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Carbon Footprint

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Gyorgyi's Discussion Section

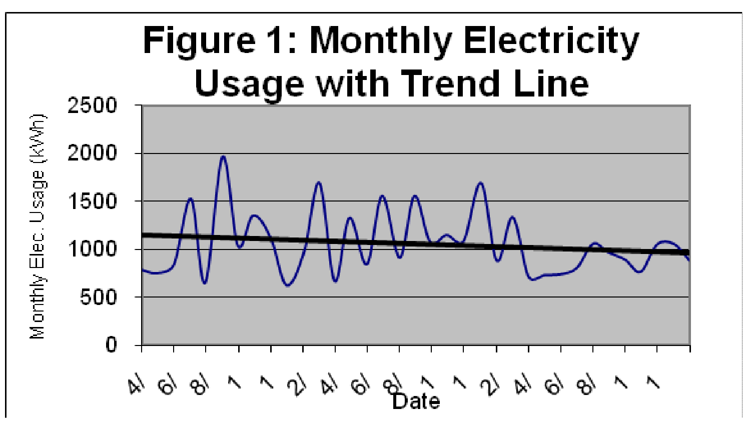
The C in Residential Energy

Introduction

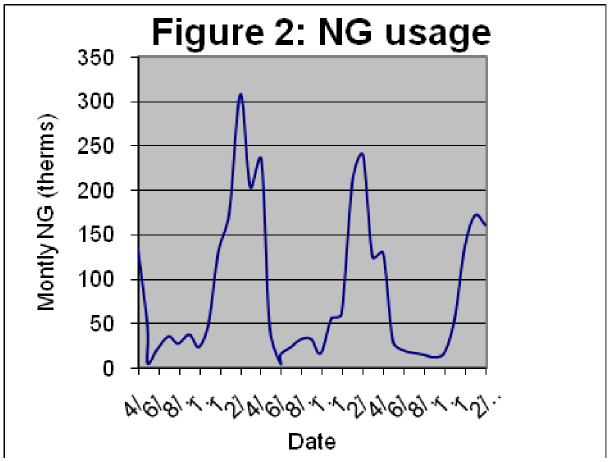
The earth is so large that in response to talk about global warming, many people say that their personal contribution to greenhouse gases is insignificant. But, using what is called a carbon footprint, an individual can determine the amount of carbon dioxide they are responsible for, and we choose carbon dioxide is chosen because it is by far the most prevalent greenhouse gas. The Intergovernmental Panel on Climate Change, IPCC, has said that to avoid crossing the critical 450ppm of atmospheric CO_2, beyond which global warming cannot be reversed, it will be necessary for the world to obtain fully 1/7 of its energy needs from carbon-free sources by 2030 (Roberts 2005). A carbon footprint is, by definition, a measure of the total set of greenhouse gases that are the result of direct and indirect actions of an individual, organization, event, or product. Being able to determine a carbon footprint is important in the context of climate change because it allows us to measure the impacts of specific actions on the environment and climate change contribution quantitatively. With this information, it is possible to calculate potential savings in greenhouse gas emissions with specific actions including energy conservation and efficiency. Being able to recognize the respective amount of greenhouse gases that each source of residential energy contributes also allows for us focus conservation and efficiency efforts where they will be most productive.

Method

I collected data for my own home's energy consumption from the utility bills that charge per unit of electricity and natural gas starting with the billing month ending April 20, 2006 and all the way through the most recent available bill on February 19, 2009. I obtain both electricity and natural gas for my household needs from New York State Electricity and Gas, NYSEG. My house is relatively new, it was built in the early 1970's and it is slightly smaller than the average suburban home in the United States at approximately 2,400 square feet. With NYSEG, for billing purposes, actual measurements of the natural gas and electricity



consumed are taken every other month, with the month in the middle being estimated. Looking at an individual month's data would thus be inaccurate, but an average for values collected on more than two consecutive months represents the actual usage. This explains the seemingly uneven electricity values in Figure 1, but the average use represented by the black trend line can clearly be seen decreasing. My home relies on natural gas for heating during the winter, which is long and cold in Central New York State. Natural gas is also used for cooking on the stove and for hot water from a boiler. In Figure 2, natural gas data over the past three years depicts these trends, showing a significant increase during the winter months and a base load throughout. To determine the amount of gasoline used by the two vehicles at my household, I used the odometer readings and dates of purchase to determine a yearly mileage which was divided by the fuel efficiency from the on-board computer in the vehicles themselves, which was the most accurate data that is available because it represents actual values that are a result of driving habits and the type of driving performed.

