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Marginal Impact of Electric Heat Pumps on Home Sale Price

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TO: **Karen Horkitz, Anu Teja, NEEA**
FROM: **Stephen Grover, Ted Helvoigt, Jenny Yaillen**
SUBJECT: **MARGINAL IMPACT OF ELECTRIC HEAT PUMPS ON HOME SALE PRICE**

SUMMARY OF FINDINGS

In November 2008, Northwest Energy Efficiency Alliance (NEEA) engaged ECONorthwest to estimate the effect that electric heat pumps have on the sale price of homes in the Northwest. In this memorandum, we describe the analytical methods followed and the results of the analysis. A summary of our findings is as follows:

- Based on hedonic regression analysis of single-family home sales in five Willamette Valley counties, we find that for Benton, Lane, and Linn counties, homes equipped with an electric heat pump sold commanded a price premium of between 1.1% and 4.4% compared to homes with other heating types, after accounting for other characteristics of the properties. For Marion and Multnomah counties, we found no statistically significant difference in sale price between homes with and without a heat pump.
    - For Benton, Lane, and Linn counties, the price premium for homes with a heat pump was greater for new homes than for existing homes.
    - There were relatively few homes in Multnomah and Marion counties listed as having a heat pump in the Multiple Listing Service data.
- Appraisers in Eugene, Olympia, Tri-Cities, and Idaho Falls were interviewed to understand how an electric heat pump is perceived by home buyers in the respective markets and to find out if—all else being equal—the appraisers made any adjustment to the appraised value of a home if it is equipped with a heat pump.
    - Appraisers in Eugene and Olympia stated that homebuyers felt "positive" or "very positive" about heat pumps. Appraisers in Tri-Cities and Idaho Falls either did not know how homebuyers perceive heat pumps or stated that homebuyers did not believe it important for a home to have a heat pump.
    - Most appraisers stated that they make an adjustment to the appraised value of a home because it has a heat pump. Of those that said they do make an adjustment,

all said the adjustment is upward. The range of adjustment extended between $1,000 and $5,000 per home or by 1.5% to 2.0% of the value of the home.

INTRODUCTION

This memorandum presents the results of the ECONorthwest analysis of the marginal impact that an electric heat pump has on the sale price of a home in various Northwest communities. The project is composed of two discrete parts.

1. Interviews with appraisers in four Northwest communities
    a. Eugene, Oregon
    b. Olympia, Washington
    c. Tri-Cities, Washington (Kennewick, Richland, and Pasco)
    d. Idaho Falls, Idaho
2. Hedonic regression analysis of home sales in Oregon's Willamette Valley between 2005 and 2008

Ideally, hedonic regression analysis would have been conducted on data from each of the communities listed above, however, we were only able to obtain data for Willamette Valley counties.[1]

The remainder of the memo is organized as follows: we begin with an overview of the appraiser survey and the responses from appraisers. We then describe the data relied on in the statistical analysis and the analytical methods followed. Finally, we present and discuss the results of the statistical analysis.

INTERVIEWS WITH RESIDENTIAL REAL ESTATE APPRAISERS

ECONorthwest conducted a short, non-statistical survey of residential home appraisers in four Northwest communities (Eugene, Olympia, Tri-Cities, Idaho Falls). The purpose of the survey was to obtain anecdotal information from appraisers to supplement the statistical analysis of Willamette Valley home sales. For each community, ECONorthwest contacted three home appraisers listed in the local area Yellow Pages directory. The survey was not conducted with statistical validity in mind. Nevertheless, appraisers were selected at random for each of the communities and the questions asked were consistent across surveys. Each survey interview began with a brief introduction of ECONorthwest and NEEA and a description of the analysis we were conducting and how the survey information would be represented in the report. Overall, the appraisers we contacted were very willing to share their knowledge of the local housing market with us.

For Eugene, four appraisers were contacted; three complete interviews were obtained and for one company, there were no appraisers available to talk with us. For Olympia, four appraisers were

[1] We would like to thank Natalie Middleton of the Oregon RMLS for her assistance in obtaining the home sales data for the Willamette Valley.

contacted; three complete interviews were obtained and there was no answer to our call for one company. For Tri-Cities, five appraisers were contacted; three complete interviews were obtained and there was no one available to talk at two of the companies. For Idaho Falls, five appraisers were contacted; three complete interviews were obtained and at one company no one was available to talk with us and at another company there was no answer to our call.

