

APPENDIX N: DIRECT USE OF NATURAL GAS

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ECONOMIC FUEL CHOICES FROM CONSUMER'S PERSPECTIVE

Background

The issue of whether it is better to use natural gas directly in hot water heaters and furnaces than to generate electricity by burning natural gas and then use electricity to heat water and homes has been raised during the development of each of the Council's plans, starting with its first. Over the years the Council has conducted multiple studies to address this issue. The issue has been described by different names including fuel choice, fuel switching, direct use of gas, and total energy efficiency.

The region's natural gas companies sued the Council after the first power plan; one of the few law suits the Council has had. The concern was that the Plan recommended that Bonneville acquire energy efficiency (through its customer utilities) by providing financial incentives to encourage consumers to install measures that improved electricity efficiency. The gas companies argued that these incentives would disadvantage natural gas companies and encourage more use of electricity. Over time the concerns have morphed into arguments that direct use of natural gas is more thermodynamically efficient (i.e. uses less total energy to produce the same end use service) and hence more benign 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 potential savings of over 730 average megawatts of cost-effective fuel-switching opportunities within the region. However, the Council has not included programs in its power plans to encourage the direct use of natural gas, or the promotion of the conversion of electric space and water heat to natural gas. The basis for this policy recommendation is that all of the Council's prior analyses have indicated that fuel choice markets are working well. Since the large electricity price increases around 1980, the electric space heating share has stopped growing in the region while the natural gas space heat share in existing homes increased from 26 to 37 percent. 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 an increased penetration of natural gas heating in the traditionally electric heat dominated multi-family market, especially in larger units and in Washington.³ Fuel

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.

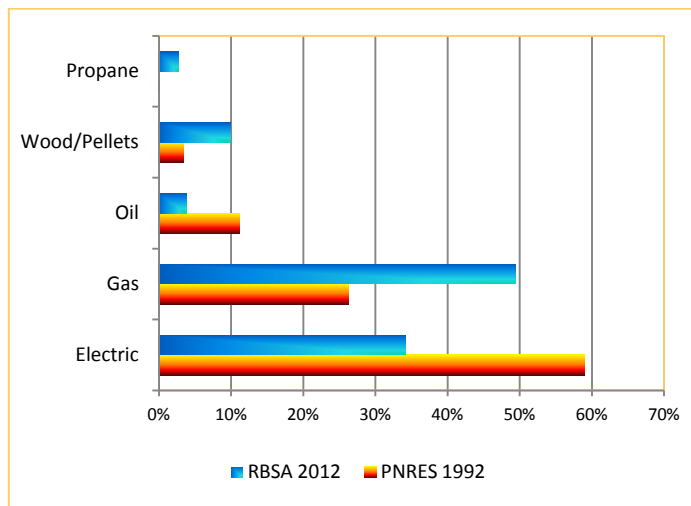
³ Northwest Energy Efficiency Alliance, MultiFamily Residential New Construction Characteristics and Practices Study. Portland, OR June 14, 2007. Prepared by RLW Analytics.



conversion of existing houses to natural gas has been an active market as well, often promoted by dual-fuel utilities.

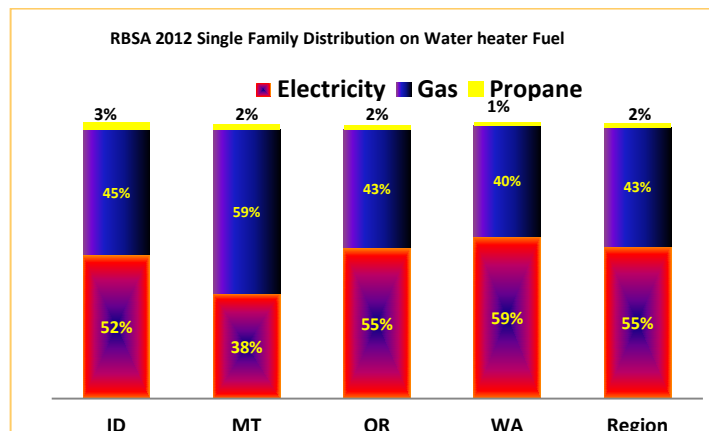
The most recent study available, the 2012 Residential Building Stock Assessment (RBSA) also conducted by NEEA, indicates that the trend of decreasing market share of electricity and increasing market share of natural gas is continuing. As Figure N - 1 shows, between 1992 and 2012 regional surveys the market share of both electric space and water heating in single family homes has declined while the market share of natural gas used for these same end uses 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 during the same period.

