ABSTRACT

The Illinois Junior Academy of Science

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CATEGORY	Electronics	STATE REGION #	6
SCHOOL	Our Lady of the Wayside	IJAS SCHOOL #	6020
CITY/ZIP	Arlington Heights, 60005	SCHOOL PHONE #	847-255-0050
SPONSOR	Mrs. Julie Gowgiel		

MARK ONE: EXPERIMENTAL INVESTIGATION [X] DESIGN INVESTIGATION [ ]

NAME OF SCIENTIST*	Andrew Bremner	GRADE	7
NAME OF SCIENTIST		GRADE	
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* If this project is awarded a monetary prize, the check will be written in this scientist's name, and it will be his/her responsibility to distribute the prize money equally among all participating scientists.

PROJECT TITLE Watt's Up?

Purpose: Which electrical device uses the most power when not in use (active standby and passive standby modes)?

Procedure:

1. Test each electronic device (iMac computer, inkjet printer, television, Xbox 360, Blu-ray player, subwoofer, TiVo DVR, and coffee maker) by plugging it into the Kill-a-Watt meter.
2. Test each device in active mode (device is on and performing primary function). Record the number of watts the device is using at thirty-second intervals for 5 minutes. (Repeat two times)
3. Test each device in active standby mode (device is on but not performing primary function). Record the number of watts the device is using at thirty-second intervals for 5 minutes. (Repeat two times)
4. Test each device in passive standby mode (device is off). Record the number of watts the device is using at thirty-second intervals for 5 minutes. (Repeat two times)

Conclusion:

In conclusion, my data does not support my hypothesis. I predicted that in active standby mode, the iMac computer would use the most power because it runs several programs. However, it actually uses the least amount of power because the iMac goes into a power saving mode. The Xbox, however, uses the most power while in active standby because it does not have a power saving mode. I also thought that in passive standby mode, the coffee maker would use the most power, but my testing proved that the TiVo DVR does.

1) Limit Abstract to 3 paragraphs (about 200 words or less). a) Purpose - what you set out to investigate; b) Procedure - how you did it; c) Conclusion - based on your results. Label each paragraph.
2) Must be typed, single-spaced on the front of this form. Do not write on the back of this form.
3) Three copies of your complete paper are required at the State Science Project Exposition.

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The Illinois Junior Academy of Science

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Safety and the Student: Experimentation or design may involve an element of risk or injury to the student, test subjects and to others. Recognition of such hazards and provision for adequate control measures are joint responsibilities of the student and the sponsor. Some of the more common risks encountered in research are those of electrical shock, infection from pathogenic organisms, uncontrolled reactions of incompatible chemicals, eye injury from materials or procedures, and fire in apparatus or work area. Countering these hazards and others with suitable safety practices is an integral part of good scientific research. In the **chart** below, list the principal hazards associated with your project, if any, and what specific precautions you have used as safeguards. Be sure to read the entire section in the *Policy and Procedure Manual of the Illinois Junior Ac of Science* entitled "Safety Guidelines for Experimentation" before completing this form.

Possible hazards	Precautions taken to deal with each hazard
Electrical shock	Adult supervision was present during testing. An adult plugged electrical devices into the Kill-a-Watt meter and also plugged the meter into the wall outlet.

Specific safety practices related to materials requiring endorsement sheets should be detailed on the specific endorsement sheet and not included on this safety sheet.

Please check off any other possible endorsements needed. Include these documents in your paper and on your board.

_____Humans as Test Subjects –for any projects involving humans including survey administration;
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WATT'S UP?

By: Andrew Bremner

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Acknowledgements

I would like to thank my mom and my dad for helping me with my testing; Miss Laughland for helping me with my review of literature; and Mrs. Gowgiel for helping me with my paper.

Purpose

Which electrical device uses the most power when not in use (active standby and passive standby modes)?

