Energy Challenges:

Tackling Energy Savings Through Purchase Habits

An Interactive Qualifying Project Report
Submitted to the faculty of
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Abstract

Through the form of purchasing, money and energy savings can be reflected upon the consumer. The topics of focus were the largest sectors within energy usage; transportation, food, and residential. A thorough analysis was performed on each topic, culminating in an energy savings chart summarizing the results and savings.

I. Introduction

Energy, which powers everything in the universe, is a commodity sought by humans. Energy powers the lights, our cars, and our bodies. To produce energy, humans consume; we consume food, consume space, and consume fuels, like oil and coal. Unfortunately, there is a finite amount of space on planet Earth, and a finite amount of fuel. Each fuel source has its limits, based around the peak of each's existence. M. King Hubbert, an esteemed geologist, defined an event known as peak oil, where oil production would meet its maximum and then terminally decline (FTL, 2008). Hubbert made his prediction for U.S.'s conventional peak oil in the 1970s and was correct, and while the world's peak oil has not yet been determined, it will eventually happen (Deffeyes, 2011). Just as there is a point of peak oil, there is also a peak point for other nonrenewable fossil fuels like coal and natural gas. Each's peak has also not be defined, but the end of resource is bound to come, it is only a matter of time.

Each of these resources is used to generate electricity, to power cars, or to heat homes. At the 2014 demand for oil (93.5 million barrels per day), natural gas (70 thousand cubic feet per day), and coal (240 thousand tons per day) we put pressures on our technology for alternatives in the field of energy production. (EIA (A), (C), 2014). Since these three sources provide the U.S and the world with most of our energy, there have been movements trying to lower our energy demand, letting our reserves of fossil fuels last longer, and maybe allowing ourselves more time to switch to reliable renewable sources (EIA (D), 2014).

The average American uses roughly 312 million Btu of energy annually (EIA (B), 2014). 312 million Btu is enough energy to power 100 incandescent light bulbs for 24 hours a day for a year, or is the amount of energy that it takes to make and assemble close to 16 new cars (UNESCO, 2008). This is no small number, but it still doesn't come even close to relating to the amount of energy that America, with all its people, industries, and businesses, uses as a whole. One of the largest uses of all the energy that is generated goes to the industry sector, using "approximately one third of total U.S. delivered energy in 2012," (EIA (E), 2014). This includes the production of everything humans use each day, from a coffee cup and a car to socks and sinks. The most efficient method of production leads to a minimal use of resources and energy, yet the average person has little influence over this factor. They cannot aim to change a large scale manufacturing plants production methods. The fact is the average person, or consumer, cannot usually affect how their products of consumption are made.

However, a person can change what they purchase, which can have a large impact on the world. This can be done throughout many sectors of peoples spending, ranging from transportation to food purchases. By carefully considering which goods or services have the lowest environmental impact, the average consumer can lower their energy demand. A very large effect one could consider more thoughtfully is their energy consumption. This includes more purchasing of local goods which reduces energy used in shipping by manufacturers, or alternatives to driving to work, which lowers an individual's own energy use. That being said, the first steps towards reducing an individual's energy consumption are often small ones.

This paper seeks to help the individual, through a series of recommendations, in reducing their energy consumption. The aim is to suggest alternatives in purchases that will lower the energy the average person uses that will be effective and easy to follow through on, incentivizing the average person to do so. However, these purchases might incur additional initial spending, but each suggestion is made such that it will in long-term goals save consumers' money.

II. Background

As it stands, Americans spend their money on a large variety of products and services across the board. Figure 1 is created using data presented by the Bureau of Labor Statistics in their report *Consumer Expenditure Survey for 2011*, there are three main areas where people spend nearly two thirds of their money annually. These areas, or sectors, are transportation, food, and housing. These main sectors are ones that can greatly impact ones' energy usage and will be thoroughly analyzed throughout the course of the paper.

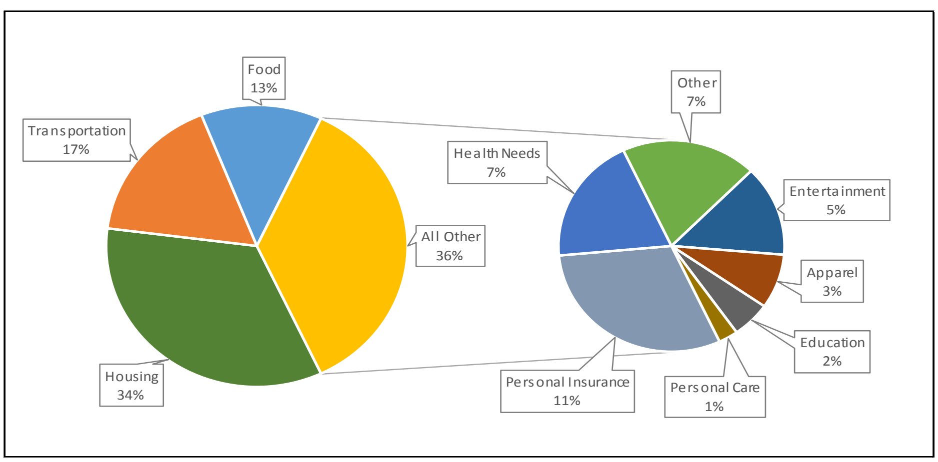

Figure 1. Consumer Spending as a Percentage, 2011. Given that three sections alone makes up 64% of consumer spending, housing, transportation, and food will be the main areas addresed in this report (BLS, 2011)

With the goal to reduce energy spending on purchases made by the consumer, or the average person, we will look at the three areas where the most money is being spent. Shown in Figure 2 below, generated using data presented by the Bureau of Labor Statistics, food, housing, and transportation are three very important sections of all consumer spending. Even as a consumer's income increases, they are still spending an equal percentage of their money in these three sections. With these areas being the most impactful parts on an individual's overall spending, we will make recommendation based on changing a person's spending in each area to reduce their energy consumption.

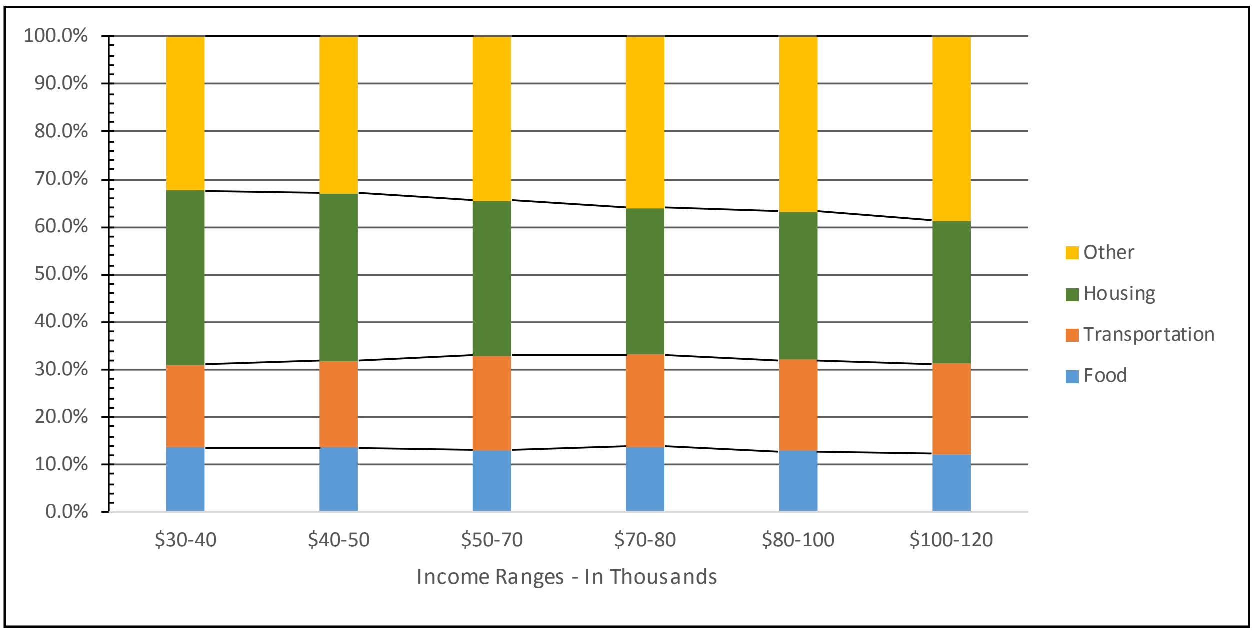

Figure 2. Consumer Expenditure for Income Ranges as a Percentage, 2012. Although the amount a person can spend is dictated by their income, the percent a consumer spends on housing, transportation, and food is constant, even as their income increases. This validates that these three areas are important for all consumers, despite their economic standings. (BLS, 2011)

There are other areas that people spend money in, and although they are not unimportant, they will be omitted from this report. Although in Figure 2 the "other section" is quite large, Figure 1 gives a better break down of what actually is in this section of spending. We have omitted these other sections because they are too broad for the scope of this paper, entertainment expenses including costs for pets to fares for movies, or personal insurance, which in some cases could be money saved in a jar. With such a large variety and based on the fact that each is a small contribution to a person's spending, we will omit them from the report.

Although people are spending money in these areas, how important are they? Do they have that much of an impact on an average American's energy usage, and if so how? Figure 3 below is adapted from information by the EIA and shows a basic breakdown of the end sector energy usage of all energy or electricity that is generated within the United States. Both the residential and transportation account for 50 percent of all energy use within the U.S. Along with this they are also the two sectors that can be directly influenced by the average person, who would live in a home or apartment and uses modern day transportation such as a train, car, or bus to travel. With such a large impact on America's energy demand, individuals can help and contribute to lowering energy demand and use.

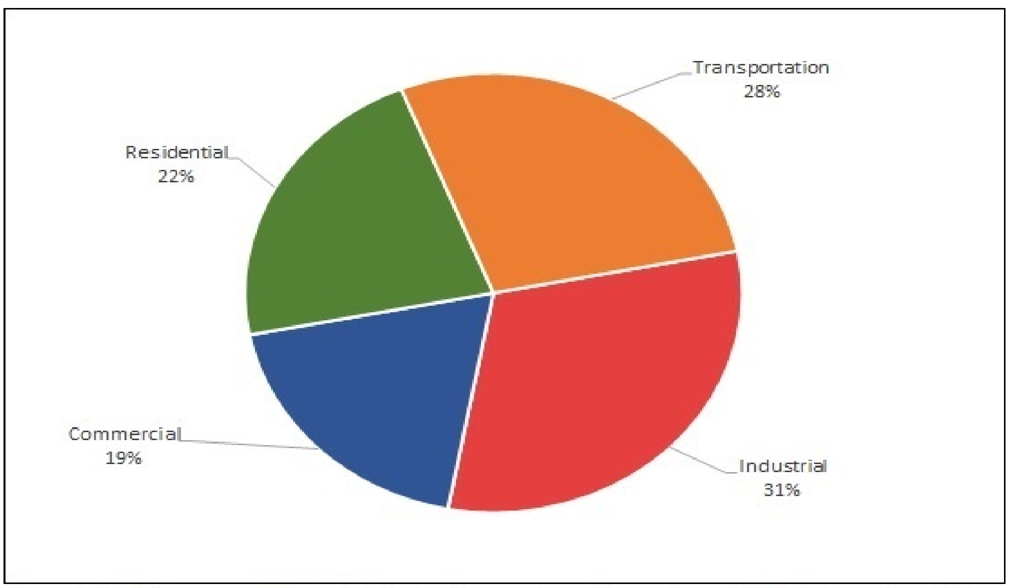

Figure 3. U.S. Energy End -Use by Sector Demand as a Percentage, 2011. The residential and transportation sectors consume 50% of all generated energy in the U.S. These two sectors are greatly influenced by the average person, allowing an individual to have a larger impact on energy consumption. (EIA, 2011)

There is a relationship between energy demand and consumer spending in some regard. The residential and transportation sectors both require a considerable amount of energy and are the two largest parts of a consumer's spending. With this comparison, there is the goal that a reduction in spending in one section would lead to a similar reduction in energy consumption. These reductions would occur through the recommendations made in the later parts of this report. While a reduction in spending could have an inverse effect on energy consumption, like purchasing a less fuel efficient car or window that passively wastes energy while it's used, that is something that will be avoided in this report.

With this large relationship between cost and energy demand in these sectors, there is a justification for further analysis on the subject. We aim to change people's energy usage through purchases; we need to look at where they are spending the most money, compared to where energy is being used. People will hopefully aim to use less energy, and the best way to do that is to focus on the areas where they are currently spending money, and incentivize our suggestions with the possibility of saving money.

III. Personal Consumer Vehicles

Transportation is used every day and is an integral part of ones' life. What is striking is how inefficient the overwhelming majority of peoples' transportation methods are. The average person is driving a typical internal combustion engine automobile, which is not an efficient method of transportation as said engine only utilizes 14%-26% of the energy from fuel to move the car. (Bandivadekar, 2008). A topic of focus is the different car technologies that exist, including a typical internal combustion engine, a hybrid drivetrain, electric engine, and a hydrogen fuel cell powered automobile. As manufacturing techniques have further developed, the cost of these advanced engine types are slowly lowering in cost and in some cases even matching that of the internal combustion engine. Ultimately, hybrid car technology is the best option today in terms of energy efficiency and cost. If one does not want to travel privately or cannot afford to purchase a hybrid vehicle, then public transportation is a viable alternative. Hybrid car technology will be analyzed, focusing on its efficiency and how it can ultimately translate into money and energy savings for the consumer.

