

Direct Use of Natural Gas: Fuel Choice from the Consumer's Perspective

January 2015

Council Document # 2015-01

Background

Whether it's better to use natural gas directly or to generate electricity for water heaters and furnaces has been a question since the Council's first power plan. Over the years, the Council has conducted numerous studies to address this issue, described variously as fuel choice, fuel switching, direct use of gas, and total energy efficiency.

The region's natural gas companies sued the Council after its first power plan. Their concern was that the plan recommended that the Bonneville Power Administration acquire energy efficiency by providing financial incentives to encourage consumers to install measures that improved electricity efficiency. Gas companies argued that these incentives would create a disadvantage for them and encourage electricity use. Over time, the argument has evolved to assert that the direct use of natural gas is more thermodynamically efficient (uses less total energy to produce the same end-use service) and is therefore better for the environment.

In 1994, the Council analyzed the economic efficiency of converting existing residential electric space and water heating systems to gas systems.¹ The results of that [study](#) found that the region could save over 730 average megawatts. Since the price increases in electricity in 1980, the market shares of electric space and water heating have declined while natural gas space and water heating shares have increased. A survey of new residential buildings conducted in 2004 for the Northwest Energy Efficiency Alliance (NEEA) found that nearly all new single-family homes constructed where natural gas was available had gas-fired forced air heating systems.² The survey also found increased natural gas heating in the traditionally electric heat dominated multi-family market, especially in larger units and in Washington.³ Fuel conversion of existing houses to natural gas has been an active market as well, often promoted by dual fuel utilities.

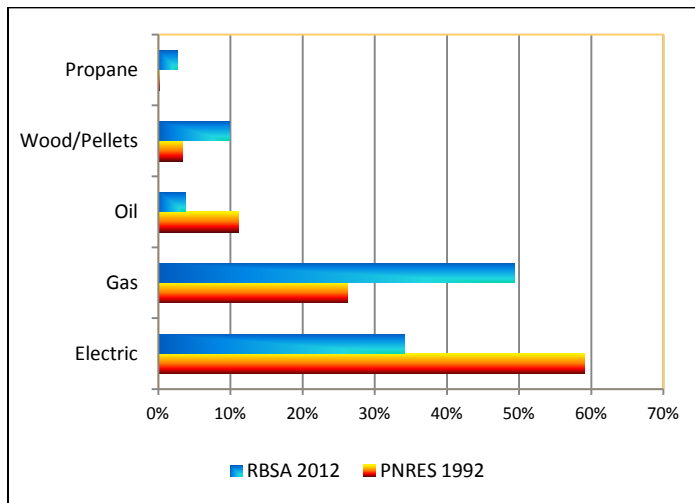
The most recent study, the 2012 Residential Building Stock Assessment, also conducted by NEEA, indicates that this trend is continuing. Between 1992 and 2012, regional surveys found that the market share of both electric space and water heating in single-family homes has continued to decline while the market share of natural gas has increased. Single-family electric space heating dropped from about 60 percent in 1992 to about 33 percent by 2012, and electric water heating's market share declined from 76 percent to about 55 percent.

¹ Northwest Power Planning Council. "Direct Use of Natural Gas: Analysis and Policy Options." Issue Paper 94-41. Portland, OR. August 11, 1994.

² Northwest Energy Efficiency Alliance, Single-Family Residential New Construction Characteristics and Practices Study. Portland, OR March 27, 2007. Prepared by RLW Analytics.

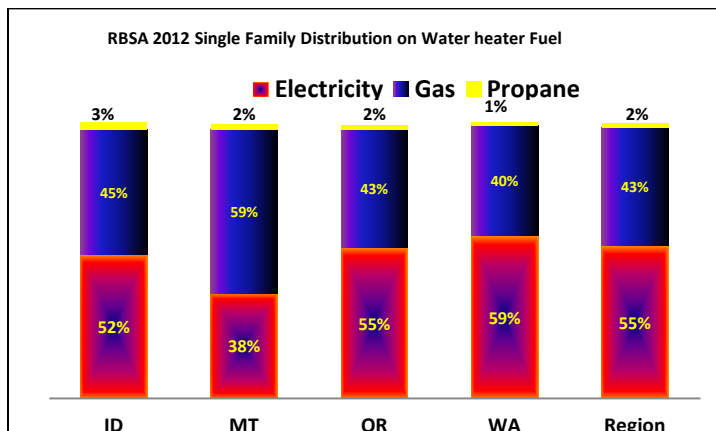
³ Northwest Energy Efficiency Alliance, MultiFamily Residential New Construction Characteristics and Practices Study. Portland, OR June 14, 2007. Prepared by RLW Analytics.