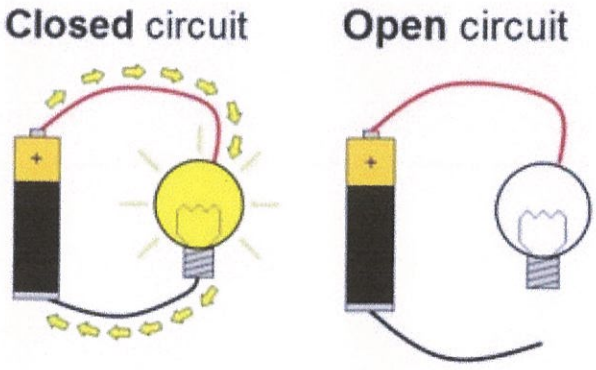
Hypothesis

If an iMac computer is in active standby mode, then it will use the most power because it keeps all of its programs running. If a coffee maker is in passive standby mode, then it will use the most power because it always runs a clock.

Review of Literature

Hundreds of dollars gone, and this is all because of standby power. Standby power is the power a device uses when it is not on and is what causes many energy bills to be very expensive. While standby power is an intriguing concept, there is a great deal of information that is crucial to know in order to fully understand it. These topics include electric circuits, Ohm's law, watts and kilowatts, and energy efficiency and conservation. These may all seem unrelated, but they fit together ("Defining and measuring standby," n. d.).

Electricity flows on a path called an electric circuit. An electric circuit can be either open or closed. When the circuit is closed, it is complete and electricity is able to flow, but when the circuit is open, the circuit is not complete, and electricity is not able to flow. For example, when a light switch is turned on, electricity flows from the power source to the light bulb. The switch opens and closes the circuit. In every electric circuit, there is a source of power and a load. The load is what is being powered by the power source. For example, in the figure below, the battery is the power source and the light bulb is the load ("Complete electrical solutions," 2013).



(Complete Electrical Solutions, 2013)

Ohm's law is used to find electromotive force in volts, current in amperes, and resistance in ohms, but current and voltage can also be used to find wattage (W), which is the measurement of power. Power is the amount of energy used at any one time. Power is measured in watts or kilowatts, which are equal to 1000 watts. The equation to find power using current and voltage is P = VI (Westcott S. & Westcott J.R, 2011).

Many people make the mistake of thinking that power and energy are the same thing. Energy is actually the amount of power used in a given amount of time and is measured in watt-hours and kilowatt-hours, though kilowatt-hours are more common. One kilowatt-hour measures the amount of kilowatts used in a single hour. To find kilowatt-hours used by a device, multiply the number of kilowatts the device was using by the number of hours it was being used. For example, if a motor that uses two kilowatts is on for three hours, it is using six kilowatt hours because 2 x 3 = 6. Energy bills are based on the number of kilowatt-hours used (Thorpe, 2010).

Households are trying to reduce the number of kilowatt-hours used by being more conservative and efficient. Energy efficiency is not the same thing as energy conservation. Energy efficiency is when less energy is used, but the same service is provided. Energy conservation is getting less service to save energy. For example, a light can be turned off to conserve energy or it can be replaced with a more energy-efficient one. Both energy conservation and efficiency save energy, even though they do it in different ways ("What is energy efficiency?," 2014)

Energy Star products can be purchased to be more energy efficient. Energy Star is a program established by the United States Environmental Protection Agency (EPA) that finds

energy-efficient appliances and devices and labels them. If an Energy Star label is on a device, then it is a more energy-efficient device. A device that is energy-efficient uses less power still works just as well as a non-efficient device. When using Energy Star products, more than 30% of the cost can be saved versus using non-Energy Star products (Thorpe, 2010).

When trying to save money on energy it is important to have energy awareness. To be energy aware is to know how much energy is being used and why. In many towns, energy companies are installing smart meters to measure how much energy different households are using at different times of the day. This information is transmitted to the owner of the household. The hope is that, with this information, households will be more efficient and conservative (Silverberg, 2014).

Energy efficiency can be expensive, and energy conservation requires sacrifice, but cutting out standby power can reduce energy consumption without sacrifice or cost. As stated earlier, standby power is the power a device uses when it is not on. For example, many computers have a "sleep mode." While in this "sleep mode," the computer is still using power. Many people are aware of this, however, it is less known that many devices also use power when they are turned off. For example, a TV when it is off, still uses power. For many devices, the only way for it to use no power is to unplug it (Hutsko, 2009).

