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INTERACTIONS BETWEEN FUEL CHOICE AND ENERGY-EFFICIENCY IN NEW HOMES IN THE PACIFIC NORTHWEST

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SUMMARY

In recent years, the Bonneville Power Administration (Bonneville) has instituted programs to promote the implementation of the residential Model Conservation Standards (MCS) issued by the Northwest Power Planning Council (Council) in 1983.[a] These standards provide alternative methods for designing and constructing homes to cost effectively reduce residential energy consumption. Authority exists to apply them only to new, electrically heated homes. Because they apply only to electrically heated homes, concerns have arisen about how the standards might affect buyers' decisions to purchase a new home, in particular, their choice of a heating fuel.

Tacoma, Washington, has been a bellwether location for Bonneville's MCS programs. Tacoma was the first jurisdiction to adopt the MCS under the Early Adopter Program (EAP). Even though the EAP required construction to the MCS, buyers still had the option to choose gas heating in new homes and avoid buying an MCS home. Consequently, an understanding of how the MCS program affects fuel choice has become essential in evaluating the program effects.

Early data suggested that electricity started losing market share in Tacoma about when the MCS went into effect in 1984, and recent data have shown that about half of electricity's share of the new home market has shifted to natural gas. This decline in electric heating was consistent with concerns about the possible detrimental effect of the cost of MCS on sales of electrically heated homes. A desire to understand the causes of the perceived decline in electricity's market share was part of the impetus for this study.

Multiple techniques and data sources are used in this study to examine the relationship between residential energy-efficiency and fuel choice in four major metropolitan areas in Washington: Spokane, Clark, Pierce, and King Counties. Recent regional surveys have shown that electricity is the predominant space heating fuel in the Pacific Northwest, but it appears to be losing its dominance in some markets such as Tacoma (in Pierce County).

(a) Washington State recently adopted MCS as the statewide code for all electrically heated homes and a less energy-efficient code for gas-heated homes. Although this study does not address these new codes, it still provides useful information about their probable effects.

Although electricity is perceived more positively than alternate fuels in most attitude categories and is the most common heating fuel, homeowners regionally prefer natural gas, by a small margin, over electricity; individuals with natural gas heating have a strong allegiance to natural gas. Economics, particularly relative utility rates, appear to play the dominant role in the buyers' fuel choice.

Our hedonic price analyses show that buyers place a substantial economic value on the energy-efficiency associated with MCS. In two Tacoma neighborhoods, we estimate that buyers pay about $3 to $5 per square foot more for MCS homes. Our results are similar in Vancouver, Washington. These results suggest that builders do not pass MCS program incentives along to buyers.

Our estimates show that, in terms of space heating fuel, gas heating commands a substantial premium over electric heating in Tacoma and Vancouver. The results are mixed in the two other Washington metropolitan areas.

A demand curve for different heating fuels has been estimated for the Washington metropolitan areas and a demand curve has been estimated for MCS based on Tacoma data. These curves provide useful insights into how buyers respond to changes in the housing market.

Conjoint analysis results provide information that can be used to estimate market shares for electrically heated, MCS homes. Our results suggest that a majority of new-home buyers in all four areas studied would choose a gas-heated home over an electrically heated home if both were built to conventional energy-efficiency levels. Even without providing an incentive to buyers to defray added higher first costs, however, increasing the efficiency of new electrically heated homes, while not changing the efficiency of gas-heated homes, would <u>increase</u> the market shares of electrically heated homes. Incentives would further increase the market shares, but only a relatively small amount in many cases.

A discrete choice framework for modeling the fuel and energy-efficiency decision would be a useful extension of the analysis conducted to date. This approach would rely on attitudinal, demographic, and fuel price data and hedonic price estimates. Fuel switching in existing homes is another area that merits further study.

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1.0 THE RESIDENTIAL FUEL CHOICE ISSUE IN THE NORTHWEST

In recent years, the Bonneville Power Administration (Bonneville) has instituted programs to promote the implementation of the residential Model Conservation Standards (MCS) issued by the Northwest Power Planning Council (Council) in 1983. These standards provide alternative methods for designing and constructing homes to cost effectively reduce residential energy consumption. The Council's and Bonneville's authority only permits applying them to new, electrically heated homes.

Because they have been applied only to homes heated with electricity, concerns have arisen about how the standards might affect buyers' decisions to purchase a new home. Specifically, since the standards are likely to increase construction costs and the sales prices of electrically heated homes, some buyers may shift to homes heated with alternative fuels, which are not required to meet the MCS. In the Northwest, the major alternative to electricity for space heating is natural gas, particularly in new homes.[a]

Tacoma, Washington, has been a bellwether location for Bonneville's MCS program, and the share of new homes heated with natural gas has increased substantially since the MCS was first implemented. Tacoma was the first jurisdiction to adopt the MCS under the Early Adopter Program (EAP); the MCS went into effect in Tacoma in 1984, raising the energy-efficiency and construction costs of new electrically heated homes. Even though the EAP required construction to the MCS, buyers still had the option to choose gas heating in new homes and avoid buying an MCS home. Consequently, an understanding of how the MCS programs affect fuel choice should be part of any evaluations of the programs' effects.

The EAP (and other MCS programs) provided significant monetary incentives to defray the costs of building to the MCS. If builders passed

(a) Washington State recently adopted the MCS as its statewide energy code for new electrically heated homes and an upgraded, but less energy-efficient, code for new natural gas-heated homes. These new standards go into effect in 1991. Their effects are not analyzed specifically in this report, but the results here should provide useful insights into their probable effects on fuel and energy-efficiency choice in new homes.

along their incentives to buyers or buyers received incentives directly, then the impacts of the MCS on buyers should have been minimized. Nevertheless, early data suggested that electricity started losing market share in Tacoma in 1984, and recent data from the city showed that about half of electricity's share of the new home market had shifted to natural gas. This decline in electric heating was consistent with concerns about the possible detrimental effect of the cost of MCS on sales of electrically heated homes, but no analysis had been done to determine what factors were causing the shift to gas heating and the role played by the MCS.

To determine the effect of MCS on the housing market, it is necessary to analyze market changes in Tacoma and other regions that adopted the MCS or implemented the Super Good Cents (SGC) program (a program providing marketing assistance and incentives to promote the voluntary selection of MCS homes). The potential impacts of the MCS on the housing market have increased as 1) more jurisdictions have adopted the MCS, 2) growing numbers of utilities have implemented the SGC program, and 3) Washington State has adopted the MCS statewide the potential impacts of the MCS on the housing market have increased. However, little is known about how Washington's adoption of the MCS and Oregon's likely adoption of it, might affect consumer and builder decisions. How the market responds is critical in Bonneville's attempts to forecast regional electricity loads and to design programs that have the desired impacts. In addition, insights about fuel and energy-efficiency choices are essential in analyzing fuel changes and efficiency changes in existing homes, which may also have significant regional impacts.

Residential fuel and energy-efficiency decision making is complex, however. The decision is usually part of a larger decision about housing services. The first decision a homeowner must make is whether to retrofit his/her current home or buy a different home. A buyer choosing to purchase a different home can consider both new and existing homes. It is unlikely that many homeowners change homes just to have a different heating fuel or energy-efficiency--one would expect these factors to be secondary to other considerations such as floor area, number of bedrooms, and location. When a housing choice is made, however, the buyer is not likely to ignore heating fuel and energy-efficiency.

Prior studies have used a variety of techniques to address residential fuel and efficiency choices. Many, such as Cohn, Hirst, and Jackson (1977), have employed econometric analysis using aggregate data to estimate aggregate fuel demands. These studies usually are not directly applicable to the issues addressed here because they focus on aggregate behavior and total household demand rather than choice made in new houses. They also are not well suited to dynamic and complex markets and situations where non-economic forces play a significant role, such as the one extant in the Northwest. Several authors have used hedonic price analysis to examine how energy-efficiency and fuel type affect housing sales price. For example, Halvorsen and Pollakowski (1981) investigated the effects of having different fuel types on home sales price. This approach is the first step in developing a demand curve combining economic and non-economic data to estimate demand under the conditions of interest for these characteristics. Palmquist (1984) is one example of applying this technique to the housing market; other authors have applied discrete choice models to analyze fuel and efficiency choices. Cameron (1985), for example, developed a nested logit model to estimate retrofit behavior. Her paper is important here because it exhibits one method for modeling homeowner decision making and it also emphasizes that retrofit is an alternative way for households to adjust their fuel type and efficiency level.

An alternative technique for analyzing homeowner choices is conjoint analysis. This methodology relies on data from simulated decisions among products (e.g., new homes) that have various combinations of different features. Louviere (1988) provides a good overview of the technique. Applications to energy-related choices in the housing market are rather limited in the open literature. Conjoint analysis has the virtue of capturing many elements of the decision process itself, rather than just providing an analysis of empirical statistical information.

Dinan (1987) provides a useful summary of attempts to analyze the residential energy-use decision process. Dinan notes the complexity of the process and cautions that the decision is based not only on current conditions, but expectations about the future and how key factors will change.

Dinan recommends an approach encompassing information on housing units, augmented with socioeconomic data, perceptions, and attitudes.

Our approach for addressing the fuel and efficiency choice issue is along the lines recommended by Dinan. We have collected a wide range of information and data and developed alternative techniques providing essential insights into the decision process. The ultimate tool for meeting Bonneville's planning and program needs would be a model having sufficient detail to provide both short- and long-term forecasts of fuel and energy-efficiency choices in the housing sector. The information, data, and techniques discussed in this report can provide the basis for such a model.

Chapter 2 of this report discusses the methodologies used in this study. Chapter 3 summarizes the results that have been obtained from applying each methodology. Chapter 4 presents an integrated review of the results, sets forth our findings, and identifies research that would provide the next step toward developing a modeling capability to predict future fuel type and energy-efficiency choices in the Northwest.

2.0 OVERVIEW OF ANALYSES

We have used multiple analytic techniques in our study of residential fuel and energy-efficiency choice in the Northwest. Largely because of the way this study has evolved, most of the techniques have been applied in certain geographic locations and to certain populations, rather than on a region-wide basis, even though Bonneville's ultimate interest is in regional analysis and predictions.

This chapter presents an overview of the fuel and energy-efficiency choice process and what parts of the process our analysis has addressed. It then discusses each of the analytic techniques used and how and where they were employed.

2.1 FUEL AND ENERGY-EFFICIENCY CHOICE PROCESS

Figure 2.1 gives a partial view of the decision process that a homeowner considering upgrading energy-efficiency or changing heating fuels can exercise. This figure reflects a situation in an area where new, electrically heated MCS homes have recently become available through a program such as the EAP.

The first choice facing the homeowner is whether to keep his or her current home or purchase a different home. If the owner decides to keep the current home, then the owner can 1) make no changes, 2) change the heating fuel, 3) weatherize it, or 4) both change the fuel and weatherize the home.

If the owner decides to purchase a different home, the individual can buy an existing home or a new home. Figure 2.1 assumes that few or no MCS homes are on the used home market, so the buyer can only consider alternative fuels and not MCS in existing homes. If the buyer decides to choose a new home, the figure presents two options: buy a custom-built home or buy a semi-custom or tract home. This bifurcation is shown to acknowledge that the buyer may actually select the fuel type in a custom-built home, whereas he will typically be forced to take the fuel type present in new semi-custom or tract homes. For any of the three housing types, the buyer may buy an electrically

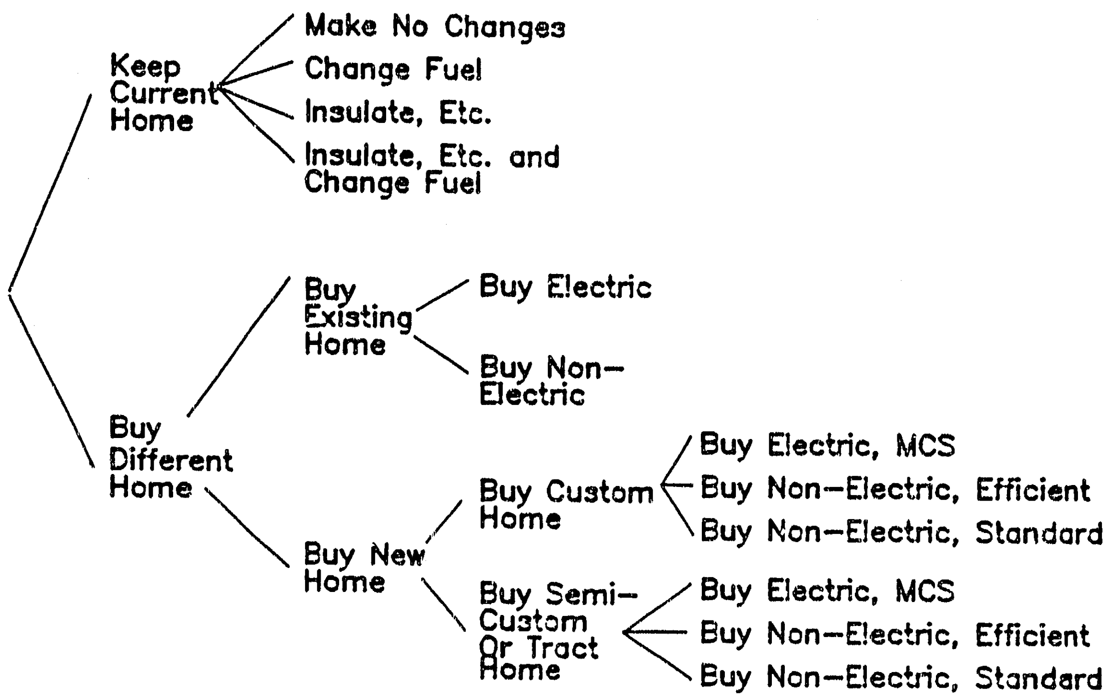

FIGURE 2.1. Process for Selecting Energy-Efficiency and Fuel Type

heated MCS home, a non-electrically heated energy-efficient home, or a non-electrically heated home with the standard efficiency level.

The decision process is even more complicated, however, because the potential buyer will actually be selecting a complete set of housing services, of which fuel type and energy-efficiency level are just two components. Each house is a complete package consisting of an energy-efficiency level, fuel type, number of bedrooms, floor area, location, price, view, etc. The potential buyer would use some evaluation process to trade off the characteristics of one housing option against all others and select the preferred one.

In addition, the individual buyer has little influence on what options are available on the housing market. Characteristics of the used homes on the market are determined by historical decisions made over a period spanning many decades. The types of new homes on the market are primarily determined by the decisions of home builders. Builders, however, are likely to be quite responsive to the aggregated preferences and demand of home buyers or the market demand.

This decision process is obviously quite complex. We have analyzed it by focusing on different pieces of the decision process and applying a range of methodologies. Table 2.1 indicates the geographic areas in Washington that we studied and the methodologies employed in each area. The remainder of this chapter describes the parts of the decision process upon which we have focused, and the areas studied and methodologies used.

2.2 SURVEY ANALYSIS

In 1988, an extensive survey was performed for Bonneville to analyze the marketing environment for their conservation activities. Harkreader and Hattrup (1988) provide a thorough description of this survey and its results.

Their survey was a phone survey conducted with a sample of households intended to be representative of Bonneville's electric utility customer districts. The sampling frame consisted of a clustered random sample of approximately 1000 households. The questionnaire included over 150 questions covering perceptions about different fuels, fuel use, fuel preferences, fuel switching activities, wood use, appliances and appliance fuels, and demographics. Our report references the results of that survey where they are directly relevant to the current study.

The second major set of survey data used in this study came from application of the same survey instrument described above to a different population--households in two areas comprised of EAP jurisdictions. Details of the data and results are reported in Lee, Englin, and Harkreader (1989). The two areas surveyed were in Southern Idaho and Western Washington. Two-hundred thirty-eight households were surveyed; about 27% were located in Southern Idaho and 73% were in Western Washington. These households differed from those surveyed originally in an important way: these respondents all

TABLE 2.1. Regions Studied and Methodologies Applied

Methodology	Region Studied: Pierce County	Spokane County	King County	Clark County
Early Adopter Program survey	Included	No	No	No
Homeowner focus groups	Yes	Yes	No	No
Homeowner conjoint analyses	Yes	Yes	Yes	Yes
Home-buyer fuel/ MCS simulations based on conjoint analyses	Yes	Yes	Yes	Yes
Heating fuel hedonic price analysis	Yes, Tacoma	Yes, Spokane	Yes, Kirkland	Yes, Vancouver
Heating fuel demand analysis	Yes, Tacoma data	Yes, Spokane data	Yes, Kirkland data	Yes, Vancouver data
Heating fuel discrete choice analysis	Yes	No	No	No
MCS hedonic price analysis	Yes, Tacoma	Yes, Spokane	No	No
MCS demand analysis	Yes	No	No	No
Home builder focus groups and conjoint analyses	Yes	No	No	No

lived in homes built and purchased since the EAP had gone into effect. They were, therefore, occupants of very new homes and occupants who had chosen either a new electrically heated MCS home or new non-electrically heated home over existing homes.

As in the original survey, the respondents were asked a wide range of questions about fuels. They were asked how important they felt it was for a heating fuel to be economical, efficient, dependable, convenient to use, safe, non-polluting, comfortable, and without an offensive odor. They also were asked to rate four different heating fuels--electricity, natural gas, wood, and oil--on each of the attributes. The respondents were questioned about the reasons why they were using their present type of heating fuel. The questionnaire also included several questions addressing heating fuel preferences and fuel switching. The survey investigated residential-fuel choice for appliances that can be fueled by either electricity or natural gas, including the cooking stove, water heater, and clothes dryer. The questionnaire also obtained information about heat pumps and occupant awareness of heat pumps.

Data from both surveys were analyzed primarily by using descriptive statistics. Life-cycle segments were also identified and differences between the statistics for different segments were explored.

In the context of the decision process summarized in Figure 2.1, these two surveys provided primarily background and attitudinal information. They provided information about what factors influenced homeowners to use, prefer, and switch their fuels. They also provided regional statistical information about the characteristics and attitudes of typical homeowners and information about buyers of new homes in two key EAP jurisdictions, where the MCS programs could be having some influence on the home-buying decision process.

2.3 HOMEOWNER FOCUS GROUPS

For the current study, focus group interviews were held to gather preliminary information on the factors that influenced new-home buyers to purchase a specific home. Focus groups are semi-structured discussions led by a moderator who introduces discussion topics, probes comments, and keeps the discussion on track; focus groups are a means to gather qualitative information. Because of group interactions and the small non-representative sample, information gathered in a focus group format is not statistically representative and findings from focus groups typically cannot be generalized to a population.

We used the information obtained in the focus groups to better formulate the design of the quantitative conjoint analysis described in Section 2.3. The focus group interviews provided valuable descriptive information seldom obtained through normal quantitative techniques. By paraphrasing and quoting the participants, the information presented in this report on the home purchase decision gives the reader a better insight into this important decision.

