January 6, 2015

MEMORANDUM

TO: **Power Committee and Full Council**

FROM: **Tom Eckman and Massoud Jourabchi**

SUBJECT: **Analysis of Direct Use of Natural Gas**

BACKGROUND:

Presenter: Tom Eckman and Massoud Jourabchi

Summary: 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. In the 2014, studying single family water heating market, the conclusion is reached that although there is potential reduction in electricity consumption given how consumers have expressed their selection, the competition between natural gas and electricity is occurring.

Staff recommends that the Council release the Direct Use of Natural Gas analysis prepared for the Draft Seventh Plan, for public comment and to provide public access to analytical spreadsheet and contractor report. Comment period to start on January 16th and end by February 20th. Staff recommends that Council consider whether to revise its existing policy for purposes of Draft Seventh Plan at March meeting.

Relevance: 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 the "more efficient use of electricity." 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.

Workplan: Direct Use of Natural Gas Analysis

Background and more Information: See attached documents.

Direct Use of Natural Gas
Economic Fuel Choices from Consumer's Perspective

January 2015

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.

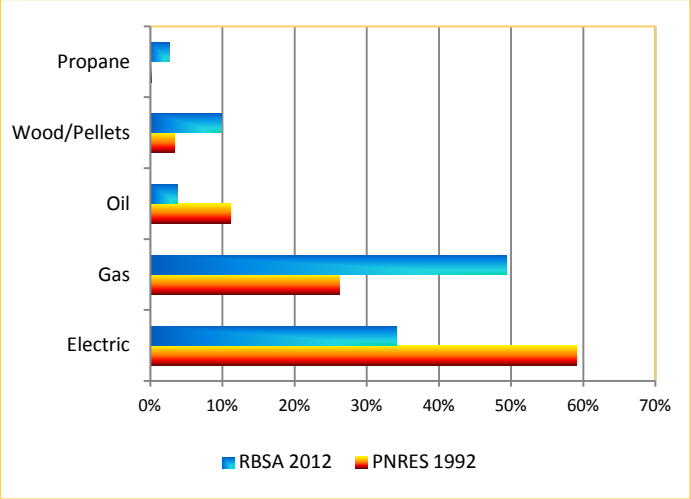
In 1994, the Council analyzed the economic efficiency of converting existing residential electric space and water heating systems to gas systems.[1] The results of that study found potential savings of over 730 MWa of cost-effective fuel-switching opportunities within the Region. However, the Council has not included programs in its power plans to encourage the direct use of natural gas, or the promote 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 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 in the decreasing market share of electricity and increasing market share of natural gas are continuing. As Figures 1 and 2 show, between 1992 and 2012 regional surveys the market share of both electric space and water heating in single family homes has continued to decline while

[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.

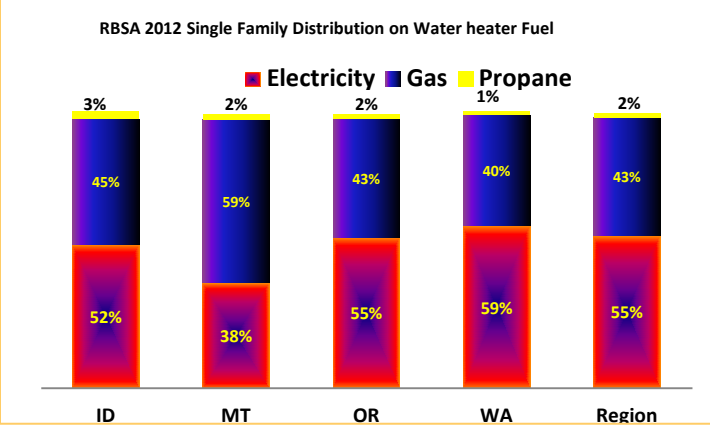
the market share of natural gas used for these same end uses has increased. Single family electric space heating, dropped from about 60% in 1992 to about 33% by 2012 and electric water heating's market share declined from 76% to about 55% during the same period.

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 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 the "more efficient use of electricity." 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 appear that no policy intervention is needed.

Findings from the Sixth Plan Analysis

The analysis conducted pursuant to the 6th Plan Action Item found that nearly three quarters (73%) of the market segments studied did not find it economically advantageous to switch their space conditioning and/or water heating fuel source. 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 6th Plan.

