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Marginal Energy Prices Report

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MARGINAL ENERGY PRICES – FINAL REPORT

EXECUTIVE SUMMARY

This report responds to a recommendation from the Department of Energy's (DOE) Advisory Committee on Appliance Energy Efficiency Standards. It presents the derivation of estimated consumer marginal energy prices for the commercial and residential sectors for use in the life-cycle cost (LCC) analyses for four of the high priority appliances' energy efficiency standards rulemakings – clothes washers, water heaters, fluorescent lamp ballasts, and central air conditioners/heat pumps.

Marginal prices as discussed here are those prices consumers pay (or save) for their last units of energy used (or saved). Marginal prices reflect a change in a consumer's bill (that might be associated with new energy efficiency standards) divided by the corresponding change in the amount of energy the consumer used.

Previous LCC analyses had either used Energy Information Administration's (EIA) Residential Energy Consumption Survey (RECS) household average prices for valuing energy savings from residential sector energy efficiency standards or a distribution of average prices derived from electric utility data for valuing energy savings from commercial sector energy efficiency standards. *Average* energy prices for a consumer are derived by dividing annual energy costs by annual energy consumption. At the utility level, average energy prices are derived by dividing annual revenues by annual energy sales.

Section I below provides background on the work developed for marginal energy prices. Section II describes the methods used to derive marginal energy prices. Other credible methods to calculate or estimate consumers' marginal energy prices were not found. Because of the complexity inherent in utility tariffs, methods that simply subtract fixed costs from average costs do not constitute a credible method for calculating marginal prices.

Section III shows the analysis for the commercial sector (for application to fluorescent lamp ballasts). The analysis centered on the calculation of electricity bills for a distribution of sample buildings in conjunction with a distribution of commercial tariffs. Jackson Associates' Market Analysis and Information System (MAISY®) database provided the source of information for the building energy and demand levels among buildings of different types. Commercial tariffs from a sample of utilities were collected and modeled..

Section IV describes the analysis for the residential sector (for application to three products: clothes washers, water heaters, and central air conditioners/heat pumps). The analysis centered on use of consumer bills from the RECS 1993 database. Seasonal marginal electricity prices and annual marginal natural gas prices were derived by calculating the slope of the regression lines associated with monthly bill and consumption data.

Prices of residential heating oil and propane were also examined. Because bills paid by residential consumers for these fuels are determined almost wholly by the volume purchased, quoted prices are essentially marginal prices. Section V presents the results of our examination of residential heating oil and propane prices.

Section VI discusses the effect of taxes on marginal prices.

A summary of the results of the analyses to derive commercial and residential marginal prices follows:

- Commercial
  - Analysis based on the LBNL/MAISY® approach.
  - Used tariffs for 21% of national commercial electricity customers.
  - Electricity marginal prices for individual customers range from 85% below to 51% above the average price for the same customer. At the consumption-weighted mean of the differences, electricity marginal prices are 5.2% lower than average prices.

- Residential
  - Analysis based on the RECS national sample.

- Electricity marginal prices for individual customers in the summer (June-September) range from 98% below to 175% above the average price for the same customer. At the consumption-weighted mean of the differences, electricity marginal prices are 2.5% higher than average prices in the summer.
- Electricity marginal prices for individual customers in the winter (the remaining eight months) range from 100% below to 130% above the average price for the same customer. At the consumption-weighted mean of the differences, electricity marginal prices are 5.3% lower than average prices in the winter.
- Gas marginal prices range for individual customers from 98% below to 248% above the average price for the same customer. At the consumption-weighted mean of the differences, gas marginal prices are 7.8% lower than average prices.

I. BACKGROUND

The Issue

In the past, DOE's analyses of the life-cycle costs of and consumer bill savings possible from appliance energy efficiency standards were based on average energy prices. Using marginal energy prices in these analyses is more theoretically sound because consumers would save energy on the margin (that is, at the price they pay for their last unit of energy), not at the average price they pay for their energy. Unfortunately, neither published nor readily available data existed for consumer marginal energy prices. Indeed, a major research effort was required to derive consumer marginal energy prices.

DOE Advisory Committee

In its April 21, 1998 letter to Secretary of Energy Pena, the Advisory Committee on Appliance Energy Efficiency Standards delivered recommendations to the Department of Energy regarding, among other things, the use of energy prices in future appliance standards rulemakings. For life-cycle cost analyses the Committee recommended that DOE should replace the use of national average energy prices with the full range of consumer marginal energy rates. Absent consumer marginal energy rate information, the Committee recommended DOE use a range of net energy rates, calculated by removing all fixed charges (such as monthly customer charges that consumers incur regardless of their monthly energy usage). In response to the Committee's recommendations, DOE[1] agreed that the use of marginal energy rates would improve the theoretical soundness of the analysis and decided to determine marginal rates using either RECS or commercially available databases. While the Department believed at that time that it was unknown if removing fixed costs is more or less reflective of marginal rates, it did not intend to take that intermediate step without evidence that the result would improve the accuracy of the analysis.

Fixed Charges

In considering the recommendation to subtract fixed charges, the Department asked LBNL to examine the data provided by the Edison Electric Institute (EEI) concerning electric rates for 104 utilities, serving over 63 million customers. The data included average prices, tail block rates and fixed charges, but not marginal prices. EEI reported that fixed charges as a weighted percentage of average prices represent 7.5 percent. However, in examining the actual rate schedules of a few of these 104 utilities, it was found that some of the reported fixed charges were actually minimum charges, not customer charges. Thus the actual fixed charges, which are independent of kilowatthour (kWh) usage, would be somewhat lower than the reported 7.5 percent depending upon how often minimum charges were considered to be customer charges within the whole EEI sample of utilities.

The Department agreed that for flat rate schedules, the removal of these adjusted fixed charges would yield the marginal rate. However, upon examining the EEI data, it was determined that most rates are not flat. Of the 104 utilities represented in the data, 100 contained average price, tail block rate and fixed charges. For utilities with a single flat rate schedule, the average price absent the fixed charges should equal the tail block rate. Of the 100 utilities, only 16 met this test within an assumed one percent reporting and rounding error. Thus, 84 percent of the utilities had non-flat rates or a mix of rate schedules which greatly complicates the determination of the marginal price. Of these 84 utilities,

[1] Letter from Dan Reicher, DOE Assistant Secretary, Energy Efficiency and Renewable Energy, to the Advisory Committee members, July 28, 1998.

roughly half had tail blocks higher than the average price, indicating inclining block rates, and half had lower tail blocks indicating declining block rates. Seasonal rates further complicate this picture.

The American Gas Association (AGA) had conducted a similar analysis using 1996 data for 264 gas utilities serving 46 million residential customers. AGA found that fixed customer charges constituted approximately 13.5% of those utilities' total gas revenues from their residential consumers. Beyond noticing that the AGA analysis included only two of California's gas utilities (e.g., it did not include data for either Pacific Gas & Electric or San Diego Gas & Electric), AGA's analysis was not closely evaluated.

Marginal Prices

With inclining or declining block rates, the actual value of consumer energy savings is the product of the marginal price, plus any applicable taxes or fees, times the energy units saved. While simple in theory, the accurate derivation of this saving is very difficult. Consumers are typically billed monthly for their energy usage and will face different marginal rates during the year depending on where their energy consumption places them in the rate schedule in any given month and how that rate may change with the time of year. It should be noted that just examining the last or tail block of a rate schedule is not sufficient since many, if not most, consumers do not progress to the last block of the rate schedule each and every month of the year. The seasonal variability of appliance usage is most obvious for space conditioning products such as air conditioners, but, in reality, almost all appliances undergo some seasonal variation in their usage. Given the possible wide range of marginal prices between winter and summer months, any significant seasonal variation in usage could have a significant effect on the marginally calculated savings.

Using actual marginal prices may yield consumer energy savings higher or lower than the past method of using average costs based on total revenue. Given the prevalence of summer peaking utilities and seasonal rates, it seems likely that appliances with heavier summer usage, particularly central air conditioners, would most probably produce a greater consumer value of savings using marginal prices. Therefore, removing fixed costs, which only guarantees lower estimates of energy prices, would then be a correction in the wrong direction.

Restructuring

Given restructuring of parts of the energy supply sector, customers may soon have more than one bill (e.g., one from the distribution company, and one or more from generators or suppliers). To capture complete information, future surveys would best gather energy pricing information directly from the customers, rather than from utilities or local distribution companies. The most efficient means to collect energy pricing information in the future involves including consumption by month and pricing information in future bills. The pricing information would include for each customer, the rate schedule: marginal rates, fixed charges, demand charges for commercial and industrial customers, or time-of-use rates where applicable.

Data Sources

In the near term (before new surveys can be crafted and implemented), several sources of information were available for this current research and analysis on marginal prices. Residential consumers' utility bills were available from the RECS 1993 survey. Commercial customers' utility bills could be approximated from monthly usage and likely utility tariff. Monthly usage for a large sample of commercial buildings was available from a commercial product, the MAISY® commercial database.[2] Utility tariff sheets were available from utility web sites, commercial services, or the utilities themselves. Data on utility sales and number of customers on various tariffs were available for investor-owned utilities from the Federal Energy Regulatory Commission (FERC) Form 1 filings made by those utilities. For municipal utilities and co-ops, equivalent tariff-level data were obtained from either the utility itself or were available from the Rural Utility Service.

[2] MAISY® is a proprietary product that was acquired by LBNL from Jackson Associates, Suite 200, 4825 Creekstone Drive, Durham, NC 27703; 919-967-9000/919-967-8040 (fax);e-mail:jjackson@ntrnet.net

II. METHODS

Calculating the true bill effects of proposed appliance energy efficiency standards on diverse U.S. consumers is difficult because of the many electricity and natural gas tariffs in place, and the complexity of these tariffs. Since the set of end-uses currently under consideration for new standards includes fluorescent lamp ballasts, calculations for commercial as well as residential electricity customers must be included, which complicates the task considerably because commercial tariffs are generally more complex.

To address this difficult research question, several complementary approaches were developed. Those approaches are briefly outlined below. Each of these approaches was a step in the overall sequence of setting up the modeling capability to allow calculation of samples of customer bills.

“Analytic” Approach

This approach was the first-cut analysis in which residential electricity and gas tariffs and commercial electricity tariffs were examined as they were collected. Comparing each particular tariff’s rate blocks to average prices yielded the maximum and minimum differences between marginal and average price possible for that particular tariff. Because consumption is unknown, actual customer marginal prices cannot be obtained by this method; only the outer bounds to those prices can be obtained. The findings from this approach were:

a) Care must be taken to find and account for all charges, since the tariffs are often complex, with a number of charges based on demand levels, voltage levels, seasons, etc. Residential tariffs tend, though, to be less complex than commercial tariffs.

b) For residential gas, individual customer marginal prices are most likely to be below average prices, but with a large range in results.

c) For residential electricity, individual customer marginal prices can show a very large range, with differences ranging from –79% to +344% compared to the average price for customers having a particular tariff, although many of the extreme results appear on tariffs that cover only a few customers and thus would be seldom experienced.

d) For commercial electricity, individual customer marginal prices also show a large range and no discernable pattern emerged from the analysis.

Because the range of differences between marginal and average prices from this analysis was large, it was concluded that simple patterns in the relationship between average and marginal prices did not seem to exist. Therefore, the focus was on the methods that permit estimation of individual customer bills: the experimental, empirical, and RECS analyses.

“Empirical” Approach

LBNL contracted with Jackson Associates for use of and enhancement to its proprietary MAISY® database of U.S. residential and commercial building energy characteristics. This approach involves allocating these residences and commercial buildings, currently only identified by state, to electric utility service territories and then to particular utility tariffs. Monthly customer bills can then be calculated with and without energy and demand savings, yielding marginal prices for each particular consumer. The method and code for conducting the allocation of customers and estimation of bills was developed using two utilities in a southern California test area, and a bill calculator function using the actual tariffs of electric and gas utilities was developed. For commercial buildings, this approach evolved into the one explained in Section III. Since an estimate of the effect on the house’s natural gas bill was also required for analysis of the three residential products (clothes washers, water heaters, and central air conditioners/heat pumps), the households were further assigned to a natural gas local distribution company (LDC) that serves a part of the territory of that residence’s electric utility. While for residential buildings, this “empirical” approach was put aside in favor of the RECS approach described below, it was used as the foundation for the “experimental” approach in the analysis of commercial sector fluorescent lamp ballasts.

“Experimental” Approach

During the collection of tariffs and the designing of the computer code for the empirical approach, a spreadsheet bill calculator was developed. Exploratory experimental tariffs could be modeled in this spreadsheet, and, together with load shapes from the general literature and estimates of monthly customer energy use effects, bills can be estimated. A variation of this method that used actual commercial tariffs and load shapes from MAISY® commercial buildings provided the technical approach used for the commercial sector analysis. See Section III for the details and results of this method as applied in final form to the analysis of the commercial sector.

<u>"Big Bang" Approach</u>
The initial sample of electric utility tariffs that was analyzed had been chosen with consideration of diversity in terms of utility ownership, geography, and utility size in mind. That sample was extended, as time permitted, but the utility-by-utility detailed approach necessarily covered only a limited fraction of the total customer population. On the other hand, a large fraction of customers in the country are actually served on a rather small number of tariffs from a limited number of large utilities. This fact suggested an alternative "big bang" approach. In this approach, the tariffs with the greatest number of customers would be examined. This approach was drawn upon to a limited degree in the expansion of the set of commercial tariffs used in the final commercial sector analysis.

