Phantom Energy of the Cell Phone

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Abstract

With the rise of technology in the U.S., energy consumption is a natural topic of concern. Are we living beyond our means with the amount of energy our electronic toys consume? Specifically, how does our increased reliance on cell phones contribute to the amount of energy our country consumes? We look at the social, economical, and energy related consequences to our steady transition from a landline based culture into a cell phone dominated society. We model this transition with a linear equation, which incorporates the energy uses of corded, cordless, and cell phones in modern society based on available data. Using this model, we are able to get a glimpse into the future. The data shows that our transition is increasing the amount of energy consumed in the U.S. because of the increased power needed to supply our new gadgets. This means that without some sort of balance between an entirely landline based society and an entirely cell phone based one, in addition to a lack of proper energy conservation practices, we may run into some serious power consumption issues.

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1 Introduction

Amidst the current technological age, the U.S. is witnessing a cell phone revolution. During this revolution we are experiencing an incline in the number of cell phones being used. In addition, people are discontinuing their landline phone services. What consequences does this cell phone revolution entail in respect to the amount of energy consumed by our nation?

We seek to compare the use of landline telephones with that of cell phones in regards to the energy consumption of each. In order to do so, we must take into consideration all possible ways in which each type of phone uses energy. Moreover, we will also consider the energy consumption practices of the U.S. in respect to the landline telephone and the cell phone.

In particular, we will consider two situations, the current U.S. and a Pseudo U.S. The basic outline of our solution will:

- Model the consequences of transitioning to an entirely cell phone U.S.
- Analyze and discuss the socioeconomics of this transition
- Model careless cell phone practices
- Use accurate data to compare careless cell phone practices to other items in standby (TV, DVR, and so forth)
- Model similar factors in a Pseudo U.S.

2 Investigating the Layout of the Problem

Before we begin to address the problem, we must indicate implicated parameters and the assumptions that we have used in order to solve the problem with our best possible solution.

2.1. Relevance of Energy Conservation

As a result of our nation's current economic status, the U.S. has become increasingly concerned with our daily energy consumption practices. In particular, many people conduct the careless practice of leaving their cell phone rechargers plugged all of the time. Furthermore, many people recharge their cell phones every night even when the cell phone does not need to be recharged. With these practices in mind, we have to consider how much energy the U.S. is wasting per year.

2.2. Definitions/Terminology

- Phantom Energy: standby energy that electronic devices use that average consumers are not aware of
- Watts: an International System unit of power equal to one joule per second
- Kilowatt-hours (kWh): a unit of electrical energy equal to the work done by one kilowatt acting for one hour [9]

$$kWh = \frac{Watts \times Hours\ Used\ Per\ Day}{1000}$$ [10]

- Barrel of Oil Equivalent (BOE): a unit of energy based on the approximate energy released by burning one barrel (42 U.S. gallons) of crude oil [5]

$$BOE = \frac{kWh}{1000 \times 1.70}$$

2.3. Assumptions

- Every person in the population is capable of using and purchasing a cell phone
- Each distinct phone type consumes equal amounts of energy
- Every cell phone recharges at the same rate and requires the same amount of energy to recharge
- People will recharge their phone overnight, every night
- On average, people charge their cell phones for .8 hours for every 24 hours
- Since the average person sleeps 8 hours a night the phone will be plugged into the charger for 7.2 hours each night with a completely charged battery
- The remaining 16 hours in a day will be spent with the phone unplugged but with the charger in the outlet
- On average, a household uses a landline telephone 3 hours per day
- The ratio of corded landline phones to cordless landline phones is 1 to 3. That is, there are 3 times as many cordless landline phones as there are corded landline phones

2.4. Restate the Problem

Given these assumptions and considerations, we are able to restate the problem and the requirements needed to complete it.

- Model the consequences of transitioning to an entirely cell phone U.S. given that the entire population is capable of using a cell phone

- Analyze if landlines or cell phones are better from an energy perspective given the 1 to 3 ratio of corded to cordless landline phones
- Model the energy costs of leaving a recharger plugged in for 16 hours without an attached phone and also a fully recharged phone for 7.2 hours
- Use accurate data to compare careless phone practices to other items in standby (TV, DVR, and so forth)
- Model the population and economic growth in a Pseudo U.S. up to the year 2050

3 Current U.S. Phone Electricity Utilization Model

Before we begin building a model for this problem we need to know a few pieces of information. We need to know the average number of households H and the number of members per household m currently in the U.S. Attempts to find current data of the number of households and members per households have proven unsuccessful. Thus, we use numbers from the last census taken by the U.S. government. Despite the lack of current data, we feel that the numbers provided by this data set still give an accurate representation of whatever the current data states.

