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Subject: Response to DOE Alternate Life Cycle Cost Analyses for DOE Direct Final Rule on Minimum Efficiencies of Residential Furnaces (GTI Project No's. 21225, 20705, and 02169)

Dear Jim and Bob:

Attached for your use is technical information in response to the DOE Alternate Life Cycle Cost Analyses posted October 14, 2011, for the DOE Direct Final Rule on Minimum Efficiencies of Residential Furnaces (GTI Project No's. 21225, 20705, and 02169). This information is intended to supplement the information included in the GTI final report entitled "Technical Analysis of DOE Direct Final Rule on Minimum Efficiencies of Residential Furnaces" (GTI-11/0006). Please contact me at (847) 768-0926 if you have any questions or need additional information on this topic.

Sincerely,

Neil P. Leslie, P.E.
R&D Director

Alternate DOE Life-Cycle Cost Analyses Posted October 14, 2011

Per an email request submitted by APGA on October 7, 2011 (Docket No. EERE-2011-BT-STD-0011-0020), DOE ran a set of alternate life-cycle cost analyses that were subsequently posted on the docket website on October 14, 2011. The request by APGA included detailed descriptions of the requested scenarios that were grouped into four cases. The first case, referred to by DOE as Case #1, is the focus of this GTI supplemental analytical review. Case #1 represents an integrated scenario that includes updated energy price projections from the AEO 2011 reference case, a fixed furnace life of 16 years, a learning curve rate of 1.0, and AGA survey data venting retrofit installation costs provided to DOE by APGA as part of the scenario request. For the alternate suite of analytical runs, DOE posted the output files with scenario descriptions on the website in an Excel spreadsheet, but did not post the input spreadsheet files. (http://www1.eere.energy.gov/buildings/appliance_standards/residential/residential_furnaces_cac_hp_direct_final_rule.html).

In response to this set of DOE runs, GTI analysts conducted a cursory review of the DOE 2009 baseline energy prices and performed additional Crystal Ball runs that attempted to use the same assumptions as DOE Case #1. Since DOE did not provide the input spreadsheet files on their docket website, GTI analysts were not able to determine the exact sources of the changes and resulting discrepancies between the GTI Crystal Ball runs and the DOE Case #1 run. However, the supplemental runs conducted by GTI do provide at least some insight regarding the differences between the GTI scenario analyses and the DOE Case #1 run.

Comparison of Baseline Energy Price Projections

DOE's Technical Support Document (TSD) used 2009 average residential gas prices as the baseline for all calculations. However, based on the methodology outlined in the TSD (Chapter 8 Life-Cycle Cost and Payback Period Analysis, pages 8-43 and 8-44), GTI analysts were not able to replicate the DOE average residential gas prices by Census Region or by State. Table 1 illustrates the differences between the DOE 2009 gas price values, the 2009 values calculated by GTI using the TSD methodology, and the 2010 values used by GTI in its AEO 2011 scenario analyses. The reason for the discrepancy is not known at this time, but the impact is significant, including in the North Region. The average difference is 8.4%, with a maximum difference of 12.9% in the North Region.

The following protocol illustrates GTI's 2009 average residential gas price calculation methodology applied to the East South Central Census Region. This methodology was applied to each census region and results were compared to the DOE values shown in Table 1.

GTI Average Residential Gas Price Calculation Methodology for East South Central Census Region:

Step 1 – Convert Average 2009 Residential Gas Prices from $/tcf to $/MMBtu[1]

State	$/tcf	Divide by Conversion Factor	$/MMBtu
Alabama	18.12	1.027	17.64
Kentucky	11.96	1.027	11.65
Mississippi	11.22	1.027	10.93
Tennessee	12.16	1.027	11.84

Step 2 – Weight the price in each state by the number of gas consumers in the state divided by the number of gas consumers in the census region. Sum the weighted prices for each state to determine the total average residential gas price for the census region, as weighted by the number of gas consumers.

[1] Data Source: Natural Gas Navigator, http://www.eia.gov/dnav/ng/ng_pri_sum_dcu_nus_a.htm, accessed October 17, 2011.

