Sustainable Energy and Innovation at The University of Toronto Scarborough

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Abstract

Concerns about climate change, the rising costs and demand of energy have increased interest in understanding various renewable and highly efficient energy techniques. Energy is a vital input for social and economic development. As a result, many activities such as agricultural and industrial practices demand for renewable energy. Several technologies have been developed and implemented at the University of Toronto Scarborough ("UTSC"). The main goal of these technologies is to reduce the demand associated with the maintenance of acceptable levels for many buildings. Energy conservation measures are developed for many of the newly constructed buildings and for buildings under refurbishment at UTSC. Buildings must successfully pass a standard energy efficiency test to become LEED Gold Certified. Overall, innovative techniques should be understood, and implemented across various buildings around the world. Researching the materials used in UTSC's infrastructure will contribute to the progress towards a sustainable future based on energy production, consumption and better energy management systems.

Keywords**:** Sustainability, Architecture, Energy Production and Consumption, LEED Gold Standards

Introduction

UTSC was built in 1964 when environmental concerns were not factored into how the buildings were constructed. In the current climate change discourse, sustainability has become a prime focus of recent developments. The purpose of this study was to determine whether the UTSC campus is sustainable by evaluating different aspects of its construction and energy use practices. Our hypothesis is that the oldest buildings, including the Humanities and Science Wing, would not be considered sustainable because of the lack of environmental concern during their construction compared to new buildings such as the Pan Am Sports Centre or the Environmental Science and Chemistry buildings. To do this, we will compare the architecture and energy production and consumption at different phases of development at UTSC. This study is important for the future of development at UTSC and in addressing some of the present design flaws that should be addressed to save energy.

Methods

In order to understand if UTSC is sustainable or not, research was split into two main streams. The first objective is to understand the architecture of UTSC and how that may affect how energy is used and to what degree. One of the most obvious architectural aspects of UTSC is the concrete on the outside and inside of the wall of the older buildings. The observation of UTSC as the first step in addressing the architecture allows us to conduct online research on the conductivity and heat transfer of the material (Prenhall, 2019). The same process is conducted for the conductivity of the large glass windows that construct another large portion of the walls.

The next objective is to measure the amounts of energy used for different purposes including heating and cooling. Online research was our primary source for information

considering that the Sustainability Office at UTSC is currently undergoing changes in management and was unavailable for support.

To measure the degree of sustainability of new buildings on campus including the Environmental Science and Chemistry building ("ESCB") and the Pan Am Sports Centre ("TPASC"), we consider the LEED green standards as a rubric. The 'Energy and Atmosphere' section of the LEED Canada checklist takes into consideration the minimum energy requirements, the optimal energy performance, and the implementation of green energy sources (LEED Green, 2019). As another measure of UTSC's sustainability, this data is compared with those from UofT St. George and University of Toronto Mississauga Campus (UTM), McMaster University in Hamilton, Ontario, and consider which strategies they use to practice sustainability. These universities were chosen because all the facilities share similar climate conditions.

Results

At UTSC, the six main uses for energy are heating, cooling, heating water, fans/pumps, receptacles, and lighting. In comparison to municipal standards, UTSC excels at limiting energy consumption despite the size of its buildings and human traffic.

Architecture

To raise the standards for living in developed countries, 35% of all energy use comes from buildings (Semantic Scholar, 2009). When temperatures outside the building fluctuate, the temperatures inside must also change in order to maintain a comfortable limit, and this becomes the top reason for energy use. Seasonality, including the temperatures outside the buildings,

should then play a factor in how our buildings are designed. For example, in Toronto we experience long and very cold winters, thus increasing the heat energy used. As mentioned earlier, UTSC uses a lot of its energy towards this very process. Much of the campus is built with concrete, especially the older buildings. This might be a large contributor to the amount of energy used in heating the campus, because concrete is not an ideal thermal insulating material. Certain materials are chosen to be used for the walls of certain buildings because of their ability to resist heat flow between both sides of the wall, evaluated by their 'R' value (Prenhall, 2019). The higher the R value, the greater the resistance to heat flow, concrete.