Figure 1: Primary Space Heating Fuel in Single Family Homes



Market share of electricity as the primary space heating fuel has declined continuously in the past two decades.

Figure 2: RBSA 2012 Single Family Distribution on Water Heater Fuel



Market share of electricity as the water heating fuel varies across the states

The Council’s policy on this issue has been very consistent. Its analysis found that while the direct use of natural gas is often more thermodynamically efficient than using electricity generated from natural gas, its economic efficiency (lower cost) depends on several factors: relative price of natural gas and electricity; space and/or water heating energy use; the cost and efficiency of space and water heating systems; and access to natural gas service.

The Council’s policy, adopted in its first plan, is that fuel switching is not conservation under the Northwest Power Act, which is defined as the “more efficient use of electricity.” Further, the Council has determined, on the basis of its earlier analysis, that fuel choice markets are reasonably competitive and should be allowed to work without interference.

Council's Existing Policy Statement Regarding Direct Use of Natural Gas

The Council recognizes that there are applications in which it is more energy efficient to use natural gas directly than to generate electricity from natural gas and then use the electricity in the end-use application. The Council also recognizes that in many cases the direct use of natural gas can be more economically efficient. These potentially cost-effective reductions in electricity use, while not defined as conservation in the sense the Council uses the term, are nevertheless alternatives to be considered in planning for future electricity requirements.

The changing nature of energy markets, the substantial benefits that can accrue from healthy competition among natural gas, electricity, and other fuels, and the desire to preserve individual energy source choices all support the Council taking a market-oriented approach to encouraging efficient fuel decisions in the region.

Sixth Power Plan Analysis of the Direct Use of Natural Gas

In light of changing technologies and energy prices and growing climate concerns, the Council was again asked to look at the issue of direct use of natural gas in the Sixth Power Plan.⁴ The Council conducted extensive analysis of the consumer space and water heating options from two perspectives. The first, the *regional* perspective, identified the residential space and water heating systems with the lowest *total cost* using the *avoided* cost of new electricity generation. The second perspective, the *consumer* perspective, identified the residential space and water heating systems with the lowest life cycle cost to consumers using *retail* market conditions. The outcome of these two analyses was then compared to determine whether the most economical systems from the regional perspective differed from those from the consumer's perspective. If the most economic systems based on the regional economics were also the most economic systems based on consumer economics, then it would appear that no policy intervention would be needed.

The major findings from analysis conducted pursuant to the 6th Plan were that:

- It was not economically advantageous to switch space conditioning and/or water heating fuel source for nearly three quarters (73%) of the market segments analyzed.
- For nearly one-quarter (22%) of the market segments considered in the analysis it was found that conversion from electric space heating and/or water heating to gas space and/or water heating was the most economical choice.
- Converting all of those households now using electricity to natural gas space or water heating where gas is the most economical fuel would reduce regional electric loads by roughly 360 average megawatts and increase regional natural gas consumption by just over 15 trillion BTU by the end of the 20-year period (2029).
- Overall, the study found that there was general alignment between the space and water heating systems that are least cost to the consumer and least total cost to the region. This alignment indicated that price signals and market conditions exist which encourage a shift to the direct use of natural gas where it is the most economical choice.

A summary of the major results from the analysis conducted pursuant to the 6th Plan appears in Table 1.

⁴ The analysis was called for in the Action Plan (ANLYS-16) for the Sixth Power Plan. The Council's 2012 study's findings were reported in Council document 2012-01, "Direct Use of Natural Gas: Economic Fuel Choices from the Regional Power System and Consumer's Perspective".

