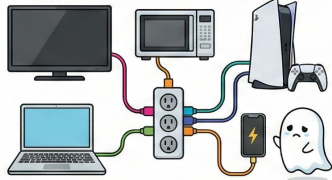


HIDDEN IN PLAIN SIGHT



POWER USED EVEN WHEN OFF

Phantom Load Research: Abstract

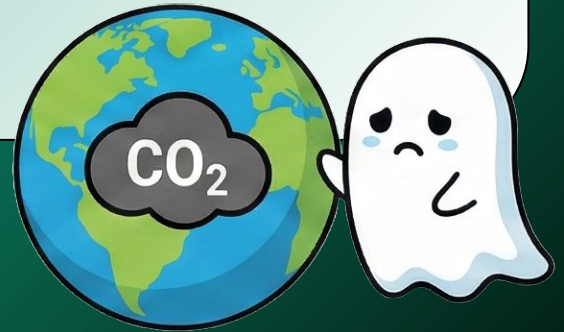
School:
Sharon Middle School
Advisor:
Micky Foley

The phantom load/standby power, despite being hidden in plain sight, is significantly tied to energy waste and carbon emissions. This study aims to prove that at least 5% of electricity generated in the US annually is wasted due to phantom load. Additionally, the rate of global warming and carbon emissions increase due to the production of the lost energy. To prove this, we identified standby devices, using smart plugs that measured the standby power loss in kWh per day. We sent out an online survey, to which 80 people across 17 states responded. Combining the measurements and survey responses, it's found that on average each US household has ≈ 54 standby devices and on average loses 695kW annually. The top 10 standby-devices account for 95+% of the total loss per house. This data, paired with information from eia (Energy Information Administration), shows that the US resident loses ≈ 106.7 T Watt annually due to standby power, which is 6.43% of the electricity generated in the US consumed by residents. This results in 90 million metric tons of carbon emissions, which is 1.6% of the total US carbon footprint. Despite this, 81% of the population are unaware/partially aware of this issue while only 24% of the 19% of people aware of the issue have the desire to use power strips to reduce the loss. Overall climate-positive action people should be made aware of this issue and use power strips or simply unplug the device when not in use.

Objectives:

Hypothesis: At least 5% of energy generated for the residential sector is wasted annually due to phantom load, which increases the rate of carbon emissions in the atmosphere.

Raise awareness on phantom load, and solutions to reduce it.



Glossary:



Sleep mode = A low power state for devices, that lies between off and fully on

Instant-start = A feature that allows devices to start nearly instantly when required

Electricity = The flow of electrons

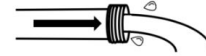
Power = The rate at which energy is used, it's unit of measurement is Watt

Current = The rate of energy flow measured in a unit called Amperes

Electric Power vs Energy

Power

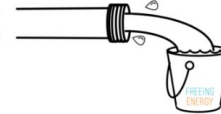
Watts or kilowatts



...is like the flow rate of the water

Energy

Watt-hours or kilowatt hours

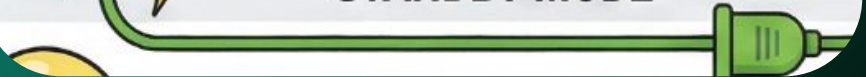


...is like the amount of water that ends up in the bucket

WHAT IS PHANTOM LOAD?



ELECTRICITY CONSUMED BY ELECTRONIC DEVICES WHILE SWITCHED OFF OR IN STANDBY MODE



Features that contribute to problem:

1. Many modern devices use a feature, known as instant-start. This feature allows devices to turn on almost instantly.
2. The electrical current still is flowing through the wire to the device even though it isn't in use, which then radiates off as thermal energy and is wasted.
3. Devices use energy to maintain internal clocks, LED light indicators, and more.
4. Devices that can be turned on by remotes, must stay on sleep mode to receive that signal from the remote, or else they wouldn't turn on.