Four focus groups were held with new-home buyers who had purchased single-family detached homes since the end of 1985. Two sessions were held in one evening, first in Spokane and then in Tacoma. The group in the first session in each location consisted of homeowners who heated primarily with electricity; the second group consisted of homeowners who heated primarily with natural gas. We attempted to recruit an equal number of males and females for each group. Of the 27 homeowners participating in the groups, 10 heated their homes with electricity, 13 heated with natural gas, and 4 heated primarily with wood, but had backup electrical systems.

The participants represented a wide variety of experiences in owning homes and in using different heating fuels. Most participants had some prior experience with different heating fuels, and most of their experiences were with electricity or natural gas. Several had used wood heat at some time; one participant from the four groups had used fuel oil to heat a previous home. Somewhat less than half the participants were first-time home buyers. Participants included owners of custom-built, semi-custom and tract homes.

Each discussion group began with the participants asked to write three factors, besides location, that had influenced them to purchase their home. The moderator facilitated the discussion by asking questions and probing comments concerning these factors. Discussing these factors led to other key issues of interest. When the discussion waned, the moderator introduced any remaining key issues. The major topics for discussion were these:

- factors that influenced the home purchase
- perceptions of, and preferences for, various heating fuels
- awareness of the MCS and Bonneville's MCS programs

- preferred incentives promoting energy-efficient homes.

The groups lasted from 1-1/2 to 2 hours. When all of the topics had been thoroughly addressed, the moderator dismissed the participants and they were paid a cooperation fee.

In terms of the decision process summarized in Figure 2.1, the homeowner focus groups provided insights into the purchase decision process. Specifically, they helped determine the key factors that buyers considered when deciding which new home to buy. In particular, they helped determine how buyers perceived different fuels and the role fuel type played in the purchase decision. They also provided some indication of how much buyers knew about the MCS in two large metropolitan areas. In addition, they helped identify how buyers perceived different incentives that might be linked to fuel type or the MCS. Finally, they provided essential information for designing the conjoint analyses described below.

2.4 HOMEOWNER CONJOINT ANALYSES

The homeowner focus groups identified several key factors that influenced the decision to purchase a home. Information from the focus groups, discussions with realtors in the study areas, and Bonneville MCS program documents was used to develop a questionnaire to collect data for a tradeoff analysis of the factors home buyers consider when purchasing a new home. By analyzing the preferences of homeowners in Washington's Spokane, Pierce, Clark, and King Counties who have recently purchased new homes, this technique identified the relative importance of fuel and energy-efficiency choices in the overall purchase decision and the preferences of recent home buyers.

We used conjoint analysis to address how fuel type and energy-efficiency affected the decision to purchase a new home. Conjoint analysis is a technique that forces respondents to make tradeoffs between different levels of important product characteristics in a hypothetical purchase situation. The technique and its use in this study are described in detail in Lee et al. (1990) and are only briefly described here.

The respondents were presented with 18 profiles describing homes with different characteristics. The respondents were asked to rank the profiles according to their preferences.

The characteristics of the home purchase profile are termed <u>factors</u>. The possible alternatives within each factor are the <u>levels of the factor</u>. For instance, an important factor in purchasing a home is the type of home, which might have "levels" such as whether the home is a tract, semi-custom, or custom-built home. From the respondent rankings, the relative importance of the factors was estimated.[a] Also estimated were the values the respondents placed on the different levels of the factors.

Including all the factors influencing the home purchase decision was not practical in the conjoint analysis. Extremely important factors such as location, availability of financing, type of financing, and the price range of the home were designed to be extraneous to the profiles since these factors were not expected to be correlated with fuel type or energy-efficiency. The respondents were asked to "keep in mind the factors and constraints that influenced their decision to purchase their present home (e.g., price, financing, location)."

To estimate just main effects of the factors of interest, and not interactions, the factors we chose were selected to be independent of each other and the profiles considered by participants were designed to be consistent with this independence. The factors included in this study and their levels are shown in Table 2.2. The factors of most concern were the type of heating fuel, the purchase incentives, and the level of energy-

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(a) The relative importance of a factor is calculated as follows: 1) the difference between the maximum and minimum utility levels is calculated for each factor; 2) these differences are summed; and 3) the relative importance of each factor is calculated by dividing the difference between its maximum and minimum utility values by the sum calculated in the second step and expressing the result as a percent.

TABLE 2.2. Home Purchase Factors and Levels Included in the Conjoint Design[a]

Factors	Levels	Factors	Levels
Type of home	Tract-built Semi-custom Custom-built	Primary Heating Fuel	Electricity Natural gas Wood
Levels in home	Single-level Multi-level	Utility Rate Discount	$15/$20 per month None
Size of home	Over 2,300 sq ft 1,700 - 2,099 sq ft 1,300 - 1,699 sq ft Under 1,300 sq ft	Cash Rebate	$1,250/$1,900 $800/$1,250 $400/$600 None
Energy-efficiency	Average efficiency High efficiency		

(a) When two values are shown separated by a slash (/), the first value was used for Pierce, Clark, and King Counties and the second value was used for Spokane County.

efficiency of the home.[a] The high energy-efficiency level was intended to be a proxy for MCS. Since most buyers were not likely to be aware of the requirements of the MCS, we included the following language in our instructions to the participants:

> "Due to upgraded windows and insulation levels, the homes built to [the high efficiency level] cost about $1,500 more to build, but will save on energy bills."

(a) The levels of the cash rebate and utility rate discount that we included in the analysis varied across the counties. The cash rebate levels were varied to be consistent with the variation in the MCS program incentives across climate regions. The monthly utility bill discount was set at $20 in Spokane County and $15 in the other three counties. This approximate level was selected because participants in the focus groups indicated levels in this range would be required for them to even take the incentives into account. The levels were slightly higher in Spokane to reflect the higher heating bills expected in this colder climate.

The intent of this language was to convey to the respondents that the higher energy-efficiency level would reduce energy bills, but that the builder would have to spend more to build the home. Whether or how the additional cost to the builder might be passed on to the buyer and how much utility bills might be reduced were left to the judgment of the respondent.

The number of factors and levels chosen allowed for a manageable quantity of profiles for the respondents to rank. Besides ranking the profiles, the respondents were asked to provide demographic and other information.

The data were collected via mail surveys in the four Washington counties. The target population, homeowners who had purchased a new home since the end of 1985, was chosen because the study addressed the fuel choice in new homes. Also, it was thought that more representative responses would be obtained from those homeowners who had recently gone through the process of buying a new home. For each county, a random sample of about 300 addresses was drawn from a list of residences that were built after 1985.

The response rate of a survey is an indication of how well the survey results represent the population they are supposed to represent. Mail surveys typically have low response rates so several precautions were taken to increase the response rate. Table 2.3 presents information about the response rates in all four counties. The rate for Spokane County was nearly 66%, a respectable level. The rate for Pierce and Clark Counties was about 55%, which is still fairly good for mail surveys. The lowest rate, approximately 46%, occurred in King County. As noted, a series of steps was taken to increase the response rate. Without having any data on those people who did not respond, it was difficult to say if or how the data were biased because of non-responses. With the response rates achieved in the surveys, the data may underrepresent certain segments of those homeowners who purchased new homes

TABLE 2.3. Survey Response Rates by County

		Pierce	Spokane	King	Clark
1.	Surveys Sent	300	300	300	322
2.	Returned to Sender (vacant, addressee moved, no such address)	54	33	47	26
3.	Non-Qualified Respondent (renter, purchased a previously owned home)	6	6	6	18
4.	Completed Surveys	133	172	113	152
5.	Response Rate 4. / (1. - 2. - 3.)	55.4%	65.9%	45.7%	54.7%

recently, but the response rates are close to levels typically considered acceptable, particularly in Spokane.[a]

In the context of the process described in Figure 2.1, the home buyer conjoint analyses helped us quantify the relative importance of different factors, particularly energy-efficiency and fuel type, in the decision to purchase a new home. They also provided initial estimates, in four major metropolitan areas, of how buyers rated different fuel types, levels of energy-efficiency, and levels of other characteristics. Additionally, they provided important quantitative information about how buyers assessed different incentive types and levels. Finally, they allowed us to simulate buyer behavior under alternative scenarios to explore how the MCS and

(a) One possible source of bias we investigated was the difference between the response rates of households for which we had occupant names and those for which we did not. For Spokane, the response rates were identical for the two groups. For Pierce County, the response rate was slightly higher (58%) where occupant names were available than where they were not (47%). Based on these results, we concluded that no bias was being introduced in Spokane due to this effect and a small amount of bias might be present in the Pierce County data due to this phenomenon.

different incentive types and levels might affect market shares of homes heated with different fuels.

2.5 HEDONIC PRICE ANALYSIS

Numerous studies have used the hedonic price analysis technique to evaluate the value of housing characteristics; hedonic price analysis is a fairly straightforward approach for assessing the impact of house attributes on the selling price. The motivation for applying the technique is to estimate the dollar value of a characteristic that is not openly observable. One classic application has been to estimate the dollar value of air pollution damage.[a] Other applications have included valuing local parks, airport noise, and not surprisingly, conservation programs.[b]

Applications of the technique start from the assumption that the price of the house is a function of the attributes of the house. This line of logic suggests that the incremental value of any particular attribute can be statistically estimated from knowledge of the selling prices of houses and the amounts of the attributes in each house. The incremental value is the dollar value of the characteristic under study. In this study, we were interested in the dollar value of different fuels and the package of MCS features. Details of the hedonic analyses conducted are presented in Lee, Englin, and Harkreader (1989) and Englin et al. (1990). A general description of the approach follows.

Operationally, the technique is implemented by using regression analysis. The selling price is regressed on the quantities of the attributes in each of the houses sold. The method disaggregates the selling price to find the contribution of each attribute to the selling price. Each housing sale is an observation. Equation (2.1) shows this relationship:

$$\text{Selling Price} = F(\text{attributes}) \qquad (2.1)$$

(a) Freeman (1979) discusses 12 different studies that have examined air pollution valuation using the hedonic technique.
(b) Laquatra (1987) gives an overview of several energy-related applications. Other applications include Laquatra (1986), Palmquist (1984, 1985), and Zaki and Isakson (1983). Rosen (1974) discusses the theoretical underpinnings of this technique.

The contribution of each attribute to the selling price depends on the demand for the attribute by home buyers, the quantity available, and the ease and expense with which the supply of the attribute can be increased.

While the function F() can take different forms, most researchers have found the linear or logarithmic linear forms to fit the best. An example linear function is shown in Equation (2.2):

$$\text{Selling Price} = a_0 + a_1{*}x_1 + a_2{*}x_2 + \ldots + e \qquad (2.2)$$

In the linear form illustrated by Equation (2.2), the incremental value of an additional unit of x_i in the selling price of the house is a_i.

Note that the estimated coefficient, a_1, is the capitalized effect. If x_1 denotes the presence of certain heating equipment, the coefficient captures the discounted value of the equipment and the expected cost of running the equipment. Decomposing the estimated coefficient depends on understanding expectations about home-heating fuel prices. Abelson and Markandya (1985) describe this problem in detail. In this study there has been no attempt to decompose the estimated effects of the equipment and expected annual operating expense.

Applying this technique to analyzing residential fuel choice is straightforward. If x_1 indicates electric space heating and x_2 indicates gas heating in Equation (2.2), then a_1 and a_2 measure the effect of the fuels on the price of the home. The difference between a_1 and a_2 is the amount that the price of the house would vary in the local housing market given the fuel type. The implications for the new home market are fairly direct. Builders would want to build the house having the greatest difference between the cost of installing the heating equipment and fuel and the price at which they could sell the home. Home buyers would, given their attitudes towards each fuel, want to spend the least for their preferred fuel.

Three factors that complicate the analysis of fuel choice in new housing are 1) the nature of existing housing available on the market, 2) expectations about fuel price changes, and 3) the dynamic nature of the housing market. Conventional applications of the hedonic technique consider new housing and existing housing to be substitutes for each other. We make a similar assumption here. Current fuel prices and future fuel price changes, either announced or simply expected, are major factors in how much home buyers are willing to pay for a house with a particular fuel. Each home buyer must trade off the equipment cost of the fuel against the operating cost (fuel price). In this way, the future price of fuels, in addition to current prices, affects the incremental price builders can receive for a house. Finally, the role of fuel type in housing prices is dynamic. As fuel prices change over time, the effects of fuel type on housing prices will also change; the analysis of a single year alone cannot always capture these effects. How quickly these effects occur and how long it takes to reestablish a long-run equilibrium is an empirical issue.

Application of the hedonic price technique requires knowledge about the sales prices and characteristics of both new and existing houses sold during specific time periods. Many of these data can be found at county assessors' offices. Our hedonic price analyses covered four metropolitan areas in Washington: two parts of Tacoma (in Pierce County), Kirkland (a suburb of Seattle in King County), Vancouver (in Clark County), and Spokane (in Spokane County). We obtained housing sales and house characteristics data from the county assessor's office in each of the counties where these cities are located. The complete listing of residential properties and historical data in each of the four counties was obtained in a computer-readable format.

The raw assessor's data contain a rich description of both the attributes of each house and the property around the house. Land descriptors include amenities such as waterfront and views, as well as indications of lot size, the quality of road access, and the condition of the land itself. In general, the neighborhoods that we analyze are sufficiently homogeneous that there is little variation in these attributes. The available house descriptors are usually even richer. Typical descriptors include age of the house, quality of construction, house type, the kind of interior and exterior walls, porches, number of bedrooms, number and kind of baths, square footage of basements and garages as well as living areas. The data also usually include information about the fireplaces, heating equipment, and other built-in appliances. Together, the property and house data provide a fairly complete picture of each property.

The data were "cleaned" to obtain a sample which was appropriate to the analysis. For example, numerous buildings were actually businesses which were zoned both residential and commercial, and these were deleted from the sample. Another difficulty was the common assessors' practice of listing the selling price for a lot with the characteristics of the house subsequently built on the lot. This problem was addressed by including only houses that had ages greater than or equal to zero and that sold for more than a specific price.

The hedonic price analysis approach helps address the decision process illustrated in Figure 2.1 by providing insights into the economics that affect the decision. It is not possible to observe directly how the market values different fuel types and energy-efficiency levels. This technique allows us to estimate the "prices" associated with these housing characteristics, and also permits treatment of the decision in a context that includes both the option of buying an existing home and buying a new home. As we apply the methodology, it facilitates examining the dynamics of the market over time, differences across regions, and the overall market demand. Finally, the technique provides valuable information that can be used in a comprehensive framework, such as discrete choice analysis, for modeling the decision process.

2.6 DISCRETE CHOICE ANALYSIS

There are many goods--usually durable goods--that are purchased one at a time by individual consumers. In these cases, the choice is not how much of the good to purchase, but rather which brand and model best fits the consumer's needs. In contrast, residential fuel choice is primarily a discrete choice. Once a homeowner has selected a heating fuel, it is quite costly to change. Of the large number of different types of discrete choice models in the econometrics literature that have been applied to model this process, the most common approach is the logit regression technique. This is the approach to modeling individual consumer's fuel choice used in this analysis to examine fuel choice in a single location, Tacoma. Details of the approach are presented in Lee, Englin, and Harkreader (1989).

Logistic (logit) regression models have two useful features in the context of this study. The first is that they allow the roles of attitudes and the various measures of cost in the individual's decision to be quantified. Once quantified, these can be compared in a meaningful way. Even though the attitude measures are ordinal, their parameter estimates can be compared to the cost measure parameter estimates and their relative importance to the decision maker compared. Second, fuel choice actions and desires can also be compared in this approach. This is accomplished by comparing the parameter estimates for one logit regression estimated for the fuel actually used and a second model estimated based on fuel preferences.

In the context of this study, the model was applied using the first EAP jurisdiction survey in Tacoma. This application assumed that the discrete choice of fuel depended on both external factors (fuel cost and hedonic price) and internal factors (fuel attitudes). The specification of the model included the attitudes towards the fuels obtained from the survey previously described and the costs of the fuels. Two specifications of fuel costs were included. The first was the average residential fuel price, and the second was the hedonic prices derived as discussed earlier.

The logit regression model was applied in two different ways. The first was to apply the model to explain the relationship among attitudes, costs, and the fuel in the house. The second was to relate attitudes and costs to the preferred fuel which, of course, was not necessarily the fuel in the house.

The data for the analysis came from the following three sources: 1) the EAP questionnaire, 2) the hedonic price results, and 3) the residential natural gas and electricity prices for a 4-year period collected from the local utilities.

In the context of this analysis, the important parts of the questionnaire were those concerning attitudes towards fuels. Attitudes towards eight different characteristics of fuels were obtained on a fuel-by-fuel basis. The eight characteristics which respondents were asked to rate are:

- cost
- efficiency
- reliability
- convenience

- safety
- heating evenness and comfort
- pollution
- odor.

The ratings were used to generate an ordinal score. These questions were asked with regard to both electricity and natural gas.

The raw attitudinal data were used to create a new set of relative attitudinal variables, constructed by subtracting the electrical score from the gas score.[a] This composition of the attitudinal data allowed the number of variables, which needed to be analyzed, to be reduced considerably. It also allowed the analysis to focus more tightly on the differences between the fuels. Since the raw rankings were ordinal, focusing on the differences also allowed simpler interpretation of the results.

The fuel prices obtained from the respective utilities were put on a common footing by converting therms into kWh using a factor of 29.3. The electric prices were adjusted downward by 70% to account for the typical combustion efficiency of existing natural gas furnaces. These fuel prices were combined with the attitudinal data in the estimation procedure.

Our use of the discrete choice approach here has been very limited, primarily by data constraints. The main purpose in applying it was to test the methodology to see what data were required, whether the data were available, and whether the technique showed promise for broader application to the fuel and energy choice process in the Northwest.

The technique offers promise for modeling the process illustrated in Figure 2.1. It brings together attitudinal, demographic, and economic data in a single model. If successful, this type of approach could provide predictions of fuel and MCS choices under different scenarios and for different regions.

(a) The best way to handle ordinal variables of this type is to create a set of dummy variables, one for each category of response for each question. However, this would have created forty variables in this application. Since there were less than 100 observations, this approach could not be supported by the data.

2.7 FUEL AND MCS DEMAND ANALYSIS

One way to integrate the estimated prices from the four cities is to use them in the estimation of demand curves. Demand curves relate the quantity of a good purchased to the price of the good. The expectation is that lower quantities of a good will be bought if it is priced higher. We have used our hedonic price estimates and other data in an attempt to reveal the residential demand curve for heating fuel type and MCS.