The interviews began with basic questions related to the primary heat systems in local residences; the perception homebuyers have of a heat pump system; and the appraiser's best estimate of the median or average home price in the local market. The responses of the appraisers to these questions are shown in Table 1.

Table 1: Initial Questions to and Responses by Appraisers in Four Northwest Housing Markets

Question	Eugene	Olympia	Tri-Cities	Idaho Falls
What is the most common primary heating system in the local housing market?	Heat pump (3)	Forced air gas or electric furnace (3)	Heat pump (2) Forced air, gas furnace (1)	Forced air furnace (3)
In your opinion, how do most homebuyers feel about a heat pump system?	Positive (2) Very positive (1)	Positive (2) Very positive (1)	Don't know (2) It's not important (1)	Buyers are uninformed (2) Don't know (1)
What is your estimate of the average or median home price in the local market?	$219,000 (1) Would need to check local MLS (2)	$250,000 (1) $285,000 (1) $280,000 (1)	$190,000 (1) $175,000 (1) $178,000 (1)	$150,000 (1) $200,000 (1) $175,000 (1)

Source: Results of ECONorthwest survey of appraisers

The results differ substantially for the four cities. In Eugene, all three appraisers stated that heat pumps are the most common heating system. Comparatively, for Olympia and Idaho Falls, all six appraisers stated that a forced air furnace (either gas or electric) was the primary heating system, and in Tri-Cities, two of the three appraisers stated forced air gas furnaces were the most common heating system and the third said heat pumps were. Appraisers in the four cities also differed on the question of homebuyer opinions about heat pumps. The appraisers in Eugene and Olympia stated that home buyers feel positive or very positive about heat pumps, whereas appraisers in Tri-Cities and Idaho Falls either stated that they did not know or that buyers either do not think that it is important to have a heat pump system or buyers are uniformed about the relative merits of a heat pump.

We then asked appraisers how the price of a home heated with only a heat pump would compare to a home heated with each of four alternative systems (see Table 2). Responses differed by city, however in no case did an appraiser state that the home price would be lower (all else being equal) if it had a heat pump rather than one of the other heating systems. All of the appraisers interviewed in Eugene and Olympia stated that a heat pump would lead to a higher house price relative to a gas or electric furnace. Comparatively, in the Tri-Cities only one appraiser stated that a heat pump would result in a higher price and all three appraisers in Idaho Falls stated the house price would be unchanged.

Table 2: All Else Being Equal, Would a Home Heated with Only a Heat Pump Result in Higher, Lower, or the Same Price as a Home Heated with Only a…

Alternative Heating System	Eugene	Olympia	Tri-Cities	Idaho Falls
Electric Furnace?	Higher (3)	Higher (3)	Same (2) Higher (1)	Same (3)
Gas Furnace?	Higher (3)	Higher (3)	Same (2) Higher (1)	Same (3)
Ceiling Heat?	Higher (2) Much higher (1)	Higher (2) Not sure (1)	Higher (2) Same (1)	Higher (2) Same (1)
Baseboard or Zonal Heat?	Higher (2) Much higher (1)	Higher (3)	Higher (2) Same (1)	Higher (2) Same (1)

Source: Results of ECONorthwest survey of appraisers

Results of the comparison between a heat pump and either ceiling or baseboard heat were more consistent across appraisers in the four cities. All appraisers in Eugene stated that a heat pump would lead to a higher or much higher resale value compared to ceiling or baseboard heating. Two of the appraisers in Olympia stated that, relative to ceiling heat, a heat pump would lead to a higher home sale price (one was "not sure") and all three stated that a home with a heat pump would result in a higher sale price than a home with baseboard heat. Two of three appraisers in both Tri-Cities and Idaho Falls stated that a home with a heat pump would result in a higher sale price and the third appraiser stated the price would be the same.