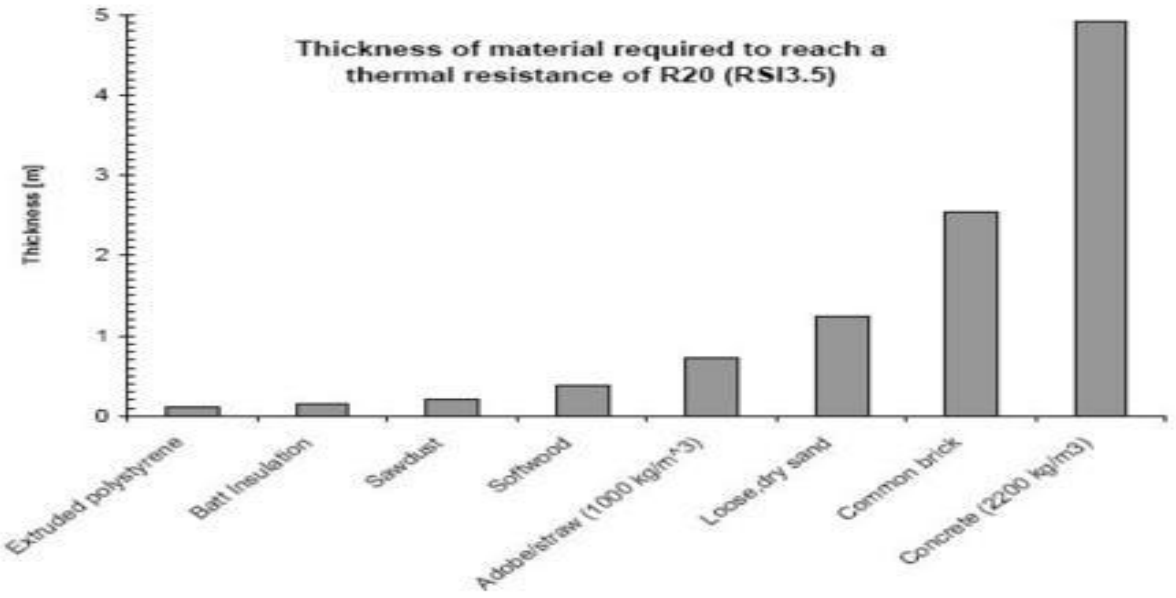


Figure 1: A comparison of how dense different insulating materials must be to reach a thermal resistance value of R20 (Prenhall, 2019).

According to Figure 1, the thickness of concrete is significantly greater than those of other materials, suggesting that concrete must have a very low R-value, thus making it a less than ideal insulator. Since Concrete has a very low R-value, massive amounts of it are required to

maintain thermal resistance, evident in the dense walls of UTSC (Prenhall, 2019). If the data were available, we would be able to assess just how dense the concrete in the walls are to determine whether it is an effective insulator on campus. Regardless, the quantities in which it is required to maintain heat within the buildings suggests that concrete is not an efficient insulator. In combination with the fact that UTSC must generate massive amounts of heat energy in the winter, there is insufficient data to conclude that UTSC's concrete design is not effective in minimizing the amount of heat produced.

Another common material that is used on the walls of UTSC buildings is glass, cold to the touch in the winter, and hot in the summer as it allows the sun's rays to heat up the building. Again, since the actual type of glass used on campus is not public knowledge, we were not able to assess whether it is a good material to use in terms of energy conservation. Based on our observations alone however, we were able to notice that the glass in older buildings such as HW and SW became quite cold in the winter, suggesting that there was significant heat loss through means of thermal conduction via the large windows. In response to this, our team could only hope that the windows were treated with a glaze that would maximize its insulating strength (Ecostar Insulation, 2019).