<u>RECS Approach</u>
Consumer marginal energy prices were estimated directly from household RECS data by calculating the slopes of the regression lines that relate customer bills and customer usage. For electricity, the slopes of the regressions for four summer months (June-September) and, separately, for the remaining ("winter") months were calculated. For natural gas, the data did not support calculations beyond the annual level. After exploring the empirical method outlined above for use in the analysis for the residential sector, the RECS method (because of its advantages which are explained further in Section IV) was adopted for the analysis of residential marginal prices in this project. See Section IV for the details and the results of this RECS method.

<u>Linkage to the Product LCC Analyses</u>
To anticipate the impact of using marginal prices in place of average prices, a simple sensitivity analysis on the LCC for each product was conducted, using a range of possible energy price variations. The results were:

a) For central air conditioners, the efficiency level having the minimum LCC was not affected over the range -25 to +25% from average energy prices.

b) For water heaters, the design option for electric water heaters having the minimum life cycle cost is sensitive to the value of marginal energy prices, but less so for natural gas water heaters.

c) For clothes washers, the efficiency level having the minimum LCC was not affected over the range –25% to +25% from average energy prices. In addition, payback period was shown to be affected by a lower percentage than the change in energy prices, because the operating savings due to water is unaffected by a change in energy price.

d) For ballasts, electronic ballasts were shown to reduce LCC at energy prices down to 45% below average, compared to energy efficient magnetic (EEM). For cathode cutouts, energy prices down to 10% below average still yielded a reduced LCC compared to EEM.

See the relevant Technical Support Documents (TSDs), Notice of Proposed Rulemakings (NOPRs), and the Advanced Notice of Proposed Rulemaking (ANOPR) – all in progress -- for information on the application of the results of the marginal energy price study to specific products.

III. ANALYSIS AND RESULTS – COMMERCIAL

Commercial marginal electricity prices were derived by calculating monthly bills for a distribution of buildings (with energy usage information) using a set of modeled commercial tariffs. This section of the Marginal Energy Prices report first describes the utility tariffs that were chosen and modeled for this analysis. Then the process for calculating the electricity bills and the marginal electricity prices for the sampled commercial buildings is described. Because commercial tariffs tend to have demand charges, the adjustment applied to represent the reduction in demand associated with new energy efficiency standards is described next. The method by which the sampled buildings are weighted in the analysis is also described. Lastly, the results of the commercial analysis are presented.

A. Tariff Collection and Modeling

Tariff Collection

For a variety of utilities around the country, commercial tariffs were collected and then modeled for use in the bill calculation process. Utilities were chosen in an attempt to obtain a sample that is generally representative of commercial customers throughout the nation. In choosing utilities, the key factors considered were geographic location, type of ownership (e.g. investor owned, publicly owned, or cooperatively owned), and size. Those factors were chosen to capture regional differences in such issues as climate, the availability of inexpensive sources of energy, the structure of regulatory oversight, and the scale of operation. Table 1 below is a list of the commercial utility sample used in this analysis. Utility tariffs were obtained from the following sources: utility web sites, a consulting company, and utilities themselves. In order to properly weight results, FERC Form 1 (or equivalent) data for the chosen utilities showing the number of customers and the sales for each of a utility's tariffs were obtained.

Table 1. Characterization and Summary of Commercial Electric Utility Sample

			By Utility		*By Modeled Tariffs*		*Percent of US in Modeled Tariffs*		*Our Sample as Percent of Utility*	
Utility	**State**	**Type**	**Total Number of Customers**	**Total Megawatt-hour Sales**	**Cust.**	**Megawatt-hour Sales**	**Cust.**	**MWh Sales**	**Cust.**	**MWh Sales**
PG&E	CA	IOU	552,901	49,530,911	401,747	16,025,437	3.0%	1.7%	73%	32%
SoCal Edison	CA	IOU	481,417	51,410,408	419,163	23,057,727	3.1%	2.5%	87%	45%
Commonwealth Edison	IL	IOU	292,709	49,933,859	291,143	25,859,649	2.2%	2.8%	99%	52%
Virginia Power	VA	IOU	189,301	20,061,476	137,813	2,696,019	1.0%	0.3%	73%	13%
Detroit Edison	MI	IOU	177,088	17,997,214	166,003	7,613,394	1.2%	0.8%	94%	42%
Alabama Power	AL	IOU	174,602	11,330,312	154,077	7,917,907	1.1%	0.9%	88%	70%
Penn Power & Light	PA	IOU	149,221	20,475,206	143,849	8,781,171	1.1%	0.9%	96%	43%
Niagara Mohawk Power	NY	IOU	148,124	23,279,622	143,590	4,550,295	1.1%	0.5%	97%	20%
NSP (MN)	MN	IOU	135,183	5,009,755	110,807	4,461,852	0.8%	0.5%	82%	89%
Union Electric Co	MO	IOU	134,699	12,189,235	120,596	8,735,132	0.9%	0.9%	90%	72%
Appalachian Power	VA	IOU	110,740	16,390,313	78,554	674,926	0.6%	0.1%	71%	4%
Jersey Central P&L	NJ	IOU	106,157	10,510,309	104,922	5,358,036	0.8%	0.6%	99%	51%
Wisconsin Elec Power	WI	IOU	93,973	18,454,563	85,735	2,705,293	0.6%	0.3%	91%	15%
Boston Edison	MA	IOU	87,644	7,991,349	80,255	2,820,415	0.6%	0.3%	92%	35%
Ohio Power Company	OH	IOU	87,314	24,917,126	6,442	6,348,160	0.0%	0.7%	7%	25%
Central Power & Light	TX	IOU	85,311	12,844,712	74,107	2,099,439	0.5%	0.2%	87%	16%
Arizona Public Service	AZ	IOU	79,755	8,524,882	78,530	6,989,968	0.6%	0.8%	98%	82%
PEPCO	MD	IOU	70,909	15,307,001	53,620	1,317,800	0.4%	0.1%	76%	9%
Cleveland Electric Illum	OH	IOU	64,907	5,883,328	63,161	2,765,339	0.5%	0.3%	97%	47%
Seattle City Light	WA	Muni	43,497	3,081,941	43,497	3,081,941	0.3%	0.3%	100%	100%
NSP (WI)	WI	IOU	31,236	866,425	27,449	831,739	0.2%	0.1%	88%	96%
Madison Gas & Electric	WI	IOU	16,220	1,727,832	14,815	685,233	0.1%	0.1%	91%	40%
Savannah Elec & Power	GA	IOU	14,100	1,156,078	708	517,052	0.0%	0.1%	5%	45%
Poudre Valley REA	CO	Co-op	2,774	377,974	2,101	96,424	0.0%	0.0%	76%	26%
Sample Total			3,329,782	389,251,831	2,802,684	145,990,348	20.7%	15.7%	84%	38%
US TOTAL			13,540,374	928,440,265						

Because tariff-level information on sales is not as readily available for publicly and cooperatively owned utilities as it is for investor-owned utilities that must report such information annually to FERC, the sample contained only one municipal utility and one co-op. While the co-op included in the analysis had an average commercial price nearly the same as the average commercial price of all of the co-ops in the country, the same was not true for the municipal utility in our sample. As a sensitivity analysis, several more municipal utilities were later added, which brought the weighted average electricity price of the municipal utilities in the sample closer to the average commercial price of all of the municipal utilities in the country. The bill calculator (which is described below) was then re-run using the expanded set of tariffs. See Section D below for the results of this sensitivity analysis.

Commercial Tariff Structure

Commercial tariffs can be complex. A commercial tariff usually includes the following types of information:

- Applicability / Availability — the type of customer served under this tariff.
- Character of Service — the type of current, voltage, and single or three-phase.
- Monthly Rate — customer charge, energy charge, demand charge (if applicable), and extra charges.
- Definition of demand charges.
- Rate periods (if time-of-use) and definition of seasons.
- Minimum monthly charge.
- Power factor adjustments and reactive power demand charges.

Commercial Spreadsheet Modeling

Generally, the commercial tariff modeling effort focused on two common categories of commercial tariffs: small general service and general service. The collected commercial tariffs were modeled in spreadsheet form, excluding some tariffs and/or components that could not be applied to buildings in MAISY®. For instance, some tariffs provide charges for both single and three-phase service. Because MAISY® does not distinguish between these two types of service, only the charges for single phase were modeled. Also, some tariffs charge different prices for primary, secondary, and transmission voltage levels. Because of the types of buildings used in MAISY®, only the secondary voltage levels were considered. Power factor and reactive demand charges, which are adjustments based on voltage and demand usage, were ignored. Other factors were ignored if the information could not be used in MAISY® or are rarely applicable. The spreadsheet also contains the number of customers in a tariff, total number of customers in a commercial utility, the megawatt-hours sold, kilowatt-hours sold per customer, and average price per kilowatt-hour. These data were extracted from FERC Form 1 for IOU's and from comparable sources for municipal utilities and co-ops.

B. Calculation of Commercial Bills and Marginal Prices

Overview

The Commercial Tariffs Spreadsheet, or CTAS, contains a collection of modeled commercial electric utility tariffs, a collection of modeled commercial buildings, and Visual Basic program modules. Each building is assigned to a group of applicable tariffs, based on building demand, and monthly bills are calculated for each tariff for a calendar year. Then, building energy usage and demands are decremented to account for savings expected from a new energy efficiency standard, monthly bills are recalculated, and the differences in bills and energy use are used to calculate marginal prices.

Commercial Tariffs

Electric utilities calculate customer bills from tariffs that define the type and amount of each charge. These charges are generally levied on a monthly basis, and generally have three main components: fixed charges, usage charges, and demand charges. These tariffs were collected for a number of US electric utilities and modeled for inclusion in CTAS calculations. CTAS contains the specific commercial tariffs for the utilities shown in Appendix 1.

In addition to the parameters necessary to calculate customer bills, information was collected for each tariff regarding the number of customers, revenues, and delivered energy. This tariff-level data on customers and delivered energy were used to weight the resulting bill and marginal price calculations to represent a national distribution of marginal prices. The calculations did not use a tariff unless it was also possible to collect usage and delivered energy data for that individual tariff (as opposed to being able to collect such information only for the entire utility or a group of that utility's tariffs). Industrial tariffs, as contrasted to commercial tariffs, have not been included in CTAS. This is primarily because the MAISY® database does not include industrial buildings.

Electric utilities typically have many commercial tariffs. Southern California Edison, for instance, has over 100 commercial tariffs. Most of these tariffs target a very small number of customers, or even individual customers, and thus have been ignored in CTAS. To maximize coverage in the limited time available, only the most-used two or three commercial tariffs for each utility have been included in CTAS. Taken together, these few tariffs cover 84% of the customers in our utility sample and 38% of the commercial electricity sales by those sampled utilities.

Generally speaking, commercial customers are assigned to a particular tariff based on their peak monthly and/or annual demand as measured in kilowatts over a short period of time, e.g. 15 or 30 minutes. This demand "window" was used to determine which of all the tariffs to apply to a particular building in the CTAS collection. For instance the GS-2 tariff carried by Southern California Edison is applied to a customer/building whose peak demand is between 20 and 500 kW. This assignment by demand window means that a particular building will have bills calculated using some subset of all the modeled tariffs, typically one tariff per utility.

CTAS Buildings/Customers

The collection of buildings contained in CTAS comes from MAISY®, a proprietary database containing weighted, representative building collections for each state. A subset of buildings was selected from MAISY®, the subsequent weighting of which was intended to create a "prototypical" set of buildings that would exist in relatively the same proportions throughout the country, and would thus be representative of customers existing within any of the modeled utility tariffs. Each sampled building in MAISY® has a large number of associated characteristics, such as size, annual peak demand, etc. Also included are hourly load profiles for an entire year. For each of seven states (California, Washington, Colorado, Illinois, Texas, New York and Georgia) a subset of buildings was selected for inclusion in CTAS. The hourly load profiles for these buildings were then extracted from MAISY® and summed up over a month. Then these monthly loads and demand peaks were inserted into CTAS. For each state, 189 buildings, with their MAISY® building weights, were included, for a total of 1323 buildings. The 1323 buildings were apportioned to the main types of commercial buildings used in EIA's Commercial Building Energy Consumption Survey (CBECS) as follows:

CBECS Building type	% of Total Commercial Buildings in US[3]	Number of Buildings in Sample	% Buildings in Sample
Education	7.6%	98	7.4%
Food Sales	3.5%	63	4.8%
Food Service	6.7%	91	6.9%
Health Care	2.5%	35	2.6%
Lodging	3.4%	42	3.2%
Mercantile and Service	30.9%	406	30.7%
Office	17.9%	231	17.5%
Public Assembly	7.6%	98	7.4%
Public Order & Safety	2.1%	28	2.1%
Religious	5.0%	63	4.8%
Warehouse & Storage	9.7%	126	9.5%
Other/Vacant	3.0%	42	3.2%
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TOTAL	100.0%	1323	100.0%

CTAS Calculations

CTAS does its work in batch mode; that is, a run is executed and output is produced, automatically weighted by building type, without any further user intervention. A run consists of the following steps, nested and repeated as explained:

[3] Source: CBECS Table BC-39: Lighting Equipment, Number of Buildings, 1995.

