Team Control Number

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

4260

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

Problem Chosen

B

2009 Mathematical Contest in Modeling (MCM) Summary Sheet

Summary

Today an increasing number of people in the world are using cell phones instead of landline phones, which is bringing us problems in terms of energy. As the cell phones are becoming more and more popular, the amount of electricity energy that cell phones used is increasing.

The simplified **main problems** we should solve are

How will the rise in the amount of cell phones affect the U.S. from an energy perspective?

Considering both the energy perspective, and convenience cell phones provide, what is the optimal way of providing phone services?

How many barrels will be used in the next 50 years according to our analysis?

We've developed several models to solve them. Finally, we came to the **conclusion:**

Requirement 1 We've found that cell phone cost 3.5 times of the energy that landline phone cost. If all the landline phones are replaced by cell phones, it will make an increase of 1197193 barrels of oil in a year.

Requirement 2 By using the Optimum Model, we calculate that about 106 million people each having a cell phone and others using landline phones is the optimal way of providing phone service to this country from both an energy perspective and the convenience perspective.

Requirement 3 Based on the answer of requirement 2, the situation is that people keep cell phone recharger plugged in we use the Time Allotting Model, and find out that $6.63\times10^{9}kwh$ energy is to be used by the two kind of phones in a year, and that is about 11279730.51 barrels of oil per year in current America as to requirement 3.

Requirement 4 33346 barrels of oil is wasted every day if Americans use their recharger devices and always left them plugged in but not charging the devices.

Requirement 5

We get a function of electricity and year relationship:

$$Q=0.039\times e^{0.0566x-104.1023}\bullet(0.5642\ln(x)-4.205)\bullet$$
$$(80.8445\ln x-612.4971)\times10^{8}$$

A function of crude oil and year relationship:

$$S = 0.039 \times e^{0.0566x - 104.1023} \bullet (0.5642 \ln(x) - 4.205)$$
$$\bullet (80.8445 \ln x - 612.4971) \times 10^{8} / 587.78$$

And get the next 50 years of electricity consumption in the prediction value and the number of barrels of crude oil prediction:

	2010	2020	2030	2040	2050
Electricity consumption (Unit: kwh)	1.27×10^{10}	2.69×10^{10}	5.5898×10^{10}	1.14×10^{11}	2.29×10^{11}
Barrels of oil	2.16×10^{7}	4.58×10^{7}	9.51×10^{7}	1.94×10^{8}	3.91×10^{8}

In all the papers, we consider that one barrel of oil can generate electricity of about 587.78kwh, so we can do the conversion between electricity and oil.

REQUIREMENT1

According to the Pew Research Center magazine, one barrel of oil can generate electricity of about 587.78kwh.

TABLE1

Compare Between Nokia and Sony Ericsson[1]

Unit: watts	Nokia（normal）	Sony Ericsson
Charging power （lithium battery）	Input power： about 22w Output power：3w	Input power： about 22w Output power：4w
Standby power	0.0152-.126	0.02
Communicating power	0.36	0.504

The voltage of cell phones：3.6V

charging voltage limitation：4.2V

Since the power of cell phones changes with the environment and temperature, the data above are changed a little by us to suit the average level.

TABLE2

The final data we make use of

	the Power of communicating	the Power of ringing	the Power of standby	the Power of charge
landline phone	（12V）1.8-3.6	13.2w	Not meaningful	Not meaningful
cell phone	0.54w	0.792w （tone） 0.306w （beep） 0.396w （backlight） 1.494w general setting (we add up the data above)	0．02w(the current is 5.6mA)	22w

We estimate that one call last 300 seconds and the average ringing last 5 seconds.

The average cell phone communication current including the tone ringing is

$$Ict = 140 \times 300 \div 305 + (85 + 220 + 110) \times 5 / 305 \approx 144.5mA$$

The average cell phone communication power including the tone ringing is

$$Pct = 0.54 \times \frac{300}{305} + 1.494 \times \frac{5}{305} = 0.56w$$

We suppose that

There are H households in the US, with m members each. The population of the current America is 3×10^8.So

$$m \times h = 3 \times 10^8 .$$

2003 traffic amounts: 42664.3 million minutes

Source: INTERNATIONAL BUREAU REPORT

In Require 1, we suppose that people charge their cell phone only when its battery is very low, and charging is needed. They never turn their cell phones off. They never use their cell phone when charging. They don't use their cell phone except communication use.

We think that the communication traffic doesn't change when the way of people's long-distance talking changes from their landline telephone to cell phone only in require 1.

TABLE3

Definition

sign	definition
T	The time that every one spend on phone in a year. (Unit: minutes)
EA	The average electricity amount of one battery of a cell phone. (Unit: mAh)
Pct	The Power of the cell phone when one is talking on the phone. (Unit: watts)
Ect	The electricity energy that a cell phone uses when one is talking on the phone in a year. (Unit: kwh)
Ict	The average current of the cell phone when one is talking on the phone, including the ringing current. (Unit: mA)
Tch	The average time that a cell phone battery is charged from low to full, which can be estimated according to our normal life
Pch	The Power of the cell phone charger, excluding the output power. (Unit: watts)
Ech	The Energy that charging the cell phone has used in a year. (Unit: kwh)
Pcs	The Power of the cell phone when standby.
Tcs	The time that a cell phone is standby in a year.
Ecs	The Energy that the cell phone has used when standby in a

	year.
Ec	The total amount of energy that someone's cell phone used in a year, and cell phone is his/her only phone
Plt	The Power of the landline phone when one is talking on the phone. (Unit: watts)
Plr	The Power of ringing of the landline phone.
El1	The total amount of energy that someone's landline phone used in a year, and landline phone is his/her only phone. We suppose that every one has a landline phone