Table 1 also shows that approximately for twenty-two percent 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. 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 1 - Disposition of Market Segments Based on Resource Portfolio Model's Selection of Least Risk Plan										
	No. Segments Represented	No. House-holds/yr	20-year Total House-holds	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)	-
Sub-Total	*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
Sub-Total	*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%	-	-	-	-	-	-
Sub-Total	*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

Using the findings from the extensive analysis done following the adoption of the Sixth Power Plan, the assessment for the draft Seventh power plan focused on those market and end use segments that promised 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 from the Draft Seventh Power Plan

The draft Seventh Plan analysis looks at the potential shift from electricity to natural gas in the single family water heating market and the state level average retail electricity and natural gas prices. 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*".

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.[4] 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 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.
2. Least Cost – This case assumes that lowest life cycle cost technology takes 100% of the market. This case is identical to that assumed in the Council's 2012 analysis.

Figures 1 and 2 below illustrates 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% electric water heater.

Figure 1: Illustrative Example of Marginal Market Share SF- Washington Less Than or Equal To 55 Gallon Water Heating

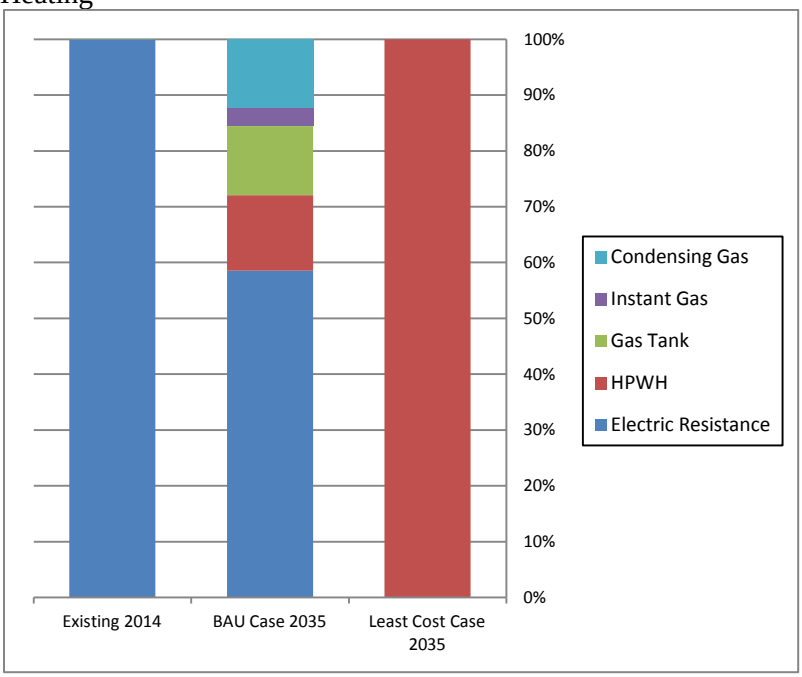


Figure 2 shows that in Oregon single family households with electric resistance water heating in 2014, 100% would convert to an natural gas water heater by 2035 if they selected the Least Cost option.

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

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

Figure 2: Illustrative Example of Marginal Market Share SF- Oregon Less Than or Equal To 55 Gallon Water Heating

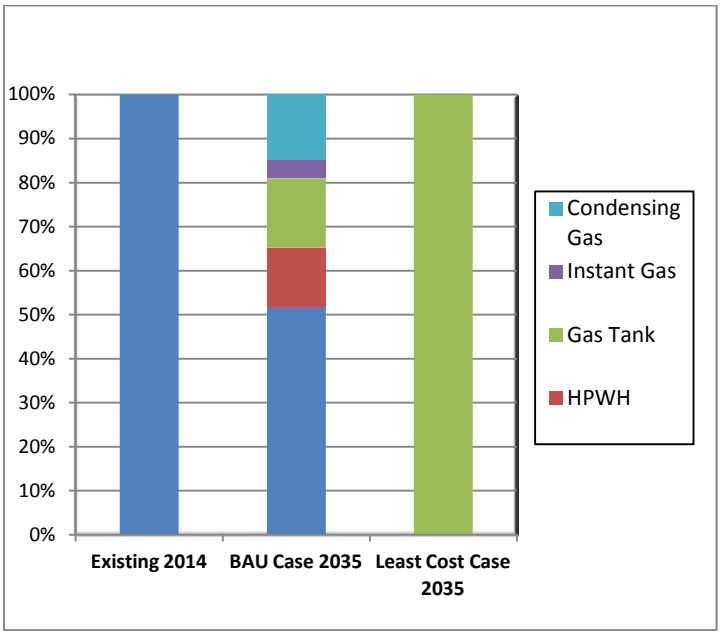


Figure 3 shows the reduction in electricity usage (MWa) when comparing regional electricity consumption for water heating in 2035 under the Least Cost scenario compared to the consumption under the Business as Usual case.

