ENERGY CONSERVATION

First step to moving to Carbon Net Zero

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KENSON GROUP CARBON NET ZERO CAPABILITY PORTFOLIO

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ABSTRACT

A review of the published literature on the theory and practice of Energy Conservation was conducted. The purpose of this review was to assess relevant information on the application of Energy Conservation as a step in moving to a net carbon zero environment. This research is part of the overall Kenson Group Carbon Net Zero Capability Portfolio that positions Kenson as a viable provider in this area.

It was found that electricity is the biggest source of energy used by humans and currently is generated primarily through the burning of the fossil fuels, i.e. coal, oil and natural gas. The combustion of these fossil fuels results in the production of the harmful greenhouse gas carbon dioxide even as these fuels are a non-renewable source of energy i.e. it does not get replenished once. As a result, practicing energy conservation will not only prolong the life cycle of our fossil fuels but subsequently reduce the amount of carbon dioxide being emitted in the environment.

Energy Conservation is the process of reducing consumption either through reduction in demand or improvement in efficiency in generation and is the first step to combating climate change. Reducing energy usage will help in the reduction of electricity being produced and thus require fewer fossil fuels to be burnt.

Energy conservation is done through numerous ways:

- Replacing less efficient light fixtures with higher efficient LED lights that produce the same amount of light using less energy
- Turning off all lights and computers and other electrical equipment once not in use to prevent phantom charges
- Replacing old technologies with newer more efficient ones
- Conducting an energy audit

Examples of energy conservation and energy auditing were found in India, where an audit was conducted on a school to reduce their overall energy usage by implementing more efficient lighting fixtures and fans. It was found that 823.78 kWh were saved per year with the new, efficient equipment. It was also found that an additional 222.30 kWh were saved by implementing a sensor-based switching model that automatically turned on and off the lights and fans according to the levels of infrared radiation picked up by the presence of humans. In total, an overall energy saving of 55.3% or 1045.4kWh was achieved by implementing these two energy efficient features which can be translated into bigger annual cost savings.

1.0 INTRODUCTION AND BACKGROUND

1.1 Fossil Fuels

Coal was used as a source of energy dating back to the 1880's during the civil war, where factories burnt it to provide electricity to make weapons for American soldiers. This marked the beginning of the long and prosperous trade of fossil fuels. Fossil fuels are created through the decomposition of plants and other organisms that were buried beneath layers of sedimentary rock and took millenniums to become the carbon-rich deposits we know as fossil fuels. These non-renewable fuels include coal, oil and natural gas. They supply 80% of the worlds' energy; electricity, heat and transportation and still currently fuel the processes that make up a huge range of products from steel to plastic.

1.1.1 Coal

Coal formed during the Carboniferous period 300 million years ago, when algae and debris from vegetation settled deeper and deeper under layers of mud. It exists naturally as black or brown chunks of sedimentary rocks that range from crumbly to relatively hard. Currently, coal supplies one third of the worldwide energy, with the top coal consumers and producers in 2018 being China, India and the United States. Coal is split up into 4 categories:

- Anthracite
- Bituminous
- Sub-bituminous
- Lignite

These vary according to their individual carbon content. Out of the three discussed fossil fuels, coal contributes 44 % to the worlds' total of CO2 emissions. The health and environmental consequences of coal use coupled with the competition from cheap natural gas, has resulted in its decline in the United States and elsewhere.

1.1.2 Oil

Crude oil was formed in the Mesozoic period dating back 200 million years ago when plankton and algae sank to the bottom of the sea and was eventually buried. It is a liquid composed mainly of carbon and hydrogen but exists in a variety of viscosities and colours, depending on its chemical composition. Crude oil, unlike coal, is extracted from both onshore and offshore wells. It is then refined to provide a variety of petroleum products such as diesel and gasoline. The United States, Saudi Arabia and Russia are the top oil-producing countries in the world accounting for about 40 percent of the world's supply.

The burning of these petroleum products contributes to nearly half of the carbon emissions in the United States alone and about one third of the global contribution. Besides the emissions from the burning of these products, major incidents have occurred within the industry regarding to oil spills.

Three of the biggest incidents were:

- Exxon Valdez Spill in 1989
- The Deepwater Horizon Disaster in 2010
- Lac Megantic Oil Train Derailment in 2013

Despite these negative impacts the demand for oil continues to rise.