There are different types of power modes, even different types of standby. There is active, active standby, and passive standby, which is considered as "off". When a device in active mode, it is on and performing its primary function. This means that it is doing what it was made to do. For example, when a DVR is on and recording, it is in its active mode. When a device is in active standby mode, it is on, but not performing its primary function, like a DVR

that is on, but not recording. When a device is in passive standby mode, it is off, but can still be turned on by a remote control, or is still performing a secondary function, like a DVR that is turned off. This is known as passive standby and not "off," because, many times, when in this mode, the device is still using power. If a device can be turned on by a remote control, has an LED status light, or has a clock, it probably uses power when it is supposed to be off. The only way for such a device to be truly off is for it to be unplugged and disconnected from power. ("Home electronics," 2013)

The Department of Energy estimates that for most families a minimum of $130 is spent annually on standby power. This may seem like a large amount, and it is. Standby power is a big problem, but can be solved by doing something as simple as unplugging a device, or using a power strip to switch off power to the device when it is not being used (Raphael, 2008).

Materials

- Kill-a-Watt meter
- iMac computer
- Inkjet printer
- Television
- Xbox 360
- Blu-Ray player
- Subwoofer
- TiVo DVR
- Coffee maker
- Stopwatch
- Extension cord

Methods of Procedure

1. Test each electronic device (iMac computer, inkjet printer, television, Xbox 360, Blu-ray player, subwoofer, TiVo DVR, and coffee maker) by plugging it into the Kill-a-Watt meter. For convenience in reading the meter, plug the Kill-a-Watt meter into an extension cord and the extension cord into the wall.

2. Test each device in active mode (device is on and performing primary function). Record the number of watts the device is using at thirty-second intervals for 5 minutes. (Repeat two times)

3. Test each device in active standby mode (device is on but not performing primary function). Record the number of watts the device is using at thirty-second intervals for 5 minutes. (Repeat two times)

4. Test each device in passive standby mode (device is off). Record the number of watts the device is using at thirty-second intervals for 5 minutes. (Repeat two times)

