Residential Oven Performance and Energy Comparison Study

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Revision History

Revision num.	Date	Description	Author(s)
0	December 2019	Initial Release	E. Ruan, R. Hedrick, D. Livchak

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Figures

Tables

Executive Summary

Frontier Energy identified and tested six of the most purchased residential gas range ovens currently on the market in 2019. Frontier characterized these six ovens in terms of preheat energy, standby energy and cooking energy. The six ovens were tested using the ASTM cook testing methodology with food product instead of the DOE cook testing methodology with aluminum blocks, as used in the previous testing. Three of the six ovens was tested using both the ASTM and DOE test methods, with the resulting data used as a model to theoretically convert and compare the cooking efficiency from aluminum blocks to more applicable food product. The recent data was combined with historical Frontier Energy test data for eight additional residential ovens that were tested in 2016.

Laboratory testing found that there are significant differences in energy use between various residential gas range oven models. Given considerations for the top results in both cooking energy efficiency and idle energy rate, Frontier identified the top 30% performing ovens. These top 30% result in an idle energy boundary of 5,700 Btu/h and an energy efficiency boundary of 26.5%. This qualifies only three of the eleven tested freestanding units as energy efficient: Model F, Model B and Model J. These three ovens have an average purchase price of $1066 and an average annual energy consumption of 12.08 therms. The other eight ovens that would thus be considered baseline ovens have an average purchase price of $916 (excluding the high end $5,000 cost of Model E) and an average annual energy consumption of 15.76 therms. This illustrates an annual energy savings of 3.68 therms, a 23% energy reduction.

Table 1: Test Results Summary (Prior Testing)

Range Top Oven	Model A	Model B	Model C	Model D	Model E	Model N	Model O	Model P
Preheat Time (min)	17.8	8.8	10.2	14.7	9.5	17.7	9.3	10.8
Preheat Energy (Btu)	2,926	2,461	2,817	2,742	4,599	2,522	2,102	4,500
Idle Energy Rate (Btu/h)	5,196	4,421	7,808	3,894	5,899	4,036	4,276	6,280
Potato Cooking Time (min)	80.8	81.3	80.8	81.6	63.7	77.7	78.6	74.2
Potato Cooking Efficiency (%)	23.2	26.5	22.9	24.4	12.6	28.1	31.3	16.4
Potato Production Capacity (lb/h)	10.7	10.6	10.7	10.6	13.6	11.1	11.0	11.7
Estimated Annual Energy Use (kBtu/yr)	1,500	1,293	1,595	1,423	2,490	1,244	1,118	2,132

Table 2: Test Results Summary (New Testing)

Range Top Oven	Model F	Model G	Model H	Model I	Model J	Model K	Model L	Model M
Preheat Time (min)	7.2	7.1	5.6	8.0	6.6	N/A	9.8	8.5
Preheat Energy (Btu)	2,082	2,153	1,590	2,457	2,108	N/A	2,053	2,029
Idle Energy Rate (Btu/h)	4,582	7,374	6,290	7,869	5,692	6,391	3,639	3,646
Potato Cooking Time (min)	69.3	69.0	83.7	94.9	92.8	73.8	79.1	74.0
Potato Cooking Efficiency (%)	32.7	21.9	24.4	21.6	27.9	25.3	24.3	22.6
Potato Production Capacity (lb/h)	12.5	12.8	10.5	9.178	9.31	11.4	5.4	5.7
Estimated Annual Energy Use (kBtu/yr)	1,100	1,514	1,293	1,593	1,249	1,656	N/A	N/A

Background

Residential range ovens can be found in nearly every home. The Lawrence Berkeley National Laboratory (LBNL) study "*Cooking Appliance Use in California Homes*"[1] found that roughly 54% of range ovens in California residences are fueled by natural gas, with ovens used primarily for dinner and sparingly for other meals. The range ovens are used much less frequently than the range tops- on average about 3 times a week, split between dinner cooking and other baking use.

The two main segments of the residential range oven market are the $500 – $1000 typical household range ovens and the $2500+ high-end range ovens. The price premium on the more expensive range ovens derives from a combination of advanced range designs, greater control options, higher quality build materials, and/or greater aesthetic appeal. Though that cost rarely goes toward improving the actual oven designs, and many high-end range ovens strongly resemble the ovens of the more typical $800 – $1200 range ovens. Both price range segments of range ovens typically include features such as

[1] Victoria L. Klug, Agnes B. Lobscheid, and Brett C. Singer. LBNL (2011). *Cooking Appliance Use in California Homes* – Data Collected from a Web-Based Survey. August 2011. LBNL-5082E. https://eetd.lbl.gov/sites/all/files/publications/lbnl-5028e-cooking-appliance.pdf

convection cooking, broiling, and self-cleaning. The most typical household range is 30-inches in width with a price point of $700 – $900 with an oven cavity between five to six cubic feet.

Approach

Under controlled laboratory conditions, researchers performed the following tests on each range oven:

- Preheat – The energy and time to bring oven cavity temperature to 400°F, as is required prior to any usage for cooking.
- Idle – Once the oven has been initially preheated, the energy required to keep the cavity at 400°F. This is used to measure energy consumption between oven preheating and actual cooking activity, which can vary per usage/household.
- Cook – The energy and time to bake a product and raise its internal temperature, which is used to both measure the production capability of the cooktop as well as the energy efficiency.

Figure 1: Temperature Calibration and Thermocouple Placement

Cook tests were performed using two methodologies, those found in the *DOE Residential Oven Test Method* and the ASTM *F1496-13 Standard Test Method for Performance of Convection Ovens*. The previous eight range ovens were tested using the *DOE Residential Oven Test Method (DOE eCFR Title 10, Part 430, Subpart B, Appendix I)*, which testing yielded cooking efficiency results that did not sufficiently differentiate the various tested ovens for a comparison testing. The testing methodology was thus switched to mirror the methodology of commercial ovens based on the ASTM *F1496-13 Standard Test Method for Performance of Convection Ovens*, cooking two full pans of [100-ct] Russet potatoes.

Figure 2: DOE Cook Test with Aluminum Block

Figure 3: ASTM Cook Test with Russet Potatoes

Cooking efficiency generated by ASTM F1496 methodology provides repeatable results and recreates the typical cooking process more accurately due to the product moisture evaporation which cannot be replicated using an aluminum block. Furthermore, potato cooking efficiency gives an end user a production capacity value based on a real food product. Two pans of potatoes were selected because two racks were supplied with most of the ovens. The pans were spaced evenly to provide optimal airflow around the cooking product for even heat distribution.

Equipment Description

Researchers conducted energy and performance testing on an additional six (6) different residential gas range ovens, to supplement the historical Frontier Energy test data for eight residential ovens tested in 2016. Ovens were selected based on an online survey of three top appliance retailers in 2019 for gas standalone ranges under $2000.

The gas ovens generally had inputs between 17,000 and 20,000 Btu/h. The exception to this was the Model K double oven, which had a top cavity with a 12,500 Btu/h input and a bottom cavity with a 14,300 Btu/h input. Range oven prices largely depended on the cooktop heating methods, control features (e.g., analogue dials, Wi-Fi connectivity), and oven features (e.g., convection, multiple fans). The tested range convection ovens were on average $350 more than the tested conventional units. The range double oven, with all the additional features, was significantly more expensive at $1,799.