1.1.3 Natural Gas

Natural gas was formed millions of years ago from decaying plant matter and other organisms. It exists as an odorless gas composed mainly of methane. Natural gas has been the sibling of oil as they surged in production in the United States over the past two decades due to the advancement in drilling technologies and techniques such as fracking. By combining fracking with horizontal drilling, the fossil fuel industry has managed to gain access to resources that before were impossible to reach due to how expensive the process was. As a result of this, natural gas too has surpassed coal in becoming the top fuel used for the production of electricity in the United States. Natural gas however, is a cleaner fuel over its counterparts, oil and coal. Burning it still contributes to carbon emission but this contribution only accounts for one fifth of the world's total emissions. Natural gas is said to be the bridge fuel to the upcoming new industry of renewables.

1.2 Impact and Reaction to Fossil Fuels

1.2.1 Global Warming

Presently, global warming has become a major battle which the world is facing. The negligence of humans has resulted in the world having a temperature increase of 1.5 ° Celsius. If the production and use of the above-mentioned fossil fuels continues, the world will be in a very dangerous place in the near future.

With that being understood, governments around the world have come together to engage efforts to ramp down greenhouse gas emissions from fossil fuels. At an international level, countries have committed to emission reduction by signing onto the 2015 Paris Agreement.

1.2.2 Paris Agreement

The Paris agreement is a legally binding international treaty on climate change. 196 countries have signed onto it agreeing to move towards carbon net zero. The goal of the initiative is to move the world away from climate change by limiting global warming to well below 2 degrees Celsius. To reach this goal, countries aim to avoid global peaking of greenhouse gas emissions as soon as possible to achieve a climate neutral world by mid-century. In keeping with this, part of what needs to be done is Energy conservation.

Energy conservation is the process of reducing demand on a limited supply and enabling that supply to begin to rebuild itself. In the case of fossil fuels, conservation would be to find new ways to tap into the earth's supply so that the oil fields are not drained completely. This thus allows the fields to replenish themselves over 100's of years. Conservation can also be practiced in our personal homes and office buildings. This research paper will clearly identify ways of practicing energy conservation in our households and our offices along with a study done in India that provides data on an energy audit done in a secondary school and how they were able to cut down their energy usage.

2.0 Research Methodology

Energy conservation at home and in the office are quite similar and both have proven to help in terms of using less energy and subsequently saving on utility bills.

Some of the common areas of practicing energy conservation are:

2.1 Lighting

It is quite a common bad habit to leave a room and forget to turn off our lights, fans and AC units. However, we often don't understand how much energy these use in our absence.

Here are some conservative practices to undertake:

- Turn off all electricals when leaving a room; not only does this practice save on electricity but it also extends the overall life of the equipment. Living in Trinidad and Tobago, we have access to the sun for the better part of 12 hours a day. Choosing to use this natural lighting over artificial lighting can reduce your monthly electricity bill.
- Replace inefficient and outdated lighting within your building. When replacing these older lighting fixtures consider upgrading to newer technologies that would require less fixtures or fewer lamps but provide the same amount of lighting.
- Replace less efficient incandescent lamps with compact fluorescent lamps. These fluorescent lamps are 4 to 6 times more efficient than its said counterpart. Replacing incandescent "EXIT" signs with LED signs is also a good practice as LEDs use about one-tenth the wattage and lasts 50 times longer than incandescent lamps.
- Install lighting occupancy sensors that automatically turn the lights on and off depending on occupancy in its vicinity. These work especially well in conference rooms, break rooms or individual offices.

2.2 Heating and Cooling

Establish a maintenance program for your HVAC equipment (Heating, Venting and Air Conditioning):

- Replace all defective equipment, piping, insulation and ducting.
- Clean all heat exchanger surfaces such as refrigerator coils, condensers and evaporators
- Clean and change accordingly all air filters
- Repair any leaks in air ducts, fittings, piping and coils.
- Replace failed motors with premium efficiency motors that operate at a lower annual cost.
- To further reduce energy use, install variable speed drives on large motor loads.
- All Air Conditioning units have an efficiency rating. When purchasing or replacing, look for ones that have a high energy efficiency ratio of 10.5 or more as these will aid in reducing operating costs for the units' life cycle.
- Make sure and ask your AC contractor to perform a "Manual N'' calculation to properly select the right size system for your specific building load characteristics.
- Manual N Calculations are done as follows:

  First determine the square footage of the vicinity where the unit is going to be placed.