A. Engine Technologies

The very common internal combustion engine has been the engine of choice for car manufacturers for quite some time. Despite its lack of efficiency, there are several positives to running this kind of engine. The initial cost of this technology is the cheapest out of all the other engine options, such as hybrid and electric powered engines. (Keveney, 2005). This is not taking into account long-term pricing, but in terms of money the consumer spends up front to purchase the car, this is the cheapest option. Convenience here is also adequate; the car has the ability to run as long as there is gas in the car. Filling up a tank of gas is also something that can be done in a matter of minutes and then immediately the car has several hundred miles worth of driving range. Internal combustion engines have long benefited both the consumer and the manufacturers; due to their long history, production has become as simplified as ever. This leads to large profit margins for the manufacturers, and in return relatively cheaper prices for the consumers when compared to alternative engine technologies. Furthermore, consumers do not need to research much on the topic, as internal combustion engines have become the easy choice.

An electric car furthers the aspect of car technologies. Electric cars have garnered a solid following in recent years due to the growth of Tesla Motors; however, electric cars are actually no greener for the environment than a typical internal combustion engine. This is for a variety of reasons but most notably because of the production process needed to produce the batteries for these cars. A study was performed on this and concluded that in the manufacture of electric car batteries, the "global warming potential" was twice that of a conventional car. Furthermore, electric vehicles have the potential to have large increases in human toxicity, metal depletion impacts, as well as fresh-water eco-toxicity. (Hawkins, 2012). These predictions were formed in analyzing the different life-cycle treatments that the batteries powering these vehicles go through. Much of the harmful effects come from the beginning and end stages of production, mainly in the production and disposal of a new or used battery. Although these cars do not emit harmful pollutants to the atmosphere, one must consider where the electricity is coming from to charge these massive batteries. There is a long supply chain before this electricity reaches the end user. The majority of the power is produced by either a coal or natural gas plant. The power generated from these power plants and then converted to a usable form of electricity. Next, the electricity travels along transmission lines, which carry the electricity over very vast distances. Following this, distribution lines carry the electricity to its final location, a consumer's home. The efficiency of electricity is lost due to the long supply chain, the efficiency falls down to only 24 percent. (National Academies, 2008). This is taking into consideration the whole process of getting the fuel source and electricity, to the car and then actually moving the car. As previously stated, an internal combustion engine is 14-26 percent efficient, therefore an electric car just falls on the higher end of the efficiency of an internal combustion engine, indicating that an electric car is actually no more efficient than an internal combustion car.

B. Hybrid Engines

Hybrid technology is one that stands on its own in terms of efficiency, with an overall engine efficiency of 38 percent. In fact, this number is only set to rise to 45 percent once Toyota releases its 2015 Prius in the summer of 2014. (SAE International, 2013). Hybrid cars do still require a conventional gas source just like that of an internal combustion engine; however, where it differs is that the hybrid vehicle is equipped with multiple batteries on board that are charged as the car is driven. Essentially, a hybrid engine is a combination of two engine technologies, electrical and internal combustion. Through numerous technological advancements, such as regenerative brakes, these batteries always stay fully charged. Regenerative brakes are a highly efficient improvement made on cars. Braking is considered a major loss in energy, mostly in the form of heat. This is where regenerative brakes come in, as they recapture this heat and convert it back into electricity sent directly into the electric portion of the engine. (Lampton, 2009). Regenerative brakes cannot be utilized in a conventional internal combustion engine because it does not have an electrical engine to send the power back into. Due to the numerous technological advantages hybrid vehicles have over internal combustion engines, an in depth look can now be performed to determine hybrid vehicles as a viable alternative.

In order to confidently recognize hybrid vehicles as the superior car choice of the modern day, its efficiency must be compared to the competing technologies. To compare resulting fuel economy ratings, a recently coined term must be used, the eGallon. An eGallon is the cost of fueling a vehicle with electricity compared to a similar vehicle that runs on gas. In other words the government eGallon calculator uses the average miles per gallon for a car and then calculates how much it would cost to drive an electric car the same distance. (Ingram(A), 2013). The average cost to charge one eGallon versus filling up a gallon of gas, is about one third. The range is greatly compromised on electric vehicles though, on average only going about 100-200 miles before requiring a charge. The graph below, provided by the United States Department of Energy, is a great illustration on how to compare three car technologies; gas, hybrid, and electric, and how much it costs per mile. According to the U.S. Energy Information Administration, the average cost of electricity in Massachusetts is 17.84 cents per kilowatt-hour. (EIA (D), 2013). The average cost of gas in Massachusetts is $3.45. These two statistics must be compared using the accompanied graph; essentially they are both used as a source of energy for an automobile. The gas pumped into a car is used to power the engine and propel the car; similarly the electricity transferred into the car is stored in batteries and then transferred to the engine to propel the car. This is where the hybrid car technology excels.

The hybrid vehicle is on par with an electric vehicle that is obtaining 3-mi/kwh efficiency, and yet it has a much lower initial cost. The mi/kwh efficiency can be viewed as an alternative unit to the miles per gallon. Since one cannot fill an electric car with gallons of gasoline, it makes more sense to use the units that are utilized when purchasing a fuel source of electrical cars, electricity. The kilowatt-hour is the unit used in pricing of electricity, therefore a mile per kilowatt-hour is fundamentally similar to that of a mile per gallon rating. They both are a relational unit of a distance to a fuel source.

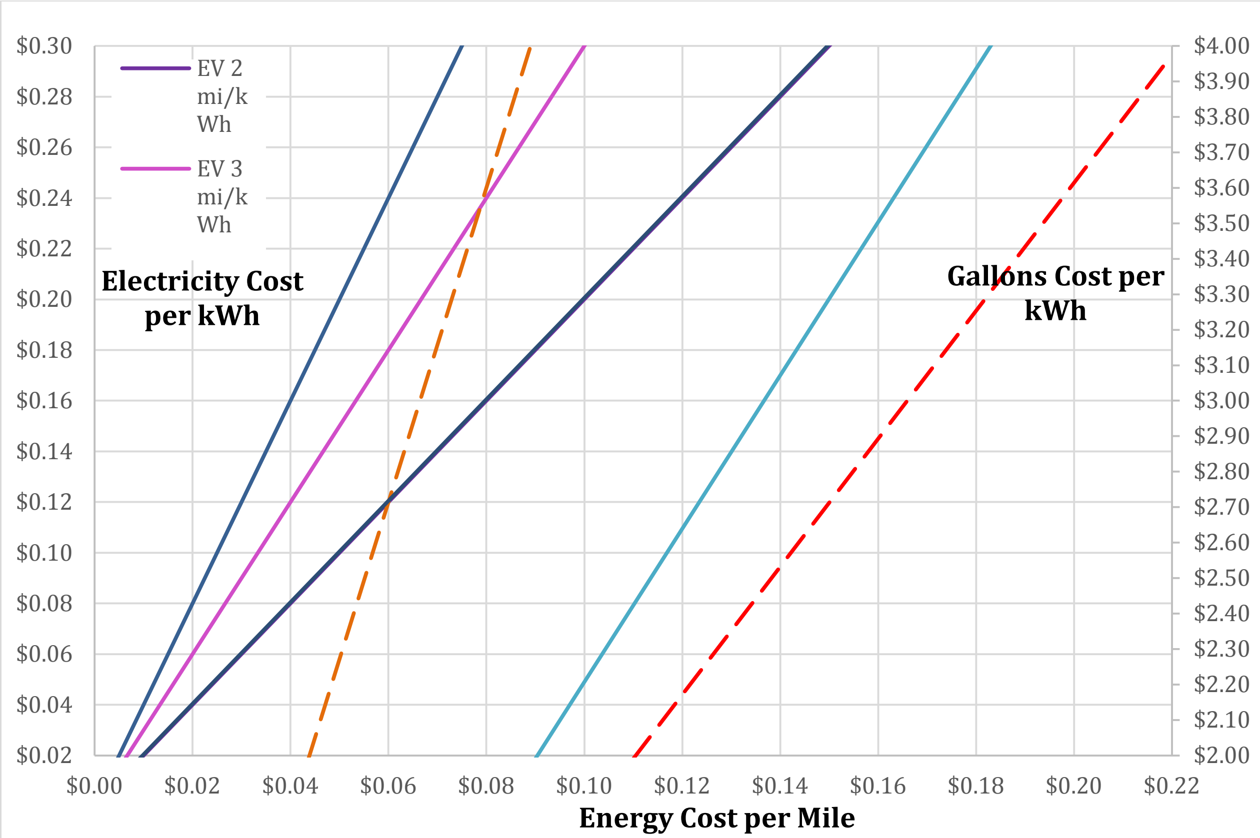

Figure 4: A graph illustrating the energy usage of different car technologies. The graph is useful because it is typically difficult to compare a gas car to an electric car in a common set of units. By utilizing the graph, the energy cost per mile can be found. The kWh is comparable to the cost per gallon, because they are both the unit used in purchasing "fuel" for both engine technologies; electric and internal combustion. (EIA (D), 2013).

Efficiency is just one piece of the puzzle. What consumers truly care about is, how much does it cost and how much am I saving. Furthermore, the goal is to save money for the consumer while trying to minimize any lifestyle change. Electric vehicles could lead to a lifestyle change because they must always be charged up and ready to go. They also exhibit the vampiric effect, which essentially means that if the car is parked in the garage for an extended period of time, the battery begins to drain. (Ingram, 2013). To effectively persuade the public to further adapt hybrid technology, an investigation was performed on one of the most iconic hybrid vehicles, the Toyota Prius. The Toyota Prius was compared to the other top selling cars in the United States, the Toyota Camry, Honda Accord, and the Honda Civic. Cost analysis was performed over a five-year span. The Toyota Prius data was exceptional in that it had substantial savings in fuel costs. (Lave, Maclean, 2002.)

	5 Year Details	Year 1 ($)	Year 2 ($)	Year 3 ($)	Year 4 ($)	Year 5 ($)	5 Year Total ($)
2012 Toyota Prius	Depreciation	2287	2005	1765	1565	1405	9027
	Taxes/Fees	1244	455	315	153	82	2249
	Financing	607	482	353	217	78	1737
	Fuel	1077	1109	1143	1177	1212	5718
	Insurance	1639	1696	1755	1816	1880	8786
	Maintenance	379	350	693	1230	665	3317
	Repairs	0	79	191	278	323	871
	True Cost to Own	7223	6176	6215	6436	5645	31705
2012 Toyota Camry	Depreciation	1900	1681	1494	1341	1222	7638
	Taxes/Fees	1129	413	287	141	77	2047
	Financing	548	434	318	196	70	1566
	Fuel	1924	1982	2041	2103	2166	10216
	Insurance	1343	1390	1439	1489	1541	7202
	Maintenance	404	360	712	1319	678	3473
	Repairs	0	79	191	278	323	871
	True Cost to Own	7248	6339	6482	6867	6077	33013
2013 Honda Accord	Depreciation	4814	1941	1708	1514	1358	11335
	Taxes/Fees	1384	505	348	166	87	2490
	Financing	663	527	384	238	85	1897
	Fuel	1924	1982	2041	2103	2166	10216
	Insurance	1420	1470	1521	1574	1629	7614
	Maintenance	96	457	265	905	1249	2972
	Repairs	0	0	81	195	284	560
	True Cost to Own	10301	6882	6348	6695	6858	37084
2012 Honda Civic	Depreciation	1484	1298	1159	1054	968	5963
	Taxes/Fees	1009	370	258	129	72	1838
	Financing	485	385	281	174	62	1387
	Fuel	1684	1734	1786	1840	1895	8939
	Insurance	1665	1723	1783	1845	1910	8926
	Maintenance	482	261	863	934	607	3147
	Repairs	0	79	191	278	323	871

Table 1: A breakdown of a True Cost to Own calculation published by Edmunds. The table takes into account all the factors that cost money when owning a car. The table provides a representation on how much a consumer will spend on their car over the course of a five-year span of ownership. The True Cost to Own calculations is a copyrighted formula that Edmunds computes, which takes into account depreciation, interest on financing, taxes and fees, insurance premiums, fuel, maintenance, repairs and federal tax credits; as well as assuming 15,000 miles driven per year. (Edmunds, 2014)

The standout factor as illustrated in the table is the amount spent on fuel over the five-year period. This is the issue that most consumers worry about on a week-to-week basis as well. For instance, when comparing the Prius against the Camry, the best-selling car in the United States, there is a savings of slightly more than $17/week. Further selling the point on hybrid vehicles, specifically the Prius, is their reliability. Due to the fact that the car actually has two engines, the battery takes some of the stress off of the internal combustion engine. To help ease the buyers mind, Toyota offers for free an eight year comprehensive warranty on the hybrid system, and if for some reason the battery fails after the eighth year, Toyota will pay the owner $200. An interesting note is that no hybrid systems have reported failures. (Toyota, 2014).

A fourteen-year study was performed spanning 155,000 miles driven on the two experiment cars, a Toyota Corolla and a Toyota Prius. The goal was to determine whether the $5540 price difference could be recovered in a reasonable time period. The concluding results found that the return of investment on hybrid vehicles was heavily weighted towards the current gas prices. For instance, back in 2001 when the average gas price was $1.51 it almost was not worth purchasing a Toyota Prius unless you planned on owning it at least six years. (Peter de Haan(A), 2007). However, for current day gas prices, the premium price paid for the car is recovered within three years, after that the Prius is advantageous. Furthermore, more consumers are making the switch over to the Toyota Prius from Toyota's other non-hybrid offerings. This is summarized in figure 5, which utilizes experimental data to demonstrate that not only is the Prius the car that is most often replaced by a newer model, but it is also the car that is most often purchased by buyers who previously did not own one.

