THE STATE CORPORATION COMMISSION
OF THE STATE OF KANSAS

In the Matter of a General Investigation of Kansas City Power & Light Company's All Electric Residential Rates.	)))	Docket No. 16-GIME-576-GIE

VERIFIED COMMENTS OF DOCTOR HOWARD J. AXELROD

Howard Axelrod, being first duly sworn upon his oath, states:

1. I am the President of Energy Strategies, Inc., and my business address is located at 1759 Stephanie Trail, Atlanta, Georgia 30329.

2. My qualifications and experience as an expert in the areas of utility regulatory economics and rate structures, among other aspects of utility regulation, are incorporated in The Kansas Citizens' Utility Ratepayer Board: Analysis of KCP&L All Electric Space Heating Rates.

3. I was retained by the Citizens' Utility Ratepayer Board (CURB) of Kansas to prepare, sponsor and defend a set of comments in the captioned docket on CURB's behalf and to perform other responsibilities in connection with the resolution of said docket, including but not limited to addressing five questions posed in the Procedural Order issued by the Kansas Corporation Commission ("Commission") on September 22, 2016.

4. In accordance with said Procedural Order and the Joint Notice Of Status Update Regarding Filing Date Of Initial Comments, which was filed by the parties on June 27, 2017, I have prepared and am sponsoring comments which are contained in The Kansas Citizens' Utility Ratepayer Board: Analysis of KCP&L All Electric Space Heating Rates, attached hereto and incorporated herein.

5. The Kansas Citizens' Utility Ratepayer Board: Analysis of KCP&L All Electric Space Heating Rates was prepared by me or under my supervision. I have personal knowledge of the statements made in The Kansas Citizens' Utility Ratepayer Board: Analysis of KCP&L All Electric Space Heating Rates, and all such statements are true and correct to the best of my knowledge. I have attached the verification, in the form normally used by the Commission in its dockets, at the end of my comments.

Further affiant saith naught.

Howard J. Axelrod

Subscribed and sworn before me on the 5th day of July, 2017.

Notary Public

My Commission expires:

The Kansas Citizens' Utility Ratepayer Board: Analysis of KCP&L All-Electric Space Heating Rates

PURSUANT TO THE KANSAS CORPORATION COMMISSION DOCKET NO. 16-GIME-576-GIE: IN A MATTER OF A GENERAL INVESTIGATION OF KANSAS CITY POWER & LIGHT COMPANY'S ALL-ELECTRIC RESIDENTIAL RATES

Prepared by Dr. Howard Axelrod and Mark Fowler
ENERGY STRATEGIES, INC. | ATLANTA, GEORGIA
JULY 5, 2017

Report Outline

1. Introduction

Study Purpose

The primary objective of this study is to analyze and respond to the five questions relating to Kansas City Power & Light's (KCP&L or company) residential all-electric heating rate pursuant to *Docket No. 16-GIME-576-GIE*. As we understand the situation, KCP&L had been offering an all-electric heating rate for over fifty years which first raised concerns in Docket No. 10-KCPE-415-RTS in 2010. At that time, several parties to the case including the Kansas Citizens' Utility Ratepayer Board (CURB), supported a position that this "special" rate and associated price "discounts" (a matter we will later address) were inappropriate and should be eliminated as subscribers to the all-electric heating rate were being subsidized by other residential customers. The Kansas Corporation Commission (KCC), contrary to the cost of service evidence produced by KCP&L, reduced the winter seasonal rate differential by nearly sixty percent and essentially provided no reasonable transition or degree of gradualism for those electric customers having limited, if any, capacity to respond to or adjust to such draconian price increases. Later, in Docket No. 16-KCPE-325-TAR, KCP&L proposed a form of customer rebate for those all-electric space heating customers to rectify the inequities caused by the sudden rise in ratepayer heating costs following the 2010 rate increase. That proposal was stayed by the KCC with the institution of the current Docket: No. *16-GIME-576-GIE.*

Cost Causality

Since 2010, CURB has significantly revised its earlier position in recognition that cost of service analyses introduced by KCP&L supported the lower energy prices associated with the all-electric space heating rate as presented by the company. Cost-causality is a primary factor

in allocating fixed and variable costs to electric ratepayers. As noted as the very first bullet in NARUC's 1992 "Electric Utility Cost Allocation Manual" section on cost of service studies in the regulatory process (Chapter 2): "Cost studies are therefore used by regulators for the following purposes:

> - **To attribute costs to different categories of customers based on how those customers cause costs to be incurred."** (page 12) (emphasis added)

The Commission in its five questions refers to the winter heating rate as a "discounted" or "incentive" rate.

As defined by the Merriam Webster On-line Dictionary, a "discount" is a *reduction made from the gross amount or value of something: such as* a (1)*: a reduction made from a regular or list price.*

We are compelled to point out in our response to the five questions, the discount that the Commission refers to is in fact a causality based assessment of costs attributed to the all-electric space heating class of customers. Those rates may be lower than rates paid by other customer classes, but distinctly are not discounted.

We must also premise our report upon the importance to all-electric customers that, subject to the application of the principles of gradualism and equity and the imposition of reasonable social engineering and regulatory policies, all-electric rates (as well as non-all-electric rates) should be cost-based. We note that the answers to the five questions posed in the Order Opening Investigation would appear to relate to the applicability of principles of gradualism and equity.

