# Creating a $CO_2$ Budget
# A Necessary Step to Cutting $CO_2$ Emissions

By Pat Murphy, Plan Curtail March 2016

Plan Curtail focuses on personal responsibility for reducing each person's annual $CO_2$ emissions as the most important factor in combatting climate change. Since the U.S. is the largest generator of $CO_2$ on a per capita basis (16.2 metric tons per person per year), it is the most important country for curtailment analysis and planning. This paper begins with a review of the world situation, moves to a national perspective, and then to the household level.

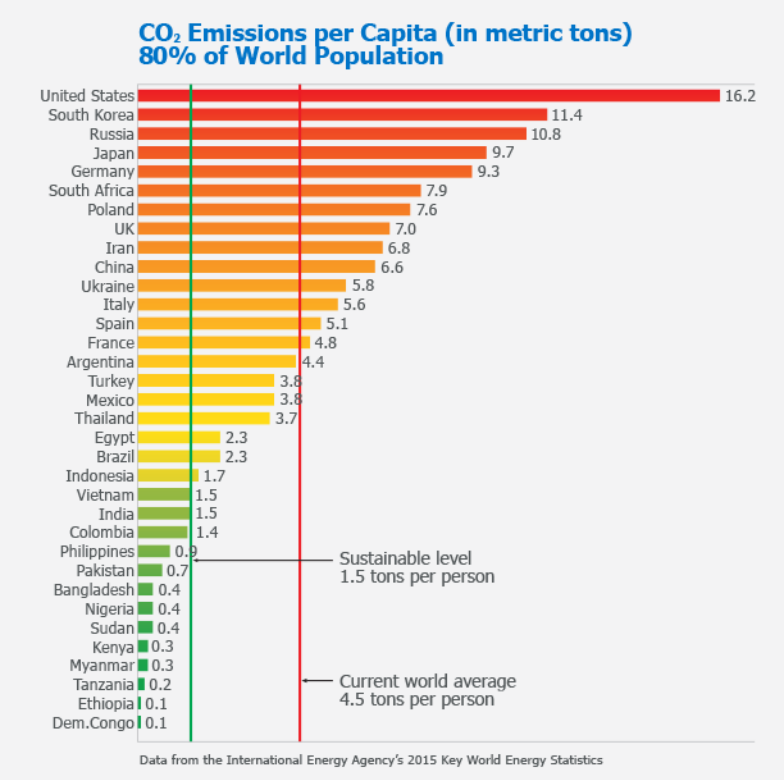


Figure 1: $CO_2$ Emissions per Capita for 34 most Populous Nations Representing 80% of the world population

### Energy and Emissions Status As of 2016

Americans annual $CO_2$ emissions of 16.2 metric tons per person are far above the world average of about 4.8 metric tons of $CO_2$ per person per year (represented by the vertical red line in Figure 1). The International Protocol for Climate Change states that the world must reach a level of about 1.5 metric tons per person per year by 2050 (represented by the vertical green line in Figure 1). The world has focused on efficiency and renewable energy to address this goal; however, it is unlikely that these technologies can ramp up fast enough to provide the necessary $CO_2$ reduction, especially if energy use continues to grow. We believe that there is no alternative to reducing energy consumption. This will require each person to begin the process of curtailing their personal energy use.

### The Limits of Efficiency

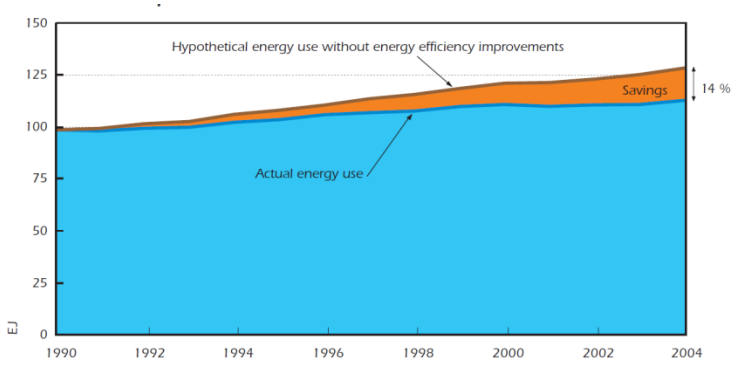


Figure 2: Energy Savings from Energy Efficiency Improvements 1990-2004

Substantial efforts to improve efficiency for every type of energy consuming machine have been underway for decades. The overall rate of efficiency improvement for a wide range of products and technologies has been 1-2% per year for more than twenty years. This rate of improvement is insufficient to reduce climate emissions to the extent needed.