- Each customer/building is considered in turn.
- For each building a selection is made of applicable tariffs, based on that building's peak annual demand.
- For each tariff a calculation of a monthly bill in $/month is performed.[4]
- A second calculation with the same month, tariff and building is performed with decremented monthly energy use and peak demand to obtain a representative change in the building's bill (in order to calculate the marginal energy price). The assumed energy use decrement is 5%; the demand decrement is 80% of 5%, that is, 4%.[5]
- A monthly marginal price in $/kWh for this month-tariff-building is computed by dividing the difference between the two bills by the difference between the two energy consumption levels, e.g., change in $/change in kWh.
- An average price in $/kWh is computed by dividing the original, undecremented bill by the original energy use, e.g. bill $/total kWh.
- The percentage difference between the average and marginal price is calculated by subtracting the average price from the marginal price and dividing by the marginal price.
- These calculations are repeated for the 12 months of a calendar year.
- Annual values are obtained for average price, marginal price, and percent difference by summing each month's values over the year and dividing by 12.
- The process is repeated for each applicable tariff for the particular customer/building.
- The next building is considered and the complete process repeated, until all customer/buildings have been processed.

CTAS Output

The output from a CTAS run is written to a comma-separated-values, or "csv" file, with a record for each building-tariff match. This file, containing the fields shown below, is loaded into a FoxPro® table where additional processing occurs to produce various charts and distributions.

Field Name	Field Description
ACCTNO	MAISY® customer / building ID number
STATE	State from which sample customer was drawn
ANPKKW	Building annual peak demand in kW measured over 1 hour
TARFTYP	Tariff group index defined by demand "window"
ARFINDX	Index used in program
TARPTR	Index used in program
UTILCO	Electric utility's name, e.g. Consolidated Edison
TARFNAME	Name of particular tariff, e.g. GS-1
NCUS	Number of customers billed under that tariff
DELVDMWH	Annual megawatthours (MWh) delivered by utility to customers under this tariff
BLDGWT	Calculated weight of building, derived in part from MAISY® weight
BLDGOPHR	Weekly hours of operation of building
ANAVGRAT	Annual average electricity price
ANMR1	Annual average electricity marginal price
ANE1	Annual percent difference between marginal and average electricity price
AVGBILL	Annual average bill, defined as average of 12 monthly bills
AVGBILL1	Annual average decremented bill, defined as average of 12 monthly average bills
AVGKWH	Annual average energy use, defined as average of 12 monthly energy usage levels
AVGKWH1	Annual average decremented energy use, defined as average of 12 monthly decremented energy usage levels

[4] See Appendix 2 for sample commercial bill calculations.

[5] The explanation of the derivation of the demand decrement appears in Appendix 3: "Demand Decrement Due to Standards – The Role of Lighting Coincidence and Diversity."

Conclusions
CTAS was designed as an analysis tool to investigate marginal prices experienced by a range of customers over a range of commercial tariffs throughout the country. It attempts to maximize coverage by running a prototypical set of customers/buildings against as broad a set of tariffs as possible, given the time constraints of the project.

C. Weighting Method

This section describes construction of the weighted distribution of commercial electricity marginal prices. The sample of commercial buildings consisted of 1323 buildings from seven states with each building supplying multiple observations to the final data set, one for each applicable tariff. Each observation in the final data set represents a unique combination of a building and an applicable tariff, for a total of 29,133 observations.

The composition of the sample posed a dual weighting problem: distributing weights across buildings and across tariffs. The weighting approach solves these problems sequentially. For each building a weight is derived from its original MAISY® building weight and scaling factors. This adjusted building weight is then apportioned across all the tariffs that were applied to the building. A composite weighting factor for each building/tariff pair combines both of these weighting factors. These weights are all based on energy, average monthly kWh usage at the building level and annual MWh sales for each tariff. Appendix 4, Weighting Method for Commercial Sample, shows the details of the approach to this dual weighting problem.

D. Results of Analysis

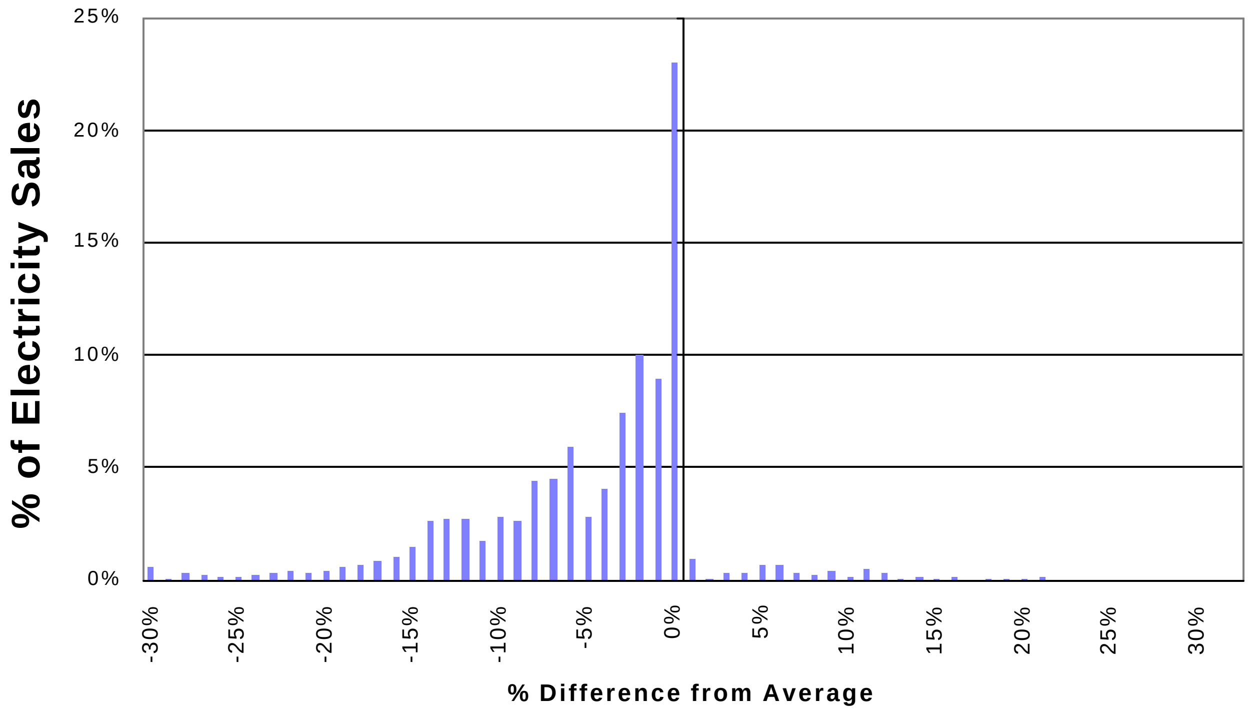
Figure 1 below displays the results of the commercial analysis by showing the distribution of the differences derived between marginal electricity prices and average electricity prices. Electricity marginal prices range from 85% below to 51% above the average price for the same customer. At the consumption-weighted mean of the differences, electricity marginal prices are 5.2% lower than average prices.[6] In the LCC analysis of commercial sector ballasts, this distribution of differences was used along with a distribution of average commercial sector electricity prices (which were obtained from EIA data on over 3000 utilities serving commercial customers) to generate a distribution of marginal electricity prices. In the LCC analysis of industrial sector ballasts, this same distribution of differences was used along with a distribution of average industrial sector electricity prices (which were obtained from EIA data on over 2000 utilities serving industrial customers) to generate a distribution of marginal electricity prices.

As a result of the sensitivity analysis mentioned earlier (where additional municipal utility tariffs were included), a similar distribution of weighted amounts were found by which average prices exceeded marginal prices, the mean of which was –5.6%.

[6] The individual amounts by which average prices exceeded marginal prices had to be binned to prepare inputs for the LCC analysis. The weighted mean of the binned distribution was –5.7%.

Figure 1.

Commercial Electricity Marginal Prices Differences from Annual Average



Marginal < Average	Marginal > Average
Mean = -5.2%	Median = -3.3%
Minimum = -85%	Maximum = +51%

IV. ANALYSIS AND RESULTS – RESIDENTIAL

Method Used to Derive Residential Electric and Natural Gas Marginal Prices

Data from the Energy Information Administration's (EIA) 1993 Residential Energy Consumption Survey (RECS) were used to calculate marginal energy prices for residential appliance owners. The main advantages of using RECS data are: 1) this survey of 7041 U.S. households was designed by EIA to be a nationally representative sample; and 2) the data are available to the public. Since RECS includes the exact amounts households paid for utility bills, there is no need to derive those bills from a combination of an appropriate tariff and each building's energy consumption. Thus, the method for deriving residential marginal energy prices was inherently simpler than our previously described method for deriving commercial marginal energy prices.

EIA had collected utility bills for up to 16 billing cycles for 6119 of the 7038 RECS households that use electricity, and for 3153 of the 4033 RECS households that use natural gas. EIA has made a public use version of these data available; it includes some error inoculation to protect the identity of individual utility customers.

Marginal energy prices were calculated by performing a separate regression analysis for each household for which billing data were available.[7] Energy consumption was plotted on the x-axis, and the consumer's energy bill was plotted on the y-axis. The slope of the regression line for each household (the change in the energy bill divided by the change in the energy consumption) equals the marginal energy price for that household.

Electricity

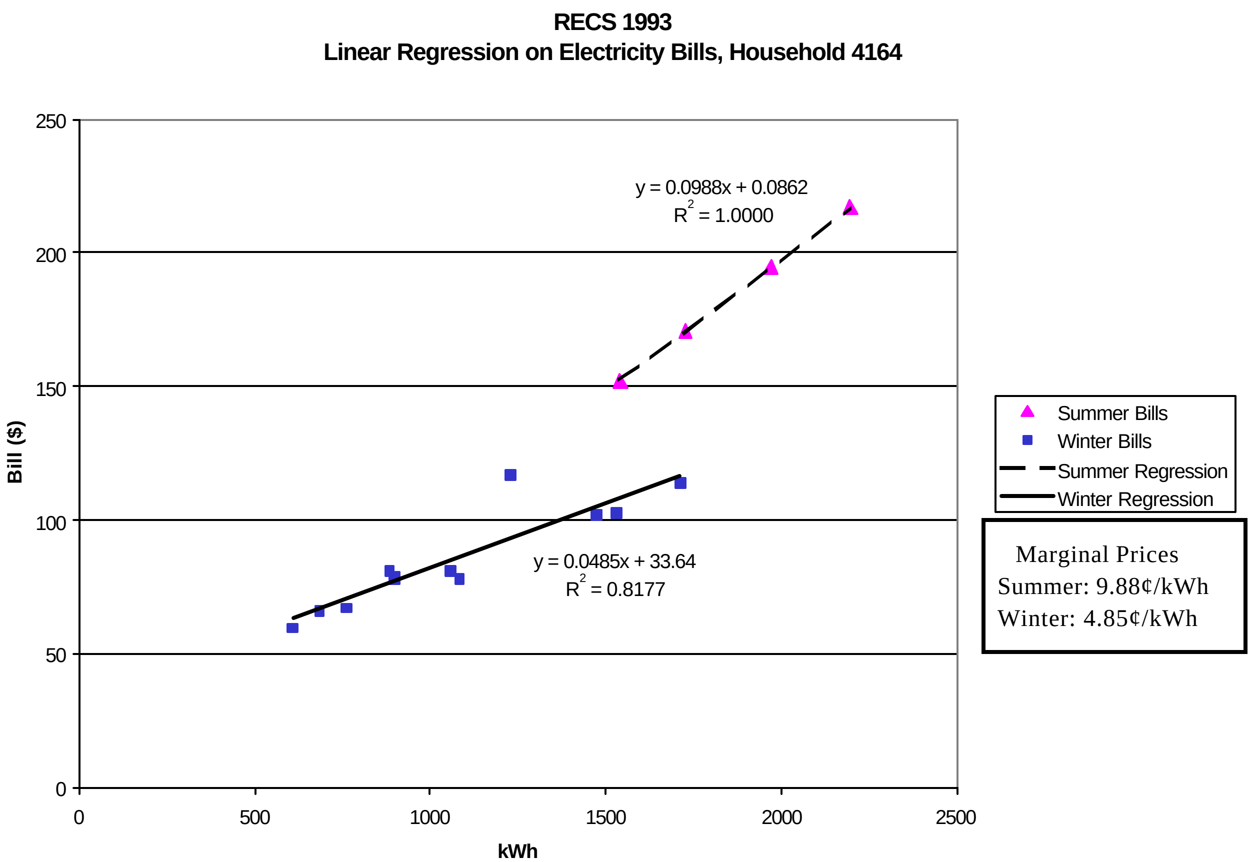
For electricity, the billing data were divided into two seasons, summer and "winter" (actually non-summer), where a bill was defined to be a summer bill if the midpoint of the billing period fell between June 1 and September 30. This division was done because review of utility tariffs (during the "Analytic" approach described earlier) had found that electric utilities often had different rates in summer vs. non-summer, and that most utilities defined summer to fall within this range of dates. A linear regression relating electricity bills and usage was performed separately for each season. The marginal electricity price for each season was estimated to be equal to the slope of the regression line. See Figure 2 below for a sample linear regression on the electricity bills of one of the RECS households.

