2009 Mathematical Contest in Modeling (MCM) Control Sheet

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Each team member must sign the statement below:

Each of us hereby testifies that our team abided by all of the contest's rules and did not consult with anyone who was not on this team in developing the enclosed solution paper.

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Problem Chosen

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Energy and the Cell Phone

Abstract

This paper discusses under certain assumed condition the changes of telephone services and energy consumption caused by the cell phone revolution, and energy waste of different electrical equipments generated on standby; establishes the following precise mathematical model; gathers relevant data to conduct model derivation and prediction.

As for the problem 1, we firstly collect available data of the number of mobile phone users in America these years, of the fixed-line telephones and mobile phones' power consumption and duration of service on normal service condition and of the power and coverage area of cell phones' signal transmitting tower. By analyzing the data, we identify the critical point between the transition period and the stabilization period, and we also consider how the updating rate and its cost of the fixed-line telephones and mobile phones impact the cell phones' total energy consumption, and finally we establish power dispersion model between the transition period and the stabilization period under assumed condition. Then we conduct evaluation, model debugging and results interpretation (P11, Chart 5).

As for the problem 2, this paper has got the conclusion from the perspective of energy, based on the analysis of the fixed-line telephones and mobile phones' energy consumption in "pseudo-American" through the model in problem 1, that offering telephone service with the fixed-line telephones is the best way. However many people choose to use mobile phone because of its function and social impact. Therefore from the energy and the function which people have to consider when they select which kind of phone to use, we further find out some factors that influence people' s choices , such as that people with different ages prefer different phones, the phones' cost, energy consumption, updating cost and functions. To quantify the above factors, this paper introduces such definitions as economical efficiency, applicability and comprehensive satisfaction degree index (P15, Table 2 and Table 3). It establishes the Computer Simulation Model of the users' selection on the two means of communication. We draw the final conclusion with the help of the computer simulation

experiment that the best telephone service is on the point when the rate of fixed-line telephones is 47.26% and that of the mobile phones 52.74%.

As for the problem 3, we establish the model of cell phone power waste according to the main factors that causes cell phone power to waste, namely, the power wasted when the charger connect the power source without charging up the cell phone, when the battery is full but the charger still connect the power source and the rate of people with such bad habits (P19, equation 21). We study and analyze the data of the mentioned factors and with the Computer simulation calculation we draw the conclusion that in America the daily wasted power by cell phone amounts to as much as 101.1 barrels of oil.

As for the problem 4, we can see from the problem 3 that charging up cell phones leads to a great deal of power waste. It therefore can be supposed that other household electrical appliances (e.g. television, DVR, computer peripheral equipment etc.) may also cause such power waste. For example, a stand-by television still consumes power. Firstly we take such factors as the stand-by power of electrical appliances in normal service, everyday stand-by time and average family ownership into account to establish an energy consumption calculation model for household electrical appliances. Then with the help of the statistical investigation of the mentioned factors' precise data of 16 electrical appliances in normal service, we put the data into the model to calculate the energy-waste volume of 16 American electrical appliances in normal service (P20, Table 6). Its total volume is 21812.4 barrels of oil.

As for the problem 5, we predict the future population development, according to which we define the telephone service user's total population, of "pseudo-American" through the Logistic population model. We also predict by Gray prediction the future GDP of "pseudo-American" and that due to its economic development mobile phones' applicability will gradually take place of the fixed-line telephones' advantageous economical efficiency, thus results in the change of the ratio between the two means of communication (P29, equation 34). With the mentioned models' conclusions and relations we finally get the energy demand volume of every 10 years because of the telephone service in the "pseudo-American" in 50 years (P30, Table 15).

In the end, we make further analysis and tests on the five models, objectively evaluate the merits and defects of each model, and develop some particular model.

Key words: Cell Phone; Energy Waste; Simulation; Demand Prediction; Mathematical Model

Contents

I. Introduction

In order to explore the impact of energy waste and other related caused by the extensive use of cell phones more particularity, explain the basic information hereby.

1.1 The basic information

This issue involves the cell phone revolution in the energy issue. Rapid increase in cell phone usage, many people use mobile phones and abandon the landline. Such a change would have a certain impact on energy consumption

Compared with landlines,cell phone has advantages of convenience,short message,various subsidiary function and so on. Everything has two sides, cell phone must be recharged on time, because of the user's bad habits,it causes a variety of electricity waste.

1.2 Problem reaffirmed

- Consider the current US, a country of about 300 million people. Estimate from available data the number H of households, with m members each, that in the past were serviced by landlines. Now, suppose that all the landlines are replaced by cell phones; that is, each of the m members of the household has a cell phone. Model the consequences of this change for electricity utilization in the current US, both during the transition and during the steady state.
- Consider a second “Pseudo US”-a country of about 300 million people with about the same economic status as the current US. However, this emerging country has neither landlines nor cell phones. What is the optimal way of providing phone service to this country from an energy perspective? Of course, cell phones have many social consequences and uses that landline phones do not allow. A discussion of the broad and hidden consequences of having only landlines, only cell phones, or a mixture of the two is welcomed.
- Cell phones periodically need to be recharged. However, many people always keep their recharger plugged in. Additionally, many people charge their phones every night, whether they need to be recharged or not. Model the energy costs of this wasteful practice for a Pseudo US. Assume that the Pseudo US supplies electricity from oil. Interpret your results in terms of barrels of oil.
- Estimates vary on the amount of energy that is used by various recharger types (TV, DVR, computer peripherals, and so forth) when left plugged in but not charging the device. Use accurate data to model the energy wasted by the current US in terms of barrels of oil per day.
- Now consider population and economic growth over the next 50 years. How might a typical Pseudo US grow? For each 10 years for the next 50 years, predict the energy needs for providing phone service based upon your analysis in the first three requirements. Again, assume electricity is provided from oil. Interpret your predictions in term of barrels of oil.

II. The Description of the Problem

2.1 Analysis of The Problem

To solve the energy and cell phone problem,we need to establish the consumption change model、the best choice for telephone service model、the energy consumption model of cell phone waste and the energy demand forecast model respectively.

Five models is easy to digest and interrelated. Data simulation idea is really the main line of modeling process，the time existing data combined，We make the most use of mathematical tools. simplifying reasonably， to make the question more specific and quantizated， And eventually establish a mathematical model which is in line with the realities and simple.

2.2 Model assumptions

- In a certain period of time,the development of economy and the supply of energy are kept stability, there will be no major incidents in American society.
- Cell phone chargers and other electrical equipment's standby power consumption levels would not change with the developing of hi-tech.
- The United States' population and economic development change along the existing level smoothly.

III. Building and Solving of Model I

Model I: a stable period with the transition period to change the model of electricity consumption

3.1 Determination of the transition period and the steady-state period

According to the subject that there are H families in United states currently,each family has M members, when every family's landlines have been replaced by cell phone , this change will reach steady-state. we can see the given data by the title:

The number of landlines under the steady state：$Q_l = 0$

The number of cell phone under the steady state：$Q_c = \sum_{i=1}^{H} M_i$

During the transition period, The number of fixed telephones decreases gradually,while the number of mobile phones increases correspondingly.It will remain unchanged when reaching the steady state.By seaching related data and using MATLAB software polyfit function curve fitting,we will get the function of the changes of the phone number via the time t:

$$Q_c = f(t),$$

Further, to derive the number of landlines: $Q_l = \sum_{i=1}^{H} M_i - f(t)$

By searching data, select the number of mobile phones of United States from 1994 to 2008. Using curce fiting by MATLAB,The chart as follows:

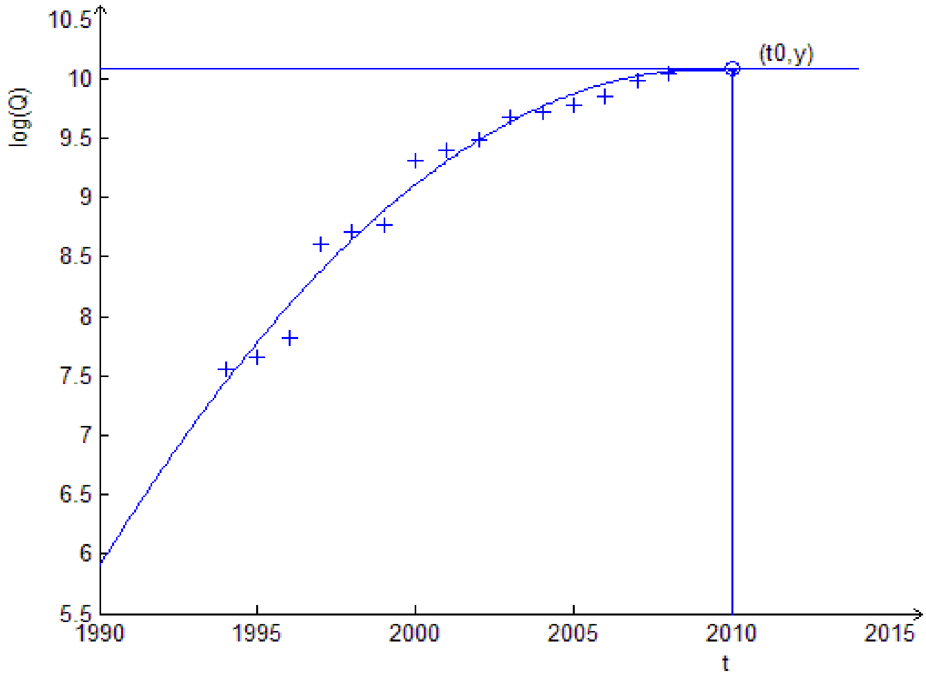

Chart 1: The number of mobile phone users on the number of plans from 1994 to 2008