Results

Researchers used the following performance metrics while comparing the gas range ovens:

- Heat-Up Time
- Standby (idle) Energy Consumption
- Cooking Energy Efficiency and Production Capacity

Heat-Up Time

Heat-up time is a function of oven power, efficiency and cavity size. The tested ovens have similar maximum input rates, so the differentiating factor will generally be the volume of space that needs to be heated and the efficacy of the burners in heating the space. The ideal oven would have a quick preheat time and a low total gas energy consumption, along with a low normalized gas energy consumption as a measure for high burner efficiency. Although measured, electric consumption contributes a negligible part to the total energy use of gas range top ovens. Convection ovens have a 100-300W cavity fan, while conventional ovens use a very small amount of energy for controls.

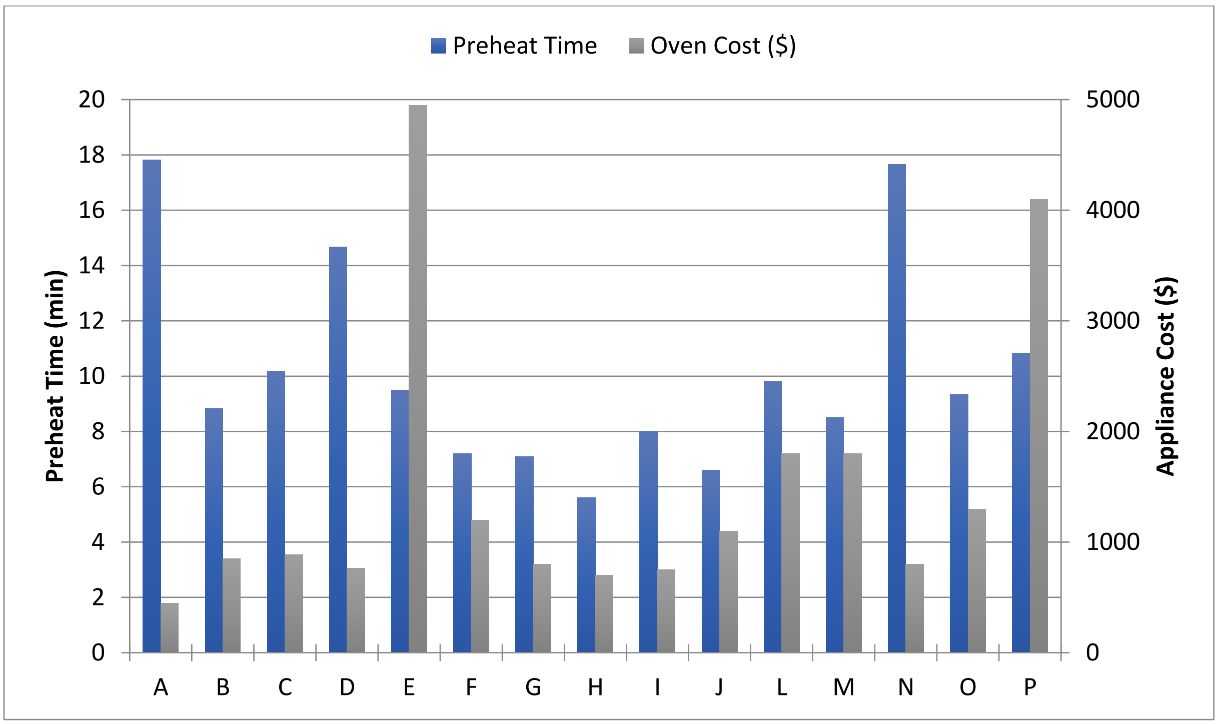


Figure 4: Preheat Times to Reach 400°F

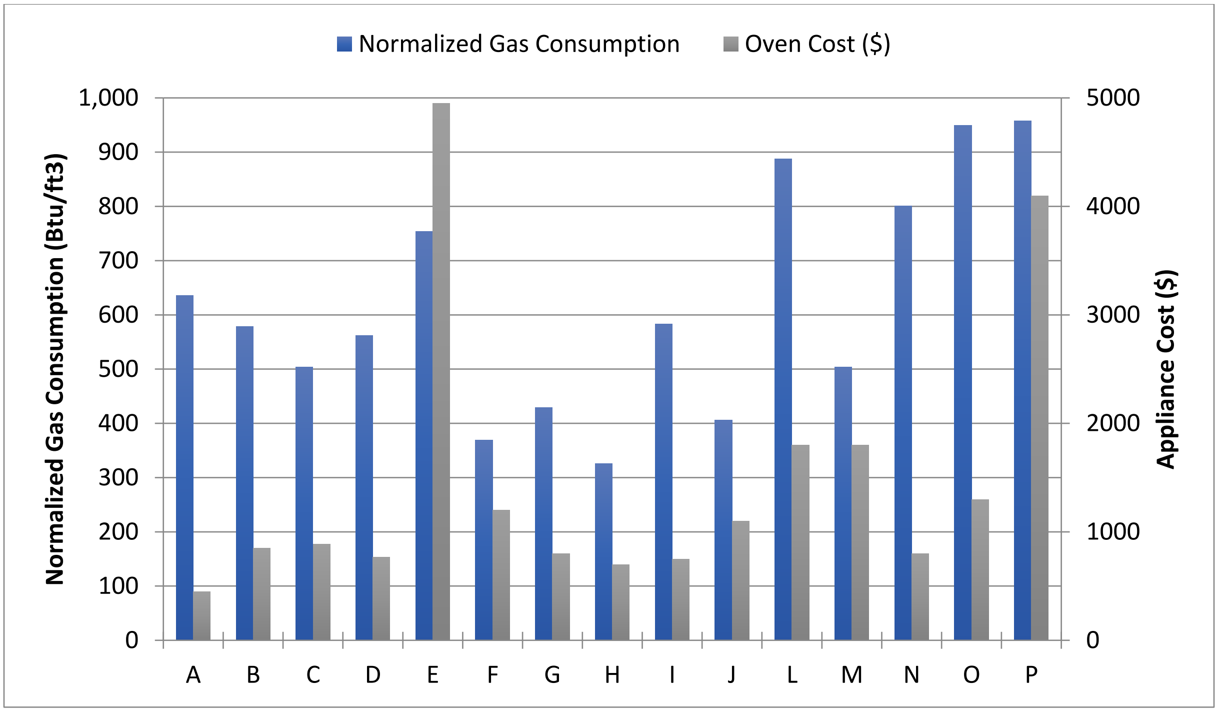
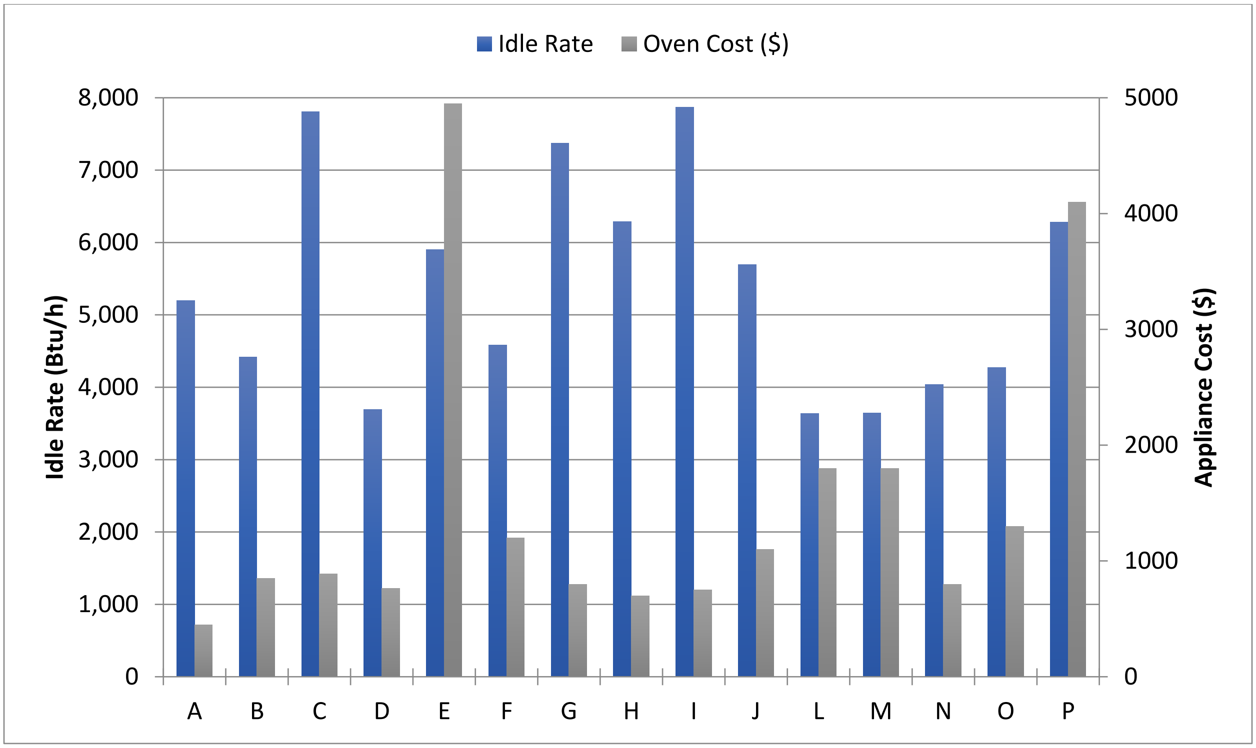