For some households, there were either not enough data or the data points were too close together or too scattered to determine a slope, particularly in the summer season. After a household-by-household examination of the outliers, slopes (marginal prices) that were either less than or equal to zero or greater than $0.22/kWh were also rejected. It was possible to calculate slopes for the summer season for 5818 households, of which 5615 had acceptable fits, yielding slopes that fell within the above range of values. It was possible to determine a slope for the "non-summer" season for all 6119 households for which electricity billing data were available. Of these households, 6098 had slopes with acceptable fits. There were a total of 5606 households for which both the summer and non-summer marginal electricity prices could be determined with acceptable fits. Seasonal prices were used for each of these households in the LCC analysis.

For households for which it was not possible to determine a seasonal rate for both seasons, or for which these rates fell outside the acceptable range, a single linear regression was performed from the data from all billing cycles. There were an additional 502 households for which a single annual marginal price could be determined. This marginal price was used in the LCC analysis for these households. Thus, of the 7038 RECS households with electricity, a marginal electricity price or prices were available for 6108 (5606 with seasonal rates, plus 502 with annual marginal prices only), or 87%. Most (919) of the households for which a marginal price was not available were those for which EIA did not collect billing data, with only 11 additional households being dropped due to an indeterminate or unacceptable regression slope.

[7] Source: Robert Latta of EIA proposed this approach.

Figure 2.



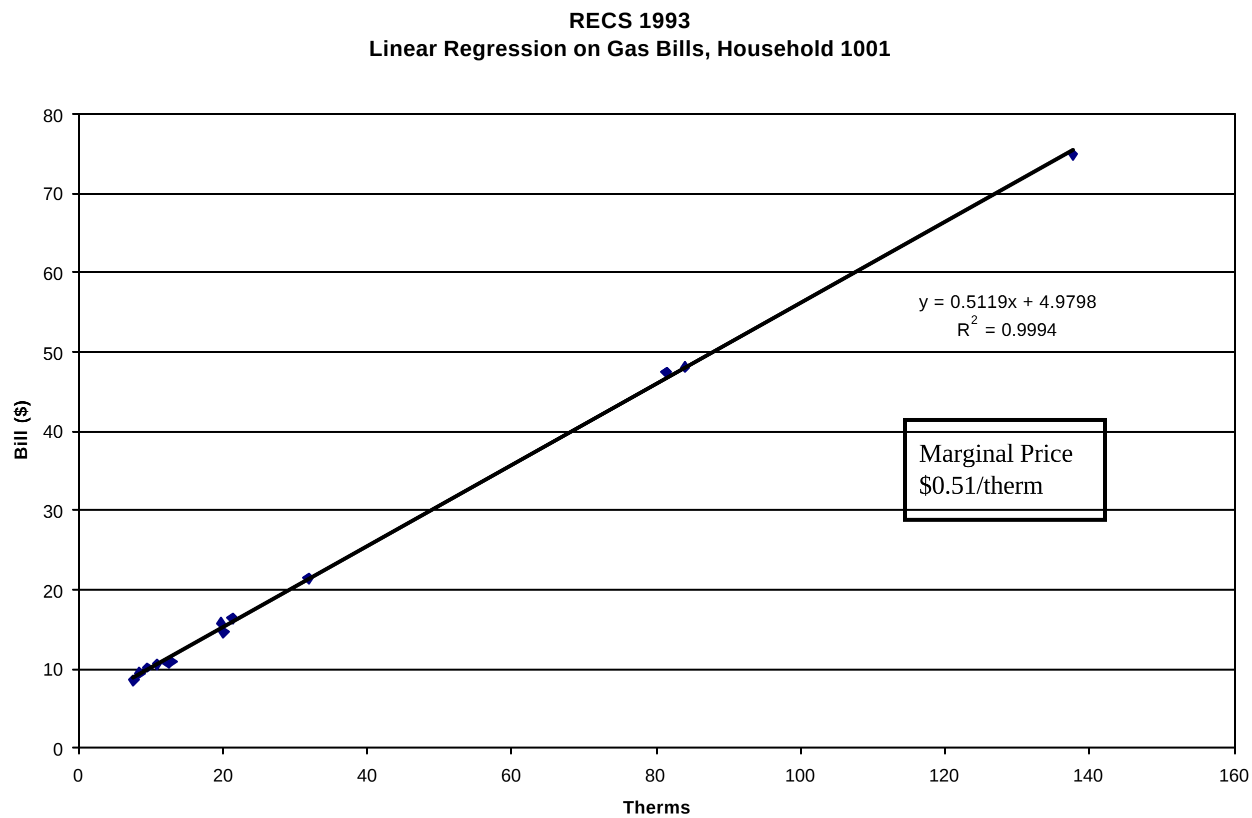
The r-squared values for the regressions of RECS electricity bills were generally very high.[8] Examination of the summer regressions and the winter regressions reveals excellent fits in both cases, with r-squared values of 0.95 or above 90% of the time for the summer bills and 75% of the time for the winter bills. (See the distribution of the r-squared values shown in Table 2.)

Natural Gas

For natural gas, the data were not divided into seasons because review of gas utility rates (during the "Analytic" approach described earlier) found that most (21 out of 27) utilities surveyed did not have seasonal rates. Also, many households have little or no gas consumption in the summer, making determination of a marginal price for this season difficult. Instead, a single regression relating natural gas bills and usage was performed using the data for all of the billing cycles. It was possible to determine a slope of the regression line for all 3153 households for which billing data were available. Slopes were rejected as unreasonable if they were less than or equal to zero, or greater than $3.20/therm. This left 3139 households, or 78% of the total of 4033 households that use natural gas. Again, most (880) of the households for which a marginal price was not available were those for which EIA did not collect billing data, with only 14 additional households dropped due to unacceptable regression slopes. See Figure 3 below for a sample linear regression on the gas bills of one of the RECS households.

[8] In a regression with a single independent variable, r-squared is the square of the correlation coefficient "r". It represents the percent of variation in the dependent variable (in this case, the household's energy bill) that can be explained by the variation in the independent variable (in this case, the household's energy consumption).

Figure 3.



The r-squared values for the regressions of RECS natural gas bills were also very high. On an annual basis, it was found that the regression line fits were excellent, with r-squared values of 0.95 more than 90% of the time. The distribution of the r-squared values for both the electricity and natural gas regressions is shown in Table 2 below.

Table 2. Distribution of r-squared Values for Electricity (Summer and Winter) and Gas Regressions

Percentile	Electricity		Natural Gas
	Summer	Winter	
99th	1	1	1
95th	1	1	1
90th	1	0.999	0.999
75th	1	0.997	0.997
50th	0.999	0.987	0.993
25th	0.99	0.956	0.984
10th	0.947	0.874	0.965
5th	0.868	0.755	0.912
1st	0.449	0.217	0.6
Mean	0.973	0.946	0.975
Number of Cases*	5667	6116	3150
Total Number of Cases	5818	6119	3153

* Cases where r-squared values could be calculated.

Electricity and Natural Gas
A statistical analysis was performed comparing the data sets for each fuel before and after dropping the households for which it was unable to calculate marginal energy prices in order to determine if any bias was being introduced by dropping those households. It was found that the subset of households that were dropped were those whose utility bills were included in the household's rent; presumably EIA could not collect billing data for those households.

Looking at just those subsets of RECS households that own the particular appliance of interest, it was found that the differences between all households and the subset for which it was able to calculate a marginal price were smaller than the differences described above for the set of all RECS households. These results may occur because households which own clothes washers, or water heaters, or central air conditioners, tend to have a relatively lower proportion of renters in the first place, so fewer households of that type were dropped. For the key parameters, differences were found to be negligible (generally 1% or less) between the appliance data set and the subset with marginal prices. Table 3 below shows the number and percent of households used in the analysis for each appliance subset after households with no marginal price were dropped.

Table 3. Number of Households in Each Appliance Data Set, and in Subsets with Marginal Prices

Appliance Subsets (HH = household)	All Households with appliance		Marginal Price Subset		Marginal Price Subset as percent of All Households	
	Survey Responses	U.S. Households (millions)*	Survey Responses	U.S. Households (millions)*	% of Survey Responses	% of Relevant U.S. Households
HHs with washer and dryer and electricity	4998	67.8	4574	61.9	92%	91%
HHs with washer and dryer and natural gas	2759	40.6	2439	35.6	88%	88%
HHs with central air conditioning	2414	32.1	2164	28.8	90%	90%
HHs with heat pumps	651	7.9	613	7.6	94%	96%
HHs with electric water heaters	2559	33.4	2323	30.3	91%	91%
HHs with natural gas water heaters	2805	41.0	2535	36.0	90%	88%
HHs with fuel oil water heaters**	176	1.8	163	1.7	93%	94%

* Sum of weights of households. The weight of each household is the number of US households represented by each RECS household.

** "Marginal Price Subset" represents the households for which an electricity marginal price is available. Fuel oil marginal price was assumed to be the same as the fuel oil average price, an assumption supported by the research reported in Section V below.

Results of Analysis
Figures 4 and 5 below display the results of the residential electricity price analysis by showing the relationship between marginal electricity prices and average electricity prices for the residential sector in the summer and the winter. Figure 6 below displays the results (on an annual basis) of the residential gas analysis.

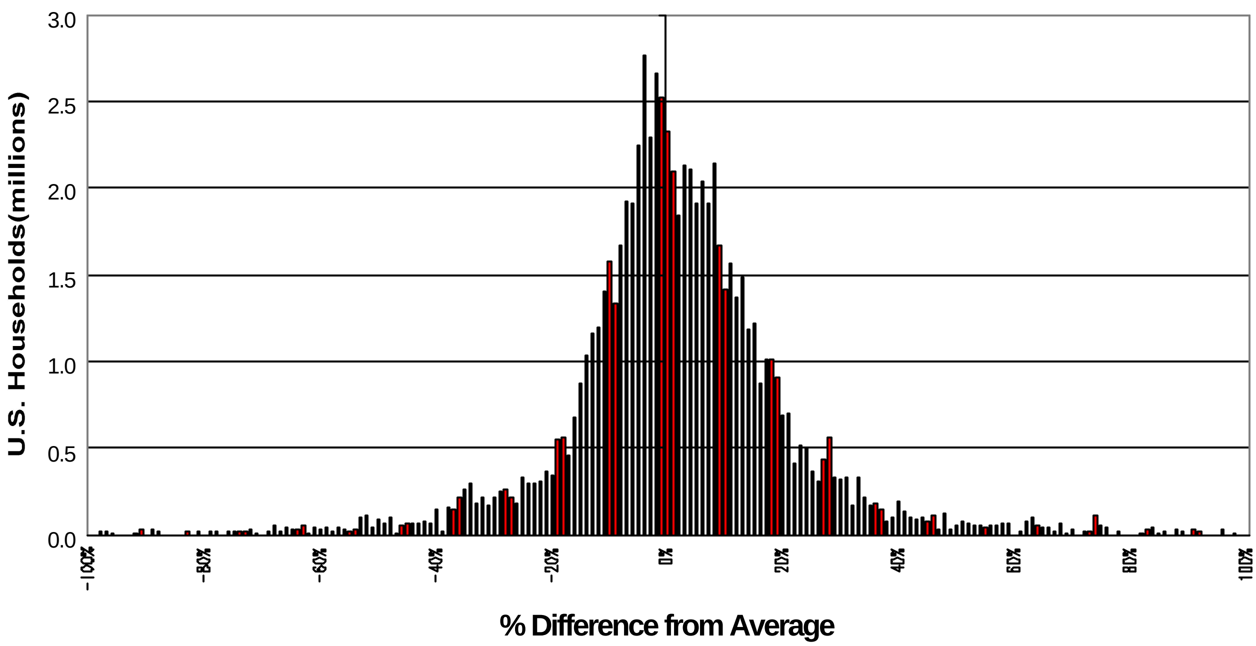
In the LCC analysis of three residential products (clothes washers, water heaters, and central air conditioners/heat pumps), the marginal electricity and natural gas prices used were derived directly from RECS. Figures 4, 5, and 6 below show how different these marginal prices are from average prices. Those marginal electricity prices in the summer (June-September) range from 98% below to 175% above the average price for the same customer. At the consumption-weighted mean of the differences, marginal electricity prices are 2.5% higher than average electricity prices in the summer. Marginal electricity prices in the “winter” (the remainder of the year) range from 100% below to 130% above the average price for the same customer. At the consumption-weighted mean of the differences, electricity marginal prices are 5.3% lower than average electricity prices in the “winter.” Marginal gas prices range from 98% below to 248% above the average price for the same customer. At the consumption-weighted mean of the differences, marginal gas prices are 7.8% lower than average gas prices.

Figure 4 below shows, for each household in the summer, the difference between the marginal electricity price for that household and that household’s annual average electricity price.

Figure 4.