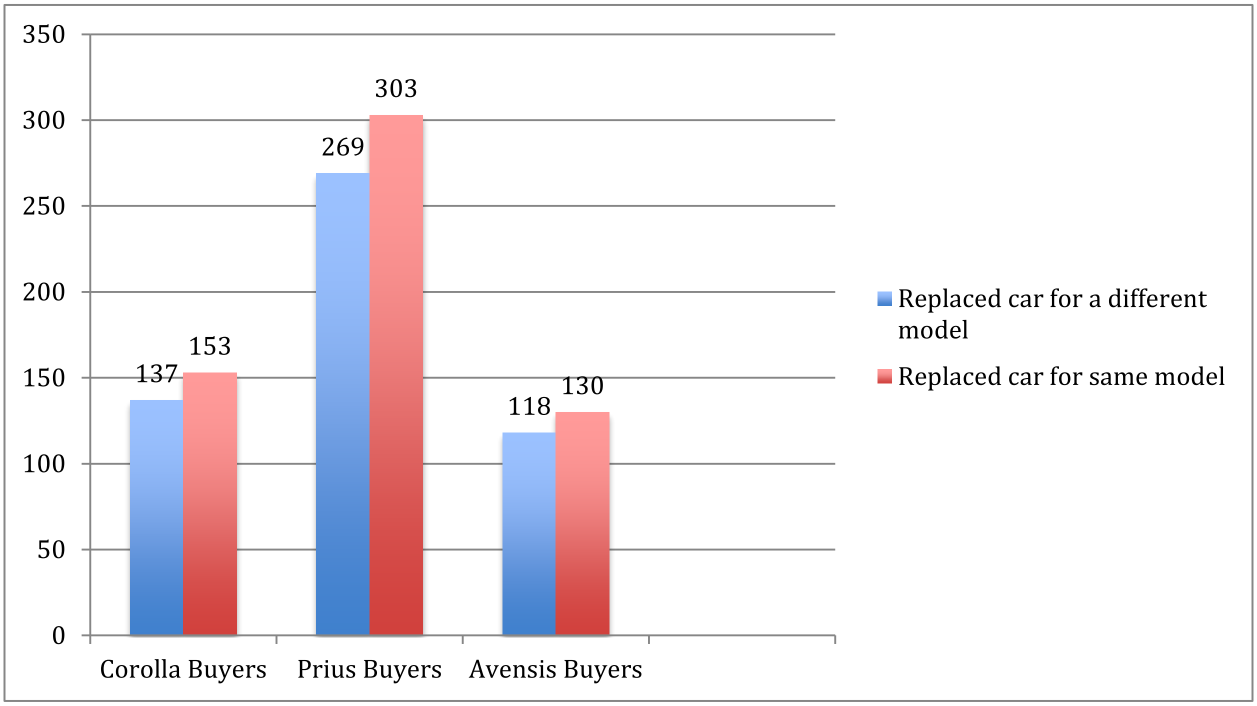

Figure 5: Chart showing Prius has the most new buyers, and many people replace their Prius with a new one. (Peter de Haan, 2007).

C. Quantitative Analysis on Energy Savings

In order to truly contemplate purchasing a hybrid vehicle an energy analysis must be performed. The average person in the United States uses 312 million Btu per year. (EIA (B), 2013). The 2014 Toyota Prius, the current model, obtains 50 miles per gallon. (Toyota, 2014). The average car in the United States reached record high miles per gallon for 2013, averaging 24.6 miles per gallon. (Ingram, 2013). The Prius still averages more than double of the record high mileage for a car in America. Basing an analysis on 15,000 miles driven per year, the Toyota Prius will use 313 fewer gallons of gas per year. A gallon of gasoline contains 116,090 Btu. (USDoE (F), 2013). That translates into 36 million Btu of energy being saves per year. Furthering this calculation in respect to total energy used yearly, that translates to 11.5 percent energy savings per year. This is a big change that can be made to save a substantial amount of one's energy usage.

Despite all the glamour encompassing the new wave of electric cars and the prestige that they hold, they are not ready to become mainstream. They still hold many limitations such as charging times, cost, and range. Furthermore, as previously discussed their efficiency of energy is no more efficient than a modern internal combustion engine. The excitement of hybrid cars has certainly died down since their original introduction in the early 21^{st} century; however, they still remain the smart, green-minded choice. The cost of a hybrid vehicle over its gas counterpart is minimal, and in some cases such as with Lincoln, they are exactly the same. (Lincoln, 2014). However, and perhaps most importantly, there is no effect or compromise that must be taken to convert to using a hybrid drivetrain. If one cannot, however afford the upfront costs of purchasing a hybrid vehicle, but still wants to make green-minded choices and be energy efficient public transportation is a viable option.

IV. Public Transportation

Public transportation dates back hundreds of years, seen first as simple ferries on waterways where travelers, for a fee, could purchase a ride across (Engage Technology, 2014). It evolved into more formal forms like stage coaches and horse drawn "buses". With the introduction of steam technology, public transportation evolved into railroads and paddle boats, and eventually to the level that humanity is at today, with anything from bullet trains and jumbo jets to taxi cabs and rickshaws. Public transportation is a large resource and allows many people to travel efficiently.

A fault of all current public transportation systems is their availability, or lack thereof. Suburbanization has created an urban space with a lower population density that cannot be sufficiently serviced by mass transit (Rodrigue, 2006). As a city spreads in size, it can only effectively support so much of its external links, and while forward progress is being made to make public transit regular in even the most rural of places, there are holes in its ever-branching web. Within this section, there will be an assumption that public transportation is an available option over taking an individual's personal vehicle. Given a case where no public transportation is available, like a rural community, and a non-motorized transportation method, like walking or bicycling, is unreasonable, a personal vehicle would of course be the best choice, if not the only one.

A. The Cost of Transportation

A large part of any individual's choice in how they plan to travel is the cost. From a daily commuter's gas expenses to a family's airfare pricings, the cost in travel is always a major factor. Price will have an impact on the popularity of public transportation.

For a better comparative analysis the following factors will be ignored; any private mode of transportation that is available, car, bicycle, etc. will involve costs that go beyond the travel costs. These include the initial investment of purchasing the car, bike, or other, and any fees for parking, licenses, insurance, and maintenance that might be required. Ideally, a car would not cost you anything beyond gas to use it, but that is simply not the case. With the assumption that a person has a private car already and is considering using public transportation to reduce daily expenses and energy usage, then those passive costs are present either way.

Table 2. Cost of Commute per City by Mode

City	Bus	Light Rail	Car
Boston	$2.00	$2.00	$1.97
Los Angeles	$1.50	$1.50	$2.01
San Francisco	$2.00	$2.00	$2.05
Portland	$2.50	$2.50	$2.00
Philadelphia	$2.25	$2.25	$1.88
Dallas	$2.50	$2.50	$1.65
San Diego	$2.50	$2.50	$2.05
Denver	$2.25	$2.25	$1.80
Salt Lake City	$2.50	$2.50	$1.80
St Louis	$2.00	$2.25	$1.69
Average	$2.20	$2.23	$1.89

A break down of the average cost of a one way commute in each city. The table shows that in most cities it is just as cheap to drive as it is to take public transportation. (From Transit Authority by City)

Table 2 shows the estimated costs of a one-way commute in ten higher populated cities across the country. The bus and rail costs are what the public systems in each city charge for a ticket; in some cases that price includes a free transfer to another bus or rail line, as of November 2013. The car costs are calculated based on the national average commute distance and fuel economy, 14 miles and 24.9 mpg respectively, and using the average gas price found in each city, circa November 2013 (UMTRI, 2014). As shown, it is cheaper in every case to take a personal vehicle over taking public transportation in terms of cost, although for several cities the costs are close. The only exception is San Francisco, where it costs five cents more to drive a car.

Table 2 uses many national averages, along with several estimated public transportation costs. As mentioned before, several of the cities allow bus and train transfers at no additional cost, but this is not always the case. For an individual who has to take several transfers in a one-way trip, this cost can add up. To avoid those additional costs, some cities offer unlimited daily, weekly, and monthly passes. These are not included in this table since not every city offers the same plan, but in every case they reduce the cost of taking public transportation below the cost of driving daily by roughly $0.50 on average. As an example: San Diego charges $72 for a monthly public transportation pass (SDMTS, 2014). With a month having roughly twenty workdays, with two trips a day, that is a minimum of 44 trips. The pass makes each trip cost about $1.64, compared to the $2.50 price per ride, or the $2.05 spent by car. Monthly passes are designed to save frequent riders money the more they use it. Given weekends, or other needs, the price per ride drops even lower still, making it a far cheaper option than private transportation.

While public transportation is a cheaper option, it can't always get you where you need to go in the fastest manner. That is where more privatized transportation wins over. Yet, not everyone can afford to purchase a car; that is where alternatives to private transportation can factor in. The option of carpooling or car sharing is available to those who know others with a vehicle and a shared destination. While sharing the initial purchase cost of the car is not common, it can be done, making it a shared vehicle, and either way all fuel costs are shared between the participants, resulting in savings for each person. There can also be other benefits for carpooling. The riders can share toll fares, use carpool lanes, and have company for the ride.

There are alternatives in transportation to cars, in the forms of a bicycle or moped. The initial cost to purchase an electric bike or moped is usually a fraction of the cost of a car. A bike can be sold new from a box store like Walmart for as low as $100 (Walmart, 2014). An electric bike or moped is a larger initial investment, from $400 - $2,500, and some mopeds are gas powered, requiring fuel. Although with their fuel economies being rated at close to 70 mpg, they are still cost effective on a daily use compared to a car, dropping commuting costs to around $0.70, city dependent (Moped World, 2014). What is even more is that a regular bicycle can be converted into an electric bike using a purchasable kit. These kits, depending on their battery or motor, can cost as little as $300 (Electric Bike Kits, 2014).

B. The Energy

Within this section there will be an analysis of the energy consumption of several modes of public transportation, and how they compare to one another and private transportation. These modes include light rail, heavy rail, busing systems, and alternative options to these that include mopeds, electric and traditional bicycles.

Table 3. Modal Energy Consumption per Passenger Mile

Type	BTUs	Average Riders	Max Riders
Motor Bus	4,365	30	60
All Automobiles	3,885	1.2	5
Light Rail	3,465	100	220
Passenger Cars	3,445	1.4	5
Heavy Rail	2,600	300	700
Toyota Prius	1,659	1.4	5

A breakdown of the energy used by different modes of transportation. Heavy rail ranks well on the amount of energy it uses per passenger mile, consuming less energy than the average car, making it a favorable mode. (O'Toole, 2008)

Table 3 analyzes the amount of energy it takes for the various modes of transportation to travel one passenger mile, which is the amount of energy to transport one passenger one mile. As shown, heavy rail is more efficient than the average passenger car, and light rail is more efficient than all automobiles, which includes SUVs and light trucks. The average bus consumes far more energy than a car, and while being able to hold a greater number of people, it is not always the case that it is filled to maximum occupancy.

The Toyota Prius is added for a comparison for the hybrid alternative and how it fairs against the other modes of transportation. It is of course the most efficient, using only two thirds in energy to its closest competitor, heavy rail.

Table 3 is generated using the average load of each vehicle taken over the course of a day, rather than each day's maximum. This means in includes the all energy that is spent when the mode, either train or bus, is operating, even when there are few or no passengers on board. It also includes when the vehicle is completely full, occurring most often at rush hour. It takes the total energy and spreads it out for the total distance the mode traveled in that day, comparing it with the average daily passenger load. The numbers in Table 3 are related to each vehicles load factor rather than the individual vehicles weight. Each vehicle is of course much heavier than its occupants, so doubling the number of passengers can effectively half the energy consumption per person, (O'Toole, 2008). This means there is an inverse relationship between the energy consumption per passenger mile and the number of passengers for all modes of transportation, especially public. If the number of passengers increases, the energy spent per passenger mile decreases, making the transportation mode more efficient.

In terms of load capacity, for trains, a rail car can hold upwards of eighty people, while a train can have six to eight rail cars in a row. This allows rail systems to carry an exponentially larger number of people than the average car. The average bus ranges around sixty maximum riders. However buses and trains are rarely run to full capacity, with rush hour exceptions, so when they are run with little or no occupants there is a waste of energy. These times increase the average energy per passenger mile for each mode.

Meanwhile a car is most often operated with one passenger, the driver and is used only when there it is needed which lowers its energy consumption and increases its efficiency.

C. Light Rail

Light rail is an intra-urban form of transport consisting of trains located above ground on fixed tracks that give them right of way, and are therefore unaffected by regular traffic. There are close to thirty cities in the United States that have a light rail system available to their public (Dickens 2013). While light rail as a whole is fairly efficient, each city runs at different energy consumptions, and would affect the local populations accordingly when looking at daily levels of energy consumption in travel.

Figure 6 shows the energy consumption of the light rail systems found in the top ten cities by rail ridership, with the addition of Pittsburgh, which has the greatest energy consuming light rail system. On the graph there are also the comparisons against the automobile energies found in Table 3. The closest city system to reaching the efficiency of the standard Toyota Prius is San Diego, operating at slightly more than 2000 BTUs per passenger mile, and Pittsburgh operates its system at nearly six times the energy, (Davis, 2013).