Table 1 - Disposition of Market Segments Based on Resource Portfolio Model's Selection of Least Risk Plan

	No. Segments Represented	No. Households/yr	20-year Total Households	Share of Total	Existing Use (MWa/yr)	Existing Use (MMBTU/yr)	Annual Change in Use (MWa/yr)	Annual Change in Use (MMBTU/yr)	Change in Use (MWa by 20th yr)	Change in Use (MMBTU by 20th yr)
Replace w/Same Fuel & Same Equipment	20	48,412	968,235	37.3%	4.92	2,500,094	-	-	-	-
w/Higher Efficiency Space Heating Equipment Only	14	1,807	36,145	1.4%	1.96	-	(1)	-	(10)	-
w/Higher Efficiency Water Heating Equipment Only	10	33,439	668,785	25.8%	21.51	-	(6)	-	(118)	-
w/Higher Efficiency Space & Water Heating Equipment	14	11,142	222,835	8.6%	15.26	-	(5)	-	(95)	-
<i>Sub-Total</i>	58	94,800	1,895,999	73.1%	43.65	2,500,094	(11)	-	(223)	-
Conversions from Electricity to Gas										
Space Heating only	11	1,520	30,400	1.2%	1.57	-	(1.55)	56,890	(31)	1,137,793
Water Heating only	6	21,197	423,940	16.3%	8.05	-	(8.05)	364,532	(161)	7,290,630
Space & Water Heating	6	5,745	114,900	4.4%	8.49	-	(8.29)	331,070	(166)	6,621,393
<i>Sub-Total</i>	23	28,462	569,240	21.9%	18.11	-	(18)	752,491	(358)	15,049,817
Conversions from Gas to Electricity										
Space Heating only	0	-	-	0.0%	-	-	-	-	-	-
Water Heating only	6	6,262	125,240	4.8%	0.10	98,713	1.21	(98,713)	24	(1,974,263)
Space & Water Heating	0	-	-	0.0%	-	-	-	-	-	-
<i>Sub-Total</i>	6	6,262	125,240	4.8%	0.10	98,713	1	(98,713)	24	(1,974,263)
Conversions from Electric Space Heating and Gas Water Heating to Gas Space Heating and Electric Water Heating	8	168	3,360	0.1%	0.16	2,648	(0.13)	3,536	(3)	70,723
Totals	95	129,692	2,593,839	100%	58	2,601,455	(27.97)	657,314	(559)	13,146,277
Changes Net of Efficiency	37	34,892	697,840	27%	18	101,361	(16.81)	657,314	(336)	13,146,277

Analysis of Direct Use of Natural Gas for the Draft Seventh Plan

The draft Seventh Power Plan analysis focuses on the eight market segments previously identified that appear to offer the best economic options for converting from electricity to natural gas. These market segments are single-family homes with electric water heating and natural gas space heating. These eight market segments were further divided into two sets of households based on water heater tank size. This was done to reflect the 2015 federal appliance standards that set different minimum efficiency levels for larger (above 55 gallon) and smaller (55 gallon and less) capacity water heaters.

Although price signals do encourage consumer decisions, market studies on how consumers make choices repeatedly show that price is not the only factor.⁵ Given this fact, the question becomes, even when price signals indicate a lowest-cost option, what will consumers actually choose?

In 2014, The Council commissioned Systematic Solutions, Inc. (SSI) to perform a study that targeted these eight market segments to estimate the share of consumers—all using electric water heating—who would

⁵ Matejla, F. and Alisdair McKay, *Rational Inattention to Discrete Choice: A New Foundation for the Multinomial Logit Model*, May 2014.

actually select the least-cost water heating system. SSI compared the historical trends in electric to gas conversions with the most economic choices available to consumers to adjust for these “non-economic” factors. SSI was also task with developing both a simplified “spreadsheet” version of its model of consumer choice and to revise the logic in the Council’s long-term load forecast model, ENERGY 2020, so that that model’s results would reflect the findings of this research.

Using these models to reflect consumer fuel choice the Council examined two scenarios:

1. Business-As-Usual – This scenario assumes the choice of water heating technologies depends on the consumer’s perceived cost of that technology and other “non-economic” factures. This case attempts to reflect the historical trends in actual consumer decisions in projecting future consumer choices.
2. Least Cost – This scenario assumes the choice of water heating technologies depends only on which technology has the lowest life-cycle cost. This technology is assumed to be selected by consumers in 100 percent of the cases. This scenario is identical to the Council’s 2012 analysis.

Figures 3 and 4 illustrate the results of this analysis using average electricity and natural gas prices (retail cost) for Washington and Oregon states for households with water heater tank capacities of 55 gallons or less.