Residential Summer Electricity Marginal Prices Differences from Annual Averages

Marginal < Average **Marginal > Average**



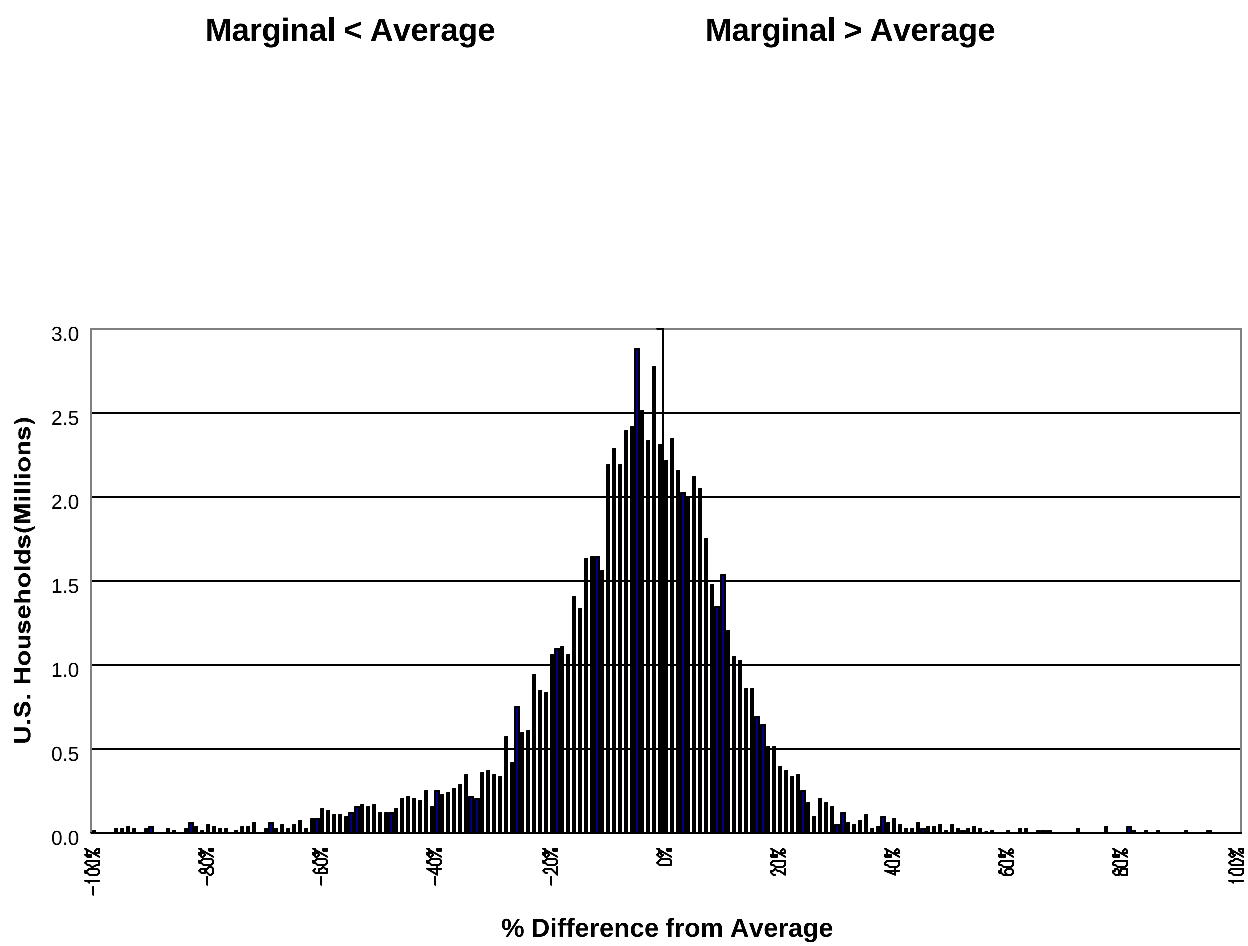
Mean = +2.5% Median = +1.4%

Minimum = -98% Minumum = +175%

Figure 5 below shows, for each household in the winter, the difference between the marginal electricity price for that household and that household's annual average electricity price.

Figure 5.

Residential Winter Electricity Marginal Prices Differences from Annual Averages

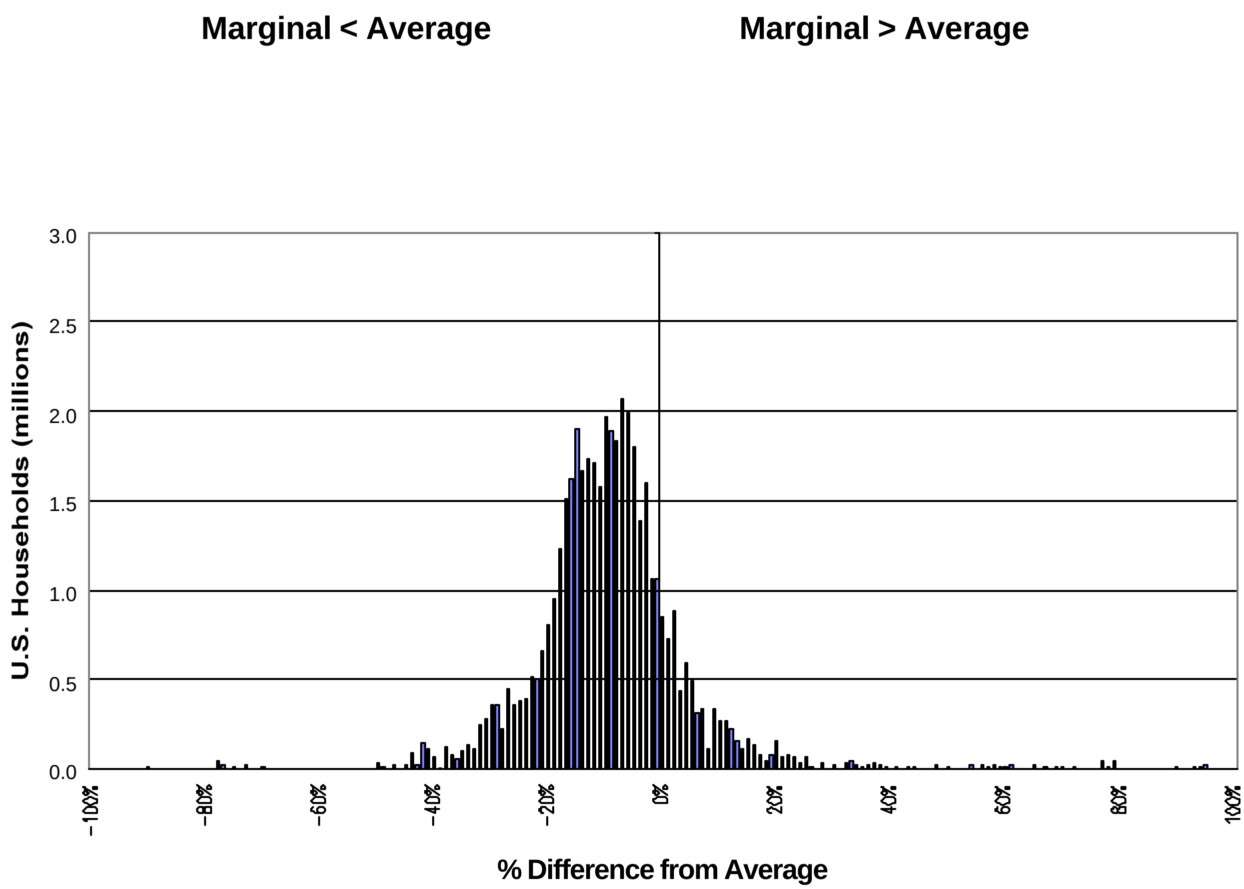


Mean = -5.3% | Median = -3.8%
Minimum = -100% | Maximum = +130%

Figure 6 below shows, for each household, the difference between the marginal gas price for that household and that household's annual average gas price.

Figure 6.

Residential Gas Marginal Prices
Differences from Annual Averages



Mean = -7.8%
Minimum = -90%

Median = -9.0%
Maximum = +248%

V. RESIDENTIAL HEATING OIL AND PROPANE

As part of the marginal fuel price study for residential utility customers in the US, brief telephone interviews were conducted from January 25 to February 5, 1999 in order to understand and characterize regional variations in pricing and distribution of residential heating oil and propane. A sample of distributors was selected from relevant internet sites, including that of the National Propane Gas Association (NPGA). The goal was to interview fuel oil and propane distributors that represent a cross-section of the industry in terms of company size and location. The interview questions were designed to identify factors (including wholesale price, annual usage, delivery, tank rental, and taxes) that affect the actual cost of heating oil and propane for residential customers and to determine any divergence between average and marginal price for these fuels.

Heating Oil

Based on telephone conversations with five East Coast distributors of home heating oil, it was learned that (1) home heating oil is not taxed, (2) heating oil storage tanks are owned, not rented, and (3) there is no additional charge for delivery, except under unusual circumstances. These are all factors likely to make average and marginal prices similar. The price per gallon ranged from $0.85 in Virginia to $0.66 in southern Maine; prices appeared to decrease from south to north. Discounts of $0.03-$0.10 per gallon are available, depending primarily on promptness of payment (e.g., within 5-10 days) or "auto-delivery" service, in which the customer allows the distributor to monitor usage and fill the tank at the distributor's convenience. See Table 4 below.

Table 4. Heating Oil Prices

Company	Dixie Gas	C&W Oil & Heating	Powers Oil Co	MacDuffie Petroleum	Eastern Propane
Location	Verona VA	Danbury CT	Foxboro MA	Hudson NH	Rochester NH
Territory	3 counties in VA	Fairfield County	metro Attleboro MA	NH, MA	southern Maine
Price/gallon	$0.85	$0.82	$0.75	$0.72	$0.66
Discount	cash paid in 5 days: $0.03	auto delivery: $0.03	paid in 7 bus days: $0.10	paid in 10 days: $0.10	none

Because the interviews indicate that the bills paid by residential consumers for heating oil are essentially volume driven, with a single block rate, the average prices inherent in those bills, as reported in RECS, were interpreted as being equivalent to marginal prices for the purposes of the LCC analyses for water heaters and clothes washers.

Propane

Based on telephone conversations with nine distributors of residential propane gas, it was learned that propane prices have much more seasonal and regional variability than home heating oil or natural gas. This volatility is due in part to the fact that the price of propane is not regulated by state public utility commissions. The three major factors that influence the retail price of residential propane are (1) wholesale price (which is primarily a reflection of local supply and demand), (2) customer annual usage, and (3) "pre-pay" agreements, all of which are embedded in the price/gallon of residential propane. State and local taxes, if any, are an additional cost. Tax on residential propane sales varies by state, county, and municipality; among our respondents it varies from none (Virginia, Texas, Wisconsin) to 8.25% (California).

Residential propane customers usually live in rural or remote areas where either natural gas service is not available or electricity service is expensive or not reliable. End uses range from cooking and water heating to pool and space heating. To the extent that propane is required to heat homes, demand for propane is highest during the winter. Our survey respondents reported winter-to-summer price differentials that range from $0.13-$0.58 per gallon. By far the most substantial cost savings are those available to residential customers who pre-pay during summer months for propane that will be delivered and used during winter. Distributors who offer these discounts are better able to anticipate the amount of propane they will need to supply, and often purchase "price insurance" (futures contract) from an energy company that effectively protects them from winter price spikes.

Because 88%-90% of propane used in the US is produced domestically, propane supplies are rarely disrupted. However, winter demand often exceeds local supply because of logistical limitations of transporting propane from where it is produced to where it is needed. Two large underground propane storage sites exist, one near Mont

Bellvue, Texas, and the second outside of Conway, Kansas. Three pipelines transport propane from these reservoirs to southern, eastern, and midwestern states. Bulk storage facilities are located at regional hubs along each pipeline; trucks transport propane between these hubs and regional distributors, who distribute the fuel to residential customers. Two of the three pipelines also carry other petroleum products, so propane delivery is often interrupted.

The cost of distributing propane (from the refinery or port to a bulk storage facility) and delivering it to the residential customer is incorporated in the price per gallon that each customer is charged. The lowest price per gallon ($0.65) was reported in northern Wisconsin, while the highest price ($1.41) was reported in Galveston, near Mont Bellvue, Texas, and adjacent to several refineries. One possible explanation for this apparent anomaly is that the price of propane in Wisconsin (where winters are harsh) is driven down by high demand and fierce competition, while the price in coastal Texas (where winters are mild) is buoyed up by relatively low demand and little competition. In fact, our results suggest that local competition (which increases along with local demand) is more a determinant of the wholesale price than is the distance from the propane source.

Next to local wholesale price, total annual usage has the largest effect on residential propane prices. The price per gallon reported in Table 5 below represents the retail price to a customer who uses a typical amount of propane compared to residential customers in that particular service territory. Volume discounts are usually available to those who use more than the typical amount of propane; volume discounts reported by our contacts range from $0.02/gal (Utah) to $0.19/gal (Florida). Similarly, customers who use less than the typical amount of propane pay more than the regular price per gallon; distributors reported additional costs of $0.10 (Wisconsin) to $0.13 (Virginia). Propane distributors often offer discounts to new residential customers because (1) they want new customers and (2) it takes a year to determine the usage of each new customer. Contacts reported new customer discounts of none (Georgia) to $0.15 (Florida) to $0.31 (Texas).