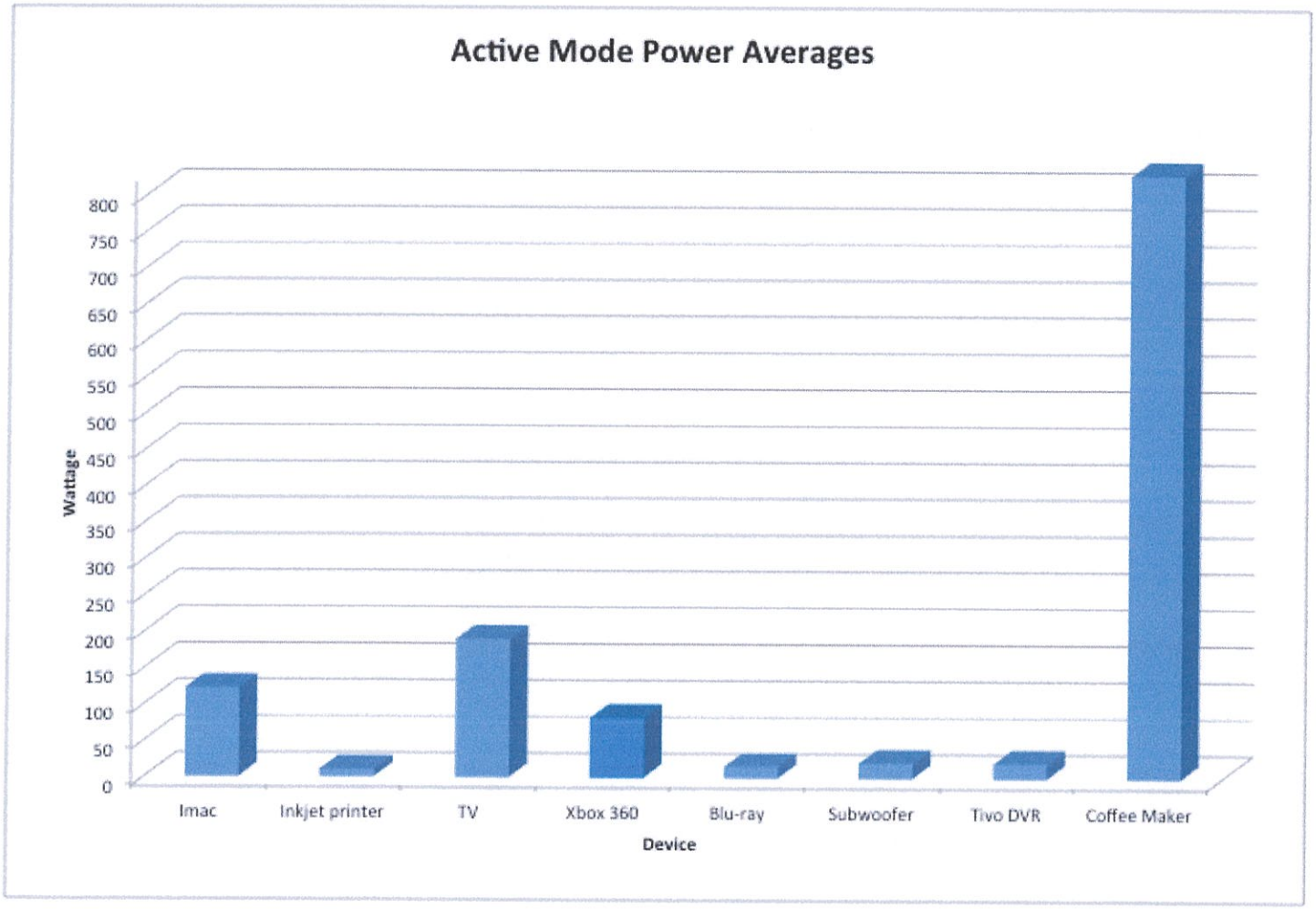
Results

Device	State	Trial#	0:00	0:30	1:00	1:30	2:00	2:30	3:00	3:30	4:00	4:30	5:00	Trial Averages	Mode averages
iMac	Active	1	106.0	115.0	123.0	120.0	125.0	126.0	121.0	122.0	127.0	126.0	124.0	121.4	122.0
		2	125.0	121.0	121.0	119.0	119.0	126.0	121.0	123.0	119.0	123.0	123.0	121.8	
		3	122.0	120.0	124.0	120.0	123.0	129.0	122.0	121.0	121.0	126.0	122.0	122.7	
iMac	Active Standby	1	1.7	1.5	1.7	1.8	1.7	1.3	1.6	1.8	1.9	1.7	1.7	1.7	1.7
		2	1.6	1.5	1.8	1.7	1.8	1.7	1.6	1.6	1.9	1.6	1.5	1.7	
		3	1.7	1.6	1.6	1.6	1.6	1.5	1.7	2.0	1.7	1.7	2.0	1.7	
iMac	Passive Standby	1	0.6	0.5	0.6	0.9	0.6	0.8	0.9	0.7	0.6	0.5	0.6	0.7	0.6
		2	0.6	0.5	0.6	0.6	0.7	0.8	0.5	0.5	0.6	0.7	0.5	0.6	
		3	0.8	0.9	0.6	0.6	0.6	0.6	0.5	0.5	0.9	0.8	0.6	0.7	
InkJet Printer	Active	1	6.3	11.0	11.2	11.0	10.8	11.0	8.3	10.5	11.1	11.0	11.2	10.3	10.3
		2	11.2	11.3	10.2	8.4	10.7	10.8	10.8	10.9	11.0	11.2	8.9	10.5	
		3	10.9	10.9	8.3	10.9	10.8	9.7	10.6	10.7	10.9	10.4	8.1	10.2	
InkJet Printer	Active Standby	1	4.4	4.4	4.3	4.4	4.3	4.3	2.8	2.8	2.8	2.8	2.8	3.6	3.0
		2	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	
		3	2.8	2.8	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.5	
InkJet Printer	Passive Standby	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
		3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
TV	Active	1	190.0	190.0	190.0	189.0	189.0	189.0	191.0	190.0	190.0	190.0	190.0	189.8	189.5
		2	190.0	190.0	189.0	189.0	190.0	189.0	190.0	190.0	189.0	190.0	190.0	189.6	
		3	189.0	191.0	190.0	190.0	190.0	190.0	190.0	189.0	189.0	189.0	184.0	189.2	
TV	Active Standby	1													
		2													
		3													
TV	Passive Standby	1	0.3	0.4	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
		2	0.4	0.4	0.4	0.3	0.4	0.4	0.4	0.4	0.3	0.4	0.4	0.4	
		3	0.4	0.4	0.4	0.3	0.4	0.4	0.4	0.3	0.3	0.4	0.3	0.4	
Xbox 360	Active	1	80.4	79.9	81.3	82.4	81.4	82.7	80.9	82.0	80.7	81.3	81.5	81.3	81.8