TABLE4

VALUE

EA	1000mAh
Pct	0.56w
Pcs	0.02w
Ict	144.5mA
Plt	3.6w
Plr	13.2w
Tch	2hours
Pch	18w

$$Tcs = 365\times 24\times 3600 - \frac{Ict\times {T}/{60} + Ics\times(365\times 24 - {T}/{60})}{EA}\times Tch\times 3600 - \frac{305}{300}T\times 60$$

（seconds）

$$T = \left(42664.3\times 10^{6}\right)\div\left(300\times 10^{6}\right)\approx 14221$$ （minutes）

Ec is the sum of **Ect**, **Ech**, and the time a cell phone is charged in a year significantly affects **Ech**. The times equal to the quotient of dividing the electricity that the cell phone uses in a year by **EA**, that is

$$\frac{Ict\times {T}/{60} + Ics\times(365\times 24 - {T}/{60})}{EA}\approx 82$$

It means a person charge his/her cell phone about 82 times in a year, and every time charging last 2 hours. So a cell phone electricity energy is

$$\begin{aligned}
&Ec\\
&= Ect + Ech + Ecs\\
&= Pct\times T\times 60 + \frac{Ict\times {T}/{60} + Ics\times(365\times 24 - {T}/{60})}{EA}\times Tch\times 3600\times Pch + Pcs\times Tcs\\
&= 11703690.11J \approx 3.25kwh
\end{aligned}$$

The landline phone electricity energy is

$$El = Plr\times\frac{T\times 60}{300s}\times 5s + Plt\times T\times 60 = 3259453.2\text{J}=0.9054\text{kwh}$$

If the whole Americans were served by landlines. Since we use the traffic data, it doesn’t matter whether every one has a landline phone or each household has a landline phone .So the electricity energy is

$$El \times 300 \times 10^6 = 271621100kwh$$

If all the landlines are replaced by cell phones. The electricity energy is

$$Ec \times 300 \times 10^6 = 975307509kwh$$

the energy that cell phone uses is 3.5 times of the energy of landlines.

The replacing make an energy increase of 703686409kwh, and it doesn't include the energy that the cell phones use when they get lost or break.

If all the landline phones are replaced by cell phones, it will make an increase of 1197193 barrels of oil.

REQUIREMENT2

TABLE5

Optimum Model

Interpretation

sign	Interpretation
$\overline{p}$	The grade/degree that represents how much we use our cell phones. Suppose people don't use other phones if they have a cell phone. We estimate that other people who only have landline phones will spend half of $\overline{p}$ on communicating by their landline phones, because landline

	phones are not convenient, and we suppose that the time the landline phones are available is about half of the time the cell phones are.(We bring cell phones everywhere with us.)So the grade/degree that represents how much we use our landline phones is $\frac{\overline{p}}{2}$
N_A	the current population of the Pseudo US.
N	Suppose that there are N million people who have cell phones.

TABLE6

VALUE OF $\overline{p}$

Value of $\overline{p}$	Grade/degree	Value of $\overline{p}$	Grade/degree
2	seldom	5	Sometime+
3	Sometime-	6	often
4	sometime	7	always

According to our normal life, most people's usage, and some data pieces, we estimate $\overline{p}$ at 5.

The communication traffic is

$$\overline{p}N+\frac{\overline{p}}{2}(N_A-N)$$

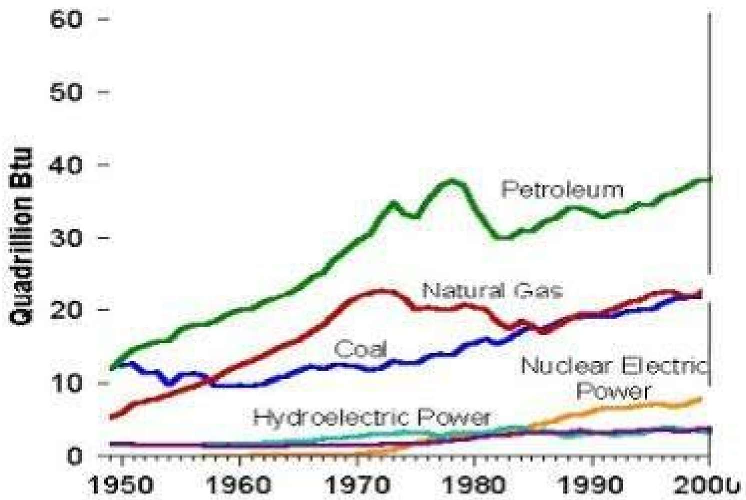
If someone that used to use landline phones changed to use cell phone, the new communication traffic is

$$\overline{p}(N+1)+\frac{\overline{p}}{2}(N_A-N-1)$$

The new energy consumption increment is temporarily K^N every year.

Graph1 [3]

Energy Consumption in the U.S.



We think there are mainly two causes to affect the energy consumption, the immanent cause and the external cause.

The immanent cause is the change of the number of the cell phone users.

The external cause is the energy price.

The energy that cell phones consume is increasing, and its trend is alike the trend of the sum of the energy growth above.

We estimate K=1.002

1.002 is a fabricated figure to describe the trend of the increase of the energy consumption.

