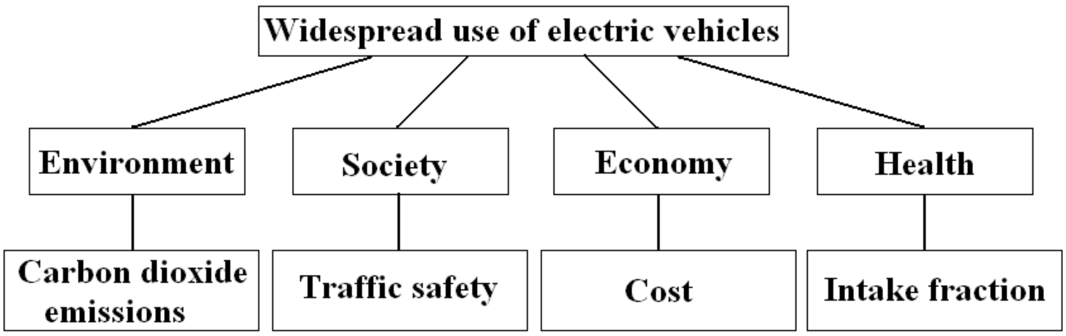
Bright Future Decorated by Electric Vehicle

Introduction

In order to evaluate the impact of the widespread use of electric vehicles in various fields, we need to establish a practicable evaluation criterion. We analyze primary factor of each part to achieves the whole analysis, so our approach is

- With available data, we model the impacts to environment，society，economy，health separately, and analyze the most important element in each part. (The analysis method is presented in Figure 1)

Figure 1



- Based on the data in the problem, we use statistics methods to compare the advantage and disadvantage of the widespread use of electric vehicles.
- According to the forecast of the Total Electrified Vehicle Sales, we optimize our primary model to calculate the total oil saved in the world.
- We construct functional relationship between the amount of electricity generation and time to forecast the additional electricity energy when electric vehicles are widely used.
- Do further discussion based on our works.

Solutions

Task 1

At the very beginning, we introduce a model about the development of different type of electric vehicles.Table1 shows fuel used by different types of vehicles.

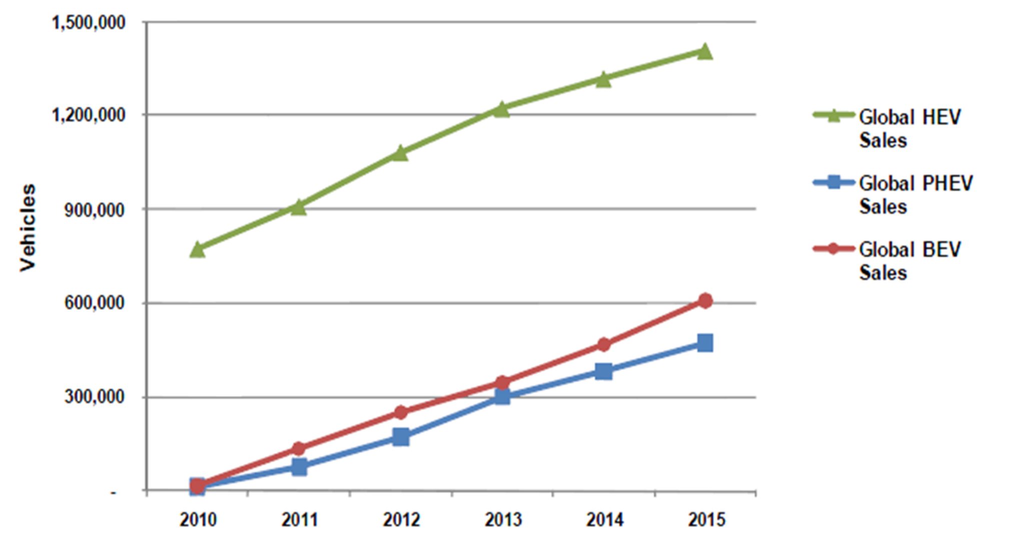
Table 1: Different types of vehicles

Fuel use in vehicle designs Vehicle type	Fuel used
All-petroleum vehicle(PV)	Most use of petroleum
Regular hybrid electric vehicle(HEV)	Less use of petroleum, but non-pluginable
Plug-in hybrid vehicle(PHEV)	Residual use of petroleum. More use of