The U.S. Census Bureau states there are 111 million households in the U.S. [7], amongst 300 million people. This leads us to conclude that there are approximately 2.7 people per household.

3.1. Energy Consumption

To begin, we divided the landline telephone into three parts:

- Landline
- Landline (cordless, ready)
- Landline (cordless, talking)

Likewise, we categorized the cell phone recharger as follows:

- Cell recharger (no phone attached)
- Cell recharger (phone attached, recharging)
- Cell recharger (phone attached, fully charged)

To determine the amount of energy being consumed by the categories above, we translate the wattage rating of each into kWh. We compute that a corded landline phone uses 0.27 watts given that it can be powered by a 9-volt battery at 30 milliamps. The remaining electrical consumption for the other types of phones is gathered from Lawrence Berkeley National Laboratory, and is presented in the following chart:

Type	Watts	Hours used	kWh (Annually)
Landline	0.27	24	2.3652
Landline (cordless, ready)	1.58	21	12.1107
Landline (cordless, talking)	1.9	3	2.0805
Cell recharger (no phone attached)	0.14	16	0.8176
Cell recharger (phone attached, recharging)	3.68	0.8	1.07456
Cell recharger (phone attached, fully charged)	2.24	7.2	5.88672

Table 1: kWh Data (source: [1])

Note that we assume that the average household will talk on a landline telephone for approximately 3 hours a day.

3.2. Derivation and Equation

In order to model the amount of energy consumption with respect to the decline of landline telephones and the incline of cell phones, we create an equation with the following variable representations:

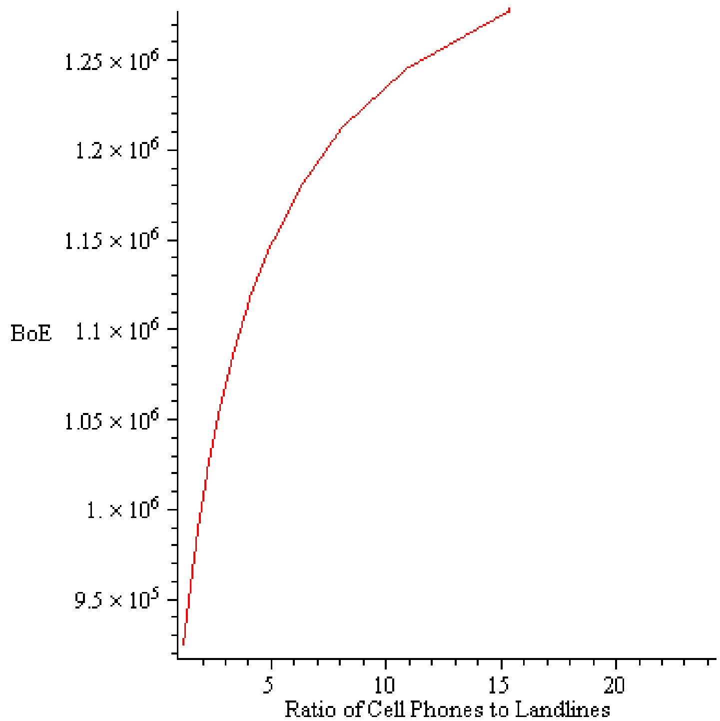
- w_1 = .27 watts (landline phone)
- w_2 = 1.58 watts (cordless, ready)
- w_3 = 1.9 watts (cordless, talking)
- w_4 = .14 watts (cell charger, no phone)
- w_5 = 3.68 watts (cell charger, charging)
- w_6 = 2.24 watts (cell charger, charged)
- h_1 = 24 hours or 100% of the day
- h_2 = 21 hours or 87.5% of the day
- h_3 = 3 hours or 12.5% of the day
- h_4 = 16 hours or 66.67% of the day
- h_5 = .8 hours or 3.3% of the day
- h_6 = 7.2 hours or 30% of the day

Note, that the hours per day are established by our previous assumptions. With these variables, our model is flexible, giving it the capability to be changed to meet different specification.

