Electronic appliances and devices are everywhere in the world, so that must mean we are using an unimaginable amount of power and energy to keep them powered. Even though that is not entirely false, some appliances and devices have incorporated low power computing and energy efficiency in their designs. For example, devices have a built in power saving mode, where the device will enter a standby or hibernation mode when not currently in use. Usually, the amount of power and energy consumed by devices and appliances are determined by the person who is using or controlling the device, but they don't realize the true amount of power being consumed. That is why this topic should become more well-known, which can expand the knowledge of those who are not aware of energy efficient techniques, and lead to an energy efficient and eco-friendly world.

Low power computing is the research area that is meant for creating and designing new hardware that has a lower power consumption rate, software that can save energy and implementing power efficient techniques to existing devices and systems [1]. When developing software that is energy efficient, algorithms that are implemented must work very efficiently so that the number of steps within the computing of the algorithm and steps to store data will be reduced. This will save power and plays a part in low-power computing [1]. Even though this area of research is not that widely known, some devices and appliances already have applied certain techniques and algorithms within them to become more energy and power efficient.

There are multiple strategies that we can implement low power computing and energy efficiency into current devices and systems. According to *The Influence of Computer Engineering on Energy Efficiency* [2], some example strategies are using smart energy management systems, implementing energy from renewable sources, designing energy efficient hardware and better managing the usage of power and energy. With smart energy management systems, we collect data in real time and use algorithms to determine the energy consumption in buildings or in vehicles, and we can determine where we can improve the efficiency of energy used. Then, the computer engineers can develop new algorithms to improve the previous algorithm, which will conserve energy and reduce waste in the end. Secondly, we can use renewable energy sources and integrate them into current systems to further improve on energy efficiency. Thanks to renewable energy, it will not affect the environment as much because this energy is generated naturally. We can then develop new algorithms, with the help of computer engineers, to organize and distribute the energy that is generated from those renewable sources. Thirdly, designing new hardware and software that is energy efficient impacts the environment less because less energy is used, but is spent efficiently. By optimizing the amount of power a piece of hardware consumes, it reduces the total energy consumption but improves the performance and lifetime of the system. Finally, people must learn how to manage their power and energy better. If we can learn how to manage our energy and power better, we can have our devices run at a higher efficiency while consuming less energy at a time. One of these techniques used in devices is called Dynamic Voltage and Frequency Scaling, which adjusts voltage and

frequency of computer hardware based on performance requirements [2]. This makes it so the device operates at a high enough level, with minimal power consumption. A good example of devices having a built in power management system is the sleep states, like standby or hibernation, which reduces the amount of power consumed during inactivity.

There are multiple companies and programs that exist already that are trying to promote energy efficiency and low power computing. *Energy Star* is one of the programs that is currently trying to promote energy efficiency. They grant labels to companies that have found ways to minimize the amount of energy spent, but maximizing the efficiency of the device. If you own a device that has the "Energy Star" label, you can already tell that the device or appliance is created in a company that designed it to be energy efficient. Some common appliances usually include refrigerators, freezers and drying or washing machines. People tend to buy the products with this label because they know that the product is energy efficient and will cost them less in the long run. Having a low utility cost is beneficial for both consumers and businesses because electricity prices continue to rise and some resources that are being used for power and energy are limited, like fossil fuels. So switching to renewable energy sources and implementing low power consumption strategies can lower the electricity cost, as well as be more eco friendly. Low power computing and energy efficiency is one of the easiest ways for the world to become more environmentally sustainable. This is because the computing world is always constantly trying to maximize the efficiency of devices but while also having the least impact on the environment possible. Because existing systems are constantly trying to improve this feature, the result will be a decrease in consumption of fossil fuels, which will also lead to a reduced environmental CO_2 footprint.

