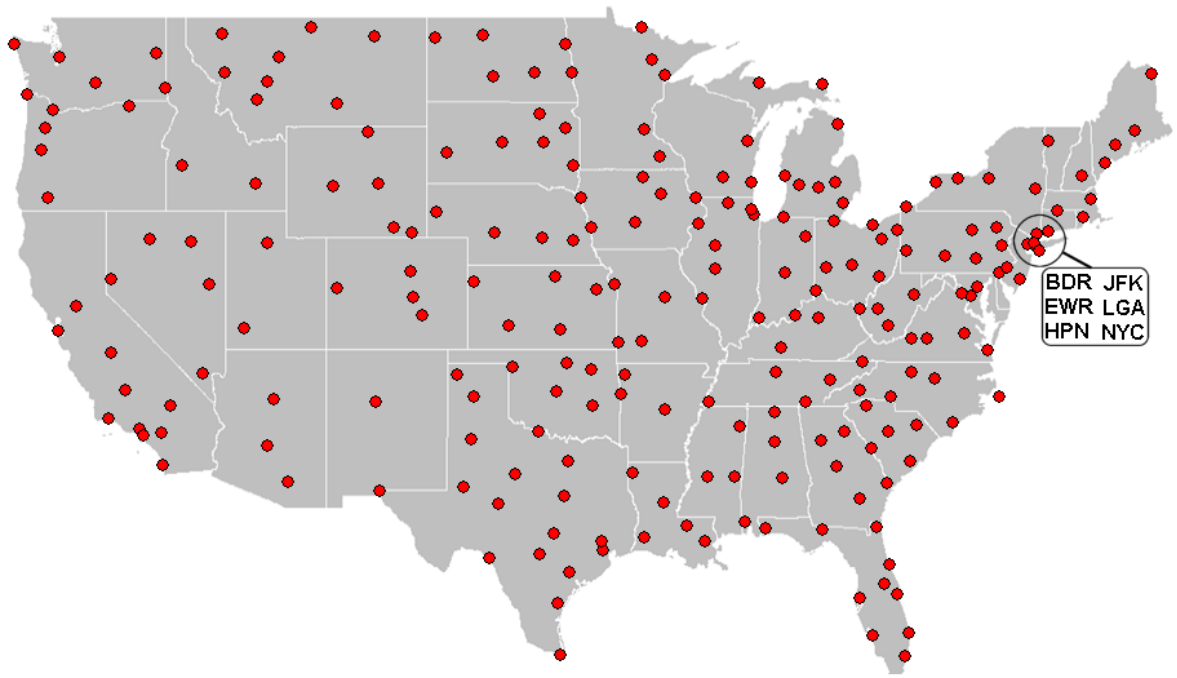
Guide to Frontier Weather's Weighted U.S. and Regional Weather Data (new 2013 data sets)

Population Weighting

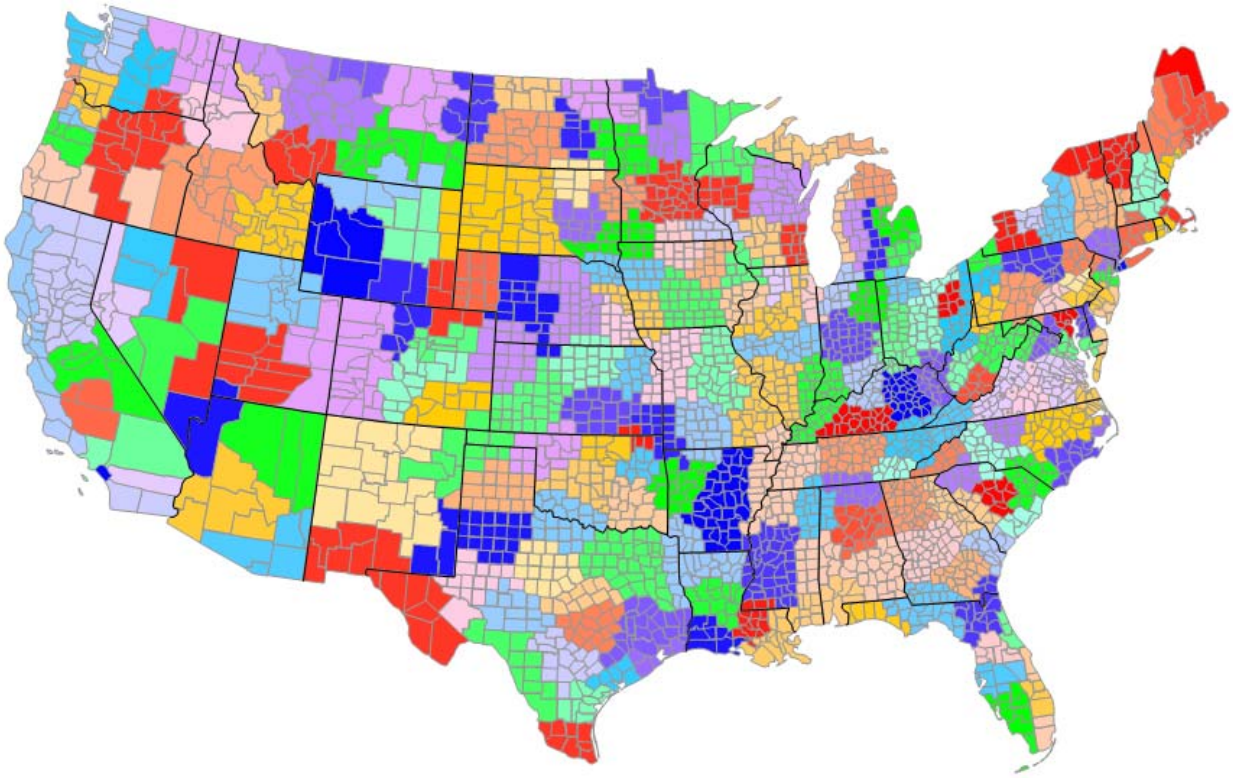
All of our U.S. and regional composite weather data sets start with county level population data. We take the yearly population statistics from the U.S. Census Bureau for every U.S. county (48 contiguous states only) and also generate estimated populations for each county for years in which no census data is available (linearly interpolating between years with census data) and extrapolating future yearly populations using linear regression techniques. These projected populations for current and future years can then be updated as new census data becomes available.