Figure 3- Reduction in Electricity Usage by 2035 (MWa)

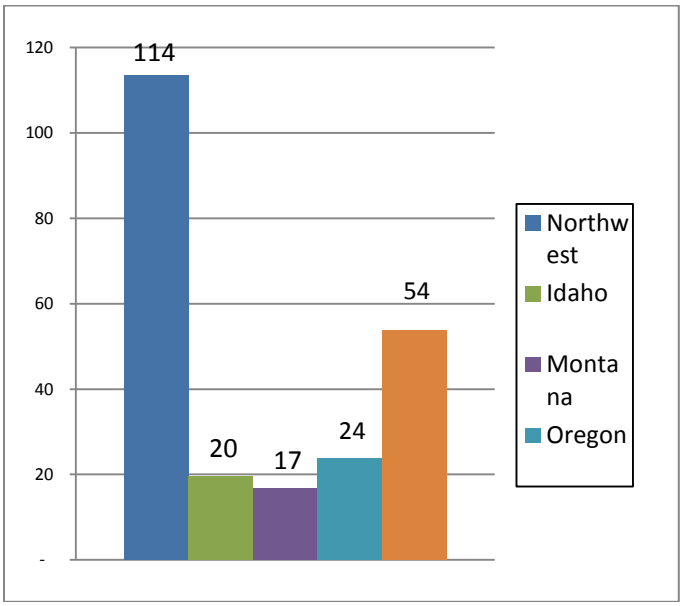
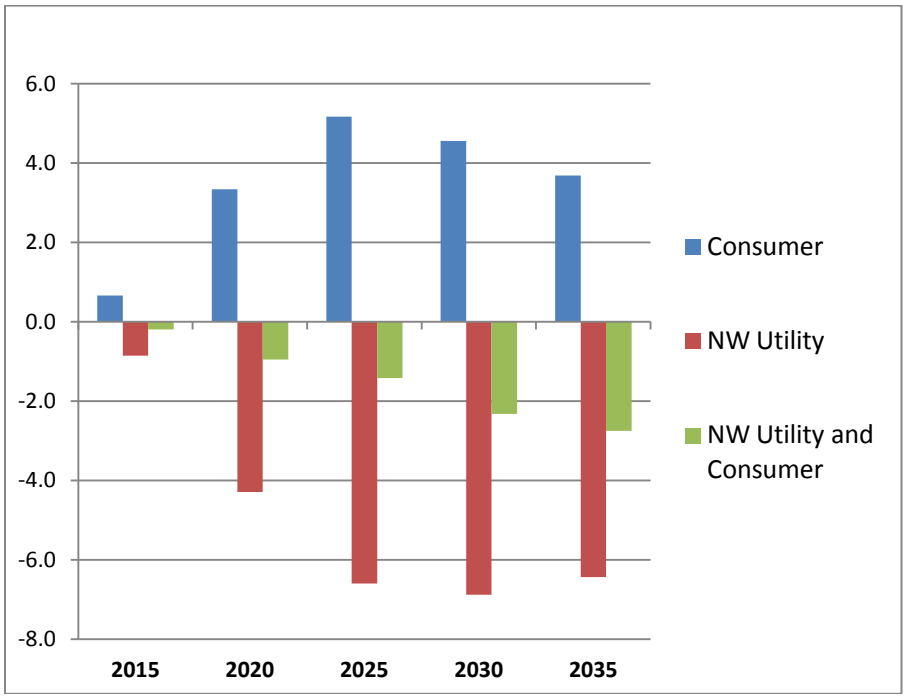


Figure 4 shows change in regional natural gas consumption by 2025 for the consumers (i.e., direct use) and for the electricity generations (NW Utility) and the net total consumption.

Figure 4- Change in Natural Gas Usage by 2035(TBTU)



Findings from the 2014 analysis:

Analysis shows:

- If consumers choose based on least cost there would be reduction in regional electricity consumption, about 1000 GWH or 114 MWa by 2035
-
- When lower demand from electric power generation is taken into account, regional natural gas consumption could also decline about 2.7 Tbtu.

Using the consumer choice modeling approach in the Council's long-term model, forecast of water heating market share for the draft Seventh Plan analysis shows continued trend in 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.