	electricity
All-electric vehicle(EV/BEV)	Most use of electricity

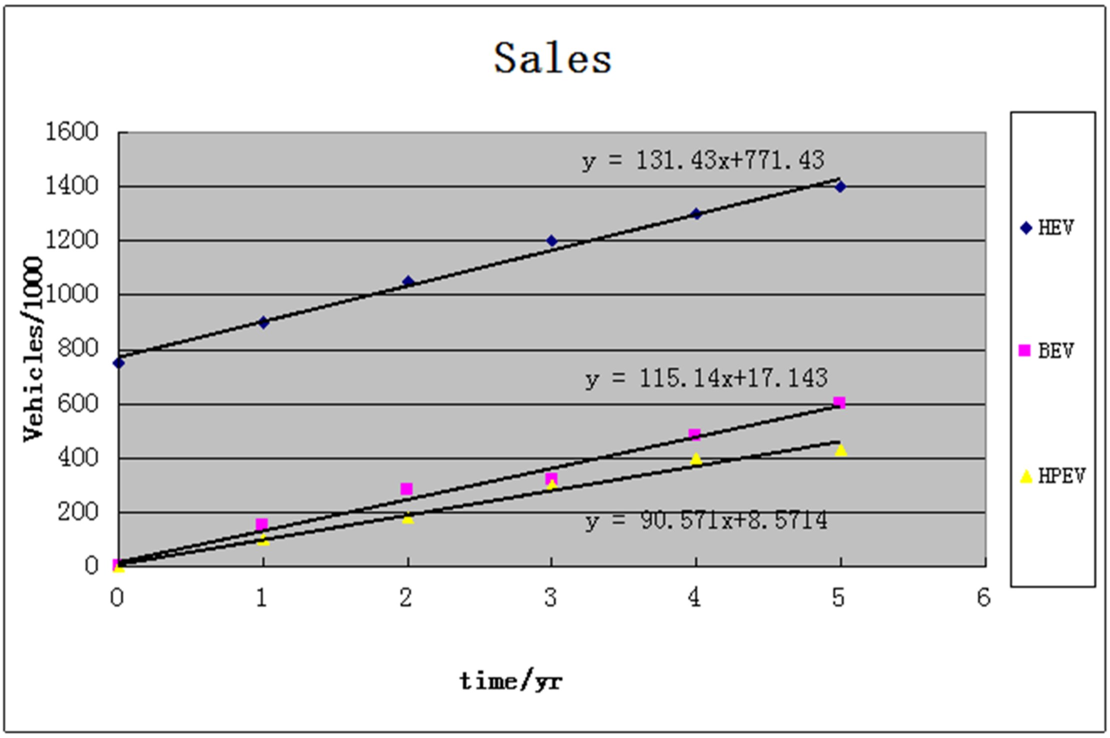
Following Figure 2 forecasts the Total Electrified Vehicle Sales, World Markets: 2010-2015. Source: Pike Research.

Figure 2: The forecast of the Total Electrified Vehicle Sales



According to the data from Figure 2, we get the analytical expressions of the Vehicle Sales based on the linear-fitting of Excel, shown in following figure.

Figure 3: the analytical expressions of the Vehicle Sales



We integral the analytical expressions of the Vehicle Sales to get he analytical expressions of the Vehicle Quantities. The result is shown as follows:

The quantity of HEV, BEV, PHEV, are successively indicated by $q_{ev1}(t)$

$q_{ev2}(t)$ and $q_{ev3}(t)$

$$q_{ev1}(t)=q_{hev}(\mathrm{t})=65.715\times \mathrm{t}^2+771.43\times \mathrm{t}$$

$$q_{ev2}(t)=q_{bev}(t)=57.57\times \mathrm{t}^2+17.143\times \mathrm{t}$$

$$q_{ev3}(t)=q_{phev}(t)=45.2855\times \mathrm{t}^2+8.5714\times \mathrm{t}$$

Model 1 The impacts to environment

Because the carbon dioxide emissions will worsen the greenhouse effect, global warming and a series of serious problems, we consider carbon dioxide emissions as the evaluation indicator to evaluate the environmental impacts of the widespread use of electric vehicles.

Let $m_i, i=1,2,3$ represent the carbon dioxide emission reduction of HEV, EV, PHEV. Thus, the total amount of carbon dioxide emission reduction can be described as:

$$R(t)=\sum_{i=1}^{3} m_i \times q_{evi}(t)$$

However, since $m_i, i=1,2,3$ depend on varies of factors, they can not be accurately measured. From the point of view of a well-to-wheel, researchers have found that the carbon dioxide emissions mostly depends on the source of the electricity used to recharge the batteries. If the electric vehicles are recharged from coal-fired plants, they usually produce slightly more carbon dioxide emissions than internal combustion engine vehicles.