The demand for heating fuel was estimated using data from the four major metropolitan areas of Washington: Tacoma, Spokane, Kirkland, and Vancouver. The data spanned the 6-year time period from 1984 through 1989.

Pooling the data from all four cities provided a usable sample of 6,488 observations. Matched with each observation was the gas-heat hedonic price for the year and city in which it was sold. Three other pieces of information were appended to each observation. These included the average natural gas and electricity prices, demographic characteristics, and measures of the health of the local economy. The full model included:

- hedonic natural gas price
- median age of residents
- average income
- college graduates
- female labor participation rate
- house age
- house size
- fireplace
- electricity/gas price ratio
- labor force participation rate.

Two demand models were examined: one with a quadratic and linear hedonoic price term and without the quadratic term.

Because of data limitations, the demand for MCS homes was estimated using only the Tacoma data. The data used contained information on 1,045 homes sold from 1985 through 1988. The Tacoma data provided four estimates of the hedonic price associated with MCS. In addition to the hedonic price data, the average prices of heating fuels, demographic variables, and measures of economic activity were appended to the data. The complete model included:

- hedonic natural gas price
- house age

- median age of residents
- average income
- % college graduates
- female labor participation rate
- house size
- fireplace
- electricity/gas price ratio
- labor force participation rate.

As with the natural gas equation, we estimated a demand equation with both a linear and quadratic hedonic price term and one with only the linear term. There were two model specification differences between the natural gas and MCS demand specifications. One was the omission of the squared fuel price ratio term. The second was the estimation of an inverse demand curve rather than a standard demand curve. Chapter 3 discusses the model specifications.

2.8 HOME-BUILDER FOCUS GROUPS AND CONJOINT ANALYSIS

Builders play a major role in making fuel choices for new homes and many factors influence their choice. Clearly, potential buyers' preferences and the costs of procuring and installing different equipment affect builders' choices. In the EAP and SGC program jurisdictions, the builders' decisions have been complicated by the requirements of these programs.

Two focus groups and a conjoint analysis were conducted with Tacoma builders. We held discussions with builders on specific issues related to the fuel-choice decision and asked builders specific questions that were the basis for the builder conjoint analysis. The intent of the builder analysis was to characterize builder perceptions and preferences and to assess the role of builders in the fuel and energy-efficiency choice process. Details of the builder focus groups and conjoint analysis are presented in Lee, Englin, and Harkreader (1989).

A list of Tacoma area home builders was provided by Tacoma Public Utilities. The list of residential builders included builders producing a variety of residential structures (single-family, duplexes, and multi-family complexes) and using different types of heating fuels. Builders on this list were contacted and asked to participate in focus groups discussing the fuel-choice decision; all the participants were either company presidents or general managers. The attendees were paid an honorarium and travel allowance.

The two focus groups were held on consecutive evenings in Tacoma. Although we had anticipated 20 people attending, a total of only 11 people attended--4 the first evening and 7 the second evening. The first group consisted of small builders who exclusively used electricity in their homes. The second group consisted of a mixture of small and large builders who primarily used electricity; one builder had also built homes using natural gas.

Although half of the builders who agreed to attend were builders of gas-heated homes, those that actually attended were essentially builders of electrically heated homes. The lack of participation by builders of gas-heated homes was unfortunate for our purposes because it reduced the representativeness of the perceptions expressed by the builders.

Six general topics were addressed by the participants in the focus groups. These topics were past behavior, decision making roles, fuel choices and relative benefits, the role of incentives, the role of market characteristics, and expectations for future trends.

For this study, the same residential builders participating in the focus groups were asked in a conjoint analysis to consider six factors thought to influence fuel choice in residential construction. The factors and the alternate levels within each factor were suggested by previous discussions with builders. The builders were presented 25 profiles of the residential fuel selection that varied the combinations of the choices within the factors and they were asked to rate the likelihood of electricity being installed as the primary heating fuel in each of the profiles. In rating the situations, the builders were told that all home-heating fuels were equally available and that they should rate the situation as if they were going to do the construction. They rated the likelihood of electricity being the primary heating fuel on a scale from 1 (very unlikely) to 10 (very likely).

Our study of builders has contributed to understanding the decision process shown in Figure 2.1 because builders play a key role in determining what fuel types are installed in new homes and how many are built to the MCS. These determinations affect the supply of new homes available to potential buyers. Although builders ultimately must build what the market demands or go out of business, they clearly have the primary role in determining the supply of new homes; this is particularly important during transition periods when external factors, such as rapid fuel price increases or adoption of the MCS, cause sudden shifts in consumer demands and builders take some time to respond to changes in the market. Our findings here are quite limited because our study of builders has been restricted to a single region, a small group of builders, and builders who install predominantly electric heat. Nevertheless, the information is useful for determining the role of builders in the process illustrated by Figure 2.1.

3.0 SUMMARY OF RESULTS

This chapter summarizes in a one place the results from the analyses described in Chapter 2. The first section discusses summary information for Bonneville's service territory to provide a context for the other results presented. The subsequent sections are organized primarily by the specific locations where we conducted our analyses. This organization is designed to give the reader a good sense of the types and amount of information we have developed on residential fuel and MCS choices for different parts of the Northwest. The final section focuses on the analysis we conducted of the demand for specific space heating fuels. Because this analysis relied upon information from the four metropolitan areas studied its results are reported last. More details on the analyses discussed here can be found in a series of prior reports including Harkreader and Hattrup (1988), Lee, Englin, and Harkreader (1989), Lee, et al. (1990), and Englin et al. (1990). Chapter 4 integrates the results presented in Chapter 3 and the other reports to show where consistencies have emerged, where inconsistencies and gaps remain, and where additional research should be focused.

3.1 REGIONAL AND EAP SURVEY RESULTS

Survey results for all types of households in Bonneville's service territory indicate that 70% are located in Western Washington; 18% in Western Oregon; 8% in Eastern Washington, Northern Idaho, and Western Montana; and 4% in Eastern Oregon and Southern Idaho.[a] The distribution of primary space heating fuels for this population is shown in Figure 3.1. Electricity predominates throughout the region and either gas or wood is the second most common heating fuel in each subregion.

In terms of preferences, 36% of all households prefer gas for space heating, 35% prefer electricity, and 14% prefer wood. Respondents give gas and electricity comparable total ratings, which are considerably higher than those for oil and wood. Table 3.1 compares the pair-wise ratings for the four

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(a) Lee, Englin, and Harkreader (1989) and Harkreader and Hattrup (1988) present details of the analyses discussed here.

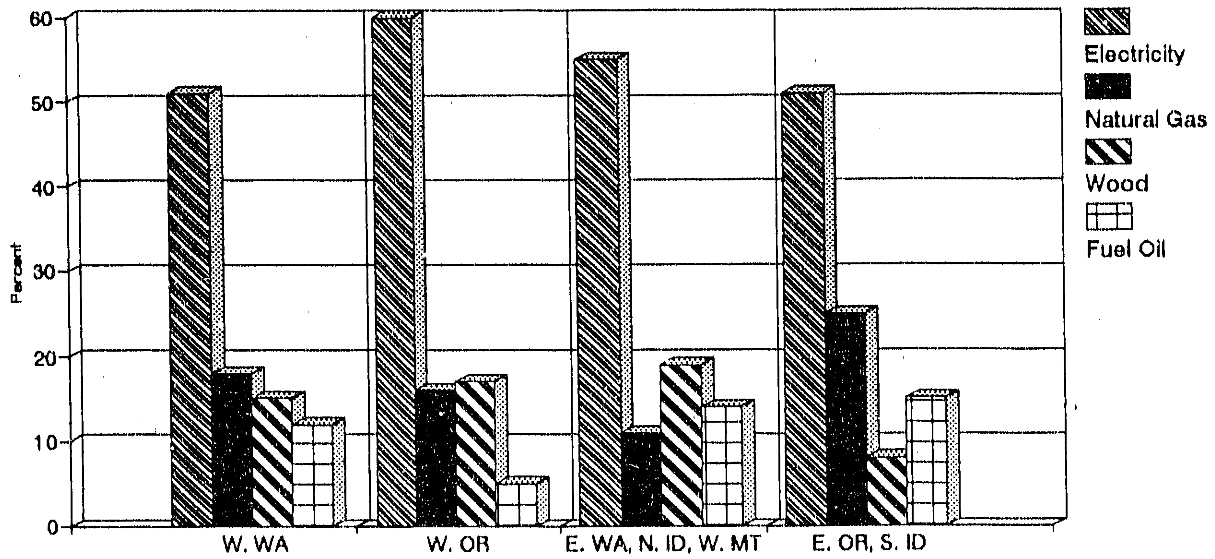

FIGURE 3.1. Primary Heating Fuel Distribution by Region (All households in Bonneville service territory)

TABLE 3.1. Comparison of Means of the Positive Perception Scale, by Fuel Attribute

Fuels	Low Cost	Dependable	Safe	Nonpolluting	Comfortable Heat	Efficient	Convenient	No Offensive Odor	Overall Positive Image[(a)]
Gas	3.06	3.21	2.88	2.98	3.45	3.23	3.26	2.92	23.22
Electricity	2.13	3.12	3.37	3.33	3.33	3.06	3.45	3.60	24.89
Gas	3.06	3.21	2.88	2.98	3.45	3.23	3.26	2.92	23.22
Wood	2.71	2.83	2.27	2.93	3.02	2.65	1.70	2.90	20.41
Gas	3.06	3.21	2.88	2.98	3.45	3.23	3.26	2.92	23.22
Oil	2.02	2.88	2.81	2.41	3.11	2.72	2.69	2.49	19.65
Electricity	2.13	3.12	3.37	3.33	3.33	3.06	3.45	3.60	24.89
Wood	2.71	2.83	2.27	2.93	3.02	2.65	1.70	2.90	20.41
Electricity	2.13	3.12	3.37	3.33	3.33	3.06	3.45	3.60	24.89
Oil	2.02	2.88	2.81	2.41	3.11	2.72	2.69	2.49	19.65
Wood	2.71	2.83	2.27	2.93	3.02	2.65	1.70	2.90	20.41
Oil	2.02	2.88	2.81	2.41	3.11	2.72	2.69	2.49	19.65

(a) A fuel's attribute means do not sum to its overall positive image mean due to missing values in the data.

fuels and presents an overall rating that sums the ratings on each attribute. Table 3.2 shows statistically significant differences in perceptions about specific fuels according to fuel type used by the respondent. Generally, users of a specific fuel tend to rate that fuel better in most categories than do people who have other primary heating fuels.

TABLE 3.2. Differences in the Perception of Fuel Attributes, by Heating Fuel Type

Heating Fuel	Attribute	Primary Heating Fuel Segment: Electricity	Natural Gas	Wood	Fuel Oil
NATURAL GAS	Low cost	3.03	3.39	2.83	2.88
	Dependable	3.21	3.40	3.09	2.96
	Safe	2.76	3.32	2.78	2.73
	Non-polluting	2.93	3.19	2.97	2.83
	Comfortable heat	3.40	3.68	3.41	3.31
	Efficient	3.19	3.44	3.12	3.09
	Convenient	3.17	3.52	3.21	3.23
	No offensive odor	2.86	3.17	2.87	2.74
	Positive image[(a)]	22.65	26.64	22.73	19.96
ELECTRICITY	Low cost	2.27	2.00	1.90	1.94
	Dependable	3.19	3.19	2.86	3.07
	Comfortable heat	3.43	3.17	3.16	3.39
	Positive image[(a)]	25.60	23.86	24.20	23.90
WOOD	Low cost	2.55	2.45	3.48	2.59
	Dependable	2.77	2.61	3.33	2.71
	Safe	2.14	2.15	2.78	2.26
	Non-polluting	2.94	3.03	2.65	3.13
	Comfortable heat	2.94	2.80	3.58	2.83
	Efficient	2.59	2.49	3.08	2.46
	Convenient	1.59	1.60	2.14	1.55
	No offensive odor	2.90	2.78	3.13	2.77
	Positive image[(a)]	19.87	19.23	24.06	19.37
FUEL OIL	Low cost	1.89	1.92	2.14	2.72
	Dependable	2.72	3.04	3.13	3.30
	Safe	2.67	2.79	1.76	3.24
	Comfortable heat	3.01	3.06	2.73	3.53
	Efficient	2.60	2.72	2.77	3.19
	Convenient	2.49	2.74	3.03	3.28
	No offensive odor	2.41	2.54	2.58	3.02
	Positive image[(a)]	18.68	19.28	18.25	24.47

(a) A fuel's attribute means do not sum to its positive image mean because of missing values in the data.

To obtain better information on key subsets of households, we conducted the same survey with a larger sample of occupants of relatively new homes in the Tacoma area and in Southern Idaho. The homes were built since the EAP went into effect in each area. In Idaho, 78% of the homes surveyed were electrically heated, 13% gas-heated, and about 10% wood-heated. In the Tacoma area (Western Washington), only 56% were electrically heated, 37% gas-heated, and about 6% used wood heat. For the two regions combined, perceptions of the attributes of gas and electricity were comparable to the perceptions for the region. Summing up the scores for each attribute, electricity rated a little higher than natural gas overall. Table 3.3 shows attitude differences between the two regions that were statistically significant. Table 3.3 is consistent with Table 3.2 in that a much larger share of new homes in the Tacoma area was heated with gas than in the Southern Idaho area. Table 3.3 shows that gas tended to be viewed more positively in Western Washington than in Southern Idaho and the converse was true with regard to electricity. Table 3.4 presents other useful information about fuel preferences for the two EAP areas. The preference for gas heating was higher in these jurisdictions combined than it was for the region as a whole. Users of a given fuel tended to prefer that fuel.

TABLE 3.3. Attributes That Are Perceived Differently Across Regions

	Western Washington	Southern Idaho
NATURAL GAS		
Safe	3.2	2.9
Non-polluting	2.8	2.4
Provides comfortable heat	3.5	3.2
Efficient	3.1	2.8
Convenient	3.3	2.8
No offensive odor	2.8	2.5
ELECTRICITY		
Low-cost	2.3	2.7

TABLE 3.4. Percentage of EAP Jurisdiction Respondents Preferring a Specific Fuel Type (By present fuel type)[(a)]

Present Heating Fuel	Preferred Heating Fuel: Electricity %	Natural Gas %	Wood %	Fuel Oil %	No Preference %
Electricity	58	30	3	2	2
Natural gas	4	95	0	0	0
Wood	25	19	56	0	0
All fuels combined	39	48	6	1	2

(a) Percentages do not add to 100 because of roundoff and exclusion of other heating fuel types.

It appeared that the preference for natural gas indicated an allegiance to natural gas that electricity did not enjoy. Ninety-five percent of natural gas users preferred their fuel, whereas only 58% of electricity users preferred electricity. The data in Table 3.4 suggested in addition that there was a potential for residential customers to switch to natural gas from electricity: 30% of electricity users indicated a preference for natural gas.

When asked how likely it was for the household to switch heating fuels in the next 2 years, only 3% of the respondents reported that they would consider it. In the past 2 years only 7% of the respondents had switched their heating fuels, and of those, half did so only because they changed residences. These results indicated that, while there might be considerable potential for fuel switching because of fuel preferences, only a small proportion of existing households had switched in the short-term. From a planning and policy perspective, however, the potential impact of fuel switching in existing households in a single year may be quite important because the impacts are comparable to those associated with new housing starts. The share of households switching fuel in any given year without changing houses was around 1.8% (n x n x 7%). This is comparable to the most probable estimates of housing stock growth rates of 1.4% to 1.9% per year (NWPPC 1986, p. 2-20). Therefore, fuel choice decisions in existing homes have the potential to change the number of homes using a specific fuel as much as decisions made in new homes.

3.2 ANALYTIC RESULTS FOR PIERCE COUNTY (TACOMA), WASHINGTON

Most of our analyses have focused on the Tacoma area because it is a bellwether area for Bonneville's MCS programs. In addition to the survey described in Section 3.1, we conducted builder focus groups, a builder conjoint analysis, two separate hedonic price analyses, focus groups of new-home buyers, and a conjoint analysis of new-home buyers in the Pierce County area.

3.2.1 Builder Focus Groups and Conjoint Analysis Results

When asked about the history of installing different fuels, all of the builders in both Tacoma focus groups indicated a history of, and preference for, all-electric homes.[a] This behavior was based on the following factors: limited availability of natural gas, incentive and advertising programs for electrically heated MCS homes, experience with electricity of both builders and consumers in the area, and lower construction costs associated with electricity. When asked about the selection of a heating fuel in their homes, the builders indicated that the fuel choice was made by the builder in most cases. The exceptions occurred when the home was built for a buyer who specified the type of heating fuel.

When asked about incentive programs, the only program mentioned was the Tacoma City Light SGC program, which offered rebates for energy-conservation construction techniques, as well as for installing an air-to-air heat exchanger. This program was the major topic of conversation for much of both sessions.[b] All of the builders had built under this program, many exclusively; a number of builders expressed the view that they were able to build to the program requirements without increasing their construction costs. It was very clear that the program instigated the application of most of the

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(a) See Lee, Englin, and Harkreader (1989) for the details of the analysis discussed here.
(b) It should be noted that the builders did not emphasize the EAP or distinguish it from SGC program.

energy conservation measures, that these techniques were now standard with the builders, and that these measures would remain after the program ended.

Regarding home buyer preferences, the builders indicated that their buyers were concerned primarily with the cost of the unit. Subsidiary concerns included size (square feet of floor area), energy-conserving characteristics, and location (utility service area due to the differing costs of electricity). No mention was made of other design elements. Customer fuel preference was perceived by the participants to be almost exclusively electricity.

When questioned concerning their future expectations, the participants mentioned one expected change most frequently: the cost of electricity will go up. Some builders also expected more fuel-efficient appliances, and most expected more conservation knowledge among consumers.

These same builders participated in a conjoint analysis. The results reported here must be qualified by the same limitations that applied to generalizing the focus group results. The results, however, should be indicative of the behavior and responses of builders of electrically heated homes.

Figure 3.2 illustrates the relative importance of five factors influencing builder fuel choice.[a] Among the focus group participants, the owner's heating fuel preference has the largest single influence on the builder's decision about the home heating fuel. The type of housing and the price of the residential units are relatively equal in their influence on fuel choice, as are the builder incentives and relative heating fuel price changes.

The utility values shown in Table 3.5 indicate the relative effect of each influencing factor level on the likelihood of electricity being installed

(a) Note that when the term "importance" is used to report results of the conjoint analyses here it is an indication of how much a particular factor influences the decision, and it is very sensitive to the range of utilities for each factor. A factor with levels that do not vary much in their utility values is determined to be of little importance in the decision. This is reasonable, even if the factor would otherwise be considered important, because the range of options for the factor is so limited that the decision maker does not have to pay much attention to it.