There are plenty of advancements in this area of research, like having longer device lifetime, meaning we can use devices for a longer period of time with the same optimal performance level. Having the lower power consumption rate means a substantial increase in battery lifetime, and people will be more inclined to buy that device in particular. Even though it may seem the lifetime is increased, it may come with some drawbacks. The technique that is usually used to reduce power consumption is by applying Dynamic Voltage and Frequency Scaling to the CPU voltage and clock rate. By reducing the voltage, the power consumption will also reduce, which is called undervolting, and is used in mobile device batteries. But because this technique reduces the voltage of the device, it can sometimes mean the performance is decreased and the time it takes to complete a task is increased. Another challenge being faced in the area of low power computing and energy efficiency is the lack of awareness and knowledge of this topic. Many people and businesses do not realize the true potential and benefits of energy efficiency and do not understand how to implement energy saving techniques in their lives. This results in less people wanting to install or purchase energy efficient appliances. For example, a European commission survey found that over 60% of european citizens are not aware of the energy efficiency directive, which is a policy aimed at improving energy efficiency within the

European union [4]. On the other hand, a survey conducted by the United States Department of Energy found that only 33% of Americans heard of the Energy Star program, a labeling program that promotes energy efficiency in appliances.

The most common appliances we see and use daily that are also usually energy efficient are in home insulation, LED bulbs and many more. The insulation found in homes are energy efficient because they reduce the amount of energy required to cool or heat a home. It can also help reduce the amount of heat that is transmitted from within the home to the outdoor environments [3]. With the help of insulation, we reduce the amount of power the air conditioning or heating units consume at once because the insulation keeps the heat out in summer and in during winter. LED light bulbs are considered the most energy efficient light bulbs to use in homes. This is because it does not cost as much, but can still produce good quality light. Another way someone can become energy efficient without energy efficient appliances is by using the devices to their most potential. An example of this is using a washing machine when it is full of dirty clothes once, instead of washing a half load of dirty clothes once.

Some buildings also incorporate energy efficient choices like automated controls, window placements or the usage of renewable energy sources. Automated control technology allows managers and owners to reduce energy consumption from lighting, heating or cooling during low operating hours. These technologies can include sensors and timers. We can also place windows in specific positions that can naturally give sunlight heating and cooling can make the building more energy efficient because you can take the natural light and heat instead of using lights or the heating system. We can also use the natural sunlight for solar panels, as they produce lots of energy that can be consumed by the person living in the building. An example of an energy efficient building is the Empire State Building. This cost to renovate the building cost $550 million, but managed to reduce the energy consumption cost by 38%. In 2012, the building managed to save 2.4 million dollars and kept 400 metric tons of carbon from the atmosphere [5].

In the end, low power computing and energy efficiency is a dedicated area of research where new hardware and software are being designed and improved to become more energy efficient. There are multiple techniques one can implement to become more energy efficient by using renewable energy as a reliable power source, like sunlight. There are many people who are unaware of this area of research and the energy efficient companies, like Energy Star, that labels appliances as energy efficient. But some appliances that are energy efficient might already be in their houses and are unaware, like insulation or LED light bulbs as they are the most efficient these days. So in the end, it is very easy to become a homeowner with an energy efficient home with energy efficient appliances, all with a little bit of research can make you that much more eco friendly and energy efficient.

References

LOW-POWER COMPUTING.
https://apiar.org.au/wp-content/uploads/2016/12/4_ICTP_OCT16_BRR727_ICT_39-50.pdf

February 07, 2024. *The Influence of Computer Engineering on Energy Efficiency.*
https://moldstud.com/articles/p-the-influence-of-computer-engineering-on-energy-efficiency#:~:t
ext=Energy%2DEfficient%20Processors&text=Computer%20engineers%20have%20made%20s
ignificant,leakage%20and%20increase%20energy%20efficiency.

July 06, 2023. *Overview of Energy-Efficient Technologies: Energy.*
https://www.usaid.gov/energy/efficiency/basics/technologies

April 12, 2023. *Energy Efficiency: Challenges and Solutions.*
https://energycentral.com/c/ee/energy-efficiency-challenges-and-solutions

Top Energy Efficiency Examples: Energy Conservation: Greenesa.
https://greenesa.com/blog/top-energy-efficiency-examples