Combining all of these assumptions gives us the following equation:

$$kWh = .365 \cdot z \cdot \{c \cdot x \cdot (w_1 \cdot h_1) + (1-c) \cdot x \cdot [(w_2 \cdot h_2) + (w_3 \cdot h_3)]\} + .365 \cdot y[(w_4 \cdot h_4) + (w_5 \cdot h_5) + (w_6 \cdot h_6)]$$

where x is the number of houses with landlines ($x \le 111{,}000{,}000$), y is the number of cell phones in the country ($y \le 300{,}000{,}000$), c is the percent of corded phones among all landline phones, and z is the number of landlines per household (we set this equal to 1 in our model). Now using MAPLE to graph the equation, given the specific requirements, we get the following graph:



Graph 1: Ratio of Cell Phone to Landline vs. Energy Consumption per Year

Assumption: Since the U.S. already has both landline telephones and cell phones we assume an initial value for both landline telephones and cell phones

From the graph it is shown that as landline telephones continue to fade out of society and cell phones become the norm, the energy consumption due to telephone use increases. Hence, the amount of oil required to power the cell phone based society will also increase.

4 Pseudo U.S. Phone Service Optimization

Suppose we are given a country with all of the attributes of the current U.S., with the exception that our pseudo country lacks any telecommunication system. To determine the optimal phone service for this pseudo U.S. country, we need only look at how the energy consumption varies depending on the number of landline telephones and cell phones.

4.1. Energy Efficient Phone Service

Using the same equation used earlier, we produce a table of data showing energy consumption depending on the amount of landlines and cell phones. However, due to lack of any telecommunication system, we start our model with zero cell phones and the maximum number of landlines. By systematically reducing the amount of landlines and increasing the number of cell phones, we were able to find an optimal telecommunication system in terms of energy consumption. The data is presented below:

Landline	Cell	kWh	BOE	Cost
111,000,000	0	1,247,051,700	733,560	$124,954,580.34
105,450,000	15,000,000	1,301,382,315	765,519	$130,398,507.95
99,900,000	30,000,000	1,355,712,930	797,478	$135,842,435.56
94,350,000	45,000,000	1,410,043,545	829,437	$141,286,363.17
88,800,000	60,000,000	1,464,374,160	861,397	$146,730,290.79
83,250,000	75,000,000	1,518,704,774	893,356	$152,174,218.40
77,700,000	90,000,000	1,573,035,389	925,315	$157,618,146.01
72,150,000	105,000,000	1,627,366,004	957,274	$163,062,073.62
66,600,000	120,000,000	1,681,696,619	989,233	$168,506,001.23
61,050,000	135,000,000	1,736,027,234	1,021,192	$173,949,928.84
55,500,000	150,000,000	1,790,357,849	1,053,152	$179,393,856.45
49,950,000	165,000,000	1,844,688,464	1,085,111	$184,837,784.06
44,400,000	180,000,000	1,899,019,079	1,117,070	$190,281,711.68
38,850,000	195,000,000	1,953,349,693	1,149,029	$195,725,639.29
33,300,000	210,000,000	2,007,680,308	1,180,988	$201,169,566.90
27,750,000	225,000,000	2,062,010,923	1,212,948	$206,613,494.51
22,200,000	240,000,000	2,116,341,538	1,244,907	$212,057,422.12
16,650,000	255,000,000	2,170,672,153	1,276,866	$217,501,349.73
11,100,000	270,000,000	2,225,002,768	1,308,825	$222,945,277.34
5,550,000	285,000,000	2,279,333,383	1,340,784	$228,389,204.95
0	300,000,000	2,333,663,998	1,372,744	$233,833,132.57

Table 2: Modeled Pseudo U.S. Energy Cost

Clearly from an entirely cost and energy perspective, a completely landline society would benefit the Pseudo U.S. the most. Later sections will discuss the social implications of each type of society on top of cost and energy.

4.2. Consequences of a Total Landline Phone Service

A society with a total landline phone service will have both its disadvantages and advantages. Based upon our own thoughts, we foresee several significant disadvantages. These include: slow business, more deaths due to slow call-and-response time, more difficulty in obtaining information, and there will be a significant increase in cost due to long distance calling fees. These disadvantages pose serious issues for a Pseudo U.S. In contrast, there also exist several advantages. These include: lack of cell phone related vehicle accidents, cheaper consumer cost, no energy required to power cell phone towers, less overall power consumption, better security, and far better reliability.