Figure 3: Example of Marginal Market Share SF- Washington Less Than or Equal To 55 Gallon Water Heating

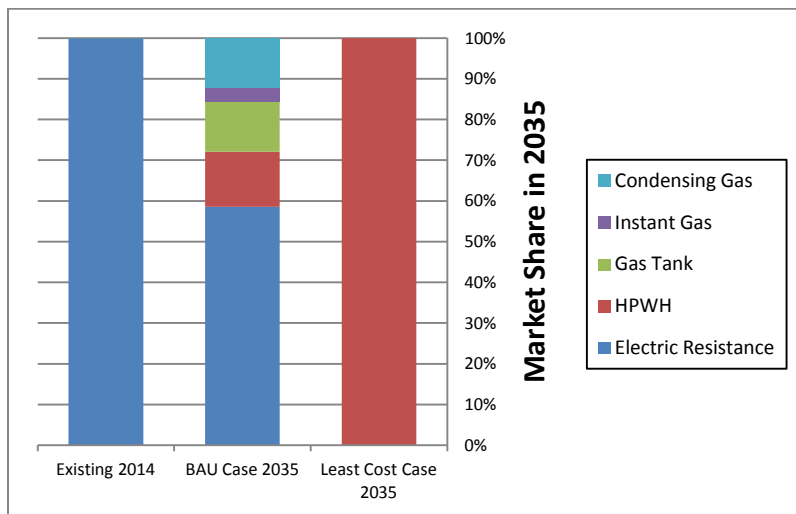


Figure 3 shows that 100 percent of single family households in Washington with electric resistance water heating in 2014 would convert to electric heat pump water heaters by 2035 if they selected the Least Cost option.

Under the BAU scenario these same households’ replacement water heaters would be divided between the five technology choices.

Figure 4: Example of Marginal Market Share SF- Oregon Less Than or Equal To 55 Gallon Water Heating

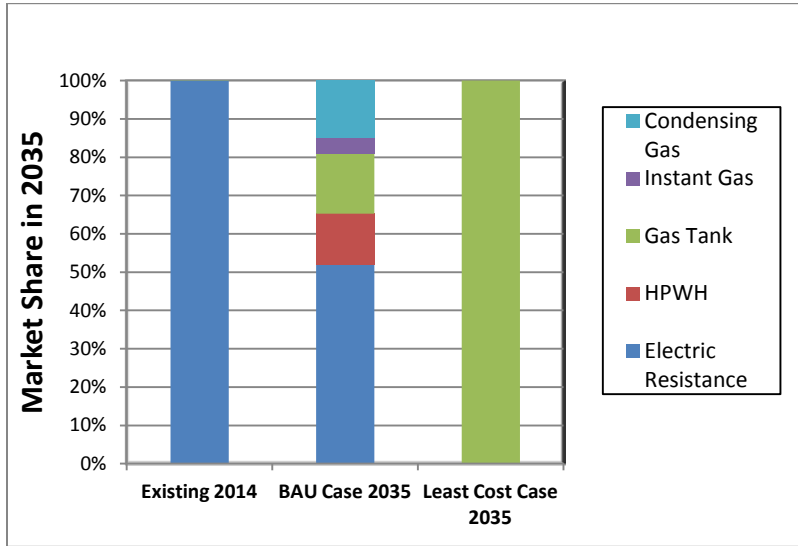


Figure 4 shows that 100 percent of single family households in Oregon with electric resistance water heating in 2014 would convert to natural gas water heaters by 2035 if they selected the Least Cost option.

Under the BAU scenario these same households' replacement water heaters would be divided between the five technology choices.

Figure 5 shows the increase in electricity use (MWh) when comparing regional electricity consumption for water heating in 2035 under the Business as Usual scenario compared to the consumption under the Least Cost scenario. This increase indicates that fewer consumers are forecast to convert to natural gas water heating than would find it economically advantageous to do so.