Each U.S. county is then assigned to a specific weather observation site. Our new set of data uses about twice as many observation sites as our older data sets resulting in improved resolution. While this makes little difference on the total U.S. level (our new U.S. population weighted data is within 0.7 degree days of the old data set each day for the entire period of record) it does have a larger impact on a regional and sub regional level. The sites chosen were those that had historical data available in our database going back to at least 1980 with minimal missing data. Any missing data was filled in using various interpolation techniques, generally setting up regression equations to interpolate data from multiple surrounding points.

The map below shows the distribution and location of the 230 or so observation sites that are used in the weighting process:



The following map of U.S. counties shows the groupings of counties that are assigned to different observation sites. Note that in some cases adjacent country groupings are similarly colored and so what appears to be a large single colored area may in fact be two distinct groupings. Additionally, some counties have been divided up such that part of the population is assigned to one site location and part of the population to another site. This was only done in a few major metro areas such as Chicago where Cook County was split up between O'Hare (ORD) and Midway (MDW) airports.

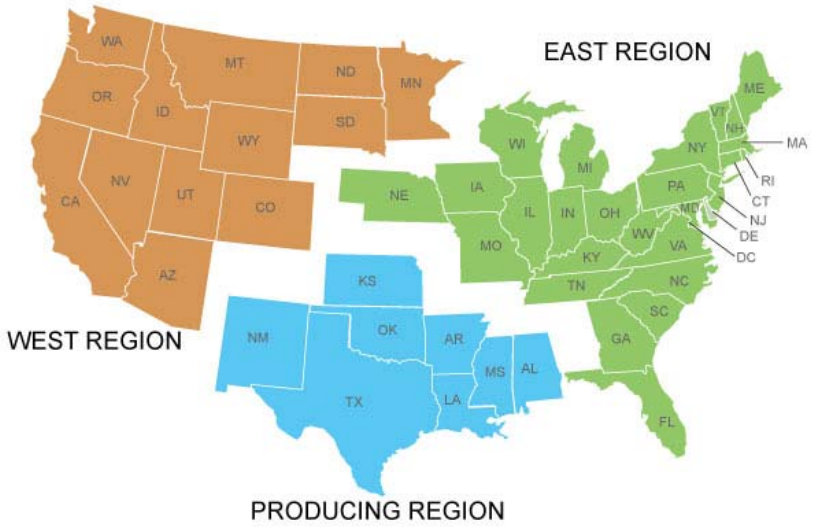


Once each county has been assigned to a specific observation site, those counties can then in turn be assigned to a specific state or region. The populations of all counties in a given state or region that use the same observation site are then summed together and divided by the total population of that state or region to determine what weighting is given to each specific observation site in each region. Note that a given observation site might be used in the population weighting of weather data in multiple states or regions.