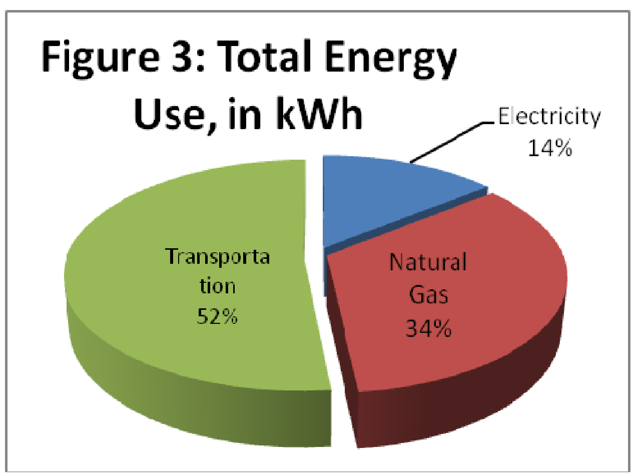


For this project, I assume that the three main sources of energy used in my home are electricity, natural gas, and gasoline for transportation. In comparison to the whole US, transportation is considered separately for many reasons, some of them including the great disparity of driving done by different people and that the separation of residential energy use from transportation in other analysis makes this data difficult to determine. To compare each of the three main energy sources against each other in terms of total energy use, it is necessary to convert them all to the same energy units. Energy units are interchangeable, given the use of "conversion factors" that relate the units to each other as multiples of each other times some constant value that accounts for the different definitions. According the US Department of Energy (2000), there are 29.3 kilowatt-hours in each therm of natural gas, and 35 kilowatt-hours in each gallon of gasoline, and electricity is billed in kilowatt-hours so to convert all to units to kilowatt-hours they are multiplied by the number of kilowatt-hour equivalents in each of their respective units. Similarly, there are "emission factors" which quantify the relation between burning certain fuels for certain purposes and a given amount of CO_2 that is emitted during their combustion. The US Environmental Protection Agency (2009) lists my household supplier of electricity's source mix as using 27% nuclear, 15.5% gas, 21.5% coal, and 54%

that is carbon-dioxide free directly from electricity production. Also from the US Department of Energy (2000), each kilowatt-hour of electricity produced from coal, petroleum or oil, and natural gas burning releases respectively 2.10, 1.97, and 1.32 pounds of CO_2; for each million BTU of natural gas burned, given there are ten BTU's in one therm, 117.1 pounds of CO_2 is released and for each gallon of gasoline burned there are 19.4 pounds of CO_2 released. Extending this calculation to the US is simply a matter of using the average national fuel mix for electricity as opposed to my own, the average total residential electricity use per household, and the average residential natural gas usage per household. To determine the footprint of the average American household from natural gas, I took the total natural gas used by the residential sector, divided that by the total number of residences, made it a monthly value, and multiplied that by the same emission factor from the US Department of Energy that I used for my own home. For electricity, I also used the same method and emission factors that I used for own home, for consistency, and used the total national electrical source mix and an average US residential electricicty consumption to compute the carbon from electricity in the same way, all data coming from the US Department of Energy. Also extending the action to reduce carbon dioxide emissions the entire US is justified because transportation is a necessary component of every household's functioning and there is similar room for efficiency and responsible driving performance increases.

