Fuel Switching in Integrated Resource Planning: The Method and the Madness

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The potential for switching consumers from electricity to natural gas for certain end uses has become an issue for electric utilities in the Pacific Northwest. This paper outlines the conditions that led to consideration of electric utility action to induce fuel switching as a "resource." An analytic framework for estimating the potential supply of fuel switching is detailed. The Bonneville Power Administration's experience with fuel choice policy development is summarized.

The paper describes a methodology for deriving a supply schedule for fuel switching. Costs are levelized to allow direct comparison with the utility's marginal cost. Additional technical issues discussed include treatment of "free riders" (consumers participating in utility programs who would have switched due to market forces alone), the consequences of switching for conservation programs, and the environmental effects of fuel switching. The public involvement process and consequent policy development of the Bonneville Power Administration is described. Conclusions from both the analytical and policy approaches are summarized.

Background

Bonneville Power Administration

The Bonneville Power Administration (Bonneville) is one of five federal power marketing agencies. Bonneville was created to market and transmit electricity from federal hydroelectric projects on the Columbia River system. Bonneville's main service area includes Washington, Oregon, Idaho, and Western Montana. Bonneville markets power from federal facilities to utilities and some large industries. The agency also sells to or exchanges power with utilities in California and Canada. In 1990, total loads were 9,311 average megawatts (aMW) with a peak load of 17,774 megawatts (MW). Bonneville's average price to public utilities was 2.33 cents per kilowatt-hour.

With the passage of the Northwest Power Act in 1980, Bonneville was given the added responsibility of acquiring conservation and additional resources sufficient to meet the future needs of its customers. In carrying our these responsibilities, Bonneville works with a regional planning entity, the Northwest Power Planning Council (Council). The Council formulates a long-term plan to guide Bonneville in its resource acquisitions.

Every two years Bonneville publishes a Resource Program, outlining the agency's resource needs and its strategy for meeting those needs. After several years of surplus resource capacity, the Pacific Northwest has reached a balance between loads and resources, and a need has developed to acquire additional resources to meet anticipated load growth.

Introduction

"Fuel choice" refers to the decision consumers face in choosing what form of energy to use for various purposes. Although the term could apply to other fuel choices and uses, this discussion deals with the choice between electricity and natural gas for use in residential space and water heating. The term "fuel switching" is also used when discussing the substitution of gas for electricity in existing buildings.

As the Northwest approaches load-resource balance, and natural gas maintains a relative price advantage over electricity, increasing attention has been focused on the use of gas, both as a means of generating electricity and as a consumer choice for end-uses. Bonneville conducted a preliminary analysis of the costs and benefits of fuel choice alternatives for its global warming study published in the 1990 Resource Program. That study suggested potential financial and environmental benefits associated with increased consumer use of natural gas.

Several other efforts have drawn Bonneville into the fuel choice issue. A member of Congress requested Bonneville to investigate fuel switching potential. Two retail utility customers sought Bonneville support for fuel switching initiatives. A utility study of transmission limitations in western Washington State included fuel switching as a possible component of an alternative to new transmission construction. Bonneville's Resource Programs Environmental Impact Statement included analysis of all current and potential resources, including fuel switching. The Council Plan includes consideration of natural gas resources, including fuel switching, and regulatory and coordinating agencies in the region have begun their own studies of fuel choice. Bonneville's own policies programs and rate structures may indirectly influence the choice between natural gas electricity in the marketplace. Before proceeding further, Bonneville decided to formulate a fuel choice policy to be included in its 1992 Resource Program.

Technical Analysis

Scope of Technical Analysis

The analytical work was narrowly defined for this process. It was designed as a scoping analysis to determine whether it would be worthwhile for Bonneville to devote further study to fuel switching policy development. It was not intended for evaluation of specific fuel switching implementation strategies. Several policy issues concerning Bonneville's role in encouraging fuel switching would need to be resolved before it would be appropriate to proceed with an analysis of implementation strategies.

