Energy Consumption and Resulting CO2 Emissions of Laptops and Smartphones

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Experiment 1

Description
This was a five day study study involving four different people. Each person had an Apple IPhone 6, an Apple Macbook 2012 laptop, or both. Using Ammeters, a device to measure kWh and watts, each person recorded how much energy their smartphone or laptop used every time they plugged it in.

Hypothesis
I predict that the amount of CO2 emissions produced through the regular use of the smart phone Apple IPhone 6, and a 2012 Apple MacBook laptop, will be a miniscule amount compared to the average amount of carbon emissions of say an average passenger vehicle.

Methodology
Once the data from the five day study were collected a series of calculations were done to convert the data in kilowatt-hours to an amount of carbon dioxide emitted for that amount of kWh. The equation to convert kilowatt-hours to carbon dioxide emitted used multiple conversion factors. Two of these conversion factors were obtained from the Energy Information Administration and they were based on how much carbon dioxide is emitted per kWh produced using coal, which is 2.17 lbs./kWh, and for natural gas, which is 1.22 lbs/kWh. The third conversion factor was derived from the Emissions and Generation Resource Integrated Database (eGRID), and is 0.61 lbs./kWh.

Results

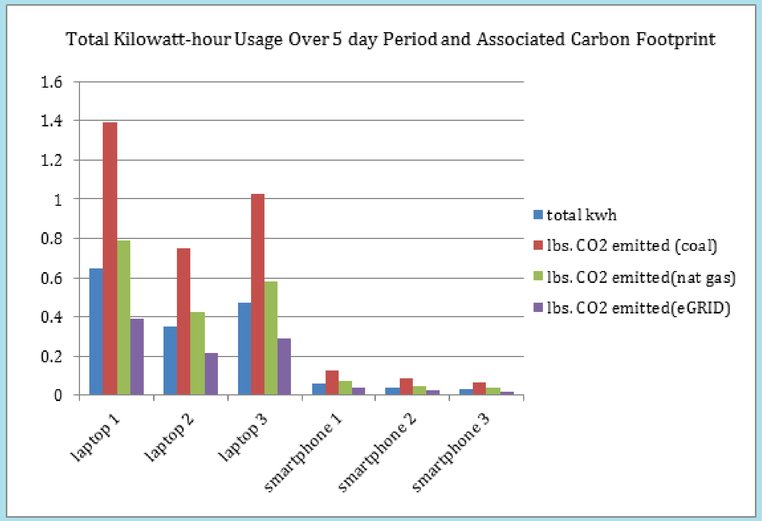

Fig 2. This figure shows the total amount of energy smartphones and laptops consumed over a 5 day period and the resulting amount of carbon dioxide emissions from that energy use

The results show that the laptops consumed energy on the order of hundredths of a kilowatt-hour for a standard charge of a few hours, and tenths of a kilowatt-hour for longer charges. The smartphones under study consumed energy on the order of thousandths of a kilowatt-hour for an average charging session.

The average amount of carbon dioxide emitted to produce the kilowatt-hours used by a laptop was 0.2987 lbs. of carbon dioxide for the eGRID conversion factor, 0.5968 lbs. for only natural gas, and 1.0566 lbs. for only subbituminous coal. To put these values into perspective, the amount of carbon produced by only using natural gas, is the same amount of carbon emitted by an average passenger vehicle driving for 0.645 miles. (EPA Greenhouse Gas Equivalencies calculator)

Introduction and Objectives

Most electricity is generated by the burning of fossil fuels. Different fossil fuels release different amounts of carbon dioxide due to the fuel source's carbon content. Burning coal will produce more carbon dioxide than oil or natural gas.

In order to understand how much electrcity smart phones and laptops consume, and how much carbon dioxide emissions this energy use results in, two experiments were performed. The goal of the first experiment was to gain an understanding of how much energy laptops and smartphones consumed over a few days, as well as the resulting carbon footprint of that energy use. The goal of the second experiment was to discover if certain ways of using these devices consumed more energy than others.

Defintitions
Watt- a rate of energy use, analgous to the term miles per hour
kiloWatt-hour- An amount of energy use. 1 kilowatt-hour is equal to the amount of energy used if you consume energy at the rate of 1000 watts for one hour.

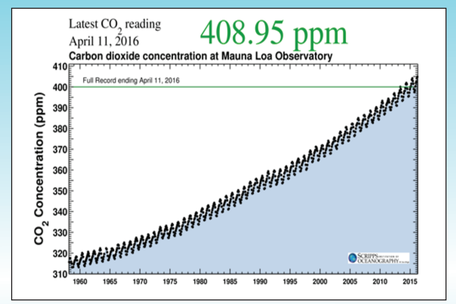

fig 1. Keeling Curve, This figure shows a clear trend of increasing carbon dioxide levels since 1960, and for this reason it is imperative that we be aware of our carbon footprints and the carbon footprints of the devices we use.
Source: Scripps Institution of Oceanography

All six ammeters used in the experiments were the Multifunctional Mini-ammeter model number DO2A made by Shenzhen Wanfang Hi-tec co.