In the general rate case in today's regulatory environment, the application of those principles and policies are usually premised upon a true, accurate and fair class cost of service study being the starting point of rate design. Thus, the Commission's approach to the issue in this docket through the five questions appears to be consistent with CURB's general position in rate cases that a class cost of service study is a good starting point for rate design. In fact, upon the basis of its study in this docket, CURB has determined that the all-electric rate which exists today can be supported by the cost-of-service of KCP&L all-electric customers.

Finally, we note that due to the limitations of available data and the passage of time, any answers to the five questions cannot conclusively show whether or not the all-electric space heating rate was historically appropriate, whether or not the all-electric space heating rate did influence consumer decision-making toward all-electric heating, and the impacts (if any) upon remaining customers should alternative sources of heating (e.g. geothermal, propane, solar, etc.) draw customers away from KCP&L. More importantly the answers, by themselves, may not substantially help the Commission to determine the justification of an all-electric space heating rate class on a cost-of-service basis and what level of rates should be approved; and, as pointed out above, it does not appear that the five questions were posed to provide a cost-of-service analysis. Illustratively, if it were assumed, *arguendo,* that the all-electric space heating rate is an accurate representation of the true costs incurred by the company on behalf of this class of customers, then many of the concerns raised in the five questions are moot. Indeed, non-all-electric heating customers are not harmed if rates for all-electric customers are reflective of the costs which the all-electric customers incur. It is in no different manner than they would be harmed because industrial rates are lower due to their load factor advantage or voltage level of service. We clearly do not think of the industrial rate as an incentive or discount.

Every effort was made to honestly and fairly address each of the five questions. However, we added, in hope that it will further assist the Commission in its deliberation, a set of recommendations that we believe best serve not just the all-electric space heating customers, but all customers that KCP&L serves. We believe that the Commission fully understood the limitations of the five questions posed in the Order Opening General Investigation because the Commission required the parties to independently analyze the positive and negative aspects of alternative methodologies which may determine the overall benefits and costs that residential all-electric space heating customers generate for the KCP&L system, including KCP&L's residential non-all-electric space heating customers.

Consumerism – Fairness, equity, social good

As a practicality, we could not explore the complete genesis of KCP&L's all-electric heating rate dating back some fifty years. It is for that very reason we invested considerable time and effort to engage in dialogue with a range of stakeholders to these proceedings. We had two conference calls that included the KCC's staff, multiple conversations with KCP&L's rate analyst and even two important in depth interviews with two CURB Board members to understand and represent the perspectives of these Board members on this issue. Given that this issue -- the justification for an all-electric residential space heating rate -- is neither a revenue requirement issue affecting all customers nor an inter-class rate allocation issue, but a residential intra-class assessment of cost allocation and cross subsidization, it does pit one group of CURB's constituencies against another. CURB sought to ethically resolve this issue by limiting its representation in this particular case to all-electric customers, preserving its positions on rate design for the general residential class in all past and future cases.

However, we found in all fairness, that the all-electric space heating classification and attendant price differentials are:

- cost based,
- reflective of the contribution those customers provide to the company's earnings via its propensity to improve system load factor,
- provides a competitive alternative to natural gas space heating which is restricted to a constrained segment of the Kansas City residential customers, and
- all-electric space heating rates could or should be even lower than current levels based on our interpretation of the company's 2015 rate case when applying the Average & Peak, 4CP cost of service methodology.[1]

We also found to be unfair the following:

- In 2010, the parties to the 10-KCPE-415-RTS proceeding failed to recognize and accommodate residential customers who were literally held hostage to a heating technology that incurred a hefty cost with few short-term options that would enable them to mitigate what amounted to a 60 percent increase in rates.
- The parties failed to recognize that while the principles of cost-causality should be the foundation of rate designs, it is not the only consideration or else the KCC would find difficulty in imposing any form of social engineering as to meeting efficiency and environmental objectives or even supporting the broader interests for the State's economic development.

[1] Docket No. 15-KCPE-116-RTS

- Applying cost of service analysis that extolls or implies a level of unfounded precision sidesteps a degree of responsibility to inform, educate and assist customers who might face resultant hardships. This matter is especially disconcerting when we found it is most unlikely that when general residential electric rates rose less than 10 percent, the all-electric space heating rate rose by over 50 percent and **had** to be adjusted in just one year. Recognizing that cost of service analysis is an imprecise[2] albeit useful tool for assigning costs, it stands to reason that a degree of conservatism should have been taken when raising rates as dramatic as had been done in 2010.

For the most part, the all-electric space heating rate may have indeed originally been a promotional rate aimed at increasing electric sales at a time and for a seasonal period when generation reserves were at a surplus. What we can surmise is that if generation surpluses existed, especially during the off-peak winter periods, it was at least anecdotally linked to lower cost to serve, although not necessarily based on a detailed cost of service analysis. However, in its 2010 rate case, KCP&L certainly presented evidence which demonstrated via cost of service analysis that the all-electric heating rate was cost justified. The key argument following the 2010 case (Docket No. 10-KCPE-415-RTS) stemmed on the rather draconian increase in the winter rate that on face value seemed to be unfair to those consumers who chose all-electric space heating systems only to find the economical rate they had been provided was abruptly increased by over 50 percent, while the general rate increase was but a fraction of their increase. We argue here that the current rate differential between the all-electric heating rate and the General Residential rate is cost justified, at a minimum, and potentially could be even greater

[2] We refer the Commission to the Rebuttal Testimony of KCP&L witness Lutz in Docket 15-KCPE-116-RTS where he addresses the diametrically opposite outcomes of the proposed space heating rate when utilizing the "Average & Peak 4CP" versus the "BIP" cost allocation methodologies. (pages 20 – 21)

based on the latest cost of service study offered by the company. The KCC's application of a fairness principle falls short by the way that rates were increased for a rather captured group of customers without adequate chance of notification or transition. The company subsequently recognized this inequity and proposed to restore some of the cost impacts via a rebate proposed in 16-KCPE-325-TAR, which was stayed by the KCC.