- Second is to determine the base BTU (BTU is the unit used to measure energy used for heating and cooling). The approximate amount of energy used to cool a square footage is 25 BTUs, so multiply this by your overall square footage from part 1 above to get your overall BTUs.
- Thirdly account for high ceilings: if the room has walls that are over 8 feet multiply the BTU calculated in part 2 by 1.25 or 25%.

2.3 Temperature Control

- In the Caribbean, we experience a hot climate all the time. Thermostats can be set between 20 and 25 degrees during the day/business hours and above 26 degrees during unoccupied hours.
- Install programmable thermostats that automatically adjust temperature settings based on the time of day and day of the week.
- Bigger facilities should consider investing in Energy Management Systems (EMS) to help monitor, control and carry out optimal energy management. Their purpose is to determine power generation or power demands that minimize objectives such as generation cost, power loss or environmental effect.

2.4 Office Equipment

- Leaving laptops and computers on is not only bad for electricity conservation but it also contributes to a small heat gain in the building resulting in AC Units having to work harder.
- Print only when necessary, apart from paper wastage this also helps cut the total amount of energy consumed by the printer.
- Adding a built-in power management system in your office can help in saving energy during periods of inactivity.
- Changing from Desktops to Laptops can help in saving 80-90% in electrical costs
- Plug load controllers should be installed in work cubicles as they help control multiple loads like monitors, task lights and fans. These devices use a motion sensor that exists with a plug load surge suppressor. This means inactive equipment can be shut down when the workstation is unoccupied.

2.5 Promote Sustainability in the Workplace

Despite following the guidelines above, nothing will change unless employees or family members really understand the importance and benefits of practicing energy conservation. Ways of promoting this sustainability throughout the company is by:

- Sending out reminders for everyone to always check that their computers are turned off and unplugged at the end of each day.
- Have them partake in energy conservation questionnaires and quizzes as this will promote self-learning and development.

Conserving more energy means improving your business profitability, helps with environmental conservation by lessening carbon pollution, improves your business' reputation and has a positive effect on your company's image and brand.

3.0 Energy Conservation in India

In 2013 India was deemed the largest producer of electricity, surpassing Japan and Russia, with a global share of 4.8% in power generation. The power generation was divided into 28.43% in renewable energy and 71.57% in non-renewable energy. Energy demand is forever growing in India with estimations of 1,392 Terawatt Hours in 2016-17 and 1,915 Terawatt Hours in 2021-2022. With the increase in demand means an increase in losses as energy is lost in transmission and distribution. India would need to add 135GW of power Generation before 2017 to keep up with the surge in energy demand.

Energy conservation campaigns have proven to be the best solution for this ever-raising energy demand. Energy conservation is using less of an energy source. Conducting an energy audit is the most efficient service which investigates the possible ways of energy conservation in a building or a system without negative output. This paper proposes the idea of reducing energy consumption in a common space such as a classroom.

The classroom discussed here is a 129.53 square foot room that can house 60 students. The classroom had 9 ceiling fans and 9 fluorescent lamps.

The following table shows the power ratings of these appliances

TABLE I
POWER CONSUMPTION OF APPLIANCES

Electrical appliances	Quantity	Power rating of the appliances (watts)	Installed capacity (watts)	Actual power consumption (watts)
Ceiling Fan	9	60	540	720
Fluorescent lamp	9	40	360	450
Total				1170

Considering all school days in a month (22 days), maximum time spent in school (8 hours) and school months in a year (10) the annual and monthly energy consumption was 2059.6 kWh and 2059.3 kWh respectively. This worked out to have an annual cost of Rs 12,355.80 for one classroom. The school being audited has 45 classrooms.

To minimize the consumption and therefore reduce overall annual cost energy, efficient appliances were recommended to replace the existing old ones along with a sensor-based switching model that can turn on and off lights and fans when required.

The Bureau of Energy Efficiency was created by the Indian Government to assist in the development of policies and strategies to aid in energy conservation. The BEE created a star model that implies a product's energy performance in the form of energy consumption. The ratings range from 1 star to 5 stars with a 5-star rating meaning highest efficiency.