Thus, to get the maximum reduction of carbon dioxide emissions, we develop a model by statistical methods based on the following assumptions:

1) Clean energy: carbon dioxide emission is zero when we use it to generate electricity.
2) Nonclean energy: carbon dioxide emission is not zero when we use it to generate electricity.

Let

p: denotes the proportion of light vehicles in road transportation sector.

q: denotes the proportion of road transportation in transportation sector.

w: denotes the proportion of clean electricity energy in electricity energy sector.

R: denotes the maximum reduction of carbon dioxide emissions of electric vehicles.

From Table 2 we get the value of w:

$$w=0.81$$

From Figure 4 we get the value of p:

$p =$ Nuclear +Hydroelectric +Other Renewables + Other

=20. 2%+6. 8%+3. 6%+0. 3%
=30. 9%

From Figure 5 we get the value of q

$$q = 60\%$$

From Table 3 we know that total U.S. carbon dioxide emissions from transportation sector energy consumption is approximately 2000 million metric tons annually. Thus, the most carbon dioxide emissions reduction of electric vehicles are

$$R = p \times q \times w \times 2000\text{mmt} = 374.4\text{mmt}$$

Table 2: Each kind of transportation vehicle's emissions (Million metric tons CO_2)

	Traffic Tools	CO_2 (Million metric tons)	Percentage
Land Transportation	Heavy Vehicles	350	81%
	Light Vehicles	1113	
	Rail	43	
Non Land Transportation	Air	171	19%
	Waterborne	58	
	Pipeline/Other	47	
	Internet'l/Bunker	84	

Table 3

U.S. Carbon Dioxide Emissions from Transportation Sector Energy Consumption, 1999-2008

(Million Metric Tons of Carbon Dioxide)

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Petroleum										
Motor Gasoline	1115.3	1122.0	1127.3	1156.1	1159.9	1181.3	1184.2	1186.9	1187.4	1134.9
LPG	0.8	0.7	0.8	0.8	1.0	1.1	1.7	1.6	1.3	1.2
Jet Fuel	245.4	253.8	242.8	236.8	231.5	239.8	246.3	239.5	238.0	226.3
Distillate Fuel	365.8	377.8	387.1	394.5	414.5	433.9	444.4	469.2	472.3	445.7
Residual Fuel	52.4	69.9	46.1	53.3	45.0	58.3	66.0	71.4	78.3	74.1
Lubricants[a]	6.8	6.7	6.1	6.0	5.6	5.6	5.6	5.5	5.6	5.2
Aviation Gas	2.7	2.5	2.4	2.3	2.1	2.2	2.4	2.3	2.2	2.0
Petroleum Subtotal	**1789.2**	**1833.4**	**1812.7**	**1849.8**	**1859.5**	**1922.2**	**1950.7**	**1976.4**	**1985.1**	**1889.4**
Coal	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Natural Gas	**35.8**	**35.7**	**34.9**	**37.2**	**33.4**	**32.0**	**33.1**	**33.2**	**35.4**	**35.9**
Electricity[b]	**3.4**	**3.6**	**3.8**	**3.6**	**4.5**	**4.7**	**4.9**	**4.7**	**5.2**	**4.9**
Total	**1828.4**	**1872.7**	**1851.4**	**1890.7**	**1897.4**	**1958.9**	**1988.7**	**2014.3**	**2025.7**	**1930.1**