Energy efficiency has always been part of improvement programs for all classes of products. However, the resulting energy savings are small as noted above. In addition, the increasing number of new kinds of machines being used has caused energy consumption to continue to rise.

## The Limits of Renewables

Renewables are a growing source of energy but still represent only a small portion of total energy used worldwide. Energy from renewables (other than hydroelectricity) increased 30% from 2004 to 2013. Figure 3 shows the relatively small share of total energy production provided by non-hydro renewables (yellow area at top of bars in Figures 3). At the same time more power plants have been constructed to meet growing demand.

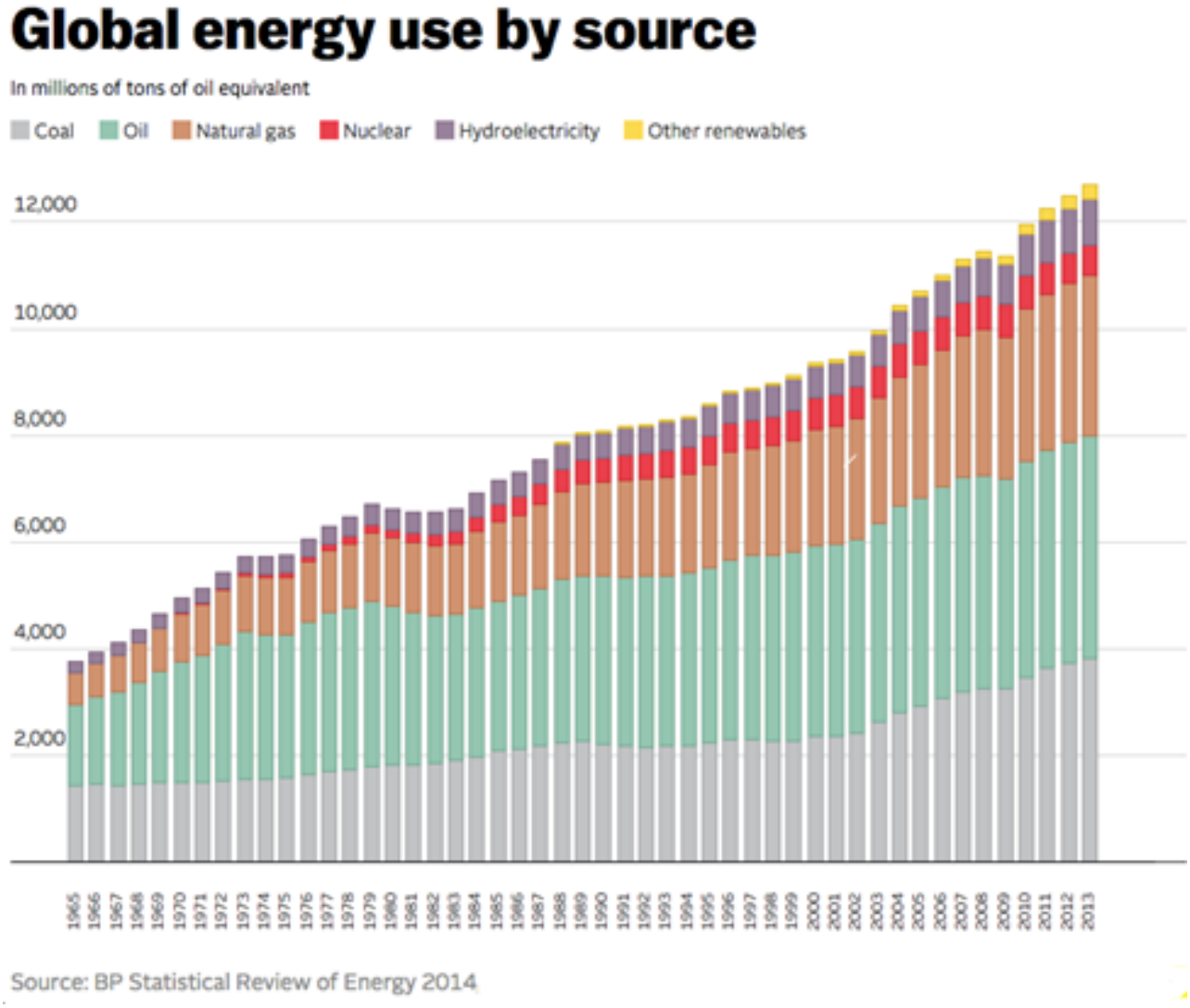


Figure 3: Past global Energy Use by Source

The U.S. has been one of the leading nations in the implementation of renewables. Figure 4 shows the percent of renewables in the US from 1965 through 2013. Note that it took almost 50 years for the renewables share to grow from 6% to a little more than 9%. The rate of growth is accelerating but from a small share of the total energy market. This is complicated by the fact that nonrenewable energy is still growing due to increased demand.

Efficiency and renewable energy will not provide large enough $CO_2$ savings quickly enough to avoid reducing our consumption. Cutting consumption, or curtailment, will also be necessary as the pressure of climate change does not permit us to continue consuming the same amount of fossil fuel energy. This may well affect the growth based high-energy economy. A less fossil fuel intensive way of life needs to be developed.