Conclusion

My hypothesis that the amount of carbon dioxide emitted through the energy consumption of smart phones and laptops would be miniscule was confirmed by this study. Being that most people who own passenger vehicles drive well over 1 mile in the course of a day, and that over the course of five days the average amount of carbon dioxide produced through laptop energy use was equivalent to the carbon footprint of driving about half a mile or in the case of smart phones 0.057 miles, it is safe to say that the use of these devices has a small contribution to the average American person's total carbon footprint, which was 37,478.6 pounds in 2011. (World Bank)

The results of the second experiments are less conclusive. More trials would have to be performed to make a more substantial case for the results found. However the data gathered by these experiments show my original hypothesis is false, at least in some cases. What this means for habits of use for laptops is that battery of laptops may recharge more efficiently while in a state of activity as opposed to when they are charged in a powered down state.

References

1. Art Diem U.S. EPA/OAP.CAMD, Cristina Quiroz, TranSystems, E.H. Pechan. How to use eGRID for Carbon Foot printing Electricity Purchases in Greenhouse Gas Emission Inventories. July 2012
2. Environmental Protection Agency (EPA), Epa Greenhouse gas equivalencies calculator https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator accessed May 13, 2016
3. The World Bank, CO2 Emissions (metric tons per capita), http://data.worldbank.org/indicator/EN.ATM.CO2E.PC accessed May 13, 2016

Experiment 2

Description
Two different 2012 Apple MacBook laptops and two different Apple IPhone 6 smart phones were used to perform a series of trials under diffrent conditions. The phones were of the same build and model, as were the laptops however they had different apps and memory.

Hypothesis
I hypothesize that certain ways of using a device such as charging a laptop while it is in a powered down sleep mode state as opposed to charging while it is in a state of activity will result in less energy being consumed, and that smart phones consume more energy while in states of activity as opposed to being left idle but still on.

Methodology
The laptop trials were done as follows: Laptop A and Laptop B are both at 60% charge at the beginning of the experiment. Both are playing a video for 1 hour. Laptop A is not plugged in, Laptop B is and is connected to an ammeter. After the first hour the kWh used by laptop B will be collected, the final charge of Laptop B and the charge of Laptop A will also be recorded. Next Laptop A will be put to sleep and then connected to an ammeter. Laptop A will be charged while in sleep mode for one hour. After the second hour the kWh used by laptop A will be collected, the final charge of Laptop A and B will also be recorded.

The phone experiment was conducted as follows: Phone A will be connected to an ammeter. A phone call will be made lasting 5 minutes. At the end of the 5-minute call, total kilowatt hours used will be recorded. Two kinds of phone calls will be performed for phone A, one involving constant talking, and one involving no talking. Phone will B will be left idle for 5 minutes. This phone too will be connected to an ammeter that will also be measuring kilowatt-hours, to be recorded at the end of the 5-minutes.

Results

Phone Call Experiment **Device: Apple IPhone 6**

Phone used	activity	total kwh
A	call with talking	0.0001
A	silent call	0.0001
A	idle	0.0002
B	call with talking	0.0003
B	silent call	0.0001
B	idle	0.0001

fig 3. Ammeters measured the kwh of phones while making calls for five minutes. Some calls involved speaking, and some were silent, the phone also measured kwh used while idle for 5 minutes.

Laptop Experiment Plugged in While in Use **Device: Apple MacBook 2012 Mid**

laptop used	charge after 1st hour	kwh after 1st hour	charge after 2nd hour
A	98%	0.0425	97%
B	91%	0.0333	90%

fig 4. Two laptops were charging while playing a video for an hour then put to sleep for an hour, the resulting energy use after the first hour as well as charge for the first and second hour is given

Laptop Experiment Plugged in While in Sleep mode **Device: Apple MacBook 2012 Mid**

laptop used	charge after 1st hour	charge after 2nd hour	kwh after 2nd hour
A	32%	84%	0.0524
B	34%	84%	0.0328

fig 5. Two laptops played a video for an hour then charged while in sleep mode for an hour, the resulting energy use after the second hour as well as charge for the first and second hour is given

These results show that, at least some of the time, a laptop can consume more energy while being plugged in during a powered down state as opposed to being plugged in during a state of activity. From the results of the phone experiment it appears that a phone being idle can consume more energy than a phone being active at least some of the time.