Figure 5: Preheat Gas Consumption Normalized for Cavity Size

Amongst all 14 of the range ovens tested, the three that heated up to 400°F the quickest were Model H, Model G, and Model J. All three of these ovens had average cavity sizes of around 5 cubic feet, meaning that the primary reason for their speed was not a small cavity, but efficient heating and insulation. This is also apparent when looking at the gas consumption normalized for cavity volume – those same three models are amongst the top four range ovens. In order, the lowest gas consumption per cubic foot of oven volume belonged to Model G, Model F and Model J. Model F had outperformed Model G in preheating efficiency and had only barely been slower to reach 400°F, so we can conclude a very strong correlation between preheat time and preheating efficiency. In terms of cost, all of these ovens fall in the low/mid-ranged price category. When not accounting for cavity volume, the ovens that required the lowest total gas energy to preheat would be the Model H, Model N, and Model M.

Standby (idle) Energy Consumption

The standby (idle) energy of an oven is defined as the energy it takes for the oven to maintain the 400±10°F cavity temperature and be ready for cooking (most residential cooking occurs between 350 and 450°F). Oven idle rate is a function of cavity surface area, insulation and burner efficiency. Smaller cavities should result in lower idle rate, however that is not always the case. Residential ovens are rarely used to their full capacity, so a larger cavity is often preheated to cook the same amount of food as the smaller cavities.



Disregarding the three ovens with a cavity volume of less than three cubic feet, the ovens that took the least energy to maintain an oven temperature of 400°F were Model M, Model D and Model B. None of these ovens were the same as those which performed best at any of the preheating criteria, except the Model M which used the second lowest total gas energy to heat up to 400°F. This illustrates the differences in factors that contribute to an energy efficient preheat and an energy efficient standby mode. Effectiveness in one of these criteria does not imply effectiveness across all criteria. The most energy efficient range top oven will depend on the specifics of how the oven is being used. More detailed information on the standby tests can be found in ***Appendix A: Energy Testing Results***.

Cooking Energy Consumption and Efficiency

The third energy metric of a range oven is efficiency which is measured through cooking. Results generated through a cooking test include: the length of time required to fully cook the product, the energy consumption to complete the cooking, and the energy efficiency of the oven while cooking. Cooking energy efficiency is defined as the ratio of energy into the food product versus the energy into the appliance. The higher the energy efficiency, the lower the thermal losses into the kitchen environment. The cooking state is generally the most heavily considered by consumers when evaluating oven performance, though it may or may not be the primary energy consuming state depending on the oven's exact usage.

The range ovens were initially evaluated by baking an aluminum block at a 400°F cavity temperature, until the temperature of the block rose by 234°F from ambient temperature, as described in the *DOE Residential Oven Test Method (DOE eCFR Title 10, Part 430, Subpart B, Appendix I).* Results generated by this testing yielded similar cook times and failed to provide visible differentiation between oven models. The testing methodology was thus switched to mirror the commercial oven methodology of the ASTM *F1496-13 Standard Test Method for Performance of Convection Ovens*, evaluating the ovens by the time and energy required to bring two pans of russet potatoes (15 potatoes per pan) from room temperature to 205°F. An essential part of energy efficiency calculations is energy going into the food which includes sensible (dry) and latent (moist) energy. The DOE test method using the aluminum block does not account for latent energy load, which is a major component of any food cooking process. The ASTM potato test includes latent energy providing efficiency results that are closer to an actual heavy food load placed into the oven.

To compare the test results from the DOE test method to the ASTM test method, three of the new ovens was tested using both methods. Using the average percentage differences in comparative test results from the three ovens, Frontier created a conversion factor to project theoretical potato test results from the initial block test results. Thus, the ovens from the first and second rounds of testing could be properly compared when used in a cooking mode. Expanded details about the block to potato test conversion methodology can be found in