Using polyfit function fit the equation as following:

$$Q_c = f(t) = e^{-0.0112141\,t^2 + 45.0653\,t - 45265} \quad ①$$

From chart 1 we can see that it is the transition period in the early use of mobile phone to the year t_0 It reaches steady state after the year t_0

3.2 The actual consumption of Landline and mobile phones in normal use

The power are different in different cell phones.Usually as follows:

$$I = 800mA$$

The current of ordinary cell phone under the normal working conditions

$$U = 3.7V$$

The voltage of ordinary cell phone under the normal working conditions

$$W = UI = 3.7 * 0.8 = 2.96(W)$$

In normal working conditions in a day,The energy consumption of the ordinary cell phone is:

$$q = W \times t = 2.96 \times 24 \div 1000 = 0.07104(kw \cdot h)$$

The results have been proved that during the process of charging the cell phone there will have 10% of the power loss, so the actual power consumption of 1 ordinary cell phone in one day is:

$$q_c = q_c^{'} / 0.9 = 0.07104 \div 0.9 = 0.07933(kw \cdot h)$$

As the mobile phones have the different functions, power consumption has a larger difference, it can be assumed that the United States mobile phone users use mobile phones to work the day the actual consumption of electricity showed a normal distribution， And its average value and standard deviation check $\mu = q_c = 0.07933$; $\sigma = 0.2$.[1]

draw the actual power consumption of the normal work day of normal distribution through computer is as follows:

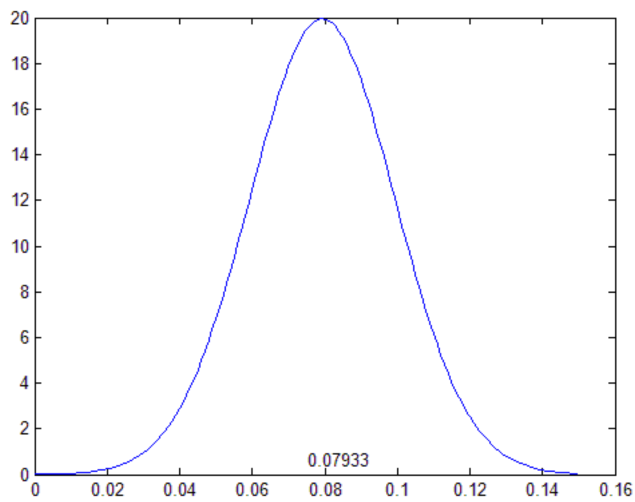

Chart 2: the normal work day of the actual phone power normal distribution

Solving the following mobile phones during the transition period and the steady state under normal use of the actual landlines and cell phone power consumption

- The electricity consumption of landlines and cell phone in one day during the steady-state period

When the changes reach steady state: $Q_{sl} = f(t > t_0) = 0$

$$Q_{sc} = f(t > t_0) = \sum_{i=1}^{H} M_i$$

The electricity consumption of cell phones per day under normally using:

$$K_{sc} = \sum_{i=1}^{Q_{sc}} q_{ci} (i = 1,2...) \qquad ②$$

The electricity consumption of landlines per day under normally using: $K_{sl} = 0$

The sum of landlines and cell phone's electricity consumption Per day during the steady state period year is:

$$w_s = K_{sc} + K_{sl} = \sum_{i=1}^{Q_{sc}} q_{ci} \quad ③$$

- The electricity consumption of landlines and cell phone per day during the transtion period

The number of cell phone in the year of t during the transition period is:

$$Q_{tc} = f(t) = e^{-0.0112141+45.0653*t-45265*t^2} \quad (t < t_0) \quad ④$$

The number of landlines are: $Q_{tl} = \sum_{i=1}^{H} M_i - f(t)$ ⑤

Under normal use, ordinary landline's actual power consumption of 0.45W, the actual consumption of electricity a day is:

$$q_l = W \times t = 0.45 \times 24 \div 1000 = 0.0118(kw \cdot h) \quad ⑥$$

Therefore, during the transitional period, the electricity consumption of the cell phone one day is:

$$K_{tc} = \sum_{i}^{Q_{tc}} q_{ci} \quad ⑦$$

The electricity consumption of the landlines one day is:

$$K_{tl} = Q_{lj} \times q_{tl} (j = 1994, 1995 \ldots t_0) \quad ⑧$$

So,The sum of landlines and cell phone's electricity consumption in one day a year during the transtion period is:

$$w_t = K_{tc} + K_{tl} = \sum_{i=1}^{Q_{tc}} q_{ci} + Q_{lj} \times q_l (i = 1,2\ldots; j = 1994,1995\ldots t_0) \quad ⑨$$

3.3 The power loss due to Landline and cell phone updates generated

When using landline and cell phones, there are many factors affecting the normal use of equipment, for example, it may be lost, damaged, more often , the user will update the current using mobile phones.So there is a problem:

It will bring more higher and newer power consumption due to the frequent update of mobile phones.

Now, assume that the integrated use of update period of landlines is 8 years and the phone is 2 years, then the corresponding update rate is：

The daily update rate of landlines is: $i_l = \frac{1}{8*365} \times 100\% = 0.03425\%$

The daily update rate of cell phone is: $i_c = \frac{1}{2*365} \times 100\% = 0.1370\%$

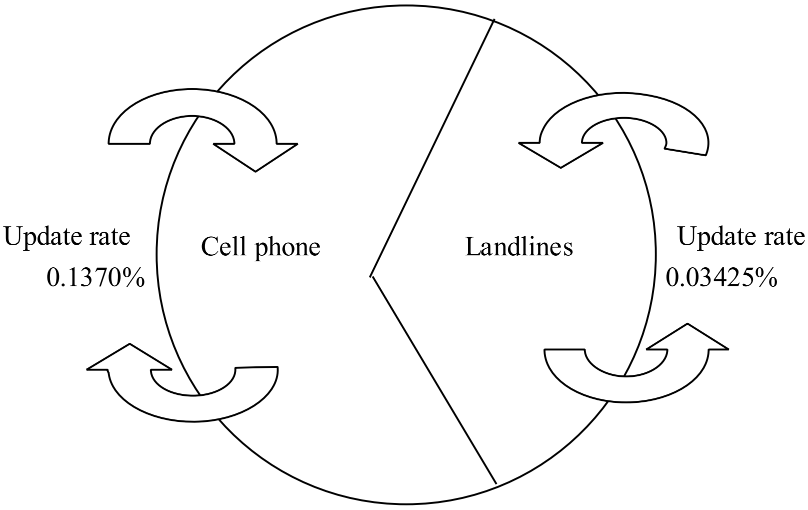

Chart 3: Annual Update Schematic of cell phone and landlines

For chart 3, the number of phone users and type are unchanged in this closed-system posed by cell phone and landline at a short time,if assume electricity consumption of each cell phone and landline is proportional to its production costs, accounts for 1%.then, the following table can be drawn:

Table 1: The cost of landline and mobile phone updates

	Average cost: dollar	Electricity costs: dollar	Electricity prices: dollar/ Degree	Electricity consumption: Degrees
landlines	20	0.2	0.1	2
Cell phone	100	1	0.1	10

Therefore, the total power loss due to the increase in equipment upgrades in the steady-state period of a day is:

$$\begin{aligned} w_{su} &= g_l \times i_l \times Q_{sl} + g_c \times i_c \times Q_{tc} = 2\times 0.03425\% \times 0 + 10\times 0.173\% \times Q_{tc} \\ &= 1.73\% \sum_{i=1}^{H} M_i \end{aligned} \quad ⑩$$

The total Increase of power loss due to equipment updates, during the transition period t (t <to) time is：

$$\begin{aligned} w_{tu} &= g_l \times i_l \times (\sum_{i=1}^{H} M_i - f(t<t_0)) + g_c \times i_c \times f(t<t_0) \\ &= 2\times 0.03425\% (\sum_{i=1}^{H} M_i - f(t<t_0)) + 10\times 0.1730\% \times \sum_{i=1}^{H} M_i \\ &= 1.7985\% \sum_{i=1}^{H} M_i - 0.0685\% f(t<t_0) \end{aligned} \quad ⑪$$