Materials:



This experiment consisted of 3 stages — Measurement, Survey and Analysis. The materials used in the experiment during these stages were as the following:

Measurement: Four Tp-Link Tapo Wifi (smartplug), Ipad 10, List of mentioned devices that use standby power, Data Sheet to collect data on 24 hrs standby power consumed

Survey: Survey sheets for initial survey design, Online Survey

Data Analysis: Internet to research, Survey Results, Microsoft Excel & Google Sheets, Powerpoint, Google Docs



Methods:

Set up:

- Gather materials
- Connect smart plug to phone
- Create survey questionnaire
- Build Online Survey
- Identify standby electronics
- Create data sheet (devices vs phantom load loss in KWh)
- Identify mechanism to release survey

Measurements

- Use smart plug for readings of phantom device for 24 hours
- Use 4 smart plugs to get readings for all devices on data sheet
- Update data sheet of lost watts hours due to standby energy

Survey:

- Survey as many houses possible and record in data sheet
- Gather online survey result

Data Analysis:

- Find average power loss due to phantom load per house annually
- Apply to larger scale: Research number of houses in U.S and find total power loss due to phantom load
- Research how much power is consumed by residential in U.S
- Find percent of power lost from total power generated in the U.S

Research:

- Research carbon emission for generating total power in U.S per year
- Research carbon emission for power wasted from residential due to vampire energy
- Calculate contribution of phantom losses to total carbon emission by power plants using prior calculations

Research and enrich conclusion:

- Effect of computed carbon emission due to vampire energy on global warming

Data Analysis:

- **Annual Household Waste:**

- Total Phantom Load Loss (per 24 hrs in KWh) = 129.44 KWh
- Total Phantom Load Loss annually (per 24 hrs in MW)= (Total Phantom Load Loss in KWh in 24hrs)*365 = 129.44 KWh *365days = 47.247 MW
- Count of Households Surveyed = 68
- U.S. home loses standby power annually = 0.695 MW =
- On average, a single U.S. home loses **695 KWatt annually** to standby power.

- **National Impact of Phantom Load Loss:**

- Count of Households in United States = 149M
- Total Phantom Load Power Loss in US Annually = $149 \times 10^6 \times 695 \text{ KW} = 103.53 \times 10^9 \text{ KW} = 103.53 \text{ TW}$
- Power loss in transmission in US annually for residential power consumption = 5% * 103.53 TW
- Total Phantom Load Loss in TW Annually (Residential Consumption)= $1.05 \times 103.53 \text{ TW} = 108.70 \text{ TW}$

38.4%
1.51 trillion kWh
residential

35.4%
1.39 trillion kWh
commercial

26.0%
1.02 trillion kWh
industrial

0.2%
0.01 trillion kWh
transportation (mostly to public transit systems)

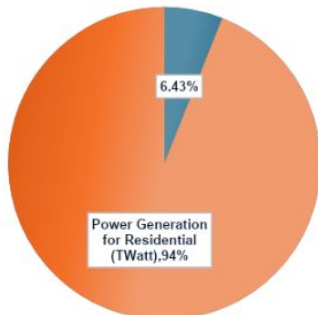
- **Device Density:** The sample set identified an average of **53.9 phantom load devices per household.**
- **Primary Contributors:** These few yet very common devices, **TVs, gaming consoles, ovens, plug-in speakers, microwaves, monitors, dishwashers, and air fryers** account for **95% of total phantom power loss.**

Data Analysis: Power loss and CO2 emission



- Residential Phantom Load Loss as a % of total power generated in US for residential use:**
 - Total Power Generation in 2025 In USA (Tera Watt) = 4400 TW
 - % of total U.S. power consumption for residential use = 38.4% of total power generated
 - Total Power Generation Per Year In USA Used For Residential (Tera Watt) = 1689.60 TW
 - % Energy loss due to Phantom Load in Residential = (Total Phantom Load Loss in TW Annually (Residential Consumption)/ Total Power Generation Per Year In USA Used For Residential (Tera Watt)) * 100 = **6.43%**