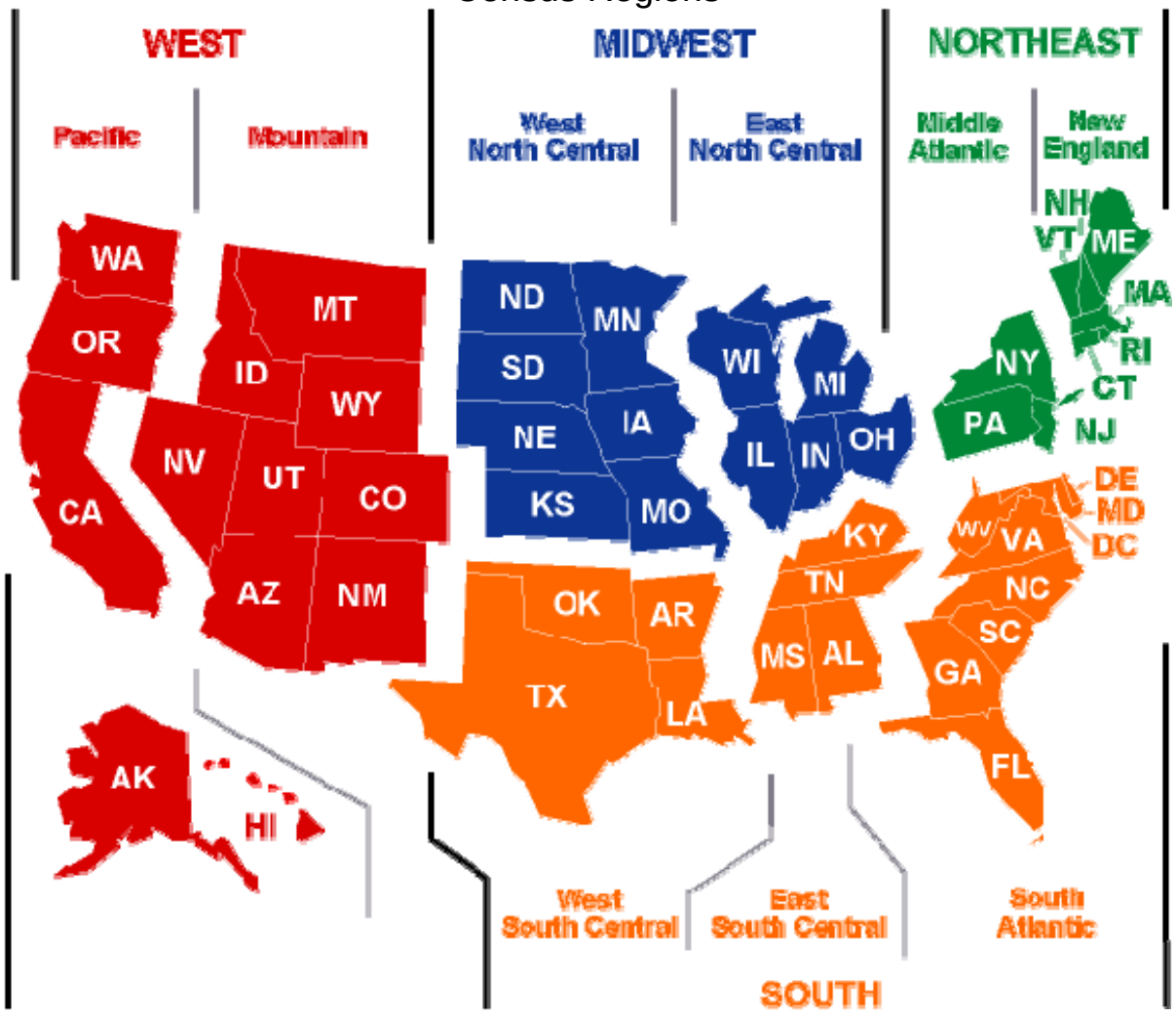
Currently, population weighted weather data is produced for the U.S. as a whole, for each state, as well as the three EIA regions, 4 main U.S. census regions, 9 U.S. census sub-regions, 8 NERC regions, and the 20 or so NERC sub-regions (eGrid regions). Population weighted data consists of high, low and average daily temperature, HDDs and CDDs and total precipitation.

The maps on the next page show the EIA, Census, and NERC regions for which population weighted data is available (in addition to the U.S. total and state values).