Energy Consumption and Production

UTSC was founded in 1964 and throughout the years as it grew larger, environmental responsibility and sustainability were not a key focus in the development of its buildings and resources. The first instance of environmental responsibility playing an important role in design was the Joan Foley Hall which is a student residence and was opened in 2003. From there on out

the newer additions to the campus in demand of the growing student population continued to keep environmental sustainability in mind with the Student Centre earning a LEED Silver status. Environmental sustainability played an important role in the design as architects worked closely with student stakeholders exploring innovative techniques to support the efficient use of energy and resources. The sustainability office was not established until 2007, it was meant to promote environmental awareness and measures in daily operations. The Instructional Centre was opened in 2011 and earned a LEED Silver status, featuring green roofs and solar panels. TPASC was opened in 2015 and was UofT's first building to be awarded the LEED Gold status by the Canadian Green Building Council. In 2016 the Environmental Science and Chemistry Building (ESCB) was opened and was built to the highest of environmental standards, featuring many aspects that contribute to lowering energy consumption. It was also awarded a LEED Gold status.

The ESCB and TPASC can be used as models of some of the best energy-efficient features and can possibly be used to apply similar features throughout the campus. These features include solar panels, geothermal heat pumps and wells, earth tubes, high-performance envelopes, and fritted glazed windows. The highest amount of energy is used towards heating and cooling at the campus and these features lower the amount of energy required to do so by a comparable amount (99% of cooling and 40% of heating).

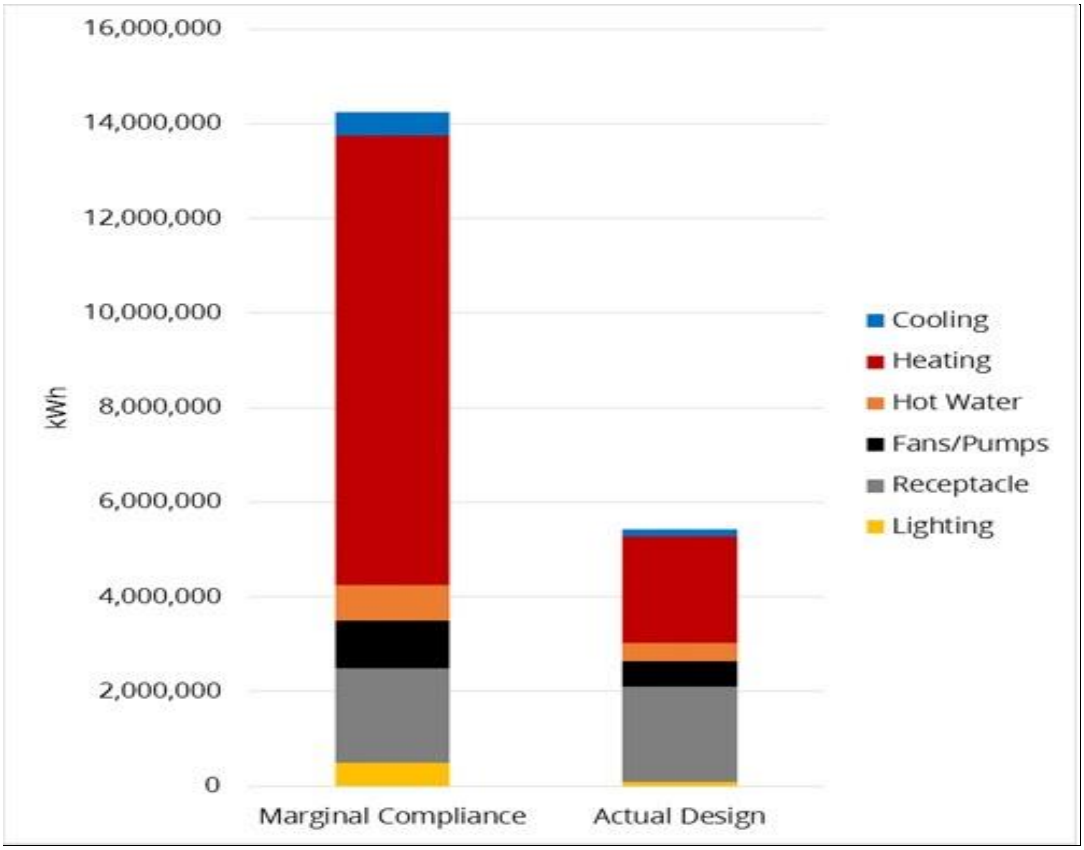


Figure 2. Energy consumption under the cities compliance vs. energy consumption achieved with features notable of the ESCB (ESCB, 2020)

The TPASC features its own geothermal field as well as many solar panels which replace a large amount of its own energy usage. We decided to look at McMaster University as it was the first university in Ontario to develop and implement a sustainable building policy. Their policy ensures that all new buildings on campus will have a minimum of LEED silver status.

