September 11, 2012

Short-Term Energy Outlook Supplement: Change in Regional and U.S. Degree-Day Calculations

Average daily temperatures during the summer and winter months, reported as population-weighted cooling degree days (CDDs) and heating degree days (HDDs), respectively, are important in explaining and forecasting the consumption of energy for space cooling and heating in the U.S. Energy Information Administration's *Short-Term Energy Outlook* (*STEO*).[1] The National Oceanic and Atmospheric Administration (NOAA) reports heating and cooling degree days at the local, state, regional, and national levels. NOAA calculates degree days for regions and the United States by weighting state degree days using fixed population shares, which are currently from the 2000 Census. Thus, historical and forecast regional and U.S. degree days reported by NOAA reflect changes in degree days over time for a given fixed population distribution. Energy consumption, however, is a function of not just changes in temperature but also of migration of the population.

Beginning with the September 2012 edition of the *STEO*, EIA will calculate and report regional and U.S. degree days using current year (populations in the same year the degree days are measured) rather than fixed state populations. This report provides a brief analysis of the differences between regional and U.S. degree days reported by NOAA and those calculated by EIA and used in the *STEO* model.

Degree Days: NOAA and EIA Methodology

A degree day is a quantitative index derived from daily temperature observations at nearly 200 major weather stations in the United States. NOAA first estimates degree days for climate divisions within states. Equations that relate the historical temperature of state climate divisions to nearby weather stations are used to estimate climate division temperatures. Between one and four weather stations are used for each equation. There are 12 monthly equations for each of the 344 state climate divisions in 48 contiguous States.

[1] Degree days are based on the assumption that when the outside temperature is 65 degrees Fahrenheit (^{o}F) we don't need heating or cooling to be comfortable. Degree days are the difference between the daily temperature mean (high temperature plus low temperature divided by two) and 65°F. If the temperature mean is above 65°F, we subtract 65 from the mean and the result is cooling degree days (otherwise CDD is equal to zero). If the temperature mean is below 65°F, we subtract the mean from 65 and the result is heating degree days (otherwise HDD is equal to zero). Each day's heating or cooling degree days are summed to create a heating- or cooling-degree-day measure for a specified reference period.

The climate division heating/cooling degree days within each state are then weighted according to each division's proportion of the state's population (currently from the 2000 Census). For example, New Jersey degree days are calculated by multiplying the degree days in each of the 3 climate divisions within the state by each division's share of the total state population and summing the three products.

New Jersey Climate Division	Population Weights
Northern	0.5677
Southern	0.4053
Coastal	0.0270
	1.0000

Regional and U.S. degree days are then calculated in proportion to the populations in the respective states. For example, the following population weights are applied for the Middle Atlantic Census region:

Middle Atlantic Census Region	Population Weights
New Jersey	0.21210
New York	0.47833
Pennsylvania	0.30957
	1.0000

The key characteristic of the NOAA procedure is that the same population weights are applied to all years. The same 2000 Census population weights are applied to temperatures recorded in 1895 and those reported in 2012. Consequently, changes in degree days reported by NOAA only partially capture changes in energy demand for space heating and cooling, missing the effect of the migration of the country's population from north and east to south and west, from colder to warmer climates.

While EIA has previously used the NOAA degree day estimates at the Census region level in preparing the STEO, the impact of population shifts on heating and cooling needs are potentially significant. For example, even though the population of the East North Central Census region increased from 41 million to 46 million between 1975 (the start of the *STEO* database) and 2011, that region's share of the total U.S. population fell from 19.1 percent in 1975 to 14.9 percent in 2011. During this period, the population in the South Atlantic Census region increased from 34 million (16.0 percent of the total 1975 U.S. population) to 61 million (19.4 percent of the 2011 total).

To reflect changes in both temperatures and population, EIA will now calculate regional and U.S. average degree days by multiplying state degree days by the state's share of the total population during the year in which the degree days were measured.[2] For example, when calculating the Middle Atlantic Census region's degree days as done above, New Jersey's HDDs in 1975 are multiplied by the state's share of the region's total population in 1975 while 2011 degree days are multiplied by the population share in 2011.