Dr. James Bonbright, in his seminal text on public utility regulation – *Principles of Public Utility Rates* (1961), reserves a whole chapter (Chapter VIII) on Fairness versus Functional Efficiency as Objectives of Rate-Making Policy. In synopsis, he concludes:

> *At the risk of being subject to the prejudices of my profession, I am convinced that the modern tendency to view fairness criteria of reasonable rates as secondary criteria, to be accepted primarily as constraints on the application of the so-called economic criteria, is a mark of progress in the development of rate-making policies designed to serve the public interest. But this means merely that fairness issues should be kept in their place. It does not mean that they should be cavalierly dismissed or even belittled. (page 123)*

In summation: 1) the rate differential between the all-electric space heating rate class and the General Residential rate class is cost justified and 2) the magnitude and pace at which the reduction in differential was imposed following the 2010 case was unfair and inequitable to essentially captive all-electric space heating customers, including some who had expended the upfront capital necessary for electric space heating with the anticipation of payback through the reduced rates.

Disclaimer

CURB's comments in this docket are provided solely from the perspective of an all-electric residential consumer served by Kansas City Power & Light Company now, which is a particular subclass of the general residential class which CURB represents in Kansas utility matters. As such, CURB's comments in this docket may not reflect the position that CURB has taken or could take on behalf of the residential class and/or small commercial class of customers of any or all Kansas utilities in all other dockets, past or present. CURB reserves the right to assert any position in future dockets on rate design and other pertinent regulatory issues, regardless of whether such position is consistent with the positions set forth herein.

2. Case History

Timeline Regarding KCP&L Kansas All-Electric Rate Changes[3]

Pre-2010

Although specific rates for electric heating have existed for KCP&L in its Kansas jurisdiction since May of 1959, the rate structures discussed in this document originated in a 1997 rate case, Docket No. 97-KCPE-661-RTS, and were ultimately concluded through a separate proceeding in 1999, Docket No. 98-KCPE-500-TAR. The rate design drew heavily from an earlier, multi-year effort in KCP&L's Missouri jurisdiction.

December 17, 2009

KCP&L files 2010 Rate Case – Docket No. 10-KCPE-415-RTS requesting that its revenue requirement be applied on an equal percentage basis across all rate classes, including electric space heat (heat pump) customers. Staff recommended elimination of the all-electric rate differential. CURB argued for reduction of the all-electric rate differential with the remainder to be phased out. Gas companies argued for complete elimination of the all-electric rate differential. KCP&L, on rebuttal, proposed a moderating alternative that maintained an all-electric rate differential but on a more modest scale than was supported by the cost studies completed at that time. The Commission ordered KCP&L's alternative rate structure be implemented and became **effective December 1, 2010**.

[3] Extracted from an informal information request received from KCP&L

Below are comparisons showing the winter electric space heat rate (2RW6A), before and after the 2010 rate case. Comparisons are also included between the winter electric space heat rate (2RW6A) and the winter general service residential rate (2RS1A). [4]

2010 Rate Increase

2RW6A Electric Space Heat	**New Winter Rate**	**Previous Winter Rate**	**% Change**
First 1,000 kWh	$0.06581	$0.05211	26% increase
Over 1,000 kWh	$0.05746	$0.03908	47% increase

2RS1A General Residential	**New Winter Rate**	**Previous Winter Rate**	**% Change**
First 1,000 kWh	$0.07312	$0.08037	9% decrease
Over 1,000 kWh	$0.07312	$0.08003	8.6% decrease

Difference between winter electric space heat and winter general residential service prior to rate increase effective December 1, 2010:

Prior to Rate Increase	**2RW6A (Electric Space Heat)**	**2RS1A (General Service Residential)**	**% Difference**
First 1,000 kWh	$0.05211	$0.08037	35%
Over 1,000 kWh	$0.03908	$0.08003	51%

[4] Please note: Only winter rates are shown. During the summer, rates are the same for all residential customers.

April 20, 2012

KCP&L files Rate Case - Docket No. Docket No. 12-KCPE-764-RTS: The Company offered a specific rate design proposal that included the following provisions (only those related to the Residential Heating rate are listed):

- Apply the increase to the rate classes to reduce inter-class disparity identified by the CCOS study, while reducing the potential for rate switching.
- Consolidate the residential rates, combining the Residential General Use (RESA) and the Residential General Use with Water Heating (RESB) into a single General Use rate. Then combine the Residential General Use with Space Heat – Two Meter (RESD), and Residential General Use and Water Heat with Space Heat – Two Meter (RESE) rates into a single two-meter Space Heat Rate.
- Adjust the customer charge for each rate as supported by the CCOS study.