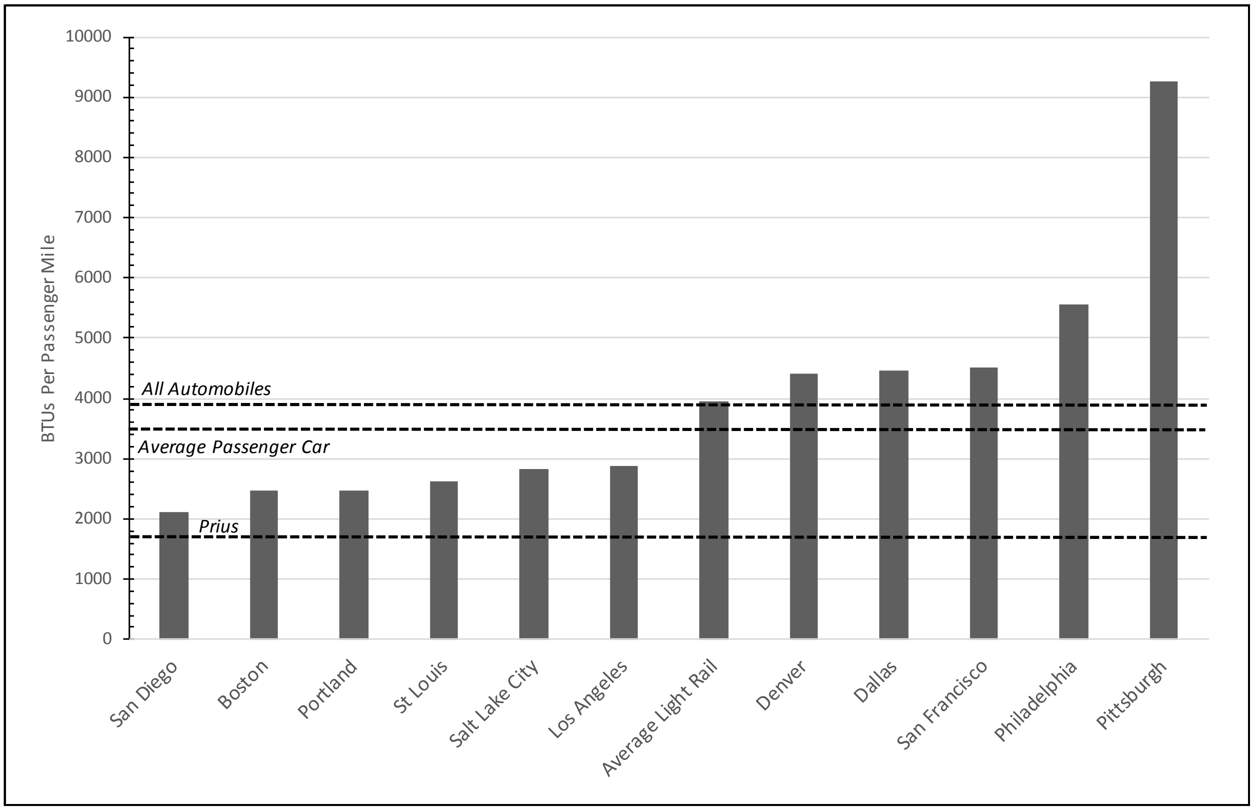

Figure 6. Light Rail Energy Consumption by City with Other Mode Comparisons. While light rail as an average uses roughly the same amount of energy as a passenger car, there are cities that operate with substantially higher energy consumption. There are a variety of factors that affect these numbers, an important one being actual accesability or daily ridership levels. If either are too low, a rail's energy consupmtion per passenger mile will grossly skewed. (Davis, 2011)

There are a series of factors that affect the energy consumption of each cities' light rail system, Pittsburg included. They include operating hours, daily ridership, system length, or how far wide the system spreads or its availability. It is notable that both the San Diego and Boston systems have over 100 vehicles in their light rail system. Pittsburg has only 83, but still has similar track length. Both Boston and San Diego have at least double the daily ridership of Pittsburg, Boston having nearly ten times the amount (Dickens, 2013). Other factors that can account for energy differences are track width, vehicle age, or electrification style, whether it is an overhead, where it draws energy from power lines that run above the train, third rail or even fourth rail system, where energy is drawn from an electric rail that runs parallel to the tracks. There are common track gauges, which is the width of the distance between the train tracks, but a wider gauge would account for a different distribution of weight and could decrease efficiency (Iwnicki, 2006). There is also the voltage of electricity that each rail operates at. There are a few common voltages, a popular one being 600 volts in direct current; this might not be ideal amount for the train at all times of the day (Fayomi, Robert, 2000).

When light rail comes into consideration as a mode of transportation, each city has to be compared differently to a car. An individual in San Diego, Boston, Portland, or Los Angeles can see the public light rail systems as a means to decrease their energy consumption by over 700 Btu per trip, and a round trip of 1400 Btu. While in other cities, there are a few more variables to factor in when it comes to looking at saving energy. Again, each energy value is taken using the average daily loads. So the more riders, the lower the values become. If someone were to switch to taking light rail, they would lower the energy required for each person to travel. The more people on the train, the better the savings in energy.

The daily average load of light rail is roughly 100 passengers per mile, with the light rail average energy usage of 3,465 Btu per passenger, giving a total around 346,500 Btu per mile (Davis, 2013). This number would be fairly constant, as that is the energy it takes to move the train a mile, and that increasing the number of people wouldn't require too much more energy, considering the additional weight. This means that if the daily load increased to 150 passengers per mile, the energy per passenger per mile would decrease to 2,310 Btu, a level of energy usage less than double the Prius'. While not great, it is a great improvement from where it originally was close to three times more. This average load increase is a lot to expect; however, public transportation as a whole can become more efficient in each city, it just requires more participants.

Light rail is for the most part an efficient way to get around. In the few cities where it uses more energy per passenger mile, that is because it doesn't have enough riders. Unfortunately in some cities light rail isn't a better option for saving energy. In Pittsburgh, the light rail system would have to run at nearly full capacity all the time to meet the energy efficiency of the average car. While not impossible, it is a tall order. This is the extreme case, and in almost any other case, taking light rail will reduce energy usage.

D. Heavy Rail

Heavy rail is another intra-urban form of transportation that is more easily recognized. It is designed to move larger quantities of passengers, and is usually removed from the regular flow of traffic, either as a subterranean system or an elevated track system operating above regular traffic streets. Given its separation, it can operate at higher speeds. While heavy rail runs by using less energy than both the average passenger cars and light rail, it again varies by city, affecting the local populations differently.

Figure 7 shows the energy usages of the heavy rail systems in top twelve by ridership of the fourteen cities that operate them. There are several rail systems that operate at a usage close to that of the Toyota Prius', while the rest are closer to the average for all automobiles. The few heavy rail systems that operate at higher energy usages suffer factors much like the light rail systems, but even the one that uses the most energy; Baltimore operates lower than the worst among the light rail systems.

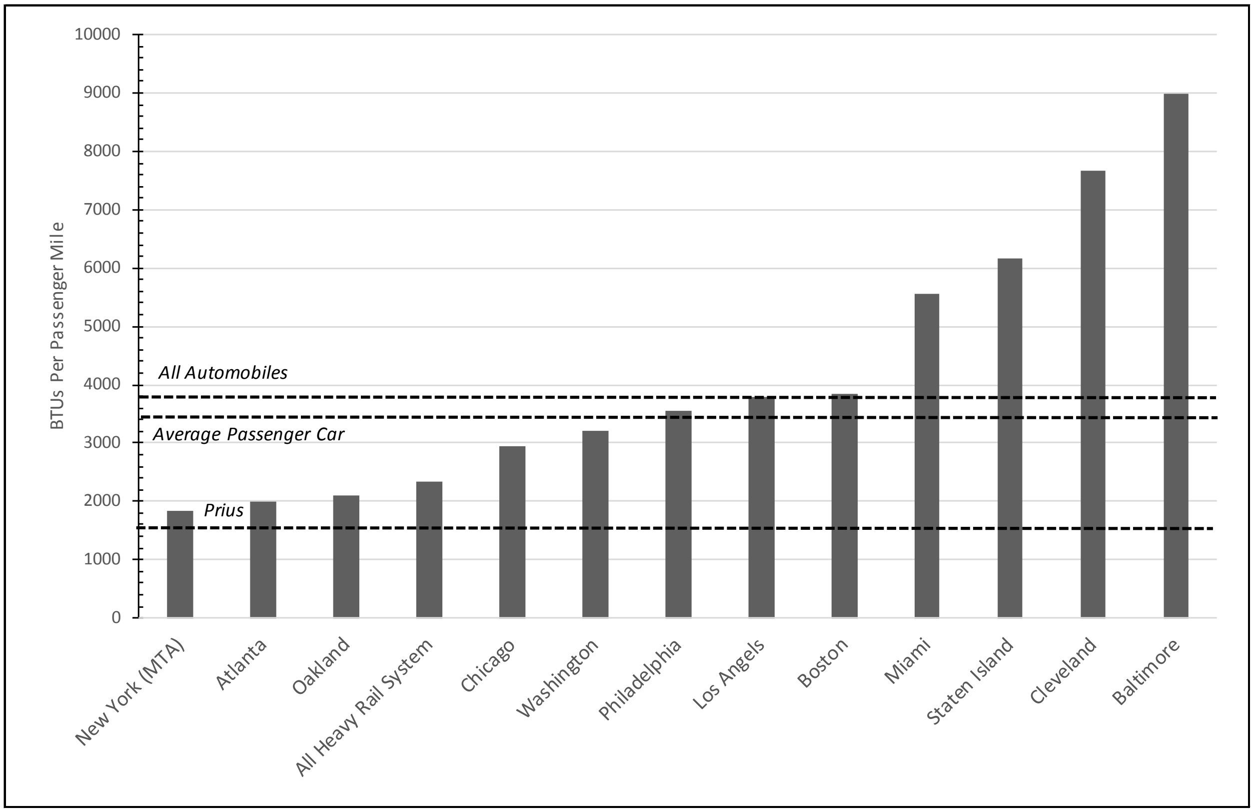

Figure 7. Heavy Rail Energy Consumption by City with Other Mode Comparisons. Heavy rail's average operates close the Prius' energy level. Given its higher passenger frequency and higher speeds, it shows off a lower energy usage than light rail. Although the same sort of factors apply that speak for the differences between energy usage in differing cities. (Davis, 2011)

The factors on the heavy rail energy efficiencies are much the same as they are for the light rail systems; namely operating hours, ridership, and track length. Looking for the comparison in the two different New York rails, the MTA and Staten Island, the MTA services over 500 times the amount of people than the Staten Island rail on the average weekday (Dickens, 2013). This vast difference can help account for the differences in energy per passenger mile, and not only in those two, but also between the others. These differences aside, heavy rail is still in most cases more efficient than taking a personal car, light rail, or bus. An individual taking heavy, as with light, rail saves the energy they would spend to drive, and reduce each other riders' energy on the train. The more people taking public transportation, the more efficient it becomes.

One thing to take into account for both light and heavy rail is that they operate on dedicated tracks and are set to more specific schedules. They are less constrained by the large number of variables that effect automobile traffic, such as inclement weather, car collisions, construction, and regular traffic jams. This allows them to run more effectively than a car or bus and can avoid the problems that regular traffic might have to face and don't suffer the energy that is lost idling at intersections.

Given that each city has its own energy consumption levels for their rail systems, the same can be said for the average energy spent by car waiting in traffic in these cities. Five miles can be a long commute in a highly populated city during rush hour when going by car. Public transportation has a more constant energy consumption level than private, and depending on travel conditions can be a better choice in cost and energy. These upsides, along with the lower energy usage of heavy rail make it a better option over taking private automobiles.

E. Buses

Along with the variety of rail systems that are offered across the United States in the unfortunately few cities, public transportation can be in the form of buses. Given their availability to travel with regular traffic, and freedom from regulated tracks, they hold a high level of accessibility over any rail system, and are common in almost every city across the country. Given their mobility, are they a more energy efficient option?

Looking at Table 3 motorbuses use the largest amount of energy compared to any of the average rail systems or cars. While not an exact measure of their true energy usage, it does give an overview on how they stack up against the averages of the other available modes. Table 4 gives a better break down of the true energy usage of buses used as public transportation (Bradley, 2007).

Table 4. Comparison of Bus Energy Usage

Type	BTU per Passenger Mile		
	Low	**Avg**	**High**
Motor Coach	685	749	862
Trolley Bus	1,130	1,321	2,582
Transit Bus	1,088	4,245	35,123

While buses are in general similar in design, how they run can differ greatly. The motor coach runs less often than a transit bus, and usually at max load, making it a more energy efficient mode of travel. The tansit bus will run constantly hoever, even if there are no passengers aboard (Bradley, 2007)

It is interesting that motor coaches, which are buses that are more often owned by a private company that sells seats for longer distanced travel, have the lowest energy consumption; their max energy usage being several hundred Btu below the minimums of the other two. This shows that motor coaches are used more efficiently, each trip being loaded to near maximum capacity, and are rated well with regards to their fuel economy. Trolley buses are the second lowest, but can be more related to light rail. They are on designated tracks, and are powered through electricity, rather than a combustion system. Although similar to light rail, trolley buses are far more common, being found in almost seventy cities across the country, given their lower level of maintenance demands and ease of adaption into a built city's infrastructure. Transit buses are the worst, and in the extreme cases, operate at seven times the energy consumption of their average, (Bradley, 2007). The energy usage in transit buses will be discussed later.

The overall low effectiveness of transit or trolley buses is that throughout the day the buses are running their routes whether or not there is demand for them. Table 4, like the previous tables and figures, utilizes averaged energies. These lull times where there are little to no passengers on the bus make it appear a less effective mode of transportation. With buses, like heavy and light rail, the more riders on the bus, the more efficient it becomes, and each rider's energy use is reduced, given the inverse relationship between energy per rider and number of riders.

The transit buses minimal energy usage can be related either to the efficiency of the transit system or more likely the fuel economy of the vehicle. Diesel-electric hybrids are common buses in the United States, with over sixty cities implementing them, and electric buses can be found in a few cites. Often these electric buses share the same constraints as a trolley bus. They are powered by electric lines installed in the ground, with an energy exchange through the gap between the bus's bottom to the ground.

An unfortunate option about busing is that, despite how efficient one type might be, the would-be rider is subject to whatever bus; be it electric, hybrid, or diesel that is available. It is not an option of the rider, waiting at a bus stop, to pass on taking a diesel bus and just wait for the electric one to come by. A city will have whichever bus type it has, and the individual has to base their ridership thusly. This aside the bus is a better option, especially during peak traffic times like during a morning commute. Taking a bus would save the individual the energy they would have spent driving, and lower each riders' energy need, saving between 4,000 and 7,000 Btu per trip, given the busload (Davis, 2007).