		2	81.6	78.9	80.8	82.0	82.2	81.9	81.2	81.7	83.0	82.0	81.1	81.5	
		3	80.4	82.9	82.3	82.9	86.3	83.1	80.7	83.2	81.5	82.7	82.6	82.6	
Xbox 360	Active Standby	1	68.6	69.1	69.4	66.7	66.6	67.1	67.0	67.2	67.4	67.4	67.6	67.6	67.8
		2	67.4	67.4	67.0	68.1	67.7	68.0	68.1	67.7	68.2	67.7	67.7	67.7	
		3	67.9	68.2	68.0	67.9	67.9	68.4	68.1	68.7	68.2	68.0	67.9	68.1	
Xbox 360	Passive Standby	1	0.0	0.0	0.3	0.0	0.0	0.3	0.0	0.0	0.3	0.0	0.3	0.1	0.1
		2	0.0	0.3	0.0	0.0	0.0	0.3	0.3	0.0	0.3	0.3	0.0	0.1	
		3	0.0	0.3	0.3	0.3	0.3	0.0	0.0	0.0	0.3	0.0	0.7	0.2	
Blu-Ray Player	Active	1	15.4	16.1	16.2	16.0	16.1	16.2	16.0	16.1	16.1	16.2	16.0	16.0	16.0
		2	16.0	15.9	15.9	15.9	16.0	15.9	15.9	15.9	15.9	15.9	15.9	15.9	
		3	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	
Blu-Ray Player	Active Standby	1	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.2	13.5	13.1	13.3
		2	13.0	13.0	13.1	13.1	13.1	13.0	13.1	13.2	13.1	13.6	13.5	13.2	
		3	13.5	13.6	13.5	13.5	13.5	13.7	13.6	13.5	13.6	13.6	13.5	13.6	
Blu-Ray Player	Passive Standby	1	0.3	0.4	0.3	0.3	0.4	0.4	0.3	0.3	0.4	0.3	0.4	0.3	0.3
		2	0.3	0.3	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.4	0.3	0.3	
		3	0.3	0.4	0.3	0.4	0.3	0.3	0.4	0.3	0.4	0.3	0.3	0.3	
Subwoofer	Active	1	20.4	20.6	20.6	20.7	20.6	20.8	20.9	20.8	20.8	20.9	20.9	20.7	21.0
		2	20.8	20.9	20.9	21.0	21.0	21.1	21.0	21.1	21.0	21.1	21.3	21.0	
		3	21.2	21.4	21.3	21.3	21.4	21.4	21.4	21.4	21.4	21.5	21.4	21.4	
Subwoofer	Active Standby	1	12.3	12.4	12.3	12.4	12.3	12.3	12.3	12.4	12.4	12.3	12.4	12.3	12.3
		2	12.3	12.3	12.2	12.2	12.3	12.3	12.3	12.3	12.3	12.2	12.3	12.3	
		3	12.3	12.3	12.3	12.3	12.4	12.4	12.3	12.3	12.3	12.1	12.3	12.3	
Subwoofer	Passive Standby	1	12.4	12.3	12.4	12.3	12.3	12.3	12.4	12.3	12.3	12.4	12.3	12.3	12.3
		2	12.3	12.3	12.3	12.2	12.3	12.3	12.3	12.3	12.3	12.2	12.3	12.3	
		3	12.4	12.3	12.4	12.4	12.4	12.3	12.3	12.4	12.3	12.3	12.4	12.4	