Appendix B: Block to Potato Test Conversion

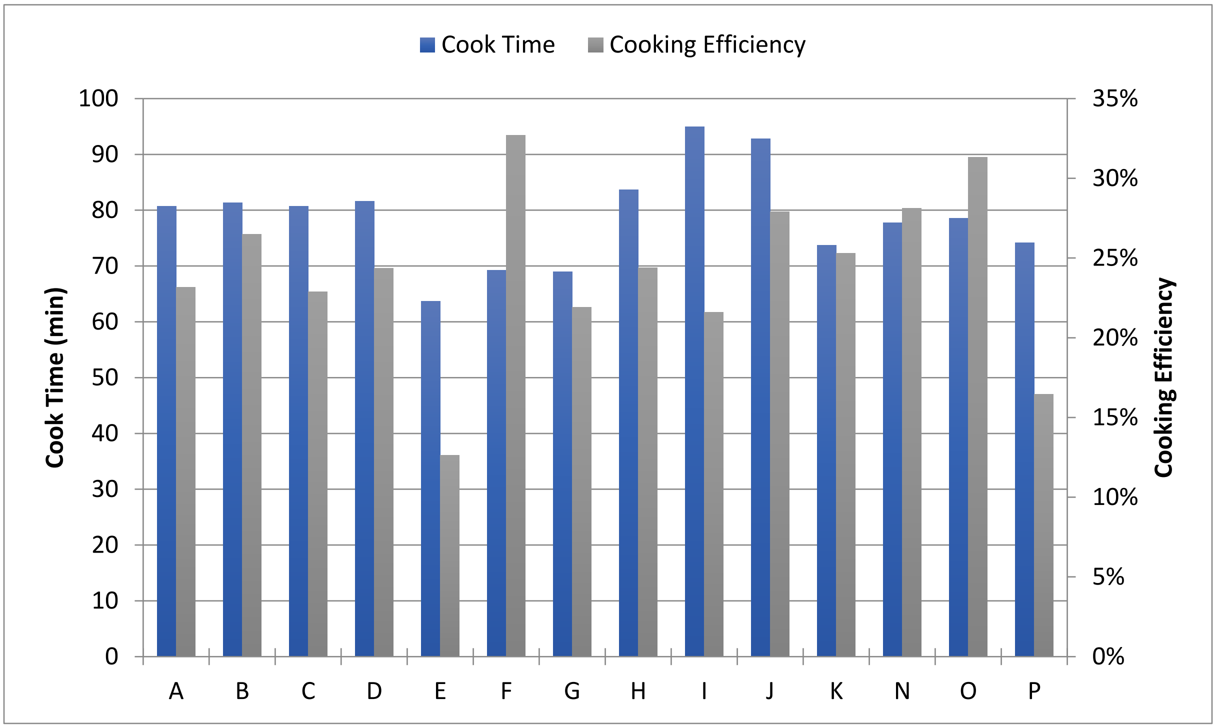


Figure 6: Cook Test Results Summary

Combining the projected potato test results for the 8 previously-tested ovens with the test results for the 6 recent models shows significant differentiation. The quickest ovens were Model E, Model G, and Model F. Potato cook times varied widely across the various ovens, from as fast as 63.7 minutes to over 94.9 minutes. Faster cook times were associated with higher production capacity, if speed and volume is needed for a kitchen.

The ovens that cooked the most efficiently however were Model F, Model J and Model B, not counting the small ovens of less than three cubic feet. Cooking efficiency varied widely across the various ovens, going as high as 32.7% and as low as 12.6%. The average cooking efficiency was generally between 20-25%.

Table 3: Potato Cook Test Theoretical Results for Previous Ovens

Range Top Oven	Model A	Model B	Model C	Model D	Model E	Model N	Model O	Model P
Cook Time (min)	80.8	81.3	80.8	81.6	63.7	77.7	78.6	74.2
Production Capacity (lb/h)	10.7	10.6	10.7	10.6	13.6	11.1	11.0	11.7
Potato Cooking Efficiency (%)	23.2%	26.5%	22.9%	24.4%	12.6%	28.1%	31.3%	16.4%

Table 4: Potato Cook Test Results for New Ovens

Range Top Oven	Model F	Model G	Model H	Model I	Model J	Model K	Model L	Model M
Cook Time (min)	69.3	69.0	83.7	94.9	92.8	73.8	79.1	74.0
Production Capacity (lb/h)	12.5	12.8	10.5	9.2	9.3	11.4	5.4	5.7
Potato Cooking Efficiency (%)	32.7%	21.9%	24.4%	21.6%	27.9%	25.3%	24.3%	22.6%

Convection Tests

Mid to high priced range top ovens often have a convection baking mode to supplement the standard mode, but consumers have minimal knowledge in understanding how these convection modes may affect cooking speed or energy use. Frontier Energy evaluated the convection modes on four of the tested ovens, for comparative results on the standard and convection baking modes. The conclusions drawn from these results range from tenuous to well-supported.

For preheats, we saw fairly minimal differences in terms of an oven's time and energy use in standard and convection modes, with the exception being that Model E's convection preheat took longer than the standard preheat. Given the relatively small difference in preheat energy though, Model E likely just missed reaching the preheat temperature on the initial upcycle and needed one more cycle of gas usage. Frontier's overall conclusion is that the preheat of an oven is relatively unaffected by the selected mode.