Figure 5 - Forecasted average market share for water heaters greater than 55 gallons in capacity

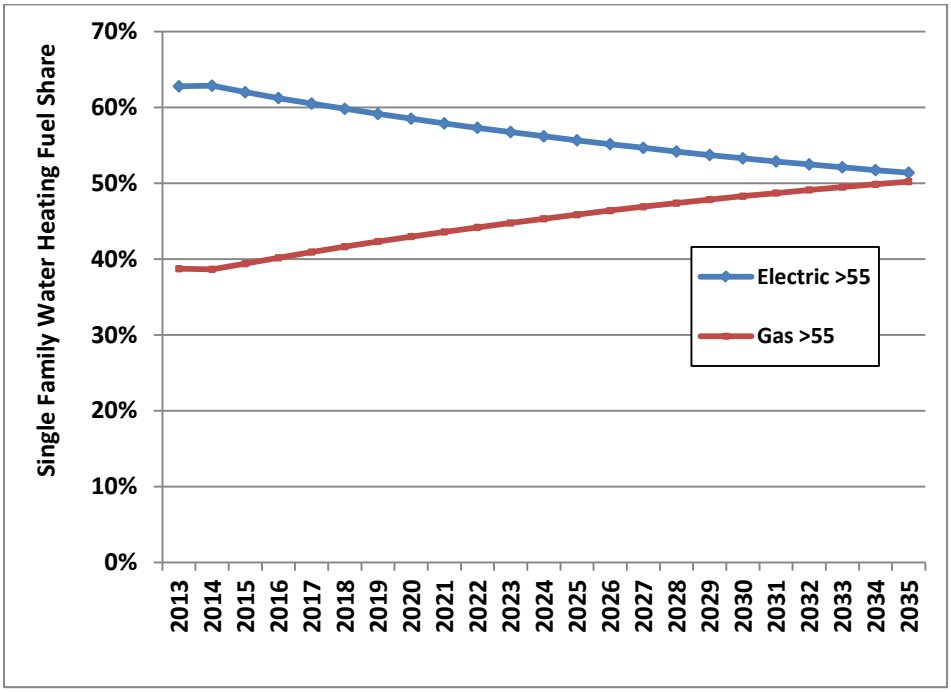
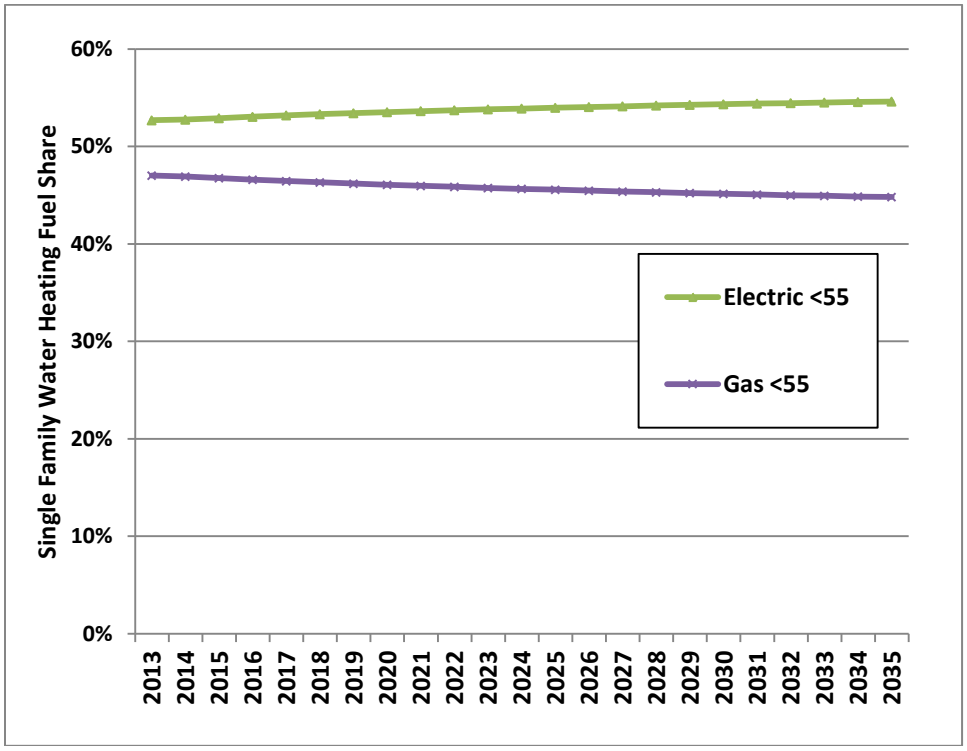


Figure 6 - Forecasted average market share for water heaters 55 gallons or less in capacity



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 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:

1) Does other data available indicate similar trends toward selection of gas water heating. If not, can this data be provided to the Council?
2) Are their program designs that have been implemented that can effectively identify consumers who are not already intending to convert to gas water heating when the option is available (i.e., when their existing electric water heater fails)?
3) Are 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?

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 (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	0.711	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 (web link to SSI report).