respectively, T=102,160,264. That means 25.5 years are needed when the rate is 30%, 40 years when the rate is 50%, and 66 years when the rate is 100%.

In the process of entering the all-electric vehicles world, people first consider the price of electric vehicles. Battery cost is the main component of the price of electric vehicles. In our model, the battery cost is the most sensitive to the rate of electric vehicles. Reducing the cost of the battery requires technical support. Only if we develop perfect technology can we get the lowest price. Therefore, we believe that technology is the key factor in the process of a complete switch to all-electric in Ireland.

5.4 Other Cases

According to the analysis above, our model is suitable for the United States and Ireland, and the calculation result is reasonable. So is it available for other countries, such as Australia, China, Indonesia, Saudi Arabia, and Singapore? The answer is yes. We have considered different geographies, population density distributions, and wealth distributions when we built the model. As long as we set the parameter values of the model according to the actual situation of each country, we can use our model to get the result. Take China as an example, we focus on the factors which are of great difference with America and Ireland, including China's land area, urban, suburban, rural population density and urban-rural income gap. The setting of the service radius of charging station and the distribution of charging stations in urban and rural areas are also different. In short, our model is universally applicable as long as we set the parameters of the model according to the actual situation of each country.

Technology mainly affects the battery of electric vehicles, charging speed, charging station facilities, manufacturing costs of electric vehicles.

Firstly, with the development of technology, battery performance can be well improved. The battery capacity is in proportion to weight. If the capacity is small, although the weight is light contributing to less loss, the vehicles need to charge for more times, which brings trouble to the owner; If the capacity is large, although the mileage will increase, due to the increase of weight, energy consumption will increase. When the battery with a larger capacity, lighter weight, longer life is created, then the electric vehicles will become more attractive. Meanwhile, due to the enhanced mileage, too many charging stations are not needed or the distance of charging stations can be increased.

In addition, compared to the traditional gas car refueling that takes only a few minutes, electric vehicles require much longer charging times. People do not want to spend too much time waiting for charging. Although supercharging is available, 30 minutes are also needed. What if people meet emergencies without time for charging? The speed of charging plays an important role in the improvement of electric vehicles. The development of technology can make it possible to increase the charging speed and reduce the waiting time, which attracts people a lot and is beneficial to the development of electric vehicles. The increasing charging speed will also reduce the number of charging piles, which helps save the cost of building a charging station.

As for the charging stations, at present, the number of them is insufficient, and the facilities are still not perfect. The electric vehicles encounter barrier in charging. However, the construction of charging stations will get better and better, which will benefit the popularization of electric vehicles.

Besides, price is a critical factor that a lot of people would consider when buying a car. Electric cars are pricey, and thus many people choose traditional gas cars. In the future, as the craft of components is more refined, with lower prices and manufacturing costs, the price of electric cars will be acceptable.

However, if another better alternative energy replaces electricity, or a new type of transport is created, electric vehicles will decline.

6.Strengths and Limitations

6.1 Strengths

- Our designed for the optimal number of charging stations is efficient and practical. Subsequent mathematical tests using Matlab agree with our working strategy under different occasions and the simulation results are consistent with reality, implying it behaves as we want.
- We formulate the problem as a network in which the proportion of electric vehicles and different conditions of the nation are changing. In this way, we simplify the complex problem into several models. The evaluation system can also be modified in a degree.
- The models used in our paper are promotional since we have referred to many classic theories like the queuing theory, Monte Carlo simulation, etc., in order to be more logical.

6.2 Limitations

- Some special data can't be found, and it makes that we have to do some proper assumptions before the solution of our models and use simulation in further evaluation. A more abundant data resource can guarantee a better result in our models.
- Assumptions made for simplicity that likely do not hold. For instance, in most runs of our model, we only consider cases when the speed of electric vehicles is constant. Indeed, there is a fundamental tradeoff here between realism and elegance, and our model arguably veers toward over realism.
- Another weakness that could be corrected with more analyses is that in analyzing plans of investment for charging stations, we naturally neglect some important factors and their interaction or other complex relationships.

7.Conclusion

Taking the appearance of Tesla model3 as the background, we analyzed the trend of capacity, sales volume and market share, and indicated the feasibility of reaching all-electric in the United States. Setting up a cost model, we figured out the optimal scale and distribution of charging stations. When the US takes a complete switch to all-electric, there will be 204,000 charging stations, 49.07% of which were in urban areas, 32.72% in rural areas and 18.21% in rural areas.

Selecting Ireland as the second case, we reset the parameter values with its unique characteristics and put into the cost model. Hence, we also worked out the optimal number and distribution of charging stations. In the meantime, based on the current rate of electric vehicles in Ireland, we suggested that the nation should strongly encourage citizens to purchase electric vehicles while building up charging stations in rural areas and cities. We believe that it will take 66 years for Ireland to be fully electrified under a timeline model.