Figure N - 1: Primary Space Heating Fuel in Single Family Homes



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

Figure N - 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 analytical findings and policy on the issue of direct use of natural gas/fuel switching have been very consistent. All of the Council's prior analysis found that while direct use of natural

gas is often more thermodynamically efficient than using electricity generated from natural gas, its economic efficiency (i.e., whether direct use of natural gas is lower cost) depends on the specific situation with respect to the 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 defines conservation as "any reduction in electric power consumption as a result of increases in the efficiency of energy use, production, or distribution."⁴ Further, the Council has determined, on the basis of its prior analysis, that fuel choice markets are reasonably competitive and that those markets should be allowed to work without interference. Thus, the current Council policy, which has been reaffirmed in each of past three plans, is:

Council 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.

In light of changing technologies and energy prices and growing climate concerns, the Council was again asked to look at the direct use of natural gas issue in the Sixth Power Plan. The analysis was called for in the Action Plan (ANLYS-16) for the Sixth Power Plan. The Council conducted extensive analysis of the consumer options from two specific approaches. The first was to determine which residential space and water heating systems have the lowest *total resource cost* (TRC) while presenting an acceptable level of risk to the region. The second objective was to determine whether the *retail* market conditions will lead consumers to generally choose those same space conditioning and water heating systems. If the systems selected based on the regional economic and risk perspective are similar to those selected based on consumer economics, then it would suggest that no policy intervention is needed.

⁴ [Northwest Power Act, §3(3), 94 Stat. 2698.]



FINDINGS FROM THE SIXTH PLAN ANALYSIS

The analysis conducted pursuant to the Sixth Plan Action Item found that nearly three quarters (73 percent) of the market segments studied did not find it economically advantageous to switch their space conditioning and/or water heating fuel source, as shown in Table N - 1. However, approximately one half of these market segments, all of which use electricity for space conditioning and/or water heating found that it was economical to upgrade the efficiency of their equipment. The 223 average megawatts of savings from these efficiency improvements were already captured in the Council's conservation supply curves and included in the Sixth Power Plan.

Table N - 1 also shows that for 22 percent of the market segments considered in the analysis the Council found that conversion from electric space heating and/or water heating to gas space and/or water heating was the most economical choice. If all of these households converted to natural gas regional electrical loads would be reduced by roughly 360 average megawatts and regional natural gas consumption would increase by just over 15 trillion BTU by the end of the 20-year period (2029). In aggregate across all market segments and excluding savings from efficiency improvements, a regional resource portfolio that reflects the economical selection of space conditioning and water heating systems would reduce regional electric loads by just under 340 average megawatts and increase regional natural gas consumption by slightly more than 13 trillion BTU.



Table N - 1: Results from Sixth Plan's Analysis of Direct Use of Natural Gas

	Segments Represented	No. Households/yr	20-year Total Households	Share of Total	Existing Use (aMW/yr)	Existing Use (MMBTU/yr)	Annual Change in Use (aMW/yr)	Change in Use (aMW 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>	<i>58</i>	<i>94,800</i>	<i>1,895,999</i>	<i>73.1%</i>	<i>43.65</i>	<i>2,500,094</i>	<i>(11)</i>	<i>(223)</i>
Convers. fr Electricity to Gas								
Space Heating only	11	1,520	30,400	1.2%	1.57	-	(1.55)	(31)
Water Heating only	6	21,197	423,940	16.3%	8.05	-	(8.05)	(161)
Space & Water Heating	6	5,745	114,900	4.4%	8.49	-	(8.29)	(166)
<i>Sub-Total</i>	<i>23</i>	<i>28,462</i>	<i>569,240</i>	<i>21.9%</i>	<i>18.11</i>	<i>-</i>	<i>(18)</i>	<i>(358)</i>
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	24
Space & Water Heating	0	-	-	0.0%	-	-	-	-
<i>Sub-Total</i>	<i>6</i>	<i>6,262</i>	<i>125,240</i>	<i>4.8%</i>	<i>0.10</i>	<i>98,713</i>	<i>1</i>	<i>24</i>
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)
Totals	95	129,692	2,593,839	100%	58	2,601,455	(27.97)	(559)
Changes Net of Efficiency	37	34,892	697,840	27%	18	101,361	(16.81)	(336)



Using the findings from the extensive analysis done following the adoption of the Sixth Power Plan, the assessment for the Seventh Power Plan focused on those market and end use segments that promised the best economic options for conversion from electricity to natural gas. The market segments with the largest potential and most favorable economics were existing single family homes with electric water heating and natural gas space heating.