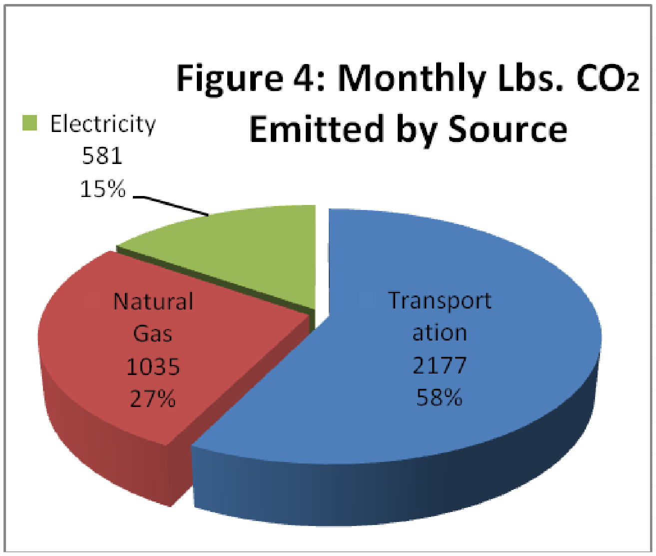
Results

By converting each energy source to the same units, we can see in Figure 3 that transportation represents 52% of total energy as opposed to natural gas and electricity only accounting for 34% and 14%, respectively. In the same way, Figure 4 depicts the contribution of each of the three analyzed sources of energy to my carbon footprint. This represents a total of 3,792 pounds of CO_2 per month and 45,509 pounds per year. Electricity contributes to a small and similar portion of both energy use and of carbon emissions. Natural gas emits notably less carbon for the amount of energy is represents, and the gasoline used in transportation emits that percentage of carbon idoxide emissions that is suceeded by cleaner-burning natural gas. The total average US residential carbon dioxide emissions



from the energy use of electricity and natural gas is 1,697 lbs. This is 5% more than the 1,616 lbs of carbon dioxide emitted by my own house.

By increasing the mileage per gallon of my residence's vehicles from 17 and 24 miles per gallon to 30 miles per gallon by buying moderately efficient vehicles when the current vehicles are replaced and by driving responsibly, transportation would produce 768 less pounds of carbon dioxide per month, cumulating to yearly savings of 9,200 pounds of carbon dioxide and 472 gallons of gasoline. The carbon dioxide-emission reduction from this action is a reduction of 20% from current emissions, which is reasonable considering that the efficiency of 52% of total energy use if being increased significantly.



If every residence was able to decrease the amount of gasoline they use by 36%, which is the reduction that my household achieves by increasing MPG to 30, by either buying more efficient vehicles, using alternative transportatin about one-third of the time, or somehow decreasing the number of miles they drive by about one-third they will experience a similar reduction in CO_2 emissions. This reduction would result in a tremendous amount of oil use reduction and would decrease the CO_2 emissions from the entire transportation sector by 21.6%, which represents a reductions of 36% on the 60% of the transportation sector that is comprised of personal vehicle use. Since, according to the US Environment Protection Agency (2009), transprtation activities accounted for 33 percent of CO_2 emissions from fossil fuel combustion, a 21.6% reduction in those emissions means that as a nation by extending fuel efficiency and responsible driving to all residential transportation, the United States would emit 7% less carbon dioxide.

Discussion

Where I say "total" energy use, that is still under the assumption that the three largest sources of energy the only which I analyzed. This means that there is no consideration for the energy used nor the carbon emitted in the production of the food I eat, the travel I perform in airplanes, the carbon emitted in the entire life cycle of electricity and natural gas usage that includes construction and decommissioning of facilities and infrastructure, and the carbon emitted in the production and transportation of all other consumer products. My own residence which I analyzed is typical in size of a suburban home, only slightly smaller, and of similar age being built in the early 70's since the average age of owner-occupied homes is 30 years (US Census Bureau, 2008). In my observation, most of the residential energy conservation efforts that I have seen have focused on electricity efficiency and more responsible electricity use, but this energy source only represents a mere 14% of total energy used and contributes only 581 of the 3,792 pounds of carbon emitted monthly at my household. An equal percentage reduction in the use of other sources, namely transportation, yields much greater savings in energy use and in carbon emissions, which is seen in Figure 4.