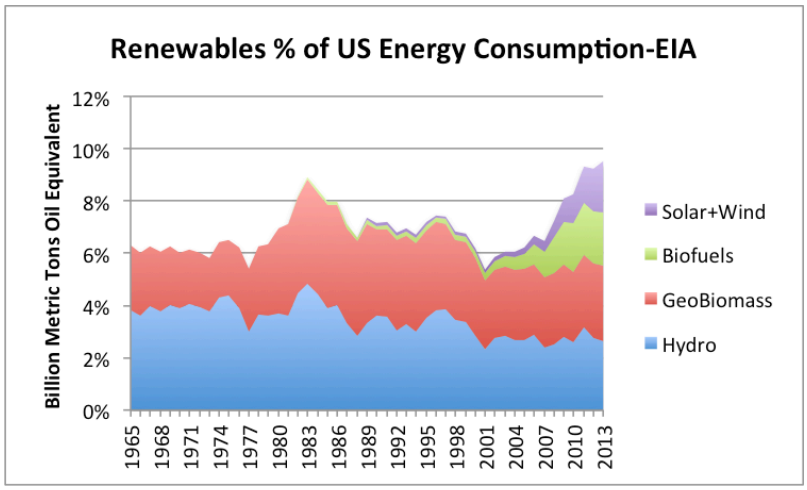

Figure 4: U.S. Historical Distribution of Renewables Share of Energy

## The Curtailer Approach

Most people live in households, so managing energy consumption on that grouping rather than on an individual analysis can be helpful. The number of people per household has been decreasing for some time while the size of homes has been increasing. Table 1 shows how the number of people in a home has been declining since 1940.

| Year | # of people per household | | Year | # of people per household |
|---|---|---|---|---|
| 2015 | 2.54 | | 1980 | 2.76 |
| 2010 | 2.59 | | 1970 | 3.14 |
| 2005 | 2.57 | | 1960 | 3.33 |
| 2000 | 2.62 | | 1950 | 3.37 |
| 1990 | 2.63 | | 1940 | 3.67 |

Table 1: Change in household size since 1940

Home energy consumption is a major source of emissions (about 21% of total emissions). Most of that consumption is for heating and cooling which is a function of house size, insulation level and air tightness. House size has increased from about 1,000 square feet in 1950 to about 2,500 square feet in 2015. Figure 5 shows the increase in the square feet per person. This is the result of a decrease in the number of people living in a household and the increasing average new home size, measured in square feet.