This study represents Bonneville's first systematic effort in fuel switching analysis. A conservative approach was chosen in order to develop the initial methodology. Areas that posed significant analytical problems or where data of sufficient quality was not available were excluded. As a result, the estimate of cost effective fuel switching is a conservative one. Exclusions of market segments should not be interpreted as a conclusion that there is no cost effective fuel switching in that segment, only that for purposes of developing an analytical framework the treatment of these sectors was secondary.

Analytical Overview

The first step in the analysis was to separate households into relatively homogeneous market segments. Then for each segment, the capital costs of conversion from electricity to gas plus the operating costs of the gas equipment were estimated and compared to Bonneville's marginal cost of electric power. If the costs of switching are less than Bonneville's marginal cost, then it should be cost-effective for society to switch the equipment. An estimate of the number of households that could be converted was multiplied by the forecast of annual electric energy consumed for the switched end-uses to derive an estimate of the total electricity load that might be displaced by fuel switching.

Market Segments

The analytical work includes only single-family and manufactured homes in areas where the market is not expected to deliver fuel switching in the immediate future. Only residential water heat and central forced air space heat load were included because this was the most probable and cost-effective source for a fuel switching policy to address.

Market segments were developed by separating the stock by housing type (single family or manufactured housing), housing vintage (new units built in 1992 or later and existing units built before 1992), the type of equipment switched (space and water heater or water heater only), and gas availability.

Households are grouped by gas availability depending on the requirements of connecting the household to natural gas service. The four categories of gas availability are: (1) households already receiving natural gas; (2) households not receiving gas, but requiring only a service drop (defined as within a quarter mile of a gas main); (3) households requiring both a main extension and service drop; and (4) households requiring more than a main extension or requiring significant distribution system expansion.

Cost Calculations

The decision on fuel choice is fundamentally a comparison of additional capital cost expense of switching to natural gas equipment compared to the operating cost savings. For analytical purposes, capital costs were categorized as either equipment, administrative, or hook-up costs. All costs were levelized over the expected life of the physical capital. Costs are expressed in terms of levelized 1990 dollars.

Capital costs fall into three categories; equipment, administrative, and gas hook-up. Equipment costs include space and/or water heating equipment, flues, venting, piping, and any required code improvements. Administrative costs were included to account for expected but unspecified costs for design, implementation and oversight of a fuel switching program. These costs were set equal to 20 percent of equipment costs, which is roughly equivalent to Bonneville's experience with conservation programs. Gas hookup costs are the costs of gas service drop and/or main extension, metering equipment and installation. Capital costs were converted to life-cycle cost using a 3 percent discount rate over the expected life of the physical capital.

Operating costs were calculated by multiplying annual energy consumption by the applicable unit price or rate. Gas consumption was calculated by dividing electricity consumption in kilowatt-hours by the relative efficiency of gas to electric equipment. This value was then multiplied by a conversion factor to convert kilowatt-hours to British thermal units (Btu).

Cost Perspectives

Cost may be calculated from several perspectives. This analysis focused on four: society, Bonneville, a retail electric utility, and a consumer. The societal perspective includes all net costs to society but excludes transfers. Because the societal perspective includes all net costs, it is the one described in detail in this paper. Other perspectives include transfers and therefore vary with different program scenarios. If either Bonneville or a retail utility operated a program, costs would be shifted from the consumer to the utility.

In existing homes, the capital equipment cost of water heat conversion was only the difference between the price of gas and electric equipment. The analysis assumed that the water heater was near the end of its useful life and would be replaced in the near future as a matter of course. The full capital cost of gas space heat was counted as a necessary cost for existing homes.

For new homes, the capital equipment cost assumed for both space and water heat was the difference between gas and electric equipment. It was assumed that the equipment is not yet installed and the relevant cost is only the extra cost of choosing new gas equipment compared to new electric equipment, not the cost of providing water and space heat.