Although alternate proposals were offered, the parties were able to reach settlement of the rate design issue. The agreement essentially implemented the proposal offered in direct testimony. From a revenue perspective, the Commission approved an increase of $33M (6.7%). The ordered revenue increase was applied equally to the classes. As a result, the increase ranged from 7.1% for Large/Large Power class to 5.2% for the Small General Service class. The Residential class received a 6.7% increase. Additionally, the order provided for an abbreviated case to be filed within twelve months of the order date. Rates effective January 1, 2013.

Difference between winter electric space heat and winter general residential service <u>after</u> the rate increase effective January 1, 2013:

After Rate Increase	2RW6A (Winter Electric Space Heat)	2RS1A (Winter General Service Residential)	% Difference
First 1,000 kWh	$0.07029	$0.07805	9.9%
Over 1,000 kWh	$0.06139	$0.07805	21.3%

December 9, 2013

KCP&L files Rate Case - Docket No. 14-KCPE-272-RTS: This docket served as the abbreviated case contemplated in the 764 docket and was focused on limited issues. Rate design changes were not included and no CCOS studies were prepared. The case was settled, providing for an $11.5M (2.2%) increase. The ordered revenue increase was applied evenly across all customer classes. Rates were **effective July 25, 2014.**

Difference between winter electric space heat and winter general residential service <u>after</u> the rate increase effective July 25, 2014:

After Rate Increase	2RW6A (Winter Electric Space Heat)	2RS1A (Winter General Service Residential)	% Difference
First 1,000 kWh	$0.07183	$0.07976	9.9%
Over 1,000 kWh	$0.06272	$0.07976	21.3%

September 15, 2014

KCP&L files 2015 Rate Case – Docket No. 15-KCPE-116-RTS requesting an increase be applied on an equal percentage basis across all rate classes, including electric space heat (heat pump) customers. CURB argued for reinstatement of all-electric rate differential to pre-415 Docket levels for a limited period of time. Gas companies argued for complete elimination of all-electric rate differential.

The parties filed a Non-Unanimous Rate Design Settlement Agreement to which CURB was a party with the caveat "This rate design settlement agreement sets forth a complete rate design settlement applicable in the event the Commission rejects CURB's proposal for reinstatement of the all-electric rate differentials." Ultimately, upon a Daubert motion filed by Kansas Gas Service, the Commission ruled, "The Commission rejects CURB's proposal to reinstate the all-electric rate discounts in effect before the Commission's Order in the 10-415 Docket." The new rates **effective October 1, 2015** preserved the post-415 Docket rate differential levels.

Difference between winter electric space heat and winter general residential service <u>after</u> the rate increase effective October 1, 2015:

After Rate Increase	**2RW6A (Winter Electric Space Heat)**	**2RS1A (Winter General Service Residential)**	**% Difference**
First 1,000 kWh	$0.07529	$0.08631	12.8%
Over 1,000 kWh	$0.06575	$0.08631	23.8%

December 31, 2015

KCP&L files for a new Residential All-Electric Rider tariff – Docket No. 16-KCPE-325-TAR. The Rider is designed to provide qualifying residential all-electric rate customers, who may have made purchasing decisions in reliance upon KCP&L's winter season energy rate differentials (as compared to the residential general use rate) in effect prior to December 2010, a means to help mitigate the impact of an abrupt change in those rate differentials that occurred on December 1, 2010, the effective date of rates resulting from KCP&L's Docket No. 10-KCPE-415-RTS.

The Commission determined that it wanted to conduct a study using an outside consultant to address specific questions about the costs and benefits of all-electric rates. The Commission issued an RFP for an outside consultant to perform such a study. To that end, the Commission opened a generic docket on June 21, 2016 – Docket No. 16-GIME-576-GIE. Accordingly,, the proceedings in the 325 Docket were stayed on June 21, 2016.

Due to due process and administrative efficiency concerns, as well as the willingness of CURB and KCP&L to sponsor testimony addressing the key issues, the Commission altered its plans to conduct the study and instead allowed CURB and other parties to conduct the study and present written reports describing the same. The parties have advised the Commission that study results could be ready and filed by July 5, 2017. Staff advised the Commission that it would provide a history of KCP&L's all-electric rates and would provide comments on any studies filed but would not file one of their own.

3. *Commission's Five Questions*

The State Corporation Commission of the State of Kansas (KCC or Commission) pursuant to Docket No. 16-GIME-576-GIE has opened a general investigation into Kansas City Power & Light Company's (KCP&L) All-Electric Residential Rates. In doing so, the Commission sought answers to the following questions:

1. Historically, are KCP&L's residential non-all-electric space heating customers better off than they would have been had KCP&L not provided a discounted electric rate for residential all-electric space heating customers? If so, how should that benefit be quantified?

2. Does KCP&L have a significantly larger residential customer base that uses electric space heating equipment than other utilities who do not offer residential electric space heating discounts? In other words, was KCP&L's program successful at increasing the number of residential all-electric space heating customers?

3. Quantify the benefits, if any, for having residential all-electric space heating customers on the system as compared to a utility that has not or does not incentivize residential all-electric space heating customers.

4. On a Benefit/Cost basis, should KCP&L's residential all-electric space heating customers receive a discount, and if they should, how large should the discount be? Are residential all-electric space heating customers paying the costs they cause for the system, more than the costs they cause, or less than the costs they cause?

5. Alternatively, if KCP&L's residential all-electric space heating customers were to convert to an alternative heating source such as geothermal, solar, natural gas or propane, what would be the cost to KCP&L's system and what would be the cost to KCP&L's other residential customers?