When considering countries with very different geographies, population density distributions, and wealth distributions, we analyzed the situation in Australia, China, Indonesia and found that the model still works. Simultaneously, we deem that battery performance, charging station facilities, economic level, etc., play a vital role in the switch to all-electric of a country.

In conclusion, our team is very certain that the methods we came up with in solving the problem are reasonable. Although our approaches and models were effective, there still remain several drawbacks, like comparatively strict assumptions.

8.Handout

Fossil fuels are non-renewable resources which will be depleted in the future. Traditional gas vehicles will lead to air pollution and the greenhouse effect. This is a global problem that all countries in the world need to discuss to solve this issue. The current feasible method is to use other clean renewable energy, electricity, instead of fossil fuels. In other words, a complete switch to all-electric is possible. However, the transition to a fully electric vehicle can not be accomplished overnight, and we encounter many obstacles in the process.

The rate of electric vehicles in economically underdeveloped areas is low. On the one hand, the developing areas do not have enough funds for the construction of charging stations. On the other hand, people in poor areas have a longer cycle of accepting new items. What’s more, it is not likely for the poor to purchase luxury products. Economic development is the basis for promoting a switch to all-electric. Government can support the development of economy in poor areas.

Besides, science and technology are primary productive forces. For technologically backward countries, the rate of electric vehicles is even lower. Technology limits the development of electric vehicles, technological advance can increase the rate of electric vehicles. Now the main technical bottlenecks that limit the rate of electric vehicles is battery technology and charging speed. By improving the quality of the battery and increasing the charging speed, people are more likely to choose electric vehicles.

To build a charging station, we need to make a rational plan and balance the cost and people's needs in order to achieve the optimal benefit. Without scientifically planning the construction of a station, it is likely to waste the fund and gain no benefit. In order to guide people to use electric vehicles, we need to consider the different needs in different regions before constructing the charging stations.

Even more, subsidy policy of purchasing electric vehicles should not be ignored by the government. In other words, by giving some subsidies, we encourage people to drive electric vehicles. Different subsidy policies have different effects. In the beginning, by increasing the amount of subsidies, it can attract people's eyes. After that, the electric vehicles are generally accepted, we can adjust the subsidy policy.

The full prohibition of gas vehicles should be implemented step by step. When the rate of electric vehicles reaches 50%, we can first ban the sale of fuel vehicles, and encourage people to buy electric vehicles. Gas vehicles can be used for a period of time, and after that, they will scrap. When the rate of electric vehicles reaches 100%, it is time to set a gas vehicle-ban to achieve the goal of migrating personal transportation towards all-electric cars.

9.Reference

[1] Sara Mehar, Sidi Mohammed Senouci. An Optimization Location Scheme for Electric Charging Stations. https://scholar.google.com

[2] Yulong Ren, Lefeng Shi, Qian Zhang, Weijian Han, Shoujun Huang. Study on Optimal Distribution and Scale of Electric Vehicle Charging Station [J]. Automation of Electric Power Systems,2011,(14):53-57.

[3] Shaoyun Ge, Liang Feng, Hong Liu, Long Wang. An Optimization Approach for the Layout and Location of Electric Vehicle Charging Stations [J]. 2012,(11):96-101. DOI:10.3969/j.issn.1004-9649.2012.11.021.

[4] Jinpeng QIU, Dongxiao NIU, Guodong ZHU. Optimized Layout of Charging Station for Electric
Vehicle Based on Firefly Algorithm. 2016, (5):105-110. DOI:10.3969/j. ISSN.1007-2691.2016.05.16.

[5] http://www.autonews.com/

[6] Yanan Zou, Zhuhe Song. Electric Vehicle Charging Station Planning and Benefits[J]. Fujian Quality Management,2017,(17):89.

[7] Inês Frade, Anabela Ribeiro, Gonçalo Gonçalves, and António Pais Antunes. Optimal Location of Charging Stations for Electric Vehicles in a Neighborhood in Lisbon,Portugal. https://scholar.google.com

[8] ELENA YUDOVINA,GEORGE MICHAILIDIS. SOCIALLY OPTIMAL CHARGING STRATEGIES FOR ELECTRIC VEHICLES.https://scholar.google.com

[9] https://www.Tesla.com/

[10] http://www.autonews.com/

[11] KOYANAGI F, INUZUKA T,URIU Y, et al. Monte Carlo simulation on the demand impact by quick chargers for electric vehicles[C]. Proceedings of IEEE Power Engineering Society Summer Meeting, July 18-22,1999, Edmonton, Canada. http://www.autonews.com/