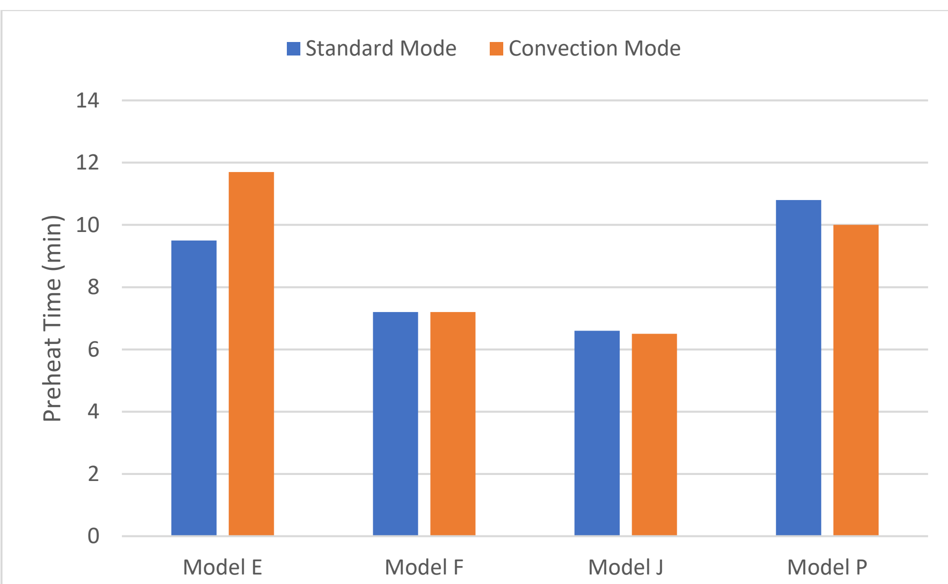


Figure 7: Convection Mode Preheat Time Comparison

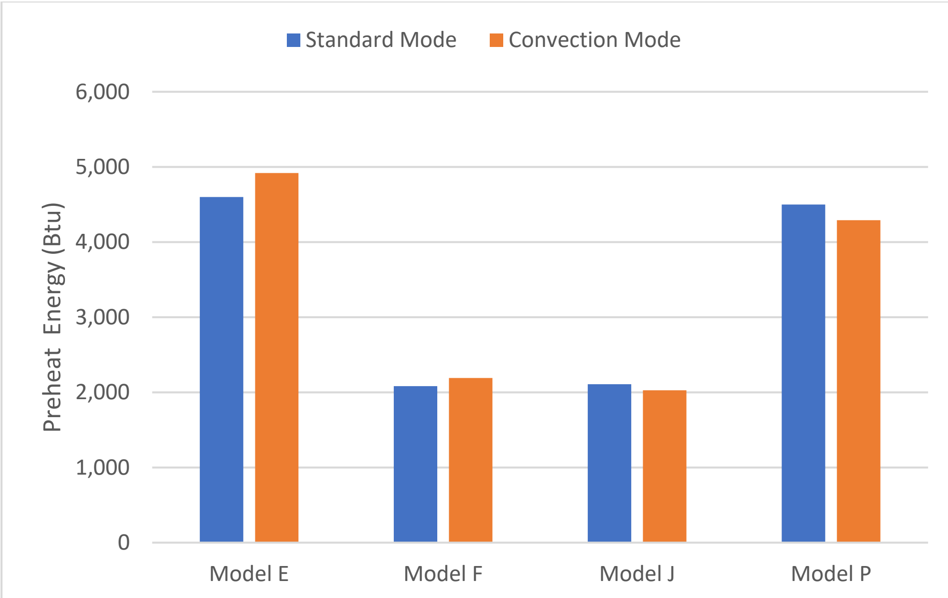


Figure 8: Convection Mode Preheat Energy Comparison

For the standby mode, the ovens again all operate similarly in both modes except for the Viking. The Viking convection mode used 62% more energy when idling in convection mode than in standby mode. For the other three ovens, the convection mode used either slightly more or about the same energy as the standard mode. This result illustrates the differences in convection mode implementation across the various ovens. Oven convection modes may sometime use more energy than the standard mode while in standby, but often not substantially more.

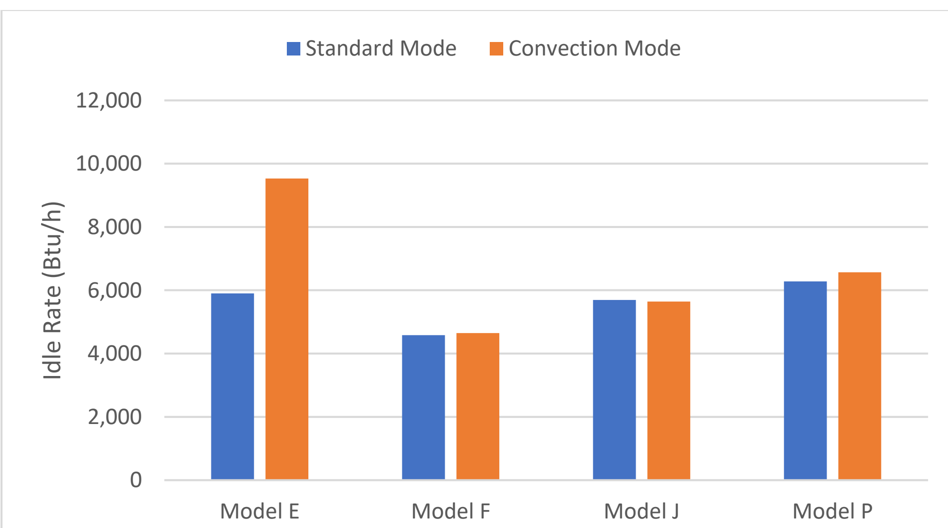


Figure 9: Convection Mode Idle Rate Comparison

For cooking, the result differentiation is generally clearer. Across all four range top ovens tested, the total energy use and cooking efficiency of the convection mode was noticeably higher than in the standard mode. The tested ovens varied in terms of cooking speed however – two of the ovens heated the product quicker in convection mode and two of the ovens heated the product quicker in standard modes. Overall though, the results show that convection mode saves energy during cooking.

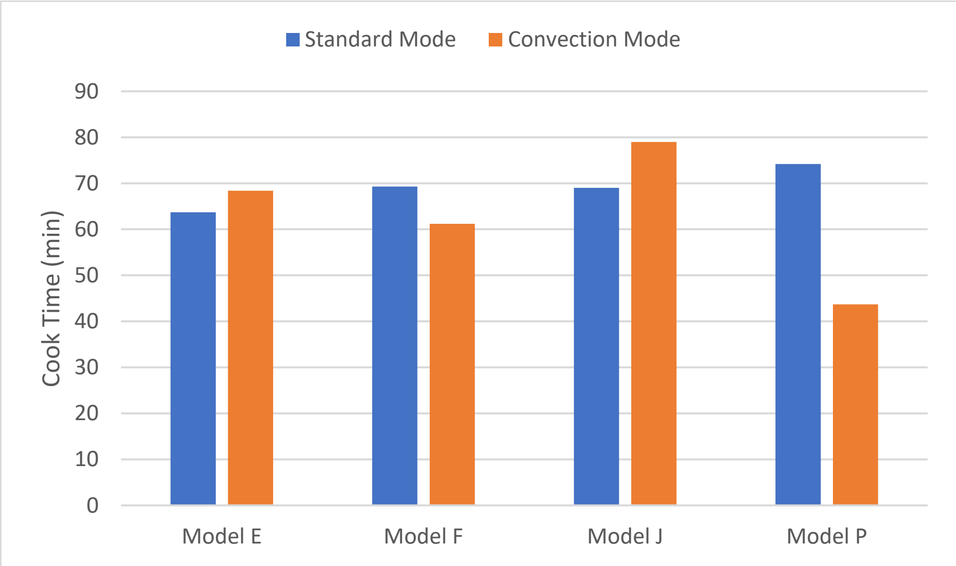


Figure 10: Convection Mode Cook Time Comparison

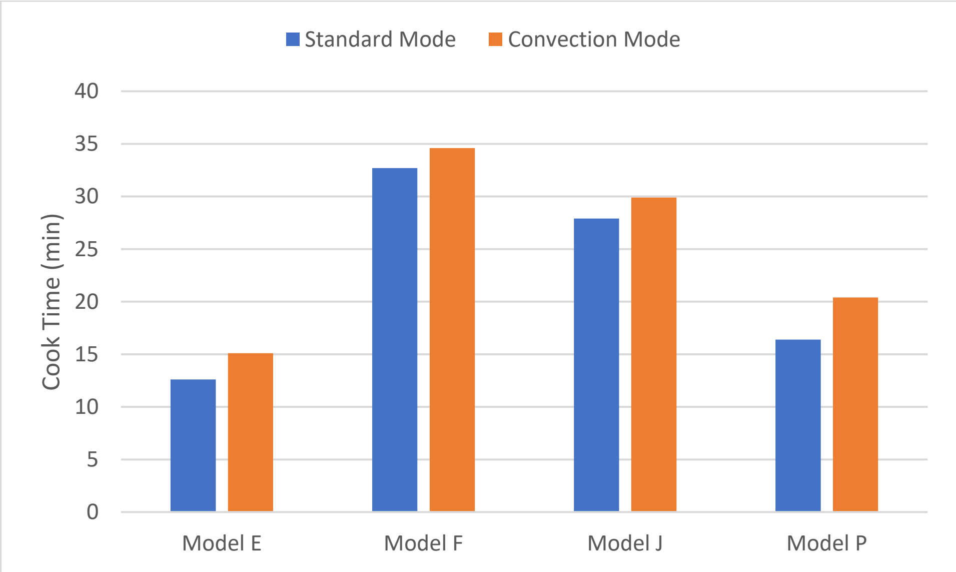


Figure 11: Convection Mode Cooking Energy Efficiency Comparison

Thus, given the relatively low impact of convection mode on preheat and standby modes (with certain exceptions), operating an oven in convection mode can on average be concluded to save energy in comparison to standard operation. Model E was an exception and used significantly more energy when idling in convection mode, but the convection mode cooking efficiency was higher. The overall energy impact of the convection mode on Model E is thus dependent on its specific usage.