Operating costs represent the annual cost associated with fueling the gas equipment minus the cost associated with the electric equipment that would have been used without fuel switching. From society's perspective the cost of fueling the gas load is the wholesale gas price plus transportation charges. The retail rate was not used because it includes costs which are already counted explicitly, such as hook-up and retail administrative costs. The equivalent savings for society is the marginal cost of new electric resources.

Two gas price scenarios were used for a sensitivity test. The low gas price scenario was based on city gate or wholesale natural gas prices. The high gas price scenario was based on a study by the Oregon Department of Energy using Northwest Natural Gas Company's avoided cost.

Potential Load

The total number of households in each market segment was multiplied by an estimated participation rate to determine the number of participating households by market segment. Participating households multiplied by the annual energy consumption for the affected end uses yields the total load potential for fuel switching. The participation rate varies by market segment and increases with time. The participation rates were based on an earlier fuel switching analysis conducted jointly by Bonneville and four large Puget Sound area electric utilities. These rates were based on the professional judgment of conservation staff at these utilities. The rates were not drawn from a technical analysis and are not tied to any specific program design.

Results

The results are summarized in Table 1. The total regional potential is approximately 385 aMW in 2010. This total includes some homes that would switch due to market forces alone. However, by screening out existing homes having gas space heat and electric water heat and all new homes built within a quarter mile of gas mains, a large portion of homes that would switch due to market forces alone were ruled out. The screened out market segments may also contain some homes that will not switch due to market forces alone. The results show that, even under the high gas price assumption, the large majority of fuel switching potential is less than Bonneville's marginal cost of approximately 33 mills/kilowatt-hours in 2010. These data do not include environmental costs.

The most cost effective market segments are the two with new homes. These are more cost effective because the capital cost of affecting a change in equipment is only the difference between gas and electric equipment as contrasted to the full cost of gas space heat equipment for a retro-fit in an existing home. The two least cost effective market segments are the ones where only the water heater equipment is switched to natural gas. The gas hook-up expense is still incurred for these homes, but much less energy load is switched when the space heater is not converted. Therefore the cost in terms of mills per kilowatt-hour are high. The results also show that holding other things equal, it is more cost effective to switch

Table 1. Regional Fuel Switching Supply - 2010

Market Segment	Total Annual Energy (aMW)	Low Gass Levelized Cost (1990) (Mills/kwh)	High Gas Levelized Cost (1990) (Mills/kwh)
New MH/CFA+WH/ME	23	15	21
New SF/CFA+WH/ME	10	19	25
Ex MH/CFA+WH/SD	54	19	25
Ex SF/CFA+WH/SD	87	20	25
Ex MH/CFA+WH/ME	42	21	27
Ex SF/CFA+WH/ME	67	22	28
Ex SF+MH/WH Only/SD	69	22	30
Ex SF+MH/WH Only/ME	34	31	39
Total/Average	385	21	28

Notes:
Ex = Existing Home
New = New Home
SF = Single Family
MH = Manufactured Housing
CFA = Central Forced Air Space Heat
WH = Water Heat
SD = Service Drop
ME = Main Extension

manufactured housing than a single family homes and also more cost effective to switch a home requiring only a service drop than one requiring a service drop and main extension.

Additional Technical Issues

Some technical issues were not included in the results. However, the treatment of these issues separately is described in the following sections.

Free Riders. Free riders, consumers participating in a funding program who would have taken the action without the program, may be a significant problem in fuel switching. Once program assumptions are defined, the cost/benefit ratio can be calculated from the consumer perspective under both the no program and program funding scenarios. Consumers who will switch under both scenarios are free riders.

From the utility perspective free riders represent costs for which no load reductions are gained. These costs should be factored into the net utility costs. From the societal perspective incentive payments are simply a transfer of wealth from the utility to the consumer. However, because a program is now operating in cases where it would not be required, the administrative cost for each free rider is a net additional cost in the societal perspective.