ANALYSIS OF DIRECT USE OF NATURAL GAS FOR THE SEVENTH POWER PLAN

The Seventh Power Plan analysis focused at the potential shift from electricity to natural gas in the single family water heating market. The analysis considers two water heater tank sizes. This was done to reflect the fact that beginning in 2015, the federal appliance standards establish different minimum efficiency levels by water heater size category, one for larger than 55 gallon capacity water heaters and another for water heaters with 55 gallon or lower capacity.

As noted previously, pursuant the Action Item ANLYS-16 in the Sixth Plan, the Council conducted a study of the direct use of natural gas as part of a continued effort to identify whether there is a need for programs encouraging consumers to switch from electric space heat and water heat to natural gas space heat and water heat. 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*". <https://www.nwcouncil.org/reports/2012-01/>.

This study analyzed 94 residential market segments and compared the consumer least-cost retrofit options to the water heating options that would be chosen given a total resource cost test. Overall, the study found that there was general alignment between the water heating systems that are least cost to the consumer and least total cost to the region. This alignment indicated that price signals exist which encourage a shift to the direct use of natural gas. Whereas price signals have been shown to be in place which encourage shifting to the direct use of natural gas, market studies on how consumers make choices have shown repeatedly that consumers do not choose based on price alone. Rather, these studies suggest that consumers are "rationally inattentive" to prices alone.⁵ Given this knowledge about consumers, the question becomes, even when price signals indicate a lowest-cost option, what will consumers *actually choose*?

To investigate the question of what consumers are likely to choose, in July 2014 the Council commissioned Systematic Solutions, Inc. (SSI) to perform a small-scale study on a targeted subset of eight segments from the original 94 residential market segments. This purpose of this study was to apply a consumer choice model to consumers' expected water heating choices to estimate the share of consumers who would actually select the least-cost water heating system. The Council commissioned SSI to develop both a "spreadsheet model" version of consumer choice analysis and

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



to conduct an analysis using the same assumptions in ENERGY 2020, the Council's long-term load forecast model.

Using Consumer Choice approach, two alternative scenarios were explored.

1. Business-As-Usual – This case assumes the market share for each choice of water heating technologies depends on the relative perceived cost of that technology compared to all other choices. The results provide a baseline of expected future behavior.
2. Least Cost – This case assumes that lowest life cycle cost technology takes 100 percent of the market. This case is identical to that assumed in the Council's 2012 analysis. It represents the maximum economic potential from switching fuels from the consumer, rather than regional perspective.

Figures N - 3 and N - 4 below illustrate the results of this analysis using the average electricity and natural gas prices (i.e., retail cost) for Washington and Oregon states. Note that analysis starts with 100 percent electric water heater saturation in both states since the “base condition” only includes homes with electric water heating. However due to differences in electricity prices and natural gas availability the marginal market shares are different between the two states.

