

## Global Warming: A Sustainable Approach for Energy Use

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Global warming is a major proponent of climate change. Awareness for this problem is one of the biggest hurdles to overcome. The Canadian government commissioned several environmental agencies to monitor climate change. The data from such studies was analysed and put into context with respect to Canadian energy projections for the future by introducing programs to implement reforms. The reduction of greenhouse gasses and toxic emissions is the goal of Local Energy Efficiency Partnership programs. This is a key step in changing regulations to attain stricter targets. In this paper we examine the effect of such programs on residential energy consumption from 1990s to 2013 using data provided by Statistics Canada. Data comparing energy consumption by decade, shows Canada's energy efficiency improved by 24%, avoiding 85.4 megatons of greenhouse gas emissions. This led to the introduction of ENERGY STAR certified products which were redesigned for eco-friendly environments. The result was, approximately 8.3 petajoules (PJ) of energy was saved equivalent to the energy used by 1.8 million cars for one year. By 2015, reports show that more than 70,000 efficient new homes had been built, consuming 20-50% less energy than typical homes.

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## I. INTRODUCTION

As technologies progress, there is no doubt that mankind benefits from the advances; however, the global warming ramifications impose a need for action and a change in direction. The increasing severity of climate change due to global warming has affected human life in many ways. There are unprecedented increases in greenhouse gases (GHG), which include carbon dioxide (CO<sub>2</sub>), carbon monoxide (CO), nitrogen oxide (NO), methane, and others. Currently, about half of the carbon dioxide released from the burning of fossil fuels remains in the atmosphere. The rest is absorbed by vegetation and the oceans<sup>[1]</sup>.

The increased CO<sub>2</sub> levels trigger chemical reactions that lead to the decreased pH of ocean waters; thus making it more acidic. Many marine organisms that have calcium carbonate shells or skeletons are negatively impacted by increasing CO<sub>2</sub> levels as it reduces the calcium carbonate levels available for such species to grow and reproduce<sup>[2]</sup>. Table (I) reveals mankind's contribution to climate change as a result of various GHG. Research shows that the overall CO<sub>2</sub> levels have increased 31% in the past 200 years, 20 Gt of Carbon added to environment since 1800s only due to deforestation and the concentration of methane gas, which is responsible for the ozone layer depletion; causing it to double in size since then. The global mean surface temperature has increased by 0.4–0.8°C in the last century above the baseline of 14°C. Increasing global temperature ultimately increases global mean sea levels at an average annual rate of 1–2mm over the last century.

Arctic sea ice thinned by 40% and decreased in extent by 10–15% since the 1950s<sup>[3]</sup>. Industry contributes directly and indirectly (through electricity consumption) about 37% of the global GHG emissions, of which over 80% is from energy use.

In this paper, we examine energy statistics from 1990s to 2013 provided by Statistics Canada in order to accurately map, solve, and ultimately reduce our ecological footprint. These statistics are composed of surveys on energy consumption and expenditures for residential and industrial sectors under a variety of categories. Consumption by home appliances, net home usage per decade and location are just some categories used to pave way for the Local Energy Efficiency Partnership (LEEP) program. LEEP is relatively a new program being used by industries for the past 10-15 years. Builders use LEEP to reduce their time and risk in finding and trying innovations that can help them build higher performance homes better, faster and more affordably. LEEP is delivered on a regional basis with the intent to establish an ongoing critical mass of builders that are capable of pulling through the best innovations suited for the region which can in turn pull through a responsive supply chain. The results include energy savings for home owners, competitive advantage for participating builders and manufacturers, and builder driven enhancement to local building practice.

Table I. Role of Different substances in greenhouse effect.

Substance	Preindustrial Concentration	Present Concentration	Annual Growth Rate (%)	Share In The Greenhouse Effect (%)
N <sub>2</sub> O	0.25	0.35	0.2	18
CH <sub>4</sub>	0.75	1.65	1.0	8

## II. METHODS

This study explores energy efficacy trends in Canada by obtaining statistical data from climate change to provide a comprehensive summary of secondary energy use related to GHG emissions. These experiments were conducted by the National Energy Use Database, commission by Statistics Canada [6]. The Government of Canada has requested this data be made open to the general public. This GHG inventory was prepared according to the specifications of Intergovernmental Panel on Climate Change, accounting for all types of GHG emissions in Canada. The government of Canada requested that these standard experiments to monitor climate change and implement programs that can reduce our ecological footprint. For the sake of this paper, only data from 1990-2013 was utilized.