Comparison of NOAA and EIA U.S. Degree Days

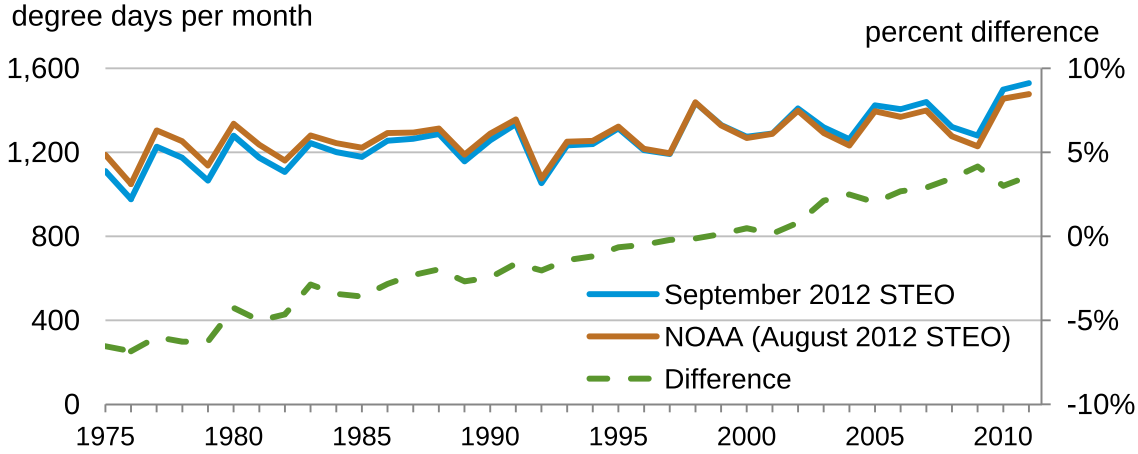
The effect of population migration on the calculated U.S. total annual degree days is shown in Figures 1 and 2. In each chart, the August 2012 *STEO* degree days represent the totals reported by NOAA using the 2000 Census populations to calculate the fixed population shares that are applied to state degree days in each year. The September 2012 *STEO* degree days represent the new current population weighting methodology.

The effect of population migration is evident in both charts. U.S. CDDs in Figure 1 (using the new current-population weights) begin 7 percent lower than fixed-weight degree days in 1975, are roughly equal in 2000, and end 4 percent higher in 2011. As the share of the total U.S. population increased in the warmer states the calculated total U.S. population-weighted CDDs and the average per-capita energy demand for space cooling increased.

Current-population-weighted HDDs in Figure 2 begin 6 percent higher in 1975 and end 2 percent lower in 2011. As the share of the population increased in the warmer states, the calculated total U.S. HDDs and the average per-capita energy demand for space heating declined.

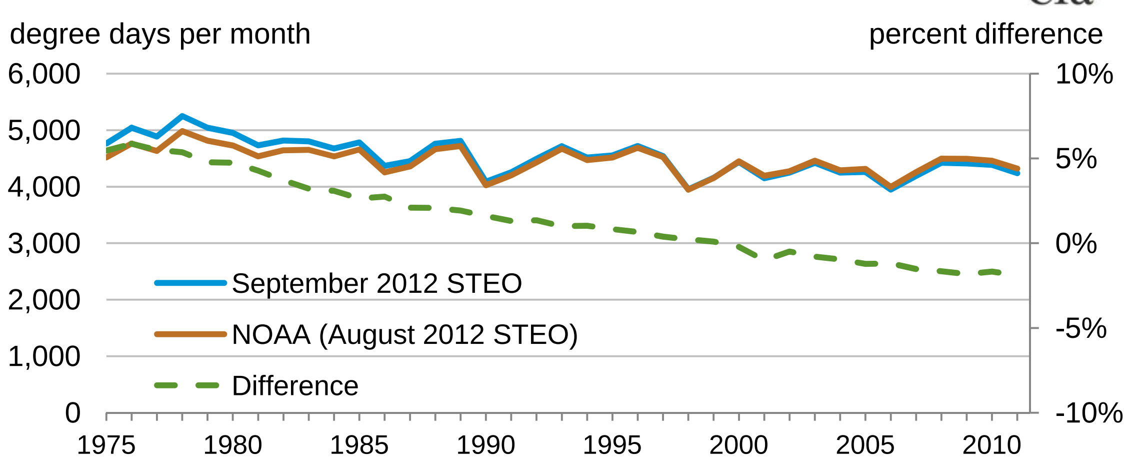
[2] State populations in the EIA *Short-Term Energy Outlook* are from the IHS/Global Insight regional macroeconomic model, which are based on annual estimates provided by the U.S. Census Bureau.

Figure 1: Comparison of U.S. Cooling Degree Days



Note: September 2012 *STEO* uses current population weights, August 2012 *STEO* used fixed 2000 Census population weights.
Source: U.S. Energy Information Administration, *Short-Term Energy Outlook*

Figure 2: Comparison of U.S. Heating Degree Days



Note: September 2012 *STEO* uses current population weights, August 2012 *STEO* used fixed 2000 Census population weights.
Source: U.S. Energy Information Administration, *Short-Term Energy Outlook*