As noted above, the increase in house size results in an increase in heating and cooling energy consumption. It also leads to an increase in energy use for goods and services since a larger home implies more furniture, more appliances and more of a variety of other energy consuming products, many of which also have a sizable amount of embodied energy from their manufacture.

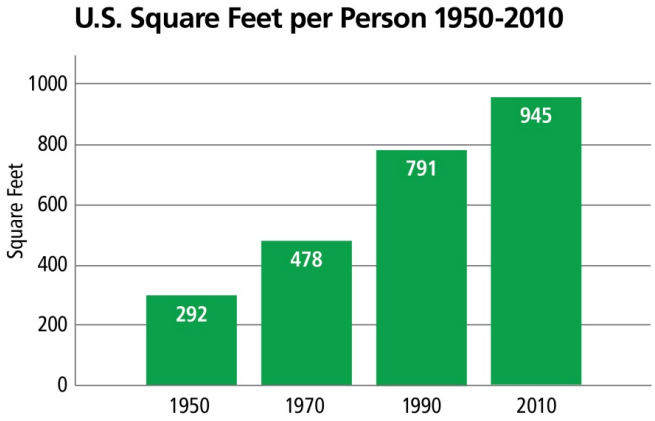

Figure 5: Change in Home Sq. Ft. per Person since 1950

## Determining $CO_2$ Sources and Percentages

Figure 6 is a conceptual model of the $CO_2$ generated by a household; it shows the main activities and provides a measure of the $CO_2$ created by such activities. It is the beginning of a model for a household $CO_2$ budget. Like a financial budget, a $CO_2$ budget gives a comprehensive and detailed list of all activities that generate $CO_2$, measured in pounds of $CO_2$ rather than dollars. Some of the $CO_2$ emissions are direct, meaning actions taken that directly generate $CO_2$, such as driving cars or heating homes. The blue sections of Figure 6 indicate direct emissions. The green sections of the same figure indicate indirect emissions, that is, the $CO_2$ generated in the manufacture and distribution of the products in our homes.