3.4 The Energy consumption of Mobile phone signal transmission stations

According to the information, cell phone is carried out through the signal transmission base stations in order to achieve the normal work ,during this period, the base stations also need to rely on electricity for normal operation, so there will be power loss too, and the power loss does not change with the phone number change . In order to ensure signal transmission smoothly,it's need to build a number of ase stations and a signal transmission network covering the United States .assuming that a transmitting station jurisdiction for R = 2km of the region, according to the United States land area, there were a total number of base stations N = 746019[4]; it's been known that the power of a transmitting station is 2W , thus, the total power consumption of all the transmitting station by the normal work day is:

$$w_{ts} = 746019 \times 2 \times 24 / 1000 = 35809(kw \cdot h).$$

3.5 The model of electricity consumption change during the transition period and steady-state period

In steady-state period, the day's total electricity consumption in the United States by the use of landline and cell phone：

$$Y_s = w_s + w_{su} + w_{ts}$$

$$Y_s = \sum_{i=1}^{Q_{sc}} q_{ci} + 1.73\% \sum_{i=1}^{H} M_i + w_{ts}$$

In transtion period, the day's total electricity consumption in the United States by the use of landline and cell phone：

$$Y_t = w_t + w_{tu} + w_{ts} \tag{12}$$

$$Y_t = (\sum_{i}^{Q_{tc}} q_{ci} + Q_{lj} \times q_l) + (1.7985\% \sum_{i=1}^{H} M_i - 0.0685\% f(t < t_0)) + w_{ts} \tag{13}$$

Thus,establish the Two-stage model of consumption change to be the different consumption between landline and cell phone during the steady-state period and transition period in a year:

$$Y = Y_s - Y_t = w_s + w_{su} - w_t - w_{tu} \tag{14}$$

That is：

$$\begin{aligned} Y &= \sum_{i=1}^{Q_{sc}} q_{ci} + 1.73\% \sum_{i=1}^{H} M_i - (\sum_{i}^{Q_{tc}} q_{ci} + Q_{lj} \times q_l) - (1.7985\% \sum_{i=1}^{H} M_i - 0.0685\% f(t < t_0)) \\ &= \sum_{i=1}^{Q_{sc}} q_{ci} - \sum_{i=1}^{Q_{tc}} q_{ci} - 0.0118 Q_{lj} + 0.0685\% (Q_{tc} - \sum_{i=1}^{H} M_i) \end{aligned} \tag{15}$$

In the formula：

q_{ci} : The Energy consumption of the number of the number of i unmber of undernomal working day the Energy consumption of the number of i under normal working day

H: The total number of households

M_i: The number of members of the first i families

Q_{sc}: The total cell phone users in the steady- state

Q_{tc}: The total mobile phone users in the t years during transition period,

Q_{lj}: The total landlines users in the j years

$f(t<t_0)$: The total cell phone users during the transition period

3.6 Model debugging and results analysis

With the continuous development of society and the State's advances, the number of households(H) 、 family members(M) and the total population will continue to change, consider the demographic structure of the composition of the United States, according to official data, there is about 80% of Americans can normally use the cell phones,so, the steady-state value may be set for:

$$Q_l = 0 \qquad Q_{sc} = 80\% \sum_{i=1}^{H} M_i = 0.80 \times 3 = 0.24(billion \cdot set)$$

Substitute the data($q_c = 0.07933$ $q_l = 0.0118$)into formula one, through the programming for computing the results obtained, and the data in chart form as follows:

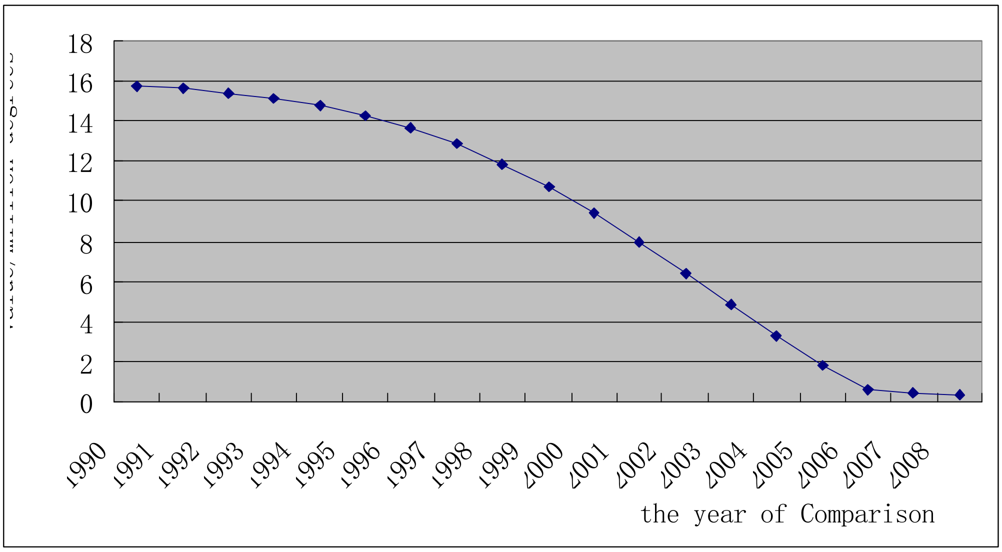

Chart 5: Electricity Consumption difference time series graph in a year during the transition period and stable period

Result Analysis:

- As can be seen from the chart, with the transition to the steady-state period of the gradual passage, the value of Y is gradually reduced and to be constant positive, that shows the tatal amount of electricity consumption during the steady-state is more greater than during the transtion; the popularity of cell phones will accelerate the use of oil energy failure.

- Calculated in accordance with the relevant, a barrel of crude oil can be equivalent to generating electricity in 1928, according to the United States Strategic Petroleum Reserve the existing volume of 700 million barrels[2], in the steady state , the United States to use the phone one day reach 0.1904 billion kwh of electricity; then the communication time provided by the reserved oil is:

$$T = \frac{7 \times 1928}{0.1904} = 70882(d) = 194(Y)$$

That is, if only use oil to provide mobile electric power, the volume of the existing Strategic Petroleum Reserve of the United States could only maintain its citizens in mobile communications 194 year.

IV. Building and Solving of Model II

4.1 Model II: the best choice model for telephone service

- **From the energy point of view, the best way of telephone service**

Through the issue of one narrative and conclusions can be drawn: from the energy point of view, it is obvious that landlines is better suited for the burgeoning countries to provide telephone services. Because when all the members of the family H by landline users are transformed into cell phone users, the electricity consumption of telephone services is in a significant improvement,which can be concluded by comparing a single landline power consumption with the cell phone

Daily power consumption of a landline:

$$e_l = 0.0118 + 0.0685\% = 0.0125 \quad (kw \cdot h / day) \tag{16}$$

Daily power consumption of a cell phone:

$$e_c = \{\frac{\sum_{i=1}^{Q_{sc}} q_{ci} + w_{ts}}{\sum_{i=1}^{H} M_i} + 0.0173\} \quad (kw \cdot h / day) \tag{17}$$

Obviously, $e_l > e_c$.therefore ,it can be the following conclusion: purely from the energy point of view, in order to provide telephone services in this country the best way is to use of fixed-line telephone.

4.2 The establishment of the best choice model of telephone service means

Considering The special use of landlines and cell phones and social impact,we can arrive at the best telephone service means.Cell phones,compared with the landlines, has a greater Social impact and more useful, the main erformances are in the following three aspects:

- Convenient; People not only can connect anyone anytime in the signal converage area,but also the cost of telephone services is much lower than the landlines.

- Short Message Service; Cell phone has SMS function, which provides users with more ways to exchange telephone service.
- Have a variety of subsidiary functions ; Ordinary mobile phone has video and audio entertainment features, camera functionality, timing, games and other functions, which greatly facilitates the user's travel And enriches the lives of users

From the first model, the plane of the energy consumption is less than the cell phone, if it focuses on the consideration of energy consumption, it would increase the number of plane, but taking (into account) the greater use of cell phones and social impact into account, you need to increase the number of mobile phone (number). Considering the energy consumption of two types of communication tools, uses and social effects, we establish a “pseudo-American”communication services computer simulation model beginning with this burgeoning “pseudo-American” which has no landline and cell phones.

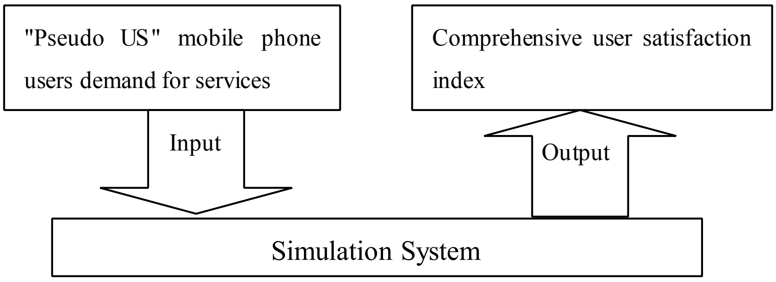

Chart 5: The simulation schematic theoretical framework

To establish a "pseudo-American" communication services computer simulation model, we must first define the following formula

Formula for Economy: $$J = \frac{w_1 \times f_1 + w_2 \times f_2 + w_3 \times f_3}{w_1 + w_2 + w_3}$$

Formula for Applicability: $$Q = \frac{v_1 \times r_1 + v_2 \times r_2 + v_3 \times r_3}{v_1 + v_2 + v_3}$$

The meaning of the letters in above formula are:

f_1: Average satisfaction index of the landline and cell phone calls

f_2: Average satisfaction index of the cost of landline and cell phone power consumption

f_3: Average satisfaction index to update the cost of landline and cell phone

r_1: Applicability Satisfaction Index of the cost to update landline and cell phone

r_2: Satisfaction Index applicability of landline and cell phone functionality in the message to the user

r_3: Satisfaction Index applicability of landline and cell phone in the other subsidiary functions to users

w_1、w_2、w_3 respectively, express the cost of landline and cellular phones, power consumption costs, update costs in the economic index on the share of the weight, resulting from difference in ages of the users.

v_1、v_2、v_3 express landline and cell phones, respectively, in fast, short message functions, other ancillary tools such as functional index on the share of the weight, resulting from difference in ages of the users .