The total energy consumption increment can be described as

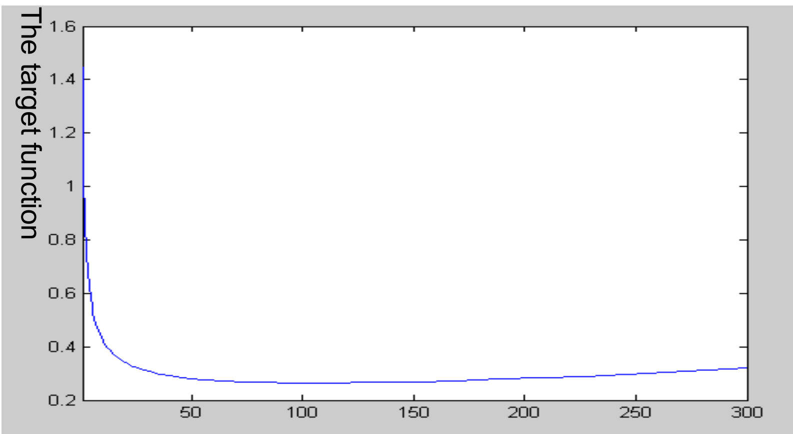
$$N \times \frac{\overline{p}}{2} + 1.002^{N}$$

The new convenience index is

$$In(N+1)$$

So the target function is

$$\min \frac{N \times \frac{\overline{p}}{2} + 1.002^{N}}{\ln(N+1)}$$



Person for million

We use TI83 Plus Texas Instruments to find out the N which does good to both the people and energy.

$$N=105.94885$$

So according to our analyses in the pseudo America, if we want to care about people’s require ,the convenience that cell phone provide, and our energy crisis, we’d better offer the phone service by a mixture of cell phone and landline phone. As to plotting out the service that the 300 million people needed, we use our Optimum Model finding out that about 106 million people having a cell phone each and others using landline phones is the optimal way of providing phone service to this country from both an energy perspective and the convenience perspective.

REQUIREMENT 3

Based upon our answer to Requirement 2

Time Allotting Model

TABLE 7

In requirement 3, we add a night charging energy aspect, so what we mention in require 1 is no longer proper. Since people do have habit of charging every night, the charging electricity energy is increasing greatly, and the waste is growing too. At first we want to find out how many people have this habit of charging every day at night in the 106 million population which was found out in requirement 2, but to our disappointment, the data of this kind of research is not available. So we've simplified the model we will use in requirement 3 in such a way that we suppose all the cell phone users are all the same. They all do recharge at every night. 24hours a day is allotted to charging time, call time, standby time. For example, 3/4 of 24hours is the standby time.

Interpretation

sign	Interpretation
$\overline{A}_1$	The average electricity power supply of landline phone when there is no call. (Unit: watts)
$\overline{A}_2$	The average electricity power of landline phone when calling. (Unit: watts)
$\overline{A}_3$	The average electricity Power of the cell phone charger, excluding the output power. (Unit: watts)
$\overline{A}_4$	The average electricity Power of the cell phone when calling. (Unit: watts)
$\overline{A}_5$	The average electricity Power of the cell phone when standby. (Unit: watts)
C_1	The time proportion of calling by landline phone in a day

C_2	The time proportion of charging the cell phone in a day
C_3	The time proportion of calling by cell phone in a day
C_4	The time proportion of standby of the cell phone in a day
Q_1	The cell phone electricity consumption in a year
Q_2	The landline phone electricity consumption in a year
Q	The total electricity consumption due to both cell phone and landline phone.

TABLE8

VALUE

Sign	Value
$\overline{A}_1$	13.2w
$\overline{A}_2$	0.0324w
$\overline{A}_3$	22w
$\overline{A}_4$	0.054w
$\overline{A}_5$	0.1w
C_1	0.25
C_2	1/12
C_3	0.007
C_4	0.75

Q_1

$=$charging electricity energy$+$calling electricity energy$+$standby electricity energy

$$= N(365\times 24\times A_3\times C_2 + 365\times 24\times A_4\times C_3 + 365\times 24\times A_5\times C_4)$$

$$= 2.628\times(A_3\times C_2 + A_4\times C_3 + A_5\times C_4)\times 10^9$$

$$= 2.628\times(22\times\frac{1}{12} + 0.054\times 0.007 + \frac{1}{10}\times\frac{3}{4})\times 10^9$$

$$= 2.628\times(22\times\frac{1}{12} + 0.054\times 0.007 + \frac{1}{10}\times\frac{3}{4})\times 10^9$$

$$= 4.9\times 10^9\, kwh$$

$Q_2=$waste in electricity supply$+$calling electricity energy

$$= (3\times 10^8\times 365\times 24\times \overline{A}_1 + 3\times 10^8\times 365\times 24\times \overline{A}_2\times C_1)$$

$$\times(1-\frac{106}{300})$$

$$= (3\times 10^8\times 365\times 24\times 13.2\times 5.5\times 10^{-5}$$

$$+3\times 10^8\times 365\times 24\times 0.0324\times\frac{1}{4}\times 10^{-3})\times(1-\frac{106}{300})$$

$$= 1.25\times 10^9\, kwh$$

The total electricity energy is

$$Q = Q_1 + Q_2 = 4.9\times 10^9\, kwh + 1.73\times 10^9 = 6.63\times 10^9\, kwh$$

It also means that 11279730.51 barrels of oil are needed.

So we use the Time Allotting Model, and find out that $6.63\times 10^9 kwh$ energy is to be used by the two kinds of phones in a year, and that is about **11279730.51 barrels of oil per year**. The answer is based upon our answer to Requirement 2.