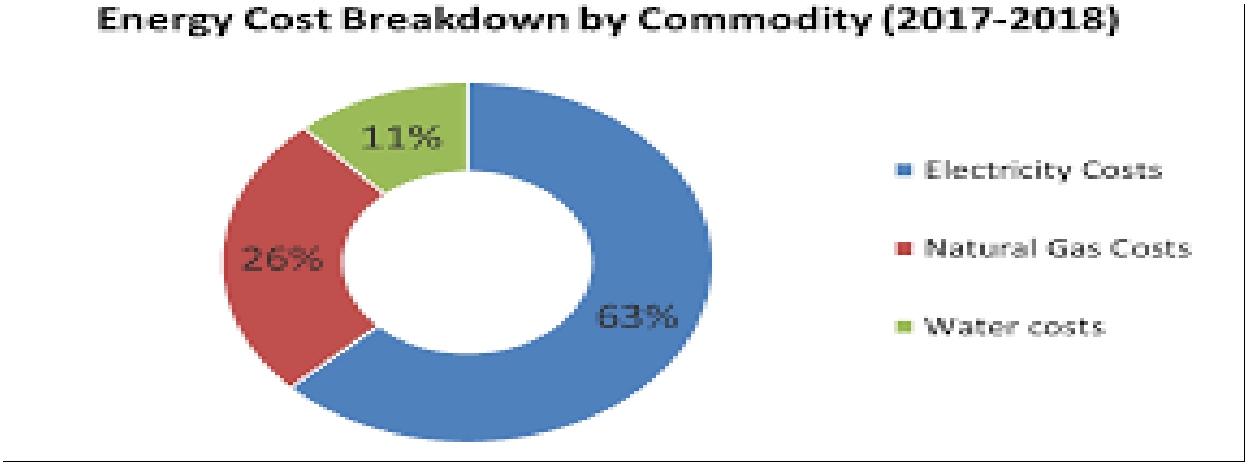


Figure 3. Energy costs at McMaster University (McMaster Energy Management Plan, 2016).

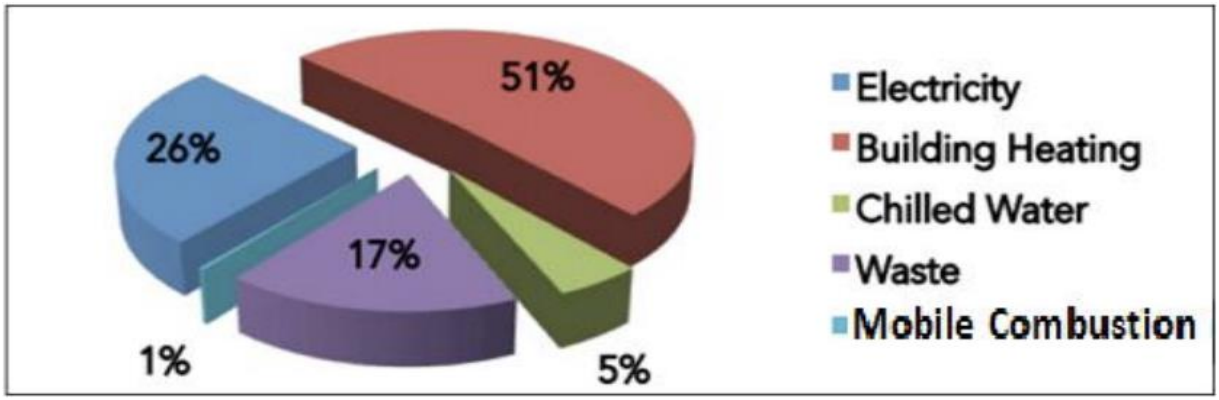


Figure 4. Greenhouse gas emissions by source, electricity usage has the highest (McMaster Energy Management Plan, 2016).