As far as long distance travel, motor coaches present a strong alternative to cars, and should be considered, given their availability.

F. Alternatives

Although public transportation is the alternative to owning a car, or vice versa, there is another option to "motorized vehicles" all together. This is presented in the forms of walking, as stated before, bicycling, or small electric vehicles like a moped. Walking is a strong and reliable form of transportation that depends on the individual, but it can be extremely slow compared to all other forms of getting around. However, it can always be considered for travel. A form that is be more efficient than walking, in terms of speed, is riding a bike. Although requiring more skill than is needed for walking, it takes, on average the same amount of energy, given the terrain (Exploratorium, 2014). Bicycling is an effective way for people to meet their personal needs to quickly travel shorter distances, and is a far cheaper option than buying a car.

Using data present by *Bicycling Magazine*, it takes the average person about 200 BTU per mile to operate a bicycle at 15 miles per hour, on flat terrain. Comparing this value to even the most efficient motor coach, or Toyota Prius, it is a fraction of the energy to travel a mile. Although biking is slower than taking a car, in many residential zones, and urban environments, speed limits are set to a range of 25-35 miles per hour. Add in the fact that in rush hour traffic, speeds can be lower, given stop and go traffic from high congestion, and 15 mph can be an acceptable rate of transport. Many cities also have private lanes for bicycles to operate safely in, so they don't have to fully mix with regular vehicular traffic.

Given the ability of the bike to traverse between traffic, take alternate routes, and its ability to even be picked up and carried, it can out maneuver any other street traffic. Only the rail systems really have an advantage over cycling, being on dedicated tracks, and maintaining more constant, higher speeds. Rail uses 10 times or more energy than cycling however, lowering its attractiveness, although this energy is not generated by the rider.

Now an individual might not be so inclined to spend their morning commute expending needed energy for the workday cycling. Therefore, there are motor bike alternatives, from electric or gas mopeds. Furthermore, there is an option to even adapt a regular bike to run off electricity. Yet there is a considerable amount of effort and additional cost that goes into converting an existing bicycle into an electric bike. That is taking an existing bike and installing a small electric motor to the rear wheel that applies force for the rider, making the experience less physically demanding.

Although an electric bike uses less energy than a regular car or the Toyota Prius, it is not by all that much. An electric bike uses about 1,360 BTU per mile, and while that is not a constant value, it is an amount required to travel at about 25 mph on flat ground (Grin Technology, 2012). Now electric bikes are often self-sustaining, meaning riding it powers the battery, but that is not always the case. Some require charging from a regular home outlet. This energy is from a power plant, and costs much less than it would to fuel a car (BLS (B), 2014).

Mopeds, a type of light motorcycle crossed with a bicycle, are designed for ease of use in transport, while having strong economic benefits. Although not all are designed the same, a large variety still have bicycle styled petals so they can be used without consuming fuel or energy from an electric battery. Mopeds can achieve speeds up to 30 mph allowing them to compete with regular traffic speeds in cities and suburban areas, while averaging at a rounded fuel economy of about 70 mpg, although more advanced models can reach well over 100 mpg (Schramm, 2005). Comparing even that average fuel economy to that of the Toyota Prius, an exemplary car with 50 mpg, yet alone to the average American car fuel economy of 24.9 mpg, the moped has a large advantage over the car (UMTRI, 2014).

Figure 8. A traditionally styled moped

Table 5. Energy Consumption by Vehicle

Type	BTU per mile
Bicycle	200
Electric Bike	1,360
Moped	1,185
Prius	1,659
Average Car	3,445

A comparative look at traditional car energy usage against alternative forms of transportation. What is interesting is that an electric bike or moped is barely more efficient than the Prius. Although a cheaper option, they don't use all that much less energy

Compiled from data present by UMTRI 2004, O'Toole 2008, Grin 2012, and Schramm 2005.

Table 5 shows a comparison of the energy each mode of transportation requires to travel one mile. The bicycle has a great advantage, but that energy is required directly from its rider and is not an altogether ideal option for most commuters given its lower maximum speeds compared to other modes. Looking again at Table 5, the moped uses less energy than the Prius and even the electric bike, having a better motor, making it a better option.

G. Car Pooling

Although not everyone cares for a moped, bicycle, or even traditional public transportation; there is another option that while still being "public" is more relatable to private transportation. This is the idea of carpooling or car sharing; where a group of individuals who take similar routes about their day, mainly a commute, can meet and share a private car owned by one of the members. This reduces the energy spent by each person, who would otherwise be driving alone. Taking the amount of energy that is used for the average driver, then dividing that five, or the full capacity of the car, you get the usage of each rider. The savings per person can be roughly 2,700 Btu a trip in a car full to five people (O'Toole). The more efficient the personal car, like a hybrid, even better savings are had.

Recommendations

With the knowledge and need of daily transportation, an individual can easily set up the means to make their commute to work, the assumed reason, the most energy efficient. Given the availability and ease of access to public transportation, it should be used. While forgoing the comforts of private transportation, and individual can save thousands of Btu per trip.

Given that a bus is already operating its route, and a train will travel between its stations, they are going to use an amount of energy already. If individuals take those modes for their commute, they reduce the energy required to transport each person, lowering the impact each rider has. This choice also means that those individuals are then not driving their own cars, saving any energy that would otherwise be required. So if an average transit bus that was used to generate the data has roughly 30 riders on it, being half a buses maximum occupancy, each rider uses 4,245 BTU (O'Toole, 2008). Compare this to 3,445 BTU each person would use while driving each of their own cars, and there is a loss of 800 BTU per person per mile. Again, if more people ride the bus, each additional rider lowers each other's energy use. It would show that it takes 7 more people to ride that bus to make each person's energy use equal to a cars, and any more than that would result in energy savings. Also, you have to take into the account that those individuals are now not driving their cars, which would use additional energy. The bus will be using energy already, and not taking it would cost more.

The same idea goes true with both type of rail systems, where the more riders, the lower energy per person, the greater the savings for each non-private driver. The savings are more substantial when more people use heavy rail, since it is a more efficient mode. There are still savings in light rail, more people to ride then don't.

However, given an individual's preferences, they will not always be inclined to take a bus or train, preferring to take a car to its alternatives. Carpooling makes its stand as being a better way for people of this preference to travel effectively with one another, allowing each rider to save energy and expenses.

A moped is a great way to get around and can save energy compared to a car. It's not always a better option though. If a moped or electric bike is used instead of a car pool, there could be a loss of energy close to 500 Btu per trip. While a rare case indeed, the moped still is a strong option for those looking to reduce their energy use.

There are quite a few modes of travel that are available to people but picking the right one will always be an issue. However an individual might feel about using public transportation, it will always result in a savings of energy. The amount saved depends on how much energy might be spent on the other modes that are available to the rider.

V. Food

Food and water are fuels that humans and other complex life forms need to survive in this world. Humans are able to survive for about three days without water and about three weeks without food (Binns, 2012). Naturally, it has driven the evolution of humanity to a point where it is neither difficult nor expensive for 87.5% of humans on Earth to obtain enough food to live (FAO, 2013). The amount of food a person would need to lead a healthy, nourished life averages between 1785 and 2640 calories for women and men respectively in America, though 14.7% of Americans remain malnourished (USDA, 2010; FAO, 2013). Despite being so blatantly important, food and water only take up 6.2% of the total United States energy budget, the energy budget being the energy that each respective industry in the United States consumed in a given year out of the total (EIA (D), 2013). This low percentage is due to the methods in which food and water are obtained nowadays, which are very different from the methods of early humans.

In the days of nomadic hunters and gatherers, humans literally followed their sources of food and water around the continents of the Eastern and eventually the Western World, and they managed to find and hunt enough to survive, if only just (Lewis, 2009). Their lives revolved completely around obtaining energy from food, so one can imagine that the majority of all human energy was spent in the pursuit and consumption of food and water. A few thousand years later, all the average American has to do to get food and water is walk or drive to the local grocery store because all the hunting, gathering, and farming has been done for him by others. The energy required for people, the consumers, to obtain food has decreased significantly, but the energy expended to grow, harvest, and transport food must also be considered as part of a person's food energy consumption, and this energy has increased significantly.

Most people do not know that the food they purchase consumes energy on its own. Energy is required to grow or raise food, especially in this age where machines are often used to expedite the process, but the average consumers do not always see this. They also do not realize how much energy then goes into the processing, packaging, and transporting of the food or beverage they are purchasing. Again, the food industry consumes only 6.2% of the total United States energy budget, which is not a lot compared to other industries, such as the oil industry which uses 33% of the total (EIA (D), 2013). Food is, however, one of the largest energy expenditures that can be legitimately influenced by the consumer. Larger industries actually produce the products, like chemicals and fuels, that supply the smaller industries, and they cannot realistically be influenced by the average consumer (EIA (D), 2013). The food industry, again, relies solely on the consumer, so the consumer could actually make a difference in this instance.

The need for food is both a blessing and a curse; it is a blessing because for once the consumer has some control, but it is a curse because every successful food corporation is competing against all other food corporations in an effort to create more customers. It is a battle over money, not providing quality sustenance. The common battleground in this corporate war is advertising; through advertising, corporations have access to the public mind because ads for products are almost everywhere civilization exists. These advertisements bias the public in a certain way and cause people to choose one brand of a product over another. Some brands, and especially some types of food, are produced less efficiently than others but are pushed so hard through advertisements that consumers are baited into purchasing them regardless of the implications. These implications include but are not limited to inefficient resource and energy usage, destructive pollution, and even animal cruelty. Again, most people do not realize how much influence they have on the food industry and how much their spending behaviors can determine industry standards, like production plant safety and efficiency regulations. The major goal, however, is to reduce one's consumption of energy in the food industry, for this drastically reduces the amount of energy the average person uses.

A. Methods of Reducing Energy Consumption through Food and Beverage Purchases

If one is concerned about his impact on the globe, he will certainly be mindful of his energy consumption, which for the average American is 853,000 Btu/day (MacKay, 2009, p. 104). An average of 40,900 Btu per day is dedicated to the production of the common foods that a single American consumes, so this can be considered as the individual food energy consumption (MacKay, 2009, p.77). Although the average daily food energy consumption is only a small chunk of the total daily energy consumption, the larger portion is mostly comprised of transportation and home energy usage (EIA (D), 2013). Food is the only major category of energy consumption that does not fall under either transportation or home energy usage, so the big question will be addressed in the following sections. How does one reduce his food energy consumption?

B. Refuse to Buy Bottled Water

There are several ways that one can reduce the amount of food energy he consumes, and it begins with the most essential of all human fuels: water. This liquid is the most valuable substance on Earth; it allows all food to grow and animals to thrive. Few people with access to clean water realize how valuable it is because one can run an endless stream from the tap and buy water from the store in a bottle or jug and end up spending very little money or effort. The truth is that water from the tap costs a fraction of what bottled water costs, and the energy consumption is also much greater for bottled water. A person can drink the daily recommended amount of water (64oz, 8 cups) from the tap for an average of $0.19 per day and from the bottle for an average of $4.98 per day (Ban the Bottle, 2013). The reason for this price difference is the plastic bottle itself, which requires about 2,000 times more energy to manufacture than it does to filter and treat the water; other processes involved in producing bottled water only account for 0.34% of the total energy (Cooley & Gleick, 2009).

Table 6: Energy Used in Bottled Water Production

Process	Energy Consumption (MJ(th)/l)
Plastic Bottle Manufacture	4.0
Water Treatment	0.0001-0.02
Filling, Labeling, and Sealing	0.01
Transportation	1.4-5.8
Cooling	0.2-0.4
Total	**5.6-10.2**

Table 6: This table illustrates the massive consumption of energy by the manufacturing of bottled water. It can be seen that processes that are “bottled specific,” (making the bottle and transporting it) account for almost 100% of the energy used in creating it. Tap water really only undergoes treatment.
Source: Cooley and Gleick, Energy Implications of Bottled Water

It is sad that the amount of bottled water purchased in the United States, about 9.1 billion gallons in 2011, has been growing each year, having gained 4.1% from 2010 to 2011, when clean tap water is so readily available (Beverage Marketing Corporation, 2012). The mass sale of bottled water would make much more sense in places where clean tap water is not so available; the US has such easy access to clean tap water but happens to be the largest worldwide consumer of bottled water (Arnold & Larsen, 2006). This practice is highly inefficient and unnecessary, for tap water, in most cases, is well regulated and perfectly safe to drink. In fact, around 40% of all bottled water sold in the US has previously come from a tap and is actually just packaged tap water (Arnold & Larsen, 2006). The Food, Drug, and Cosmetic Act of 2013 set the regulatory standards for bottled water, and the Safe Water Drinking Act of 2012 set the regulatory standards for tap water, and overall, tap water is held to a higher standard (USFDA, 2013; EPA, 2012). A table of comparisons between tap and bottled water (below) shows that bottled water does not require testing for *Fecal Coliform*, a horrendous strain of bacteria, or Asbestos, a known carcinogen. These are things that should not be in water meant for drinking, and tap water is tested for these hazards and more to ensure purity and sanitation (Olson, 1999).