REQUIREMENT4：

In requirement 4, we first find the average standby power or charging power when left plugged in but not charging the device. We call this wasted power.

TABLE9 [4]

The Power of Various Recharger Types

i	Recharger types	Different power data	The average wasted power $j_i (i = 1, 2..., 3)$
1	Notebook computer	2（standby）	2w
2	TV(49 inches)	1（standby）	1w
3	PC	40 （ PDP ） 51.48 （WinXP standby） 7.5（sleeping）4.81 （plugged in）	20w
4	PSP	2w（charging）	2w
5	Speaker	5w （ no change if turned down or up）	5w
6	19inches LCD	3.5（standby）	3.5w
7	19inches PDP	34（standby）	34w

8	GBA	4w（standby）	4w

TABLE10

Sign	Definition
$l_i (i=1,2...,8)$	The average percentage of population who use the i type of device
$j_i (i=1,2...,3)$	The average wasted power
$T_i (i=1,2...,3)$	The average time people spend on the device

The total electricity energy consumption of America is

$$(\sum_{i=1}^{8} l_i j_i T_i) \times N_A (1 \le i \le 8)$$

According to our normal life experience and some data pieces from the Internet, we estimate the value of $l_i (i=1,2...,8)$ and $T_i (i=1,2...,3)$ of each recharger types.

TABLE11

$l_i (i=1,2...,8)$	Value	$l_i (i=1,2...,8)$	Value
l_1	0.45	l_5	0.56
l_2	0.32	l_6	0.51
l_3	0.76	l_7	0.42
l_4	0.38	l_8	0.25

TABLE12

$T_i(i=1,2...,3)$	Value	$T_i(i=1,2...,3)$	Value
T_1	6	T_5	2
T_2	3.5	T_6	1.5
T_3	4	T_7	1.5
T_4	2	T_8	2

The whole country's electricity consumption of each recharger types are

$$(j_1 l_1 T_1)\times N_A = 2\times10^{-3}\times0.45\times6\times3\times10^{8} = 1.62\times10^{6}$$
$$(j_2 l_2 T_2)\times N_A = 1\times10^{-3}\times0.32\times3.5\times3\times10^{8} = 3.36\times10^{5}$$
$$(j_3 l_3 T_3)\times N_A = 20\times10^{-3}\times0.32\times4\times3\times10^{8} = 7.68\times10^{6}$$
$$(j_4 l_4 T_4)\times N_A = 2\times10^{-3}\times0.38\times2\times3\times10^{8} = 4.56\times10^{5}$$
$$(j_5 l_5 T_5)\times N_A = 5\times10^{-3}\times0.56\times2\times3\times10^{8} = 1.68\times10^{6}$$
$$(j_6 l_6 T_6)\times N_A = 3.5\times10^{-3}\times0.51\times1.5\times3\times10^{8} = 8.03\times10^{5}$$
$$(j_7 l_7 T_7)\times N_A = 34\times10^{-3}\times0.42\times1.5\times3\times10^{8} = 6.43\times10^{6}$$
$$(j_8 l_8 T_8)\times N_A = 4\times10^{-3}\times0.25\times2\times3\times10^{8} = 6.0\times10^{5}$$

$$\begin{aligned}
&(\sum_{i=1}^{8} j_i l_i T_i)\times N_A \\
&= 1.62\times10^{6} + 3.36\times10^{5} + 7.68\times10^{6} + 4.56\times10^{5} + 1.68\times10^{6} \\
&+ 8.03\times10^{5} + 6.43\times10^{6} + 6.0\times10^{5} \\
&= 1.96\times10^{7}(kwh)
\end{aligned}$$

So the total electricity energy consumption is $1.96\times10^{7}(kwh)$ by adding up all the wasted energy of each device that we have calculated above.

And it means 33346 barrels of oil is wasted every day if Americans use their recharger devices and always left them plugged in but not charging the devices.

REQUIREMENT5

In requirement 5, what to do first is to predict the development of population and economic of a typical Pseudo US. We use the data of the population in the past 20 years and the data of American GDP in the past 18 years to predict the population growth and the GDP growth over the next 50 years. By using MATLAB7.0, we've done the curvilinear regression of population and GDP. (See Figure 1)