4. *Our Methodology*

Our approach to addressing the five questions raised by the KCC included a 5-step process:

1. **Multiple contacts with primary stakeholders** including the KCC staff, KCP&L rate experts, CURB staff and selected Board members of CURB, to ascertain and understand the positions which CURB has taken and believes are appropriate on behalf of the KCP&L all-electric class so as to put in perspective a holistic response to each of the KCC's five questions.

2. The **rate designs** for KCP&L as well as all the major utilities in contiguous states were examined and compared.

3. **Rate Design/Cost of Service experts** from each of these utilities were contacted and interviewed. Interview questions related to the history of their residential rate structure including all-electric space heating. Interviews with KCP&L were more extensive and focused on prior rate cases, COS analysis and history of the all-electric heating rate issue.

4. **Internet search** including the SNL utility search engine, was employed to identify studies, reports, other rate cases, etc. relating to the genesis of the all-electric heating rates.

5. **In depth review of prior KCP&L** rate applications with a focus on expert testimony and analysis offered by CURB, KCC staff and KCP&L.

These five steps are expanded upon below:

Stakeholder Input

As indicated earlier, because CURB most closely represents the all-electric consumer in this docket and due consideration of its concerns is very important, we sought to obtain the historic and current perspective of CURB through two of its Board members, so as to appreciate and represent the positions it has as to the All-Electric Space Heating residential customers in all aspects of this report. As we addressed the Commission's five questions, we also sought the input from KCC staff and KCP&L's rate experts. Our collective assessment from all of these key stakeholders to the electric utility regulatory process was used to analyze and respond to the KCC's questions but also reflect upon CURB's own Board's greatest concerns.

Based upon our interviews and research, it appears that CURB's most prevalent concerns (as the representative of the all-electric class) focused on:

- The magnitude of the KCC's 2010 increase in the all-electric space heating rate.
- The lack of consideration and fairness and equity to those rate payers who had little time to prepare for or even respond to the rapid rise in space heating costs.
- The uncertainly around KCP&L's proposal (in 16-KCPE-325-TAR) to compensate those all-electric space heating customers impacted by the 2010 rate increase. To CURB, this docket provides an avenue to discuss fairness and equity concerns arising out of the burdensome amount of rate increase suffered by the all-electric rate class arising out of the rate design in 10-KCPE-415-RTS. CURB believes that all of the Commission is compassionate about the approximately 60% increase in rates which were imposed upon that class and, therefore, would want to ensure that gradualism and equity are duly considered.

- The KCC has not explored alternative and innovative rate structures that could help these effected customers mitigate these increases.

Peer Group Development- Rate Design and Cost of Service Experts

The four-step process first involved identifying a potential peer group of utilities for a review and comparison of their rate designs with those of KCP&L. Initial reviews narrowed the potential peer group to the Southwest Power Pool and utilities in Kansas and contiguous states. Additional analysis of company characteristics and winter weather characteristics, notably heating degree days, resulted in further narrowing of the peer group to utilities in contiguous states.

The primary peer group was narrowed to include:

Kansas

- Kansas City Power and Light
- Kansas City Board of Public Utilities
- Westar

Nebraska

- Nebraska Public Power
- Omaha Power District

Oklahoma

- Oklahoma Gas and Electric
- Public Service of Oklahoma

Missouri

- KCP&L Missouri

- City of Springfield (utilities Division)
- Ameren Missouri

Colorado

- Public Service of Colorado

The peer group was chosen for their similarity in weather patterns, in particular heating degree days and geographic similarities. Our analysis deliberately did not attempt to limit the search for peers who have a defined space heating rate.

Rate Designs

After solidifying the peer group for our review, we identified all current rates and tariffs using the official company websites and links. The review was somewhat complicated by the fact that each of the peer group utilities have numerous differences in such rate items as nomenclature, winter/summer seasons for rate purposes, taxes, geographic rate differences (i.e. outside city limits) and similar. After reviewing the tariffs in detail, we elected not to attempt to include the minor differences and instead to focus on the winter/summer rate differentials regardless of terminology used. The differentials are discussed at length later in our report findings. All the data was accumulated into spreadsheets to enable a side by side comparison, the results of which are referenced throughout this report and included as appendices.

Rate Design/Cost of Service Experts

The peer group identified in the Rate Design step was also utilized for the direct, in depth discussions regarding rate design. Rate experts from all the peer group utilities were contacted. We were ultimately successful in conducting in-depth interviews with experts from eight of the

peer utilities. In those cases where we were unsuccessful in conducting interviews, multiple contact attempts were made up to the development of this report.

Interview questions asked of the rate experts related to the history of their residential rate structure including all-electric space heating, winter/summer rate differentials, drivers of any rate incentives, demand charges, cost of service studies, alternative space heating incentives (rebates) and current rate design considerations. The representatives from these utilities were very forthcoming and provided our review with invaluable insight not only into the rate structures but also into the history and thought processes behind their rates. Interviews with KCP&L were more extensive and focused on prior rate cases, COS analysis and history of the all-electric heating rate issue.