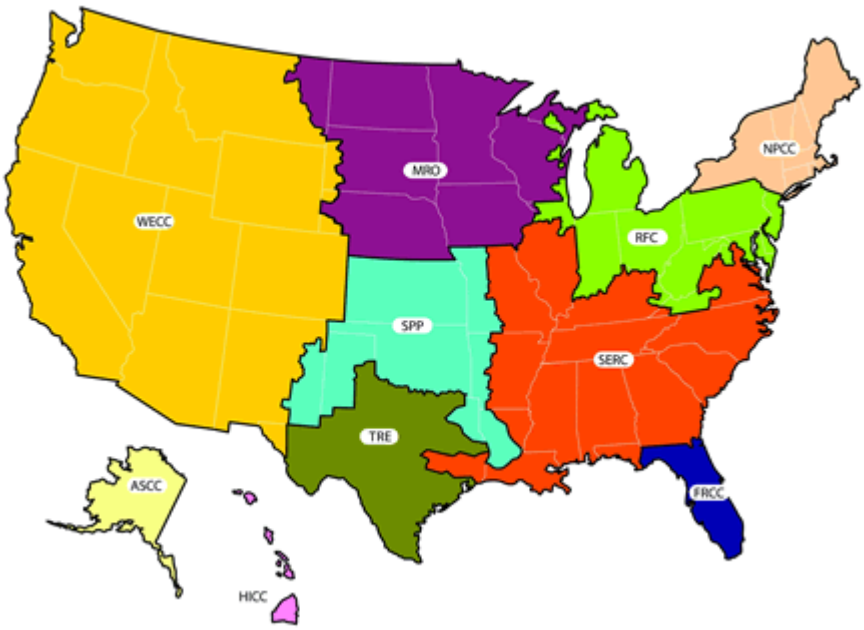
EIA Regions



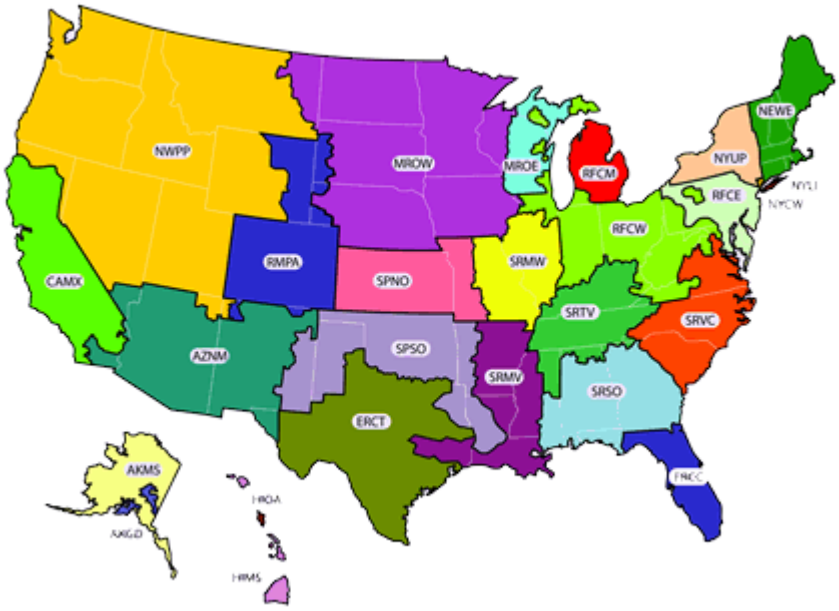
Census Regions



NERC Regions

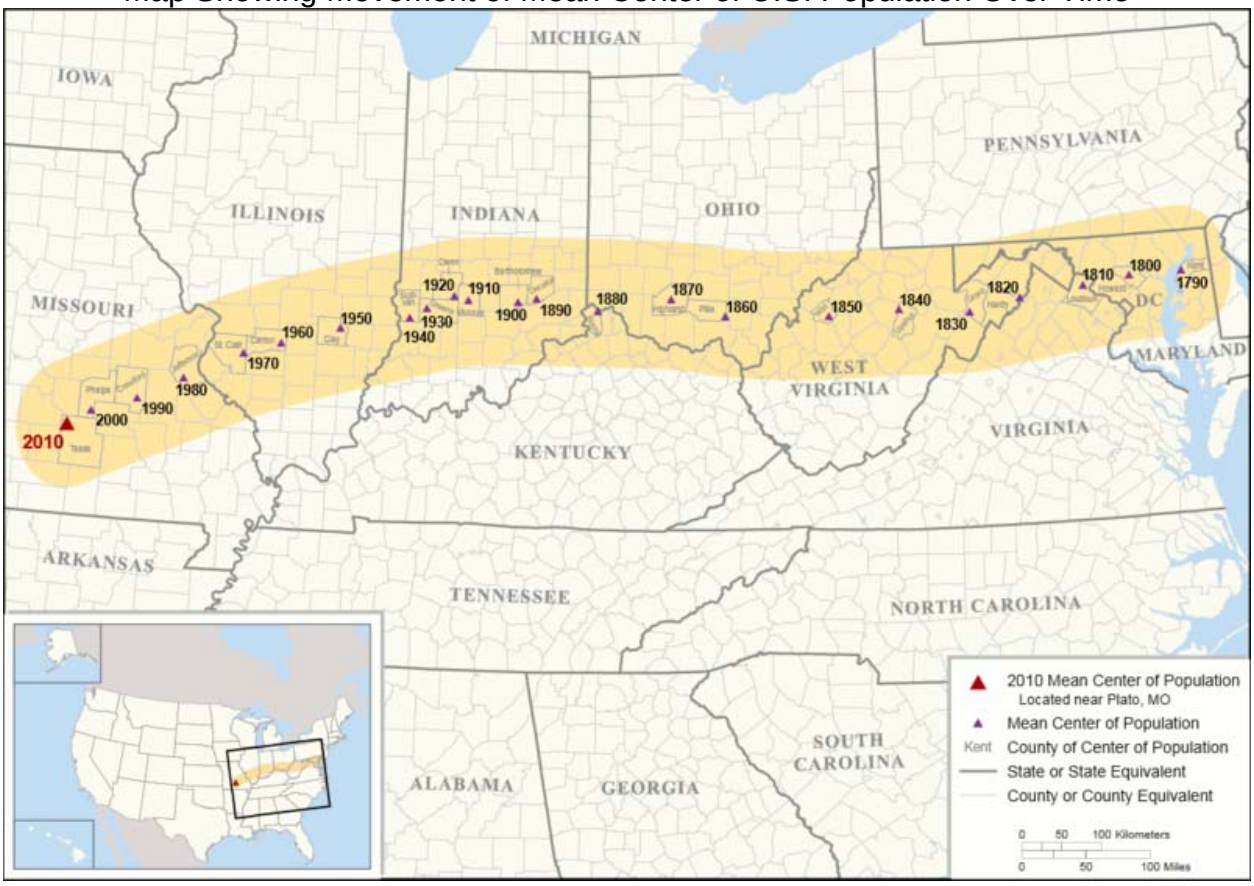


NERC Sub-Regions (eGrid Regions)



We also produce two sets of population weighted data. The first set uses weights that vary by year based on what the population was and is projected to be for each calendar year. Since the mean population center of the U.S. has been shifting steadily southwestward as populations decrease portions of the Midwest and Northeast and increase across the southern and southwestern U.S., population weighted data that has weights varying by year will show a warming trend over time based on the shifting population demographics. This set of population weighted data will correlate better with actual historical demand data.

Map Showing Movement of Mean Center of U.S. Population Over Time



We also offer a set of population weighted weather data (for the U.S. and all regions) that has all weights fixed to 2010 census values. This data set with fixed weights is likely more useful for comparing what current energy demand would have been with historical weather conditions.

All of our population weighted data sets are available for multiple time frames going back to 1980 and going forward as far as 9 months into the future. The forecast data is derived from our long range seasonal forecasts as well as our 15 day forecasts that are updated twice per day. While daily forecast values are produced going out 9 months in advance, we are not trying to actually predict daily weather events 9 months into the future. Rather, the monthly forecasts are downscaled into a daily format for use in calculating weekly and monthly degree day totals, and allowing for comparisons to previous years over varying time scales as well as general long-range demand modeling efforts.