The operating course of our regression in MATLAB7.0 is

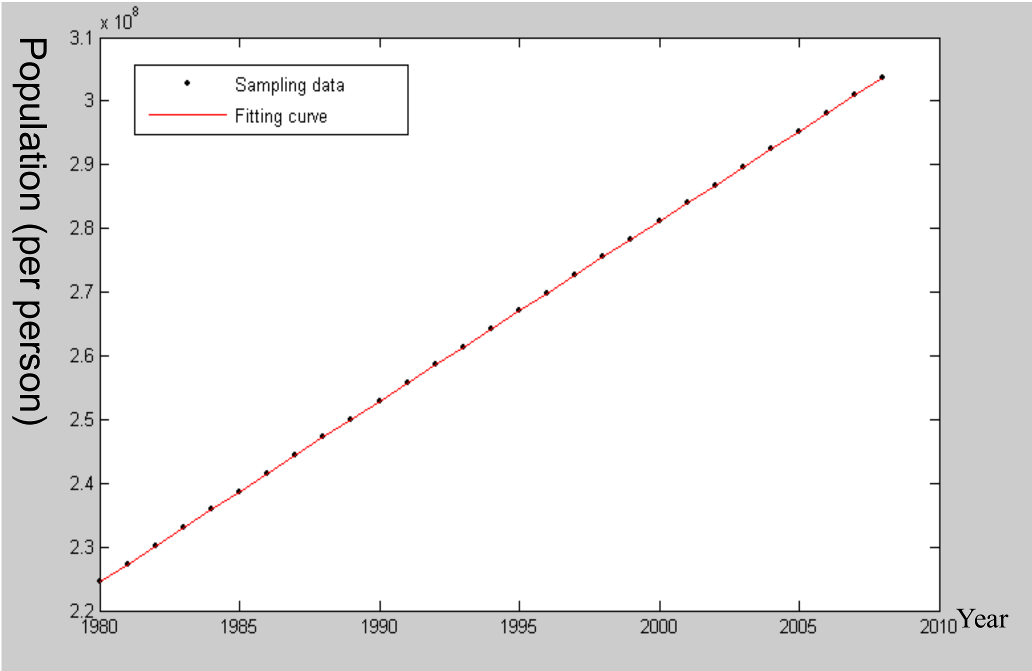
```
>> x=1980:2008;
>>
y=[227726000,229966000,232188000,234307000,236348000,238466000,240651000,242804000,
245021000,247342000,250132000,253493000,256894000,260255000,263436000,266557000,269
667000,272912000,276115000,279295000,282339000,285024000,287676000,290343000,293028
000,295734000,298444000,301140000,303825000];
>> P=polyfit(log(x),y,1)

P =

   1.0e+010 *

      0.5642     -4.2605
```

```
>> yi=polyval(P,log(x));
>> plot(x,yi,'k.');
>> hold on;
>> plot(x,yi,'r');
>> legend('Sampling data','Fitting curve');
>> hold off;
```



(Figure 1)

We got the function of population (f) with years(x):

$$f(x) = 10^{10} \times (0.5642\ln(x) - 4.205)$$

And we use the logarithmic function to predict the population for each 10 years for the next 50 years.

year	2010	2020	2030	2040	2050
Population	3.093×10^{8}	3.37×10^{8}	3.652×10^{8}	3.929×10^{8}	4.205×10^{8}

Then we predict the trend of the development of economic using the data from TA BLE .We suppose that GDP represent the economic of a typical Pseudo US

By using MATLAB7.0 to do the exponent function, we got the curvilinear regression of GDP. (See Figure 2)

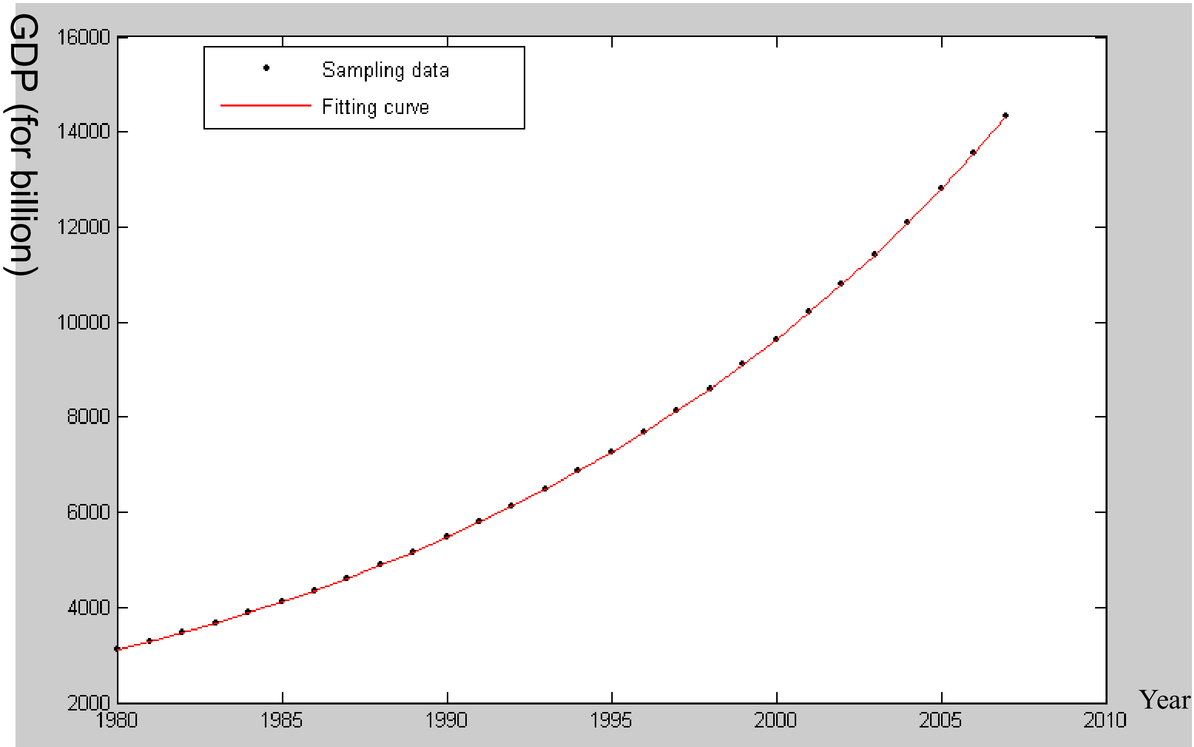
The operating course of our regression in MATLAB7.0 is

```
>> x=1980:2007;
>>
y=[2789.5,3128.4,3255.0,3536.7,3933.2,4220.3,4462.8,4739.5,5103.8,5484.4,5803.1,5995.9,6337.7,6657.4,7072.2,7397.7,7816.9,8304.3,8747.0,9268.4,9817.0,10128.0,10469.6,10960.8,11685.9,12433.9,13194.7,13841.3];
>> P=polyfit(x,log(y),1)

P =

    0.0566 -104.1023

>> yi=exp(polyval(P,x));
>> plot(x,yi,'k.');
>> hold on;
>> plot(x,yi,'r');
>> legend('Sampling data','Fitting curve');
>> hold off;
```



(Figure 2)

We got the function of GDP in all (h) with years (x):

$$h(x) = e^{0.0566x - 104.1023}$$

And we use the exponent function to predict the population for each 10 years for the next 50 years.