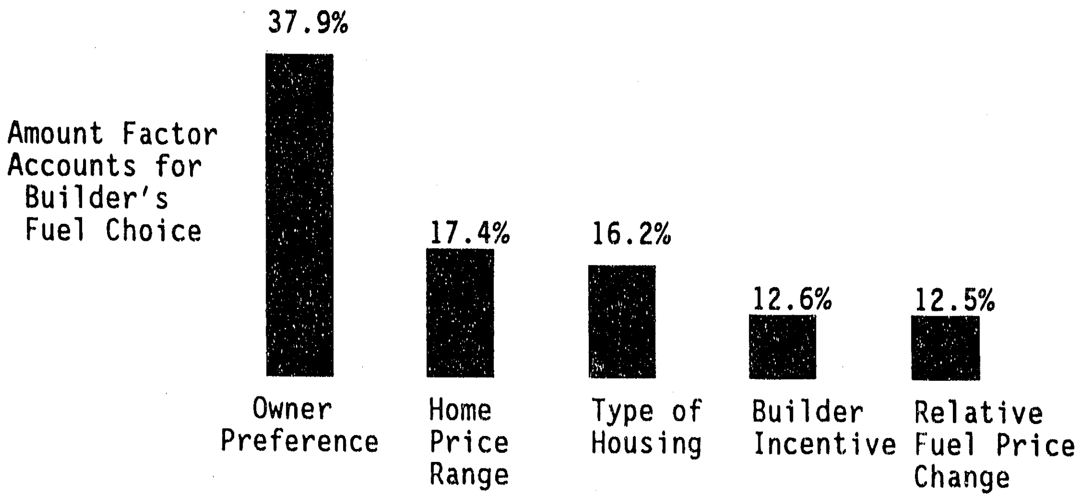

FIGURE 3.2. Relative Importance of Fuel Choice Factors of Tacoma Builders

TABLE 3.5. Relative Utility Values of Factor Levels, Tacoma Builders

Fuel Choice Factor									
Housing Type		House Price Range		Owner Heating Fuel Preference		Builder Incentive		Relative Fuel Price Changes	
Level	Utility	Level	Utility	Level	Utility	Level	Utility	Level	Utility
Single-family tract	0.637	High	-0.902	Electricity	1.926	High ($300)	0.606	Electricity increasing	-0.448
Single-family custom	-0.778	Medium	0.623	Nat. gas	-1.392	Low ($50)	-0.500	Nat. gas increasing	0.645
Multi-family	0.257	Low	0.279	Wood	-0.534	None	-0.106	Similar changes	-0.197
Du-,tri-,quad plex	-0.115								

as the primary heating fuel.[a] Since this trade-off analysis assumes linearity and little or no correlation among the factors, the overall utility for a profile can be estimated by adding the utility values for each factor

(a) Note that the utility values for a particular factor are constrained by the statistical technique used so that they must add up to zero. Consequently, a negative utility for a given factor level does not mean that the builder would choose something other than electricity, but only that the probability of selecting electricity is lower relative to levels that are positive.

level in the profile of interest.[a] For example, the profile with the greatest likelihood for installing electricity consists of a single-family, tract home in a moderate price range, where the owner prefers electrical heat, the builder is receiving a high incentive for installing electrical heat, and the price of natural gas is increasing relative to the price of electricity (total utility = 4.437).

We can make some observations about the relative importance of different factors in the builder's fuel selection, e.g., perceived owner preferences for electricity over natural gas or wood increase the probability of a builder's installing electric heating. Also, high-end and custom homes are less likely to be built with electric heating. We considered three builder incentive levels for installing electric heat: $300 per unit (high), $50 (low), and no incentive present. The results suggest, quite logically, that relatively large builder incentives may be effective in protecting electricity's market share. The utility values also suggest another interesting effect of incentive levels. The low incentive level is less likely to convince the builder to select electricity than no incentive at all. While this seems illogical, it is possible that builders anticipate that certain costs would be incurred in applying for an incentive (additional paperwork, time, etc.), and an incentive of $50 would be inadequate to cover these costs.

3.2.2 New-Home Buyer Focus Groups

The recent buyers of new homes in our focus groups in Tacoma indicated that the most important reasons for purchasing their home was floor plan features or aesthetic qualities of the home.[b] The appearance of the home was what first attracted the home buyer.

A larger number of first-time home buyers than other participants mentioned financial reasons for purchasing their homes. These reasons included special low-interest rates for their particular home and an affordable price.

(a) We examined the correlation between the effects of the factors and levels and found no evidence that the analysis needed to include interactions.
(b) See Lee, Harkreader, Bruneau, and Volke (1990) for the details of the analysis discussed here.

The energy-efficiency of a new home was considered in the purchase decision, but other factors appeared to be more important. In fact, energy-efficiency was initially mentioned by only one focus group participant. However, after it was brought up by the moderator, almost all the participants said they considered this aspect when looking for a home to buy. Many associated energy-efficiency with construction quality of the home, and it was the general consensus that their homes were well-built and used energy efficiently.

The type of heating fuel the home used was initially mentioned by only a few people. But when the groups were probed about the importance of the fuel decision, a distinct pattern appeared. Most participants in the non-electric heat group stated that they had specifically selected natural gas. Participants in this group were very pro-natural gas. Only one participant in the electric heat groups mentioned heating with electricity as a reason for purchasing the home. Several of these participants were satisfied with their electric heat, but it was not a reason for purchasing the home.

Of those participants expressing a preference for a heating fuel, the majority preferred natural gas. The fuel choice was very important to these homeowners in their decision to purchase their home. The number of participants that preferred electricity or preferred wood was about the same.

In general, the participants felt that natural gas was very cost-effective, efficient, and clean, and there was very little concern over the safety of natural gas. The natural gas companies, who were perceived to be service-oriented and to respond quickly to problems, also helped the image of natural gas.

The preferences of the participants in the electric-heat group were mostly for electricity; two preferred to have natural gas as a heating fuel. Most perceived electricity to be clean and to provide comfortable heat, but none considered it the least expensive heating fuel. However, it was mentioned that costs for electricity in the Northwest were considerably lower than in other parts of the nation and, especially for those having lived in other areas, the cost of Northwest electricity was of little concern. The convenience of paying only one fuel bill was also mentioned. The type of electric heating system was important for the electricity preference, e.g., baseboard systems were perceived as inefficient, unsightly, and inconvenient.

The participants were familiar with the Super Good Cents (SGC) program through television advertisements. Participants in the electric-heat group knew the (SGC) homes were highly energy-efficient and used electricity, but individuals in the non-electric heat group knew fewer specifics about the program. They mostly recognized the name of the program.

Approximately half the Tacoma participants owned Super Good Cents MCS program homes. In general, these homeowners were satisfied with, and proud of, their homes, and considered them quality homes. They noted that there was very little difference in the price of the Super Good Cents homes compared with other homes they had considered.[a] The advantages of program homes mentioned in the Tacoma groups were energy-efficiency, quality construction, and quiet interiors.[b]

Those participants heating their home with natural gas felt their homes were just as well-built and energy-efficient as Super Good Cents homes. Their general feeling was that the local building codes had been improved and all homes had to be built with energy-efficiency in mind. None of the Tacoma participants was aware of the MCS.

The groups were also asked to discuss some hypothetical incentive programs for encouraging the purchase of highly efficient homes. The possible incentives considered were:

- a cash rebate paid directly to the homeowner
- a cash rebate paid towards the down payment

(a) This was consistent with our hedonic price analyses, discussed in the following section, which suggested that the premium paid for MCS homes was largely offset by the lower price associated with electric heat.

(b) One participant who owned a custom-built program home mentioned several disadvantages of the program. He felt the requirements for the allowable square footage of window area were too restrictive; the type of windows and doors required to meet the standards were too expensive; also, the required air-to-air heat exchanger was expensive, noisy, and useless. This person felt that program homes were well-built and energy-efficient, but too expensive and the requirements too restrictive.

- a cash rebate paid towards the mortgage closing costs
- a discounted mortgage interest rate
- an increase in the amount of credit for which one can qualify for a home loan
- guaranteed discounts on utility rates.

In general, the reactions to the cash rebate programs were very positive. The preference, by far, was for cash rebates paid directly to the home buyer as opposed to the down payment or mortgage closing costs. Most of the participants did not like the idea of a cash rebate with strings attached stipulating where it must be applied. A few participants did not like the idea of providing cash rebates, in any form, for energy-efficient homes. These people felt that one does not get anything for free, and the rebates would ultimately drive housing prices up. Also the rebates seemed like a "quick fix" to a long-term problem of improving the energy-efficiency of the building stock. Most of those expressing doubts about the rebates preferred incentives that would take a long-term approach.

The discounted interest rates incentive for purchasing an energy-efficient home received the most praise of the six programs presented. The most negative reaction towards any one of the programs was directed against the program that would increase the amount of a home mortgage for which a buyer could qualify if he purchased an energy-efficient home. Most of the participants felt that this was a "credit card" approach and would allow people to get into financial troubles. A few thought such a program would allow those who were just short of qualifying to purchase a home. These participants felt the program would be more attractive to the first-time home buyer.

Discounts on utility rates also were well received by almost everyone. This approach was perceived as promoting energy-efficiency with a long-term incentive. However, many in the groups were skeptical that utilities would offer such a program or were skeptical about the motivations for offering such a program.[a] Even with this skepticism, the program offering discounted utility rates was viewed positively overall.

When discussing cash rebates, the minimum acceptable incentive was around $1,000; participants felt that any amount below $1,000 would not be much of an inducement to purchase a highly energy-efficient home. Most of the participants felt, however, that they would pay an extra $2,500 to $5,000 for a highly efficient home and an incentive promoting energy-efficiency should be in this range.[b] For the incentive programs directed towards monthly savings (discounted interest rates and utility rates), the participants felt that, in general, the programs would have to reduce bills between $15 and $30 a month for them to want to participate.

3.2.3 Hedonic Price Analyses

We conducted two separate hedonic price analyses in the Tacoma area.[c] One was conducted for a specific neighborhood for the years 1981 through 1987 using a log-linear specification. The second was conducted for a different neighborhood for 1984 through 1988, using a linear specification.

Table 3.6 presents the regressions results from the first neighborhood.[d] This table shows only the results related to fuel type and the MCS. The regressions for the first neighborhood generally perform well. Adjusted R-squareds range between 0.57 and 0.83, with most around 0.80. The coefficients for each forced-air system and fuel type measure the effect of the fuel and equipment type relative to baseboard electric heat.[e] The coefficient for an oil furnace was statistically significantly different from zero only in 1981 (at the 0.05 level) and, applying weaker criteria, 1984 (at

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(a) It was stated that discounted utility rates might be a disguised attempt to lock homeowners into a costly heating fuel type. Also, it was felt that discounted utility rates would encourage energy consumption under the guise of saving energy.
(b) These perceptions about incentives and willingness to pay for higher energy-efficiency appear somewhat contradictory. They are relevant to the quantitative analyses discussed later in this report.
(c) See Lee, Englin, and Harkreader (1989) and Englin et al. (1990) for more details on the analyses discussed here.
(d) Coefficients must be multiplied by the mean sales price to derive the mean hedonic price for each house feature.
(e) There were no heat pumps in our sample.

TABLE 3.6. Tacoma Model Results in First Neighborhood[a]

	1987	1986	1985	1984	1983	1982	1981
MCS sq ft	0.0706	0.0491	0.0465	-0.00857	--	--	--
	(2.17)	(1.76)	(1.22)	(-0.25)	--	--	--
MCS $/sq ft	5.10	3.73	3.43	--	--	--	--
Oil Forced Air	36.44	64.68	-96.96	98.34	9.82	125.12	172.44
	(0.66)	(0.85)	(-0.79)	(1.39)	(0.14)	(1.31)	(2.19)
Gas Forced Air	131.05	112.7	86.55	25.44	-20.95	85.88	66.73
	(2.90)	(3.11)	(1.62)	(0.60)	(-0.48)	(1.05)	(1.25)
Gas Price, $	4300	2400	--	--	--	-1300	--
Electric Forced Air	71.55	80.63	27.82	41.86	90.91	104.65	-14.50
	(1.77)	(1.87)	(0.46)	(1.10)	(1.69)	(1.50)	(-0.20)
Observations	126	125	133	159	163	109	109
R-Squared	0.79	0.85	0.73	0.81	0.79	0.62	0.83
Adj R-Squared	0.76	0.83	0.70	0.80	0.77	0.57	0.81

(a) Note that all coefficients have been multiplied by 1000 for presentation purposes and t-statistics are shown in parentheses. Gas heat hedonic prices are based on the difference between the coefficients for gas and electric forced-air heat.

the 0.15 level). The value of an electric forced-air furnace was positive, relative to baseboard electric, in all years except 1981. In 1981 and 1985 the value was not statistically significant, and in the remaining years it was significant at about the 0.1 level. The values for gas forced-air heating are generally positive, although they are not statistically significant at conventional levels until the 1985 through 1987 period.

The incremental value of homes built to the MCS was estimated on a per-square-foot basis. This specification was used for two reasons. First, the cost of building to the MCS would be expected to vary with the size of a home because larger homes would require installing more insulation, larger areas of upgraded windows, etc. Second, the incentive paid under the EAP varied with floor area (up to certain limits); therefore, it would offset the incremental cost by an amount related to the area and would offset buyer costs in proportion to floor area <u>if passed along to buyers</u>. The incremental MCS value per square foot was estimated in regressions for new, electrically heated homes sold from June 1984 through 1987. In Table 3.6, the parameter estimate is negative and insignificant in 1984, positive but not quite significant at conventional levels in 1985, and positive and significant in 1986 and 1987.[a]

Table 3.7 shows similar results for the second neighborhood analyzed in Tacoma. After examining different model specifications, a linear specification of the model was selected for this neighborhood because it performed the best.

The data were pooled over the period 1984 through 1988. Single-family homes heated with either forced-air, heat pumps, or baseboard heating systems using natural gas or electricity were included in this model. Heating fuel and equipment type were separated in this analysis by defining separate variables for both characteristics. The effect of the MCS was incorporated as before using a square footage for MCS homes.

TABLE 3.7. Tacoma Model Results in Second Neighborhood

Variable	Estimated Coefficient	t-Statistic
Gas dummy, 1984	$3,157.68	2.40
Gas dummy, 1985	$2,676.79	2.10
Gas dummy, 1986	$1,558.71	1.35
Gas dummy, 1987	$2,254.98	2.18
Gas dummy, 1988	-$635.11	-0.37
Forced air dummy	$1,768.09	3.12
Heat pump dummy	$4,268.25	3.53
MCS sq ft - 85	$3.59	2.77
MCS sq ft - 86	$3.25	3.84
MCS sq ft - 87	$3.75	4.33
MCS sq ft - 88	$5.65	7.77
Number of Observations	1270	
R-squared	0.93	
Corrected R-squared	0.93	

(a) The ambiguous results for 1984 are probably attributable to data uncertainties. We assumed all electrically heated homes sold after May 1984 were MCS homes; however, many could have been permitted prior to MCS code implementation and grandfathered in. This misclassification of some 1984 non-MCS homes as MCS homes is probably responsible for the difficulty in isolating the effect of MCS on 1984 home prices.

The R-squared for this model was 0.93. Nearly 1,300 observations were included in this pooled model. In general, the model was well-behaved and the coefficients were as expected. The estimated coefficients for both of the heating system dummies were statistically significant and positive. The coefficient for gas heating was significant in 3 of the 5 years.

Table 3.8 summarizes the results from these two hedonic analyses in Tacoma. For the first neighborhood analysis, subtracting the effect of electric forced-air heat from gas forced-air heat provides an estimate of the pure fuel hedonic price effect. In the second neighborhood analysis, the fuel hedonic price is estimated directly. In the first analysis, the value of forced-air heating is estimated by the hedonic price of electric forced-air heating since it is estimated relative to electric baseboard. In the second analysis, this value is estimated directly.

The values for gas heat show that gas heating has been valued higher than electric heating since the mid-1980s. Both analyses support this result, although their estimates vary some. Heat pumps were worth an average of $4,300 more than baseboard electric systems between 1984 and 1988.

The MCS value is surprisingly stable and consistent between the two analyses and over the time period examined. Of the eight estimates, five were significant at the 0.05 level. They were all within the range of $3.30 to $5.70 per square foot.

Because the role of fuel type and MCS is of primary importance to Bonneville, we examine the implications of our Tacoma hedonic price results further. First of all, it was noted earlier that gas heat has been installed in a growing fraction of new homes in Tacoma since the MCS went into effect. While our analyses do not definitively determine how much of a role the MCS has played in this shift, the trend in the hedonic prices for natural gas heat relative to electric heat suggests that electric heat has become less attractive economically to buyers in Tacoma. Figure 3.3 presents information that summarizes two trends in Tacoma, based on local fuel prices and our hedonic prices from the first Tacoma analysis.

The figure shows the ratio of electricity to gas prices (adjusted for heating equipment efficiency) and the difference in hedonic prices for these

TABLE 3.8. Summary of Results for Two Tacoma Neighborhoods(a)

Year	Oil Heat, $		Gas Heat, $		Forced-Air, $		Heat Pump, $		MCS, $/sq ft	
	1	2	1	2	1	2	1	2	1	2
1981	---	N/A	---	N/A	---	N/A	N/A	N/A	N/A	N/A
1982	1,500	N/A	-1,300	N/A	7,400	N/A	N/A	N/A	N/A	N/A
1983	---	N/A	---	N/A	7,100	N/A	N/A	N/A	N/A	N/A
1984	4,300	N/A	---	<u>3,200</u>	3,200	<u>1,800</u>	N/A	<u>4,300</u>	---	N/A
1985	---	N/A	---	<u>2,700</u>	---	<u>1,800</u>	N/A	<u>4,300</u>	3.4	<u>3.6</u>
1986	---	N/A	2,400	1,600	6,100	<u>1,800</u>	N/A	<u>4,300</u>	3.7	<u>3.3</u>
1987	---	N/A	4,300	<u>2,300</u>	5,200	<u>1,800</u>	N/A	<u>4,300</u>	<u>5.1</u>	<u>3.8</u>
1988	N/A	N/A	N/A	---	N/A	<u>1,800</u>	N/A	<u>4,300</u>	N/A	<u>5.7</u>

(a) Notes: 1) Results in column 1 are from the first area analyzed in Tacoma; column 2 results are from the second area and analysis. 2) Values for each heating fuel in area 1 are the difference between the hedonic price for that fuel and electric, forced-air heat. 3) Values for forced-air in area 1 are based on the coefficients for forced-air, electric heat. 4) "N/A" indicates that the value was not estimated. 5) "---" indicates that the estimated value is not reported because one or more of the required coefficients had a t-statistic of less than 1.0. 6) Underlined values are significant at the 0.05 level or better. 7) All values have been rounded to two significant digits.

two fuels (electricity minus gas).[a] Clearly, the trend in electricity utility prices has been upward. At the same time, a general decline in the value of electric heat can be observed. The hedonic prices appear to reflect the response of buyers to changing fuel prices in their valuation of different heating fuels. These trends suggest that the market share for electricity has declined in Tacoma, in part, as a result of the trend in fuel prices. The following discussion provides insights into how the MCS has affected market shares.