Table 5: Oven Operation Comparison of Standard and Convection Modes

Range Top Oven	Model E		Model F		Model J		Model P	
	Std	Conv	Std	Conv	Std	Conv	Std	Conv
Measured Oven Cavity Size (ft^3)	6.1		5.6		5.2		4.7	
Preheat Time (min)	9.5	11.7	7.2	7.2	6.6	6.5	10.8	10.0
Preheat Energy (Btu)	4,599	4,918	2,082	2,192	2,108	2,027	4,500	4,290
Idle Energy Rate (Btu/h)	5,899	9,529	4,582	4,646	5,692	5,646	6,280	6,571
Potato Cooking Time (min)	63.7	68.4	69.3	61.2	69.0	79.0	74.2	43.7
Potato Cooking Energy (Btu)	27,696	23,121	9,458	8,944	13,081	11,930	19,851	15,957
Potato Cooking Efficiency (%)	12.6	15.1	32.7	34.6	27.9	29.9	16.4	20.4

Energy Cost Model

Components of the above energy tests were compiled into an energy model to estimate the amount of annual energy consumed for each oven model. Below is a table of input assumptions for the energy model, which assumes the range top oven is used on average three times per week on average, as concluded in the market analysis. Each use is estimated to on average consist an oven preheat, 15 minutes of standby use and one cooking load (30 minutes, the time to cook 5lbs of potatoes). The assumptions for this model are based off the oven usage findings from The Lawrence Berkeley National Laboratory (LBNL) study "*Cooking Appliance Use in California Homes*".

Table 6: Energy Model Assumptions

Average Oven Uses Per Week	3
Standby Mode Duration	15 minutes
Cooking Mode Duration	30 minutes (time to cook 5lb of potatoes)
Oven Uses Per Year	156

These assumptions were applied to the fourteen different oven models in the table below.

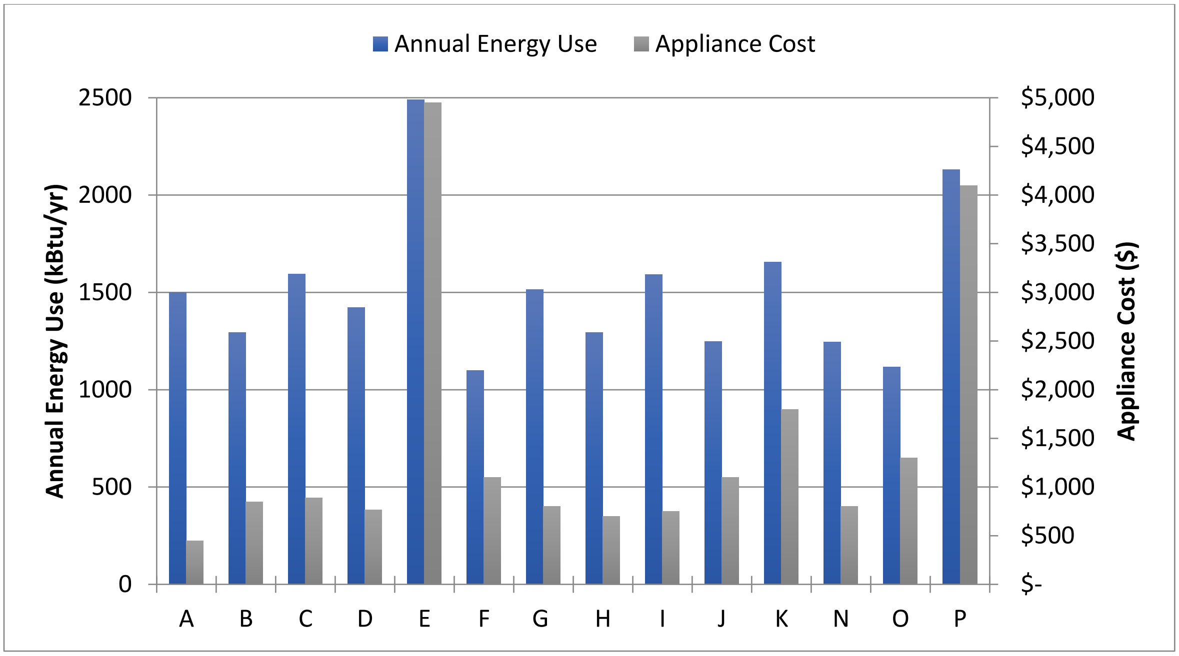


Figure 12: Energy Model Calculated Annual Energy Costs

Among the eleven freestanding range ovens, the units that had the lowest annual energy cost based on this model were Model F, Model J and Model B. These models had an average annual energy use 23% lower than the other models. When comparing oven initial purchase cost to annual energy use, Frontier found that higher purchase price generally correlated with lower annual energy use. This was only accurate up to the midrange price points however; for prices greater than $1500, higher purchase costs did not have the same correlation with energy use. The highest annual energy use was attributed the most expensive model, the Model E ($4,949). The incremental price differences from $500 up to $1500 likely correlate to increased build quality, more efficient burners and higher insulation. After that however, the additional costs are likely to be from extraneous features such as luxury materials, aesthetics and hi-tech controls.