Years	2010	2020	2030	2040	2050
GDP in all	1.699×10^{4}	1.993×10^{4}	5.27×10^{4}	9.293×10^{4}	1.637×10^{5}

To our disappointment, the data of the growth of the population who own a cell phone. So we suppose that the trend of the growth of the population who own a cell phone is like the function of population's trend. Then we do the curvilinear regression of the population who own a cell phone. (See Figure 3)

The operating course of our regression in MATLAB7.0 is：

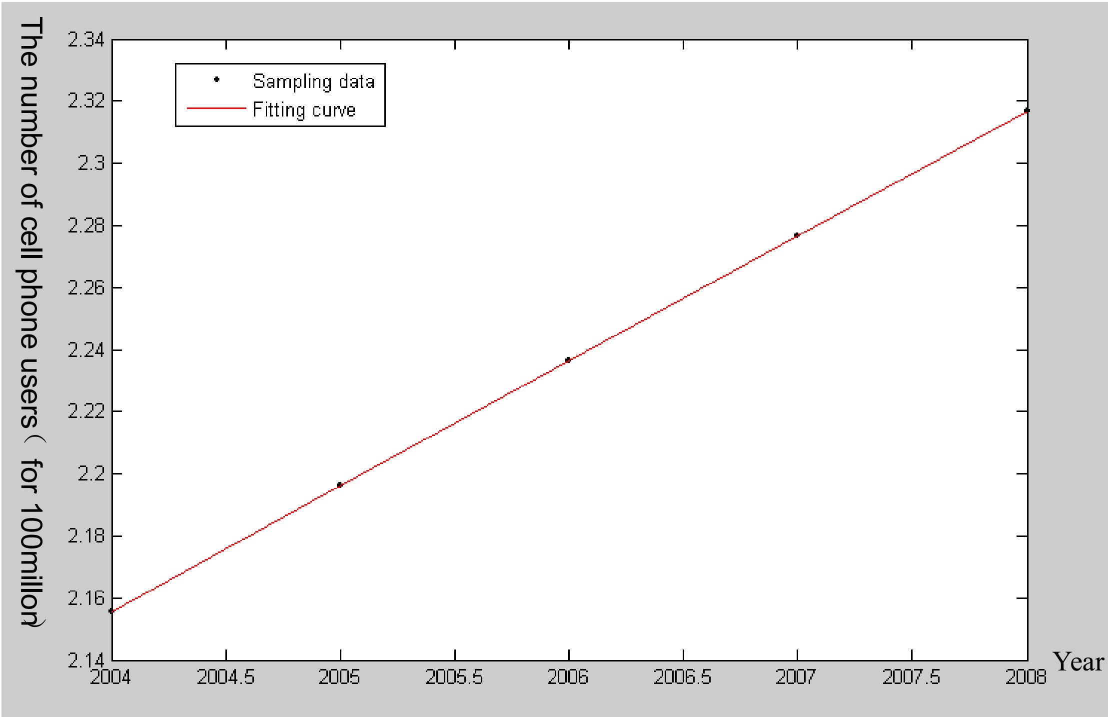
```
>> x=[2004,2005,2006,2007,2008];
>> y=[2.147,2.203,i2.241,2.282,2.309];
>> P=polyfit(log(x),y,1)

P =

    80.8445 -612.4971

>> yi=polyval(P,log(x));
```

```
>> plot(x,yi,'k.');
>> hold on;
>> plot(x,yi,'r');
>> legend('Sampling data','Fitting curve');
>> hold off;
```



(Figure 3)

We got the function of the number of cell phone users (J) with years (x): $J(x) = 80.8445 \ln x - 612.4971$

And we use the logarithmic function to predict the population of the cell phone users for each 10 years for the next 50 years.

Years	2010	2020	2030	2040	2050
Cell phones users in all	2.397×10^{8}	2.7987×10^{8}	3.1977×10^{8}	3.603×10^{8}	3.9905×10^{8}

Since the cell phone growth is also affected by the economy.