(a) Note that the hedonic price differences are calculated regardless of whether the values were statistically significant.

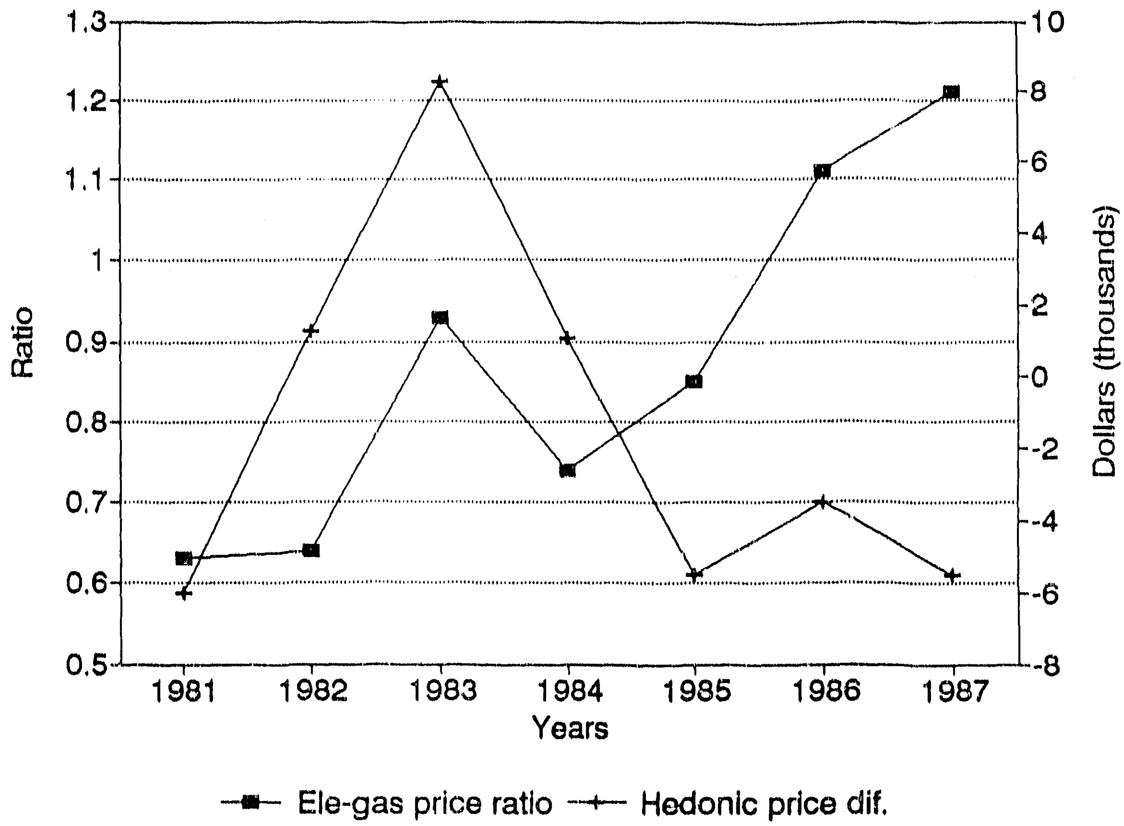

FIGURE 3.3. Fuel Price Ratio (Electricity/Gas) and Difference in Hedonic Price (Electricity - Gas), Tacoma

It is clear from our other results that builders are sensitive to the market through buyer preferences and demands. In anything but the very short term, buyer demand largely determines what builders decide to build. To investigate the economics that face builders, we look at the builders' financial situation.

Table 3.9 presents the builder's "balance" sheet for the fuel choice. A builder who could estimate reasonably well how much buyers were willing to pay to have different heating fuels could calculate what the profit margin would be for either gas- or electrically heated homes in any particular year. A useful example is 1987. The table shows the calculations for 1,000- and 1,500-square-foot houses based on the results from our first analysis of Tacoma.

TABLE 3.9. Sample Builder Financial Calculations[a]

	Gas	Electric	
1987 Calculations		1500 sq ft	1000 sq.ft.
Fuel hedonic price differential	$4,300	0	0
MCS hedonic price differential	0	$7,650	$5,100
MCS construction cost effect	0	-$3,000	-$2,000
MCS incentive	0	$1,500	$1,000
Total net profit	$4,300	$6,150	$4,100
1986 Calculations			
Fuel hedonic price differential	$2,400	0	0
MCS hedonic price differential	0	$5,550	$3,700
MCS construction cost effect	0	-$3,000	-$2,000
MCS incentive	0	$1,500	$1,000
Total net profit	$2,400	$4,050	$2,700

(a) The calculations assume MCS homes cost an additional $2 per sq ft to build and that incentive levels are $1 per sq ft. The difference between electric and gas forced-air system coefficients represents a pure fuel effect if the mechanical portion of the electric and gas forced-air systems are equal in cost.

The results indicate that in 1987, 1,500-square-foot houses were most profitable if they were built with electric, rather than gas, forced-air heat and received the MCS incentive. If the incentive had been dropped, or passed through to the buyer, 1,100 sq ft electrically heated homes would have been about as profitable as gas-heated houses. On the other hand, smaller houses were somewhat less profitable to build with electric heat. If the MCS incentive had been dropped, or passed through to the buyer, small electrically heated houses would have returned about $1,300 less profit than gas-heated houses. Calculations for 1986 show similar results.

Because the hedonic price analyses show that buyers have paid substantial premiums for MCS homes, they suggest that builders in Tacoma do not typically pass the MCS incentive through to buyers.[a] Even though MCS homes cost more to build, the economics to the builder, particularly with the incentive, appear attractive enough that builders would not shift to building gas-heated homes exclusively. The willingness of buyers to pay a premium for MCS homes indicates that early MCS home buyers have placed a substantial value on owning such homes.

To fully understand the market response it is essential to develop information about MCS supply and demand. Section 3.2.5 addresses the demand side. A study of the supply side was beyond the scope of this project, but such a study would be essential to Bonneville to allow an adequate understanding of the influence that the MCS has on the housing market.

3.2.4 Logit Discrete Choice Analysis

The first set of Tacoma hedonic price estimates was used, with other data as described earlier, in a logit model applied in two ways.[b] The first was to examine the actual fuel in the house and relative prices and individual attitudes. The second was to examine the preferred heating fuel. This approach allowed comparing the factors influencing the actual fuel and the preferred fuel.

Table 3.10 shows the final results. The regressions predict choices reasonably well and conform to most prior expectations about model specification. The individual's perceived cost is always a statistically significant factor in fuel choice. The difference in perceived safety is also an important factor in both regressions. The number of bathrooms is important in the model for actual fuel chosen. Its statistical significance and parameter estimate are fairly robust with respect to model specification, and

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(a) Although Bonneville does not dictate who receives the program incentives, it appears that in Tacoma the builders have received the large majority of the incentives (personal communication with Ms. Barb Orthund, Tacoma City Light, November 15, 1990). Our analysis suggests that the builders typically keep the incentive as part of their profit.
(b) See Lee, Englin, and Harkreader (1989) for details of this analysis.

TABLE 3.10. Logit Regression Results[a]

Dependent Variable = 1 if gas; 0 if electricity

Independent Variable	Actual Fuel	Preferred Fuel
Constant	-6.698*	-1.363
	(-2.041)	(-0.442)
Low cost difference	0.516*	0.900*
	(2.327)	(3.487)
Safety difference	0.946*	0.791*
	(2.901)	(2.824)
Male education	-0.271	-0.111
	(-1.547)	(-0.623)
Male age	0.04286	0.01986
	(1.581)	(0.695)
Female age	0.2996	0.272
	(1.467)	(1.253)
Number of bathrooms	1.678*	-0.151
	(2.562)	(-0.248)
Adjusted fuel price	-0.0239	0.02008
	(-0.577)	(0.456)
Pure hedonic fuel price	52.930	-23.351
	(0.804)	(-0.555)
Pure hedonic fuel price squared	-0.0786	-80.0336
	(-0.968)	(-0.133)
Log likelihood	-41.8	-38.6
Number of observations	92	82
Percent correctly predicted	81.52	79.27

(a) The t-statistics are shown in parentheses and coefficients with an asterisk are significant at the 0.1 level or beyond. "Adjusted fuel price" takes heating equipment efficiency into account.

it is included, therefore, without strong prior expectations about its role in fuel choice.

The final set of variables in the choice regressions are price variables. The price variables are specific to the year the house was bought. These include the equipment-efficiency-adjusted fuel prices, the hedonic price of the fuel, and the hedonic price squared. The hedonic price squared is included to capture expected non-linearity in the effect of the hedonic price on the fuel choice.

The adjusted fuel price difference is negative in the actual fuel choice regression and positive in the preferred choice regression. The parameter size is about equal. The negative coefficient in the actual choice regression is the expected one: as gas becomes more expensive relative to electricity, the likelihood of choosing gas goes down. The difficulty this application faces is that only four price differences (for the years 1984 through 1988) are represented. The lack of precision of the parameter estimates and the apparently wrong sign of the coefficient in the preferred fuel case are most likely due to the lack of variation in the data.

The hedonic prices are also entered in the equation. The regression for actual fuel does not conform to expectations about the hedonic price effect: the pure hedonic price effect is positive, and the squared term is negative. Neither coefficient is statistically significant. In the regression for the preferred fuel, the hedonic price results do not agree well with expectations. Both coefficients are negative, and both have markedly reduced levels of significance. Overall, these variables do not perform very well, and they also suffer from a lack of variation in the data.

Generally, the coefficients in the model based on the actual fuel choice have the anticipated signs, and the model performs reasonably well. The model based on stated fuel preferences, however, is less satisfying. One explanation for this lies in the way in which the data were gathered and organized. The regression using the actual fuel choice related the actual prices in the year the choice was made to the choice. The preferred fuel model, however, related those same prices to current owner preferences. Since many of these interviewees bought their homes 2, 3, or 4 years ago, fuel prices from those years need not be particularly good indicators of what people would choose today.[a] An expanded sample, either cross-sectional or inter-temporal, would increase our ability to discern the effect of fuel prices on individual choices.

(a) The best approach, of course, is to relate today's fuel prices to the preferred fuels. However since this study examines only Tacoma, there would be only a single set of prices and estimation is impossible.

3.2.5 MCS Demand

Table 3.11 shows the MCS inverse demand analysis results for the specification that best fit the Tacoma data.[a] As noted earlier, difficulties in identifying MCS homes in other locations prevented us from analyzing MCS demand elsewhere.[b]

An inverse demand function was chosen for this demand analysis (see Englin et al. 1990). The inverse demand function treats the hedonic price ($ per sq ft built to the MCS) as the dependent variable and the quantity of MCS (in square feet) and other variables as the independent variables. This model uses both the hedonic price and the hedonic price squared.

The inverse demand function generally behaved as anticipated. In this specification, the demand equation slopes downward at a diminishing rate. The demand curve does not convey much information about the relationship between hedonic prices and quantity beyond a simple average of the prices. The results suggest that the hedonic price of MCS is not likely to move much from the $3.50 to $5.00 per sq ft range, and this finding is consistent with the hedonic price analysis in Vancouver.

The demographic variables are not statistically significant, probably because of the limited variation in zip code-level demographic variable averages in a single neighborhood. On the other hand, the house variables, size and fireplace, are statistically significant. The fuel price ratio is statistically significant and is clearly an important determinant of the demand for MCS housing. As would be expected, higher prices for electricity

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(a) The data also were analyzed with a specification excluding the quadratic hedonic price term. It produced results similar to the quadratic specification results, but did not fit the data as well and, because of the lack of a quadratic term, was unable to capture any marginally diminishing effects of price. See Englin et al. (1990) for more details.

(b) The MCS specification used in this analysis was the same as that for the natural gas analysis reported later except that the squared electricity natural gas price ratio term was omitted here. It was omitted because it drove the R-squared of the regression to 0.98 and caused both price ratio terms to have t-statistics over 100. This was likely the result of there being only 4 independent price ratio terms; one for 1985, 1986, 1987, and 1988.

TABLE 3.11. MCS Inverse Demand Model Results[a]

Variable	Quadratic Model Estimated Coefficients
Constant	1.7000 (2.29)
MCS quantity (sq ft)	-0.000943 (-2.69)
MCS quantity squared $(sq\ ft)^2$	0.0000007 (2.93)
Median age (yr)	0.000943 (0.02)
Average income ($)	0.0000448 (0.91)
% College graduates	-0.00557 (-0.01)
Female labor force participation rate (%)	0.0598 (0.23)
House age (yr)	-0.000611 (-0.46)
House size (sq ft)	-0.000171 (-1.95)
Fireplace	0.108 (1.98)
Electricity-Gas price ratio ($ per kWh/$ per therm)	56.4 (17.85)
Labor force participation rate (%)	-0.0767 (-0.36)
Number of observations	1045
R-squared	0.26
Corrected R-squared	0.25
Standard error of the regression	0.784
Mean of dependent variable	4.02

(a) t-statistics are shown in parentheses.

relative to natural gas increase the amount that buyers are willing to pay for MCS homes.

The equation is most easily interpreted as a market demand equation. By aggregating across individuals, the total MCS square footage that will be purchased in a city can be calculated using a given price per square foot for MCS. The electricity-natural gas price ratio coefficient can be used to examine shifts in MCS demand resulting from changes in relative utility prices. The results indicate that a 10% increase in the relative price of electricity would increase the value of electrically heated MCS homes 25 cents per sq ft. The change in the value of MCS homes and the estimated change in energy and utility bill savings attributable to the MCS can be combined to calculate consumer discount rates. We estimate a consumer discount rate of between 7% and 9% if electricity prices increase 10% faster than gas prices.

3.2.6 New-Home Buyer Conjoint Analysis

The survey for the Pierce County conjoint analysis, besides gathering information on buyers' house profile rankings, also collected data on key characteristics of the respondents and their homes through a series of questions on the survey.[a] Table 3.12 shows the characteristics data.

Cross-tabulations of these data were also examined to reveal information about market segments. Those people who reported purchasing semi-custom or custom homes tended to choose the primary heating fuel for the home. While most people purchased semi-custom homes, first-time buyers usually purchased a

(a) See Lee et al. (1990) for additional details on the results reported here.

TABLE 3.12. Description of the Pierce County Respondents and Their Homes

Respondents' Characteristics		Sample %
Sex	Male	67
	Female	33
Age	Under 25	5
	15 - 34	29
	35 - 44	36
	45 - 54	15
	55 - 64	14
	65 and over	2
Home's primary heating fuel selection	Selected home's fuel	47
	Selected home with preferred fuel	19
	Someone else made the fuel choice	34
Number of homes owned	1	38
	2	22
	3 - 4	24
	5 or more	16
Primary heating fuel	Electricity	62
	Natural gas	30
	Wood	8
	Other	0
Secondary heating fuel	Electricity	11
	Natural gas	0
	Wood	46
	Other	0
	Do not have one	42
Type of home	Custom-built	36
	Semi-custom	34
	Tract	30
Purchase price of home	Under $60,000	12
	$60,000 - $79,999	28
	$80,000 - $99,999	28
	$100,000 - $119,999	9
	$120,000 - $139,999	4
	$140,000 - $159,999	5
	$160,000 - $179,999	3
	$180,000 - $199,999	3
	$200,000 and over	8

tract or a semi-custom home, whereas other buyers tended to purchase semi-custom or custom homes. Accordingly, first-time homeowners were currently living in less expensive homes and tended to be younger, usually less than 35 years old. These data showed that 36% of the Pierce County homes were custom-built homes.

Respondents who did not decide on the type of primary heating fuel for their home more often than not owned an electrically heated home. In Pierce County, homeowners who did not choose their fuel tended to be first-time homeowners. First-time home buyers predominantly bought electrically heated homes, whereas other buyers predominantly bought non-electrically heated new homes.[a]

Fifty-eight percent of the respondents in Pierce County had a secondary heating fuel. The secondary heating fuel was usually wood.

The house profile rankings collected through this survey were the basis for a conjoint analysis of the house purchase decision. The primary output from a conjoint analysis is a set of values indicating the utility that respondents attach to each level of the factors considered. These utility values are estimated for each respondent, and the group utility values are the average of the individual utility values. The group utility values are used to estimate the total value respondents would place on a hypothetical home purchase situation. The total utility value is the sum of the utility values for the factor levels in the situation.

The relative importance of each factor in the purchase decision was calculated from the conjoint analysis data; Table 3.13 indicates the estimated relative importance of each factor included in the Pierce County conjoint analysis. The relative importance of the factors takes into account only those factors that were included in the design. Factors such as location and financing, which might be more important to the home buyer than some of the factors considered here, were not included in the analysis.

(a) In Pierce County, 68% of first-time buyers purchased electrically heated homes, whereas only 40% of buyers purchasing their second or subsequent home bought homes heated with electricity.

TABLE 3.13. Relative Importance of Factors, Pierce County

Factors	Relative Importance, %
Primary heating fuel	34.8
House size	32.9
House type	15.9
Cash rebate	6.7
Energy-efficiency of home	3.6
Levels in home	3.1
Presence of a utility rate discount	3.0

The most important factor in Pierce County is the primary heating fuel; it is slightly more important than house size. It appears that the high importance calculated for the primary fuel type results mostly from the inclusion of wood heating as an option because participants who dislike wood heat have relatively strong negative reactions to wood heat. If only electricity and gas were included in the analysis, it is likely that the importance of fuel type would have been considerably less.

In order of importance, the rest of the factors are house type, cash rebate, energy-efficiency, levels in home, and utility rate discount. Factors that represent aesthetic qualities or floor plan features (house type, size, and number of levels) account for over 50% of the total range in utility values and are much more important than the purchase incentives or the level of energy-efficiency of the home.

Table 3.14 contains the group utility values for each factor level. Within each factor, the most preferred levels have the highest positive

TABLE 3.14. Pierce County Utility Values for the Factor Levels

Factor	Factor Levels	Factor Level Utility Values
House type	Tract	-1.49
	Custom	0.66
	Semi-custom	0.83
Levels in home	Single-level	0.23
	Multi-level	-0.23
House size	1,100 sq ft	19.47
	1,500 sq ft	22.83
	1,900 sq ft	24.21
	2,300 sq ft	23.60
		vector 2.47
		quad. -0.06
Primary heating fuel	Wood	-3.20
	Electricity	1.32
	Natural gas	1.89
Cash rebate	None	0.00
	$400	0.32
	$800	0.63
	$1,250	0.99
		vector 0.08
Presence of a utility rate discount	No rate discount	-0.22
	$15/month	0.22
Energy-efficiency of home	Average efficiency	-0.26
	High efficiency	0.26

utility values.[a] A negative utility does not mean that the respondents place no value on the particular level; it just means that the respondents value that level less than other levels. For the factors that have quantities associated with them (such as house size or the level of a cash rebate), the utility values are a function of a vector (linear) coefficient and possibly a quadratic term. In this analysis the relationship between the size of a home and the utility value for the size is curvilinear: homeowners tend to value larger homes more up to a certain floor area, then their utility value declines with larger floor area.