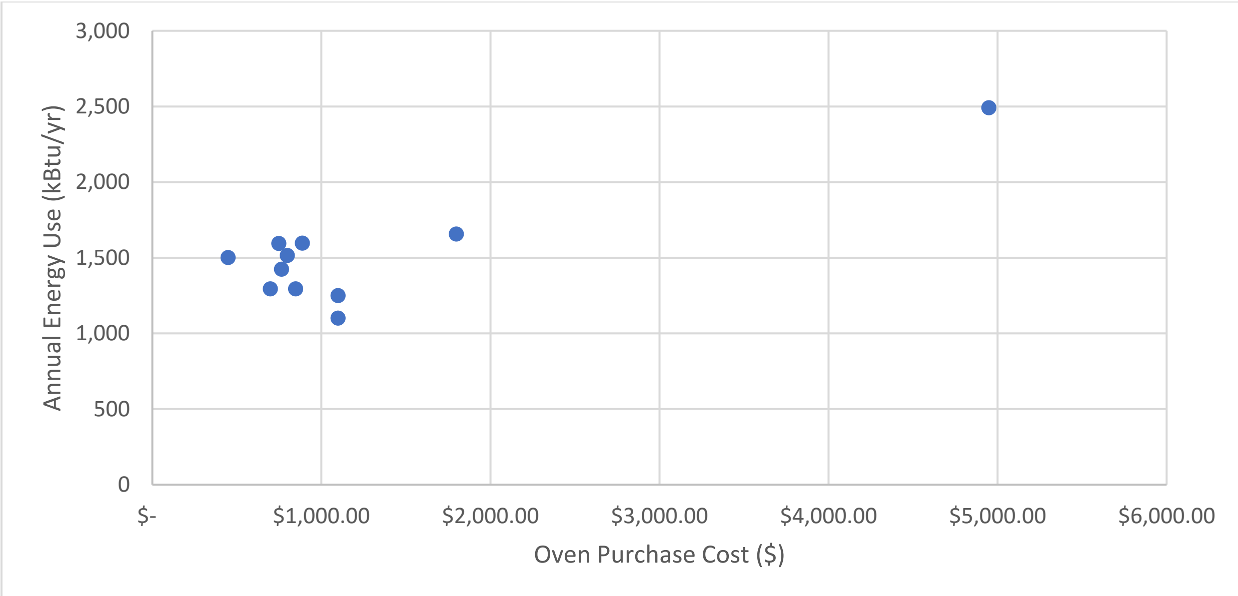


Figure 13: Comparison Plot Between Oven Cost and Annual Energy Cost to Operate

Conclusion

There are significant differences in energy use between various residential gas range top oven models. Range top ovens that had low standby rates typically were also more efficient in cooking, though their speed and thus production capacity weren't necessarily better. Given considerations for the top results in both cooking energy efficiency and idle energy rate, Frontier proposes an idle energy boundary of 5,700 Btu/h and an energy efficiency boundary of 26.5%.

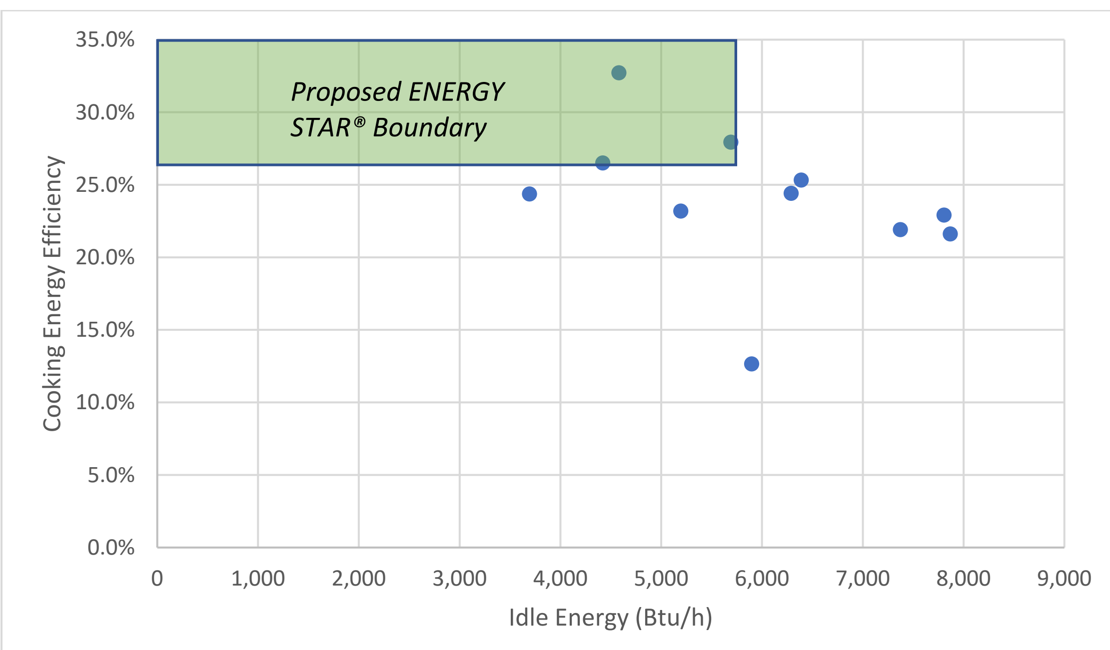


Figure 14: Comparison Plot Between Standby Energy and Cooking Energy Efficiency

This qualifies only three of the eleven tested freestanding units as energy efficient, Model F, Model B and Model J. These three ovens have an average purchase price of $1066 and an average annual energy consumption of 12.08 therms. The other eight ovens that would thus be considered baseline ovens have an average purchase price of $916 (excluding the high end $5,000 cost of Model E) and an average annual energy consumption of 15.76 therms. Thus we find that energy efficient range ovens can be expected to save on average about 23% of the annual energy cost of a typical baseline unit. For ovens that can operate in both convection and standard modes, operating in convection mode will generally provide better performance in terms of speed and cooking efficiency. However, the inconsistencies among the small sample size of convection ovens tested indicate that further testing is needed to more conclusively characterize this difference. The full test results for all 14 tested ovens can be found in ***Table 7*** and ***Table 8***.

Table 7: Test Results Summary (Prior Testing)

Range Top Oven	Model A	Model B	Model C	Model D	Model E	Model N	Model O	Model P
Measured Oven Cavity Size (ft^3)	4.6	4.3	5.6	4.9	6.1	3.1	2.2	4.7
Preheat Time (min)	17.8	8.8	10.2	14.7	9.5	17.7	9.3	10.8
Preheat Energy (Btu)	2,926	2,461	2,817	2,742	4,599	2,522	2,102	4,500
Idle Energy Rate (Btu/h)	5,196	4,421	7,808	3,894	5,899	4,036	4,276	6,280
Block Cooking Time (min)	49.0	49.3	49.0	49.5	38.7	47.2	47.7	45.0
Block Cooking Efficiency (%)	6.9	7.9	6.9	7.3	3.8	8.4	9.4	4.9
Potato Cooking Time (min)	80.8	81.3	80.8	81.6	63.7	77.7	78.6	74.2
Potato Cooking Efficiency (%)	23.2	26.5	22.9	24.4	12.6	28.1	31.3	16.4
Potato Production Capacity (lb/h)	10.7	10.6	10.7	10.6	13.6	11.1	11.0	11.7
Estimated Annual Energy Use (kBtu)	1,500	1,293	1,595	1,423	2,490	1,244	1,118	2,132

Table 8: Test Results Summary (New Testing)

Range Top Oven	Model F	Model G	Model H	Model I	Model J	Model K	Model L	Model M
Measured Oven Cavity Size (ft^3)	4.6	4.3	5.6	4.9	6.1	3.1	2.2	4.7
Preheat Time (min)	7.2	7.1	5.6	8.0	6.6	N/A	9.8	8.5
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Potato Cooking Time (min)	69.3	69.0	83.7	94.9	92.8	73.8	79.1	74.0
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Estimated Annual Energy Use (kBtu/yr)	1,100	1,514	1,293	1,593	1,249	1,656	N/A	N/A

References

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2. Denis Livchak, Russell Hedrick, and Richard Young. Frontier Energy (2019). *Residential Cooktop Performance and Energy Comparison Study.* Frontier Energy Report 501318071-R0. July 2019.

3. American Society for Testing and Materials, 2018. *Standard Test Method for Performance of Convection Ovens.* ASTM Designation F1496-13. In Annual Book of ASTM Standards, West Conshohocken, PA.