Finally, appraisers were asked if—all else being equal—they make an adjustment to the appraised value of a home because it has a heat pump. And if so, what is the typical adjustment in either dollar or percentage terms? The results for these questions are shown in Table 3. For Eugene and Olympia, all appraisers stated that they make at least a small upward adjustment. For Tri-Cities, only one of the appraisers stated they usually make an (upward) adjustment to the appraised value of a house because it has a heat pump. The other two appraisers stated they make no adjustment. For Idaho Falls, two of the three appraisers stated they usually make an adjustment and one stated that he did not. For those appraises that stated they do (or usually do) make an adjustment, the dollar value of the adjustment ranged from as low as a $1,000 increase to as high as a $5,000 increase in the appraised value of a house.

Table 3: Impact of a Heat Pump on the Appraised Value of a Home

Question	Eugene	Olympia	Tri-Cities	Idaho Falls
Do you make an adjustment to the assessed value of a home because it has a heat pump?	Yes, upward (1) Often yes (1) Yes, small upward (1)	Yes, upward (3)	No (2) Usually (1)	Sometimes (2) No (1)
How much of an adjustment do you make? (percentage or dollar adjustment)	1.5% - 2.0% (1) A small increase (1) $1,000 - $2,000 (1)	$2,000 (1) $3,000 - $4,000 (1) $3,000 (1)	None (2) $1,500 - $2,000 (1)	$2,000 - $5,000 (1) $1,500 - $2,500 (1) None (1)

Source: Results of ECONorthwest survey of appraisers

DATA

The data used in the statistical analysis were obtained from the Oregon Regional Multiple Listing Service (RMLS), which provides real estate listings for the Portland Metropolitan area, much of the Willamette Valley, and other counties throughout Oregon and into Washington.[2] RMLS offers a free search of real estate listings through their website for residential, multifamily, commercial, land, and farm properties. The Oregon RMLS was contacted directly to obtain the large database query required for this analysis. The data obtained from the RMLS included the information shown in Table 4.

Table 4: Housing Variables Received from Portland RMLS

Variable Name	Description
Sale Price	Sale price of home in current year dollars
Size	Size of home in square feet
Bedrooms	Number of bedrooms
Baths	Number of bathrooms
Sale Year	Index of year house was sold (2005=1, 2006=2, …)
Built Year	Year house was built
Age	Sale Year – Built Year
Heating System	Indicator variable of the type of heating system

Source: Oregon RMLS

Housing Stock and Recent Home Sales in the Willamette Valley

The counties included in this analysis include Oregon's most populous county (Multnomah), as well as four other counties located in the Willamette Valley. The number of housing units differs considerably between the five counties, with 35,202 housing units in Benton County and 310,352 in Multnomah in 2007 (see Table 5). Each county is comprised of varying proportions of rural

[2] A total of 16 counties in Oregon and 4 in Washington are listed in the Oregon RMLS database.

and urban/suburban residents, and, with the exception of Linn County, all counties comprise or are part of a Metropolitan Statistical Area.[3]

Table 5: Housing Units by County and Year

County	2004	2005	2006	2007	Avg. Annual Growth
Benton	33,947	34,333	34,848	35,202	1.2%
Lane	144,372	145,877	147,976	149,374	1.1%
Linn	44,462	45,199	46,042	46,744	1.7%
Marion	113,794	115,499	117,150	118,767	1.4%
Multnomah	299,975	303,091	306,926	310,352	1.1%
As a Percent of Oregon's Total Housing Stock	41%	41%	41%	41%	

Source: Population Division, U.S. Census Bureau, Annual Estimates of Housing Units for Counties in Oregon

The median home price increased for all counties between 2005 and 2007 and increased through 2008 for Benton County (see Table 6). On a weighted average basis, the median price for all counties increased on an average annual basis by 8.7% between 2005 and 2007, but dropped by 5.5% between 2007 and 2008. Benton and Multnomah counties consistently posted the highest median price, with Linn County consistently posting the lowest.