To sum up, we can draw comprehensive formula for calculating the personal satisfaction:

$$F_i = J + Q = \frac{w_1 \times f_1 + w_2 \times f_2 + w_3 \times f_3}{w_1 + w_2 + w_3} + \frac{v_1 \times r_1 + v_2 \times r_2 + v_3 \times r_3}{v_1 + v_2 + v_3} \quad ⑱$$

Comprehensive formula for calculating the mean satisfaction

$$S = \frac{\sum F_i}{\sum_{i=1}^{H} M_i} \quad ⑲$$

4.3 Computer simulation test of the best choice for telephone service model

Due to factors such as age and disability makes some people can not use the telephone or mobile phone and other communication tools, Which make up 20% of the “pseudo-American” population,approximately 0.6 billion people. the remaining pseudo-American population , about 2.4 billion people, have communication capabilities ,their distribution is about: young people accounted for about 20%, about 55 percent of middle-aged, old age accounted for about 25%. Due to differences in age and experience, the above three kinds of people on fixed and mobile telephone preference is different from the youth's preference for two types of communication tools the same extent, the choice of fixed telephone as a communication tool is the probability was 0.5 for the average, 0.2 for the standard deviation of normal distribution; middle-aged as a result of the work's sake, have more preferences in mobile phone, Its selection of fixed telephone as a communications tool is a positive probability to 0.4 for the average, 0.2 for the standard deviation of normal distribution; the elderly because of age, have more preferences in the solid mobile phone, and its selection of fixed telephone as a communication tool is a positive probability to 0.6 for the average, 0.2 for the standard deviation of normal distribution.

Simplified treatment：

- The "pseudo-American" who has the communications capabilities up to ten thousand man-made units simulation experiment.
- The following three tables have been collated after Analysis

Table 2: Economic indicators for the applicability of the integrated coefficient table

	Economic Coefficient f_i			Applicability coefficient r_i		
	Consumption index	Charges index	Updated cost index	Convenient index	communication satisfaction index	Subsidiary function satisfaction index
Landlines	0.8	0.55	0.9	0.3	0.1	0.2
Cell phone	0.2	0.45	0.1	0.7	0.9	0.8

Table 3: the proportion of the economy and the applicability table

	Economy						Applicability					
	Charges		Electricity charges		Update cost		Convenient		Short Message		Subsidiary function	
	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ
Young people	4	1.2	2	0.6	5	1.5	6	1.6	5	1.5	4	1.2
Middle-aged	5	1.5	3	0.7	4	1.2	7	1.8	3	0.7	4	1.2
Old-aged	6	1.6	4	1.2	3	0.7	3	0.7	3	0.7	3	0.7

Table 4: Population of all ages on the landlines preferences

User groups	Overall preference	Mean Probability	The probability of the standard deviation
Young people	Neutral	0.5	0.2
Middle-aged	Preferred cell phone	0.4	0.2
Old-aged	Preferred landlines	0.6	0.2

Concrete steps to realize see Figure 6:

- The first step: Through the table 3 for every 0.03 million young people have communications capabilities, middle-aged or old-aged landlines selected probability simulation, get a 24000×1 probability matrix，At the same time, to determine the value of each probability，If the probability value is greater than 0.5, the value set to 1，landlines depends on its selection as a communications tool; If the probability value of less than 0.5, the value set to 0, Depending on their choice of cell phones as a communication tool. At the same time, Table II simulation data to generate two types of communication tools and the applicability of the economic weight coefficient.
- The second step: Calculate economic and applicability'scoefficient of two Communication tools
- The third step: Operate the Simulation System

- The forth step: Calculate the max value of Optimal ratio and Composite satisfaction of andlines and cell phone.

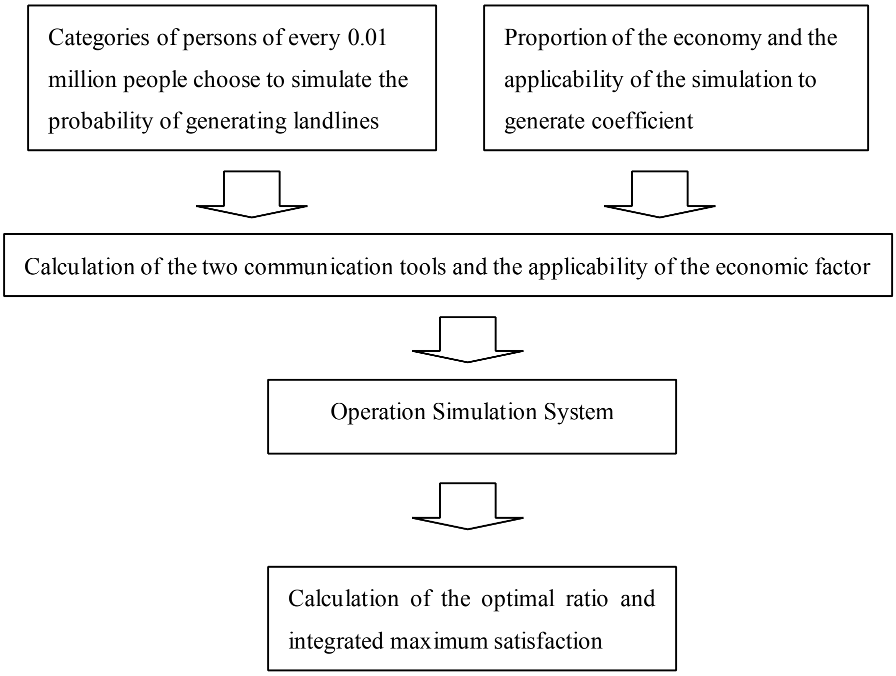

Figure 6: The Solving diagram of computer simulation model

Table 5: Simulation results

	Proportion of landlines users	Coefficient of economic satisfaction	coefficient of Adaptive satisfaction	coefficient of Composite Satisfaction
The first simulation	0. 4728	93. 9561	104. 7568	99. 987
The second simulation	0. 4728	93. 9824	104. 7949	100. 0261
The third simulation	0. 4729	94. 0122	104. 7729	100. 0162
The forth simulation	0. 4726	93. 9691	104. 8444	100. 0298

From Table 5, we can see that four analog integrated coefficient of the highest satisfaction value is 100.0298, simulation results of satisfaction with the highest combined corresponding to the ratio of allocation of telephone service should be the best, that is, the total number of telephone landline subscribers accounted for 47.26% of service users. This shows that the "pseudo-American", when providing landline and mobile phone service at the same time, and the subscribers of the landline telephone service making up 47.26% of total users of telephone services is the best way. If we use a fixed telephone simulation only, we will arrive at the Composite Satisfaction factor of 40.22; if we use mobile phones to carry out simulation only, the integrated satisfaction derived coefficient: 51.67

V. Building and Solving of Model III

----waste of phone power consumption model

5.1 Modeling preparation

- No-load power consumption of mobile phone charger

Mobile phone charger when not in use will be flying power plug, This is because the transformer step-down charger, and its line of AC was partly wrapped in a loop, so there is power consumption. Electronic step-down charger play rectifier buck and energy of the electronic components themselves, in the no-load case, its power is about 0.15W. In addition, the current of a small red light on the charger is usually 5 ~ 10mA, and the current transformer is used after the power supply voltage, which is a 5V resistor string, a total power consumption is about 0.05W. To sum up, cell phone chargers when not in use are still flying plug the power consumption of 0.2w.

- Test power consumption, through the experimence of charging mobile phone overnight

We selecte one of Nokia, Samsung, Motorola cell phone as one of the experimental samples, make the three mobile phone at the same time plug in the charger, and then the two charger were received in one Meter. When the mobile phone battery charging, It will record the energy consumed by their own. And continue to pay attention to meter after phone charge ending so as to prove the scientific nature of this experiment. After calculation for mobile phones charging, it will be used 3 hours or so for ending the mobile phone charging ,respectively, Their respective power consumption has been approximately 0.01 degrees. Cell phone charger from full power until the completion of 10 hours, they continue to charge all electricity consumed about 0.015 degrees. Therefore, we can consider charging for mobile phones because energy waste caused by an average of 0.015 degrees per set.

- Energy conversion calculation of one barrel of oil

The energy content of various fuels are different, Such as one ton of coal equal to about 7560 kwh, 1 metric ton peat equal to about 2200 kwh, 1 ton of coke equal to r 7790 kwh, 1 cubic meter gas equal to 4.7 kwh, etc. For convenience of use, unifie standards, conducting energy quantity, quality comparison, it will be coal, petroleum, natural gas and so on according to a certain proportion of unity to express converted into standard coal(1 kg of standard coal for thermal value 29.3076 MJ, that is a ton of standard coal for MJ 29,307.6). According to estimates, each kg of crude oil for 1.43 kilograms of standard coal, electricity (equivalent) 0.123 kilograms of standard coal / kWh. In addition, 1 barrel = 158.98 liters, if the volume converted to weight, and crude oil density are related. Assumpt that the crude oil density is 0.99 kg / L, then the weight of a barrel of crude oil is 158.98 × 0.99 = 157.3902kg, Therefore, we can calculate the power of a barrel of oil equivalent is $\phi = 1830 kw \cdot h / barrel$.