A star rating table for Ceiling fans and fluorescent bulbs can be seen below:

TABLE II
STAR RATING OF CEILING FANS

Star Rating Index Calculation for Ceiling Fans	
Star Rating	**Service Value for Ceiling Fans**
1 Star	≥ 3.2 to < 3.4
2 Star	≥ 3.4 to < 3.6
3 Star	≥ 3.6 to < 3.8
4 Star	≥ 3.8 to < 4.0
5 Star	≥ 4.0

The star rating for Fluorescent bulbs is:

Table III STAR RATING OF FLUORESCENT BULBS

	hrs of use	hrs of use	hrs of use
1 Star	<61	<52	<49
2 Star	>=61 & <67	>=52 & <57	>=49 & <54
3 Star	>=67 & <86	>=57 & <77	>=54 & <73
4 Star	>=86 & <92	>=77 & <83	>=73 & <78
5 Star	>=92	>=83	>=78

As you can see by the tables the higher the star level the higher the efficiency and therefore the higher the energy conservation. With this being understood the existing appliances were going to be replaced by higher rating, more efficient appliances.

The table below will show the difference in power consumption between the two.

TABLE IV
DIFFERNCE IN POWER CONSUMPTION WITH 5 STAR RATED APPLIANCES

Electrical Appliance	Quantity	Power rating in watts	Power Consumption with 5 star rated appliances (watts)	Power consumption with present appliances (watts)	Difference in power consumption (watts)
5 star ceiling fan	9	50	450	720	270
5 star fluorescent lamp	9	28	252	450	198
Total			702	1170	468

With the implementation of the new more efficient appliances for the same timeline as before of 22 school days in a month, 8 hours spent at the institute and 10 school months of the year the power consumption dropped to 1235.52 kWh monthly and 1,235.52 kWh annually. This then has resulted in the cost per year dropping to Rs. 7,413.12.

The table below shows the energy savings.

Electric Appliance	Energy Consumption of Existing Appliances	Energy Consumption of 5 Star Appliances	Percent Saved with 5 Star Appliances
Ceiling Fan	720W	450W	
Fluorescent Lamps	450W	252W	
Month Total	205.92kW	123.55kW	
Year Total	2059.20kW	1235.52kW	40%

Sensor based switching model

The intention behind the sensor-based switching model is to minimize energy usage by automatically switching on and off switches when required. Once motion is detected such as students inside a classroom the switch will be switched on providing them adequate lighting and breeze. However, when classes are finished and students leave, the sensor will not pick up on any motion and therefore turn off all lighting fixtures and fans thereby conserving energy. This model sensor uses a Passive Infrared Sensor or PIR for short. PIR sensors detect changes in the amount of infrared radiation impinging upon it. This then varies according to temperature and surface characteristics of objects in front the sensor. A human passing close to the sensor changes the air temperature around it to body temperature. This change in temperature triggers the sensor to turn on whatever it is attached to.

The basic circuit of a sensor-based switching model is shown below:

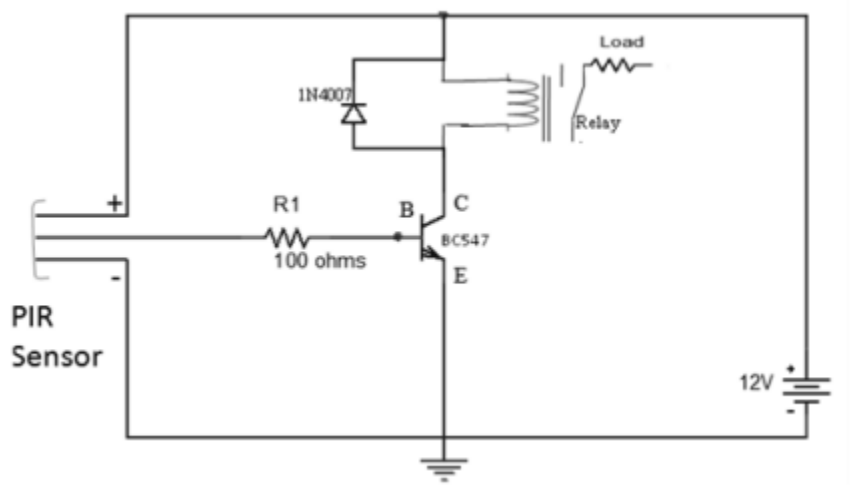


Figure 1 Circuit Diagram of the sensor-based switching model

The implementation of these sensors coupled with the installation of newer more efficient appliances has resulted in the following energy savings:

TABLE VI
ENERGY CONSUMPTION AFTER THE SENSOR BASED SWITCHING SYSTEM IS INSTALLED

Electric appliance	Energy consumption with the existing system per month (kWh)	Energy consumption with 5 star rated appliances per month(kWh)	Energy consumption with the sensor based switching system per month(kWh)
Ceiling fan	126.72	79.2	67.05
Fluorescent lamp	79.2	44.35	37.548
Total	205.92	123.55	104.598

Table VII ENERGY SAVING AFTER SENSOR BASED SWITCHING SYSTEM IS INSTALLED

Electric Appliance	Energy Consumption with Sensor Based Switching System/KWh	Energy Consumption with Energy Saving Appliances/KWh	Percentage Saved with both SBSS and Energy Saving Appliances/%
Ceiling Fan	67.05	79.2	
Fluorescent Lamp	37.54	44.35	
Month Total	104.59	123.55	
Year Total	1045.98	1235.52	15.3

4.0 Analysis and Discussion

The literature chosen discussed practical ways on how one can conserve energy in the office space and in your home. The Primary categories to achieve energy conservation was lighting, office equipment and maintenance of equipment. Acts such as:

- Taking off lights and equipment once finished or leaving a room
- Replacing old equipment with newer more efficient ones
- Servicing existing equipment to ensure they're running at maximum efficiency

are the primary ways of conserving energy and thereby cost savings. Later, a study conducted in India showed that by applying these practices to real life situations energy savings and cost savings could be achieved. The Indian school begun by replacing their older ceiling fans and lights with ones that had a higher efficiency rating according to the Bureau of Energy Efficiency. The older equipment had an annual energy usage of 2059.3kWh while the newer ones only used 1235.2kWh. This provided them with annual energy savings of 823.7kWh. Further savings was achieved through the implementation of a sensor-based switching system. This system worked by turning on and off the lights and fans due to the amount of infrared radiation gotten from the presence and movement of humans in its vicinity. By adding this further energy savings of 222kWh were received. The data suggests that by practicing these conservation methods you can lower your energy bill by 55.3% totaling up to 1045.4kWh of saved energy annually (Cost savings can be derived by multiplying your countries currency by their per kWh). Note must be taken to the fact that this number is drawn specifically from ceiling fans and lights and therefore is subject to change according to what equipment is being used.

CONCLUSIONS & RECOMMENDATIONS

Energy Conservation is the process of reducing demand on a limited energy supply and finding alternatives that provide the same end product by using less energy. It was seen that conserving energy comes in many ways:

- Lighting
- Heating and Cooling Spaces
- Temperature Control
- Office Equipment
- Promotion of Sustainability in the Workplace
- Conduct Energy Audits

It was shown in the Indian school case study that by implementing some of the above energy saving methods that up to 1045.4kWh of power can be saved annually. These savings will not only contribute to less fossil fuels being burned but subsequently a reduction in the greenhouse gas carbon dioxide. Although the renewable energy industry is growing to replace fossil fuels as the primary source of energy, we as individuals and corporations need to be more liable for our energy consumption to aid in this transition period. By following these steps and procedures, we can begin slowly reducing our carbon footprint on our planet so by midcentury we can achieve carbon net zero.

Energy conservation is the first stepping-stone in the movement toward carbon neutrality. However, as seen it incorporates a lot of steps. We at Kenson have taken it upon ourselves to map out the best route to take in order to achieve this within your own business or home.

I. *Begin with Educating your employees/family members:* Education is the first step in achieving Energy Conservation as getting them to understand the importance of it and need for it sets a fantastic foundation for the next few steps.
II. *Start Small:* Focus on the smaller things first such as turning off lights, computers and air conditioning once leaving a room and fixing all leaks whether it be piping leaks or air leaks in an Air-conditioned room.
III. *Conduct an Energy Audit:* Get an audit done on your building. This will provide you with the relevant information on your energy usage.
IV. *Change out inefficient equipment with more efficient ones:* Once the audit is done you will be able to see where you can cut down on your energy use. Replacing incandescent bulbs with LEDs and replacing older equipment with newer more efficient ones is a great place to start.

By following these steps, you will be doing your part in contributing to the movement to carbon neutrality and thereby combating climate change.

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