So the electricity consumption target function is

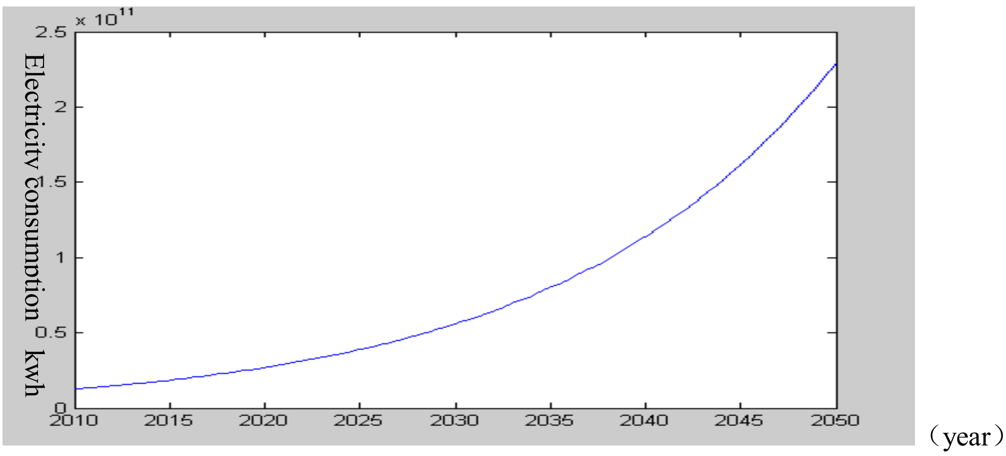
$$Q=\frac{4.9\times10^{9}}{3\times10^{8}}ext_1 \bullet ext_2 J(x)=\frac{10^{10}\times(0.5642\ln(x)-4.205)}{N_A}$$
$$\bullet\frac{e^{0.0566x-104.1023}}{H_{\text{A}}}\bullet(80.8445\ln x-612.4971)\times10^{8}$$

$$=\frac{4.9\times10^{9}}{3\times10^{8}}\bullet\frac{e^{0.0566x-104.1023}}{13841.3}\bullet\frac{10^{10}\times(0.5642\ln(x)-4.205)}{3\times10^{8}}\bullet$$
$$(80.8445\ln x-612.4971)\times10^{8}$$

$$=\frac{4.9\times10^{9}}{3\times10^{8}}\bullet0.00241\times e^{0.0566x-104.1023}\bullet(0.5642\ln(x)-4.205)$$
$$\bullet(80.8445\ln x-612.4971)\times10^{8}$$

$$=0.039\times e^{0.0566x-104.1023}\bullet(0.5642\ln(x)-4.205)$$
$$\bullet(80.8445\ln x-612.4971)\times10^{8}$$

Figure 4 is curve of the electricity consumption target function.

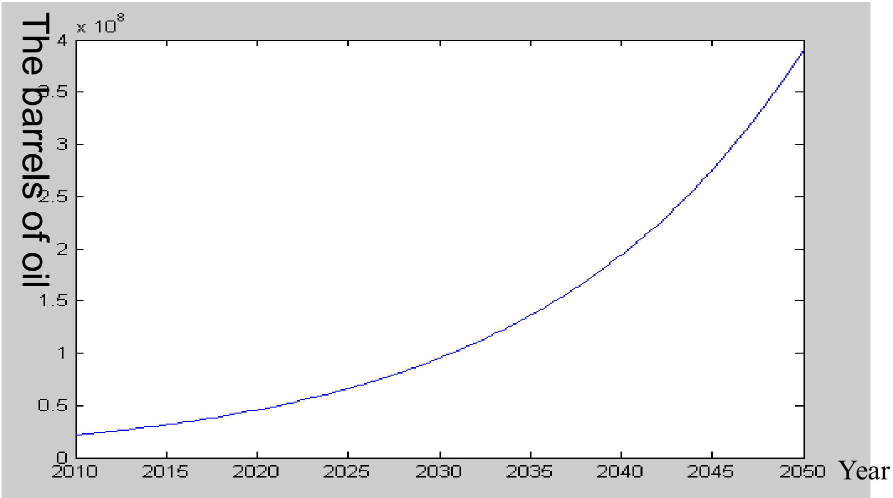


(Figure 4)

The barrels of oil that needed for the year is

$$S = 0.039 \times e^{0.0566x-104.1023} \bullet (0.5642\ln(x) - 4.205)$$
$$\bullet (80.8445\ln x - 612.4971) \times 10^8 / 587.78$$

Figure 5 is the barrels of oil that needed for the year.



(Figure 5)

	2010	2020	2030	2040	2050
Electricity consumption（kwh）	1.27×10^{10}	2.69×10^{10}	5.5898×10^{10}	1.14×10^{11}	2.29×10^{11}
Barrels of oil	2.16×10^{7}	4.58×10^{7}	9.51×10^{7}	1.94×10^{8}	3.91×10^{8}

Model advantages

1. We take the extent of satisfaction with cell phone users and cell phone on the adverse effects of energy society considered, and the design of the objective function, to derive its equilibrium point, the number of cell phone users is expected when the number of the most reasonable.

2. We use the equilibrium data to obtain the energy consumption in a

typical Pseudo US, in fact, indirectly proves that this can save some energy, so the model is reasonable.

3. We believe that the phone is a big consumer of electricity. We take this into account, in order to make the model closer to real life; we reference the online search data and our own experience of life to define the average use of cell phones and so on. This is our advantage.

4. The technical parameters we use is calculated at our cell phones in order to ensure its practicality.

5. We take into account the economy, the population, the number of cell phone users development trends and forecasting, and comprehensive consideration. Then get the more accurately the US have been near 50-year trends.

Model shortcomings

1. We have not found some accurate data to support our model.

2. We have some of the calculation is only expected, they do not necessarily reflect real life.

3. When we forecast in the next 50 years of development, we did not take into account the current financial crisis.

4. The model should not fully reflect the current US.

Our result（Conclusion）:

1 The result of the Requirement 1:

If the whole Americans were served by landlines. The electricity energy is

$$El \times 300 \times 10^{6} = 271621100kwh$$

If all the landlines are replaced by cell phones, the electricity energy is

$$Ec \times 300 \times 10^{6} = 975307509kwh$$

2 The result of the Requirement 2: (The optimal plan)

We have work out the target function is

$$\min \frac{N \times \frac{\overline{p}}{2} + 1.002^{N}}{\ln(N+1)}$$

We use TI83 Plus Texas Instruments to find out the N which does good to both the people and energy.