Table 6: Median Sales Price by County and Year

County	2005	2006	2007	2008
Benton	$222,500	$252,500	$275,700	$300,000
Lane	$198,000	$226,000	$235,000	$222,000
Linn	$160,000	$177,000	$193,650	$178,250
Marion	$178,900	$208,000	$226,900	$210,000
Multnomah	$225,000	$258,000	$275,000	$264,000
Weighted Average	$209,260	$235,611	$246,926	$233,322

Source: ECONorthwest analysis of Oregon RMLS data

The percentage of homes sold in each county with a heat pump system varies considerably between counties (see Table 7). At the low end, Oregon RMLS data indicate that only 3% to 5% of homes sold in Multnomah County had a heat pump. At the upper end, 22% to 31% of homes sold in Benton and Lane counties had a heat pump. The proportion of homes sold in Linn and Marion counties with a heat pump ranged from 11% to 22 %, but RMLS data indicates that for 2006 and 2007 no new homes sold during this period had a heat pump.[4]

[3] Benton County comprises the Corvallis MSA; Lane County comprises the Eugene-Springfield MSA; Marion County is part of the Salem MSA (along with Polk County); Multnomah is part of the Portland-Vancouver-Beaverton MSA (along with Clackamas, Columbia, Washington, and Yamhill counties in Oregon and Clark and Skamania counties in Washington).

[4] Note: it is possible and even likely that some homes with a heat pump also had a gas or electric furnace, which was listed as the heat source for the house.

Table 7: Percent of Home Sales with Heat Pump by County and Year

County	2005		2006		2007		2008	
	All	New	All	New	All	New	All	New
Benton	22%	0%	31%	25%	28%	47%	24%	33%
Lane	26%	25%	26%	21%	27%	25%	30%	29%
Linn	18%	8%	15%	13%	14%	14%	22%	21%
Marion	12%	2%	11%	0%	12%	0%	14%	2%
Multnomah	3%	1%	4%	1%	4%	5%	4%	4%
Weighted Average	14%	10%	15%	9%	17%	13%	19%	15%

Source: ECONorthwest analysis of Oregon RMLS data

ANALYTICAL METHODS

A hedonic property value model captures the value of differences in the characteristics of residential properties and locations. The model allows for the estimation of implicit prices of the characteristics that differentiate closely related products that are not separable from the product—such as housing.[5] Ideally, the specification of the hedonic model would include the structural characteristics of the property (e.g. square feet, bedrooms, etc.), characteristics of the neighborhood (e.g. school district, distance to nearest major business center), and environmental characteristics (e.g. distance to amenities and/or disamenities). The generalized form of such a model could be defined as:

$$HousePrice_i = f(Structure_i, Neighborhood_i, Environment_i)$$

It is the interaction between all the structural, neighborhood, and environmental variables that is hypothesized to dictate the value of a residential property and, to the extent that information on each of these three characteristic types are available, a fully specified hedonic price model should include them.

In practice, however, it often happens that data on one or more of the characteristics of the property are not available. In these instances, care should be taken to reduce or even eliminate the potential for omitted variable bias.[6] In this analysis, we follow the technique described by Carriazo (2008) to account for an asymmetric random error, hypothesized to exist due to one or more omitted variables in the hedonic regression model.[7] Stochastic frontier methods are used in order to decompose the random error term into two components: the usual zero mean, constant variance symmetric random error, and an asymmetric random error associated with the

[5] Freeman, M., 1992, *The Measurement of Environmental and Resource Values: Theory and Methods*, Resources for the Future. P125.

[6] Omitted variable bias is a distortion of the empirical results of a statistical regression model due to one or more explanatory variables being excluded (missing) from the model. Omission of a relevant variable results in biased estimates—in an unknown direction—of the coefficients of the included variables.

[7] Carriazo Osorio, F., 2008, Measuring Urban Amenities and Disamenities: A Spatial Hedonic Analysis in Bogota, Columbia, American Journal of Agricultural Economics, Dec 2008.

characteristics of the houses observable to the buyers, but not represented in the data.[8] For the stochastic frontier based model, we assume that the asymmetric error term varies for homes with heat pumps and homes without heat pumps. A heteroscedastic (asymmetric error only) frontier regression model is estimated using the LimDep econometric software. For each housing market considered in this analysis, both ordinary least squares (OLS)-based and frontier-based models are estimated.