Table 7: US Bottled Water Change (Volume and Spending) from 2009-2011

Year	**Volume (10^6 gal)**	**Annual % Change in Volume**	**Spending (10^6 dollars)**	**Annual % Change in Spending**
2009	8,453.10	NA	10,601.30	NA
2010	8750.6	3.5	10,683.80	0.8
2011	9107.3	4.1	11,083.80	3.7

Table 7: This table illustrates the increasing amount of bottled water consumed by Americans each year and the profit flow therein. Many Americans have access to perfectly acceptable tap water, though most would do well to use a filter before drinking it; the numbers should not be so.
Source: Beverage Marketing Corporation, 2012

Table 8: Some Key Differences Between EPA Tap Water and FDA Bottled Water Rules						
Water Type	Required Disinfection	Confirmed E. Coli and Fecal Coliform Ban?	Testing Frequency for Bacteria	Must Filter to Remove Pathogens or Strictly Protected Source	Must Test for Cryptosporidium, Giardia, Viruses	Testing Frequency for Most Synthetic Organic Chemicals
Bottled	No	No	1/week	No	No	1/year
Carbonated or Seltzer	No	No	None	No	No	None
Big City Tap	Yes	Yes	Hundreds/month	Yes	Yes	1/quarter

Table 8: This table shows the standards of testing and purity to which bottled and tap water are held. It can be concluded that tap water is tested more rigorously than bottled water, though tap water may have a slight metallic taste from the pipes through which it flows; this problem can be easily solved by using a filter. Bottled water is now tested for *E. Coli*; this chart is somewhat outdated.
Source: Olson, Erik D*, Natural Resources Defense Council, 1999*

What this issue of bottled water really boils down to is convenience. It can be more convenient to run out the door and pick up a bottle or two on the way to work than to plan ahead and fill up a reusable bottle. It is just as easy, if not more so, to use a reusable water bottle, such as a Nalgene, which costs under $20 (Nalgene Store, 2014). This one liter Nalgene equates to the price of about thirteen 500mL bottles of water at $1.45 each; if the average American uses 167 plastic water bottles per year, using a Nalgene could save them $225 per year (Beverage Marketing Corporation, 2012). One can easily use a cup and a filtered pitcher, such as Brita or Pur, when at home for under $30, as well, to ensure that the tap water is sanitary and pure (Target, 2014). In short, choosing tap water over bottled water is cheaper, more energy efficient, and generally safer.

C. Gardening and Growing Food

Water, being the most intrinsically valuable substance on the planet, will surely receive more attention in the coming years seeing that many countries worldwide will be entering a period of severe water shortage due to population increase and other factors (Amarasinghe, Seckler et al., 1998). Water also greatly impacts the ability to grow and produce the second most intrinsically valuable substance on the planet: food, without which humanity would perish swiftly (Binns, 2012). This brings up the question of whether growing one's own food in a garden or greenhouse is possible if water runs short and large scale crops become exorbitantly expensive. It is possible, but water shortage in America has not yet become a problem. Instead, the question should be whether enough food can be sustainably grown in a personal garden or greenhouse to be able to feed a person or family and, in doing so, reduce their food energy consumption.

The energy cost of growing one's own food is a variable number, and there is no equation or table that pinpoints it exactly, but certain factors can be weighed against each other when comparing growing food at home to buying food from the store. The first energy benefit is avoiding the commute to the store; growing one's own food eliminates the need to travel to the store to fill the cabinets and refrigerator. The average American spends 12.5 minutes each way in transit, so right away 25 minutes of a running car (93.8% use a car) are eliminated, which, depending on the type of car, could be saving gallons of gasoline (energy) per month (Borisova & Brown, 2007). Another energy benefit of growing one's own food is that there will not be any packaging involved, other than the initial container of seeds. Though food surely requires more energy to test and process, it can be assumed that the energy cost of packaging food is near that of creating a plastic water bottle. Every food package that a person avoids buying requires around 3790 Btu to manufacture, so the savings on energy equates to how many packaged items a person can replace with homegrown ones. Growing one's own food can lead to energy savings on par with eliminating bottled water, but because more energy goes into the processing of food, there are even more opportunities for energy savings (Cooley & Gleick, 2009).

As the field of vision increases, more energy savings can be seen. Transportation, not just to the store but from the food source to the store, can be eliminated almost completely because none of the homegrown food needs to be shipped across the country. The average distance store-bought food travels before reaching the dinner plate is 1500 miles (National Resources Defense Council, 2007). Yet again, this energy sink can be eliminated by growing food in a garden, not to mention all of the greenhouse gases and other pollutants that are released during transportation and processing that no longer even come into play. Of course, before the food can be processed and shipped, it must be grown, yet the large-scale agricultural practices of today are not as efficient as they could be. For example, it can be observed (while flying in a plane over the Midwestern US) that many crops are watered in a circular fashion via rotating sprinklers. In such warm states, some of the water shot into the air evaporates before it even touches the crops, and even then, water evaporates off of the leaves and stems before getting to the roots, where the water is really absorbed. Underground irrigation would be a much more efficient choice because the water goes directly to the roots to be absorbed and utilized by the crops. To reiterate: many of these energy and resource sinks can be avoided by growing one's own food.

Though growing food in a garden may sound appealing, there are more aspects to consider than just the energy consumption that will be avoided; growing one's own food will still consume energy and will present other obstacles, as well. The main source of energy for growing one's own food, other than the sun, is the gardener's own body. Energy will need to be exerted by the gardener in a number of ways to ensure that the crops he has planted will grow properly and survive until the harvest. For starters, the gardener will have to till and prepare the earth, making sure that the soil conditions, such as pH and moisture content, are at least close to what his crop requires. He will also have to protect this newly established plot of fertile land from intruders, mainly critters that want to eat his crops, so he will build a fence. Once his plot is prepared and protected, the gardener will need to plant his seeds and tend to them every day to ensure the health, quality, and success of the crops. The daily time commitment is completely variable because, "as you sow, so shall you reap," and the gardener will essentially harvest crops whose quality and quantity reflect his commitment to the garden (Call & Oebker, 2008).

For a busy American, a large time commitment to a garden after a long day of work does not seem like a rational idea, especially when one can simply go to the store and buy anything. The time commitment, though it may be excessive, may not even yield a successful crop at the end of the season for many other reasons, such as weeds, bugs, and climate. The weather in some states is just not the ideal for some plants, so they will not grow to be the way they look in the store regardless of how much time is invested. That being said, in New England it could be quite difficult to grow enough food to sustain oneself through the winter; that is a major climate issue in some cases. While all these issues arise in the discussion of growing fruits and vegetables, the discussion of growing things like wheat gets even stickier. The time commitment required for turning wheat into flour and bread is grueling, especially when added to the preexisting time commitment of gardening (Pitzer, 2010). On the whole, if one wanted to sustain himself on homegrown food, it would be a challenge, the likes of which many people have never seen before and would not be able to face. Using gardening to supplement normal shopping trips, however, is entirely possible and not nearly as time intensive as it would be to grow all one's food.

D. Reduce the amount Meat in the Diet

It should be noted that while in some cases it can be possible to grow all the food a person could need, it is not yet possible to grow meat (animal flesh) in a garden, which is why it was not mentioned in the previous section. The way one would "grow," his own meat would be to purchase a cow, chicken, or pig and feed it on grains that he grows; the amount of time this tacks onto the already immense commitment of growing food does not appeal to many people. This is also not a very sustainable option because the energy that is required to raise and feed the livestock is much greater than the energy that is received from the meat upon eating it (MacKay, 2009, p.77). A very simple solution to this problem of meat inefficiency is the elimination (or reduction) of meat from a person's diet; without the need for meat, the energy toll of feeding that person goes down significantly, nearly 27,300 Btu/day (MacKay, 2009, p.77).

Growing food takes a lot of time and effort, and it may be astounding that 89 billion pounds (47%) of soy and 580 billion pounds (60%) of corn grown in the US goes into feeding livestock for human consumption (Olson, 2006; Murphy, 2001; Thiesse, 2013). That amount of food could potentially feed 800 million people (Olson, 2006). In addition, the prices of grain products are usually lower than those of meat, so if the livestock sector of grain consumption was reduced or eliminated, it seems that many more people would be able to eat affordably. On top of being a huge sink for grown food, livestock are the most inefficient means of food. As was said before, the food (energy) input for producing meat is much higher than that for producing grown foods, such as broccoli, corn, and wheat. The ratio of energy input (food energy given to livestock) to energy output (energy gained by eating livestock) for many animals is contained in a **Table 9** below. It can be seen that Lamb and Beef Cattle top the chart at 57:1 and 40:1 respectively, while Corn takes the bottom-most spot, actually putting out more energy that it takes in, though this is due to the energy gained from the sun, which cannot be measured accurately (Pimentel & Pimentel, 2003). Other grown foods also absorb energy from the sun and provide more food energy than they require.

Table 9: Energy Input to Output of Food Products

Food	Energy Ratio (In: Out)
Lamb	57:1
Beef Cattle	40:1
Eggs	39:1
Swine	14:1
Dairy Products	14:1
Turkey	10:1
Chicken	4:1
Corn	1:4*

Table 9: This table seeks to demonstrate the energy efficiencies of certain food products, especially those that are meat products. The table should be read as, "it requires X amount of energy to sustain this animal for long enough to be able to produce Y amount of energy." Corn seems to produce more energy than it requires, and this is because it utilizes a great portion of energy directly from the sun, which cannot be measured and is not factored in as energy input.
Source: Pimentel, D*, American Journal of Clinical Nutrition*

The energy inefficiency of meat products is not the only disadvantage of including them in a person's diet; the meat industry is a huge contributor of greenhouse gases, adding an estimated 37% of all methane and 65% of all nitrous oxide that is released into the atmosphere (Castel, Gerber, et al., 2006). The livestock themselves are the main source of methane, for they digest via enteric fermentation; this digestive system allows livestock to be able to consume and digest highly fibrous materials that humans cannot, such as grass and hay, but the resulting production of methane through belching and flatulence is enormous, accounting for 25% of total livestock emissions (McMichael, Powles, et al., 2007). Then there is the manure which, in the United States, is not often handled and stored properly; it is allowed to pile up and sit instead of being spread out properly as fertilizer. These manure piles or pits, since pits are standard for manure storage, end up releasing a whopping 30% of the total livestock gas emissions because, when manure decomposes on top of more manure without anything using the produced nutrients, those nutrients decompose and release massive amounts of methane and nitrous oxide (Castel, Gerber, et al., 2006). The main reason that manure becomes such a problem is that there is simply too much of it; the reason behind the excess of manure is that there are too many animals being raised for slaughter, specifically on large commercial farms that produce the most affordable meats (Castel, Gerber, et al. 2006).

E. Conclusion

Food and water are the two most valuable fuels on the planet, yet only a small portion of the United States' total energy budget is dedicated to this industry, amounting to 6.2% (EIA (D), 2013). The food industry, however, is one of the few large energy consumers that can be directly influenced by the customers; larger energy consumers actually supply other industries and can only be directly affected by their industrial buyers. There are a few major things that can be done to reduce the energy consumption of the food industry to which the average American contributes. The first method is a very simple thing: **refuse to buy or consume bottled water**. Bottled water costs much more than tap water, uses much more energy (99% of bottled water energy is used by the bottle), and is usually not as safe as tap water, since tap water is held to higher testing standards by regulatory agencies. The second method is the most difficult mentioned in this section:

grow food instead of buying it. Growing one's own food eliminates a lot of energy sinks in the food system, mainly the transportation and packaging of food, but this can be very difficult and time intensive to do and is not a feasible option for most Americans. The final method of reducing food energy consumption is: **reduce meat consumption**. Meat is the most inefficient food consumed by humans, requiring a much greater energy input to output ratio than all vegetables, fruits, and legumes, not to mention that the meat industry contributes a huge amount of greenhouse gases to the atmosphere, specifically methane (MacKay, 2009; Castel, Gerber, et. al., 2006). Not only will taking some, if not all, of these actions greatly reduce one's food energy consumption and expenditures, they will also lead to a better and more sustainable future for humans as more sustainable methods are supported by the consumer.

VI. Residential Energy Usage

113 million residences in the U.S. collectively use 22% of the total energy and spend at least 2000 dollars annually on their utility bills (USDoE, 2011). They consumed approximately 35% of all national electricity and strongly depend on natural gas for heating, both of which consequently generates 18% of the greenhouse gas emissions due to the combustion of natural gas and petroleum products (Parker, 2009). Moreover, the energy demand in households has been increasing at a rate of 15-18% each year, while the supplies are dropping about 5–7% annually (Emery & Kippenhan, 2006). If this trend continues, in the future it may result in the shortage of fossil fuels and an even larger accumulation of hazardous greenhouse gases. It is, therefore highly recommended for

residents to review their energy usage performance in order to avoid unnecessary energy consumption.

A wise approach to home energy assessment is to find out where most energy goes and see if any improvements can be made in these areas. Depending on the different household activities and purposes, the amount of energy used varies. Through investigation, it is found that the biggest portion of energy goes to space heating and cooling, which accounts for 42%, followed by lighting and electronics (35%), water heating (18%) and other miscellaneous uses (U.S. Energy Information Administration, 2009). Considering that changes in the most energy consuming sectors may reflect more obvious energy reduction, this section of the report will mainly focus on discussing energy efficient strategies in heating and cooling as well as in lighting. With respect to each strategy, the amount of savings, in terms of both energy and money, will be estimated to give people a direct perception. Furthermore, since non-renewable fuels is exhausting for the time being, this section will also discuss whether sustainable energy, such as solar power, can be served as a substitution.