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

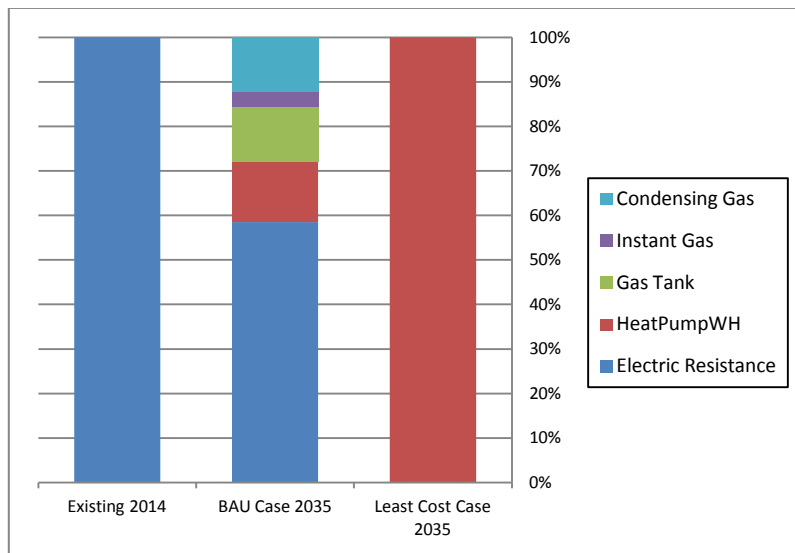


Figure N-3 shows that in Washington single family households with electric resistance water heating in 2014, 100% would convert to heat pump water heaters by 2035 if they selected the Least Cost option.

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

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

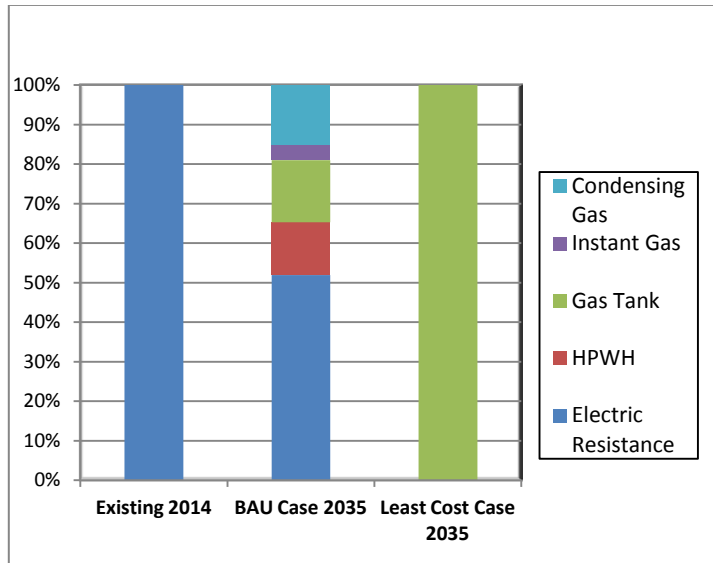


Figure N-4 shows that in Oregon single family households with electric resistance water heating in 2014, 100% would convert to an natural gas water heater by 2035 if they selected the Least Cost option.

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

Figure N - 5 shows the reduction in electricity usage (in average megawatts) when comparing regional electricity consumption for water heating in 2035 under the Least Cost scenario compared to the consumption under the Business as Usual case.

Figure N - 5: Reduction in Electricity Usage by 2035 (aMW)

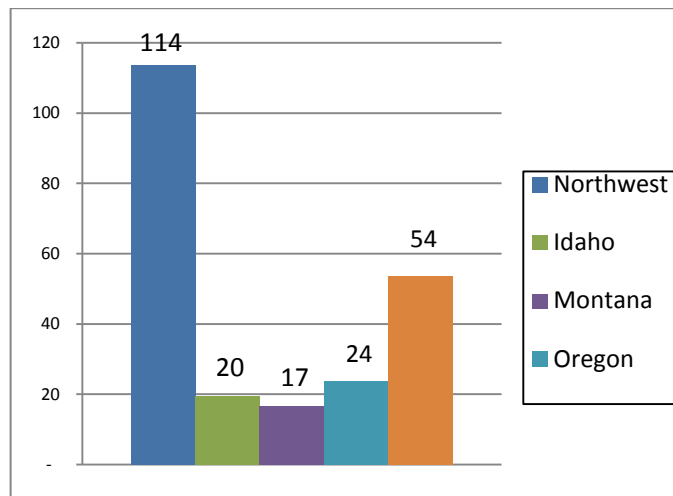
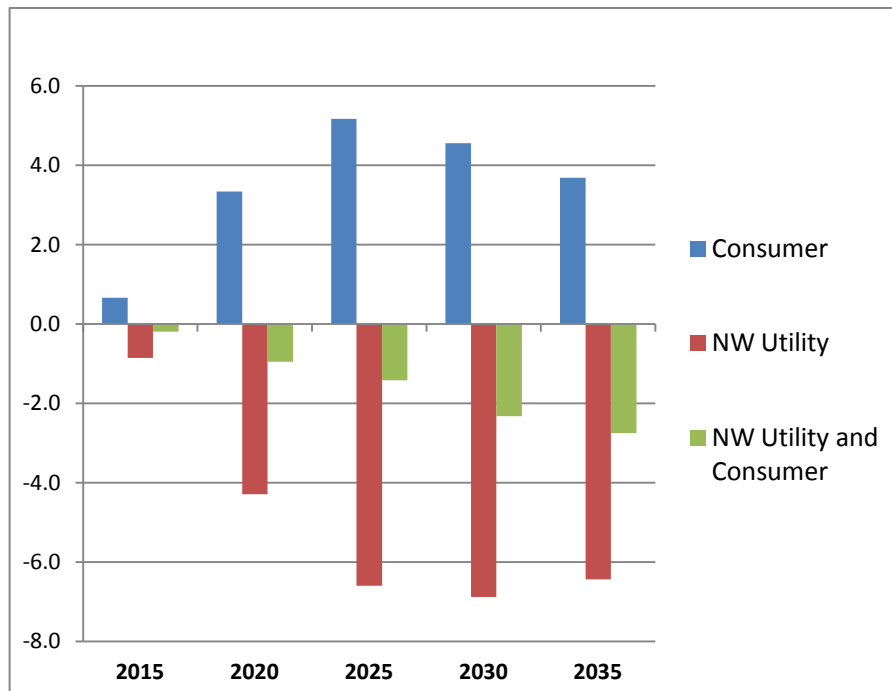