Most population weighted weather data files are also offered in two different file formats so that the data will be more readily compatible with different analysis systems that may be in place on the user end. The top of the next page shows a screen shot from the data page illustrating the number of data files available. We currently offer 156 different population weighted weather data files. All of which are updated twice per day Monday through Friday, once by 7:30 AM and again by around 2PM.

Selection of Current Population Weighted Weather Data files

New Experimental Population Weighted Weather Data							
Date Range	**U.S. Data**	**State Data**	**EIA Region** Click for Map	**NERC Region** Click for Map	**NERC SubRegion** Click for Map	**Census Region** Click for Map	**Census SubRegion** Click for Map
1980 through 2012	PWvbY | PWf2010	PWvbY | PWf2010 Alt Fmt | Alt Fmt	PWvbY | PWf2010 Alt Fmt | Alt Fmt	PWvbY | PWf2010 Alt Fmt | Alt Fmt	PWvbY | PWf2010 Alt Fmt | Alt Fmt	PWvbY | PWf2010 Alt Fmt | Alt Fmt	PWvbY | PWf2010 Alt Fmt | Alt Fmt
2013 through 9 Month Forecast	PWvbY | PWf2010	PWvbY | PWf2010 Alt Fmt | Alt Fmt	PWvbY | PWf2010 Alt Fmt | Alt Fmt	PWvbY | PWf2010 Alt Fmt | Alt Fmt	PWvbY | PWf2010 Alt Fmt | Alt Fmt	PWvbY | PWf2010 Alt Fmt | Alt Fmt	PWvbY | PWf2010 Alt Fmt | Alt Fmt
1996 through 9 Month Forecast	PWvbY | PWf2010	PWvbY | PWf2010 Alt Fmt | Alt Fmt	PWvbY | PWf2010 Alt Fmt | Alt Fmt	PWvbY | PWf2010 Alt Fmt | Alt Fmt	PWvbY | PWf2010 Alt Fmt | Alt Fmt	PWvbY | PWf2010 Alt Fmt | Alt Fmt	PWvbY | PWf2010 Alt Fmt | Alt Fmt
Last 15 Days through 15 Day Forecast	PWvbY | PWf2010	PWvbY | PWf2010 Alt Fmt | Alt Fmt	PWvbY | PWf2010 Alt Fmt | Alt Fmt	PWvbY | PWf2010 Alt Fmt | Alt Fmt	PWvbY | PWf2010 Alt Fmt | Alt Fmt	PWvbY | PWf2010 Alt Fmt | Alt Fmt	PWvbY | PWf2010 Alt Fmt | Alt Fmt
Last 3 Months through 9 Month Forecast	PWvbY | PWf2010	PWvbY | PWf2010 Alt Fmt | Alt Fmt	PWvbY | PWf2010 Alt Fmt | Alt Fmt	PWvbY | PWf2010 Alt Fmt | Alt Fmt	PWvbY | PWf2010 Alt Fmt | Alt Fmt	PWvbY | PWf2010 Alt Fmt | Alt Fmt	PWvbY | PWf2010 Alt Fmt | Alt Fmt
Monthly Averages/Totals	PWvbY | PWf2010	PWvbY | PWf2010 Alt Fmt | Alt Fmt	PWvbY | PWf2010 Alt Fmt | Alt Fmt	PWvbY | PWf2010 Alt Fmt | Alt Fmt	PWvbY | PWf2010 Alt Fmt | Alt Fmt	PWvbY | PWf2010 Alt Fmt | Alt Fmt	PWvbY | PWf2010 Alt Fmt | Alt Fmt

The above data sets use 230 observation sites to calculate the various population weighted data sets versus only 121 observation sites in the old data sets.
PWvbY = Population weights vary by yearly population data **PWf2010** = Population weights fixed for all years to 2010 populations

Natural Gas, Electric, Fuel Oil and Propane Heating Weighting HDDs

In addition to the new set of population weighted weather data files, we have also produced a new set of weighted HDDs based on Natural Gas, Electric, Fuel Oil and Propane heating weighted data. All of these data sets start with the state population weighted weather data. Effectively, we take the population weighted degree days for each state, and then weight those states to come up with national and regional HDD composites based on the reported breakdown in household heating type. So, for Natural Gas heating the methodology is:

$$\text{State Weight} = \frac{\text{Number Households X Percent Households Using NG as Primary Heating Source}}{\text{Total Number of U.S. or Regional Households Using NG as Primary Heating Source}}$$

So, for Illinois for 2013:

$$\frac{\text{5,420,913 Households X 0.84834 (fraction of households heating with NG)}}{\text{73,705,706 Total U.S. Households Heating with NG}} = \text{0.0624 (U.S. weight)}$$

The NG heating weight for Illinois is about the same as that of New York State (0.0664) since while New York has more households and total population, only 59% of them heat with NG as a primary fuel source.

The table on the top of next page ranks each state based on the NG heating weight for that state. Note that the top 8 states account for 50% of the total weightings and the bottom 20 states only account for 10% of the total weightings. Keep in mind these are rankings based on weights derived from the total number of households using NG for heating in each state. A ranking of actual NG demand or actual weighted HDD totals for each state would look much different. While California has the largest weighting (as a result of it having far and away the largest population), the very mild weather there relative to the Midwest and Northeast results in it having a much lower than 13% contribution to the U.S. HDD totals.