4.3. Consequences of a Completely Cell Phone Society

Likewise, a society with only cell phones has its own advantages and disadvantages. Some advantages are: increased speed of communication and speed of business, allowing fast and up-to-date access to information and ability to talk to anyone, anywhere.

Some disadvantages are: high consumer cost for big families, increased vehicle related accidents from talking on cell phones, increased possibility of fraud because of theft of a cell phone, and they are easy to lose, and dropped calls are very common.

4.4. Consequences of Both Phone Services

Despite the advantages and disadvantages of both situations discussed above, in regards to the socioeconomic perspective, we feel that a mixture of both landline telephones and cell phones would provide the most satisfactory environment for a Pseudo U.S. This would allow for the increased security that landlines offer and an increased information gathering capability that cell phones offer. Furthermore, since cell phones use an increased amount of energy, providing the option of landlines will decrease the overall energy consumption and thus the overall cost.

5 Modeling Careless Energy Practices

Although the data shows that the best system on a purely energy conservation basis is to have an entirely landline based system, for the sake of argument we will consider the energy consequences of an entirely cell phone based system. Therefore, we can use our initial equation and set all the x values equal to zero. Our new equation is the following:

$$kWh = .365 \cdot \mathrm{y}[(\mathrm{w}_4 \cdot \mathrm{h}_4) + (\mathrm{w}_5 \cdot \mathrm{h}_5) + (\mathrm{w}_6 \cdot \mathrm{h}_6)]$$

From our model, we are able to see that the total amount of energy required to fuel 300 million cell phones is about 2,333,663,998 kWh. Using our numbers for the amount of energy consumed by a recharger without a phone and by a recharger plugged into an already charged phone, we get the following data:

Cell charger [no phone] (kWh)	245,280,000
Cell charger [phone recharged] (kWh)	+1,766,016,000
Wasted energy consumption (kWh)	=2,011,296,000

Table 3: Wasted Amount of Energy in kWh

Based on the 2008 national average cost per kWh of 10.02 cents [2], this amount of wasted energy requires a funding of $201,531,859 or about 118,548 BOE per day. In contrast, the energy consumed to simply recharge all the cell phones comes out to be 322,367,998 kWh which cost about $32,301,273 or only 19,000 BOE per day. Therefore, a society which has energy conscious citizens can make a significant difference in the amount of oil consumption per day by both unplugging their rechargers when not in use and also unplugging them when they are no longer needed to recharge their cellular devices.

6 Wasteful Electronics of the U.S.

Cell phones are not the only devices that have phantom energy. Many other household electronic devices also consume this so called phantom energy. In order to model this problem, we choose seven common household devices. First off, we must define several assumptions concerning the amount of use for each device.

Assumptions:

- The average off time of a digital cable box is 17.217 hours, due to the assumption that it is off for however long the TV is turned off
- We hold the same assumption for game consoles
- The average movie is two hours and due to laziness, we assumed a DVD/VCR player is used for about 4 hours a day on average, and is off for 20 hours a day
- The average desktop computer is in sleep mode for 16 hours a day
- The average notebook computer is in sleep mode for 18 hours a day

- The average inkjet printer is used for 2 hours a day, and off for 22 hours a day
- We assume that each of household has one of each of the following electronic devices

The table below will show these electronics and how much phantom energy each of them consumes:

Electronic Devices	Avg. Wattage	Est. time in state (per day)	KWh (per day)	BOE (per day)
Computer, Desktop (sleep)	21.13	16	37,526,880	22,074
Computer, Notebook (sleep)	15.77	18	31,508,460	18,534
Set-top Box, Digital Cable with DVR (off by remote)	43.46	17.217	83,055,841	48,856
Television, CRT (off by remote)	3.06	17.217	5,847,926	3,439
DVD/VCR (off)	5.04	20	11,188,800	6,581
Game Console (off)	1.01	17.217	1,930,197	1,135
Printer, Inkjet (off)	1.26	22	3,076,920	1,809
			Total (all households)	**102,432**

Table 4: Phantom Energy Consumption of Other Common Electronics

Note that the wattages were found from actual data [1] and the estimated time that a TV is off per day is as well [4], and thus it is actual data and not an assumption.

Compared to the BOE that cell phones consume from phantom energy, we see that cell phones actually consume more energy than all these appliances combined.