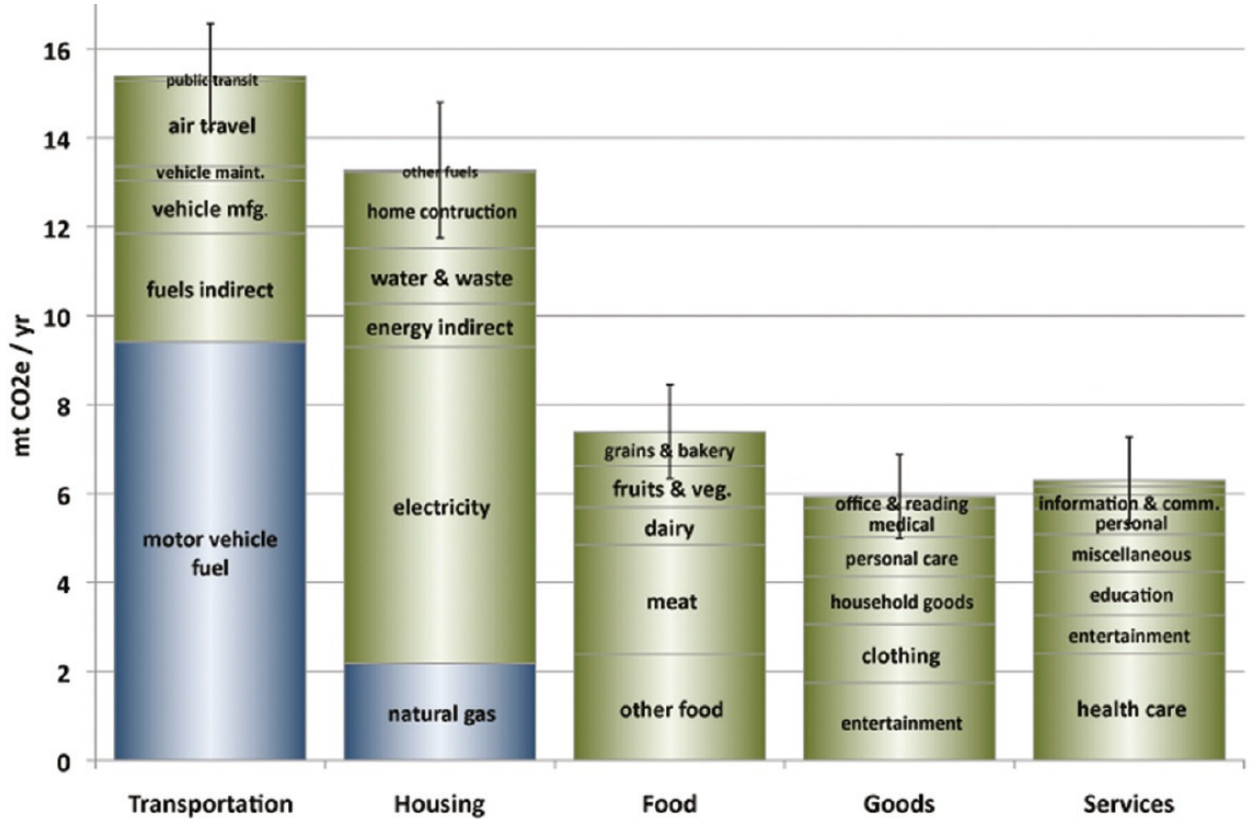


Figure 6 - Total carbon footprint of the typical U.S. household (48 t $CO_2$e/yr.)
Developed by the Cool Climate group at the University of California at Berkeley.

Data from the International Energy Agencies (IEA) 2015 Key World Energy Statistics report can be used to find total metric tons per household. This is done by multiplying the annual $CO_2$ generated per person of 16.2 metric tons times 2.54 (the average number of persons in a household) for average yearly emissions of 41 metric tons. This is significantly lower than Cool Climate's estimated 48 metric tons per year shown in Figure 6. The difference can be partially explained by their inclusion of the embodied energy of Chinese imports in the Cool Climate model. Some analysts have suggested that 3 to 5 metric tons per person should be moved from China's energy budget to the U.S. Adding four tons to the IEA numbers gives a result of 45 metric tons, closer to the 48 tons from Cool Climate.

There are five main categories in the Cool Climate model. Table 2 shows the distribution of annual greenhouse gas emissions (GHG), which include $CO_2$, for all five categories.

| Classification | Metric Tons GHG Per Household | Metric Tons GHG Per Capita |
|---|---|---|
| Transportation | 14.5 | 5.2 |
| Housing | 14.1 | 5.1 |
| Food | 7.0 | 2.5 |
| Goods | 6.8 | 2.4 |
| Services | 6.0 | 2.3 |

Table 2: Distribution of GHGs across five categories

## One Size Does Not Fit All

An analysis of this kind must take into account regional and local conditions as well as household uniqueness. Greenhouse gas emissions will be different for different places in the country. Hot southern climates or cold northern ones make a significant difference in housing emissions. This breakdown of the categories is valuable in that it provides a national perspective that can be changed for local conditions.

Every household will also be different. Some people may commute long distances; others may work close to home. Commute distance affects transportation. The number of people in a household affects food $CO_2$ emissions. People in one household may eat out more than those in another. Or they may use more electric gadgets or electronics. Figure 3 shows the benefits for each household creating their own unique $CO_2$ model and budget.