Internet Search

Our internet search included the use of the SNL utility search engine, as well as a broader search focusing on scientific and scholarly articles and data. The SNL search was employed to identify specific studies, reports, other rate cases, etc. relating to the genesis of the all-electric heating rates. The broader internet search focused on available tariffs and rate cases as well as supporting documentation. We also utilized this step to accumulate analytical data including weather history, energy costs and trends, heating efficiency comparisons and pertinent news stories such as those on the recent Oklahoma Gas and Electric rate case. Sources included the Department of Energy- Energy Information Administration (EIA), the American Gas Association (AGA), the National Propane Gas Association (NPGA), universities and the National Regulatory Research Institute. Where questions arose from the internet searches we made direct contact with the organizations responsible for the data for clarification. We also interviewed companies offering alternatives to electric space heating for information such as

propane tank installation costs and delivery limitation in the KCP&L territory when the internet search did not yield reliable or sufficiently detailed information.

KCP&L Rate Applications.

Our in-depth review of prior KCP&L rate applications included a focus on expert testimony and analysis offered by CURB, KCC staff and KCP&L.

Summary of Findings

In responding to the 5 Questions raised by the KCC we reached the following general conclusions:

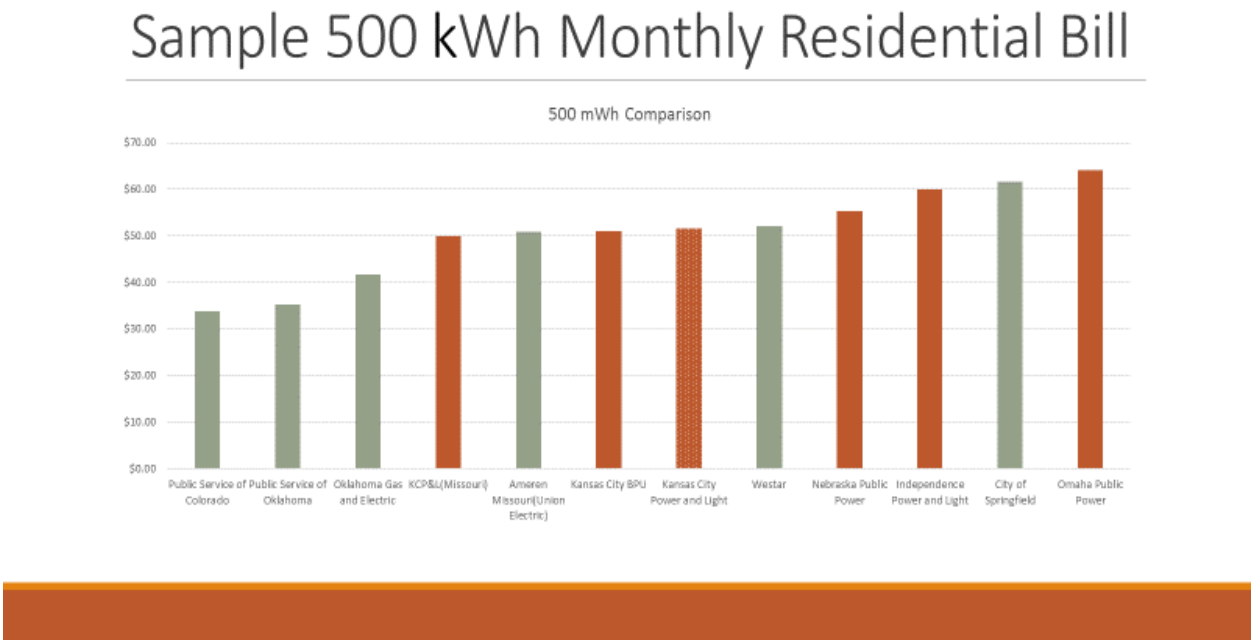
1. The utilities reviewed all offered a seasonally differentiated price for winter usage. Some chose to offer all-electric heating rates, while others simply offered a general residential rate with a summer/winter differential and a declining block rate. We found that the difference in a typical all-electric heating rate versus a general summer/winter differentiated rate was not significant. KCP&L's response to CURB Data Request – 3, indicated that during 2015, the average residential usage of electricity during the winter season was:

    - 791 kwh for General Residential
    - 1,160 kwh for 1-Meter All-Electric Space Heating
    - 907 kwh for 2-Meter All-Electric Space Heating

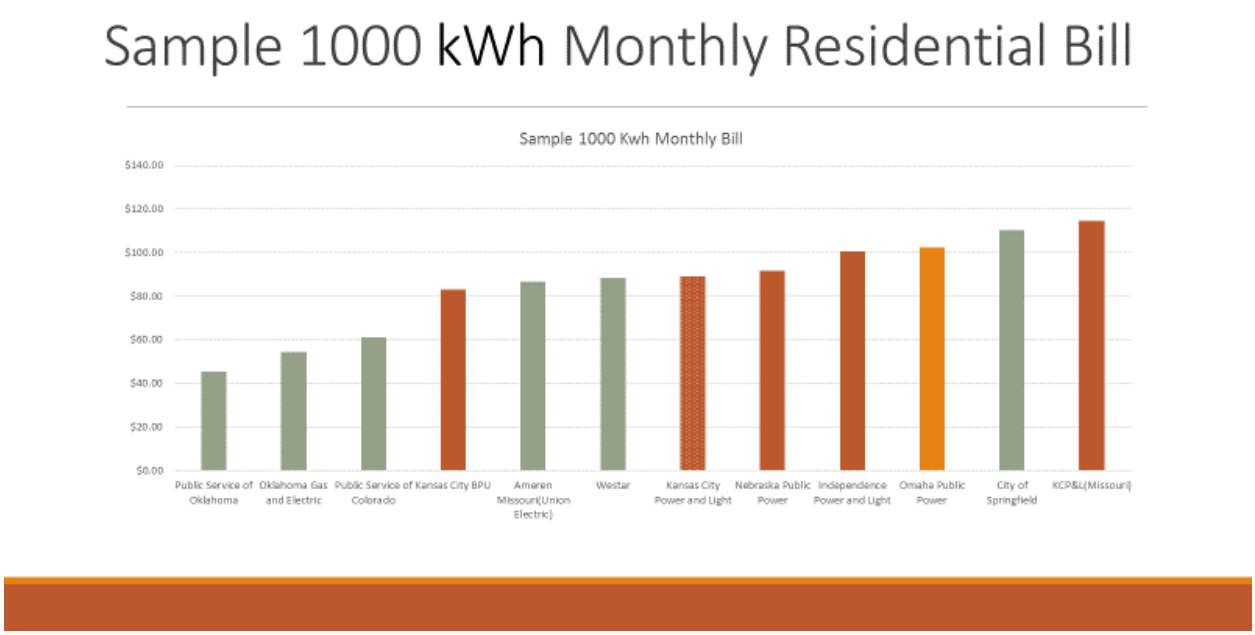
    To capture the full range of usage patterns, we compared KCP&L's winter heating rate to other regional electric utilities for 500 kWh, 1,000 kWh and 2,000 kWh per month.