Residential customers store propane in on-site tanks that range in size from 100 to 1,000 gallons; tank size increases with the number of end uses, severity of the climate, and difficulty of site access. Some customers lease (rent) tanks from their propane distributor. Renting relieves the customer of responsibility for tank maintenance and provides flexibility for temporary or mobile home owners, but prevents the customer from shopping around for the lowest fuel price among local distributors. Customers who purchase their own tanks do so for several reasons. Permanent, year-round homes in rural areas tend to have a larger number of propane end uses and bigger tanks, which, because they are unsightly and take up space, tend to be installed underground. Distributors are reluctant to lease underground tanks because leak detection and maintenance is more difficult, so buried tanks are usually owned. Owning a storage tank also allows a customer to shop around for the best available propane price. Among our respondents, percentage of tanks leased from a distributor ranges from none (Maine, Virginia) to virtually all (Utah, California). Tank rental fees depend on tank size and/or annual usage; annual fees range from none (Wisconsin) to $100 (Utah), but generally they are $50-100.

Because the interviews with propane distributors indicate that the bills paid by residential consumers for propane are essentially volume driven, with a single block rate, the average prices inherent in those bills, as reported in RECS, were interpreted as being equivalent to marginal prices for the purposes of the LCC analyses for water heaters and clothes washers.

Table 5. Propane Prices

Company	Suburban Propane	River Country Co-op (Cenex)	Eastern Propane
Location	**Gilroy CA**	**Chippewa Falls WI**	**Rochester NH**
Territory	3 counties	northwest WI	southern ME
Typical tank size	250, 500 gal	500 gal	500 gal
Typical Usage	4 people, 2000 SF home: 500 gal/yr		
$/gal, regular	**$1.45 winter, $1.30 summer**	**$0.65**	**$0.98-1.01**
Tax	7.25-8.25%, depends on locality	none in WI	unsure
$/gal, discount	new customer: $1.16 winter	$0.05 off for cash if tank is owned	$0.05/gal if paid in 15 days
	new customer: $1.03 summer	prepay price guarantee: $0.50/gal	
$/gal, addtl	will-call delivery: $0.10/gal	$0.10/gal if tank rented	
		< 250 gal/yr: $0.10/gal more	
Tank rentals	most are rented	40% rented	no rentals
Rental fees	$65/yr for 250 gal	no rental fees	
	$90/yr for 500 gal		

Company	Blossman Gas	Corbin Gas	Amerigas
Location	**Pensacola FL**	**Atlanta GA**	**Salt Lake City UT**
Territory	MS, FL, NC	Metro Atlanta	Salt Lake City
Typical tank size	< 250 gal	250, 330 gal	500 gal
Typical Usage	< 250 gal/year		
$/gal, regular	**$1.14**	**$0.99**	**$0.86**
Tax	none	~7%, depends on county	6% home heat
$/gal, discount	new customer: $0.99	no new customer discount	volume: $0.02/gal
	for volume: if > 100 gal. $1.06;		
	> 150 gal, $1.00; >500 gal, $0.95		
$/gal, addtl			
Tank rentals	500 gal tanks are owned	60% rented	virtually all
Rental fees	250 gal: $25-48/yr, depends on use	$30-80/yr, depends on usage	500 gal: $80/yr
	100 gal: $36-72/yr, depends on use		1,000 gal: $105/yr

Company	All-Star Gas	United Propane	Dixie Gas
Location	**Galveston TX**	**Salisbury MD**	**Verona VA**
Territory	Bolivar Island	Maryland	VA, some of WV
Typical tank size	120 gal, 250 gal	500 gal	325, 500 gal
Typical Usage			
$/gal, regular	**$1.41**	**$1.15**	**$1.05**
Tax	none	depends on county; no state tax	none in VA, some in WV
$/gal, discount	new customer: $1.10	$0.08/gal if tank is owned	> 800 gal/yr: $1.02
	prepay, >350 gal/yr: $0.83-0.99	2% off if paid within 10 days	
$/gal, addtl			< 400 gal/yr: $1.18
Tank rentals	50-60% rented	25% rented	no rentals
Rental fees	all size tanks: $85/yr	depends on usage (gallons/year)	
		ave $12.5/qtr for 500 gal tank	

VI. TAXES

Overview

The marginal energy prices that consumers experience can be affected by the taxes that those consumers pay as part of their energy bills. Those energy bills can include taxes in two fundamentally different ways. First, tax obligations that an energy utility itself incurs (such as federal income taxes and property taxes) are most often considered to be part of the utility's revenue requirements. Consequently, such taxes are embedded within approved utility rates; they are not itemized on utility bills (even the unbundled bills that are becoming more prevalent in the utility industry, particularly as electricity restructuring occurs in more states). Prices paid by consumers are higher (than they otherwise would be) to the degree that these sorts of taxes are included in their utilities' base rates. But, because consumer energy savings (from using appliances that are more energy efficient) would not directly and immediately reduce the level of these embedded taxes, the existence of these taxes does not affect the calculation of consumers' marginal energy prices in a manner that is relevant to this research project.

The second, and more directly visible, way in which consumers pay taxes when they pay their energy bills is through paying various sorts of taxes (or fees) as direct add-ons to their energy bills. These taxes (such as utility users taxes, franchise fees, and regulatory fees) are often called "pass-through" taxes. They are taxes assessed by state and/or local jurisdictions. They are collected by utilities on behalf of consumers and then are passed on by those utilities to the jurisdictions that imposed them. Since these taxes are not considered to be part of a utility's revenue requirements, they are not embedded within utility rates. Rather, such taxes are listed as line items on consumers' bills. The marginal prices that consumers pay for energy are directly affected by the existence of this type of tax; indeed, consumers' marginal energy prices are higher than they would be if these taxes and fees did not exist. This type of tax is usually assessed as either a fixed percentage of the pre-tax energy bill or as a fixed dollar amount per energy unit. In some instances, pass-through taxes using both types of assessment mechanisms are added to consumers' bills. For either type of pass-through tax assessment, the consumption of less energy (due to using appliances that are more energy-efficient) will reduce (on a direct and immediate basis) the tax portion of the energy bill as well as the non-tax portion of that bill. For that reason, this research project is interested in the degree of those savings.

Range and Magnitude of Pass-Through Taxes

Because pass-through taxes are assessed by individual states and local jurisdictions, they can vary widely in their magnitude, even within the same utility service territory (see below). There are four main types of pass-through taxes:

1) state sales taxes (see Appendix 5, Table 6)
2) state utility regulatory assessments (see Appendix 5, Table 7)
3) state taxes on units of energy (see Appendix 5, Table 8)
4) local utility users taxes

These taxes individually range in size from being non-existent in some areas to being as much as 10% in other areas[9]. In addition, because these sorts of taxes are set by various government agencies, they rarely appear on published utility tariffs. They appear as line item charges on consumers' actual bills. Therefore, determining what these taxes (especially those that are locally imposed) really are for particular customers of particular utilities would be a very difficult task. As EIA said in its 1994 report "End-Use Taxes: Current EIA Practices,"

> "Adding statutory taxes to pre-tax prices is a tedious, error-prone process. … Because of the wide variety of taxes imposed by local governments, the tax adjustment is only practicable at the State level."[10]

[9] The highest single tax rate for energy that the research uncovered was for one small city in California that imposes a utility users tax of 9.9%. Otherwise, the highest utility users tax rate the research uncovered is 8%. State-level sales taxes and other state-level taxes can raise the effective tax to consumers beyond these levels, though.

[10] EIA, "End Use Taxes: Current EIA Practices," August 1994, page 29.

The EIA report provides a state-by-state list of sales and use taxes on end-use energy consumption.[11] It also indicates the states in which energy consumption (by energy fuel type) is exempt from state sales and use taxes. In addition, this report includes an estimate of the magnitude of the possible effect of including State sales taxes in energy prices. For electricity prices, EIA's report shows that on average electricity prices for the residential sector rise only 0.9% with the inclusion of state sales taxes. The range of increase in individual states is from 2% to 6.5% for those states where electricity consumption in the residential sector is not exempt from sales tax. For the commercial sector, the rise in electricity prices due to the inclusion of the applicable state sales taxes would be 4.2% on average for the nation, with a range by state of from 3% to 8% for those states where electricity consumption is not exempt from sales tax. (EIA's report does not include similar estimates of the effect of including state sales taxes on the consumption of natural gas.)

To get a sense for the magnitude and variation of other state and local-level taxes, various sources were consulted. The most comprehensive survey of other taxes on a state level was found in a report on state and local taxation by the Alliance to Save Energy (ASE).[12] This report reveals that percentage taxes for regulatory assessments in the 39 states that impose them (see Appendix 5, Table 7; taken from ASE's report) range in size from 0.02% to 0.50%. In other states, such as California, cities can charge consumers a utility users tax. One city imposes a 9.9% utility users tax.[13] Several other cities set this tax as high as 7.5% or 8.0%.

Taxes or fees on units of energy consumed range in size from 0.015 cents per kWh to 0.26 cents per kWh in the nine states (see Appendix 5, Table 8; taken from ASE's report) that impose that type of tax on energy used by consumers. In California, for instance, while PG&E customers pay a $0.0002/kWh in support of the California Energy Commission, customers of SDG&E also pay regulatory fees amounting to $0.00012/kWh on the electricity portion of their bills and $0.00078/therm on the gas portion of their bills. States that have no sales taxes are not prohibited from imposing electric and gas regulatory assessments and kWh taxes on electricity. Variations and anomalies such as these make an exhaustive study of the actual taxes and fees associated with utility energy bills around the country, and even those associated with this project's modest utility sample, beyond our scope. Indeed, it is unlikely that anyone has ever conducted a survey of state and local taxes comprehensive enough to capture the type of utility users taxes that can occur in California alone.[14] As a result, the effect of taxes on marginal prices was addressed in the manner outlined below.

Impact of Taxes on Marginal Prices

Pass-through taxes increase consumers' energy bills; they also increase consumers' marginal prices. For a percentage-based pass-through tax (like the utility users tax described above), which is applied to the whole energy bill (including any fixed charges, such as customer charges), the consumer's marginal price is increased by the percentage size of the tax itself. Thus, an 8% tax would increase a consumer's marginal price by 8%. Consumers taxed at the 2% level would have a marginal price 2% higher than if they paid no pass-through taxes. Because taxes on units of energy (like the per kWh regulatory fees described above) do not apply to fixed charges, they raise marginal prices in a non-linear, but still minor and easily calculated, manner.

Impact of Taxes on Savings

Since consumers both pay and save at a rate equal to the marginal price, other things being equal, reductions in energy consumption due to new appliance energy efficiency standards will cause reductions in the size of the pass-through

[11] Ibid, Table B2. The relevant portions of EIA's Table B2 are shown in Appendix 5, Table 6 of this report.

[12] The Alliance to Save Energy, "State and Local Taxation: Energy Policy by Accident," 1994.

[13] For example, in the Pacific Gas and Electric Company (PG&E) service territory of northern California, the size of the percentage-based utility users tax, which is applied to both the electricity and natural gas components of a PG&E customer's bill, varies from 0% in many of the cities and counties served by PG&E to as much as 9.9% in one city, 8.0% in five cities and 7.5% in eight cities. A total of 68 cities in PG&E's service area currently impose this type of tax on energy consumption by their residents. While higher utility users tax rates may exist in California or in other states, no evidence of them was found.

[14] Andrew Hoerner, Center for a Sustainable Economy, personal communication, February 10, 1999. Additional sources whose web sites were consulted for information on state and local energy taxes included The Federation of Tax Administrators, EPRI, and The Multistate Tax Commission.

taxes consumers pay, whether those taxes are percentage taxes or per-unit taxes. The resulting reductions in tax payments are savings to the consumer directly associated with the more efficient appliances. Consumers facing 8% tax prices will save an additional 8% beyond what they would have saved if they did not have to pay such taxes in the first place. Consumers with 2% taxes will save an additional 2% of their (pre-tax) bill when their energy consumption is reduced by using appliances that are more energy-efficient.

Treatment of Taxes in This Research Project

This project used two main approaches to derive marginal prices. The RECS-based approach used actual consumer bills that already include all taxes (both those embedded in utility rates and pass-through taxes). Therefore, the marginal prices derived from those bills "automatically" take into account the effects of changes in taxes due to changes in energy consumption. For use in life-cycle cost or savings analyses, no further adjustments are needed to reflect the existence of taxes in the marginal prices derived from the RECS-based approach.

The MAISY®-based approach involved using distributions of both building energy usage levels (from the MAISY® database) and utility tariffs to derive commercial electricity bills. Because those utility tariffs do not already include pass-through taxes, the marginal prices derived by this approach are smaller than they otherwise would be to the degree that pass-through taxes apply to the sampled buildings. Therefore, when analyzing the results of this research effort, consideration should be given to the applicability of the four types of pass-through taxes mentioned here (state-level sales and use taxes, other state-level % taxes, $ per energy unit taxes, and locally imposed utility users taxes) to derive marginal electricity prices for commercial buildings that include taxes. While adding the pass-through taxes applicable at the state level (from the EIA and ASE report tables shown below) would involve a non-trivial and very time-consuming, but still relatively straightforward exercise, there is no clear way to obtain the level of the locally determined utility users tax that might apply to the sampled buildings. Therefore, because of the lack of comprehensive information on the magnitude of the locally imposed utility users taxes, one must be aware that the marginal prices so calculated may not be as high as they really should be wherever those taxes would apply. Thus, marginal prices and savings for an individual consumer may still be understated by from 0% to 10%.