State	2009 No. Gas Consumers[2]	Weighted Price	Total Average Residential Gas Price
Alabama	782,814	17.64 * (782,814/3,053,195) = 4.52	-
Kentucky	751,449	11.65 * (751,449/3,053,195) = 2.87	-
Mississippi	436,649	10.93 * (436,649 /3,053,195) = 1.56	-
Tennessee	1,082,283	11.84 * (1,082,283/3,053,195) = 4.20	-
East South Central Total	3,053,195		4.52 + 2.87 + 1.56 + 4.20 = 13.15

Table 1: Comparison of DOE and GTI 2009 Residential Average Gas Prices

Div or State	Census Region	DOE 2009 Average Residential Gas Price [1] ($/MMBtu)	GTI 2009 Average Residential Gas Price ($/MMBtu)	GTI 2010 Average Residential Gas Price ($/MMBtu)	2009 % Change (GTI Value/DOE Value)
1	New England	16.37	14.74	14.50	90.0%
2	Middle Atlantic (excludes NY)	15.24	14.26	13.17	93.6%
3	East North Central	11.65	10.56	9.80	90.6%
4	West North Central	11.64	10.14	9.74	87.1%
5	South Atlantic (excludes FL)	17.17	14.43	13.83	84.0%
6	East South Central	14.38	13.15	11.11	91.4%
7	West South Central (excludes TX)	13.74	12.19	11.09	88.7%
8	Mountain	11.99	11.11	10.05	92.7%
9	Pacific (excludes CA)	14.69	13.85	12.15	94.3%
10	New York	15.27	14.65	13.46	95.9%
11	California	9.07	9.18	9.04	101.2%
12	Texas	12.43	10.90	10.31	87.7%
13	Florida	21.01	19.65	17.38	93.5%
-	U.S.	12.92	11.82	10.74	91.5%
-	AVERAGE				91.6%

All prices are in 2009$
Data Source:
1 - DOE Spreadsheet LCC_Payback_lcc_furnace_2011-06-06 posted on website

[2] Data Source: Natural Gas Navigator, Number of Natural Gas Consumers per State, http://www.eia.gov/dnav/ng/ng_cons_num_a_EPG0_VN3_Count_a.htm, accessed October 17, 2011.

Comparison of Case #1 Scenario Results

Table 2 through Table 10 compare the DOE Case #1 analysis results for the North Region and the GTI analysis results for similar assumptions (except venting installation costs). Since no input files were provided by DOE, GTI analysts were not able to replicate exactly the input values used by DOE for the AGA survey venting installation costs, and were not able to verify the value of the baseline energy prices used by DOE in its analyses. Table 5 through Table 7 show the GTI analysis results using GTI 2010 Average Residential Gas Prices. Table 8 through Table 10 show the GTI analysis results using the DOE 2009 Average Residential Gas Prices.

These comparisons illustrate the significant impact of the assumed input parameters on the results. The DOE analysis results for Case #1 show a positive lifecycle benefit for the North Region Retrofit market of $9 for the 90% furnace. This is in contrast to the negative lifecycle costs for the same consumers using either of the GTI scenarios (-$42 or -$16). The difference in the DOE and GTI baseline residential price assumptions is not known with certainty without access to the DOE input spreadsheet.

The 2009 baseline residential price used in the second GTI scenario is likely to provide the highest LCC benefit for the 90% furnace using the DOE venting installation costs that appear to be lower than the AGA venting survey cost range. Despite this a priori expectation, the DOE benefit of +$9 is actually higher than the -$16 cost for the North Region retrofit customer for the 90% furnace. The most likely explanation for this difference is the DOE use of the AGA venting survey data in its scenario, whereas the GTI scenario used the original DOE venting installation cost data because of previous difficulties attempting to incorporate the AGA venting survey data into the analysis. The input spreadsheet files are necessary to understand the DOE methodology and exact reasons for the differences.

Conclusions

The GTI review of the DOE alternate LCC analyses conducted by DOE at the request of APGA includes the following findings:

- Based on the methodology outlined in the TSD, GTI analysts were not able to replicate the DOE average residential gas prices by Census Region or by State. The average difference between the DOE spreadsheet values and the GTI calculated values is 8.4%, with a maximum difference of 12.9% in the North Region.
- The DOE analysis results for Case #1 show a positive lifecycle benefit for the North Region Retrofit market of $9 for the 90% furnace. This is in contrast to the negative lifecycle costs for the same consumers using either of the GTI scenarios (-$42 or -$16).
- Despite the a priori expectation when GTI analysts used the DOE 2009 baseline prices, the DOE benefit of +$9 is actually higher than the -$16 cost for the North Region retrofit customer for the 90% furnace. The input spreadsheet files are necessary to understand the DOE methodology and exact reasons for the differences.

DOE Alternate Scenario Analytical Runs – Case #1 Posted on DOE Website:

Table 2: DOE Alternate Scenario – Case #1 North Region Composite Results

Simulation Results NORTH — **AEO 2011 - Reference Case**

		Average LCC Results							Payback Results	
Level	Description	Installed Price	Lifetime Oper. Cost*	LCC	LCC Savings	Net Cost	No Impact	Net Benefit	Median	Average
NWGF	5,986									
0	80% AFUE - Increased HX Area	$2,024	$7,871	$9,896						
1	90% AFUE - Condensing Design	$2,573	$7,098	$9,670	$62	13%	71%	16%	11.7	14.1
2	92% AFUE - Increased HX Area	$2,642	$6,960	$9,601	$91	15%	56%	29%	9.4	11.6
3	95% AFUE - Increased HX Area	$2,806	$6,763	$9,570	$115	36%	23%	41%	11.9	13.9
4	98% AFUE - Max Tech	$3,091	$6,681	$9,771	-$85	76%	1%	23%	21.6	36.0