Figure 5: Increase in Electricity Use by 2035 (MWh) Under the Business-As-Usual Scenario Compared to the Least-Cost Scenario

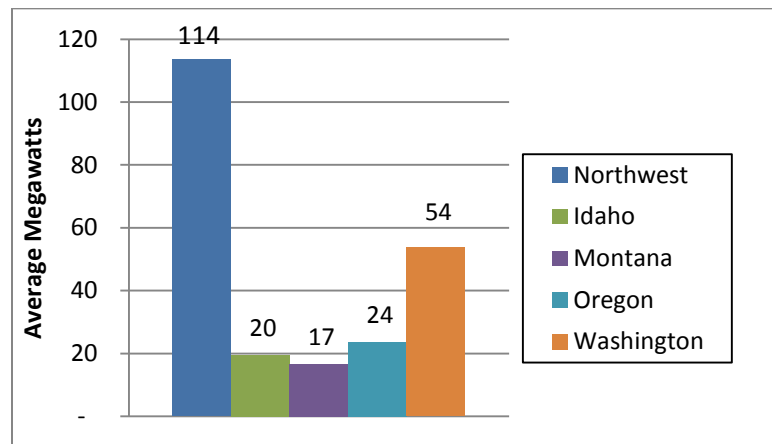
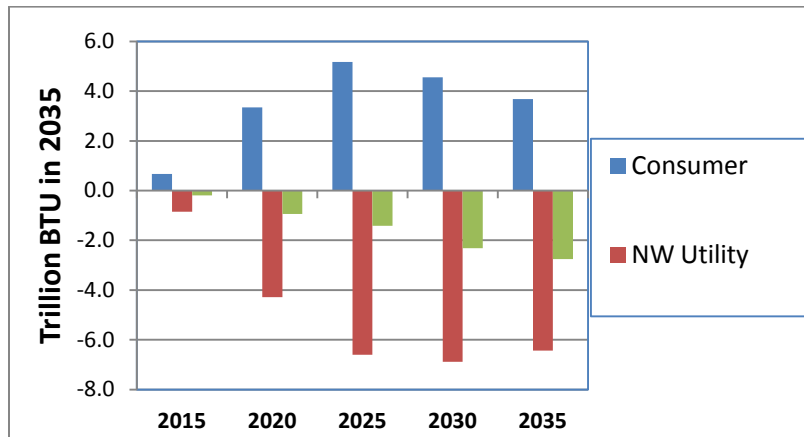


Figure 6 shows change in regional natural gas consumption by 2035 for the consumers (i.e., direct use) and for the electricity generations (NW Utility) and the total natural gas consumption in the Business As Usual scenario compared to the Least Cost scenario. As show in this figure, total regional consumption of natural gas is nearly three trillion BTU larger under the Business as Usual scenario that it is under the Least Cost scenario. This is a result of the fact that fewer consumers convert to natural gas under the Business As Usual scenario than would under the Least Cost scenario.

Figure 6: Change in Regional Natural Gas Use by Consumers, Utilities and Total Consumption by 2035



Figures 7 and 8 show that use of the Business As Usual assumptions (i.e., actual consumer choice) results in a forecast that continues the trend of switching from electricity as the fuel for water heating to natural gas. The speed of conversion reflected in the market share trends vary depending on the size of water heaters and consumer’s needs.

Figure 7: Forecast Average Market Share for Water Heaters More Than 55 gallons

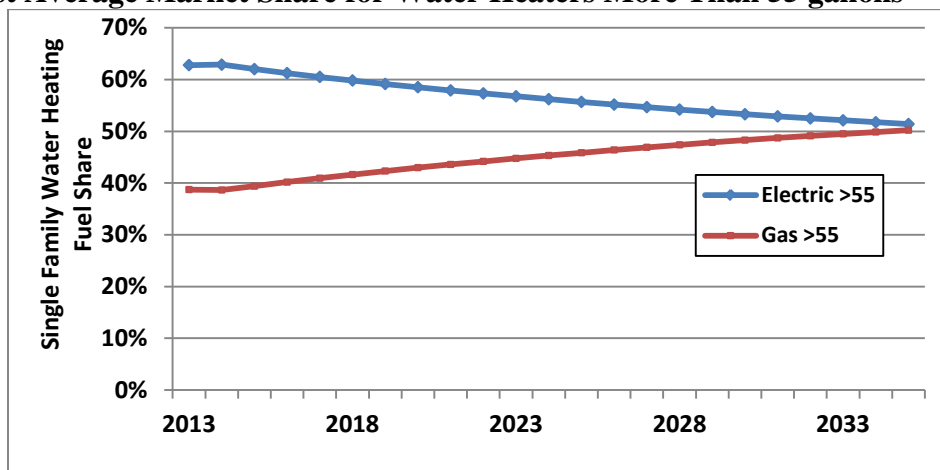
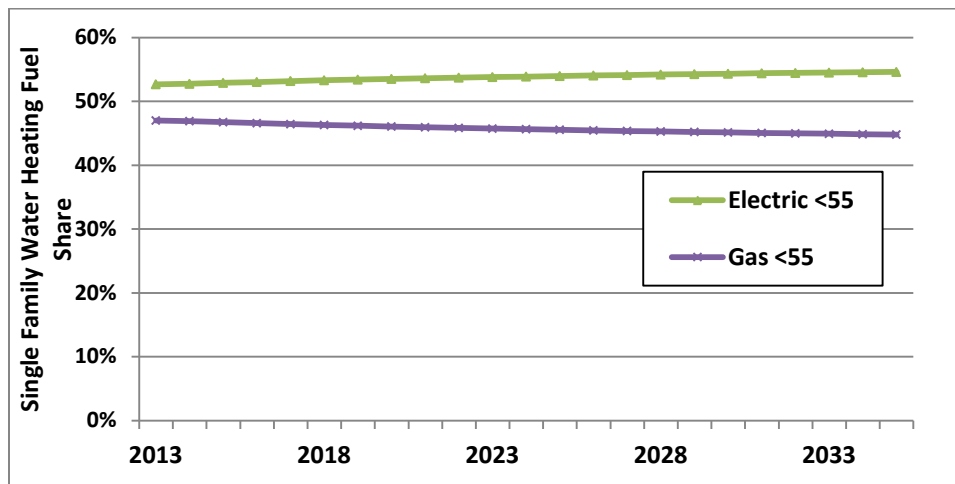