Taxes and Average Prices

Once marginal prices are calculated and taxes are considered, a comparison with regularly published average prices, such as those issued by EIA, may be desired. Those published average prices are calculated by dividing utility revenues by sales. With regard to whether or not these published average prices include taxes, the underlying question is which taxes are included in utility revenues. It is clear that embedded taxes are included within the utility revenue requirements that form the basis for utility revenues through the traditional rate-setting process; however, it is not clear whether pass-through taxes are considered to be part of utility revenues. In response to the request for clarity on this issue, EIA referred us to a page in EIA's "Electric Sales and Revenue 1997" report that contains the following statement:

> "Taxing authorities differ on whether a specific tax is assessed to the utility or to the consumer, a difference that in turn determines whether or not the tax is included in the electric utility's operating revenues."[15]

Therefore, it is concluded that one cannot know for sure whether pass-through taxes, especially those imposed by local government agencies, are included in utility revenues and thus included in average prices. While this lack of certainty about the inclusion of pass-through taxes in published average prices jeopardizes any comparison of average and marginal prices, it is believed that comparing RECS-based marginal prices with published average prices would be more sound, for example, than comparing marginal prices derived by the MAISY®-based approach (where taxes must be added in manually) with published average prices.

Tax Feedback Loops

Some might argue that local governments (and perhaps even state governments) might raise their locally-imposed utility tax rates if the revenues they obtain from consumers' energy bills decline because consumers use less energy as a consequence of improved appliance energy-efficiency standards. This project did not attempt to analyze such

[15] EIA, "Energy Sales and Revenue 1997," page 1.

positions. It is noted that while similar arguments have been made during debates on electric industry restructuring occurring around the country, there is no widespread agreement on their validity.

Conclusion

This report has not attempted to account for all appropriate taxes in the calculation of marginal energy prices in the analysis because it is essentially impossible to do so. Comparisons between published average energy prices and calculated marginal energy prices must be made with care because they are subject to error for the same reasons. This report indicates the degree of error that may be present.

The derivation of commercial consumer marginal electricity prices excludes pass-through taxes and thus underestimates consumers' marginal bill savings by 0% to as much as 10%, depending upon the level of state and locally imposed taxes. In contrast, the derivation of marginal electricity and gas prices for the residential sector from actual consumer bills from RECS includes pass-through taxes; thus, the underestimation of consumers' marginal bill savings inherent in the commercial analysis does not exist in the residential analysis.

Appendix 1. Tariffs Used in the Commercial Analysis

Utility	State	Tariff	Utility	State	Tariff
Alabama Power	AL	LPEM	NSP	WI	Cg-5
Alabama Power	AL	LPM	Niagara Mohawk Power Corp	NY	SC-2 Demand
Alabama Power	AL	LPS	Niagara Mohawk Power Corp	NY	SC-2 Non-Demand
Appalachian Power Co	VA	SGS	Ohio Power Company	OH	GS3-11
Arizona Public Service	AZ	E30	PEPCO	DC	GS
Arizona Public Service	AZ	E32	Pacific Gas and Electric	CA	A1
Boston Edison	MA	G-1	Pacific Gas and Electric	CA	A10
Boston Edison	MA	G-2	Pennsylvania Power & Light	PA	GS-1
Central Power and Light	TX	21	Pennsylvania Power & Light	PA	GS-3
Cleveland Electric Illum. Co	OH	Gen Comm	Poudre Valley	CO	B-97
Cleveland Electric Illum. Co	OH	Lg Comm	Savannah Electric and Power	GA	GS-7
Commonwealth Edison Co	IL	Rate 6 non-	Seattle City Light	WA	Rate 31
Detroit Edison	MI	TOU	Seattle City Light	WA	Rate 34
Jersey Central Power & Light	NJ	D3	SoCal Edison	CA	GS-1
Madison G&E	WI	GS	SoCal Edison	CA	GS-2
Madison G&E	WI	Cg-1	Union Electric Co.	MO	No. 2
NSP	MN	Cg-5	Union Electric Co.	MO	No. 3
NSP	MN	A10, D12, E13	Virginia Power Company	VA	GS-1
NSP	WI	A14, D16,E15	Wisconsin Electric Power	WI	Cg 1
NSP	WI	Cg-2			
		Cg-2 unmetered			

Appendix 2. Examples of Commercial Bill Calculations

Commercial tariffs generally fall into two categories, non-demand and demand. Demand is measured in kilowatts (kW) required by the customer over a relatively short time period, often 30 minutes. Meters are installed at the customer site to measure monthly and sometimes annual peak demand, and these are used to compute the demand component of the customer's bill.

Typically demand tariffs are assigned to large customers, such as office buildings, hospitals, and malls. Non-demand tariffs are assigned to smaller customers, such as restaurants and small grocery stores. An example of each is illustrated below.

Example 1: Non-demand tariff

Utility:		Alabama Power
Tariff:		Commercial, LPS
Customer Base Charge:		$8.65/mo.
Summer Energy Charge:		$0.06223/kWh
Winter Energy Charge:		$0.05843/kWh
Customer:	Usage:	2547 kWh
	Month:	January
	Baseline Bill:	$157.47 = 8.65 + ($0.05843 * 2547)
Bill with 5% Usage Decrement:		(Figures below include rounding)
	Usage:	2420 kWh = 2547 kWh – (0.05 * 2547 kWh)
	Bill:	$150.03 = 8.65 + ($0.05843 * 2420)
	Monthly Average Price:	$0.06183/kWh = $157.47 / 2547
	Monthly Marginal Price:	$0.05843/kWh = Bill Savings / Energy Savings = ($157.47 - $150.03) / (2547 - 2420)

Example 2: Demand Tariff

Utility:		Southern California Edison
Tariff:		Commercial GS2
Tariff Min/Max kW:		80 - 2000 kW/hr (measured over 15 minutes)
Customer Base Charge:		$60.30/mo.
Energy Block Cutoffs:		Block 1: 300 kWh/kW (based on monthly peak kW)
Energy Charge, Block 1:		$0.07692/kWh
Energy Charge, Block 2:		$0.04391/kWh
Demand Charge Component 1:		$5.40 (Summer), $5.40 (Winter)
Demand Charge Component 2:		$7.75 (Summer), $0.00 (Winter)
Customer	Usage:	150388 kWh
	Month:	May
	Monthly Peak kW:	71 kW (over 15 minutes)
	Baseline Bill:	$7750.35 = $60.30 + ((300*71)*$0.07692) + ((150388 - (300*71))*$0.04391) + (71*$5.40)
Bill with 5% Energy and 4% Demand Decrement:		$7376.71 = $60.30 + ((300*(71*0.96))*$0.07692) + (((150388*0.95) - (300*(71*0.96)))*$0.04391) + ((71*0.96)*$5.40)
	Monthly Average Price:	$0.05163/kWh = 7376.71 / (150388*0.95)
	Monthly Marginal Price:	$0.04969/kWh = Bill Savings / Energy Savings = ($7750.35 - $7376.71) / (150388 - (150388 * 0.95))

Appendix 3. Demand Decrement Due to Standards - The Role of Lighting Coincidence and Diversity

In the process of marginal price estimation, it is necessary to account for demand charges in the calculation of some commercial sector bills. Demand charges depend upon the peak building demand (kW) each month. For each customer or building analyzed, the monthly energy use (kWh) and the monthly demand (kW) are based on actual annual kWh and actual summer and winter peak kW and summer and winter average peak kW. Since a change from energy-efficient magnetic (EEM) ballasts meeting the current standard to electronic ballasts for four-foot T12 systems would save about 15% of lighting energy used by fluorescent lamps and since about 30-35% of building energy use is for lighting, about 5% of building energy use will be saved if EEM ballasts are converted to electronic ballasts. The 5% reduction was assumed to occur every month.

It is also necessary to estimate the reduction in peak demand if building energy use is reduced by 5% on average. Some analysts prefer to discuss this issue in terms of diversity and coincidence. Coincidence is the lighting kW during the building peak divided by the lighting peak kW. In this situation, the coincidence factor was expected to be close to 1.0 since, whatever the maximum number of lamps that operate during the lighting peak, a very similar number of lamps can be expected to operate during the building peak. EEI has suggested using 0.9 for the default coincidence factor.[16]

Coincidence factor (C) = lighting kW during building peak/lighting peak kW

The diversity factor is a measure of the percent of the installed kW for lighting used during the lighting peak. Diversity is already accounted for because the actual building energy usage (which comes from the MAISY® database) already excludes those lamps not in use during some parts of the day. Instead the concern is with lighting average kW because that is, in essence, reduced by 5% in the bill calculator when monthly energy use is reduced by 5%. It is assumed that the lighting hours do not change when more efficient ballasts are installed.

Diversity (D) = lighting peak kW/lighting kW installed

Some analysts might multiply coincidence (C) times diversity (D); that would not yield the desired ratio of lighting kW during the building peak to lighting average kW.

In relative terms, demand reduction is assumed to be 80% of energy savings. For 5% energy savings, it is assumed that the demand reduction would be 4% of peak kW. This means that if 500 identical fixtures are operating on average, that only 400 (or 80%) are operating during the building peak demand period. The 80% value relative to the average value is used because the monthly lighting energy use can be considered to be equal to some average kW times the monthly lighting hours and the monthly lighting energy use is reduced by a fixed percentage.

[16] See comment #12 on the Draft Report on Potential Impact of Possible Energy Efficiency Levels for Fluorescent Lamp Ballasts,, received by DOE from Steve Rosenstock of EEI on August 28, 1997.

Appendix 4: Weighting Method for Commercial Sample

The composition of the commercial sample posed a dual weighting problem: distributing weights across buildings and across the approximately 20 tariffs that were applied to each building. The weighting approach solves these problems sequentially. The first step is to develop building weights, derived from the original MAISY® building weight and scaling factors (based on kWh usage), as discussed below. This adjusted building weight is then apportioned across all the tariffs (weighted by annual MWh sales) that were applied to the building. The composite weighting factor for each building/tariff pair combines both of these weighting factors.

Calculation of Adjusted Building Weights

Each building in the sample is viewed as representing a share of the commercial buildings in its region of the US. State and regional scaling factors were developed and used to rescale the individual buildings' MAISY® weights to represent national usage, as described below.

The first step was to account for the fact that the sample was a subset of the MAISY® buildings for each state. For each of the seven states a state factor was computed:

$$\text{State Factor} = \frac{\text{Sum of MAISY}^{\circledR}\text{ weights for all buildings in the state}}{\text{Sum of MAISY}^{\circledR}\text{ weights for sampled buildings in the state}}$$

The statewide energy usage represented by each sampled building was then computed by multiplying the building's MAISY® weight by its average annual energy usage and the state factor. For each sampled building i:

$$\text{Building i's Adjusted State Energy Use} = \text{Annual kWh}_i * \text{MAISY}^{\circledR}\text{ Weight}_i * \text{State Factor}$$

The next step was to scale state usage to regional usage. US Census Divisions were assigned to one of seven regions, each represented by a state in our sample. Census Divisions not directly represented by a state in our sample were assigned to a state representing the most similar adjacent division. The table below shows the mapping of sampled states to Census Divisions.

Assignment of Sampled States to Census Divisions for Weighting Calculations

Sampled State	**Census Division(s) Represented**
New York	Middle Atlantic, New England
Illinois	East North Central, West North Central
Georgia	South Atlantic, East South Central
Texas	West South Central
Colorado	Mountain
Washington	Pacific Contiguous (excluding California), Pacific Noncontiguous
California	California

Region Factors were then computed based on state and regional commercial retail electricity sales derived from 1998 EIA data (see the table below). The Region Factors are the ratio of commercial sector electricity sales in the division(s) corresponding with each of the sampled states to the commercial sector electricity sales in each of those individual states.

$$\text{Region Factor} = \frac{\text{Regional Retail Commercial Sales}}{\text{State Retail Commercial Sales}}$$

Applying the Region Factors was the next step in computing the Adjusted Building Weights for each building:

$$\text{Building i's Adjusted Region Energy Use} = \text{Region Factor} * \text{Building i's Adjusted State Energy Use}$$

The final step in calculating the Adjusted Building Weight takes each building as a share of the national total. For each sampled building i:

$$\text{Adjusted Building Weight}_i = \frac{\text{Adjusted Region Energy Use}_i}{\text{Sum of Adjusted Region Energy Use for all sampled buildings}}$$

For each sampled building, the Adjusted Building Weight is the percentage of national energy use represented by that building.