The utility value results are an overall average for the new-home buyers in the county and they do not necessarily describe the utility values of segments of the new-home buyer population. Because targeting programs to specific subgroups is often cost-effective, we compared the conjoint analysis results with the demographics of specific subgroups of respondents.

Pierce County respondents have a higher utility value for the type of home they currently own. For example, although tract homes have the lowest utility values across all the respondents, tract-home owners have higher utility values for tract homes than either custom- or semi-custom-home owners.

The respondents' utility values for the number of levels in a home indicate that first-time homeowners tend to want multi-level homes, whereas homeowners over 55 and previous homeowners prefer single-level homes. We believe this finding is reasonable because older people are likely to prefer not to negotiate stairs, and older people usually have owned more homes.

(a) For testing the reliability of our results, 2 of the 18 profiles the respondents were asked to rank were hold-out cards. The group utility values were estimated using only the other 16 profiles. These group utility values were then used to predict the ranking of the 2 hold-out cards. Two measures of the reliability of the conjoint results were calculated: the hold-out card correlation and the absolute difference between the predicted ranks and the actual ranks of the hold-out cards. There was a high correlation (0.86) between the predicted and actual ranks of the hold-out cards. The absolute difference between ranks indicated that the group utility values were able to predict the actual ranks of the hold-out cards within approximately plus or minus two and half ranks. By this measure, the conjoint analysis results were able to predict on the average which quartile the hold-out cards would fall in.

Similar to the results for home type, the respondents have higher utility values for the heating fuel they presently use. Respondents over 55 years old have higher utility values for electricity than those under 55 years old. A cash rebate incentive is better accepted among tract-home owners and homeowners under 35 years old. Pierce County homeowners over 55 have a lower utility value (15.21) for a 1,500 square foot home than those between 35 and 54 (21.33) and those under 35 (29.58); thus older homeowners appear less likelv to prefer larger homes.

The above discussion indicates that specific groups of homeowners value certain characteristics of a home more than other groups of homeowners. We addressed this by segmenting homeowners into groups with similar utility values.[a] The segmentation approach and results for Pierce County and the other three counties studied are discussed in detail in Lee et al. (1990). Such information could be useful for targeting programs.

A strength of conjoint analysis is the ability to use the utility values to simulate the respondents' choice behavior in hypothetical situations. The simulations shed some light on important programmatic and planning questions by using the individuals' utilities for the factor levels calculated in the conjoint analysis. Given a specific situation, the utility values for the levels of the factors in the situation are summed to produce a total utility value for that situation.[b]

We simulated the decision to purchase an electrically heated house or one heated with natural gas by starting with six typical houses. These six were various combinations of house type (custom or tract) and floor area

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(a) The method used was a K-means cluster analysis of the respondents' utility values. This clustering technique splits the sample into a specified number of groups such that the between-groups variation in the group means is as large as possible relative to within-group variation of the utility values.

(b) We examined two models to estimate how many respondents would choose which home in the simulations: the first-choice model and the Bradley, Terry, and Luce (BTL) model (Bretton-Clarke 1987). The first-choice model, which simply selects as the respondent's choice the alternative with the highest utility value, matched the actual market shares data best and we used it for each of the four counties studied and report its results here.

(1,100, 1,900, or 2,300 square feet). The houses were assumed to be multi-level. Simulations were then used to estimate market shares for each basic house type under six hypothetical situations. All six house types were included in each simulation, but the primary heating fuel, the purchase incentives, and the level of energy-efficiency were varied. The effect on fuel choice was determined by adding up the shares of homes with electrical heat and the shares with gas heat.

The base simulation includes electrically heated homes with the same level of energy-efficiency as the alternative gas-heated homes and with no purchase incentives. This basically models the situation in the absence of the MCS for electrically heated homes and without any incentives associated with energy-efficiency. In the second simulation, the electrically heated homes are energy-efficient homes with no purchase incentives. For our purposes, the efficiency level of the energy-efficient homes is assumed to be comparable to MCS. Each simulation thereafter adds alternative purchase incentives for the energy-efficient (MCS), electrically heated homes. Table 3.15 displays the simulation results for Pierce County.

Under the base case, i.e., equal energy-efficiencies and no purchase incentives, the simulation indicates a larger market share for natural gas heating than electric heating. When MCS is introduced for electrically heated homes, without any incentives, the estimated market share for electricity increases by about two percentage points. This suggests that buyers attach a value to energy-efficiency even without incentives to defray the added first-

TABLE 3.15. Percentage of Respondents Predicted to Choose Home with a Particular Primary Heating Fuel, Pierce County

	Case					
				MCS, Cash Rebate		
	Base	MCS	MCS, Rate Discount[a]	$400	$800	$1,250
Electric home	44%	46%	50%	53%	58%	61%
Natural gas home	56%	54%	50%	48%	42%	39%

(a) $15/month

cost. The remaining columns show the effects of different types of incentives tied to MCS, electrically heated homes.

The utility rate discount ($15/month) causes the share of electrically heated, MCS homes to increase to 50%. The last three columns show the effect of cash rebates on market shares. The lowest rebate level, $400, produces a penetration effect slightly larger than the utility rate discount, increasing the share of electrically heated houses to 53%. The highest rebate, $1,250, increases the market share to about 61%. The effect of the rebate tends to decline as the rebate amount increases, but larger rebates have a significant effect on the shares of electrically heated homes.

There was no systematic way to test the results of the market simulations; however, we were able to compare our estimates to actual market data in Tacoma. In 1987, the share of new homes in Tacoma heated with electricity was around 55% [Lee, Englin, and Harkreader (1989, p. 1.5)]. Our estimate based on the highest incentive level was 61%, which was quite close to the observed share.[a] If we assumed that builders did not pass the incentives along to buyers as the hedonic price analysis suggested, then this simulation estimated that 46% of new homes would be electrically heated. This estimate was less than the actual market shares. These two simulation-based estimates bracketed the actual value. Our estimates were in the same range as the reported shares, and this supported the validity of the simulation model used here. More tests of the ability of our results to fit empirical data would be required to establish the level of confidence that could be attributed to predictions from the market shares analysis. While these results did not resolve the issue of what the shares would have been without incentives, they suggested that incentives received by buyers could contribute about another 10% to the market share of electrically heated homes.

(a) The $1,250 incentive is comparable to the amount paid to builders in Tacoma under the MCS programs. The reader should note that in our analysis the incentives were assumed to be directed at the buyer, whereas the MCS programs typically give the incentives to builders and, as noted earlier, predominantly went to the builders in Tacoma.

3.3 ANALYTIC RESULTS FOR SPOKANE COUNTY, WASHINGTON

The second most fully analyzed area in our study was Spokane County, where we conducted a hedonic price analysis, buyer focus groups, and buyer conjoint analysis.

3.3.1 Hedonic Price Analysis

The results of the hedonic price regression analysis for a selected Spokane area are summarized in Table 3.16.[a] The equation had an R-squared of 0.73.

The dummy variables for heating equipment types and two of four gas fuel variables were statistically significant. The heating equipment variables have credible coefficients. The estimated impact of forced-air heating on the value of a home, as compared to electric baseboard, is about $4,000. Electric wall heaters, however, make the average home about $2,300 less valuable than a home with baseboard heat. The coefficients of the fuel type variables are statistically significant in 1986 and in 1988.[b] In both these years the value for gas heat is negative.

TABLE 3.16. Spokane Area Model Results (Dependent variable: Sale price)

Independent Variable	Estimated Coefficient	t-Statistic
Forced air	$4073	4.34
Wall furnace	-$2311	-3.23
Gas dummy, 1986	-$5327	-2.89
Gas dummy, 1987	$1486	0.85
Gas dummy, 1988	-$3458	-2.06
Gas dummy, 1989	$ 580	0.12
Number of Observations	2897	
R-squared	0.74	
Corrected R-squared	0.73	

(a) Englin et al. (1990) present more information on this analysis.
(b) "Gas dummy" indicates the hedonic price for gas heating compared to electric heating.

When we attempted to include the effect of MCS in our analysis, we discovered that no MCS homes built under the EAP or SGC were in our sample. It appeared that the actual population of MCS homes in Spokane was quite small at the time we conducted our analysis and that the assessor's database available to us included no MCS homes because of the lag-time involved in getting the data into the database. Consequently, we were unable to estimate the value of MCS in Spokane.

3.3.2 New-Home Buyer Focus Groups

The buyer focus group results for the Spokane area agree quite closely with those from Tacoma.[a] The differences are pointed out here.

Spokane homeowners tended to have more familiarity with wood heat than homeowners in Tacoma. Over half the focus group participants had used wood heat at one time or another. In addition, most of the participants who had electricity as their primary heating fuel actually preferred wood.

The other way Spokane homeowners differed from their counterparts in Tacoma was less familiarity with SGC homes. Only a few of the participants knew anything about Bonneville's SGC program.

3.3.3 New-Home Buyer Conjoint Analysis

The conjoint analysis of new-home buyers in Spokane produced results quite similar to those for Tacoma.[b] Table 3.17 summarizes the characteristics of the participants in Spokane and their homes. An examination of this table and Table 3.12, as well as the cross-tabulations of the data, shows only a few differences between the Tacoma and Spokane samples.

In Spokane, over half the participants indicated they lived in custom-built homes, whereas only 36% of the Pierce County participants did.[c] In Spokane County, a larger percentage of people reported deciding on their

(a) See Lee et al. (1990) for more information on this analysis.
(b) Lee et al. (1990) present more information on this analysis.
(c) We suspected that the large share of respondents reporting custom-built homes in Spokane might have been due to differences in the response rates for households where we did and did not have occupant names. As discussed in Section 2.3, however, there was no difference in the response rates between these two groups in Spokane.

TABLE 3.17. Description of the Spokane County Respondents and Their Homes

Respondents' Characteristics		Sample %
Sex	Male	62
	Female	38
Age	Under 25	4
	15 - 34	30
	35 - 44	42
	45 - 54	15
	55 - 64	6
	65 and over	3
Home's primary heating fuel selection	Selected home's fuel	62
	Selected home with preferred fuel	14
	Someone else made the fuel choice	24
Number of homes owned	1	16
	2	30
	3 - 4	36
	5 or more	17
Primary heating fuel	Electricity	42
	Natural gas	44
	Wood	12
	Fuel Oil	1
	Propane	1
Secondary heating fuel	Electricity	14
	Natural gas	2
	Wood	38
	Fuel Oil	1
	Propane	1
	Kerosene	1
	Do not have one	44
Type of home	Custom-built	54
	Semi-custom	37
	Tract	9
Purchase price of home	Under $60,000	7
	$60,000 - $79,999	27
	$80,000 - $99,999	26
	$100,000 - $119,999	10
	$120,000 - $139,999	13
	$140,000 - $159,999	6
	$160,000 - $179,999	2
	$180,000 - $199,999	4
	$200,000 and over	5

primary heating fuel, regardless of the number of homes they had purchased or their age. Also, Spokane County respondents with more expensive homes had a slight tendency to have non-electric primary heating fuels. A few respondents in Spokane County used natural or propane gas, fuel oil, or kerosene as a secondary heating fuel.

Table 3.18 presents the importance levels as determined from the Spokane conjoint analysis. These results are essentially the same as those for Tacoma.

Table 3.19 presents the utility values for the different factor levels included in the Spokane conjoint analysis.[a] Again, these results agree quite well with those for Tacoma. The only notable difference is a reversal in the utilities for multi-level and single-level homes.

A market shares simulation was also conducted in Spokane. The results are shown in Table 3.20. The estimated base market share (no MCS, no incentives) for electric heat was only 23%. Introduction of MCS for electrically heated homes increased this share substantially, to 37%. The addition of incentives, however, appeared to have a relatively small effect. While higher cash rebates increased the market share, their effect diminished

TABLE 3.18. Relative Importance of Factors, Spokane County

Factors	Relative Importance, %
Primary heating fuel	33.2
House size	32.9
House type	18.2
Cash rebate	6.6
Energy-efficiency of home	4.9
Levels in home	2.4
Presence of a utility rate discount	1.7

(a) The correlation coefficient for the conjoint analysis hold-out card results was 0.84, indicating that the results predicted the respondents' choice very well.

TABLE 3.19. Spokane County Utility Values for the Factor Levels

Factor	Factor Levels	Factor Level Utility Values
House type	Tract	-1.69
	Custom	0.99
	Semi-custom	0.71
Levels in home	Single-level	-0.18
	Multi-level	0.18
House size	1,100 sq ft	19.57
	1,500 sq ft	22.96
	1,900 sq ft	24.38
	2,300 sq ft	23.81
		vector 2.46
		quad. -0.06
Primary heating fuel	Wood	-2.68
	Electricity	0.45
	Natural gas	2.23
Cash rebate	None	0.00
	$600	0.31
	$1,250	0.65
	$1,900	0.99
		vector 0.05
Presence of a utility rate discount	No rate discount	-0.13
	$20/month	0.13
Energy-efficiency of home	Average efficiency	-0.36
	High efficiency	0.36

TABLE 3.20. Percentage of Respondents Predicted to Choose Home With a Particular Primary Heating Fuel, Spokane County

	Case					
				MCS, Cash Rebate		
	Base	MCS	MCS, Rate Discount[(a)]	$600	$1,250	$1,900
Electric home	23%	37%	41%	40%	44%	47%
Natural gas home	77%	63%	59%	60%	56%	53%

(a) $20/month

as the rebate levels increased. The rate discount had an effect on estimated market shares that was equivalent to about an $800 cash rebate. The incentive levels simulated are slightly higher than those for Tacoma to account for the climate and MCS program differences between the two areas.

There was no independent source of data available to validate our simulation results. We were able, however, to compare the simulation results with our demographic data for the conjoint survey respondents. That survey indicated that 42% of new homes in Spokane County had electric heat. The City of Spokane adopted the MCS as code in December 1987, and outside the city two of the utilities have joined the SGC program at different times since 1986. Consequently, there is no simple simulation case that corresponds directly to the situation in Spokane County. For comparison purposes, we used a case with a $1,900 incentive provided for MCS homes, recognizing that this would be likely to overstate the effect on the electric heat market share. The estimated market share for this case was 47%, slightly larger than the value for our sample. Under the condition that the incentive was not passed along to buyers, our estimated market share was 37%, slightly under the value observed in our sample. This comparison demonstrated that the simulation produced reasonably accurate market share estimates.

3.4 ANALYTIC RESULTS FOR KING COUNTY, WASHINGTON

Our King County analyses were limited to a hedonic price analysis and conjoint analysis. No focus groups were conducted in King County.

3.4.1 Hedonic Price Analysis

The hedonic price analysis was conducted in Kirkland, a community in King County outside of Seattle.[a] It was restricted to using the hedonic price technique to determine the effect of fuel type on sales price. No data for MCS or SGC program homes were available to allow estimation of the value of MCS.

The Kirkland hedonic price regression was specified in log-linear form, using pooled data. The dependent variable was the log of the sales price of

(a) Englin et al. (1990) present a detailed description of this analysis.

the house, and the explanatory variables consisted of a constant, a set of annual intercept terms, a set of house characteristics terms, a set of annual fuel dummy variables, and a set of heating system dummy variables.

The Kirkland sample consisted of 5 years of county assessor data, 1984 through 1988. Table 3.21 presents a summary of the regression results for the Kirkland model. The model had an adjusted R-squared of 0.77, indicating a reasonably good fit.

All of the gas heat dummy variable coefficients were negative and the coefficients for 1987 and 1988 were statistically significant. The dollar contribution to sales price of gas heat over electric, all other factors held constant, is also shown for each year. In the 2 years for which statistically significant estimates were obtained, the values of the gas heat coefficient were virtually identical. Neither of the heating equipment variable coefficients was statistically significant in this model. Despite their lack of statistical significance, both estimates had the expected sign and reasonable magnitudes.

TABLE 3.21. Kirkland Model Results[(a)]

Variable	Estimated Coefficient	t-Statistic	Estimated Price
Gas dummy, 1984	-0.0029	-1.13	-$3,000
Gas dummy, 1985	-0.0023	-0.06	-$ 242
Gas dummy, 1986	-0.0492	-1.59	-$5,100
Gas dummy, 1987	-0.0610	-2.12	-$6,300
Gas dummy, 1988	-0.0591	-2.14	-$6,100
Forced air	0.0466	1.56	$4,500
Floor or wall furnace	-0.0164	-0.48	-$1,700
Number of observations	451		
R-squared	0.79		
Corrected R-squared	0.77		

(a) Values significant at the 0.05 level are underlined.

3.4.2 New-Home Buyer Conjoint Analysis

The conjoint analysis in King County used a survey of new-home buyers throughout King County; therefore, it included Kirkland as well as other areas in the random sample.[a]

Table 3.22 summarizes the characteristics of the survey respondents in King County and their homes. Compared with Pierce County, far fewer new King County houses had electric heat and more were considered to be semi-custom. Otherwise, the characteristics agreed fairly closely with those for Pierce County.

Table 3.23 presents the importance levels of the factors as determined from the conjoint data for King County. The major difference with the other counties was the large importance of fuel type in King County. The utility values (see Table 3.24) suggested that this was due to a strong negative reaction to wood heat.

Table 3.24 presents the utility values for the different factor levels.[b] These results are fairly similar to those for the counties discussed previously.

Table 3.25 shows the results of the market shares analysis for King County. The estimated base case market share (no MCS, no incentives) for electric heat was only 13%, the lowest of all the counties studied. Introduction of MCS for electrically heated homes increased this share to 24%, a substantial increase but still a small share. The introduction of incentives had an additional, but smaller effect. While higher cash rebates increased the market share, their effect diminished as the rebate levels increased. The $15/month rate discount had an effect on estimated market shares that was equivalent to about an $800 cash rebate.

(a) See Lee et al. (1990) for more details of this analysis.
(b) The correlation coefficient for the hold-out cards was 0.87, indicating that the conjoint analysis performed very well in predicting the respondents' choices.