4. Department of Energy, 2016. *Appendix I to Subpart B of Part 430 – Uniform Test Method for Measuring the Energy Consumption of Conventional Ranges, Conventional Cooking Tops, Conventional Ovens and Microwave Ovens.* Title 10 of the Code of Federal Regulations, Chapter II, 1-1-16 Edition.

Appendix A: Energy Testing Results and Cost Model

Combined with the data for eight residential range ovens tested in 2016, Frontier Energy identified and tested a total of fourteen residential range ovens. Frontier Energy characterized the range ovens in terms of preheat energy, standby energy and cooking energy. The test data was integrated into an energy cost model based off of The Lawrence Berkeley National Laboratory (LBNL) study "*Cooking Appliance Use in California Homes*", to estimate and compare the expected energy costs of each range oven.

Table 9: Oven Heat-Up Time to 400°F Results (Prior Testing)

Range Top Oven	Model A	Model B	Model C	Model D	Model E	Model N	Model O	Model P
Measured Oven Cavity Size (ft^3)	4.6	4.3	5.6	4.9	6.1	3.1	2.2	4.7
Oven Heat-Up Time (min)	17.8	8.8	10.2	14.7	9.5	17.7	9.3	10.8
Gas Consumption (Btu)	2,926	2,461	2,817	2,742	4,599	2,522	2,102	4,500
Normalized Gas Consumption (Btu/ft^3)	636	579	504	562	754	801	950	957
Electric Consumption (Wh)	73	1	66	67	1	69	4	80

Table 10: Oven Heat-Up Time to 400°F Results (New Testing)

Range Top Oven	Model F	Model G	Model H	Model I	Model J	Model K	Model L
Measured Oven Cavity Size (ft^3)	5.6	5.0	4.9	4.2	5.2	2.3	4.0
Oven Heat-Up Time (min)	7.2	7.1	5.6	8.0	6.6	9.8	8.5
Gas Consumption (Btu)	2,082	2,153	1,590	2,457	2,108	2,053	2,029
Normalized Gas Consumption (Btu/ft^3)	369	429	326	583	407	888	504

Electric Consumption (Wh)	47	54	41	52	45	68	56

Table 11: Oven Idle Energy at 400°F (Prior Testing)

Range Top Oven	Model A	Model B	Model C	Model D	Model E	Model N	Model O	Model P
Measured Oven Cavity Size (ft^3)	4.6	4.3	5.6	4.9	6.1	3.1	2.2	4.7
Gas Energy Rate (Btu/h)	5,196	4,421	7,808	3,894	5,899	4,036	4,276	6,280
Electric Energy Rate (W)	144	7	297	102	16	129	21	174

Table 12: Oven Idle Energy at 400°F (New Testing)

Range Top Oven	Model F	Model G	Model H	Model I	Model J	Model K	Model L	Model M
Measured Oven Cavity Size (ft^3)	5.6	5.0	4.9	4.2	5.2	6.3	2.3	4.0
Gas Energy Rate (Btu/h)	4,582	7,374	6,290	7,869	5,692	6,391	3,639	3,646
Electric Energy Rate (W)	140	212	151	180	145	349	134	243

Table 13: Energy Cost Model (Prior Testing)

Range Top Oven	Model A	Model B	Model C	Model D	Model E	Model N	Model O	Model P
Appliance Cost	$449	$849	$888	$765	$4949	$800	$1299	$4099
Preheat Energy Per Use (Btu)	2,926	2,461	2,817	2,742	4,599	2,522	2,102	4,500
Idle Energy Per Use (Btu)	1,299	1,105	1,952	924	1,475	1,009	1,069	1,570
Cooking Energy Per Use (Btu)	5,393	4,719	5,458	5,458	9,890	4,442	3,992	7,599
Total Energy Per Use (Btu)	9,617	8,285	10,227	9,124	15,964	7,973	7,164	13,669

Estimated Annual Energy Use (kBtu)	1,500	1,293	1,595	1,423	2,490	1,244	1,118	2,132

Table 14: Energy Cost Model (New Testing)

Range Top Oven	**Model F**	**Model G**	**Model H**	**Model I**	**Model J**	**Model K**
Appliance Cost	$1,099	$799	$699	$749	$1,099	$1,799
Preheat Energy Per Use (Btu)	2,082	2,153	1,590	2,457	2,108	4,082
Idle Energy Per Use (Btu)	1,146	1,844	1,573	1,967	1,423	1,598
Cooking Energy Per Use (Btu)	3,823	5,708	5,123	5,787	4,477	4,939
Total Energy Per Use (Btu)	7,050	9,704	8,285	10,211	8,008	10,619
Estimated Annual Energy Use (kBtu/yr)	1,100	1,514	1,293	1,593	1,249	1,656

Appendix B: Block to Potato Test Conversion

Under the previous DOE test method, four out of the eight ovens had cook times between 49 and 49.5 minutes. Three of the others took between 45 and 48 minutes to raise the aluminum block by 234°F, with the single outlier taking nearly 39 minutes. With the ASTM test method, the cook time of the potatoes varied from 69 to 84 minutes, with an outlier at nearly 95 minutes. As such, the test results between the two sets of tests could not be directly compared and could only be compared within each test set.

Table 15: Oven Cooking at 400°F (Prior Testing)

Range Top Oven	Model A	Model B	Model C	Model D	Model E	Model N	Model O	Model P
Measured Oven Cavity Size (ft^3)	4.6	4.3	5.6	4.9	6.1	3.1	2.2	4.7
Cook Time (min)	49.0	49.3	49.0	49.5	38.7	47.2	47.7	45.0
Gas Consumption (Btu)	6,055	5,740	6,100	5,758	12,040	4,932	4,812	8,630
Electric Consumption (Wh)	153	5	163	147	7	143	17	187
Aluminum Block Cooking Efficiency (%)	6.9	7.9	6.9	7.3	3.8	8.4	9.4	4.9

Table 16: Oven Cooking at 400°F (New Testing)

Range Top Oven	Model F	Model G	Model H	Model I	Model J	Model K	Model F	Model G
Measured Oven Cavity Size (ft^3)	5.6	5.0	4.9	4.2	5.2	6.3	2.3	4.0
Cook Time (min)	69.3	69.0	83.7	94.9	92.8	73.8	79.1	74.0
Gas Consumption (Btu)	9,458	1,4304	14,055	17,274	13,081	11,739	6,523	6,526
Electric Consumption (Wh)	247	311	334	386	310	578	240	382

Potato Cooking Efficiency (%)	32.7%	21.9%	24.4%	21.6%	27.9%	25.3%	24.3%	22.6%

To compare the test results from the DOE test method to the ASTM test method, Model F, Model G and Model J were tested using both methods. Using the percentage differences in comparative test results from the three oven, the block test results from the previous ovens were converted to project theoretical potato test results. Thus the ovens from the first and second rounds of testing could be properly compared when used in a cooking mode.

Table 17: Block and Potato Testing Comparison

	Model F Block to Potato Test Conversion Factor	Model G Block to Potato Test Conversion Factor	Model J Block to Potato Test Conversion Factor	Final Conversion Factor
Cook Time (min)	1.44	1.57	1.94	1.65
Gas Consumption (Btu)	2.29	2.11	2.45	2.30
Cooking Efficiency (%)	2.95	3.63	2.50	3.35