Derivation of State and Regional Weights Used in Computed Tariff Average Rates						
	Sum of Bldg Wts			Commercial kWh (millions)		
State	Sampled Buildings	State	State Factor	State	Region	Region Factor
California	24506	557548	22.75	6710	6710	1.00
Colorado	12698	84339	6.64	1203	4933	4.10
Georgia	14022	140103	9.99	2369	20465	8.64
Illinois	15645	205813	13.16	4312	17431	4.04
New York	28734	331675	11.54	3895	12526	3.22
Texas	46881	331176	7.06	6142	8911	1.45
Washington	18221	120664	6.62	1833	3306	1.80
Total	160707	1771318			74282	

<u>Derivation of Weights for Building/Tariff Pairs</u>
In the second phase of the weighting process, the weight for each building was apportioned across the applicable tariffs that had been used to compute marginal prices for it. These building/tariff weights sum to one for the entire sample and to the Adjusted Building Weight for each sampled building.

A different set of weights was computed for each sampled building because a unique set of tariffs was applied to each sampled building based on its particular pattern of energy usage. The building-specific tariff weights were computed using the FERC data on MWh sales for each tariff.[17]

This process was implemented in two steps.

The first step was to calculate the relative weight of each of the tariffs that were applied to a building. For each building (denoted by i) and tariff (denoted by j):

$$\text{Share of Tariff } j \text{ for Building } i = \frac{\text{MWh Sales for Tariff } j}{\text{Sum of MWh Sales for All Tariffs Applicable to Building } i}$$

[17] The annual reports that IOUs submit to FERC, "Form 1 - Annual Report for Major Electric Utilities, Licensees, and Others", include information on the utilities' sales, number of customers, and average rate by tariff or rate schedule on "page" 304 of that form ("Sales of Electricity by Rate Schedules"). An electronic database of the FERC Form 1 filings (that included page 304 data) was obtained from a commercial service known as Energy Central News.

The building-specific tariff weights were then combined with the adjusted building weights to obtain a unique weight for each building/tariff pair:

$$\text{Weight for Building i on Tariff j} = \text{Adjusted Building Weight}_i * \text{Share of Tariff j for Building i}$$

These are the weights that were used to calculate weighted averages for the sample and for binning the data to derive the distribution of percent differences between average and marginal prices (called epsilons) for use in the LCC analysis.

Appendix 5. Tax Tables.

Table 6. Sales and Use Taxes on End-Use Energy Consumption (with date of last effective change in parentheses)
(Source: EIA End-Use Taxes, Current EIA Practices, 1994. Table B2) EIA's source for this table is: State Taxation/Revenue Offices and Research Institute of America, All States Tax Guide, March 29, 1993.

State	*Electric*	*Natural Gas*
AL	Tax Rate Schedule: 0-40 kWh – 4% >40-60 kWh – 3% >60 kWh – 2% (7/1/63)	Tax Rate: 4% (7/1/63)
AK	No Sales Tax	No Sales Tax
AZ	Tax Rate: 5% (6/1/83)	Same as Electric
AR	Tax Rate: 4.5% (5/7/91) Exemption(s): Residents with income less than $12,000 on first 500 kWh per month, manufacturing aluminum by electrolytic reduction, & qualified steel manufacturers.	Tax Rate: 4.5% (5/7/91) Exemption(s): Qualified steel manufacturers.
CA	Tax Rate: 6% (7/15/91) Exemption(s): Residential Energy Surcharge--excise tax (0.1mill per kWh).	Tax Rate: 6% (7/15/91) Exemption(s): Residential, commercial, and industrial.
CO	Tax Rate: 3% (8/1/84) Exemption(s): Residential and industrial.	Tax Rate: 3% (8/1/84) Exemption(s): Residential heating, manufacturing processing, mining, irrigation, communications, and transportation.
CT	Tax Rate: 6% (10/1/91) Exemption(s): Residential – first $150/month; 75% for powering industrial manufacturing plant or directly used in farming, fabrication or manufacturing.	Tax Rate: 6% (10/1/91) Exemption(s): Residential - 75% for powering industrial manufacturing plant or directly used in farming, fabrication or manufacturing. Includes bottled propane.
DE	No Sales Tax	No Sales Tax
DC	Tax Rate: 6% (6/1/80) Exemption(s): Residential and used in manufacturing.	Same as Electric

FL	Tax Rate: 6% (2/1/88) Exemption(s): Residential and by qualified businesses In enterprise zones.	Tax Rate: 6% (2/1/88) Exemption(s): Residential, used in manufacturing at a fixed location in the State, boiler fuel, and space flights.
GA	Tax Rate: 4% (4/1/89)	Tax Rate: 4% (4/1/89) Exemption(s): Heating structures for poultry raising.
HI	Tax Rate: 4% (7/1/91) Exemption(s): Utility services and fuels.	Same as Electric
ID	Tax Rate: 4% (4/1/86) Exemption(s): Residential, commercial and industrial.	Tax Rate: 4% (4/1/86) Exemption(s): Residential, commercial, and industrial fuels.
IL	Subject to utility tax: Rate: 32 one-hundredth ¢/kWh, or 5% of gross receipts, whichever is less.	Subject to Gas Tax under Gas Tax Revenue Act. Rate: 2.4¢/therm or 5% of gross receipts, whichever is less.
IN	Tax Rate: 5% (1/1/83) Exemption(s): Manufacturing for production, farmers, and restaurants. Public Utilities: gross revenue tax of 0.15%	Same as Electric
IA	Tax Rate: 5% (7/1/92) Exemption(s): Manufacturing processing.	Tax Rate: 5% (7/1/92) Exemption(s): Manufacturing processing, fuels for agriculture, creameries, dairies and ice cream factories.
KS	Tax Rate: 4.25% (7/1/89) Exemption(s): Residential, farm use (no irrigation), manufacturing, and mining.	Tax Rate: 4.25% (7/1/89) Exemption(s): Residential, farm use, manufacturing, and mining.
KY	Tax Rate: 6% (7/1/90) Exemption(s): Residential sector.	Tax Rate: 6% (4/9/90) Exemption(s): Residential sector.
LA	Tax Rate: 4% (7/1/84) Exemption(s): Chloralkali Manufacturers.	Tax Rate: 4% (7/1/84) Exemption(s): Agriculture, and fuel for boilers.

ME	Tax Rate: 6% (8/1/91) Rate is 1% on 95% of electricity used in manufacturing facility. Exemption(s): 0-750 kWh in residential sector.	Tax Rate: 6% (8/1/91) Rate is 1% on 95% of gas used in manufacturing facility. Exemption(s): Residential.
MD	Tax Rate: 5% (6/1/77) Exemption(s): Residential, four units or fewer.	Tax Rate: 5% (6/1/77) Exemption(s): Residential, four units or fewer, and manufacturing.
MA	Tax Rate: 5% (11/12/75) Exemption(s): Residential and manufacturing when used for production and/or the company has fewer than six employees.	Tax Rate: 5% (11/12/75) Exemption(s): Residential and Industrial.
MI	Tax Rate: 4% (1/1/61) Exemption(s): Agriculture	Same as Electric
MN	Tax Rate: 6% (6/18/91) Exempt from sales tax.	Same as Electric
MS	Tax Rate: 6% (12/1/83) Manufacturers and some agricultural activities pay at 1.5%. Exemption(s): Residential.	Same as Electric
MO	5.725% Sales Tax (7/1/92) Exemption(s): Residential, drying farm crops. Manufacturers are exempt from paying the tax for the amount that exceeds 10% of the cost of production.	5.725% Sales Tax (7/1/92) Exemption(s): Residential and drying farm crops.
MT	No Taxes	No Taxes
NE	Tax Rate: 5% (7/10/90) Exempt if >50% is used for processing, manufacturing, refining, farming and irrigation, or for hospital use.	Same as Electric
NV	Tax Rate: 6.5% (10/1/91)	Tax Rate: 6.5% (10/1/91)

	Exempt if delivered through lines.	Exempt if delivered to customers through mains, lines, or pipes and residential heating.
NH	No Sales Tax	No Sales Tax
NJ	Tax Rate: 7% (7/1/90) Electric utility sales are exempt.	Tax Rate: 7% (7/1/90) Natural gas utilities sales are exempt.
NM	Tax Rate: 5% (7/9/91) Exemption(s): Warehouse and offices.	Tax Rate: 5% (7/9/91)
NY	Tax Rate: 4% (7/1/71) Exemption(s): Residential, agricultural use, and manufacturing assembling, mining, and research (direct-predominant use).	Tax Rate: 4% (7/1/71) Exemption(s): Residential, agricultural use, and fuel for manufacturing assembling, mining, and research (direct and predominant use).
NC	Tax Rate: 4% (7/16/91) Manufacturers pay 1% for use in production.	Tax Rate: 4% (7/16/91) Farmers, manufacturers, and commercial laundries and dry cleaners pay 1%.
ND	Tax Rate: 5% (12/6/89) Electricity is exempt.	Tax Rate: 5% (12/6/89)
OH	Tax Rate: 5% (1/24/81) Electricity and utility services are exempt.	Tax Rate: 5% (1/24/81) Natural gas is exempt from sales tax.
OK	Tax Rate: 4.5% (5/1/90) Exemption(s): Residential and manufacturing.	4.5% Sales Tax (5/1/90) Exemption(s): Residential and manufacturing.
OR	No Sales Tax	No Sales Tax
PA	Tax Rate: 6% (11/1/68) Exemption(s): Residential.	Tax Rate: 6% (11/5/68) Exemption(s): Residential.
RI	Tax Rate: 7% (7/1/90) Exemption(s): Residential.	Tax Rate: 7% (7/1/90) Exemption(s): Residential, and fuel for plants and flowers.
SC	Tax Rate: 5% (7/1/84) Exemption(s): Residential, crop irrigation, and radio	Tax Rate: 5% (7/1/84) Exemption(s): Residential, manufacturing, agricultural curing,

	broadcasting.	poultry production, and motor fuel, except aviation fuels.
SD	Tax Rate: 4% (3/1/88) Exemption(s): Farm use.	Same as Electric
TN	Tax Rate: 6% (4/1/92) Rate is 1.5% for manufacturers, and for farmers for use in food production, and for nurserymen for use in growing horticultural products. Exemption(s): Residential	Same as Electric
TX	6.25% Sales Tax (7/1/90) Exemption(s): Non-commercial or non-business use.	Same as Electric
UT	Tax Rate: 5% (1/1/90) Rate is 2% for Residential. Exemption(s): All other businesses are exempt from sales tax except commercial business.	Tax Rate: 5% (1/1/90) Rate is 2 percent for Residential. Exemption(s): Greenhouses (wholesale), irrigation, and orchards.
VT	Tax Rate: 5% (6/1/91) Exemption(s): Taxpayer-generated and 60% used in own business.	Tax Rate: 5% (6/1/91) Exemption(s): Residential and for agricultural use. Motor fuels otherwise taxed except jet fuel.
VA	Tax Rate: 3.5% (1/1/87) Exemption(s): Electricity through lines for manufacturing for direct processing, making feed for sale or resale, commercial leasing or renting of laundered textile products sold to watermen for extracting fish, bivalves, or crustaceans from water.	Tax Rate: 3.5% (1/1/87) Exemption(s): Residential and manufacturing for direct processing, making feed for sale or resale, commercial leasing or renting of laundered textile products sold to watermen for extracting fish, bivalves, or crustaceans from water and for drying or curing crops.
WA	Tax Rate: 6.5% (1/1/87)	Same as Electric
WV	Tax Rate: 6% (6/1/88) Electricity sales are exempt.	Tax Rate 6% (6/1/88) Natural gas sales are exempt.
WI	Tax Rate: 5% (5/1/88) Exemption(s):	Tax Rate: 5% (5/1/88) Exemption(s):

	Residential and farming: November through April.	Residential and farming: November through April; commercial fishing, interstate and foreign commerce, and railroads.
WY	Tax Rate: 3% (7/1/67) Exemption(s): Manufacturing process, and agricultural use.	Same as Electric

Table 7. Gas and Electric Utility Regulatory Assessments by States[18]

State	Tax Rate (% of Retail Price)	State	Tax Rate (% of Retail Price)
AK	rate unavailable	MN	rate unavailable
AL	0.15%	MS	0.16%
AZ	0.20%	MT	0.28%
AR	0.40%	NV	0.43%
CO	0.20%	NJ	0.25%
DE	0.20%	NM	0.50%
FL	0.13%	NY	0.33%
GA	Fee based on property value	OR	0.25%
HA	0.13%	PA	0.30%
ID	0.30%	SC	rate unavailable
IL	0.19%	SD	0.15%
IN	0.15%	TN	0.08%
IA	0.10%	TX	0.17%
KS	0.20%	UT	0.30%
KY	0.20%	VT	0.50%
LA	0.04%	VA	0.20%
ME	0.25%	WA	0.20%
MD	0.17%	WV	0.29%
MA	0.25%	WY	0.30%
MI	0.02%		

Table 8. kWh Taxes on Electricity[19]

State	Tax Rate
AL	0.04 cents/kWh hydroelectricity
AK	0.025-0.05 cents/kWh electric co-ops
CA	0.02 cents/kWh electricity consumed
ID	0.05 cents/kWh hydroelectricity
MD	0.015 cents/kWh electricity consumed
MT	0.02 cents/kWh electricity produced
ND	0.025 cents/kWh electricity generated from coal
SC	0.05 cents/kWh electricity produced
WV	0.26 cents/kWh electricity produced

[18] ASE Report, Table 5 on page 8.
[19] ASE Report, Table 6 on page 8.