5.2 Modeling and Solving

With the principle from the simple to the complex ,establish two models, The first model assumes that all mobile phone users have all kinds of waste, This is an ideal worst-case scenario, it is also possible the maximum amount of energy wasted; The second model to fully consider the practical problems that waste energy only occurs in some mobile phone users ,in the use of simulation ideas, to calculate the value of that wasted energy is most likely to happen.

- First, Assume that all mobile phone users have a trial a waste of improper conduct, that they always inserte the charger in the electrical socket, and charge the phone all the night every time when the phone need to be charged. Based on this assumption, indicate by the problem II's results that " "Pseudo-American" has 240 million mobile phone users, of which 52.74% for mobile phone users, that is, there are 186.53 million mobile phone users. Further, assuming that the average ordinary mobile phone are on one charge every three days so that you can calculate the amount of energy waste caused by the use of mobile phones of the whole "pseudo-American," the amount is:

$$W_t = \frac{\left(\frac{0.2kw\times 24h}{1000} + \frac{0.015kw\cdot h}{3}\right)\times 1.8653\times 10^8}{\phi} = 998.8(Barrels/day) \quad ⑳$$

- Furtherly full considerate the act of wasting energy occurs only in part of mobile phone users in reality, and use mathematical simulation principle to make the following parameter settings:

$\Phi(\mu_1,\sigma_1)$: Means that the proportion of someone who have the habit of wasting energy is in line with the average μ_1 standard deviation of σ_1 of the normal distribution.

$\Phi(\mu_2,\sigma_2)$: Means that the charger has been plugged into an electrical socket on the individual mobile phone users will plug the charger in one day on the slot number of hours in line with the average value of a, the standard deviation of normal distribution for b.

$\Phi(\mu_3,\sigma_3)$: Means the proportion of cell phone users who charges all night in the total number of users is in line with the average value of μ_3 and the standard deviation of normal distribution for σ_3

So that: $p_1 = \Phi(\mu_1,\sigma_1)$

$$\text{n} = 1.8653\times 10^9 p_1$$

$$t_i = \Phi(\mu_2,\sigma_2).(i = 1、2、\cdots、\text{n})$$

$$p_2 = \Phi(\mu_3,\sigma_3)$$

Then, we can draw the following formula for calculating based on the model 1:

$$W_s = \frac{0.2\times 10^{-3}\times\sum_{i=1}^{n} t_i + 1.8653\times 10^8\times 5\times 10^{-3}\times p_2}{\phi} \quad ㉑$$

$$= (1.093\times 10^{-7}\sum_{i=1}^{n} t_i + 509.64 p_2)(Barrels/day)$$

In the formula， $\mathrm{n}=1.8653\times10^{8}p_1$， $\phi=1830kw\cdot h/barrel$

In order to test the model, assuming a reasonable following data:

$p_1=\Phi(\mu_1,\sigma_1)=\Phi(20\%,8\%)$ Mean for the average case of the day have 20% of mobile phone users, the existence of empty waste charger.

$t_i=\Phi(\mu_2,\sigma_2)=\Phi(12,5).(i=1、2、\cdots、\mathrm{n})$ Means that in one day exist in the user make cell phone charger no-load, the charger no-load time an average of 12 hours.

$p_2=\Phi(\mu_3,\sigma_3)=\Phi(10\%,5\%)$ Mean, in the average case, each day has 10% of mobile phone users need to recharge your mobile phone will be charging all night.

Using MATLAB software, you can realize this test calculation, simulation 500 times from the average calculation results can be drawn ：

$$W_s=1.093\times10^{-7}\sum_{i=1}^{n}t_i+509.64p_2=101.1\,(Barrels/day) \quad ⑫$$

In the formula： $\mathrm{n}=1.8653\times10^{9}p_1$

- Result Analysis: The first model assumes that all mobile phone users have the habit of all kinds of waste, This is the worst-case scenario, The maximum amount of energy wasted is potential $998.8(Barrels/day)$; In the second model, We give serious consideration to a number of factors ,which include the proportion of charger no-load users、the time of charger no-load and the proportion of users who charge the mobile phone battery all night .Using the idea of simulation,We calculate the most likely value of the energy wasted is $101.1\,(Barrels/day)$

VI. Building and Solving of Model IV

----Model IV: household appliances, standby power waste model

6.2 Analysis of the problem

From Model 3 we can see that the problems which arise in the cell phone charging process (mobile phone charger is connected with the power but not with the mobile phone or cell phone battery is full but it is still on charge, etc.) lead to a great waste of electricity. We can think of other electrical appliances (such as TV, DVR, computer peripheral equipment, etc) which will also cause such a similar electricity waste. For example, the TV in standby mode still runs away with electricity. However, due to the different conditions of electrical equipments in different families, such as the different number of television sets and different standby time of each television, in order to solve this problem, we need to do computer simulation to the type, number, standby power, standby time and other detail problems of the electrical equipments of each family, and establish a computer simulation model.

6.2 Modeling preparation

Because of the different standby power of different brands of electrical appliances, we gain the average standby power according to the standby power of the first 10 sales of electrical appliances, and at the same time, figure out the average standby time and household ownership of various electrical appliances. The list is as follows.

Table 6: relevant parameter values of different household appliances

Serial Number	Home Appliances	Standby power		The daily average of standby time		The average number of Appliances family owned	
		Average /w	Standard deviation /w	Average /h	Standard deviation /h	Average	Standard deviation
1	TV	6.4	1.2	4.3	1.8	2.7	0.9
2	Set-top boxes	10.2	2.3	4.3	1.8	2.7	0.9
3	VCR	5.3	1.2	3.2	1.1	2.1	0.71
4	Music Box	5.2	1.2	5.1	2.1	1.2	0.5
5	CD player	2.2	0.5	2.2	0.9	0.8	0.13
6	Receiver	2.8	0.9	0.6	0.14	0.6	0.11
7	Tape player	1	0.2	6.5	2.1	1.2	0.31
8	Fax	5	1.8	0.3	0.07	0.8	0.12
9	Tower	1.2	0.09	2.2	0.09	0.61	0.17
10	Display	2	0.07	4	1.5	1.1	0.19
11	Printer	4.2	1.1	0.21	0.09	0.6	0.11
12	Subwoofer	6.9	2.1	4	1.3	1.2	0.05
13	Notebook	4.5	1.3	2.3	1.1	0.74	0.21
14	Copiers	5.1	0.9	0.19	0.05	0.62	0.32
15	Microwave	2.8	0.8	2	0.9	1.02	0.41
16	Furnace	5	1.7	0.5	0.1	1.4	0.21

6.3 Modeling and Solving

- Symbol Description

n_i: Expressing serial number for the number of electrical appliances, and $n_i = \Phi(\mu_{1i}, \sigma_{1i})$

p_i: Express serial number for standby electrical power,and $p_i = \Phi(\mu_{2i}, \sigma_{2i})$

t_i: Express serial number for the electrical standby time, and $t_i = \Phi(\mu_{3i}, \sigma_{3i})$

- The establishment of model

Power consumption of the j families electrical equipment every day:

$$q_j = \frac{\sum_{i=1}^{16} n_i p_i t_i}{\phi} (barrels) \quad ㉓$$

The total power consumption of household electrical appliances equipment in the United States every day：

$$Q = \frac{\sum_{j=1}^{H} q_j}{\phi} = \frac{\sum_{j=1}^{H}\sum_{i=1}^{16} n_i p_i t_i}{\phi} (barrels) \quad ㉔$$

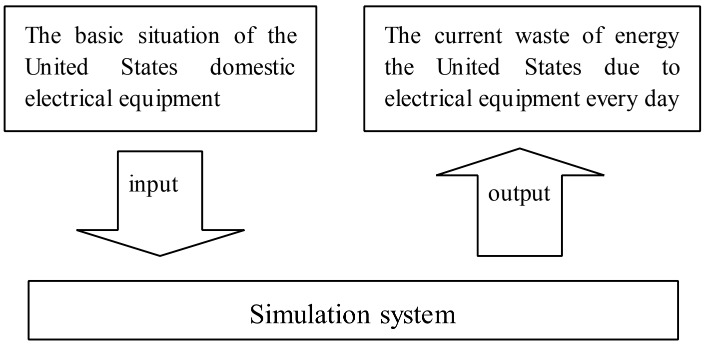

Figure 7: Schematic diagram of simulation experiment the theoretical framework

- Model Solution

Through the data of Table 6, we can do a more appropriate measurement to the energy waste situation of American household appliances. For the waste situation of most household appliances in a country, the randomicity is big. This is mainly manifested in the everyday number of the various energy-wasted appliances throughout the country, the wasted time of each appliance, and different standby time. Thus, while we are dealing with so many related data, we must see clearly the complexity of the problem, and make full use of the idea of the mathematical data simulation to get the numerical value immediately by the normal distribution, and then get the average after repeated simulation. Thus we get the following equivalent table of the total value of the wasted oil everyday because of different kinds of energy-wasted household appliances in American families.