Figure 3 describes energy-savings and increased efficiency over the lifespan of the building. McMaster University ("McMaster") has implemented several initiatives to aid in decreasing energy consumption which include LED lighting retrofitting and controlled ventilation. Combined, these initiatives save more than 2,000,000 kWh in electricity savings as well as reduced gas consumption, reducing the amount of Greenhouse Gas ("GHG") emitted. Electricity usage has been shown to be the primary factor contributing to GHG emissions and

limiting electricity usage is one of McMasters's basis for their energy management plan. Overall, Figure 4 suggests that McMasters's energy management plan is extremely in-depth and contains a lot of information that contributes to their many ongoing and completed projects throughout the campus. These plans are designed to not only ensure the sustainable use of energy in new buildings but also work on many existing features to reduce energy consumption from a wide range of areas which include electricity, gas, and water. McMaster includes funding and savings of their plan as well as regulatory references such as the Ontario Cap and Trade Regulation (McMaster Energy Management Plan, 2016).

Comparably, UTSC currently lacks such initiatives that tackle the existing features throughout the campus. The primary focus is on newer buildings without much mention of gas or water usage and what they contribute to energy consumption.

The St. George campus of UofT has an official energy plan. Achievements in their dedication to the environment have been documented and well-funded through the university. There is a sustainability yearbook which promotes sustainable developments because of the spotlight they are given on the campus. In their plan, they outline clear, set goals for their energy usage compared to UTSC's "shot in the dark". UTSC does follow the city regulations but fails to set goals for themselves the same way St.George does. St.George had a complete 5-year plan set from 2016-2020 for the energy goals for each year for individual buildings. UTSC has been comparably discreet in setting goals for energy use across campus.

At St. George, energy usage is explicitly outlined with where the usages are needed most and how exactly the energy is obtained. For example, there are central chiller plants that use steam power to create energy for most of the campus. There are other sources such as third-party steam and Toronto Hydro, but those resources are relied on much less.

At UTM, the last energy plan was released in 2014 and is like the development of the newer LEED certified buildings of UTSC. Their focus was to retrofit the campus by replacing the inefficient central chiller with a newer energy efficient one. They focused on similar architecture to the ESCB with high performance envelopes, geothermal energy construction in their Instructional Centre, a beginning for solar energy by outfitting two solar arrays on the top of buildings. Their largest projects in this plan were to drastically change their energy sources on campus. They planned to replace each boiler as the youngest was around 30 years old, they wanted to meter all energy usage because "If you can't measure it, you can't manage it" (UofT, 2014). Finally, they planned to create a building dashboard that shows real-time energy use at UTM in individual buildings so that energy can be managed through the dashboard.

Recommendation

The largest step UTSC needs to take to become a stronger leader in energy sustainability is to set and publish goals for themselves similar to the St.George's goal list (UofT, 2014). This transparency will allow for stronger student-led programs like the St. George sustainability yearbook. Considering the research, UTSC could benefit in the future in terms of energy conservation by using better insulation materials than concrete and sealed windows to minimize loss of heat.

Short Term Goals

For UTSC, it would be beneficial to concentrate on modifying the older buildings to reflect the sustainability values. For UTSC to continue with these values, it would be beneficial to present new policy developments within the University. For example, the University can create a Water Conservation Plan. This would focus on managing water demand and improve the

efficiency of water use. Another policy that UTSC should consider is creating a Building Material Policy Plan. This plan would help decrease the amount of Greenhouse Gas emissions.

Long Term Goals

UTSC should work with the Office of Sustainability's Academic Advisory Committee to approach instructors about offering electronic or online texts, print-free notes and electronic assignment submissions. This is important for UTSC and Scarborough's community as it will work towards creating awareness for future generations. Lastly, the University should aim to provide 20% of energy from renewable sources. This process could be implemented within University classes. Teaching students how to think about sustainability in practice will allow them to connect to global issues.

Conclusion

Although data was difficult to access, we were able to support our hypothesis: the newer phases of UTSC's development is considered sustainable according to the Ontario LEED Green standards and should be models for future development on campus. The older phases of UTSC are less efficient in conserving energy and thus increases the energy demands. There have been major improvements in energy saving measures on campus since it was first built, including the use of geothermal and solar energy to power newer buildings. One of the newest additions, TPASC, is recognized as among the best in the world by LEED, having met strict standards in design, construction, maintenance and operations. As development continues, we expect to see an increase in sustainable practices at UTSC.