Device	State	Trial#	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	Trial Averages	Mode averages
TiVo DVR	Active	1	20.2	20.2	20.3	20.1	20.3	20.5	20.4	20.2	20.9	20.3	20.4	20.3	20.7
		2	20.4	20.3	20.8	20.7	20.8	20.5	20.4	20.2	20.9	20.3	20.4	20.5	
		3	21.2	21.4	21.3	21.3	21.4	21.4	21.4	21.4	21.4	21.5	21.4	21.4	
TiVo DVR	Active Standby	1													
		2													
		3													
TiVo DVR	Passive Standby	1	19.3	19.1	19.2	19.3	19.0	19.2	19.1	19.2	19.2	18.9	19.1	19.1	19.1
		2	19.1	19.2	19.1	19.1	19.2	19.0	19.0	19.1	19.1	19.2	19.2	19.1	
		3	19.1	19.1	19.1	19.1	19.1	19.2	18.9	19.3	19.1	19.1	19.0	19.1	
Coffee Maker	Active	1	858.0	854.0	854.0	852.0	851.0	851.0	854.0	854.0	854.0	854.0	854.0	853.6	828.6
		2	854.0	854.0	82.0	854.0	850.0	850.0	851.0	852.0	852.0	850.0	850.0	781.7	
		3	852.0	850.0	850.0	850.0	851.0	850.0	852.0	850.0	850.0	850.0	850.0	850.5	
Coffee Maker	Active Standby	1	0.5	0.5	0.3	0.5	0.6	0.4	0.6	0.5	0.7	856.0	0.4	78.3	52.2
		2	0.5	0.5	0.3	0.5	0.4	851.0	0.6	0.5	0.5	0.4	0.5	77.8	
		3	0.4	0.5	0.4	0.5	0.5	0.5	0.5	0.3	0.5	0.4	0.5	0.5	
Coffee Maker	Passive Standby	1	0.6	0.5	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
		2	0.6	0.5	0.4	0.4	0.5	0.4	0.4	0.4	0.4	0.5	0.5	0.5	
		3	0.5	0.5	0.5	0.5	0.5	0.6	0.5	0.5	0.5	0.5	0.6	0.5	