TABLE 3.22. Description of the King County Respondents and Their Homes

Respondents' Characteristics		Sample %
Sex	Male	60
	Female	40
Age	Under 35	34
	35 - 54	57
	55 and over	9
Home's primary heating fuel selection	Selected home's fuel	29
	Selected home with preferred fuel	30
	Someone else made the fuel choice	41
Number of homes owned	1	28
	2	27
	3 - 4	30
	5 or more	15
Primary heating fuel	Electricity	21
	Natural gas	75
	Wood	3
	Other	2
Secondary heating fuel	Electricity	7
	Natural gas	2
	Wood	46
	Other	3
	Do not have one	44
Type of home	Custom-built	21
	Semi-custom	55
	Tract	24
Purchase price of home	Under $100,000	37
	$100,000 - $229,999	54
	$230,000 and over	26

TABLE 3.23. Relative Importance of Factors, King County

Factors	Relative Importance, %
Primary heating fuel	48.6
House size	31.9
House type	5.8
Cash rebate	6.1
Energy-efficiency of home	1.7
Levels in home	0.7
Presence of a utility rate discount	5.1

As with most of the counties, we had no independent source of data with which to compare our simulation results. We were able, however, to compare the simulation results with our demographic data for the conjoint survey respondents. That survey indicated that 21% of new homes in King County had electric heat. Seattle had no residential MCS program in effect and, because of its size, dominated the county statistics. For this reason, we used our simulation estimate of a 13% electric-heat market share for comparison. The simulation estimate agreed fairly well with the survey data in magnitude, but the percentage difference was quite large. The fact that some parts of King County did have MCS programs during this period, which would increase our simulation-based market share estimate, could account for much of the difference between the two values.

3.5 ANALYTIC RESULTS FOR CLARK COUNTY, WASHINGTON

Our Clark County analyses were limited to a hedonic price analysis and conjoint analysis. No focus groups were conducted in Clark County.

TABLE 3.24. King County Utility Values for the Factor Levels

Factor	Factor Levels	Factor Level Utility Values
House type	Tract	-0.62
	Custom	0.31
	Semi-custom	0.31
Levels in home	Single-level	0.06
	Multi-level	-0.06
House size	1,100 sq ft	14.70
	1,500 sq ft	17.70
	1,900 sq ft	19.46
	2,300 sq ft	19.96
		vector 1.77
		quad. -0.04
Primary heating fuel	Wood	-4.18
	Electricity	0.58
	Natural gas	3.60
Cash rebate	None	0.00
	$400	0.32
	$800	0.63
	$1,250	0.99
		vector 0.08
Presence of a utility rate discount	No rate discount	-0.40
	$15/month	0.40
Energy-efficiency of home	Average efficiency	-0.14
	High efficiency	0.14

TABLE 3.25. Percentage of Respondents Predicted to Choose Home With a Particular Primary Heating Fuel, King County

	Case					
				MCS, Cash Rebate		
	Base	MCS	MCS, Rate Discount[(a)]	$400	$800	$1,250
Electric home	13%	24%	31%	25%	30%	33%
Natural gas home	87%	76%	69%	75%	70%	67%

(a) $15/month

3.5.1 Hedonic Price Analysis

Our hedonic price analysis for Clark County was conducted for an area primarily within Vancouver, Washington.[a] Unlike the situation for Kirkland,there were some MCS homes in our database so we were able to estimate the effect of MCS on sales price. Table 3.26 shows the results from our log-linear, pooled model for Vancouver. The model fits the data reasonably well with an R-squared of 0.77. This regression is estimated over 3,862 housing sales.

Three of four gas heat dummy variables are significant at the 0.01 level. Evaluated at the average house price the coefficients imply that a gas-heated house commanded a premium of $18,300 in 1985. Premiums in the next 3 years dropped to more credible levels: $7,800 in 1986, $3,400 in 1987, and $6,850 in 1988. The coefficients are consistent with gas being the higher valued home heating fuel.

TABLE 3.26. Vancouver Model Results[a]

Variable	Estimated Coefficient	t-Statistic	Estimated Price
Gas dummy, 1985	0.271	6.28	$18,300*
Gas dummy, 1986	0.115	2.52	$ 7,800*
Gas dummy, 1987	0.051	1.23	$ 3,400*
Gas dummy, 1988	0.101	3.27	$ 6,850*
Forced air	0.0710	5.90	$ 4,800*
Wall heater	-0.0252	-3.07	-$ 1,700*
Heat pump	0.218	31.80	$14,800*
MCS floor area 1987	0.0000497	0.95	$3.36/sq ft
MCS floor area 1988	0.0000271	0.82	$1.83/sq ft
Number of observations	3862		
R-squared	0.78		
Corrected R-squared	0.78		

(a) Values significant at the 0.05 level are marked with an asterisk.

(a) See Englin et al. (1990) for the details of this analysis.

Heating equipment variables also perform well; each is significant at the 0.01 level or higher. The forced-air and wall-heater terms are both reasonable. Forced-air heating increases the value of the average home $4,800 over electric baseboard. Wall heaters decrease the value from electric baseboard by $1,700. The increase attributable to heat pumps is $14,800, and this seems fairly high. The heat pump variable is likely to be proxying attributes of the house in addition to the heat pump. This seems especially likely given the very high t-statistic (31.7) associated with heat pumps.

The final set of variables of special interest in this study are the Bonneville MCS program variables. "MCS floor area 1987" is the variable for the number of square feet in each MCS home sold in 1987, and "MCS floor area 1988" is the corresponding variable for 1988. Neither of these variables is significant at conventional levels. Keeping the lack of significance in mind, it is still possible to evaluate the estimates at the mean housing price. The 1987 value of MCS is $3.36 per square foot. The value in 1988 is $1.83 per square foot. These estimates appear to be on a par with the Tacoma estimates presented earlier.

3.5.2 New-Home Buyer Conjoint Analysis

The conjoint analysis in Clark County used a survey of new-home buyers throughout the county.[a] The sample included households in Vancouver as well as other areas in the county.

Table 3.27 summarizes the characteristics of the Clark County survey respondents and their homes. The demographics were very similar to those for Pierce County shown in Table 3.12. The only significant difference was the larger share of respondents who were 55 or older; this appeared linked to the larger proportion who indicated that they had owned three or more homes.

Table 3.28 presents the importance levels of the factors as determined from the conjoint data for Clark County. As in all the counties, fuel type was the most important single factor. The ranking and importance of the other factors agreed fairly closely with Pierce County results.

(a) See Lee et al. (1990) for details of the conjoint analysis.

TABLE 3.27. Description of the Clark County Respondents and Their Homes

Respondents' Characteristics		Sample %
Sex	Male	54
	Female	46
Age	Under 35	30
	35 - 54	49
	55 and over	22
Home's primary heating fuel selection	Selected home's fuel	40
	Selected home with preferred fuel	21
	Someone else made the fuel choice	39
Number of homes owned	1	19
	2	23
	3 - 4	35
	5 or more	23
Primary heating fuel	Electricity	63
	Natural gas	36
	Wood	1
	Other	0
Secondary heating fuel	Electricity	8
	Natural gas	5
	Wood	37
	Other	4
	Do not have one	47
Type of home	Custom-built	32
	Semi-custom	48
	Tract	20
Purchase price of home	Under $100,000	55
	$100,000 - $159,999	39
	$160,000 and over	6

TABLE 3.28. Relative Importance of Factors, Clark County

Factors	Relative Importance, %
Primary heating fuel	38.7
House size	29.3
House type	12.3
Cash rebate	5.8
Energy-efficiency of home	2.5
Levels in home	6.5
Presence of a utility rate discount	4.9

Table 3.29 presents the utility values for the different factor levels.[a] These results fell into the range of the results for the other counties discussed previously.

Table 3.30 shows the results of the market shares analysis for Clark County. The estimated base case market share (no MCS, no incentives) for electric heat was about 39%, comparable to Pierce County. Introduction of MCS for electrically heated homes increased this share to about 44%, again quite similar to Pierce County. The addition of incentives produced less of an effect than in the Pierce County simulations. Like the other counties, higher cash rebates increased the market share, but unlike the other counties, their effect did not diminish as the rebate levels increased. The $15/month rate discount had an effect on estimated market shares comparable to the effect of the $1,250 cash rebate.

To validate our simulation results, we compared them with our demographic data for the conjoint survey respondents. That survey indicated that 63% of new homes in Clark County had electric heat. The Clark County

(a) The correlation coefficient for the hold-out cards was 0.82, indicating that the conjoint analysis performed very well in predicting the respondents' choices.

TABLE 3.29. Clark County Utility Values for the Factor Levels

Factor	Factor Levels	Factor Level Utility Values
House type	Tract	-1.22
	Custom	0.59
	Semi-custom	0.63
Levels in home	Single-level	0.49
	Multi-level	-0.49
House size	1,100 sq ft	15.19
	1,500 sq ft	18.08
	1,900 sq ft	19.55
	2,300 sq ft	19.61
		vector 1.86
		quad. -0.04
Primary heating fuel	Wood	-3.71
	Electricity	1.62
	Natural gas	2.10
Cash rebate	None	0.00
	$400	0.28
	$800	0.56
	$1,250	0.88
		vector 0.07
Presence of a utility rate discount	No rate discount	-0.37
	$15/month	0.37
Energy-efficiency of home	Average efficiency	-0.18
	High efficiency	0.18

TABLE 3.30. Percentage of Respondents Predicted to Choose Home With a Particular Primary Heating Fuel, Clark County

	Case					
				MCS, Cash Rebate		
	Base	MCS	MCS, Rate Discount(a)	$400	$800	$1,250
Electric home	39%	44%	56%	48%	50%	57%
Natural gas home	61%	56%	44%	52%	50%	43%

(a) $15/month

Public Utility District began its SGC program in 1986, and since then has made incentive payments of $1,000 to builders or buyers of certified SGC homes. The incentive payments have been paid predominantly to builders.[a] Therefore, we used the simulation results shown in Table 3.30 based on no cash rebate for comparison purposes. The simulation results predicted that about 44% of new homes would have electric heat. This was nearly one-third less than the market share estimate of 63% from our survey data, indicating that the simulation underestimated the share of electrically heated homes. This may have been due, in part, to the fact that the incentives went to about 20% of the buyers, rather than the builders, in the early years of the program. It also may reflect the effectiveness of the utility's marketing efforts under the SGC program.

3.6 FUEL DEMAND ANALYSIS

We combine the hedonic price estimates and other data from the four metropolitan areas studied to estimate the demand curve for natural gas heating.[b] These data include both new and existing homes sold in the different years and locations studied. Our specification relates the quantity of gas-heated houses demanded to the natural gas hedonic fuel prices. The natural gas demand regression includes the hedonic price and the hedonic price squared and is reported in Table 3.31.

The model is based upon a discrete choice, natural gas or electricity, but is modelled in a continuous framework. As a result, the quantity measure is most easily interpreted when treated as a market demand curve. This is done by aggregating the quantity of gas heating demanded by each person in the market to find the market share of gas heating at a given price. The results generally fall into reasonable ranges. All variables are significant at beyond the 0.01 level.

Most importantly, the hedonic natural gas price and price-squared coefficients are significant and have the theoretically anticipated signs:

(a) Personal communication with Ms. Denise McMann, Clark County Public Utility, December 4, 1990.
(b) See Englin et al. (1990) for more details on this analysis.

TABLE 3.31. Quadratic Natural Gas Demand Model Results

Variable	Estimated Coefficient	t-Statistic
Constant	0.683	8.68
Hedonic natural gas price, \$	-0.000144	-12.45
Hedonic natural gas price squared, $\$^2$	0.000000002	5.20
Median age of residents, yr	-0.0123	-8.77
Average income, \$/yr	0.0000421	14.33
Percent college graduates	0.0190	12.70
Female labor participation rate, %	0.00656	3.55
Building age, yr	0.00290	11.72
House size, sq ft	0.0000853	10.02
Fireplace	0.00304	4.77
Electricity/Gas price ratio, (kWh/therms)	-20.3	-16.30
Electricity/Gas price ratio squared, $(\text{kWh/therms})^2$	101.0	14.69
Labor force participation rate, %	-0.0216	-9.47
Number of observations	6488	
R-squared	0.31	
Corrected R-squared	0.31	
Standard error of the regression	0.260	
Mean of Dependent Variable	0.111	

the demand for natural gas heating declines for higher hedonic prices, but at a smaller rate as the hedonic price increases. The elasticity of demand evaluated at the mean hedonic price and quantity is -0.325, indicating that for a 1% increase in the hedonic price of natural gas heating the demand decreases by 0.325%.

Changes in relative utility fuel prices have the effect of shifting the demand for natural-gas heating. For current average fuel prices, the model predicts a reasonable response to changes in the fuel-price ratio: as electricity prices increase relative to gas prices, the demand for natural gas heating increases. The model predicts fairly modest growth in the number of houses sold with gas heating if electricity prices increase up to 2.5% more per year than gas prices. Because of the quadratic functional form, the model does not predict results consistent with expectations if the ratio of electricity prices to gas prices is below current average values.

This econometric analysis of fuel demand in Washington provides one starting point for analyzing the market for different residential heating fuels. It relies upon the hedonic price analyses conducted in this study. To fully analyze the heating fuel choice in a demand and supply framework, it would be essential to also characterize the supply curve for heating fuel types in the housing market. As noted earlier, however, analysis of the supply curve was beyond the scope of this study.

4.0 FINDINGS

Although the choice of residential heating fuel and efficiency level in new homes is the focal point of Bonneville's interest, the buyer makes this decision in a much broader context. The potential new-home buyer can choose from at least three alternatives: retrofitting the current home, buying an existing home, or buying a new home. The residential heating fuel and energy-efficiency level choices in a new home, however, are just two of the decisions a potential buyer must make. To properly characterize the buyer's decision, analysis of the decision must reflect this overall context to a suitable degree.

Several general types of factors affect the buyer's decision. Buyer attitudes toward different fuels and energy-efficiency levels influence preferences and choices. The economics, both first cost and operating costs, also affect a buyer's choices. Furthermore, the economic impacts of a home's energy-efficiency and fuel type are coupled through the interaction between energy-efficiency and amount of fuel consumed for heating. Introduction of the MCS has complicated these interactions because the MCS applies only to electrically heated homes, and MCS program financial incentives can affect the economics of the fuel and efficiency selection.

To explore these complicated interactions, our analysis has addressed the issues from a number of different perspectives with a variety of techniques and analytic methodologies. Our analysis also has included selected information on demographics, attitudes, market forces, and the overall home purchase decision.

Results reported here provide a broad view of residential fuel and energy-efficiency perceptions, economics, and preferences in the Northwest. Such a view is required as the basis for predicting home-buyer fuel and energy-efficiency choices. In selected locations, detailed information is now available about these issues; in others, only more general information is available. This chapter presents a picture of the knowledge currently available as a result of this ongoing research. It points out consistent results that are emerging and potential inconsistencies that have arisen from applying different methodologies and using different data.

4.1 DEMOGRAPHICS

The regional survey of the Bonneville customer utilities service territory reveals the importance of the Western Washington area in Bonneville's planning and program efforts. The survey provides a rough estimate of the geographic distribution of Bonneville's residential customers: the large majority of households, 70%, are located in Western Washington; 18% are located in Western Oregon; only 8% are in a composite area of Eastern Washington, Northern Idaho, and Western Montana; and the remaining households, 4%, are located in Eastern Oregon and Southern Idaho. Whatever activities are conducted involving residential energy-efficiency and fuel choice, they are likely to have the largest impacts if implemented in Western Washington and Oregon.[a]

Regionally, electricity is the predominant space heating fuel, but it appears to be losing its dominance in some markets. In the regional survey of existing homes, 54% of households report using electricity as the primary heating fuel, 17% report using natural gas, 16% report using wood, and 12% report using oil. The household surveys for new homes built in the Tacoma, Washington, area and Southern Idaho since the EAP went into effect show some significant differences relative to the regional housing stock. In Idaho, the survey shows that electricity commands 78% of the new home market, while gas represents only 13%; virtually no new homes use oil. Historical data from Idaho Falls indicate that electricity has maintained a market share of between 80% and over 90% since 1981. In Tacoma, the survey indicates that electricity is used in about 56% of new homes and gas is used in 37%, a relatively high proportion compared to the region. Historical data show that electricity's market share in Tacoma steadily dropped in the 1980s, from its levels of about 95% in 1981.

4.2 FUEL PERCEPTIONS AND PREFERENCES

With a history of low electricity prices, consumers in the Northwest have selected electric heating in higher proportions than elsewhere in the

(a) The recent adoption of the MCS in Washington and potential adoption in Oregon emphasize the significance of these two states.

country. The resulting widespread familiarity with electric heating clearly has shaped attitudes toward electricity and other heating fuels. Recent changes, however, in the prices of different fuels or other forces that may alter these attitudes are likely to affect future fuel choices in new homes and fuel switching in existing homes.

4.2.1 Fuel Perceptions

Our regional household survey indicates that, in most attitude categories, electricity is perceived more positively than alternate fuels. Across the region, electricity is considered to be safer, less polluting, and more convenient than natural gas. On the other hand, gas is considered to be more comfortable and more efficient.

Our regional survey and surveys of recent buyers in the Tacoma and Southern Idaho areas provide an important insight into these perceptions. The regional survey shows that users of a specific fuel type consistently rate their fuel better in most categories than do users of other fuels. The surveys conducted in Tacoma and Southern Idaho support this observation. Recent new-home buyers in the Tacoma area rate gas more positively than do similar buyers in Southern Idaho. As noted earlier, the proportion of new homes in Tacoma heated with gas grew rapidly during the 1980s, from about 5% to nearly 45%, while it remained at about 10% or less in Southern Idaho; thus, the proportion of our respondents with experience with gas heat was considerably higher in Tacoma than Southern Idaho. These observations indicate that, as might be expected, attitudes toward a given fuel tend to be more positive for individuals having firsthand experience with the fuel.

Our very limited study of builders suggests that they make fuel decisions primarily in response to market demand and the preferences of individual buyers. Nevertheless, builders do have their own perceptions of different fuels and their perceptions influence their fuel installation decision. The Tacoma area builder interviews were limited to those who predominantly installed electric heat. Among these builders, the perception is that electric heat is easier and cheaper to install. Electricity is also perceived to be more widely available. These builders have less experience with gas heating and feel that their buyers also are less familiar with gas.

In terms of fuel prices, the builders feel that electricity prices have increased during the past few years and expect electricity prices to continue increasing. These Tacoma area builders generally concur with buyers' perceptions of different fuels and, although the builders are usually the fuel choosers, their choices ultimately reflect market forces and individual buyer preferences.

4.2.2 Fuel Preferences

Buyers and builders may prefer one heating fuel over another for a number of reasons. Perceptions of the characteristics of each heating fuel (and heating equipment types) largely determine buyer and builder preferences. Home buyers compare characteristics of one fuel to those of alternative fuels and then weigh the characteristics in some way to determine their personal ranking of the fuels, or their preferences.