At the same time, according to the summary of the wasted energy of various appliances, we find that the everyday amount of wasted oil of American families because of electrical equipments is 21,812.369 barrels.

Table 7: The total energy wasted of the American family electrical equipment every day

Serial number	Home Appliances	The total daily waste of energy / $barrels$	Serial number	Home Appliances	The total daily waste of energy / $barrels$
1	TV	4796.62	9	Tower	105.159
2	Set-top boxes	7714.52	10	Display	567.928
3	VCR	2315.94	11	Printer	34.1086
4	Music Box	2091.46	12	Subwoofer	2152.46
5	CD player	249.595	13	Notebook	492.863
6	Receiver	65.6054	14	Copiers	39.1859
7	Tape player	504.258	15	Microwave	376.124
8	Fax	77.787	16e	Furnace	228.76

VII. Building and Solving of Model V

----Model V: Energy Demand Forecast Model

7.1 modeling ideas

- To seek the relationship among the national population growth, economic growth and the energy consumption.

The growth of national population and economy will definitely affect the rate of energy consumption to some extent, There will be some kind of mutual relations between the growth of population and the growth of economy in terms of quantity, Through the data searched in internet, combining with modeling results of the first question, we established the prediction model of population growth and economic growth, Under the precise requirements, we established a multi-factor regression model to determine the relationship of the population growth, economic growth and energy consumption

- Establish evaluation criteria that whether the country grow

we can see whether a country has been growing greatly from economic, scientific, technological, military, cultural and many other areas. However, the title emphasizes that we should deal the problem from the country's energy point of view and from the provision of telephone service areas, Therefore, combining the modeling results of the second question,establish an evaluation criteria integrated phone users satisfaction, to evaluate whether the country is growing.

- To establish prediction model of energy demand to provide telephone services

After determining the relationship of population growth, economic growth and energy consumption After determing the Relations among Population growth, economic growth and energy consumption, Combining with the third question results and waste of energy modeling of structural changes in energy demand trends, In meeting the standards under the premise of development and growth, we predict the energy to provide telephone services every 10 years during the next 50 years, and ultimately,to conduct electricity and the number of inter-oil conversion.

7.2 Modeling

7.2.1 Predict population of "pseudo-American" 's development in the next 50 years by Logistic Model

To seek the relationship among the national population growth, economic growth and the energy consumption.

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- Block plays the role of population growth reflectes in the impact of growth rate r ,making r decline with the increase in population. if r is expressed as a function of x , $r(x)$,it should be a decreasing function, That is:

$$\frac{dx}{dt} = r(x)x, x(0) = x_0 .$$

one of the most simple assumption for $r(x)$ is that Setting up $r(x)$ to x by the linear function,that is:

$$r(x) = r - sx(r > 0, s > 0).$$

Here, r is called the inherent growth, Means the growth rate when the population is so smaller (in theory is $x = 0$). In order to determine the significance of coefficient s, introduce the argest population x_m that natural resources and environmental conditions can accommodate. When $x = x_m$, its population is no longer increased, that is, the growth rate $r(x_m) = 0$, then available:

$$r(x) = r(1 - \frac{x}{x_m}).$$

$$\frac{dx}{dt} = rx(1 - \frac{x}{x_m}), x(0) = x_0.$$

$$x(t) = \frac{x_m}{1 + (\frac{x_m}{x_0} - 1)e^{-rt}}.$$

We have to use the following population growth block model to predict the population development of "pseudo-American" Since the model should not be linearized, we can not use the theory of linear regression analysis for parameter estimation, we do not have further transformed into the equation as follows:

$$\frac{dx/dt}{x} = r - sx, s = \frac{r}{x_m}.$$

assume $y = \frac{dx/dt}{x}$, can be linearized into: $y = r - sx$.

Table 8 Population statistics of The United States(unit: millions)

year	1790	1800	1810	1820	1830	1840	1850	1860	1870	1880	1890
population	3.9	5.3	7.2	9.6	12.9	17.1	23.2	31.4	38.6	50.2	62.9
year	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000
population	76.0	92.0	106.5	123.2	131.7	150.7	179.3	204.0	226.5	251.4	281.4

From Table 8, x can be directly obtained,and y can be calculated by using the data in table 8. On this basis,using the theory of linear regression analysis parameters r and x_m can be estimated

Use the above method,we have used population statistics of The United States from 1860 to 2000 to build mathematical model of predicting the growth of American population

$$x = \frac{412.0886}{1+101.5355e^{-0.2557t}}. \quad ㉕$$

in which the unit of X millions of people

Use Logistic population model to predict population growth of the United States during nearly two centuries and compare with the actual population

Table 8 Logistic model the difference of prediction the United States population in Logistic model and the true population

year	1770	1800	1810	1820	1830	1840	1850	1860	1870	1880	1890
actual	3.9	5.3	7.2	9.6	12.9	17.1	23.2	31.4	38.6	50.2	62.9
Prediction	4.1	5.3	6.9	8.8	11.3	15.4	19.4	25.5	30.8	40.1	48.6
year	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000
actual	76.0	92.0	106.5	123.2	131.7	150.7	179.3	204.0	226.5	251.4	281.4
Prediction	60.2	78.2	91.6	110.2	132.2	156.5	182.4	209.2	236.0	262.1	286.6

From table 8,It is ideal that we predict population growth of the United States during nearly two centuries by logistic population mode, Apart from the mid-19th century to the mid-20th century the fitting result is not very good, the rest of the fitting are ideal. Especially for the latter part of the prediction of population development, it can reflect the reality of the development of the United States population more truely, so it can be used to reflect and predict the future 50 years the development of the United States population.

Table 9 The prediction of American population by logistic population mode

year	2010	2020	2030	2040	2050	2060
Prediction / Millions	309.0	328.9	346.1	360.8	373.0	383.0

Table 9 shows, the population of the United States will reach 309 million in 2010,and they will reach 328.9 million, until 2060, the population of the United States are forecasted to reach 38.3 billion , their average growth rate is 4.39%, And these are the United States population growth prediction basic information

7.2.2 "Pseudo US" in the next 50 the economic development of gray prediction model

- Step one: given the original data as shown in the table

Table 10： the value of GDP in the United States 1938-2008

年份	1938	1948	1958	1968	1978	1988	1998	2008
GDP（亿）	86.1	269.2	467.2	910.0	2,294.7	5,103.8	8,747.0	14,280.7

- Step two: different years will accumulate to a new series

$$x^{(1)} = \sum_{m=1}^{i} x^{(0)}(m), i = 1,2,3,\cdots\cdots N \quad ㉖$$

$$x^{(1)} = [86.1, 355.3, 822.5, 1732.5, 4027.2, 9131, 17878., 32158.7]$$

- The third step: Construction of data matrices and

$$B = \begin{bmatrix} -\frac{1}{2}\left[x^{(1)}(1) + x^{(1)}(2)\right] & 1 \\ -\frac{1}{2}\left[x^{(1)}(2) + x^{(1)}(3)\right] & 1 \\ \cdots & \\ -\frac{1}{2}\left[x^{(1)}(n-1) + x^{(1)}(n)\right] & 1 \end{bmatrix} = \begin{bmatrix} -220.7 & 1 \\ -588.9 & 1 \\ -1277.5 & 1 \\ -2879.85 & 1 \\ -6579.1 & 1 \\ -13504.5 & 1 \\ -25018.35 & 1 \end{bmatrix}$$

$$Y_n = [x^{(1)}(2), x^{(1)}(3), \cdots x^{(1)}(N)]^T = [355.3, 822.5, 1732.5, 4027.2, 9131, 17878, 32158.7]$$

- Step four: Solving the development of gray a few days and endogenous control of gray number. Posed to be located and estimated parameters vector $A = \begin{bmatrix} \partial \\ \mu \end{bmatrix}$

According to least squares method： $A = \left(B^T \bullet B\right)^{-1} \bullet B^T Y = \begin{pmatrix} 20.454 \\ -0.124 \end{pmatrix}$

- Step five: model is as follows

$$\hat{X}^{(1)}(k+1) = \left[X^{(0)}(1) - \frac{\mu}{a}\right] e^{-ak} + \frac{\mu}{a} = 256.3379 e^{0.51} - 618.8004 \quad ㉗$$

- Sixth step: seek to restore the function

$$\hat{X}^{(0)}(k+1) = (-\partial)\left[X^{(0)}(1) - \frac{\mu}{a}\right] e^{-ak} \quad ㉘$$

- The seventh step: To carry out precision tests to $GM(1,1)$ prediction model

According to the model we can restore the value and calculate the error rate. In 1938-2008 the United States gross national product to restore the original value with the value and error rate is shown in table 3 ,showing a higher prediction accuracy

Table 11: Prediction and to restore the original value of the gray value and the error rate table

Serial number	Original value Billions of dollars	the value of Restore Billions of dollars	Residuals	Error rate /%
1	86.1	84.4	-1.7	-1.97
2	269.2	268.0.	-1.2	-0.45
3	467.2	480.8	13.6	2.9
4	910	890.4	-19.6	-2.1
5	2294.7	2439.9	145	6.3
6	5103.8	4810.5	-293.3	-3.7
7	8747	8996.5	249.5	2.85
8	14280.7	15197.9	917.2	6.42

- The eighth step: According to the model ,predict 10 years, 2O years, 30 years ,40 years. 50 years. the GDP of the United States,as table 12 shown

Table 12 : The GDP of The United States forecast

Year	2010	2020	2030	2040	2050	2060
Predictive value / Billions of dollars	21839.7	31677.4	4126.8	59496.5	59496.5	78095.0

7.2.3 "Pseudo US," the next 50 years to provide telephone services in the energy demand forecast model

- The rate of American who have the ability to use telephone services will not be a result of changes of economic development or other factors That is, 20% of the total population which include infants、young children、disabilities and special population are out of telephone service ,In the next 50 years, telephone users total population of 80%
- We can know from the conclusions of solving the problem 1.