Interaction Among Programs. Two or more programs may be aimed at the same end-use, such as conservation and fuel switching. For electric load reductions, the total load reduction is equal to the reduction from the single largest program. Program affects are not additive if they overlap. However, total energy effects may be additive by switching to the most efficient fuel for the end-use and the implementation of conservation measures to reduce further the energy required for the efficient fuel.

Environmental Effects of Fuel Switching. The marginal generating resource in Bonneville's acquisition strategy is a gas fired combustion turbine. Because both fuel switching and CTs use natural gas as a fuel, the difference in environmental consequences will be a function of the amount of gas used and the location of its use.

The location of use will influence some environmental costs because the same amount of some pollutants in more densely populated areas will be more costly. For the Pacific Northwest, the cost of nitrogen oxides and particulates may vary between east and west of the Cascade Mountains. Currently proposed CT's are located in the more densely populated western side. For fuel switching, it is assumed that the switching occurs proportionate to the population. These assumptions were incorporated into the economic costs.

The amount of gas used was determined by dividing the Btu consumption at the end-use level by the efficiency of the resource and adjusting for transmission and distribution losses. For fuel switching the efficiency is simply the efficiency of the end-use equipment. A weighted average equipment efficiency of 67 percent was derived by multiplying the proportion of total load switching in each end-use by the equipment efficiency of the relevant end-use equipment. For a CT the gas requirements must also be divided by the efficiency of the CT.

Losses associated with fuel switching were estimated to be 8.8 percent for gas transmission and distribution. Losses for the CT case were assumed to be the average of losses for gas and electric transmission, 7.5 percent.

The Btu requirements are converted to the total pounds produced for various pollutants using the following conversion rates of pounds per million Btu: Nitrogen Oxides=0.174, Sulfur Oxides=.001, Total Particulates=.001, Carbon Dioxide=118; the cost of other pollutants was insignificant.

In order to calculate environmental costs, the total pounds of pollutants emitted annually are multiplied by the estimated economic cost per pound of each of the pollutants. No national consensus exists of these environmental costs, therefore estimates from four different organizations (Bonneville, Washington State Energy Office, California Energy Commission, Nevada Public Service Commission) are calculated. The environmental cost of fuel switching ranges from 0.3 mills/kilowatt-hour to 10.5 mills/kilowatt-hour. The environmental cost of a CT ranges from 1.7 mills/ kilowatt-hour to 17.8 mills/ kilowatt-hour. Therefore, the difference between fuel switching and CT generation range from approximately 1.4 mills/ kilowatt-hours to 7.3 mills/kwh. Bonneville's estimates produced the lowest cost for both resources and the lowest differential; Nevada estimates were the highest.

Technical Conclusions

Although some refinements are yet to be included, the results still indicate a strong probability that some cost effective fuel switching will not be delivered by current market forces. These results pass the threshold test defined as the scope of the analysis, suggesting that Bonneville should investigate the policy questions associated with fuel switching.

Policy Development

Concurrent with the initiation of technical studies, Bonneville conducted a two-phase public involvement process. Bonneville had several objectives for the public process:

- To provide opportunities for broad regional participation in discussion and consideration of fuel choice issues;
- To identify technical, institutional and environmental issues surrounding consumer fuel choice and end use fuel switching;
- To develop, refine, and test an analytical framework for addressing technical, institutional, and environmental issues;
- To provide a comprehensive background and context for regional fuel choice policy discussions;
- To present preliminary findings and conclusions for public review and comment;
- To propose a Bonneville policy direction for public review and comment.

Phase 1: Fuel Choice Consultation Group

Bonneville met first with public utility managers to learn how energy markets were operating and expected to operate in their service territories. Through this consultation Bonneville developed a better understanding of how fuel switching affects the business interests of its utility customers. The managers also worked with Bonneville to help identify policy and analytical considerations that Bonneville's customers view as key elements of a Bonneville fuel choice policy. These customer considerations, outlined in the following section, formed the basis for Bonneville's policy formulation.