All dollar values are in 2009 $ * discounted and summed over lifetime of equipment

Table 3: DOE Alternate Scenario – Case #1 North Region Retrofit Results

Simulation Results NORTH - Replacements — **AEO 2011 - Reference Case**

		Average LCC Results							Payback Results	
Level	Description	Installed Price	Lifetime Oper. Cost*	LCC	LCC Savings	Net Cost	No Impact	Net Benefit	Median	Average
NWGF	4,465									
0	80% AFUE - Increased HX Area	$1,844	$7,829	$9,673						
1	90% AFUE - Condensing Design	$2,567	$7,059	$9,625	$9	16%	72%	12%	14.0	17.2
2	92% AFUE - Increased HX Area	$2,633	$6,921	$9,554	$39	18%	57%	25%	10.8	13.2
3	95% AFUE - Increased HX Area	$2,792	$6,726	$9,518	$67	38%	23%	39%	12.1	14.3
4	98% AFUE - Max Tech	$3,055	$6,643	$9,698	-$112	77%	1%	22%	21.2	34.0

All dollar values are in 2009 $ * discounted and summed over lifetime of equipment

Table 4: DOE Alternate Scenario – Case #1 North Region New Construction Results

Simulation Results NORTH - New Construction — **AEO 2011 - Reference Case**

		Average LCC Results							Payback Results	
Level	Description	Installed Price	Lifetime Oper. Cost*	LCC	LCC Savings	Net Cost	No Impact	Net Benefit	Median	Average
NWGF	1,521									
0	80% AFUE - Increased HX Area	$2,552	$7,997	$10,549						
1	90% AFUE - Condensing Design	$2,590	$7,212	$9,802	$217	3%	70%	27%	3.9	5.6
2	92% AFUE - Increased HX Area	$2,666	$7,072	$9,738	$245	6%	55%	39%	6.7	7.2
3	95% AFUE - Increased HX Area	$2,848	$6,874	$9,722	$257	29%	23%	48%	11.1	12.7
4	98% AFUE - Max Tech	$3,195	$6,793	$9,988	-$8	72%	1%	27%	23.5	42.0

All dollar values are in 2009 $ * discounted and summed over lifetime of equipment

GTI Run of DOE Case #1 with the GTI 2010 Average Residential Prices

Table 5: GTI Case #1 with 2010 Prices – North Region Composite Results

Simulation Results NORTH Composite			AEO 2011 Gas Forecast, Reference Case, 2010 Gas Prices, 16 years mean life, Learning curve 1								
			Average LCC Results							Payback Results	
Level	Description	Count	Installed Price	Lifetime Oper. Cost*	LCC	LCC Savings	Net Cost	No Impact	Net Benefit	Median	Average
NWGF		5,986									
0	80% AFUE - Increased HX Area		$1,996	$6,983	$8,979						
1	90% AFUE - Condensing Design		$2,591	$6,308	$8,899	$18	16%	71%	13%	14.3	18.2
2	92% AFUE - Increased HX Area		$2,660	$6,187	$8,847	$40	19%	56%	25%	11.2	14.4
3	95% AFUE - Increased HX Area		$2,825	$6,015	$8,839	$45	44%	23%	34%	13.9	16.5
4	98% AFUE - Max Tech		$3,109	$5,972	$9,081	-$194	82%	1%	17%	25.4	41.4
All dollar values are in 2009 $			** discounted and summed over lifetime of equipment*								

Table 6: GTI Case #1 with 2010 Prices – North Region Retrofit Results

Simulation Results NORTH Replacement			AEO 2011 Gas Forecast, Reference Case, 2010 Gas Prices, 16 years mean life, Learning curve 1								
			Average LCC Results							Payback Results	
Level	Description	Count	Installed Price	Lifetime Oper. Cost*	LCC	LCC Savings	Net Cost	No Impact	Net Benefit	Median	Average
NWGF		4,465									
0	80% AFUE - Increased HX Area		$1,803	$6,943	$8,746						
1	90% AFUE - Condensing Design		$2,595	$6,272	$8,867	-$42	19%	72%	9%	18.1	22.4
2	92% AFUE - Increased HX Area		$2,661	$6,151	$8,813	-$19	22%	57%	21%	13.2	16.6
3	95% AFUE - Increased HX Area		$2,820	$5,980	$8,800	-$10	46%	23%	31%	14.3	17.2
4	98% AFUE - Max Tech		$3,083	$5,936	$9,019	-$228	85%	1%	15%	25.3	40.4
All dollar values are in 2009 $			** discounted and summed over lifetime of equipment*								