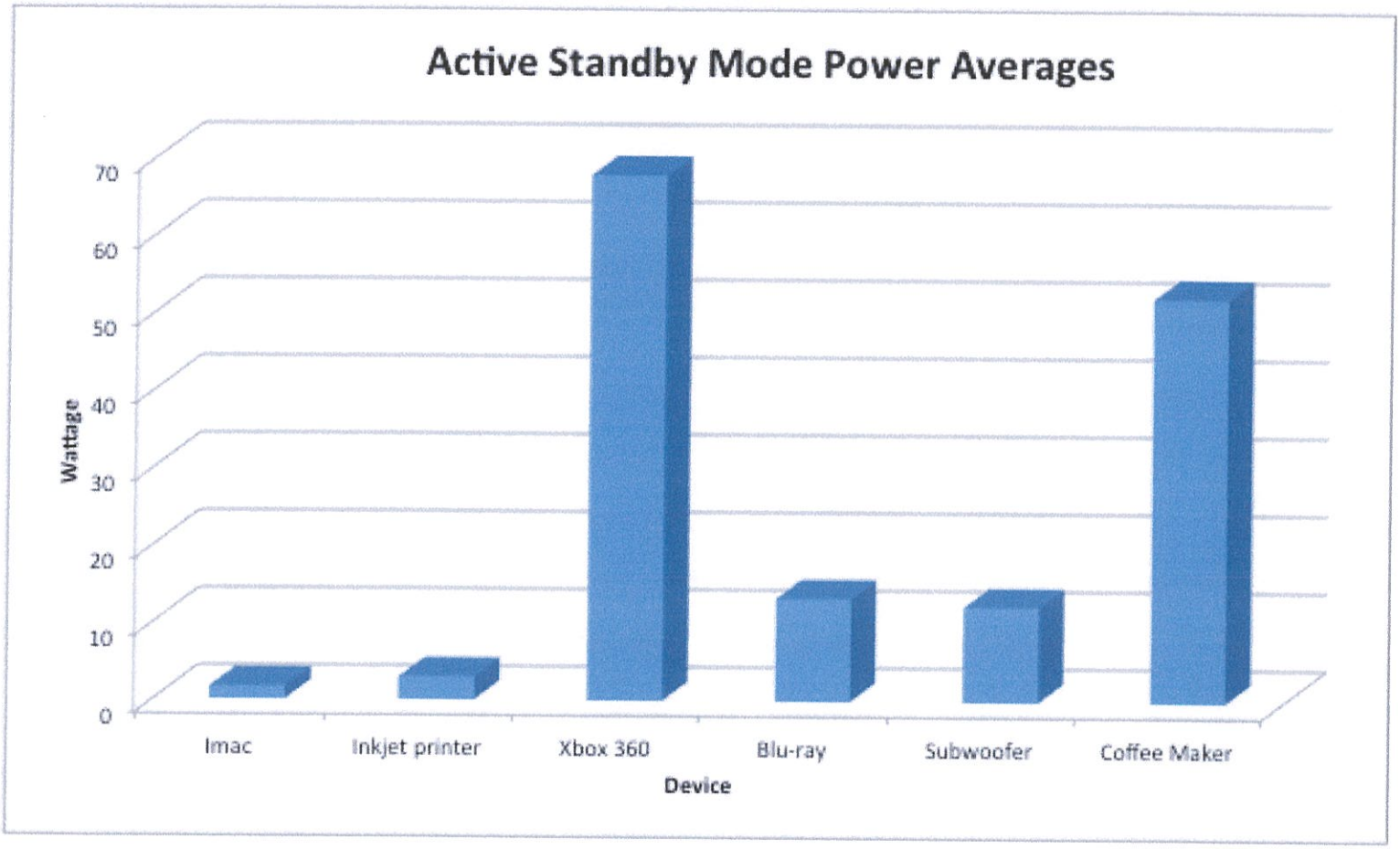
Active Mode

Device	Imac	Inkjet printer	TV	Xbox 360	Blu-ray	Subwoofer	Tivo DVR	Coffee Maker
Wattage	122.0	10.3	189.6	81.8	16.0	21.0	20.8	828.6