7 In 50 Years

Suppose we want to model population growth and energy consumption up to 50 years from now. In order to create accurate estimates of the population growth and energy consumption, we use a logistic growth equation to estimate the population. The general form of this is:

$$P(t) = \frac{L}{1 + Ce^{-kt}}$$

Then, by using data from the U.S. Census Bureau and using MAPLE to do the hard calculations, we solve for the constants *L*, *C*, and *k*, to obtain our equation for population growth:

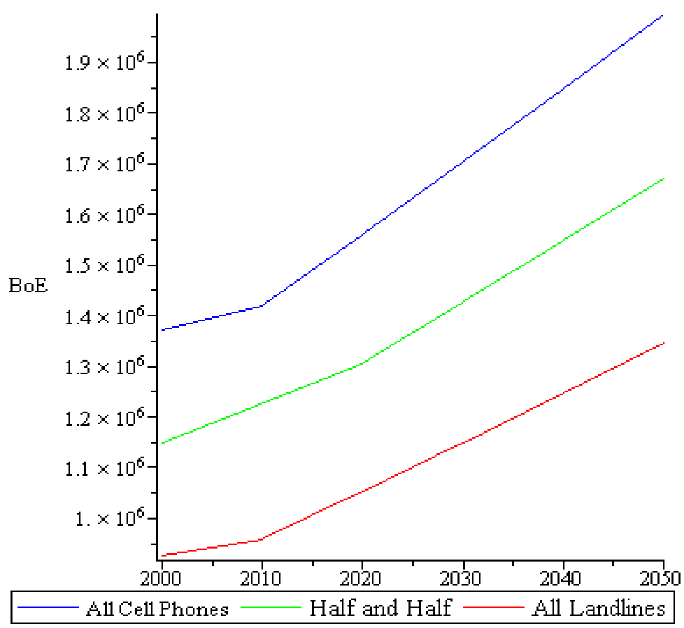
$$P(t) = \frac{810.9524047}{1 + 9.042375306 \cdot e^{-0.01567489364t}}$$

From that equation we estimate the population in 10 year increments up to 2050. Moreover, we calculate the energy consumption for various scenarios of cell phone to landline ratio for our pseudo U.S. in BOE per day:

Year	Population	All cell phones (BOE)	50/50 (BOE)	All landlines (BOE)
2000	300,000,000	1,372,744	1,149,673	926,602
2010	310,400,000	1,420,332	1,189,528	958,724
2020	341,000,000	1,560,352	1,306,795	1,053,237
2030	372,300,000	1,703,575	1,426,744	1,149,913
2040	404,000,000	1,848,628	1,548,226	1,247,824
2050	436,000,000	1,995,054	1,670,858	1,346,661

Table 5: Modeling Future Energy consumption

It is easy to see in the graphical plot below that, in fact, the all cell phone scenario will result in an energy bust if the population does not compensate for phantom energy by reducing careless actions.



Graph 2: Future Energy Consumption in Three Scenarios

8 Evaluation of Methods and Results

A vital assumption is that each household has only one landline phone (our z variable set equal to 1). If we change this number from 1 to a number larger than 1.87 we would see an inverse effect in energy cost and consumption as cell phones become the main telecommunication system. That is to say that if the average number of landline phones per household jumps to any number greater than 1.87, we will see that cell phones become a more efficient means of communication in terms of energy consumption. However, due to logical social implications, this scenario is not likely to occur. Hence, we are confident in the data our model produced.

8.1. Strengths

- We utilize a simple model with easily manipulated variables
- Simple and concise calculations
- Model allows for a wide range of applications and states of phone use in a country
- Largely based upon data from reliable sources

8.2. Weaknesses

- We did not incorporate the fact that a person in a household could have both a landline and a cell phone
- We were unsuccessful in incorporating a variable that was influenced by breaking or losing cell phones. We could incorporate this by researching the energy required to build and recycle cell phones
- We assume that every person is capable of buying and using a cell phone

8.3. Conclusion/Recommendations

As a result of our model and other calculations we have come to several interesting conclusions. As was shown by our model, a country with only landline phones will provide the most efficient use of energy. In addition, if population and cell phone growth continue to increase at their current rates, the U.S. will soon consume more energy in cell phone use than is readily available in the market. One way to combat this is to practice good energy conservation by only plugging a cell phone into the recharger when it needs to be recharged. Additionally, we suggest equilibrium between the amount of landlines and cell phones, which entails more energy consumption than just landlines alone, but will provide a better social structure.

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