.

Daily power consumption of a landline

$$e_l = 0.0118 + 0.0685\% = 0.0125(kw \cdot h / day) \quad (29)$$

Daily power consumption of a cell phone

$$e_c = \{\frac{\sum_{i=1}^{Q_{sc}} q_{ci} + 35809}{\sum_{i=1}^{H} M_i} + 0.0173\}(kw \cdot h / day) \quad (30)$$

- We can know from the conclusions by Solving the problem II that for "pseudo-American", it is the best way that landline and cell phone service are provided at the same time and landline telephone service subscribers to total users are at 47.26% of telephone services

GDP output in every 10 years during the next 50 years in the "pseudo-American" are predicted through the gray prediction model, which we can see in Table 12. Because of the growth of the economy , the landlines have no longer obvious economic advantages, on the contrary, the applicability of cell phones advantage show more prominent, and this led to a telephone service ratio change. The changes of telephone service over the next 50 years can be determined as follows the way through the simulation analysis

G_i: Means that the prediction value of the i-year's GDP，i=1，2，3，4，5

p_i: Mean proportion of the future i-year landline telephone service in proportion.

$$p_i = \begin{cases} 47.26\% & i=1 \\ (1-\frac{G_i - G_{i-1}}{G_{i-1}}) \times 47.26\% & i = 2、3、4、5 \end{cases} \quad (31)$$

Into the specific numerical, we can draw two kinds of telephone services in the future the allocation ratio, and results is in the following table

Table 13: Proportional distribution of Telephone services in the future in "Pseudo-American"

Year	2010	2020	2030	2040	2050	2060
The proportion of landlines /% p_i	47.26	21.29	18.57	16.46	14.77	13.40
The proportion of cell phone/% （1- p_i）	52.74	78.71	81.43	83.54	85.23	86.60

- calculation of Cell phone waste of energy

we can see that daily use of mobile phones in the United States of energy waste in conclusions from the third model

$$W_s = \frac{0.2\times10^{-3}\times\sum_{i=1}^{n} t_i + 1.8653\times10^{8}\times5\times10^{-3}\times p_2}{1830\, kw\cdot h/\mathbf{B}} = (1.093\times10^{-7}\sum_{i=1}^{n} t_i + 509.64 p_2)(Barrels / day) \quad (32)$$

In the formula: $p_1 = \Phi(\mu_1, \sigma_1)$ $\quad$ $n = 1.8653\times10^9 p_1$

$t_i = \Phi(\mu_2, \sigma_2).(i = 1、2、\cdots、n)$

$p_2 = \Phi(\mu_3, \sigma_3)$

Assumpt that waste habits of mobile phone users in the next 50 years will not change and the same with proportion of mobile phone users, the amount of energy wasted by daily use of mobile phones is directly proportional to the number of entire population.

- The definition of the meaning of symbols is as follows

  B: A telephone service in the future energy demand

  N_l: The number of landlines users

  E_l: The a landline's average energy consumption per year

  N_c: The number of cell phone users

  E_c: The average energy Consumption of mobile phone each year,

  W_c: Amount of energy wasted due within one year of phone users caused by bad habits

Then, on a future energy demand in telephone service has the following relationship

$$B = N_l \times E_l + N_c \times E_c + W_c \qquad ⑬$$

Into the formula, the factor-specific expression can be drawn

$$\begin{aligned}
B &= N_l \times E_l + N_c \times E_c + W_c \\
&= p_i \sum M \times \frac{0.0125 \times 365}{\phi} + (1-p_i)\sum M \times \left(\frac{\sum_{i=1}^{Q_{sc}} q_{ci} + 35809}{\sum M} + 0.0173\right) \times \frac{365}{\phi} \\
&\quad + (1.093 \times 10^{-7} \sum_{i=1}^{n} t_i + 509.64 p_2) \times \frac{(1-p_i) \times \sum M}{80\% \times 47.26\% \times 3 \times 10^8} \times 365 \qquad ⑭ \\
&= 0.0036\sum M + 0.1995(1-p_i)\sum q - 0.0011 p_i \sum M - 7142(1-p_i) \\
&\quad + 3.517 \times 10^{-13}(1-p_i)\sum M \sum t + 1.640 \times 10^{-3}(1-p_i)P_2 \sum M
\end{aligned}$$

Note: The unit of barrels

In the formula

$\sum M$: The total population of"Pseudo-American" call to service users

$\sum q$: "Pseudo-American" mobile phone users using a mobile phone power consumption of the daily normal use and

$\sum t$: "Pseudo-American" mobile phone users to its mobile phone charger, and the no-load hours

p_2: All night to recharge cell phones mobile phone users, mobile phones accounted for the proportion of the total number of users

- Simulation data test of model

$\sum M$ means the total population of "pseudo-American" telephone service users,which is in proportion to the total population of the United States ,so, By 80% for Calculated,the number of telephone service users a year in the future can be get.

$\sum q$ means the sum of all cell phone's Power consumption a day,in this , Simulation of its compliance with $q_i = \Phi(\mu,\sigma) = \Phi(0.07933,0.02)$ $(i = 1、2、\cdots、 \mathrm{N_c})$ Normal distribution, Run many times can be drawn from the average of a future mobile phone users in daily normal use of cell phones and power consumption.

$\sum t$ Means "pseudo-American" mobile phone users to its mobile phone charger, and the no-load hours , in this, Simulation of its compliance with $t_i = \Phi(\mu_2,\sigma_2) = \Phi(12,5).(i = 1、2、\cdots、 \mathrm{n})$ Normal distribution. Run many times one day can be drawn from the average mobile phone users to make mobile phone charger no-load times

p_2 the proportion of recharging cell phone All night, Simulation of its compliance normal distributionwith $p_2 = \Phi(\mu_3,\sigma_3) = \Phi(10\%,5\%)$ we can get the number of mobile phone users through running many times.

Table 14: Parameter simulation results of Model V

Year	2010	2020	2030	2040	2050	2060
Telephone service users / million	247.2	263.12	276.88	288.64	298.4	306.4
Landline users / million	116.83	124.35	130.85	136.41	141.02	144.80
cell phone users / million	130.37	138.77	146.03	152.23	157.38	161.60
cell phone energy consumption /barrels/day	10.34	11.01	11.58	12.08	12.48	12.82
Charger no-load time /h	1564.5	1665.2	1752.3	1826.7	1888.5	1939.1
The proportion of Night charge users / million	10.02	9.97	10.00	9.99	10.01	10.00
The proportion of Landline users /%	47.26	21.29	18.57	16.46	14.77	13.40

Using MATLAB software, you can realize this test calculation, simulation of multiple for an average, results can be drawn as follows:

Table 15:"Pseudo-American" mobile phone service energy demand forecast the next 50 years

Year	2010	2020	2030	2040	2050	2060
Supply of Telephone service energy /thousand barrels	2449.7	4637.1	5185.6	5655.2	6025.4	6377.9

The tests of results: it is predicted that 244.97 barrels will be used in 2010 by the telephone service , 4,637,1 barrels in 2020 ,..., 6,377,900 barrels in 2060.so forecast results meet the actual situation

VIII. Model Evaluation and Promotion

This title is a energy problem talking about the changes in energy use causing by mobile phone revolution and the energy wasted by standby electrical equipment. In the basis of accurate data referring to the internet and books,we establish the exact mathematical model to deal with the title.

Model I, we collected comprehensive data, and then given full consideration to various factors, established in line with the requirements of the transition period and stable period of consumption more satisfied with poor model. Data reflect the reality of the ideal, but difficult to model part of the data collection and statistics, so we pass the data simulation method to calculate the final result.

Model II, for the "pseudo-American", from the energy point of view, we can come to the use of fixed-line to provide telephone services is the best form. Further, taking into account the unique features of mobile phones and social implications, through analysis of different age groups on the telephone preference service, telephone service in two ways to quantify the economic and the applicability of the introduction of integrated Satisfaction Index, the establishment of a stable two-state telephone service means the proportion of the game model. This is the title of modeling the process of an innovation in point, the quantification of perceptual indicators of reasonably practicable, is to determine the final ratio of the crucial aspect.

Model III, we make full use of a simulation of thinking, taking into account the calculated no-load in all mobile phone charger mobile phone users in the proportion of no-load length of time, all night charging users the proportion of random data, to calculate the use of mobile phones the amount of energy wasted in the simulation calculation model. Model after the first data modeling simulation test the idea of a more objective reflection of the state the nature of the test results is also convincing to a certain extent.

Model IV, through a variety of electrical parameters of the collection of accurate data, we have established a household electrical equipment, waste of energy calculation model. The authority of its data in the problem solving process has played a crucial role, the real authority of the data so that the model results more convincing.