Graphs 1 – 3 below illustrate the differences among the regional utilities studied. Generally, we found that except for utilities in Oklahoma and Colorado, KCP&L's all-electric space heating rate was comparable to both the all-electric space heating rates and the residential winter rates for utilities in Missouri and Kansas and slightly less than those in Nebraska. At 500 kWh per month usage, costs ranged within plus or minus $10; at 1,000 kWh per month, plus or minus $20 and at 2,000 kWh per month, plus or minus $40.

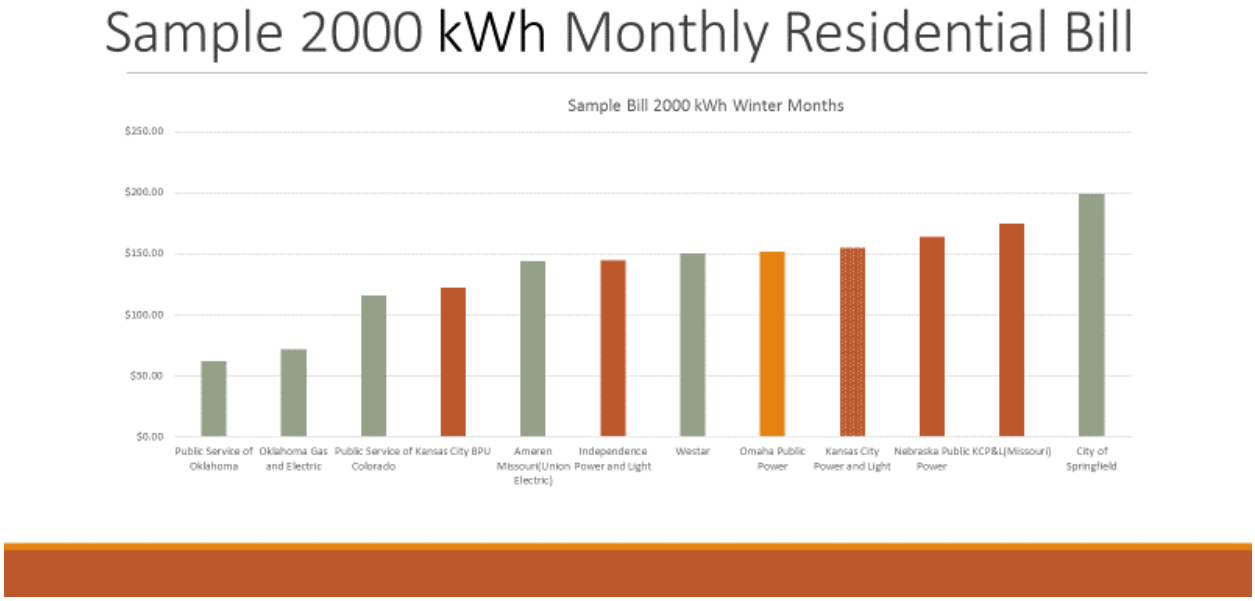
Graph 1



Graph 2



Graph 3



2. All the utilities interviewed indicated that the design of their residential rate was cost based using conventional embedded cost of service analyses.

3. Our internet search found few, if any, comparable regulatory issues or concerns relating to all-electric space heating rates.

4. Our independent review of the 2015 KCP&L rate case and associated COS studies led us to conclude that the residential all-electric space heating rate was cost justified. Our further discussions with key KCC staff and KCP&L personnel confirmed our findings.

5. We further found that the current rate differential provided to space heating customers appeared reasonable from a cost perspective, although our cursory review of the two COS studies suggested that a further discount in the tail block could be justified. Using the Company's Rate Settlement spreadsheet, we found that a $.01 kWh reduction in the tail block from $.06527 kWh to $.05527 kWh reduced the revenues by approximately $2.5 million which resulted in a return on rate base consistent with the General Residential rate.

Table 1 below lists the names of electric utilities contacted in our research study.