Ranking of U.S. States Based on NG Heating Weights (for 2013)

Rank	State	StateWeight	CumulativeWeight
1	CA	0.1330	0.1330
2	NY	0.0664	0.1994
3	IL	0.0624	0.2618
4	TX	0.0586	0.3204
5	MI	0.0552	0.3757
6	OH	0.0525	0.4281
7	PA	0.0427	0.4709
8	NJ	0.0379	0.5088
9	WI	0.0286	0.5374
10	GA	0.0275	0.5649
11	IN	0.0273	0.5922
12	MN	0.0258	0.6180
13	CO	0.0249	0.6429
14	MO	0.0241	0.6670
15	NC	0.0215	0.6885
16	MA	0.0203	0.7088
17	VA	0.0185	0.7273
18	WA	0.0160	0.7433
19	MD	0.0159	0.7592
20	AZ	0.0157	0.7749
21	TN	0.0154	0.7903
22	OK	0.0149	0.8052
23	IA	0.0148	0.8199
24	KS	0.0133	0.8332
25	KY	0.0125	0.8457

Rank	State	StateWeight	CumulativeWeight
26	UT	0.0123	0.8581
27	AL	0.0118	0.8699
28	NV	0.0115	0.8814
29	LA	0.0107	0.8920
30	NM	0.0100	0.9020
31	OR	0.0095	0.9116
32	AR	0.0092	0.9207
33	SC	0.0089	0.9296
34	MS	0.0082	0.9378
35	NE	0.0080	0.9458
36	FL	0.0074	0.9532
37	CT	0.0073	0.9605
38	WV	0.0058	0.9663
39	ID	0.0055	0.9718
40	MT	0.0047	0.9765
41	SD	0.0035	0.9800
42	RI	0.0034	0.9834
43	NH	0.0030	0.9864
44	DE	0.0030	0.9895
45	WY	0.0027	0.9921
46	DC	0.0026	0.9947
47	ND	0.0025	0.9973
48	VT	0.0015	0.9987
49	ME	0.0013	1.0000

The same process is used to determine the weightings of each state within a given EIA region as well as calculating the weights for Propane and Fuel (Heating) Oil. In our previous NG weighted HDD data sets, we attempted to combine NG demand from houses that used NG to heat the home directly, as well as those that used electric heat but where a portion of that electricity was generated from natural gas fired power plants. Given the rapidly changing nature of natural gas power generation, those data sets have quickly become less accurate with time since they are all based on a set of fixed weights derived from older generation data. Our new data sets break out the natural gas and electric heating HDDs into two distinct sets, but also still provided a combined value that weights the two sets together. The electric heating weights are derived in the same way that the natural gas heating weights are. The combined weights add up the number of households using NG for heating along with the number of households that heat with electricity derived from NG fired power plants. That value is determined by multiplying the fraction of homes heating with electricity with the fraction of electricity derived from NG power plants.

There are a number of issues to be resolved when combining these two data sets, some of which have been accounted for in a reasonable way, and others which have not yet been fully accounted for. The main issues are that not all electricity is produced and consumed in the same state, electricity is lost in transmission, electric furnaces/heaters are generally less efficient than NG furnaces, and the average size of homes that use electric heat is smaller than the average size of homes that use NG

furnaces. Additionally, electric heat is more common in attached housing than detached housing. Since these types of housing units have fewer exterior walls, they generally lose heat (on a per unit basis) slower than detached houses do given similar insulation and building characteristics. We made no attempt to account for the last few issues, and to some extent they will offset each other. We did try to account for the fact that electricity is consumed and produced in different regions by looking at the total amount of NG power production in each power region of the country instead of each individual state. So, all the states in the SERC region, for example, use the same percent of power generated from NG with the idea that power is being shared on the grid equally across the entire region. That of course is not completely accurate, but should be more accurate than looking at power generation on a state by state level. This regional value of NG power production is then multiplied by each states fraction of households using electric heat to derive a state weight for electric heating as well as the approximate number of households that effectively heat their homes using power produced by a NG fired power plant. That number of households is then added to the number of households heating directly with NG. This combined total is then used to derive the state weights for the U.S. and EIA regions in the combined HDD data set. Since the vast majority of households in the U.S. heat with either natural gas or electricity (the major exception being the Northeast where heating oil is still used), and an increasing percentage of electricity is being produced by natural gas fired power plants, the combined NG+Electric heating weighted HDD values will be more similar to the population weighted HDD values than to the NG heating weighted HDDs.

Ranking of U.S. States Based on Electric Heating Weights (for 2013)

Rank	State	StateWeight	CumulativeWeight
1	FL	0.1731	0.1731
2	TX	0.1194	0.2925
3	CA	0.0719	0.3644
4	NC	0.0542	0.4186
5	GA	0.0440	0.4626
6	VA	0.0361	0.4987
7	AZ	0.0353	0.5340
8	TN	0.0343	0.5683
9	WA	0.0314	0.5997
10	SC	0.0308	0.6305
11	AL	0.0269	0.6574
12	LA	0.0241	0.6815
13	PA	0.0239	0.7054
14	OH	0.0230	0.7284
15	KY	0.0199	0.7483
16	MD	0.0198	0.7681
17	MO	0.0192	0.7873
18	OR	0.0166	0.8039
19	NY	0.0162	0.8201
20	IL	0.0159	0.8360
21	IN	0.0158	0.8518
22	MS	0.0139	0.8657
23	AR	0.0129	0.8786
24	OK	0.0122	0.8908
25	CO	0.0089	0.8997