Total Power Generated For Households vs Standby Power Loss



Carbon Emission due to Phantom Load Loss



1.61% Of Total US CO2 Emission

Total Annual Electricity Generation in the U.S. (TWh)	4400.00
Percentage of U.S. Electricity Consumption Used by Residential (EIA)	38.4%
Annual Electricity Generation For Residential Use in the U.S. (TWh)	1689.60
Percentage of Residential Power Generation Lost to Phantom Load	6.43%
U.S. CO ₂ Emissions from Electricity Generation (Billion Metric Tons)	1.44
Carbon Emissions in the U.S. Due to Phantom Load Loss (Million Metric Tons)	90
Total U.S. CO ₂ Emissions (Billion Metric Tons)	5.76
Carbon Emissions from Phantom Load as a Percentage of Total U.S. CO₂ Emissions	1.61%

Solutions:

1. Unplugging devices when they aren't in use
2. Smart power strips
3. Smart plugs



Benefits:

1. Since less electricity would be wasted, the electricity bills will be lower
2. Since less electricity would be generated at the power plant, less carbon emissions would happen and the environmental impact would be less

Constraints and possible errors:

Some respondents submitted surveys multiple times causing duplicate surveys, these duplicate surveys caused challenges initially during data analysis

Out of the 80 unique surveys some surveys responses were unrealistic and incorrectly filled, in these surveys some respondents had submitted phantom load hours very very close to 0 which had a huge impact on data analysis

Not all devices were available for testing.

How we calculated/curated the data:

Duplicate surveys were addressed and fixed by identifying them and excluding them. Initially 109 responses were received but after the removal of the duplicate surveys there were 80 responses.

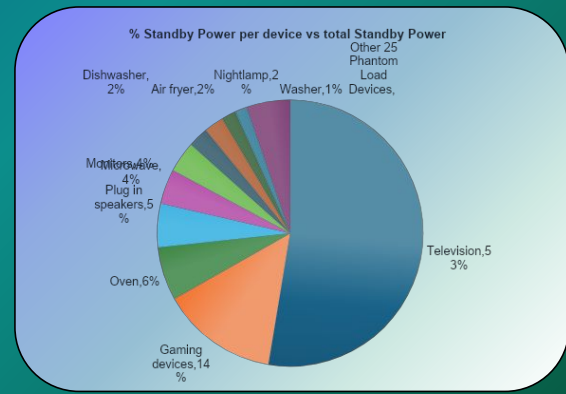
Incorrect surveys were identified and removed these surveys data analysis was more accurate. Out of 80 unique surveys 12 were found to be unrealistic and incorrect, leaving 68 unique and valid survey.

To address the limitation on having all devices available for experimentation, online information was referred to for phantom load loss measurements on unavailable devices.

Conclusions:

In the data analysis it is seen that 6.43% of the electricity generated for the residential sector is wasted due to standby power, this exceeds the 5% prediction that was made to begin with thus proving the hypothesis. With a total of 108.7 Terawatts of power lost annually, this electricity wasted results in 90 million metric tons of carbon emissions, which accounts for 1.6% of total CO2 emissions in the US. A key takeaway from this study is the massive awareness gap of this issue. 81% of the population in the US is unaware or somewhat aware of this issue, and among 19% who are aware, 24% show interest in using a solution to reduce electricity losses. It was found that the top 10 common and phantom load consuming devices account for 95+% of electricity waste, and focusing on just those devices can reduce carbon emissions and reduce the massive impact of the environment significantly. Research also shows that global CO2 emissions overall are causing 0.36F global temperature increase per decade and phantom load loss is contributing more than 1.5% in this. Reducing this loss can significantly help the environment by lowering global warming rate.

Since, 81% out of those who responded to our survey were not aware of phantom load and our survey end page provides insight on phantom load and few possible solutions. We've made more people aware, of phantom load, and possible solutions such as smart plugs, smart power strips, and simply unplugging devices. Out of the 19% aware of phantom load 24% don't currently use power strips but expressed interest in them, which if expanded could help reduce some phantom load.



Device Name	Share of Standby Power As Percentage of Total Household Standby Power
Television	53%
Gaming devices	14%
Oven	6%
Plug in speakers	5%
Microwave	4%
Monitors	4%
Dishwasher	2%
Air fryer	2%
Nightlamp	2%
Washer	1%
Other phantom load devices	5%

What we want to do next time:

The survey in this study could be improved by improving its reach across the US and by identifying a better sample set of population with the following consideration: household size, consumption pattern, regions, include more devices, and population density of state.

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