RESULTS AND DISCUSSION OF THE STATISTICAL ANALYSIS

Hedonic regression models were developed separately for each county (Benton and Linn counties were combined) and for sales of new and existing homes (eight independently estimated models in total). Detailed results of the regression models are presented in Appendices I and II. The coefficient estimates of interest—the (marginal) demand elasticity for a home with a heat pump—are shown in Table 8. Elasticity estimates are shown for both the OLS and stochastic frontier models, however, with one exception, it is the stochastic frontier-based estimates that we assume are the appropriate elasticity estimates.[9]

Table 8: Heat Pump Price Elasticity Estimates by County for New Home and Existing Home Sales

County	Existing Homes		New Homes	
	OLS	Frontier	OLS	Frontier
Benton/Linn	*Biased*	**0.011**	*Biased*	**0.044***
Lane	**0.020*****	NA	**0.037*****	NA
Marion	0.003	-0.024	Too few sales of homes with heat pump	
Multnomah	0.009	0.006	Too few sales of homes with heat pump	

Source: ECONorthwest analysis of Oregon RMLS data

* Statistically significantly at the 0.05 level.

*** Statistically significantly at the 0.01 level.

Beginning with sales of existing homes, the model results indicate that the existence of a heat pump has a positive and statistically significant impact on sale price in Lane County. Homes in this county are more likely to have a heat pump than homes in Benton, Linn, Marion, or Multnomah County. For the Lane County, the OLS-based estimated elasticity is 0.02, which would indicate that on average—and holding all else constant—a home with a heat pump would sell for 2.0% more than a home with another source of heat. Assuming an average house price of $200,000, this would indicate that a heat pump would lead to a $4,000 greater price. Although only speculation, the statistically significant and positive elasticity estimate for Lane County may be due to the relatively high proportion of homes with ceiling heat (about 20% of homes sold between 2005-2008). Ceiling heat, popular with Lane County homebuilders in the 1960s and

[8] For information on stochastic frontier regression models, see: Kumbhakar, S.C., and C.A.K. Lovell, 2000, Stochastic Frontier Analysis, Cambridge University Press, Cambridge UK.

[9] As was discussed above, we assume the OLS-based estimates of the heat pump elasticities are biased due to one or more omitted variables. However, based on results of the stochastic frontier modeling, this is not the case for new home sales in Lane County. The frontier regression results indicate that there is not an inherent (omitted variable) bias in the OLS estimates for the Lane County new home model.

1970s due to its low cost of installation and the low cost of electricity at that time, is regarded today as energy inefficient and a less desirable form of heat. For Marion County, we found the elasticity estimate to be negative, but not statistically significant and for Benton/Linn and Multnomah counties to be positive, but not statistically significant.

For new home sales, we estimate the demand elasticity for a heat pump is 0.044 for Benton/Linn County, indicating that, holding all else equal, the average home would sell for 4.4% more if it has a heat pump. For Lane County, the elasticity estimate is slightly smaller at 3.7%. It is unclear why the elasticity estimates would be this high for new homes. It may be that some or even all of the homes indicated by the MLS as having a heat pump in fact have a dual fuel system (i.e. a gas furnace/heat pump combination). Such units have grown in popularity in recent years because they offer the advantages of both systems. The purchase cost of a dual unit is the marginal cost of the heat pump, as it would share the same ducts as a gas (or other fuel) furnace. Alternatively, it may be that buyers place such a premium on a heat pump, relative to other heating systems. For Marion and Multnomah counties, there were too few observations to estimate the hedonic home price model.

APPENDIX I: REGRESSION RESULTS: SALES OF EXISTING HOMES

Table 9: Ordinary Least Square Regression Results—Lane County

Variable	Coefficient	St. Error	T-stat	Significance
Constant	9.927	0.047	213.042	0.000
Heat Pump*	**0.020**	**0.003**	**5.902**	**0.000**
Ln(FT^2/Bedroom)	0.064	0.008	7.704	0.000
Ln(FT^2)	0.258	0.008	33.595	0.000
2006 Indicator	0.125	0.004	32.757	0.000
2007 Indicator	0.163	0.004	41.005	0.000
2008 Indicator	0.095	0.004	21.856	0.000
Eugene	0.046	0.003	15.427	0.000
House Age	-0.006	0.002	-3.937	0.000
R^2 = 0.39	F-statistic = 602		Observations = 7,498	

Source: ECONorthwest analysis of Portland RMLS data

* Impact on sale price of having a heat pump is statistically significantly different from zero at the 0.01 level.