Rank	State	StateWeight	CumulativeWeight
26	NJ	0.0083	0.9080
27	WI	0.0081	0.9161
28	MA	0.0080	0.9241
29	MN	0.0079	0.9321
30	WV	0.0078	0.9399
31	NV	0.0078	0.9477
32	MI	0.0074	0.9551
33	KS	0.0056	0.9607
34	IA	0.0053	0.9660
35	CT	0.0046	0.9706
36	ID	0.0045	0.9751
37	NE	0.0043	0.9794
38	NM	0.0030	0.9824
39	DE	0.0027	0.9851
40	ND	0.0025	0.9876
41	DC	0.0022	0.9898
42	MT	0.0022	0.9920
43	SD	0.0021	0.9941
44	UT	0.0019	0.9960
45	WY	0.0013	0.9973
46	NH	0.0010	0.9983
47	RI	0.0008	0.9991
48	ME	0.0007	0.9997
49	VT	0.0003	1.0000

Ranking of U.S. States Based on Combined NG + Electric Heating Weights (for 2013)

Rank	State	StateWeight	CumulativeWeight
1	CA	0.1325	0.1325
2	TX	0.0818	0.2143
3	FL	0.0598	0.2741
4	NY	0.0565	0.3306
5	IL	0.0532	0.3838
6	MI	0.0465	0.4303
7	OH	0.0455	0.4758
8	PA	0.0375	0.5133
9	NJ	0.0322	0.5455
10	GA	0.0269	0.5725
11	IN	0.0240	0.5965
12	WI	0.0239	0.6204
13	NC	0.0229	0.6433
14	CO	0.0220	0.6653
15	MO	0.0218	0.6871
16	MN	0.0216	0.7087
17	VA	0.0187	0.7274
18	AZ	0.0182	0.7456
19	MA	0.0176	0.7632
20	WA	0.0163	0.7795
21	TN	0.0160	0.7955
22	MD	0.0149	0.8104
23	OK	0.0144	0.8248
24	IA	0.0124	0.8372
25	AL	0.0123	0.8495

Rank	State	StateWeight	CumulativeWeight
26	KY	0.0122	0.8617
27	KS	0.0120	0.8737
28	LA	0.0111	0.8848
29	NV	0.0107	0.8955
30	UT	0.0105	0.9060
31	SC	0.0102	0.9162
32	OR	0.0095	0.9258
33	AR	0.0088	0.9346
34	NM	0.0087	0.9433
35	MS	0.0081	0.9514
36	NE	0.0067	0.9582
37	CT	0.0064	0.9646
38	WV	0.0055	0.9701
39	ID	0.0052	0.9753
40	MT	0.0043	0.9796
41	SD	0.0029	0.9825
42	RI	0.0029	0.9854
43	DE	0.0027	0.9881
44	NH	0.0026	0.9907
45	WY	0.0024	0.9931
46	DC	0.0024	0.9955
47	ND	0.0021	0.9976
48	VT	0.0012	0.9989
49	ME	0.0011	1.0000

Our HDD data sets are also available in two versions like our population weighted data sets: one where weights vary by year, and one where all weights are fixed to 2010 values. The data set that uses the varying weights utilizes not only populations that vary by year, but also yearly values of the percent of homes that utilize NG, electricity or other means for heating, and yearly values for percent of power generated by natural gas fired power plants. The data set with the fixed weights has all weights for all years fixed to those observed in 2010.

Current Table of Available Gas, Electric, Fuel Oil, Propane and AC Weighted Data

New Experimental Natural Gas, Electric, Fuel Oil and Propane Heating Weighted HDDs and NG/AC Weighted CDDs
We plan to get a detailed description of how all the data are calculated and weighted up in the next couple days.

Date Range	U.S. and EIA Region NG, Electric and Combined HDDs	U.S. Fuel Oil and Propane Heating Weighted HDDs	U.S. and EIA Region NG and AC Weighted CDDs
1980 through 2012	PWvbY | PWf2010	PWvbY | PWf2010	PWvbY | PWf2010
2013 through 9 Month Forecast	PWvbY | PWf2010	PWvbY | PWf2010	PWvbY | PWf2010
1996 through 9 Month Forecast	PWvbY | PWf2010	PWvbY | PWf2010	PWvbY | PWf2010
Last 15 Days through 15 Day Forecast	PWvbY | PWf2010	PWvbY | PWf2010	PWvbY | PWf2010
Last 3 Months through 9 Month Forecast	PWvbY | PWf2010	PWvbY | PWf2010	PWvbY | PWf2010
Monthly Averages/Totals	PWvbY | PWf2010	PWvbY | PWf2010	PWvbY | PWf2010

PWvbY = Weights vary by year as a result of population and heating fuel changes **PWf2010** = Weights fixed to 2010 values

Air Conditioning and Natural Gas Weighting CDDs

Our previous data sets attempted to gas weight U.S. and regional CDDs, and our latest date set does as well, but once again with some increased precision and accuracy. The new data set for gas weighted CDD data is produced in much the same way as electric heating weighted HDDs. The percent of households in each state that have air conditioning is multiplied by the fraction of power generation from NG in the power region that state predominately resides in. As can be seen from the table below, California, Texas and Florida account for fully half the total U.S. weighting. Not surprisingly, many northern states where a smaller percentage of homes have air conditioning and less power is generated from natural gas generally have a very small weighting. Like the combined NG heating + electric heating data sets, the gas weighted CDD data is converging towards the population weighted CDD data with time as the number of households with air conditioning slowly grows nearer to 100% and natural gas power production becomes more widespread.