Utilizing trusted sources provided by the government to perform climate change experiments result in huge data sets, thus only select data was used for analysis. Table I-VI<sup>[4,5]</sup> contain summarized data provided the by open source policies of Stats Canada. Prior to any graphical representation, the raw data was examined, adapted, and rounded (for some tables) to nearest whole number figure.

During the examination of statistics, inclusion criteria was as follows: Residential sector initiatives, LEEP impacted appliances, and statistics from 1990 till 2013. For the purposes of this article, exclusion criteria encompasses the other sectors contributing to GHG emissions.

## III. RESULTS

To improve energy consumption, it is important to examine all energy dependent sectors in order to customize GHG reduction strategies. Figure 1 shows the energy use per sector and the emissions produced per sector corresponding to Tables II-III.

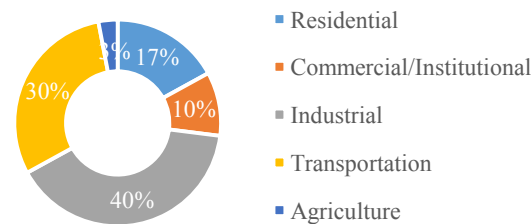
**Table II.** Energy Produced Per Sector in 2013

Sector	Energy Use (PJ)
Residential	1517.45
Commercial/Institutional	917.10
Industrial	3525.28
Transportation	2685.52
Agriculture	278.61
Total	8923.96

**Table III.** GHG Emissions Produced Per Sector (Mt of CO<sub>2</sub>)

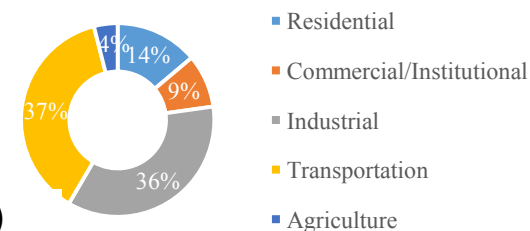
Sector (Mt)	1990	1995	2000	2005	2010	2013
Residential	72	71	76	77	69	66
Commercial	41	43	51	48	46	42
Industrial	141	148	161	168	167	174
Transportation	132	146	161	173	182	186
Agriculture	13	14	16	16	17	19
Total	399	422	465	482	481	487

### Energy Use by Sector (2013)



1a)

### GHG Produced by Sector (2013)



1b)

**Figure 1** Shows the distribution of energy use and GHG emissions by sector:

a) Percent Energy consumption

b) Percent greenhouse gas (GHG) emissions

Energy consumed by the transportation and agriculture sectors is relatively more GHG emissions than other sectors. It can be seen that while transportation accounts for 30% of energy consumption, it produces 37% of the emissions, the highest of all emissions by sector.

As a result of monitoring GHG emissions, the need for eco-friendly designs has become at the top of the design criteria. This data helps law makers accurately regulate manufactures and apply the necessary emission targets for the future. Focusing on the residential sector, the staggering changes and development in how technology is produced, has had a positive impact on home appliances. The Canadian government utilizes this data by setting regulations in place to reduce emissions. After introducing the LEEP program with manufactures, it encourages redesigning this sector for ecofriendly solutions. By setting limits (i.e. Carbon Tax) as to what manufactures can produce, economic solutions arise. Industries have now came up with Energy-STAR efficient products that surpass our current power utilities and appliances. The LEEP program encompasses heavy duty appliances such as refrigerators, freezers, washers, and dryers.

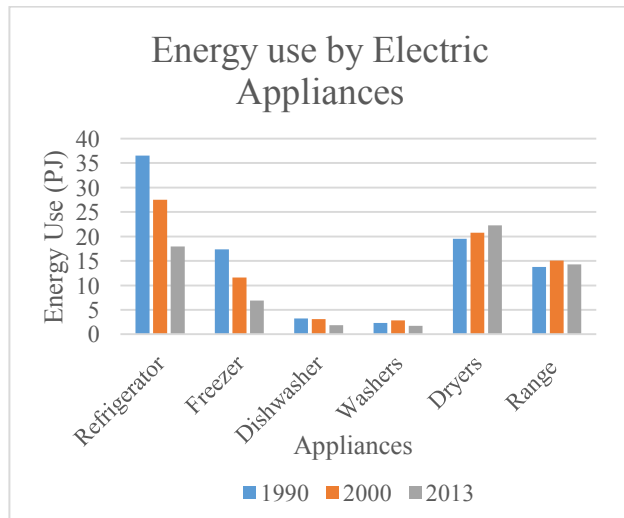
Monitoring climate change with respect to these new regulations, Table IV shows the change in consumption by house hold products from the 1990 till 2013. This data is also illustrated in Figure 2.