Our survey of the Bonneville service territory indicates that homeowners regionally prefer natural gas, by a small margin, over electricity. Thirty-six percent prefer gas; 35% prefer electricity; and 14% prefer wood. The remainder prefer other fuels such as oil and kerosene. Based on the statistics reported earlier, the proportion of households preferring gas is higher than the proportion using gas as the primary heating fuel; the opposite is true for electricity.

Our survey of households in the Tacoma and Southern Idaho EAP jurisdictions affirms the preference for natural gas. These survey respondents are buyers of new homes built since the EAP went into effect, and their combined preference for natural gas is more pronounced than the preference across all types of households regionally: 48% prefer natural gas, 39% prefer electricity, and 9% prefer other fuels. Because of its larger population, these preferences are dominated by the results for the Tacoma area.

Results from the homeowner focus groups and conjoint analysis in Pierce County (Tacoma) also reveal a natural gas preference. A majority of the focus group participants express a preference for natural gas. Based on the conjoint analysis simulations, we estimate that if the MCS and associated programs were not in place the market share for new, gas-heated homes in the

Tacoma area would be about 56%, compared with 44% for electrically heated homes.

The homeowner focus groups and conjoint analysis in Spokane also provide results very similar to those for Tacoma. A majority of the focus group participants prefer natural gas for basically the same reasons as the Tacoma participants. Without any MCS programs, our simulation results indicate that 77% of Spokane County new-home buyers would select natural gas heating. The results for Clark County and King County also suggest a strong preference for natural gas; 62% and 87% of new homes in Clark and King County, respectively, would have natural gas heating if no MCS programs were in place.

The results from the hedonic price analyses in the Tacoma area are consistent with our fuel preference results for Tacoma, but the Spokane results are not. The hedonic price estimates for natural gas heating relative to electric heating in Tacoma show that buyers have been willing to pay several thousand dollars more to have natural gas heating since the mid-1980s; two different neighborhoods in Tacoma exhibit very similar results. These results are consistent with a home buyer preference for gas heat. In Spokane, on the other hand, the hedonic price analysis shows buyers typically have paid less for homes heated with natural gas than with electricity during the 1980s.

The hedonic price analyses conducted in Kirkland and Vancouver, Washington, indicate a difference in fuel preferences between these two regions. The results for Vancouver are consistent with a preference for natural gas: the hedonic price estimates for gas heat are consistently larger than those for electric heat. In Kirkland, on the other hand, the results are consistent with a preference for electricity and seem to contradict the conjoint analysis results for King County where Kirkland is located.

Although the information on fuel preferences produced by the different analytic techniques appear to be inconsistent in Spokane and Kirkland, reasonable explanations can be given for why the results might differ. Possible explanations include differences related to the location of the households included in the hedonic price and conjoint analyses, and differences between the populations included in the conjoint analysis (recent buyers of new homes) and in the hedonic price analysis (buyers of all homes). Without further study, we cannot isolate the factors responsible for these differences.

A fuel preference phenomenon surfacing repeatedly is the strong allegiance of individuals with natural gas heating to natural gas. In the regional survey, 80% of the households using natural gas indicate that it is their preferred heating fuel. On the other hand, only 53% of households using electric heating prefer electricity. The survey of the two EAP jurisdictions shows an even stronger allegiance to natural gas: 95% of households using natural gas prefer natural gas, while only 58% of the households using electricity actually prefer electricity. Comments from the Tacoma and Spokane buyer focus groups also are consistent with this phenomenon. Owners of gas-heated homes tend to be strong advocates of gas heating; owners of electrically heated homes tend to be noncommittal in their comments about electric heat. Similarly, the buyer focus groups show that owners of gas-heated homes are more likely to have chosen their heating fuel. It appears clear, in at least the major population centers of the Northwest, that homeowners who have gas heating strongly prefer natural gas, whereas owners of electrically heated homes are relatively uncommitted to electricity.

Much of the evidence accumulated in this study suggests that economics, particularly relative fuel prices, play a dominant role in a household's residential fuel choice. In support of this hypothesis is the fact that our regional data show that electricity is rated better than gas in most attribute categories, yet gas is the preferred fuel; we believe that this is because natural gas is perceived to be more economical by more households than electricity and that to consumers the economic advantages outweigh the minor, non-economic advantages of electricity.

Regionally, households perceive electricity to be more expensive than wood, and wood to be more expensive than natural gas. Expectations about future prices also look poor for electricity: 52% of regional respondents feel that electricity will be the most expensive fuel in 5 years, while only 7% believe that gas will be.

The builder focus groups also support the observations presented above about buyer preferences and the role of economics in the fuel decision-making process. Information from the focus groups indicates that buyers prefer natural gas to electricity overall. Builders, on the other hand, believe that it is more expensive to install gas heating and that this higher first cost dissuades the typical buyer, who is very sensitive to the initial cost of a home, from buying new home with gas heat. The builder conjoint analysis suggests that the way the housing market accommodates this situation is in part through the installation of gas heating in custom-built and higher-priced homes. In the first case, the buyer plays a more active role in the fuel selection; in the second, the buyer is less sensitive to the added cost.

4.3 ENERGY-EFFICIENCY ATTITUDES AND PREFERENCES

One set of our results indicates that buyers of new homes do not consider energy-efficiency to be a very important factor in their buying decision. On the other hand, results from other analyses we have conducted show that buyers in fact pay a premium for homes built to the MCS. Different methodologies produce these alternative findings.

In four focus groups of recent new-home buyers in Tacoma and Spokane, only one participant mentioned energy-efficiency when asked what factors affected their purchase decision. When the moderator raised the topic of energy-efficiency, however, many participants indicated that they had taken it into account in their decision. Nevertheless, since it was not mentioned initially, energy-efficiency was probably not among the primary decision factors.

The conjoint analyses provide similar findings. In four Washington counties, the conjoint analyses indicate that energy-efficiency (equivalent to about the MCS level) ranks only fifth or lower out of 7 decision factors.

Our results from the hedonic price analyses in Tacoma and Vancouver, however, show that buyers place a substantial economic value on the energy-efficiency level associated with MCS. In two distinct neighborhoods in Tacoma, we estimate that buyers pay about $3 to $5 per square foot more for MCS homes. In Vancouver we find similar results, although the estimates are not statistically significant, presumably because of the limited sample size. These results suggest that energy-efficiency is considered important enough that buyers pay a considerable amount for it.

The low importance rankings from the conjoint analysis and the relatively high MCS values from the hedonic price analysis are not necessarily contradictory. While the conjoint analysis does not indicate that energy-efficiency is very important in the house choice process, it does indicate that energy-efficiency is preferred even though higher purchase costs may result. Our simulations show that energy-efficiency alone would increase the market share for electrically heated homes even without any incentive.

Presumably as a result of Bonneville's information transfer processes, buyer awareness about energy-efficiency has improved. Based on the buyer focus groups, buyers in Tacoma are generally knowledgeable about the SGC program. In Spokane, where the program has not been in effect as long, awareness is less. Builders feel that the trend will be toward increased buyer awareness about energy conservation.

The focus groups in Tacoma and Spokane also reveal that buyers tend to equate energy-efficiency with home quality. Buyer comments suggest that they perceive energy-efficient homes to be built better than conventional homes. This provides evidence that the information provided to buyers through the MCS programs has been influential. This association between energy-efficiency and quality might be part of the reason buyers place a value on the MCS as high as our hedonic price analyses indicate they do.

4.4 MODELING THE FUEL TYPE AND ENERGY-EFFICIENCY CHOICE

A homeowner can select a residential fuel type and energy-efficiency level by either retrofitting his/her current home or buying a different home. If the owner chooses to purchase a different home, the home can be either an existing or new home. The fuel type and efficiency level ultimately chosen depend on preferences, prices, supply, and other factors. In addition, as noted earlier, the choice of an efficiency level and fuel type interact, particularly through the influences of Bonneville's programs. Our aim here has been to analyze several of the factors that affect the fuel type and energy-efficiency level choice, without developing a single, simplified choice model that might neglect some of the salient factors affecting these decisions. The results of the current analysis can provide the basis for an effort to model residential fuel and energy-efficiency decision making useful to future Bonneville program and planning activities.

4.4.1 Factors Affecting Fuel and Efficiency Choice in New Homes

Our study has focused on fuel and efficiency level choices in new homes because Bonneville's MCS programs affect only new, electrically heated homes. As noted earlier, however, new MCS homes compete with many alternatives, including retrofits of existing homes, new gas-heated homes, and existing gas- and electrically heated homes. The decision to purchase the MCS home ultimately depends on many factors.

First of all, various buyer characteristics affect the decision. Demographics, such as income, education, and sex, may influence the choice. Preferences, such as those for different fuels or energy conservation, affect the choice. Perceptions about the different fuels or the value of energy savings also influence the decision.

The decision also depends substantially on the characteristics of the housing market. For example, the supply of MCS homes may be greatly constrained by a shortage of builders trained to build to MCS requirements, or existing gas-heated or electrically heated homes may be in short supply.

Most significantly, economics have a large effect on the purchase decision. The costs of constructing to the MCS increase the cost of new electrically heated homes. Current and anticipated fuel prices affect the buyer's decision. How the market values MCS and different fuel types affects how much a buyer has to pay for a house with the desired features. And, incentives may reduce the price to a buyer or the construction cost to the builder.

Clearly, all of these factors cannot be taken fully into account in modeling the residential fuel and energy-efficiency decision process. The remainder of this section discusses how we have included some of these factors in our analyses and what enhancements could be made to the analyses discussed here.

4.4.2 Summary of Results

The hedonic price analysis technique has proven useful for gaining insights into how the market values important housing characteristics such as fuel type and energy-efficiency. The technique has helped determine the market value of alternative fuels and the MCS. The values we have estimated provide evidence that the market value for MCS is currently in excess of the additional construction cost, and our results strongly suggest that builders have not passed MCS program incentives along to buyers.

The hedonic prices estimated for different fuels suggest that in Tacoma and Vancouver gas heating commands a substantial premium over electric heating. In two other areas, the results were mixed. In addition, the value of different heating fuels appeared to vary over time and might depend, in large part, on relative fuel prices.

The hedonic prices are also useful in modeling buyer decision making because they represent the implicit market price that buyers face when they choose between different heating fuels and energy-efficiency levels. When a buyer examines the fuel and MCS options available, he or she must factor in the price implicitly paid for electric heating and MCS in the sales price of an MCS home.

We have used the hedonic prices in one way to predict fuel type in individual homes by using them in a preliminary discrete choice model. We combined the hedonic prices, fuel prices, and attitudinal information from our Tacoma survey data in a logit model to estimate the probability that gas (or electric) heat is installed. One virtue of this approach is its ability to integrate attitudinal and economics data in a common framework. Data limitations here restrict the utility and validity of this model, but initial results have shown that this model is a promising approach.

We have also used the hedonic prices to develop demand curves for MCS and natural gas heating. Since such demand curves cannot be estimated without the hedonic prices and we have estimated these prices, this study has provided one previously unavailable essential piece of information required in an econometrically based approach to estimate market demand for MCS and fuel type.

The demand analysis for MCS gave qualitatively reasonable results, but the analysis was so limited in scope that we believe further work is necessary before the technique can be used satisfactorily to predict regional penetration rates for the MCS. Current results are most useful for evaluating the effects of changing fuel prices and demographics on MCS demand.

Another method we have applied to estimate fuel and MCS effects on the housing market is conjoint analysis. Our approach treats the selection of heating fuel and energy-efficiency jointly within the context of the overall decision to purchase a new home. Various fuel types and energy-efficiency levels are considered as features that a buyer can trade off against alternative levels of other features such as floor area, house type, and financial incentives. Our results showed that fuel type was an important factor in the decision when wood, gas, and electricity were considered as options. Energy-efficiency appeared to be less important. The conjoint analysis results also provided information that was used to estimate market shares for electrically heated, MCS homes.

Our conjoint analysis results suggested that from 56% to 87% of new-home buyers in the four counties studied would prefer a gas-heated home over an electrically heated home if both were built to the same conventional energy-efficiency levels. They also suggested that if all new electrically heated homes were required to meet the MCS while gas-heated homes stayed at conventional efficiency levels, the market shares for gas-heated homes would decrease to between 54% and 77%, depending on the county. Providing a cash rebate of around $500 for electrically heated MCS homes would decrease the shares of gas-heated homes to between 48% and 76%, depending on the county. Applying instead a monthly utility rate discount between $15 and $20 for electrically heated MCS homes would decrease the market shares for gas-heated homes to between 42% and 69%. These results provided an indication of how market shares might respond under alternative scenarios, but they were limited by the fact that they were based on hypothetical decisions rather than empirical data. On the other hand, they are directly relevant to the

Bonneville programs because they are based on information from recent buyers of new homes.

4.4.3 Future Directions

It would be desirable to extend the conjoint analysis to other areas. The scope of this study limited the conjoint analysis to four metropolitan areas in Washington. It would be beneficial to extend the analysis to Washington areas including other metropolitan and rural regions. It also would be desirable to extend the conjoint analysis to other states, such as Oregon, where adoption of the MCS is likely in the near future. More extensive conjoint analysis results would also provide the basis for regional estimates of MCS and fuel type near-term market shares.

The conjoint analysis described here also provides potentially useful marketing information. The estimated effects of utility rate discounts, in lieu of cash rebates, suggest that rate discounts may be a useful incentive to incorporate in MCS programs. Rate discounts have the advantage of reducing near-term cash flow impacts on utilities. Specific market segments have been identified that could be used to target and focus Bonneville programs. Extending the analysis to other regions would help provide similar segmentation information on a larger scale.

The hedonic price analyses presented here have been used to estimate the implicit prices of MCS and different fuel types. Unfortunately, in isolation these estimated prices unveil little about the underlying supply and demand conditions, which are the essential components needed to characterize current behavior and project behavior under different conditions. The supply of MCS homes and the demand for MCS homes determine the MCS hedonic prices and the penetration of MCS in the housing market. The same is true for different fuel types. Thus, another way to address the question of MCS and fuel type market shares is to estimate the market demand and supply curves for these characteristics.

We report on part of the supply-demand equation here. We have analyzed market demand for different fuel types by integrating the hedonic price estimates from the different areas studied in the region. Supplemented with demographics data, the current fuel-type hedonic price have been used to estimate a demand curve for different fuel types. The fuel-type demand analysis provides reasonable first estimates of market demand and shows promise as a technique for estimating market shares for heating fuels.

An MCS demand curve has been estimated based on the limited data available in Tacoma. Although these initial results show promise, their usefulness suffers from the lack of more extensive data at the time we conducted our analysis. The current MCS hedonic price analyses could be supplemented with estimates for areas where a larger population of MCS homes is available, and the results could be integrated with demographics data to estimate an MCS demand curve representing a larger geographic area. This demand curve then would provide a basis for estimating demand in locations other than those studied and under potential future conditions.

Combining the demand curves with supply curves would provide an estimate of market prices and quantities for the housing characteristics of interest. Housing supply curves could be developed from information collected on housing producers and the existing housing market.

A discrete choice framework also could be developed for modeling the fuel and energy-efficiency decision. This approach would rely on attitudinal, demographic, and price data and hedonic price estimates. An initial effort described here showed promise, but was limited by data constraints. A more comprehensive model relying on cross-sectional and time-series data, some of which is available as a result of this study, would likely be more successful and directly useful to Bonneville.

Finally, very little analysis has been conducted of fuel switching in existing homes, yet its annual impacts are comparable to those of fuel choices made in new homes each year. Some of the techniques discussed here could be applied to existing homes to predict fuel switching in existing homes. Data collected as part of this study, as well as other data, could be used to address this issue.

5.0 REFERENCES

Abelson, P.W., and A. Markandya. 1985. "The Interpretation of Capitalized Hedonic Prices in a Dynamic Environment." Journal of Environmental Economics and Management 12:195-206.

Bretton-Clarke. 1987. "Conjoint Analyzer, Version 2." New York.

Cameron, T. 1985. "A Nested Logit Model of Energy Conservation Activity by Owners of Existing Single Family Dwellings." Review of Economics and Statistics 67:205-211.

Cohn, S., E. Hirst, and J. Jackson. 1977. Econometric Analyses of Household Fuel Demands, ORNL CON-7, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Dinan, T. M. 1987. "An Examination of the Consumer Decision Process for Residential Energy Use." Energy Systems and Policy 10(4):345-371

Englin, J. E., S. A. Shankle, A. D. Lee, D. C. Kavanaugh. 1990. An Econometric Analysis of Housing Prices: The Impact of Fuel Type and Energy-Efficiency in the Pacific Northwest. PNL-7593, Pacific Northwest Laboratory, Richland, Washington.

Freeman, M. 1979. The Benefits of Environmental Improvement. Johns Hopkins University Press, Baltimore, Maryland.

Halvorsen, R., and H. Pollakowski. 1981. "The Effects of Fuel Prices on House Prices." Urban Studies 18:205-211.

Harkreader, S. A., and M. P. Hattrup. 1988. The Pacific Northwest Residential Consumer: Perceptions and Preferences of Home Heating Fuels, Major Appliances, and Appliance Fuels. PNL-6605, Pacific Northwest Laboratory, Richland, Washington.

Laquatra, J. 1986. "Housing Market Capitalization of Thermal Integrity." Energy Economics 8:134-138.

Laquatra, J. 1987. "Valuation of Household Investment in Energy-Efficient Design." In Energy Efficiency: Perspectives on Individual Behavior, W. Kempton and M. Neiman, eds., Washington, D.C.

Lee, A. D., S. A. Harkreader, C. L. Bruneau, and S. M. Volke. 1990. Northwest Home Buyers' Fuel and Energy Efficiency Preferences. PNL-7536, Pacific Northwest Laboratory, Richland, Washington.

Lee, A. D., J. E. Englin, and S. A. Harkreader. 1989. Residential Fuel Choice in the Pacific Northwest. PNL-6650, Pacific Northwest Laboratory, Richland, Washington.

Louviere, J. J. 1988. Analyzing Decision Making--Metric Conjoint Analysis. Sage Publications, Newbury Park, California.

Northwest Power Planning Council (NWPPC). 1986. Northwest Conservation and Electric Power Plan, Vol. 2. Portland, Oregon.

Palmquist, R. 1985. "Alternative Techniques for Developing Real Estate Price Indexes." Review of Economics and Statistics (67):442-448.

Palmquist, R. 1984. "Estimating the Demand for the Characteristics of Housing." Review of Economics and Statistics (66):394-404.

Rosen, S. 1974. "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition." Journal of Political Economy (82):35-55.

Zaki, A., and H. Isakson. 1983. "The Impact of Energy Prices: A Housing Market Analysis." Energy Economics (5):100-104.

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