Bibliography

Burke, A. (2011). Group Work: How to Use Groups Effectively. Retrieved 2020, from https://uncw.edu/jet/articles/vol11_2/burke.pdf

Chu, S., Cui, Y. & Liu, N. The path towards sustainable energy. Nature Mater 16, 16–22 (2017). https://doi.org/10.1038/nmat4834

Chu, S., Majumdar, A. (2012). Opportunities and challenges for a sustainable energy future. Nature 488, 294–303. https://doi.org/10.1038/nature11475

EcoStar Insulation. (2019). Insulation R Values. Retrieved April 07, 2020, from https://www.ecostarinsulation.ca/blog/insulation-r-value

ESCB – Environmental Science and Chemistry Building. (2020). Retrieved February 4, 2020, from https://www.utsc.utoronto.ca/projects/escb/

Gertler, M. S. (2016). Beyond Divestment: Taking Decisive Action on Climate Change. Retrieved February 4, 2020, from https://www.president.utoronto.ca/beyond-divestmenttaking-decisive-action-on-climate-change

Glaser, L. (1970). Electricity uses, analysis of existing and planned university buildings, and opportunities for life cycle costing [master's thesis]. Retrieved February 4, 2020, from https://open.library.ubc.ca/collections/24/items/1.03404825

Green, C. (2009). Building Design and Construction: LEED® Canada NC v2009. Retrieved April 7, 2020, from https://www.cagbc.org/CAGBC/Programs/LEED/LEED_Canada_Rating_System/Building_Design_and_Construction_LEED_Canada_NC_v2009.aspx

Jafary, M., Wright, M., Shephard, L., & Gomez, J. (2016). Understanding Campus Energy Consumption -- People, Buildings and Technology. Retrieved February 4, 2020, from https://ieeexplore.ieee.org/document/7462518/

Kawakubo, S., Murakami, S., Ikaga, T.& Y.Asami (2018) Sustainability assessment of cities: SDGs and GHG emissions.Building Research & Information, 46(5):528-539, DOI:10.1080/09613218.2017.1356120

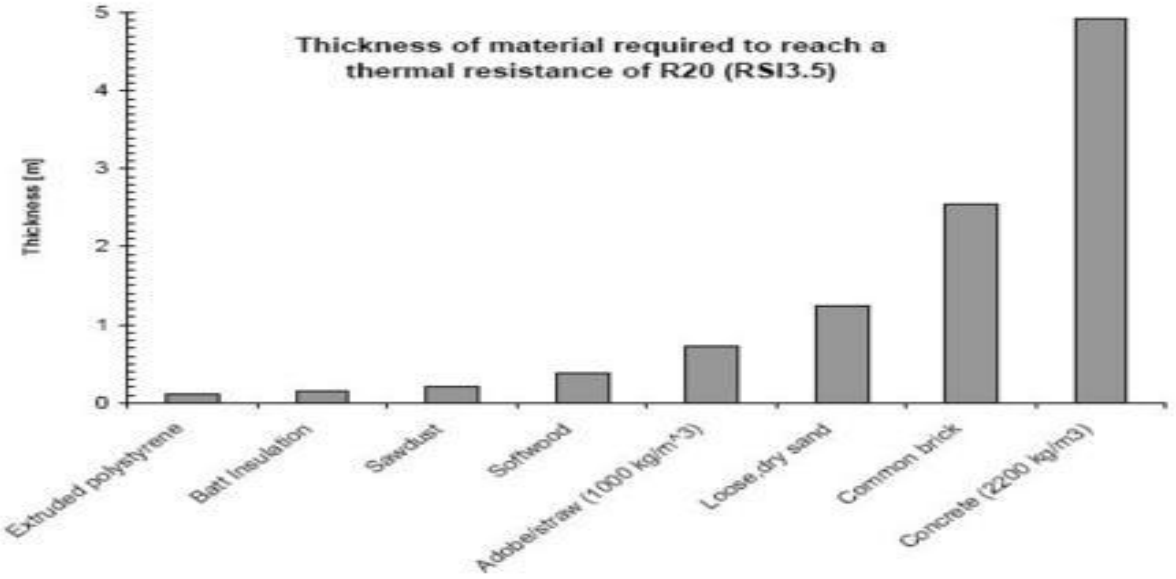
McMaster's Energy Management Plan. (2016). Retrieved April 06, 2020, from https://facilities.mcmaster.ca/app/uploads/2018/10/2016-Energy-Management-Plan-1.pdf?fbclid=IwAR0lL22_xGAJAtfUYXL4kS8fY8G7jfyIns-nmujex4WErTnhYWVVYDCStOQ