Table 7 GTI Case #1 with 2010 Prices – North Region New Construction Results

Simulation Results NORTH New Construction			AEO 2011 Gas Forecast, Reference Case, 2010 Gas Prices, 16 years mean life, Learning curve 1								
			Average LCC Results							Payback Results	
Level	Description	Count	Installed Price	Lifetime Oper. Cost*	LCC	LCC Savings	Net Cost	No Impact	Net Benefit	Median	Average
NWGF		1,521									
0	80% AFUE - Increased HX Area		$2,560	$7,100	$9,661						
1	90% AFUE - Condensing Design		$2,579	$6,414	$8,994	$194	5%	70%	25%	3.7	6.3
2	92% AFUE - Increased HX Area		$2,656	$6,292	$8,947	$214	9%	55%	36%	7.4	8.2
3	95% AFUE - Increased HX Area		$2,837	$6,117	$8,955	$207	35%	23%	41%	12.9	14.4
4	98% AFUE - Max Tech		$3,185	$6,076	$9,261	-$97	76%	1%	23%	26.3	44.2
All dollar values are in 2009 $			** discounted and summed over lifetime of equipment*								

GTI Run of DOE Case #1 with DOE 2009 Average Residential Prices

Table 8: GTI Case #1 with DOE 2009 Prices – North Region Composite Results

Simulation Results NORTH Composite AEO 2011 Gas Forecast, Reference Case, 2009 Gas Prices, 16 years mean life, Learning curve 1											
			Average LCC Results							Payback Results	
Level	Description	Count	Installed Price	Lifetime Oper. Cost	LCC	LCC Savings	Net Cost	No Impact	Net Benefit	Median	Average
NWGF		5,986									
0	80% AFUE - Increased HX Area		$1,996	$7,790	$9,785						
1	90% AFUE - Condensing Design		$2,591	$7,025	$9,616	$44	14%	71%	15%	12.3	15.4
2	92% AFUE - Increased HX Area		$2,660	$6,888	$9,548	$73	16%	56%	27%	9.7	12.4
3	95% AFUE - Increased HX Area		$2,825	$6,694	$9,519	$95	37%	23%	41%	12.1	14.3
4	98% AFUE - Max Tech		$3,109	$6,614	$9,723	-$108	77%	1%	22%	22.0	36.5
All dollar values are in 2009 $			** discounted and summed over lifetime of equipment*								

Table 9: GTI Case #1 with DOE 2009 Prices – North Region Retrofit Results

Simulation Results NORTH Replacement AEO 2011 Gas Forecast, Reference Case, 2009 Gas Prices, 16 years mean life, Learning curve 1											
			Average LCC Results							Payback Results	
Level	Description	Count	Installed Price	Lifetime Oper. Cost	LCC	LCC Savings	Net Cost	No Impact	Net Benefit	Median	Average
NWGF		4,465									
0	80% AFUE - Increased HX Area		$1,803	$7,748	$9,551						
1	90% AFUE - Condensing Design		$2,595	$6,987	$9,582	-$16	17%	72%	11%	15.5	19.0
2	92% AFUE - Increased HX Area		$2,661	$6,851	$9,512	$13	19%	57%	23%	11.0	14.3
3	95% AFUE - Increased HX Area		$2,820	$6,658	$9,478	$39	39%	23%	38%	12.4	14.9
4	98% AFUE - Max Tech		$3,083	$6,577	$9,660	-$142	79%	1%	20%	21.5	34.8
All dollar values are in 2009 $			** discounted and summed over lifetime of equipment*								

Table 10: GTI Case #1 with DOE 2009 Prices – North Region New Construction Results

Simulation Results NORTH New Construction AEO 2011 Gas Forecast, Reference Case, 2009 Gas Prices, 16 years mean life, Learning curve 1											
			Average LCC Results							Payback Results	
Level	Description	Count	Installed Price	Lifetime Oper. Cost	LCC	LCC Savings	Net Cost	No Impact	Net Benefit	Median	Average
NWGF		1,521									
0	80% AFUE - Increased HX Area		$2,560	$7,911	$10,472						
1	90% AFUE - Condensing Design		$2,579	$7,136	$9,715	$222	3%	70%	27%	3.3	5.4
2	92% AFUE - Increased HX Area		$2,656	$6,998	$9,653	$249	6%	55%	39%	6.5	7.0
3	95% AFUE - Increased HX Area		$2,837	$6,801	$9,639	$259	29%	23%	48%	11.2	12.6
4	98% AFUE - Max Tech		$3,185	$6,723	$9,908	-$9	72%	1%	27%	23.4	41.6
All dollar values are in 2009 $			** discounted and summed over lifetime of equipment*								