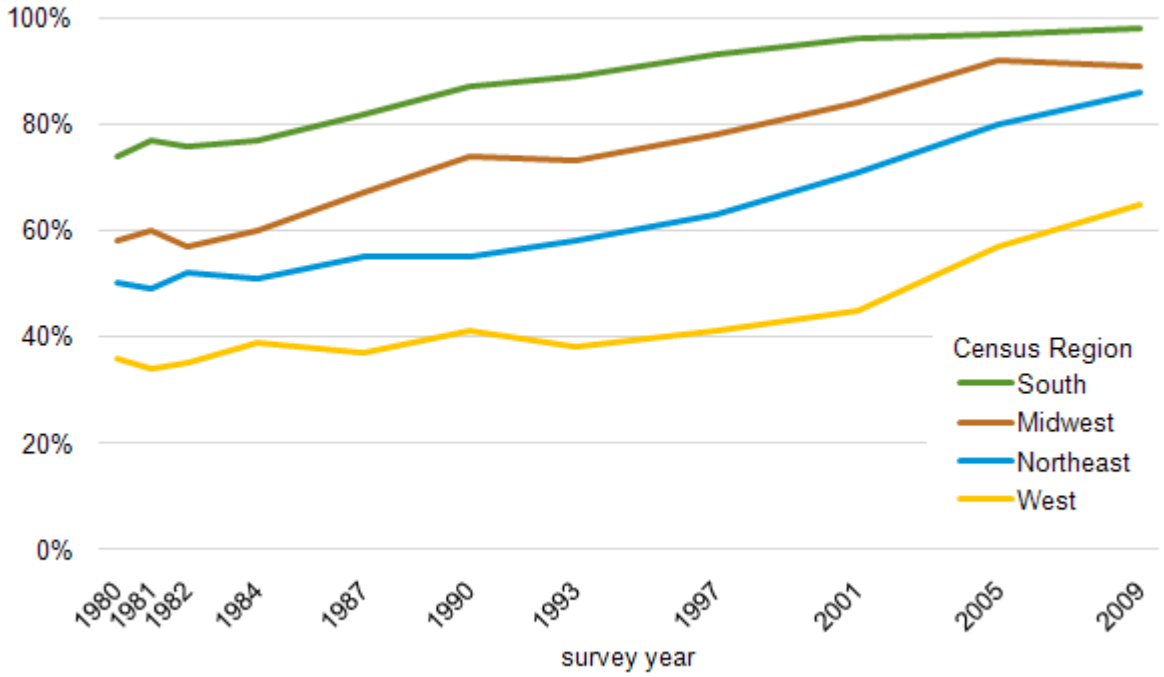
Like other data sets, the gas weighted CDD data is available in one version that has weights varying by year and one version where weights for all years are fixed to those in 2010.

Ranking of States Based on %Homes with AC x %Power Produced from NG (for 2013)

Rank	State	StateWeight	CumulativeWeight
1	CA	0.1839	0.1839
2	FL	0.1644	0.3482
3	TX	0.1625	0.5108
4	NY	0.0384	0.5492
5	PA	0.0264	0.5756
6	IL	0.0254	0.6010
7	OH	0.0246	0.6257
8	NC	0.0238	0.6495
9	GA	0.0225	0.6720
10	MI	0.0219	0.6938
11	AZ	0.0188	0.7127
12	VA	0.0183	0.7310
13	NJ	0.0169	0.7478
14	OK	0.0162	0.7641
15	TN	0.0153	0.7794
16	CO	0.0145	0.7938
17	MO	0.0142	0.8081
18	IN	0.0135	0.8216
19	MA	0.0133	0.8349
20	WA	0.0124	0.8473
21	MD	0.0119	0.8592
22	AL	0.0118	0.8710
23	SC	0.0118	0.8828
24	KS	0.0116	0.8944
25	LA	0.0106	0.9050

Rank	State	StateWeight	CumulativeWeight
26	KY	0.0104	0.9154
27	NV	0.0078	0.9232
28	OR	0.0072	0.9304
29	AR	0.0072	0.9376
30	CT	0.0070	0.9446
31	MS	0.0069	0.9515
32	UT	0.0064	0.9580
33	NM	0.0059	0.9639
34	WV	0.0044	0.9683
35	ID	0.0044	0.9727
36	ME	0.0035	0.9762
37	MT	0.0032	0.9793
38	NH	0.0030	0.9823
39	WI	0.0029	0.9852
40	MN	0.0026	0.9879
41	RI	0.0022	0.9901
42	DE	0.0021	0.9921
43	WY	0.0017	0.9938
44	VT	0.0016	0.9954
45	IA	0.0015	0.9969
46	DC	0.0015	0.9983
47	NE	0.0009	0.9992
48	SD	0.0004	0.9996
49	ND	0.0004	1.0000

Figure 1. Steady rise in air conditioned homes in all regions of the U.S.
percent of homes with AC



Source: U.S. Energy Information Administration, 2009 Residential Energy Consumption Survey