Naylor, David. (2008) Towards 2030: A Long-Term Planning Framework for the University of Toronto. University of Toronto-Scarborough. (2010). Sustainability Report-2010. www.utsc.utoronto.ca/sustainability/people-planet-prosperity. Accessed 4 Feb. 2020.

UTSC Homepage. (1970). Retrieved April 09, 2020, from https://www.utsc.utoronto.ca/aboutus/historical-timeline

Vanry, J. (2015). A case study assessment of the energy consumption of LEED ... Retrieved from http://hdl.handle.net/10012/9682

Figures:



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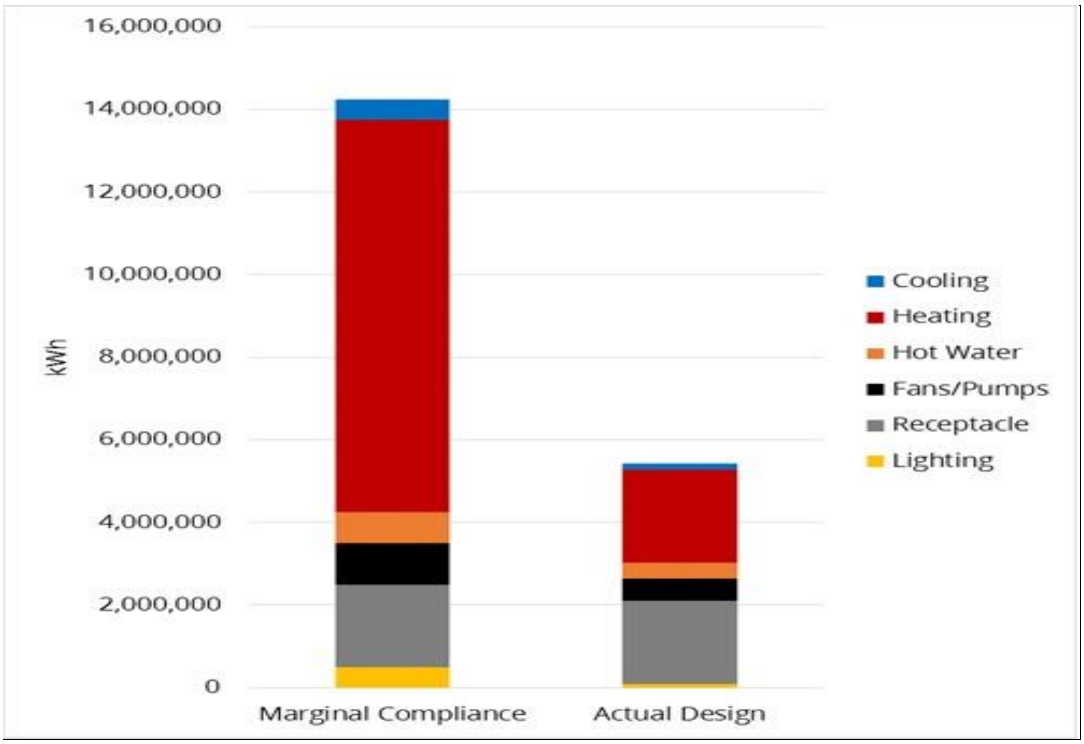