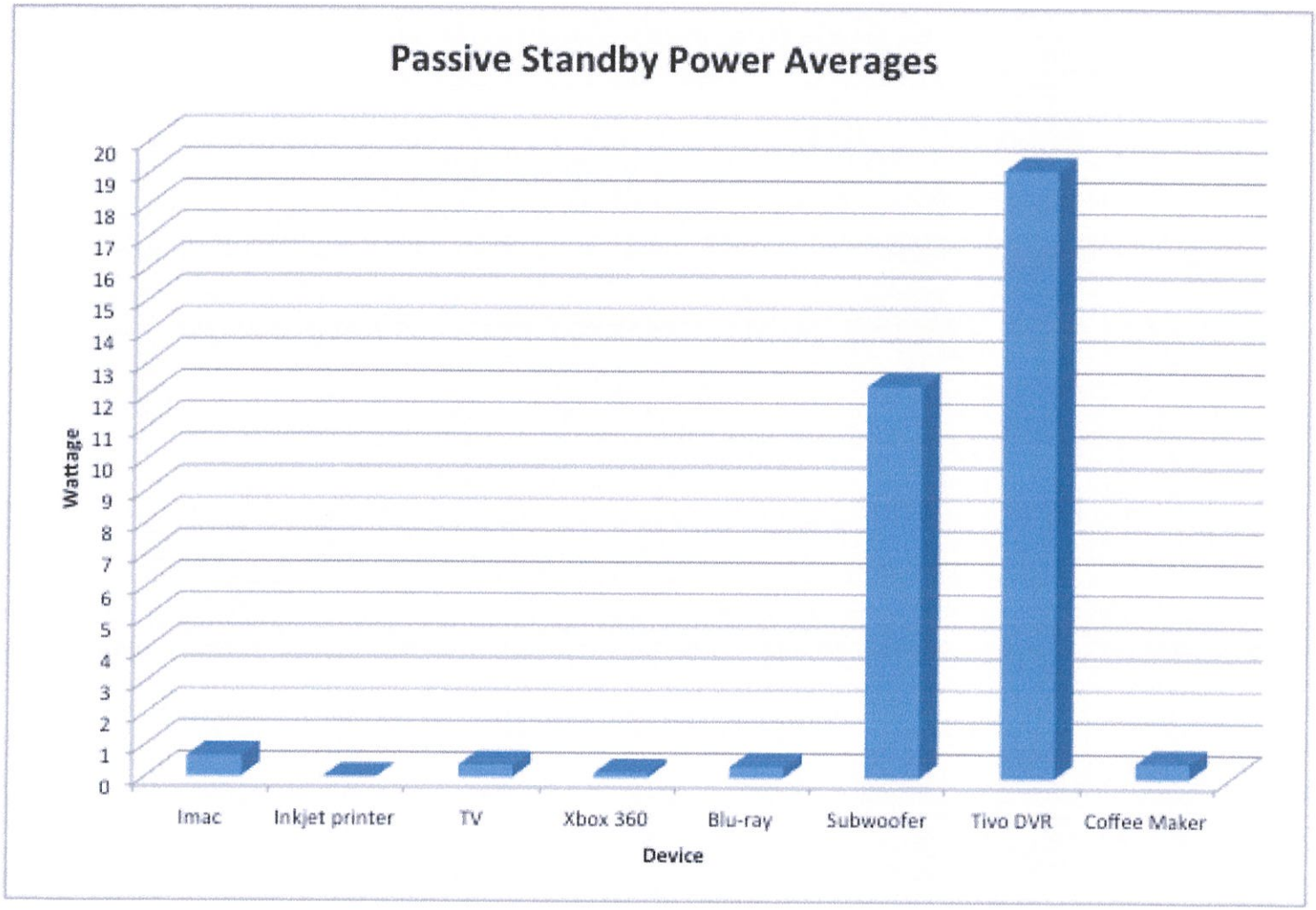
Active Standby

Device	Imac	Inkjet printer	Xbox 360	Blu-ray	Subwoofer	Coffee Maker
Wattage	1.7	3.0	67.8	13.3	12.3	52.2



Passive Standby

Device	Imac	Inkjet printer	TV	Xbox 360	Blu-ray	Subwoofer	Tivo DVR	Coffee Maker
Wattage	0.7	0.0	0.4	0.2	0.3	12.3	19.1	0.5



Interpretation of Data

My first graph shows the wattage the devices use when in active mode. I noticed that the coffee maker uses the most power by a significant amount. It uses 829 watts, which is 639 more watts than the television uses, which was the second greatest power consumer. I also noticed that the inkjet printer uses the least power with 10 watts. This is 818 watts less than the coffee maker, making the range on this graph rather large. My purpose is to find which device uses the most power in active standby and passive standby modes. However, to better understand these modes, I wanted to show the amount of power these devices use when people consider them "on" and "working".

My next graph shows the wattage the devices use when in active standby mode. It is clear to see from this graph, that the Xbox 360 uses the most power and that the iMac uses the least. The Xbox 360 uses 68 watts, which is 66 watts more than the iMac, which only uses 2 watts. This is because the iMac has a power saving "sleep mode", while the Xbox 360 does not. The TiVo DVR and the television are not present on this graph because they do not have an active standby mode.

My third and final graph shows the wattage the devices use when in passive standby mode. It is evident, that most electronic devices use very little power when considered "off". Surprisingly, the TiVo DVR uses about the same amount of power "off" as when "on". It uses 21 watts when it is "on" and 19 watts when it is "off". The subwoofer also uses a lot of power when not in use. It uses 12 watts when considered "off". The inkjet printer is the only device that uses no power (0 watts) when "off". This is because the other devices have a light on

Conclusion

In conclusion, my data does not support my hypothesis. I predicted that in active standby mode, the iMac computer would use the most power because it runs several programs. However, it actually uses the least amount of power because the iMac goes into a power saving mode. The Xbox, however, uses the most power while in active standby because it does not have a power saving mode. I also thought that in passive standby mode, the coffee maker would use the most power, but my testing proved that the TiVo DVR does. The coffee make uses the most power when actually brewing coffee, but uses minimal power when turned off. The low power simply keeps the digital clock running. The high amount of power the TiVo DVR uses when turned off is very surprising because it uses about the same number of watts as when active. I now realize that the DVR never truly turns off, it is always in a recording mode.

Energy efficiency and conservation are critical parts of today's society. Households are strongly encouraged to reduce the amount of power used on a daily basis. Some proactive actions are to purchase Energy Star products, have a Smart meter installed, or to simply unplug devices when not being used. The use of power strips that can be easily turned off is very convenient and helpful. In my house, the DVR and subwoofer are two electronic devices that can be turned off to save much energy and money.

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