The reduction that I chose was able to cut down on my household's CO_2 emissions very significantly, greater than 20%, because it substantially reduced the main source of emissions, and a reduction in the consumption of gasoline is also very cost effective. By saving 472 gallons of gasoline each year, at current gasoline prices that represents a yearly savings of over $1,000 in New York, and if gasoline prices rise above $4/gallon like they are expected to, by driving responsibly in fuel-efficient vehicles my family could save over $2,000 per year. This is certainly a substantial amount, and with high gasoline prices it provides the opportunity for a net positive return on investment for even expensive upgrades that achieve an overall 30 miles per gallon efficiency. Going even beyond that level of efficiency is not unreasonable with hybrid cars that get greater than 50 miles per gallon, and more advances are expected to come, so my action is definitely cost-effective and will only become more so as time and technology progress.

The fact that my own home emits 5% less carbon dioxide than the average American household from natural gas and electricity is very reasonable, and makes perfect sense when looking at the numbers. We use about twice as much natural gas, for heating, cooking, and hot water, as the average residence but natural gas is a relatively clean burning fuel. Our electricity use is close to average, but only 21.5% of our electricity mix comes from the most carbon-intensive fuel, coal, compared to 49% of the national electricity production coming from coal. In total, our electricity comes 54% from sources that emit no carbon in the direct production of electricity, which is notably high because we purchase two 100-kWh blocks of clean, new wind energy.

As with any calculation based on actual data, there are levels of uncertainty in the amounts of carbon actually emitted and in the effectiveness of extending a reduction of gasoline use to a nation scale. Automobile manufacturers have limited options of vehicles that are efficient, and in some cases it is not reasonable for someone to drive an efficient vehicle. If, for instance, they need to tow cargo or have the ability to accommodate very large families it is unlikely that these people will be able to use much less gasoline. It is also not entirely certain the exact amount of carbon dioxide that is emitted from any combustion reaction, and although the values that I used are reputable there remains a small percentage of possible error caused by incomplete combustion and the emission technologies in the vehicles themselves.

Conclusion

Residential energy and its abundance is taken for granted by most people in our society today. The carbon dioxide emissions of the average US house are significant, although only considering three of many sources of emissions. With only a small change in the efficiency of the vehicles that my household uses for transportation, we would be able to reduce our carbon footprint by 20% and this is very hopeful that as a nation Americans can meet the IPCC guidelines to reduce carbon emissions and use renewable energy. The year 2030 is close, but with actions like the one I projected, it could be possible to meet the goal of 1/7 energy coming from renewable sources in that time frame, by reducing US carbon dioxide emissions significantly to allow for the renewables we already use and those that will continue to install to make up more significant parts of our energy mix. Although these changes are simple and have been known for a long time, efficiency and energy conservation has not been a concern of Americans over the past two decades. The problem is for the average American household, that it's got to matter, and with education about issues and rising public concern over climate change, it will.

References Cited

Carner, Channele (2003, Apr 28). Carbon Dioxide Emissions from the generation of electric power in the United States. Retrieved March 26, 2009, from EIA CO_2 Emissions Report Web site: http://www.eia.doe.gov/cneaf/electricity/page/co2_report/co2report.html

Environmental Protection Agency, (2009). How clean is the electricity I use? Power profiler. Retrieved March 26, 2009, from EPA Clean Energy Web site: http://www.epa.gov/cleanenergy/energy-and-you/how-clean.html

Energy Information Administration, (2000). Voluntary reporting of greenhouse gases program. Retrieved March 26, 2009, from EIA: Official Energy Statistics from the US Government Web site: http://www.eia.doe.gov/oiaf/1605/coefficients.html

Roberts, Paul (2005). *The End Of Oil*. First Mariner Books.

US Census Bureau, Housing and Household Economic Statistics Division (2008). American Housing Survey - FAQ. Retrieved March 26, 2009, from US Census Bureau: American Housing Survey Web site: http://www.census.gov/hhes/www/housing/ahs/ahsfaq.html

US Environmental Protection Agency, (2009, Feb). Executive Summary. *2009 Draft U.S. Greenhouse Gas Inventory Report*, Retrieved March 16, 2009, from http://epa.gov/climatechange/emissions/downloads09/07ES.pdf