A. Reduce energy in space heating and cooling via thermostats

The heavy dependence on the natural gases for heating and cooling does not only consume the most energy resource in a house , but also is the leading contributor to the generation of greenhouse gases in the residential sector, which in fact represent 77% of all direct fossil fuel CO_2 emissions in this category (Elsawaf, Salam, Abaza, 2012). To minimize the waste production, one can adopt a thermostat at home, since thermostat technology has become an expanding field in the effort to go green over the last 65 years, and today it controls 9% of the total energy use in the United States and similar amounts in most developed countries (Peffer, Meier, Aragon, Perry & Pritoni, 2011). With such a large amount of energy in play, it is essential to understand how thermostat functions and the interaction between thermostats and occupants. A residential thermostat consists of an electrical sensor that measures the home temperature and signals to a regulator, which turns the heating system on or off accordingly. Given the fact that thermostats are sensitive to the surrounding condition, there are different ways to operate them to attain thermal comfort with greatest possible energy savings, as discussed in the following paragraphs.

a. Adjust set point temperature

Various factors can influence the amount of energy savings, one of which is the dependence on set point temperature, which is the temperature desired by the homeowner for any given time period. A previous research study examines the influence of set point temperature on utility bills in single families in both Michigan and Florida. The two locations represent different climate zones and are compared to determine the energy saving effects. In Michigan, since the set point temperature for the heating system is set higher due to its cold climate, more heating energy is consumed at an increase rate of 1759.3 KWh per degree Celsius all year (Moon and Han, 2011). On the other hand, since the room temperature is kept at a higher level, the energy required by cooling in summer will be less than that on average. With each degree Celsius decrease in cooling, an additional 214.9 kWh of is required (Moon and Han, 2011). In this case, the dependence of set point temperature shows more significance on heating than on cooling. On the other hand, in Florida where the climate is hot and humid, people depend more on cooling than on heating, so the set up temperature is usually kept lower than the national average. The result turns out that if the set up temperature is raised up by one degree Celsius, cooling energy can be reduced by 859.5 KWh annually; whereas if one degree Celsius is lowered for heating, only 82.3 KWh can be saved a year (Moon and Han, 2011).

By comparing the results, we noticed that a suitable set-point temperature has potential to cut down energy usage. In cold regions it offers more savings on space heating whereas in hot areas it influences more on cooling energy reduction. Residents living in distinctive climate zones should take advantage of the saving patterns summarized above and start off conserving energy by adjusting the set point temperature accordingly.

b. Adjust Set back/up temperature

If reducing the costs of heating and cooling is at high priority, then a setback thermostat can also help to achieve that goal. A setback thermostat is also called a programmable thermostat; it is different than non-programmable thermostats, which keep the indoor temperature constant until it is manually changed. Many people think that more energy can be saved by keeping the house at a constant temperature throughout the day, but recent paper argues that a programmable thermostat can save both money and energy by adjusting the temperature depending on the time of the day and who is at home (Testa and Walker, 2014). EPA survey groups also report that about half of all households usually do not have someone at home during the day; if they can turn the room temperature back to 5 degree Celsius when they are out, every year they can save 5% to 15% on their heating bill (USDoE (A), 2013).

Inspired from the procedure when studying the effects of set up temperature, here we again take climate condition into account and investigate how they can interact with energy conservation. In this study, Worcester, Massachusetts and Orlando, Florida are served as two representatives. To assist our calculations, a spreadsheet published by US

EPA & DOE is used. Since the spreadsheet already includes almost all possible variables in different areas, such as fuel price and climate data, the results are reliable and reasonable. The calculation starts with a typical family which owns one oil furnace heating system, and the temperature is assumed to be set back 8 hours during the night and 10 hours during the day. We also set 68F as the comparison temperature, and each time as we set the temperature back by 4F, the spreadsheet gives out a corresponding energy cost. By comparing the costs, the percentage of savings can then be calculated and the result tells that the lower the temperature we set back, the more savings we can get. Table 10 depicts that with every 4F decrease in temperature, there's an average of 11% annual savings on energy costs in Worcester, which is more significant that the 3% annual saving in Orlando. Similar for space cooling, we control the setup hours to be 8 hours during the night and 10 hours during the day. If a central air conditioning is used as a cooling system, a 7% of energy is saved in Florida for every 2F increase in setup temperature, compared with around 1% saving in Worcester, as seen in Table 11.

To sum up, we found out that when heating systems are setback to the same temperature, more energy can be conserved in cold regions than in warm regions; while for cooling systems, setup temperature plays a more dominant role in conserving energy in hot areas than in cold areas.

Table 10. Influence of setback temperature on energy savings

Heating in Worcester MA	Typical indoor temperature (F)	Set back temperature during sleep(F)	Set back temperature during the day(F)	Annual energy costs($)	**Percentage of savings**
	68	68	68	2258	**0%**
	68	64	64	2042	**9.60%**
	68	60	60	1826	**10.40%**
	68	56	56	1610	**11.90%**
Heating in Orlando FL	Typical indoor temperature (F)	Set back temperature during sleep(F)	Set back temperature during the day(F)	Annual energy costs($)	**Percentage of savings**
	68	68	68	673	**0%**
	68	64	64	653	**3.00%**
	68	60	60	632	**3.30%**
	68	56	56	612	**3.10%**

With every 4F decrease in temperature, there's an average of 11% annual savings on energy costs in Worcester, which is more significant that the 3% annual saving in Orlando.

Table 11. Influence of setup temperature on energy savings

Cooling in Worcester MA	Typical indoor temperature (F)	Setup temperature during sleep (F)	Setup temperature during the day (F)	Annual energy costs ($)	**Percentage of savings**
	73	75	75	851	**0.23%**
	73	77	77	849	**1.78%**
	73	79	79	839	**1.72%**
	73	81	81	833	**1.90%**
Cooling in Orlando FL	Typical indoor temperature (F)	Setup temperature during sleep (F)	Setup temperature during the day (F)	Annual energy costs ($)	**Percentage of savings**
	73	75	68	835	**6.70%**
	73	77	64	779	**7.20%**
	73	79	60	722	**7.90%**
	73	81	56	665	**8.20%**

For cooling systems, a 7% of energy is saved in Florida for every 2F increase in setup temperature, compared with around 1.5% saving in Worcester.

c. Related Problems with thermostats and solutions

To this today, 91 million households have installed thermostats for their home heating, and 27 percent of those have adopted programmable thermostats (USDoE (A), 2013). The popularity of thermostats demonstrates how conscious of future energy savings consumers have become, but there is also one concern with the use of thermostats (Peffer, Meier, Aragon, Perry & Pritoni, 2011). Unlike the replacement of an old heat pump, the benefits from a thermostat must involve continuous human participation. That is to say, the house owner must set up a proper temperature before leaving the house or going to bed so that the value of using a thermostat can be reflected. However, only less than half of households actually turn the heat down during sleeping hours, and one third of households state they have technical problems with thermostats and feel confused about how to use them (USDoE, 2011). It is understandable that as technology improves, thermostats now consist of multiple functions rather than just temperature control, but in order to show its importance in saving energy, a good thermostat must be easy to use. Luckily, today many projects which design more user friendly thermostats have been undertaken by manufacturers, researchers, and students (Peffer, Meier, Aragon, Perry & Pritoni, 2011). In Human Factors courses at universities, designing a more user-friendly thermostat is a popular assignment. Furthermore, many small firms, often rooted in Silicon Valley, have already entered the market to design new thermostats which have connections to smartphones and the internet (Peffer, Meier, Aragon, Perry & Pritoni, 2011). We believe that In the near future, thermostats will become less like an appendage to the residence's heating and cooling system and more like a new category of electronics that is handy and useful.

B. Weather-stripping the House

Going along with thermostats brings up the conversation as to whether we can help save energy, in the form of hot or cold air, being lost through the numerous air leaks throughout ones' home. In fact, ones' home has so many air leaks that if all of them were to be completely sealed, there would be an estimated 20% reduction on electrical bills. (USDoE (E), 2012). However, doing so is not practical because finding every single air leak is nearly impossible. A more feasible and practical approach is to use weather-stripping on all windows and doors. There are numerous types of weather-stripping to choose from, including tension seals, reinforced vinyl, and rubber adhesives. The table 12 details all of the materials that can be used along with their specific properties, leading some to better be used for doors or windows. All aim to serve the same basic purpose of preventing any air from coming in and out of the opening. By doing so, one would approximately save 10%-15% on their electrical bills. A very nice savings when looking at how simple the process is and how relevantly cheap the materials are. (The National Academies, 2008). One afternoon and under $100 can be all it takes to shed some money from a monthly energy bill and ultimately save money.

Weather-Stripping	Best Use	Cost	Advantages	Disadvantages
Tension Seal	Inside the hinges of windows, top and sides of doors	Moderate	Durable, invisible once installed, very effective, easy to install	Surfaces must be flat and smooth.
Felt	Around a door or window	Low	Easy to install, very cheap	Low durability, least effective method.
Reinforced Foam	Bottom of doors, top and bottom of windows.	Low	Effective at preventive air leaks, rigid	Can be difficult to install, very visible, manufacturing process is not green.
Tape	Top and bottom of windows and doors, irregularly shaped cracks	Low	Extremely easy to install, can be reinforced with staples	Low durability, visible
Reinforced Vinyl	Top or bottom of windows, bottom of doors	Low to moderate	Easy to install, self-adhesive, durable, comes in varying colors	Visible, may not adhere to all surfaces such as metal.
Door Sweep	Bottom of swinging doors	Moderate to high	Easy to install, adjustable for uneven thresholds.	Visible, can drag on carpets.
Magnetic	Top and sides of doors, windows	High	Very effective sealer	None
Rubber	Around a door	Moderate to high	Effective air sealer	Challenging install.
Reinforced Silicone	Door jamb or window stop	Moderate to high	Seals well	Challenging install
Door shoe	Seal space beneath door	Moderate to high	Can be used on uneven openings, prevents water from coming in, replaceable vinyl inserts	Expensive, install is difficult.

Table 12: Table detailing the numerous methods of weather-stripping, showing the advantages and disadvantages of each along with a relative price point. (USDoE (E), 2012).

C. Energy from the sun

As energy prices keep rising every year, maximizing the energy performance of today's buildings is at the top of list for architects as well as homeowners, and the numerous benefits of solar energy are suitable to meet this desire. The source of solar energy comes from the nuclear fusion within the sun, since its production rate is much higher than its consumption rate, it is unlikely to have a depletion problem like conventional fuels (Brisan, Ferrandino, Khandaker & Zorrilla, 2010). To some extent, it also means self-reliance on producing energy, so any place that sunlight reaches can have a solar energy system set up, even in remote areas of the country. Plus, natural sunlight is green and does not emit hazardous gases.

a. Passive Solar energy

The simplest application is the use of passive solar energy, which does not require energy conversion, for instance, redesigning the window system for a house to allow more natural light coming in. A house with a good spread of natural light can benefit from the reduced requirement for artificial light, which can be critical to conserve energy over time. Take a simple calculation: an incandescent bulb uses 60 watts of energy an hour, meaning that one could conserve almost 22000 watts of energy per year by switching off one light an hour every day; that is enough energy to power a television for a month (Hammond, Zhang & Jones, 2013). Another advantage that comes along with less artificial lighting is the fall-off of carbon emissions, given the fact that lighting is one of the leading contributors to carbon emissions, often estimated as 20–40% of the total building energy consumption (Hawker, 2006).

In terms of redesigning the window system, the use of skylights is an excellent way to bring predominant brightness with little supplementary artificial lighting. Compared with standard vertical windows, skylights allow 3 times more of sunlight passing through, even under overcast conditions (Eskom, 2011). A previous research study also demonstrated the benefits skylights have, with the level of benefit varies with several factors, particularly the area of skylight installed and the designed illumination level in a house (Hawker, 2006). As shown in figure 9, the energy taken by the lighting system is converted into equivalent carbon dioxide emissions to illustrate the overall influence that skylight areas have on atmosphere. It shows that the bigger the skylight area is, the lower the power that is used to generate electricity. Plus it also shows that the higher the illumination level, the greater the energy reduction is, but also with greater savings as the area increases (Hawker, 2006). For instance, when a 300 lux illumination level skylight increases its room occupancy from 0 to 20 percent, the annual carbon dioxide output drop from 2.8 to 0.2 pounds per square feet. As for a 600 lux illumination level of skylight, the overall effect on the environment is greater than that of a 300 lux one, but the savings come with it is also much more, which drops from 4.8 to 0.6 pounds per square feet with a same increment in occupancy percentage.

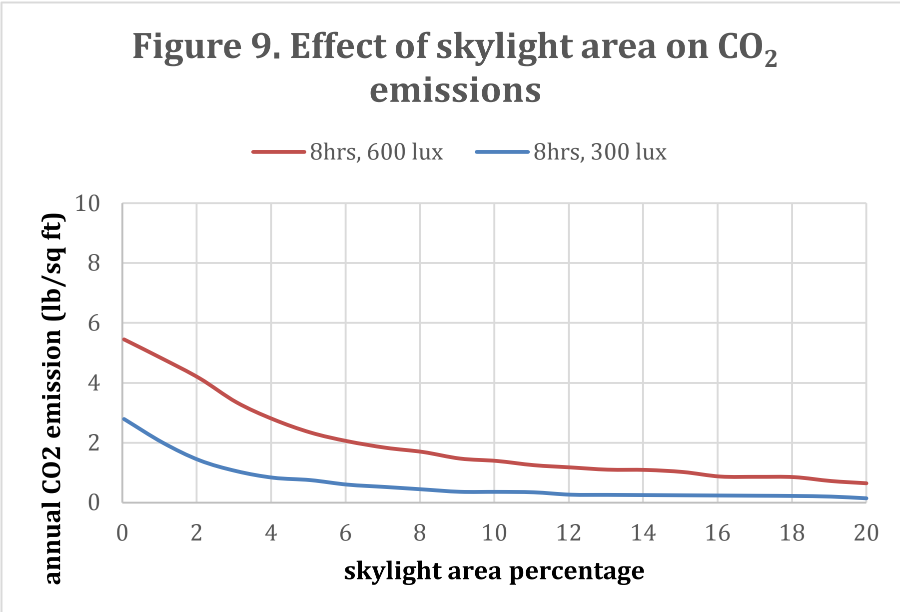

Fig. 9 lighting level is measured in lux. A lighting level of 300 lux is relatively low, whereas 600 lux is an ideal illumination level for normal reading tasks. The graph shows that the higher the illumination level is, the more energy saved. The amount of energy which is conserved is also proportional to the occupancy percentage of a skylight in a room. (Hawker, 2006)

Despite the advantages skylights have over traditional windows, there is also a widely held concern that skylights may have poor insulation which then allows more heating running away and essentially brings up the overall energy cost. However, this myth is proved to be wrong by the Institute of Energy & Sustainable Development years ago. The institution states that in relation to skylights, heating is only one element of the energy equation, and the amount of energy required to generate artificial light is much greater than the compensate for the loss of thermal energy through the skylight windows (NARM, 2006). Besides hearing the voice from the institution, one may also adopt double-pane glass and several coats of insulating glaze, which may help to prevent energy loss in winter and excess heat in summer (USDoE (D), 2012).