N=105.94885

3 The result of the Requirement 3:

The total electricity energy is

$$Q = Q_1 + Q_2 = 4.9 \times 10^{9} kwh + 1.73 \times 10^{9} = 6.63 \times 10^{9} kwh$$

It also means that 11279730.51 barrels of oil are needed.

4 The result of the Requirement 4:

The energy costs of this wasteful practice for a current US reaches 33346 barrels of oil.

5 The result of the Requirement 5:

1 、 $f(x) = 10^{10} \times (0.5642\ln(x) - 4.205)$ The population growth function

2、 The GDP growth function is

$$h(x)=e^{0.0566x-104.1023}$$

3、The ratio of the population growth is

$$ext_1=\frac{10^{10}\times(0.5642\ln(x)-4.205)}{N_A}$$

4、The ratio of the GDP growth is

$$ext_2=\frac{h(x)}{H_A}=\frac{e^{0.0566x-104.1023}}{H_A}$$

5、The cell phone user function is(x is the year)

$$J(x)=80.8445\ln x-612.4971$$

——the electricity consumption target function is

$$Q=0.039\times Q=Q=Q$$
$$=e^{0.0566x-104.1023}\bullet(0.5642\ln(x)-4.205)\bullet(80.8445\ln x-612.4971)\times10^{8}$$

——the barrels of oil that needed for the year is

$$S=0.039\times e^{0.0566x-104.1023}\bullet(0.5642\ln(x)-4.205)$$
$$\bullet(80.8445\ln x-612.4971)\times10^{8}/587.78$$

	2010	2020	2030	2040	2050
Electricity consumption（Unit: kwh）	1.27×10^{10}	2.69×10^{10}	5.5898×10^{10}	1.14×10^{11}	2.29×10^{11}
Barrels of oil	2.16×10^{7}	4.58×10^{7}	9.51×10^{7}	1.94×10^{8}	3.91×10^{8}

We hope that the Americans use cell phones as little as possible, slowing the growth of the use of cell phone trends, thereby slowing the consumption of energy, because, after all, some resources are limited.

Acknowledgments:

Thanks to our mentors Mr. Xilin Xie and Ms. Yunping Fang.

Reference

Source: the Nokia and Sony Ericsson cell phones

http://hi.baidu.com/%B2%A4%B2%CB%B1%F9%B1%F9/blog/item/a5c6fe8255ed7aba6c8119b7.html

http://baike.baidu.com

http://baike.baidu.com/view/148370.htm

http://bible.younet.com/files/2003/06/23/44832.shtml

EIA, Energy Information Administration

http://digi.it.sohu.com/20080409/n256176529.shtml

http://baike.360.cn/4003312/18176080.html

http://www.eia.doe.gov/aer/txt/ptb1601.html

Software used

Mathworks.Matlab.7.0

Attached Paper

Year	U.S. Gross Domestic Product		
	Billion Nominal Dollars [2]	Billion Chained (2000) Dollars [3]	Implicit Price Deflator [4] (2000 = 1.00000)
1980	2,789.5	5,161.7	.54043
1981	3,128.4	5,291.7	.59119
1982	3,255.0	5,189.3	.62726
1983	3,536.7	5,423.8	.65207
1984	3,933.2	5,813.6	.67655
1985	4,220.3	6,053.7	.69713
1986	4,462.8	6,263.6	.71250
1987	4,739.5	6,475.1	.73196
1988	5,103.8	6,742.7	.75694
1989	5,484.4	6,981.4	.78556
1990	5,803.1	7,112.5	.81590
1991	5,995.9	7,100.5	.84444
1992	6,337.7	7,336.6	.86385
1993	6,657.4	7,532.7	.88381
1994	7,072.2	7,835.5	.90259
1995	7,397.7	8,031.7	.92106
1996	7,816.9	8,328.9	.93852
1997	8,304.3	8,703.5	.95414
1998	8,747.0	9,066.9	.96472
1999	9,268.4	9,470.3	.97868
2000	9,817.0	9,817.0	1.00000
2001	10,128.0	9,890.7	1.02399
2002	10,469.6	10,048.8	1.04187
2003	10,960.8	10,301.0	1.06404
2004	[R] 11,685.9	[R] 10,675.8	[R] 1.09462
2005	[R] 12,433.9	[R] 11,003.4	[R] 1.13000
2006	[R] 13,194.7	[R] 11,319.4	[R] 1.16567
2007	13,841.3	11,566.8	1.19664

Name	**Population United States**
Units of Measure	Population
Last Updated	5/15/2007
Source	U.S. Census Bureau, International Data Base
Source URL	http://www.census.gov/ipc/www/idbsprd.html
Source Document	
Updater	Zach Levin
Display on Graph	
Legend	United States Population [334] - www.data360.org
Notes	
1980	227,726,000
1981	229,966,000
1982	232,188,000
1983	234,307,000
1984	236,348,000
1985	238,466,000
1986	240,651,000
1987	242,804,000
1988	245,021,000
1989	247,342,000
1990	250,132,000
1991	253,493,000
1992	256,894,000
1993	260,255,000
1994	263,436,000
1995	266,557,000
1996	269,667,000
1997	272,912,000
1998	276,115,000
1999	279,295,000

2000	282,339,000
2001	285,024,000
2002	287,676,000
2003	290,343,000
2004	293,028,000
2005	295,734,000
2006	298,444,000
2007	301,140,000
2008	303,825,000