Figure N - 6 shows change in regional natural gas consumption by 2035 for the consumers (i.e., direct use) and for the electricity generators (Northwest Utility) and the net total consumption.

Figure N - 6: Change in Natural Gas Usage by 2035(TBTU)



Findings from the 2014 analysis:

Analysis shows:

- If consumers choose water heating fuel source based on least cost there would be reduction in regional electricity consumption, about 1000 gigawatt-hours (GWh) per year or 114 average megawatts (aMW) by 2035
- When lower demand from electric power generation is taken into account, regional natural gas consumption could also decline about 2.7 trillion British thermal units (Tbtu).

Using the consumer choice modeling approach in the Council's long-term model, the forecast of water heating market share for the draft Seventh Plan analysis shows continued trend in the switch 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. Figures N – 7 and N – 8 show the trend in electric and gas water heating market share for tanks with greater than 55 gallon capacity (N – 7) or less and those with 55 gallon or less capacity (N – 8). As can be seen from these figures, gas water heating's market share significantly increases in the larger tank category, while market shares for gas decline slowly in the smaller capacity tank category. This reflects the fact that gas and electric water heating technologies in the smaller capacity tank category are not significantly different in cost throughout the planning period.



Figure N - 7: Forecasted average market share for water heaters greater than 55 gallons in capacity (BAU)