Model V, we Logistic population model prediction of the "pseudo-American" population in the future development and the basis for the top of the telephone service to determine the proportion of the total population of users. Gray prediction model through the prediction of "pseudo-American" future value of GDP, due to changes in economic growth, fixed phones are no longer obvious economic advantages, but the applicability of the advantages of mobile phones become more prominent, so that it led to the proportion of telephone services changes. Through the introduction of the model in front of the relevant conclusions and relationship in order to work out a "pseudo-American," the next 50 years every 10 years to provide telephone services due to the resulting demand for energy. Such modeling ideas, the more reasonable explanation for the population and economic development of the telephone service the relationship between energy demand, resulting in a reasonable and credible. However, in establishing the course of the five models, each model of the main line contact unclear, more dispersed. In the follow-up work, can be further summed up the characteristics of a model in order to establish a more consistent solution of the model. In addition, the model can also be applied to other areas of energy waste and the demand for the calculation and prediction, such as transport and energy fields.

IX. References

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X. Appendix

Appendix 1: the United States time-series equation matlab program

```
p=[1994    1900
   1995    2101
   1996    2500
   1997    5500
   1998    6020
   1999    6400
   2000    11000
   2001    12010
   2002    13200
   2003    15900
   2004    16730
   2005    17500
   2006    18900
   2007    21500
   2008    23000
   2009    24000
   2010    24000
   2011    25000];

q=[1994    1900
   1995    2101
   1996    2500
   1997    5500
   1998    6020
   1999    6400
   2000    11000
   2001    12010
   2002    13200
   2003    15900
   2004    16730
   2005    17500
   2006    18900
   2007    21500
   2008    23000];

x=p(:,1);y1=p(:,2);y=log(y1);plot(q(:,1),log(q(:,2)),'+');
hold on
a=polyfit(x,y,2);x1=1990:0.1:2010;y1=a(3)+a(2)*x1+a(1)*x1.^2;
plot(x1,y1)
plot(1990:0.1:2012,10.0858)
for j=2010:0.01:2014;plot(j,10.0858,'b');end
gtext({'(t0,y)'});ylabel(' log(Q)');xlabel(' t');hold on
plot(1990:0.01:2010,10.0858,'b')
for i=5.5:0.01:10.0858;plot(2010,i);end
plot(2010,10.0858,'o')
```

Appendix II: "pseudo-American" of fixed line and mobile phones optimal ratio and the highest satisfaction with the computer simulation system procedures

```
for j=1:10;p1=0;q1=0;a=normrnd(0.5,0.2,4800,1);b=normrnd(0.4,0.2,13200,1);
c=normrnd(0.6,0.2,6000,1);d=[a;b;c];e=round(d);
qin=[normrnd(4,1.2,1,4800)' normrnd(2,0.8,1,4800)' normrnd(5,1.5,1,4800)'
normrnd(6,1.6,1,4800)' normrnd(5,1.5,1,4800)' normrnd(4,1,1,4800)'];
zhong=[normrnd(5,1.5,1,13200)' normrnd(3,0.7,1,13200)' normrnd(4,1,1,13200)'
normrnd(7,1.8,1,13200)' normrnd(3,0.7,1,13200)' normrnd(4,1,1,13200)'];
```

```
lao=[normrnd(6,1.6,1,6000)' normrnd(4,1,1,6000)' normrnd(3,0.7,1,6000)'
normrnd(3,0.7,1,6000)' normrnd(3,0.7,1,6000)' normrnd(3,0.7,1,6000)'];
f=[qin;zhong;lao];
for i=1:24000;if e(i,1)==1
p(i,1)=(55*f(i,1)+80*f(i,2)+90*f(i,3))/(f(i,1)+f(i,2)+f(i,3))+(30*f(i,4)+10*f(i,5)+20*f(i,
6))/(f(i,4)+f(i,5)+f(i,6));
p1=p1+1;else
q(i,1)=(45*f(i,1)+20*f(i,2)+10*f(i,3))/(f(i,1)+f(i,2)+f(i,3))+(70*f(i,4)+90*f(i,5)+80*f(i,
6))/(f(i,4)+f(i,5)+f(i,6));
q1=q1+1;end;end
gu=sum(p)/p1;yi=sum(q)/q1;bi=gu/(yi+gu);s=(sum(p)+sum(q))/24000
```

Appendix III

```
for i=1:500;p1=normrnd(0.2,0.08);p2=normrnd(0.1,0.05);n=1.8653*10^8*p1;
n1=round(n/1000);t=normrnd(12,5,n1,1);tt=sum(t)*1000;
w(i)=1.093*10^(-7)*tt+509.64*p2;end;mean(w)
```

Appendix IV

```
j=0;qci=normrnd(0.07933,0.02,24000,1);sqci=sum(qci)*10000;
for i=1990:1:2008;j=j+1;
y(j)=exp(-0.0112141*i^2+45.0653*i-45265.0);
q(j)=(24000-y(j))*10^4*0.0118;qc(j)=0.07933*y(j)*10000;
s(j)=sqci-qc(j)-q(j)-0.000685*2.4*10^8+0.000685*y(j)*10000;end
```

Appendix IV： American families every day because of the electrical equipment waste of energy the total simulation system procedures

```
for ii=1:10
p=[normrnd(6.4,1.2,11915,1) normrnd(10.2,2.3,11915,1) normrnd(5.3,1.2,11915,1)
normrnd(5.2,1.2,11915,1) normrnd(2.2,0.5,11915,1) normrnd(2.8,0.9,11915,1)
normrnd(1,0.2,11915,1) normrnd(5,1.8,11915,1) normrnd(1.2,0.09,11915,1)
normrnd(2,0.7,11915,1) normrnd(4.2,1.1,11915,1) normrnd(6.9,2.1,11915,1)
normrnd(4.5,1.3,11915,1) normrnd(5.1,0.9,11915,1) normrnd(2.8,0.8,11915,1)
normrnd(5,1.7,11915,1)];
t=[normrnd(4.3,1.8,11915,1) normrnd(4.3,1.8,11915,1) normrnd(3.2,1.1,11915,1)
normrnd(5.1,2.1,11915,1) normrnd(2.2,0.9,11915,1) normrnd(0.6,0.14,11915,1)
normrnd(6.5,2.1,11915,1) normrnd(0.3,0.07,11915,1) normrnd(2.2,0.09,11915,1)
normrnd(4,1.5,11915,1) normrnd(0.21,0.09,11915,1) normrnd(4,1.3,11915,1)
normrnd(2.3,1.1,11915,1) normrnd(0.19,0.05,11915,1) normrnd(2,0.9,11915,1)
normrnd(0.5,0.1,11915,1)];
```

```
n=[normrnd(2.7,0.9,11915,1) normrnd(2.7,0.9,11915,1) normrnd(2.1,0.71,11915,1)
normrnd(1.2,0.5,11915,1) normrnd(0.8,0.13,11915,1) normrnd(0.6,0.11,11915,1)
normrnd(1.2,0.31,11915,1) normrnd(0.8,0.12,11915,1) normrnd(0.61,0.17,11915,1)
normrnd(1.1,0.19,11915,1) normrnd(0.6,0.11,11915,1) normrnd(1.2,0.05,11915,1)
normrnd(0.74,0.21,11915,1) normrnd(0.62,0.32,11915,1) normrnd(1.02,0.41,11915,1)
normrnd(1.4,0.21,11915,1)];
for i=1:11915;for j=1:16;a(i,j)=p(i,j)*t(i,j)*n(i,j)*10;end;end
c=sum(a)';success=xlswrite('e:\4',c); b(ii)=sum(sum(a));
p=[];t=[];n=[];end;bb=mean(b)
```

Appendix VI: In accordance with the least square method for ∂ and μ constitute the parameters to be estimated vector A

```
aa=[1    86.1
    2    269.2
    3    467.2
    4    910.0
    5    2294.7
    6    5103.8
    7    8747.0
    8    14280.7];
plot(aa(:,1),aa(:,2));aaa(8)=0;a1=0;for i=1:8aaa(i)=a1+aa(i,2);
a1=aaa(i);end
aaa
for i=1:7;a2(i)=-1/2*(aaa(i)+aaa(i+1));Y(i)=aaa(i+1);end
B=[a2' ones(1,7)'];A=inv(B'*B)*a2'*a3
```

Appendix 7: The prediction of energy demand for telephone service

```
a=[21839.7  31677.4 44126.8 59496.5 78095.0 100230.8];
b=1000000*[309.0    328.9    346.1    360.8    373.0    383.0];
p=0.01*[47.26    21.29    18.57    16.46    14.77    13.40];
for i=1:6
c(i)=(1-p(i))*b(i)*mean(normrnd(0.07933,0.02,10000,1)) ;
d(i)=(1-p(i))*b(i)*mean(normrnd(12,5,10000,1)) ;
e(i)=mean(normrnd(0.1,0.02,10000,1)) ;    B(i)=0.0036*b(i)-0.0011*p(i)*b(i)-7142*(1-
p(i))+3.517*10^(-13)*(1-p(i))*b(i)*d(i)+0.00164*(1-p(i))*e(i)*b(i)+0.1995*(1-
p(i))*c(i);
end
B'
```