**Table IV.** Energy Use by Electric Appliances (PJ)

Energy Used by major home appliances (PJ)	1990	1995	2000	2005	2010	2013
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## Economic Approaches for Energy Use

Refrigerator	36.52	31.55	27.53	22.76	18.74	17.92
Freezer	17.39	14.88	11.61	8.91	6.94	6.92
Dishwasher	3.25	3.16	3.11	2.94	2.20	1.89
Clothes Washer	2.30	2.56	2.87	2.88	2.05	1.70
Clothes Dryers	19.49	19.17	20.75	22.14	21.35	22.28
Range	13.75	13.80	15.08	16.00	14.59	14.31

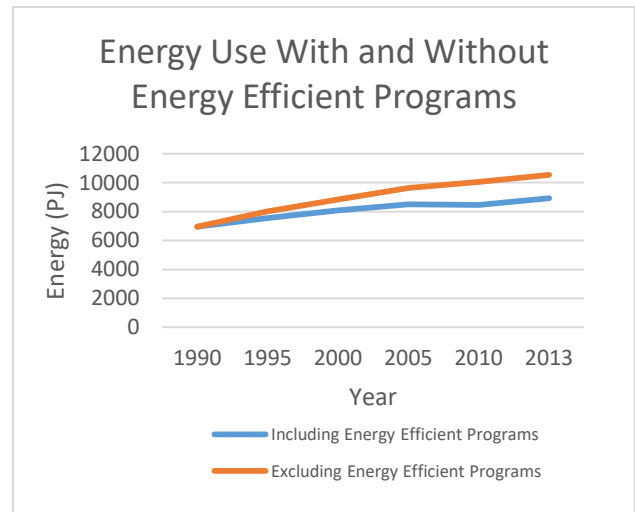


**Figure 2** shows the decrease in energy consumption among major appliances in Canada between 1990 and 2013. It can be seen that all new (2013) appliances that have utilized energy star options have a significant energy consumption gap than their older (1990) counterparts.

Energy efficiency improvements in the residential sector have resulted in significant savings between 1990 and 2013. These improvements include changes to the residential thermal envelope (insulation, windows, etc.) and changes to the efficiency of energy-consuming items in the home, such as furnaces, appliances, lighting and air conditioning. Table (V) monitors the energy use for all sectors including and excluding energy efficient programs from 1990 to 2013. Combining all sectors, Canadians saved a total of 1613 PJ (Figure 3) of energy and \$37.6 billion. Energy efficiency in the residential sector alone improved by 45%, allowing Canadians to save 639 PJ of energy and \$12 billion in energy costs in 2013<sup>[6]</sup>. This analysis was performed under the relationship that one PJ is approximately equal to the energy used by more than 9000 homes/year.

**Table V.** Energy Use with and Without Energy Efficient Programs

Energy Use (PJ)	1990	1995	2000	2005	2010	2013
Including Energy Efficient Programs	6957	7547	8090	8506	8462	8924
Excluding Energy Efficient Programs	6957	8025	8828	9638	10059	10537



**Figure 3** illustrates energy saved from improvements in all sectors. A total of 1613 PJ of energy saved from 1990-2013. While total energy used by final consumers in Canada increased by 28% between 1990 and 2013, it would have increased by 52% without energy efficacy improvements.

In order to maintain the drive for reduction in GHG, the Canadian government has set a regulation projection as to where it sees itself in the future. As seen in Table (VI).

**Table VI.** Global renewable energy projections by 2040 <sup>[7]</sup>

Energy Sources (PJ)	2001	2010	2020	2030	2040
Total energy consumption (million tons oil equivalent)	10038	10549	11425	12352	13310
Total Renewable energy sources (RES)	1365.5	1745.5	2964.4	4289	6351
RES contributions (%)	13.6	16.6	23.6	34.7	47.7