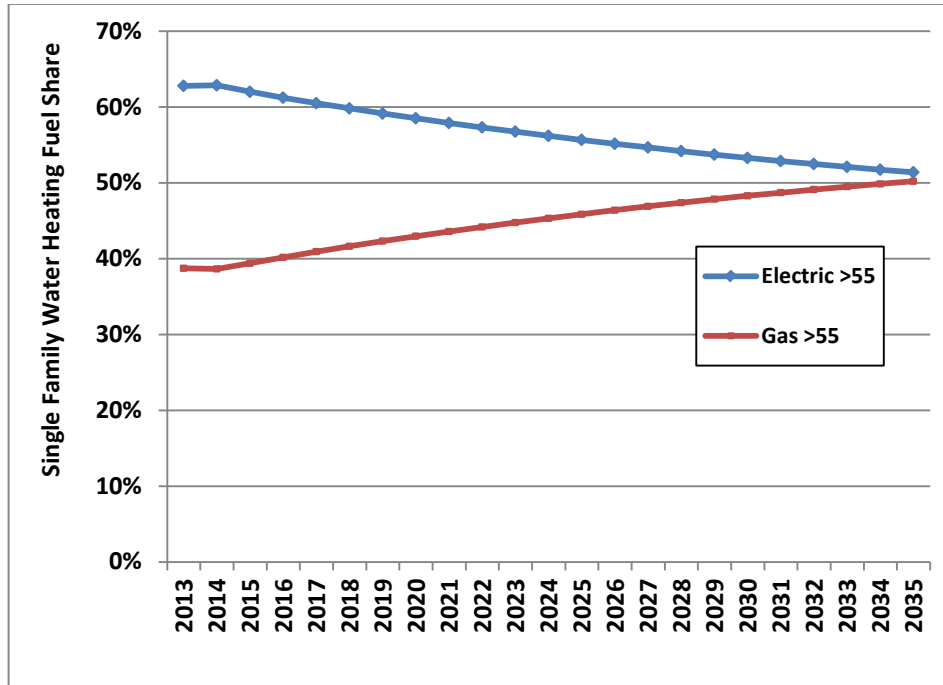
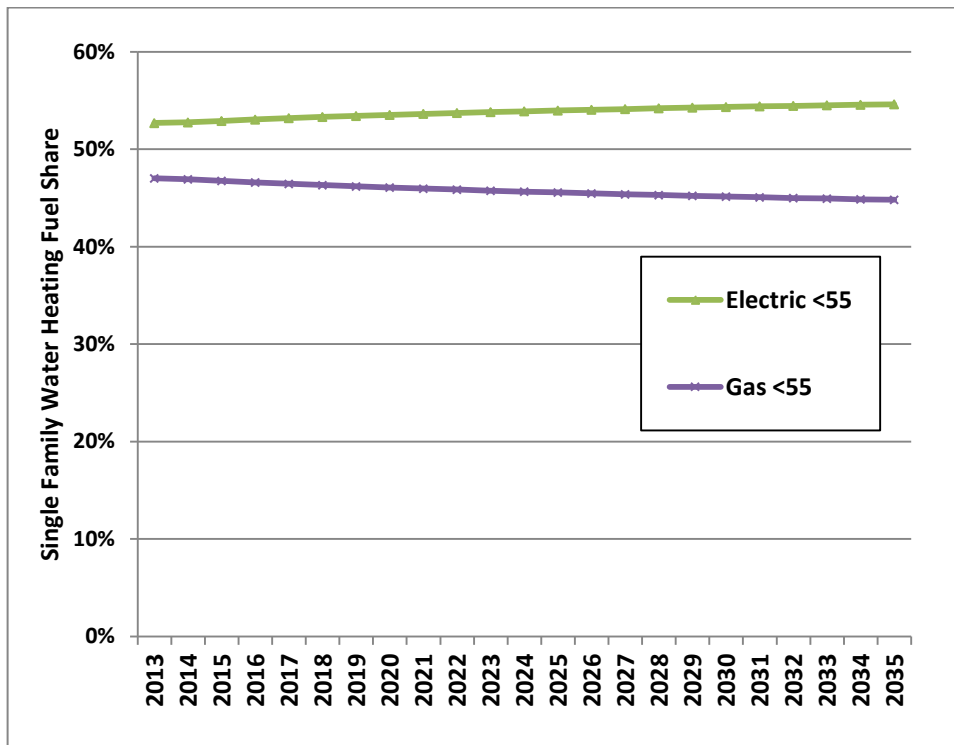


Figure N - 8: Forecasted average market share for water heaters 55 gallons or less in capacity



The findings from the 2014 Direct Use of Natural Gas study were reviewed by the Council and then released for public comment. Feedback from regional entities on the analysis specifically ask for comments on these three questions:

- 1) “Are there data that show the trends Council is observing are not correct?”
- 2) “If one were to decide to intervene in water heating fuel choice market, are their practical program designs to identify consumers who could convert to gas water heating when the option is available?”
- 3) “Are there future market conditions (fuel prices, technology changes, non-price factors) such that the competition between natural gas and electricity warrant Council intervention in the market?”

The Council received written comment from: two private citizens, Energy Trust of Oregon, City of Ellensburg Municipal Utility (electric and natural gas service area), NW Gas Association, Cascade Natural Gas, Northwest Natural, Puget Sound Energy, and Portland General Electric. In addition the Council received three academic papers on the topic from Portland State University graduate students studying Demand Response.

A summary of the feedback received and the details of each respondent’s comments are available from the council website. <http://www.nwcouncil.org/energy/powerplan/7/DUG7thPlan>

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 electric 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 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, the study suggests that natural gas will continue to gain space and water heating market share while electricity’s share of these end uses will continue to decrease.

Given the above findings and the public comments received, the Council decided to retain its current policy with a minor modification: the word “preserve” in the original statement was replaced with the work “promote”.



Revised Council 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.

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