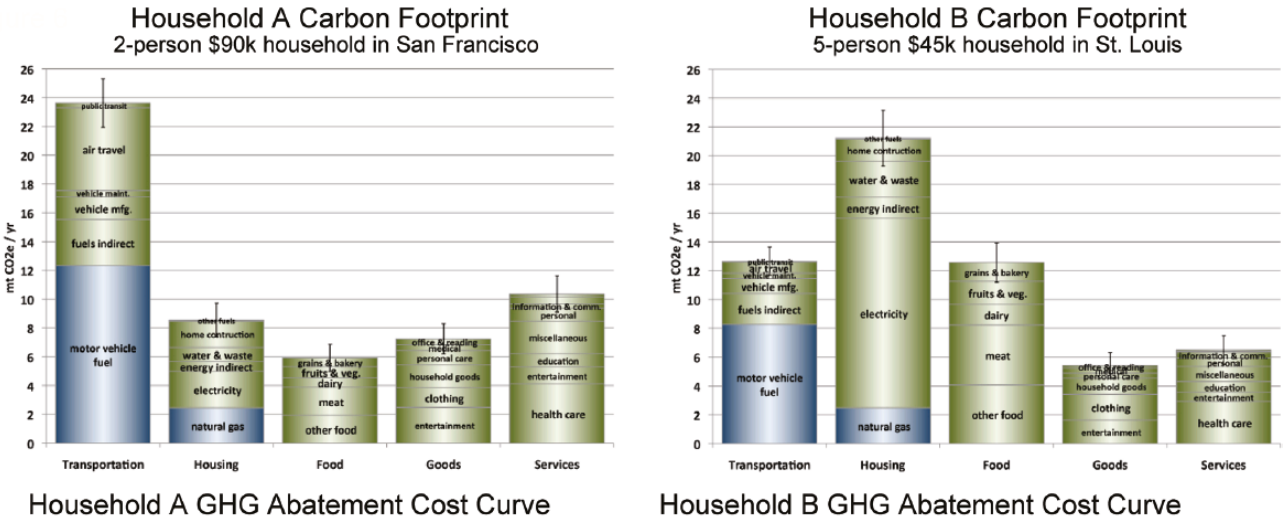


Figure 7. Carbon footprints and GHG abatement cost curves for example households.

Goods and Services are higher in household A, an upper income two-person household in the San Francisco Bay Area, than in household B, a middle-income five-person household in St. Louis. Carbon footprints are shown for the major categories of emissions. This illustrates the differences due to differing weather conditions and lifestyles.

## Goods and Services

Goods and Services are a new area of study for Plan Curtail. Hybrid and electric cars address transportation, green and energy efficient building addresses housing, and reduced meat consumption – together with growing local and organic food – has been the focus for food $CO_2$ reductions.

Housing $CO_2$ emissions come from furnaces, air conditioners, refrigerators, and hot water heaters. Most housing fuels are natural gas or electricity. Transportation $CO_2$ is generated principally from driving cars and flying in commercial air planes, its fuels are gasoline and jet fuel. Food $CO_2$ comes from our choice of food, with the highest emissions from meats and other animal products (eggs, cheese), with grains, vegetables, fruits and nuts being the other principle categories. Goods and Services include a wide variety of sub-categories (shown in Table 3) such as appliances, electronics, clothing and health care. To create a $CO_2$ budget requires allocating estimates to these categories. Cool Climate has created an initial set of values.

| CATEGORIES | METRIC TONS OF $CO_2$ PER YEAR |
|---|---|
| **GOODS** | |
| Electronics/Toys/Recreation | 1.5 |
| Clothing | 1.3 |
| Appliances/Furniture/Household Equipment | 1.1 |
| Personal Care/Cleaning | 0.9 |
| Medical Supplies/Medicine | 0.7 |
| Paper - Office and Reading | 0.3 |
| Subtotal Goods | 5.8 |
| **SERVICES** | |
| Healthcare | 2.4 |
| Education | 1.0 |
| Entertainment and Recreation | 0.9 |
| Miscellaneous | 0.8 |
| Personal Business | 0.6 |
| Information and Communication | 0.3 |
| Organizations & charity | 0.2 |
| Household Maintenance and repair | 0.1 |
| Subtotal Services | 6.3 |
| | |
| Total Goods and Services | 12.1 |

Table 3: Breakdown of Goods and Services

It is easy to dismiss the items in Goods and Services and instead focus on something straightforward such as gasoline for driving or natural gas for home heating. But Goods and Services cannot be overlooked. Their total of 12.1 metric tons is twice the current world average for all emissions and far from the 1.5 metric ton limit needed by 2050.

This section on Goods and Services illustrates the depth of our consumer-oriented lifestyle. Reducing $CO_2$ is not just limited to cars and furnaces or air travel. We will need to begin reducing energy use for a very wide range of product and service offerings. This will mean consuming less as our current lifestyle is neither energy sustainable nor emissions reducing.