Figure 8: Forecast Average Market Share for Water Heaters 55 gallons or Less



2014 Analysis Findings

- If consumers choose based on least cost, regional electricity consumption would be lower by about 1,000 GWH per year or 114 average megawatts by 2035
- When lower demand from electric power generation is taken into account, regional natural gas consumption could also decline about 2.7 Tbtu.
- The Draft Seventh Plan forecast of water heating market share shows a continued trend from electricity as the fuel for water heating to natural gas. The speed of conversion reflected in the market share trends vary, depending on the size of water heaters and consumer needs.

Conclusions and Recommendations

In preparation for the draft Seventh Power Plan the Council reviewed its prior findings on the economics of direct use of natural gas to displace residential space and/or water heating. An updated analysis was performed that focused on the eight market segments identified in the Council's 2012 assessment as providing both consumers and the region with economic benefits through conversion from electricity to natural gas. The updated analysis estimated the share of single family homes with electric water heating and natural gas space heating that would find economic benefits by conversion to natural gas water heating when their existing water heater required replacement. Two estimates were made. The first, which is comparable to the 2012 analysis, assumed that in all cases the most economical (i.e. lowest life cycle cost) water heating fuel type would be selected. The second case, assumed that consumers would not always select the lowest cost option due to other "non-economic" barriers to conversion. This second scenario (the Business As Usual scenario) is judged to be more reflective of actual consumer behavior and has been incorporated into the Council draft load forecast for the Seventh Plan. This case found that fewer, but still a significant share of households would alter their existing water heating fuel. Moreover, based on historical fuel selection trends it appears that natural gas continues to gain space and water heating market share while electricity's share of these end uses continues to decrease.

Given the above findings, the Council does not propose to alter its existing policy with respect to the direct use of natural gas for the purposes of developing the its draft Seventh Power Plan.

Public Comment

The Council is requesting public comment on its Direct Use of Natural Gas analysis. Specifically, the Council is soliciting comment on the following issues:

- Is there data that contradicts the trends toward gas water heating? If so, please send it to us.
- Are there program designs that have successfully identified consumers interested in converting to gas water heating?
- Is it possible that future market conditions (fuel prices, technology changes, non-price factors) would warrant Council intervention in the market?

Appendix A – Summary of Market Share Changes Under Business as Usual and Least Cost Scenarios

Regional impact summary for water heaters greater than 55 gallons

The following tables illustrate the shift in average market share of electric resistant storage water heater starting 2014 through 2035 for water heaters greater than 55 gallons in capacity. As shown in Table A1, under the BAU case, market share of electric water heaters declines, while as shown in Table A2 the Least Cost scenario, the electric water heaters remain dominant. However, in both scenarios electric water heating technology changes from storage water heaters to heat-pump water heaters, largely as a consequence of new federal standards. Table A3 shows the difference in regional natural gas consumption between the BAU and Least Cost scenarios for water heater greater than 55 gallons in capacity.