As for the cost, on a national basis, most families spend 1812 dollars on their skylights, including the money paid for design and labor (Homeadvisor,Inc 2013). The price for the window itself is cost efficient, with a price of $150 for a single 2 ft. x 2 ft. fixed one and $330 for a large 4 ft. x 4 ft. fixed one; a venting skylight is about double the cost of a fixed skylight and there is also a slightly difference in price between the material used (Homeadvisor,Inc 2013). An investment of nearly 2000 dollars may not look attractive at the first glance, but with hundreds of dollars saved on electricity and heating, payback years will not be that long. Furthermore, federal government provides tax incentives for up to 30%; together with other assistant programs, the final price will decrease (USDoE (D), 2012).

There are also clever tactics that can be employed to yield the maximum amount of savings. In places where the winter is long, the sun is at a lower angle to the surface of the Earth, and daylight hours are relatively shorter (Brisan, Ferrandino, Zorrilla, 2010). In this case, southern facing skylights are favorable, since they have greatest potential to allow more sunlight to come in, together with desirable passive heat, which can be used as part of space heating (USDoE (D), 2012). Vice versa, a north-facing skylight could provide a fairly constant but cool illumination, which is suitable when the environment is already warm enough. Skylight windows are a smart use of what nature already provides for us. They offer an opportunity to save energy and enhance the quality of the environment; however, utilizing solely passive solar energy is by far not enough if people want to reduce the dependence on fossil fuels. Thus, solar energy must be converted into a more efficient form in order to meet our needs.

b. Photovoltaics

A more efficient utilization of solar energy is through solar photovoltaic systems (PV system). The photovoltaic system converts the sunlight into electricity through an array of solar panels that connect to a building's electrical system. When the sun hits the solar semiconductor material on the panels, it frees the electrons and then forms an electrical current. The more intense the radiation is, the more electricity can be generated. Since 2001, solar power production in the US has grown almost fourfold, surpassing the 3,300 megawatt mark, more than enough electricity to light all the homes in New Jersey for a year (Frishberg, 2013). Compared with the usage of passive solar power, solar photovoltaic system provides a better source of solar energy due its high power generation.

The amount of energy savings is substantial for residents to understand before making a decision, and this can be reflected by the percentage of electricity which can be covered by the PV system. The average New England household uses 7452 KWh of electricity per year and an average residential solar system is usually designed to be around 5000W (Energy Information Association, 2005). In Massachusetts, an optimal 1000W solar PV system can generally produce 1200 kWh of electricity per year, which means that a 5000W system will produce roughly 6,000 kWh per year (Massachusetts clean energy center, 2014). This will cover approximately 80% of the total electricity used annually under optimal conditions. Plus, electricity customers using solar panels are offered with Net-Metering service, which means if the PV system produces more power than the family actually needs, customers are welcomed to sell back their energy and receive credits for that (Massachusetts clean energy center, 2014). This policy again provides opportunity for households to cut down their energy cost. Furthermore, the environmental benefits PV systems contribute is considerable: for every 1,000 kWh of electricity produced by solar power reduces emissions by nearly 8 pounds of sulfur dioxide, 5 pounds of nitrogen oxides, and more than 1,400 pounds of carbon dioxide (USDoE (B), 2004). In this case, during the entire life span of a PV system, roughly 20 years, though some of the systems built in the 1980s are reported to be still functioning as well, the total gas emissions eliminated will be tremendous. In general, PV systems seem to be a wise investment that offers impressive benefits.

The cost of the system sways people's decision as well. In 1974, President Ford's Energy Resources Council believed that, "Solar energy would become a significant energy source after 1985 because of technological advances and the high recovery and storage costs of fossil fuels" (Sobel, 1975). Predictions that solar energy will be cost-competitive with conventional energy (i.e. fossil fuels and nuclear power) have continued ever since (Richter, 2007). It is true that 40 years later, in some part of the country, such as Texas, it has already reached a point where the value of electricity generated by PV has equaled the cost of electricity generated by conventional fuels; but all that is true except for the upfront capital investment (Bradford, 2006). Today the initial cost of installing a residential PV system still remains pretty high, even if the projects are economical in the long run. In the short term, it costs around 20000 dollars in the US, which may also vary with different suppliers and sizes (Richter, 2007). Combing with the savings from PV, the payback period usually lasts for 8-10 years in Massachusetts, even if the price has been decreasing over the past 30 years (Massachusetts clean energy center, 2014). The National Renewable Energy Laboratory's study proves that the direct manufacturing price drops by 17% with every double of production each year and this trend will continue up to 2050, with respect to a relatively stable electricity price (Richter, 2007). Plus, government also provides attractive policies such as sales tax exemption, federal tax credit and Massachusetts personal income tax credit, so that the upfront cost can be offset by 15-30% (Massachusetts residential guide to solar power, 2013). In conclusion, even though today most sales are assisted by favorable government policies, this trend will keep accelerating; plus if the upfront cost could be reduced, or if the lifespan for PV systems could be extended, then its average cost over its entire lifespan will certainly be reduced, making it an attractive option for residents to go green.

VII. Recommendations and Energy Saving Tables

Recommendation	Energy Saved (Btu/year)	Money Saved (yearly)	Percentage (yearly)* 312 million Btu/year per person	References
Using public transportation over private	17.1 – 38 MBtu	$120-$480	5% - 12%	(O'Toole, 2008)
Using a carpool for transportation alternative	4.5 – 12.3 MBtu	$360-$720	1.4% - 4%	(O'Toole, 2008)
Using an Electric Bike or Moped as an alternative	14.4 – 24.7 MBtu	~$1,080-$1,440	4.6% - 8%	(Schramm, 2005)

Table 13. A summarized look at the expected savings in energy and money that can be expected by using each recommended alternative to private transportation. While using public transport is not the best way to save money, it is the best to save energy.
*** The total amount of energy an American use in a year. (EIA (B), 2013)**

Public transportation offers a large benefit in energy savings, as long as an individual is willing to use it. From the figure above, a person can save anywhere between 5 and 12 percent of their annual energy consumption by using any form of public transportation that was discussed. There is such a range as not all forms of public transportation share the same efficiency. As discussed heavy rail is roughly the best form to use, while buses are the worst. However taking a bus, especially during peak travel times, makes it more efficient that driving alone in a car.

The energy saved was calculated by taking the differences in the energy a person would use driving a car against the energy they would require on a bus or light rail, given either are near maximum capacity, and they are alone in the car. This is then calculated with the average commute distance for Americans, which is 29.4 miles round trip, and the amount of workdays in the year, which for traditional office workers is 233. This gives the minimum energy savings, against the maximum, which uses the energy differences in the car and heavy rail, and assumes travel is required every day.

The savings for using private transportation will also vary, and depend on how frequent a person would drive, and the existence of a weekly, monthly, or even yearly plans that a public transit system might have, against the price of gas, and the fuel efficiency of a car. The minimum is the amount saved by buying daily passes, the maximum is the amount saved when a person buys a monthly pass. This is still a rough estimate however.

Concerning the use of a carpool, there again is a range. The energy saved is measured as the differences in energy required by a single car occupant against an occupant in a car with more than one. In the full car situation, as discussed earlier, a car will use about the same energy to travel the same distance, so adding more people lowers the amount each one uses. The annual savings is calculated the same a public transportation, using 233 workdays for the minimum or every day of the year for the maximum. The minimum also uses energy savings in a car with two people, while the maximum assumes the car is full, where the average American car holds five people. The savings for the car-pooling situation is roughly estimated where fuel costs are being shared between all the passengers evenly, and depends on how many people are sharing the split, and how often the car is being driven.

The electric bike and moped savings are calculated much the same as the other ones, using the differences in energy usage compared to the amount of a car, and the distance traveled, and the number of days of travel. The minimum is for a less efficient bike against a more efficient car, and the maximum is for a more efficient bike against a less efficient car. Where savings in concerned, there is a range that depends on the fuel economy of the moped, and the energy demands of the bike. If it is a moped, the get substantially better gas mileage over a car, while an electric bike is charged though outlet supplied electricity, which on average is about $0.12 per kWh, or about $0.04 per kBtu (BLS (B), 2014).

In every case, there is great saving in energy and money when an individual takes an alternative to private transportation. Even if that alterative is simply carpooling, you can save between up to 12 percent of your annual energy usage by using a different form of transportation. Given the variety and choices, along with the savings, public transportation is a better choice.

Recommendation	Energy Saved (Btu/year)	Money Saved (yearly)	Percentage (yearly)* 312 million Btu/year per person	Reference
Driving a hybrid vehicle	36 million (313 gallons/year)	$1,077	11.54%	Peter de Haan, 2007
Weather-stripping windows and doors throughout your home.	3.7-5.5 million Btu	$130-$195	1.2%-1.8%	Department of Energy, 2012

Table 14. The table analyzes energy and monetary savings by utilizing the recommendations stated. The table also shows the percentage of energy saved based off of a yearly figure of a person using 312 million Btu per year.
*** The total amount of energy an American use in a year. (EIA (B), 2013)**

As previously discussed, transportation is a major source of energy usage and expenditures. That is why energy saving decisions made within this field can reflect such a large amount of savings in both energy and money. The switch to driving a hybrid vehicle will cost the consumer in the beginning; however, with estimated money savings of about one thousand dollars per year, this cost can quickly be recovered. This number is highly dependent upon the cost of gasoline. The cost of gasoline has only been rising in recent years, which would then translate to larger money savings for the consumer.

Weather-stripping ones' home does not reflect the same amount of money saved when compared to a hybrid vehicle; however, it does have a nice return of investment. Weather-stripping materials are relatively cheap, thus allowing a return on the investment within one year, leading every consequential year to be money savings for the consumer.

Recommendation	Energy Saved (Btu/year)	Money Saved (yearly)	Percentage (yearly)* 312 million Btu/year per person	Reference
Do not purchase or use disposable plastic water bottles	0.6 MBtu	$250	0.2%	Cooley & Gleick, 2009
Grow food in a garden to supplement or eliminate shopping trips	1.4 MBtu	N/A	0.5%	NRDC, 2007;
Switch to a vegetarian or reduced meat diet	9.6 MBtu	N/A	3.2%	MacKay, 2009

Table 15. Three main alternative food purchasing behaviors help conserving energy. Even though the amount of savings is not as much as that in other sectors, it is still a sizable amount.
*** The total amount of energy an American use in a year. (EIA (B), 2013)**

The three main avenues to reducing a person's food energy consumption are refusing to use disposable plastic water bottles, growing food in a garden, and switching to a reduced or non-meat diet. The energy savings from not using plastic water bottles is about 3790 Btu and $1.45 per bottle, and since the average American uses 167 plastic water bottles per year, the savings amount to 0.6 million Btu and $250. Energy savings from growing food in a garden are a little bit more complicated because of the numerous variables. Assuming that a person grows all of his food, 2000 lbs per year, he can eliminate 1/20 of a food truck delivery, which is normally 40,000 lbs. Around 45,000 Btu worth of plastic packaging is also eliminated, which amounts to 1.4 million Btu in combination with the food delivery savings. Reducing or eliminating meat from a person's diet results in the largest energy savings mentioned in regards to food. Energy used by meat production is about 27,300 Btu per day, and the full vegetarian diet represented in the table eliminates this energy consumption for a full year, resulting in 9.6 million Btu saved per year. If a person were to follow all of these recommendations regarding food, only 3.9% of the total yearly energy consumption would be eliminated, but as transportation and home energy usage account for much more energy consumption, 3.9% is a sizeable amount.

Recommendation	**Energy Saved (Btu/year)**	**Money Saved (yearly)**	**Percentage (yearly)* 312 million Btu/year per person**	**Reference**
Setting back the heating by 2^{o}C during night	4.6 million Btu	$216	1.40%	US EPA & DOE
Replacing 5 incandescent light bulbs with ENERGY STAR qualified ones	0.9 million Btu	$45	0.27%	USDoE (C), 2006
Setting down the heating temperature by 1^{o}C everyday	6 million Btu	$280	1.8%-1.9%	Moon & Han, 2011
Setting up the cooling temperature by 1^{o}C everyday	0.7 million Btu	$35	0.20%	US EPA & DOE

Table 16. A list of practical and feasible ways to reduce energy consumption at home. It is noticeable that reduction in space heating and cooling usage results in significant amount of energy savings per year.
*** The total amount of energy an American use in a year. (EIA (B), 2013)**

In the residential sector, people can also find some form of solutions to survive in the fuel crisis, which can be categorized in two paths. One of which is to avoid unnecessary use of nonrenewable energy with the help of today's temperature control technology, such as a thermostat. By adjusting the indoor temperature with respect to people's real need, there is a considerable amount of energy and monetary savings, as summarized in the above chart. Another solution is to find a sustainable energy resource before our coal or natural gases diminish; even though there are constrains lifted on technology in the second path, future technology will certainly progress and in turn bring us a cheaper renewable energy resource. And having cheaper clean energy at home means greater savings and less harmful disruption to our home planet.

With the demand and use of energy being so high, each person can do their part to reduce the consumption and demand. Each of the suggestions made in this report lead to energy savings, and while some might be larger than others, they all count towards reducing energy usage. While in some cases the energy saved might not be a lot, the money a person can save by following through on can be substantial, like in the case of using a hybrid vehicle or electric bicycle. Some of these recommendations would require a change in the way a person lives their life, but if humanity wishes to use less energy while simultaneously advancing, change will be required.

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