Phase 2: Technical Work Group

After meeting with utility managers, Bonneville convened a technical work group representing Bonneville customers and other interested parties to review Bonneville's analytical methods, key assumptions, data, and preliminary findings and conclusions. The technical work group also served as a forum for sharing the results of work done by others.

Customer Considerations

A major accomplishment of the Fuel Choice Consultation Group was the development of "customer considerations" that reflect the concerns of Bonneville's public utility customers. Customers represented in the group had a wealth of knowledge and varied experience to offer. Some were encountering rapid load growth; others were expecting little or no growth. In some service areas there is no natural gas available; in others gas is a direct competitor; in still others gas is seen as a viable alternative to ease the pressure of rapid electricity load growth. One public utility customer sells both gas and electricity; another expects to enter the gas business soon.

With these diverse perspectives, the utility managers had varying opinions concerning Bonneville's role. Some strongly oppose any intentional action by Bonneville to influence fuel choice. They maintain that the existing market is adequate to induce consumers to make appropriate fuel choices. Any action by Bonneville to change its current programs or practices would be viewed by these managers as market interference, and therefore undesirable.

Most of the managers agree that market allocation of energy services does promote greater efficiency. However, some managers disagree that the status quo represents an efficient market. These managers argue that current policies, programs and rate structures in both the natural gas and electricity industries have distorted the market in some areas. They allow for the possibility that some action by Bonneville might serve to improve the operation of the market.

The Fuel Choice Consultation Group agreed that any Bonneville policies or programs that influence consumer fuel choice should address the following key considerations:

Utility Choice. Allow for voluntary participation, flexibility and responsiveness to local situations.

Consumer Choice. Encourage efficient market allocation of energy services; preserve consumer choice.

Public Agency Roles. Acknowledge the unique relationship between public utilities and their customers; take into account the legal authorities of both Bonneville and its customers.

Intraregional Equity. Consider issues of equity among customers and inequitable local impacts.

Gas Industry Policy. Recognize differences between the electric and natural gas industries including obligation to serve, incentive for conservation, and rate design. Assess the degree of uncertainty over gas supply and price. Look at the potential for subsidization of gas consumers and gas company stockholders.

Conclusions

Several insights for policy development can be drawn from the scoping analysis. The technical analysis indicates that there is potential for regionally cost-effective fuel switching beyond that expected to occur as a result of current market forces. The amount may be substantial over the 20-year planning horizon; however, only a small portion of this potential could be considered a "lost opportunity" if not captured in the near term. In addition, the potential is not evenly distributed within the region.

The public process confirmed that there is not yet regional consensus on fuel switching potential. Both the amount projected to occur as a result of existing market forces and the amount available through cost effective utility action are disputed.

The analysis did not address whether actions by Bonneville or its utility customers could be effective in capturing potential benefits through programmatic fuel switching. There is not a "critical mass" of regional support for Bonneville action. Concerns over lost revenue and potential inequities currently outweigh interest in pursuing regional fuel switching. However, a number of utilities are pursuing pilot projects in their service areas to test various programmatic approaches and levels of incentives. Natural gas utilities are active participants in some of these projects.

Bonneville has concluded that there is no immediate need or justification for Bonneville to pursue fuel switching at this time. An important factor in our consideration is that BPA is now initiating a major effort to capture all cost-effective conservation in the service territories of our customers. This will require significant BPA and customer resource commitments. We believe that the urgency in securing the cooperation of our customers in achieving our aggressive conservation targets outweighs the interest in diverting their attention to fuel switching at this time. As we proceed with this strategy, we will assess our fuel choice policy in light of conservation achievements.

Bonneville will continue to monitor market-induced fuel switching and improve its characterization of fuel choice and fuel switching in load forecasts. Bonneville has also committed to review its existing policies and programs to assess their effects on fuel choice.

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