Table A1 - BAU Case Average Market Shares (%) - Northwest, Single Family, Gas FAF, >55 Gallons, Electric Resistance is starting water heater

Water Heating Replacement	2015	2020	2025	2030	2035
Electric Resistance	92.9%	64.1%	44.3%	30.6%	21.1%
HPWH	3.9%	19.3%	30.0%	37.2%	42.2%
Gas Tank	0.0%	0.0%	0.0%	0.0%	0.0%
Instant Gas	1.0%	5.1%	8.0%	10.1%	11.6%
Condensing Gas	2.3%	11.5%	17.8%	22.1%	25.1%

Table A2 - Least Cost Case Average Market Shares (%) - Northwest, Single Family, Gas FAF, >55 Gallons, Electric Resistance is starting water heater

Water Heating Replacement	2015	2020	2025	2030	2035
Electric Resistance	92.9%	64.1%	44.3%	30.6%	21.1%
HPWH	7.1%	35.9%	55.7%	69.4%	78.9%
Gas Tank	0.0%	0.0%	0.0%	0.0%	0.0%
Instant Gas	0.0%	0.0%	0.0%	0.0%	0.0%
Condensing Gas	0.0%	0.0%	0.0%	0.0%	0.0%

Table A3 -Change in Natural Gas Usage Least Cost vs. BAU Case (TBtu) - Northwest, Single Family, Gas FAF, >55 Gallons, Electric Resistance is starting water heater

	2015	2020	2025	2030	2035
Consumer's Change in Natural Gas Usage	-0.045	-0.227	-0.354	-0.442	-0.503
Utility Change in Natural Gas Usage	0.034	0.173	0.269	0.336	0.383
Net Change in Natural Gas Usage	-0.011	-0.054	-0.085	-0.106	-0.120

Regional impact summary for water heaters with 55 gallons or less of capacity

The following tables illustrate the shift in average market share of electric resistant storage water heater starting 2014 through 2035 for water heaters with 55 gallons or less in capacity. As shown in Table A4, under the BAU case, market share of electric water heaters declines, while as shown in Table A5 the Least Cost scenario, the electric water heaters remain dominant. However, in both scenarios electric water heating technology changes from storage water heaters to heat-pump water heaters, largely as a consequence of new federal standards. Table A6 shows the difference in regional natural gas consumption between the BAU and Least Cost scenarios for water heater greater than 55 gallons in capacity

Table A4 - BAU Case Average Market Shares (%) - Northwest, Single Family, Gas FAF, <=55 Gallons, Electric Resistance is starting water heater

Water Heating Replacement	2015	2020	2025	2030	2035
Electric Resistance	98.4%	92.1%	87.2%	82.0%	75.0%
HPWH	0.0%	0.0%	0.3%	1.5%	4.2%
Gas Tank	1.6%	7.9%	12.1%	14.6%	15.3%
Instant Gas	0.0%	0.0%	0.1%	0.4%	1.2%
Condensing Gas	0.0%	0.0%	0.3%	1.5%	4.4%

Table A5 - Least Cost Case Average Market Shares (%) - Northwest, Single Family, Gas FAF, <=55 Gallons, Electric Resistance is starting water heater

Water Heating Replacement	2015	2020	2025	2030	2035
Electric Resistance	92.9%	64.1%	44.3%	30.6%	21.1%
HPWH	0.0%	0.0%	0.0%	14.5%	27.5%
Gas Tank	7.1%	35.9%	55.7%	54.9%	51.4%
Instant Gas	0.0%	0.0%	0.0%	0.0%	0.0%
Condensing Gas	0.0%	0.0%	0.0%	0.0%	0.0%

Table A5 - Change in Natural Gas Usage Least Cost vs. BAU Case (Tutu) - Northwest, Single Family, Gas FAF, <=55 Gallons, Electric Resistance is starting water heater

	2015	2020	2025	2030	2035
Consumer's Change in Natural Gas Usage	0.711	3.567	5.527	4.999	4.188
Utility Change in Natural Gas Usage	-0.889	-4.459	-6.865	-7.216	-6.820
Net Change in Natural Gas Usage	-0.179	-0.892	-1.337	-2.217	-2.631

The detail on the methodology and input assumptions and outputs from the 2014 analysis are available at <http://www.nwcouncil.org/energy/powerplan/7/DUG7thPlan>