Table 10: *Frontier*-Based Regression Results—Linn/Benton Counties

Variable	Coefficient	St. Error	T-stat	Significance
Constant	5.871	10.038	0.585	0.559
Heat Pump*	**0.011**	**5.971**	**0.002**	**0.999**
Ln(FT^2/Bedroom)	0.049	0.055	0.905	0.366
Ln(FT^2)	0.801	0.045	17.725	0.000
2006 Indicator	0.070	0.031	2.253	0.024
2007 Indicator	0.139	0.030	4.568	0.000
2008 Indicator	0.040	0.029	1.400	0.161
House Age	5.871	10.038	0.585	0.559
R^2 = 0.39	F-statistic = 602		Observations = 7,498	

Source: ECONorthwest analysis of Portland RMLS data

* Impact on sale price of having a heat pump is not statistically significantly different from zero.

Table 11: Ordinary Least Square Regression Results—Marion County

Variable	Coefficient	St. Error	t-stat	Significance
Constant	7.031	0.108	65.188	0.000
Heat Pump*	**0.003**	**0.013**	**0.273**	**0.785**
Ln(FT^2/Bedroom)	0.003	0.022	0.130	0.897
Ln(FT^2)	0.701	0.018	38.344	0.000
2006 Indicator	0.144	0.012	12.053	0.000
2007 Indicator	0.211	0.012	17.701	0.000
2008 Indicator	0.157	0.013	12.074	0.000
House Age	-0.036	0.004	-8.541	0.000
R^2 = 0.56	F-statistic = 495		Observations = 2,732	

Source: ECONorthwest analysis of Portland RMLS data

* Impact on sale price of having a heat pump is not statistically significantly different from zero.

Table 12: Ordinary Least Square Regression Results—Multnomah County

Variable	Coefficient	St. Error	t-stat	Significance
Constant	10.878	0.040	274.617	0.000
Heat Pump*	**0.009**	**0.008**	**1.153**	**0.249**
Ln(FT^2/Bedroom)	0.021	0.004	4.890	0.000
Ln(FT^2)	0.182	0.006	31.449	0.000
2006 Indicator	0.149	0.004	35.743	0.000
2007 Indicator	0.209	0.005	46.048	0.000
2008 Indicator	0.155	0.005	30.241	0.000
Portland	0.049	0.004	12.412	0.000
House Age	-0.016	0.002	-8.899	0.000
R^2 = 0.40	F-statistic = 488		Observations = 5,905	

Source: ECONorthwest analysis of Portland RMLS data

* Impact on sale price of having a heat pump is not statistically significantly different from zero.

APPENDIX II: REGRESSION RESULTS: SALES OF NEW HOMES

Table 13: Ordinary Least Square Regression Results—Lane County

Variable	Coefficient	St. Error	t-stat	Significance
Constant	8.905	0.117	76.147	0.000
Heat Pump*	**0.037**	**0.008**	**4.662**	**0.000**
Ln(FT^2/Bedroom)	0.174	0.019	9.195	0.000
Ln(FT^2)	0.299	0.016	18.408	0.000
2006 Indicator	0.133	0.009	15.431	0.000
2007 Indicator	0.161	0.008	19.279	0.000
2008 Indicator	0.135	0.010	13.889	0.000
Eugene	0.067	0.007	9.791	0.000
R^2 = 0.59	F-statistic = 217		Observations = 1,036	

Source: ECONorthwest analysis of Portland RMLS data

* Impact on sale price of having a heat pump is statistically significantly different from zero at the 0.01 level.

Table 14: *Frontier*-Based Regression Results—Linn/Benton Counties

Variable	Coefficient	St. Error	t-stat	Significance
Constant	5.904	0.261	22.659	0.000
Heat Pump*	**0.044**	**0.025**	**1.791**	**0.073**
Ln(FT^2/Bedroom)	0.071	0.059	1.202	0.229
Ln(FT^2)	0.776	0.046	16.708	0.000
2006 Indicator	0.102	0.047	2.178	0.029
2007 Indicator	0.092	0.045	2.039	0.042
2008 Indicator	0.042	0.046	0.921	0.357
Log LH = 138	Max LH Estimation—No F-stat		Observations = 199	

Source: ECONorthwest analysis of Portland RMLS data

* Impact on sale price of having a heat pump is statistically significantly different from zero at the 0.10 level.

Marion County:

Too few sales of new homes with heat pumps in data set

Multnomah County:

Too few sales of new homes with heat pumps in data set