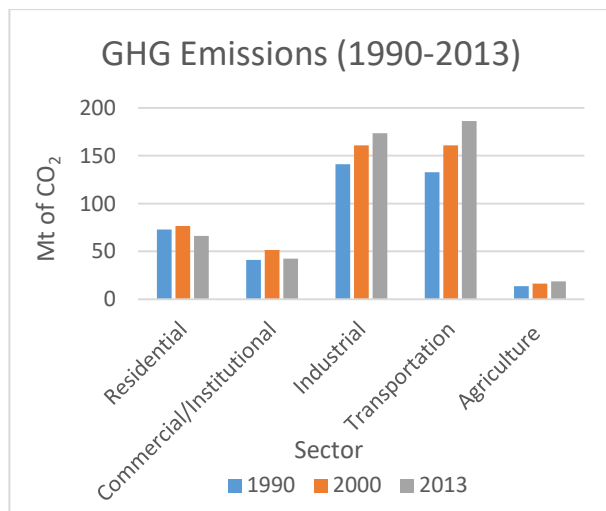
## IV. DISCUSSION

The objective of this study was to investigate the truths about global warming and what necessary steps must be taken to solve this problem. As presented in Table I, CO<sub>2</sub> emissions account for 71% of GHG due to human activity. There is no doubt that climate change due to global warming is real. In fact, according to Table I CO<sub>2</sub> emissions are still on the rise amongst other harmful toxic emissions. The Canadian government took the first step in solving the problem by commissioning several environmental agencies to monitor climate change. With this data, analysts propose different environmental solutions to everyday problems.

The scope of this research paper focuses on the residential sector, which was heavily targeted in order to present solutions to the 'average Joe'. To be specific, the residential sector is now following the LEEP program<sup>[4]</sup> where home owners and manufactures work together for economic solutions that fit each sector's needs. In the past, generally home manufactures would offer only layout design options to buyers, now manufactures can do much more by including energy efficient designs,

appliances and even protocol that home owners use to further benefit their utility breakdown. Figure 2 illustrates home appliances that have applied energy efficient programs like the Energy-STAR products. As shown, the appliances in 1990 versus 2013 have different energy spectrums. Appliances in the 1990 like refrigerators, freezers, or dishwashers consume almost double the energy required than their newer counterparts. This small step multiples around all sectors and with time, emission rates will decrease. The changes made to appliances and other energy efficient products have resulted in savings. Figure 3 illustrates the energy consumption for all sectors with and without energy efficiency improvements since the 90s. Had we not changed to energy efficient programs we would have not saved 1613 PJ of energy that would have cost Canadians a total of \$37.6 billion.

The real question arises, have our changes made an impact on GHG production. The answer to that question is complex. Yes CO<sub>2</sub> emissions are still climbing yearly; however, the rate of emission production has decreased—although not as much as expected. Figure 4 shows that yes the residential sector has seen an overall decrease by 9%. Nevertheless, the industrial and transportation sector has seen an increase by 23% and 40% respectively. This is due to the ongoing world population growth as well as the booming industrial era. Nonetheless, when compared to previous decades those numbers have decreased ever so slightly. Because of gradual energy efficiency changes, home owners can now buy homes 30% larger in size than previously built homes and expect similar utility consumptions.



**Figure 4** illustrates the GHG produced between 1990 and 2013 with respect to new energy efficiency standards by sector. It can be seen that the overall GHG produced by the residential sector has decreased by 9% with the help of new government regulations.

Examining Table VI Canada's plan by 2040, a significant increase in renewable energy sources from

16.6% in 2010 to 47.7% by 2040 indicates that far more work is to be done in reducing our ecological foot print. These goals help manufactures update or redesign products to meet new industry standard. These standards are what evolves our understanding in on going global warming problem.

## V. CONCLUSIONS

In summary, this paper examined the GHG phenomenon, which is one of the key factors in global warming. By obtaining data and monitoring climate change, efficiency questions arise. This leads to solutions and sustainable approaches for the future. The Canadian government set projections in order to reduce GHG and effectively solve the global warming problem. This paper examined the residential sector extensively and what has been done to solve this problem. The data compares energy and efficiency of the residential sector from 1990 till 2015. In that time frame, including all sectors energy efficacy in Canada improved by 24%, energy efficiency improvements avoided 85.4 megatons of GHG emissions. Overall, Canadians saved \$37.6 billion because of these improvements. During the 2013-2015 reporting period, LEEP programs have saved Canadians approximately 8.3 petajoules of energy from using ENERGY STAR certified products- equivalent to the energy used by 1.8 million cars for one year. By mar 31<sup>st</sup>, 2015, more than 70,000 efficient new homes had been built since the inception of the ENERGY STAR for New Homes initiative, consuming 20-50% less energy than typical homes<sup>[8]</sup>.

Although Canada strives to have renewable energy constitute 47% of energy sources, it is important that we as citizens push our governments for stricter goals. Most importantly, as engineers, it is up to us to advance the efficacy of such technologies and come up with innovative methods to produce clean energy.

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## Notes and References

a) R. Gergis was the primary (only) author of this paper. Data selection, analysis, and final manuscript was prepared by the author.

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