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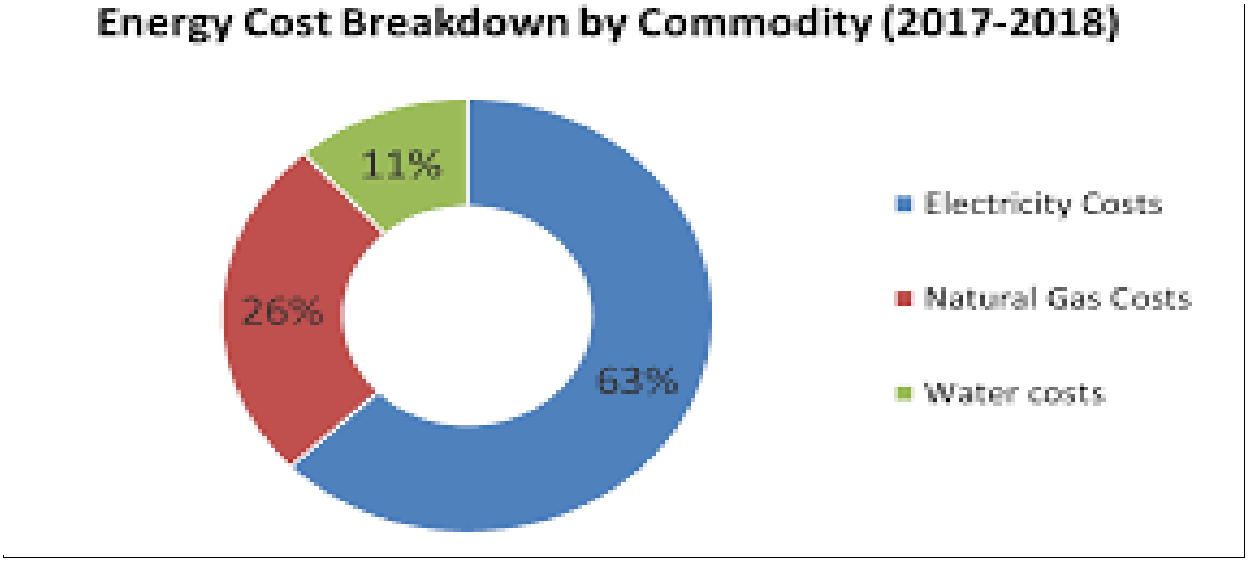

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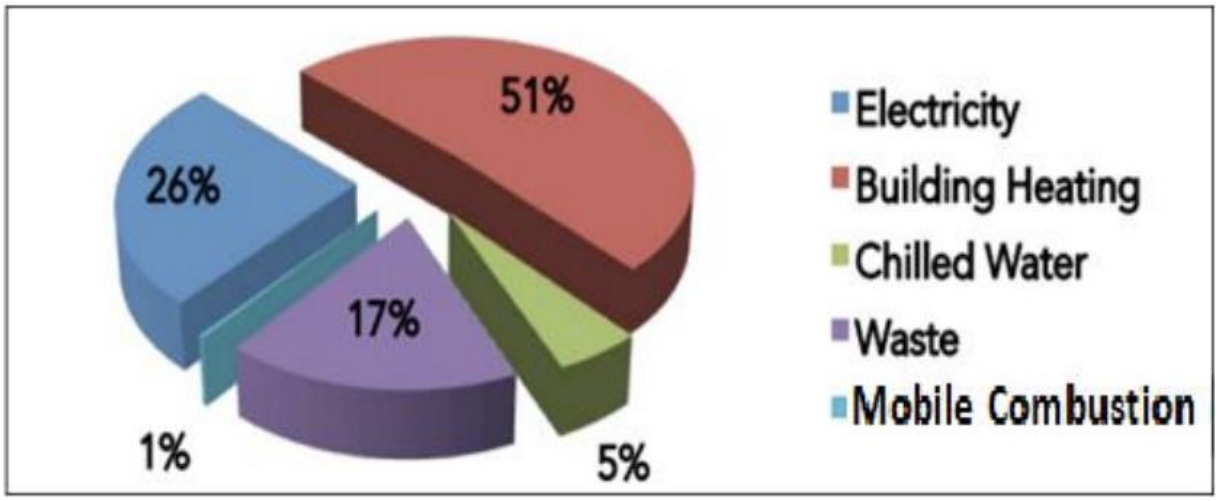

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