Figure 4

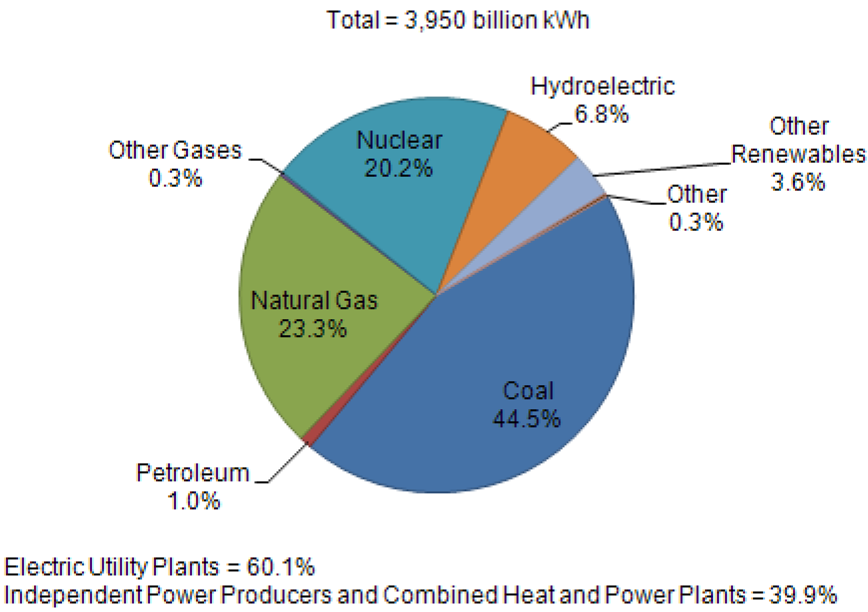
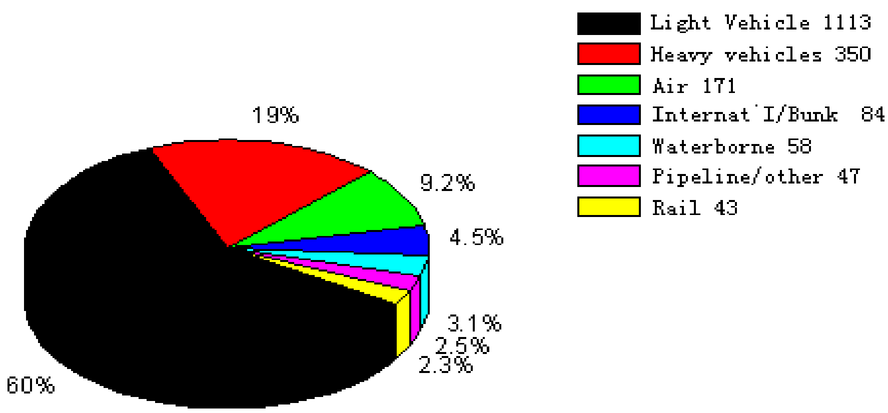


Figure 5



Model 2 The impacts to society

In order to clarify the social impacts of the widespread use of electric vehicles, we consider traffic safety as the most important element.

In this model we introduce a macroscopic evaluation model of many objects.

We give a finite set Q:

$$Q = \{q_{1,}q_2,...,q_n\}$$

The element $q_i(i = 1,2,...,n)$ in Q denotes one of our evaluation objects (for example different transportation tools).

Another finite set K:

$$K = \{k_1, k_2,..., k_m\}$$

The element $k_j(j = 1,2,...,m)$ in K denotes one of our evaluation indicators.

Let u_j be the membership function of evaluation indicator k_j, we get:

$$u_j = u(k_j), u_j \in [0,1]$$

Then we set a fuzzy subset U, we can obtain

$$U = \{u_1, u_2, ...u_m\}$$

To seek a fuzzy subset B:

$$B = \{b_1, b_2, ...b_m\}, b_i \in [0,1]$$

The element b_i in B denotes comprehensive evaluation indicator of evaluation object q_i.

1. Because membership function u_j applies to each evaluation object q_i, then we can get a evaluation matrix R, and we call it fuzzy relation. That is:

$$R : Q \times U \to [0,1]$$

$$R = \begin{bmatrix} R_1 \\ R_2 \\ \vdots \\ R_n \end{bmatrix} = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ r_{n1} & r_{n2} & \cdots & r_{nm} \end{bmatrix}_{n\times m}$$

r_{ij} is the membership of evaluation object q_i about evaluation indicator k_j, $r_{ij} = R(q_i, u_j) \in [0,1]$.

2. We set a fuzzy vector A:

$$\text{A}=\begin{bmatrix} a_1 \\ a_2 \\ \vdots \\ a_m \end{bmatrix}$$

The element in A denotes relative importance of each evaluation indicator.

3. Our evaluation model as follows:

$$B = R \otimes A$$

Its expanded form :

$$\begin{bmatrix} B(q_1) \\ B(q_2) \\ \vdots \\ B(q_n) \end{bmatrix} = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ r_{n1} & r_{n2} & \cdots & r_{mn} \end{bmatrix} \otimes \begin{bmatrix} a_1 \\ a_2 \\ \vdots \\ a_n \end{bmatrix}$$

4. The calculation of synthesis assessment :