Table 1

Utility Survey Participants	IOU or Public Power	All-Electric-Heating Rate?
Kansas		
1. KCP&L	IOU	Y
2. Westar	IOU	N
3. KC BPU	PP	Y
Nebraska		
1. OPPD	PP	Y*
2. NPPD	PP	Y
Oklahoma		
1. Oklahoma Gas & Electric	IOU	N
2. Public Service Company of Oklahoma (AEP)	IOU	N
Missouri		
1. KCP&L	IOU	Y
2. Ameren	IOU	N
3. City of Springfield	PP	N
4. Independence Power & Light	PP	Y
Colorado		
1. Xcel Energy (Public Service of Colorado)	IOU	N

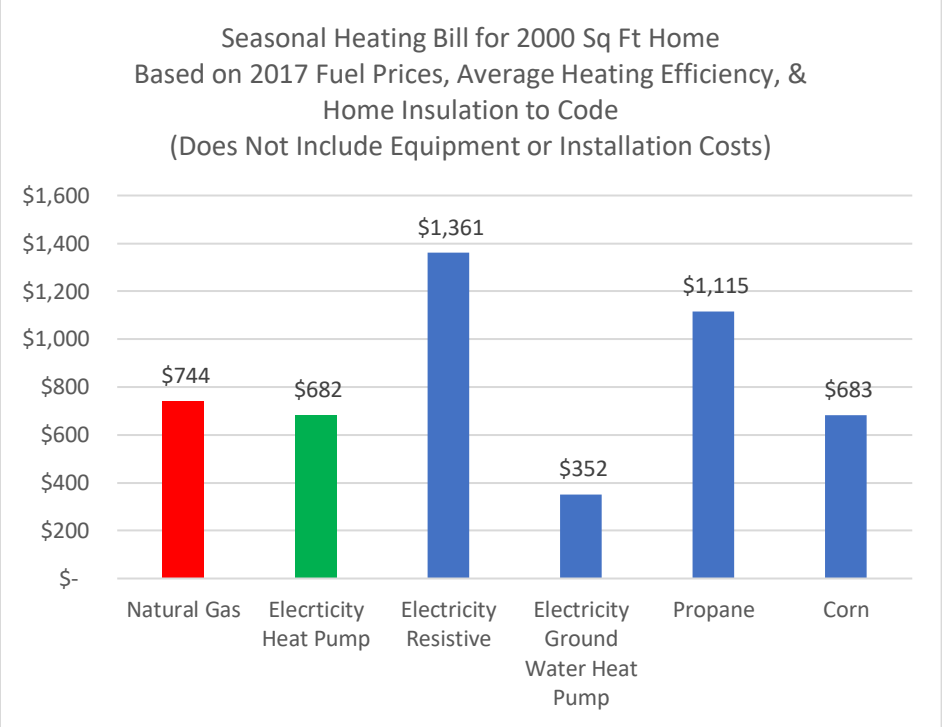
5. *CURB's Response to the KCC Questions*

KCC Question No. 1: Historically, are KCP&L's residential non-all-electric space heating customers better off than they would have been had KCP&L not provided a discounted electric rate for residential all-electric space heating customers? If so, how should that benefit be quantified?

CURB's Response to Question No.1:

The benefit to the KCP&L system brought by all-electric customers is reflected in CURB's response to Question No. 3. However, we would add that, if KCP&L's all-electric space heating rate was based upon a cost of service study (COSS) that allocates costs driven by causality principles, all other customer classes including residential non-all-electric space heating customers are not unfairly affected by the level of "discount" offered to the electric heating participants. In this respect, the term "discount" is a misnomer, where rate differences between and among rate classes are intended to be cost based, and as such, reflective of differences in embedded costs, not an implied rate discount.

Graph 4



Conceptually, there is some consensus among affected parties that all customers are better off if electric rates are based on a fair allocation of costs, as accurate pricing signals help all customers and society to best allocate their limited resources in the most efficient manner. A true discount that is not cost based, for example, might influence some customers to use more electricity that in the long run drives up marginal costs, i.e., requiring the addition of higher cost utility investments that all customers must bear.

Moreover, it is our opinion that, at least for the last several years residential non-all-electric customers may have likely benefited regardless of the all-electric rate, had their choice been to install an efficient gas furnace as natural gas prices have been and expected to remain at extremely low levels. Graph 4 above compares the seasonal cost for the most typical forms of space heating in Kansas with electricity heat pumps and

natural gas systems being the most prevalent. Using 2016- 2017 fuel prices and a range of home efficiencies (i.e. levels of insulation) and heating appliance performance standards (i.e. average, code and high efficiency standards) the cost for a 2,000-square foot home was calculated.[5,6] We found that the seasonal heating costs were highly competitive between natural gas and electricity. Only ground water heat pumps (geothermal) was considerable less competitive; however, the $3,000 - $4,000 added installation costs was not included in this comparison.

It is worth noting that space heating as a percentage of overall home energy use regardless of fuel source or rates has declined from 1993 levels. In 1993, space heating was 53.1 percent of home energy use. *See Appendix D.* This declined to 41.5 percent in 2009. Preliminary 2015 data indicates that this trend has continued although results are not final.

In response to Question No. 1, from both a cost of service and a gas/electric, cost/benefit analysis, both all-electric and natural gas heating customers fare equally regardless of fuel choice.

KCC Question No. 2: Does KCP&L have a significantly larger residential customer base that uses electric space heating equipment than other utilities who do not offer residential electric space heating discounts? In other words, was KCP&L's program successful at increasing the number of residential all-electric space heating customers?

[5] See Appendix A for the complete results including three ranges of performance for home and heating appliance efficiency.

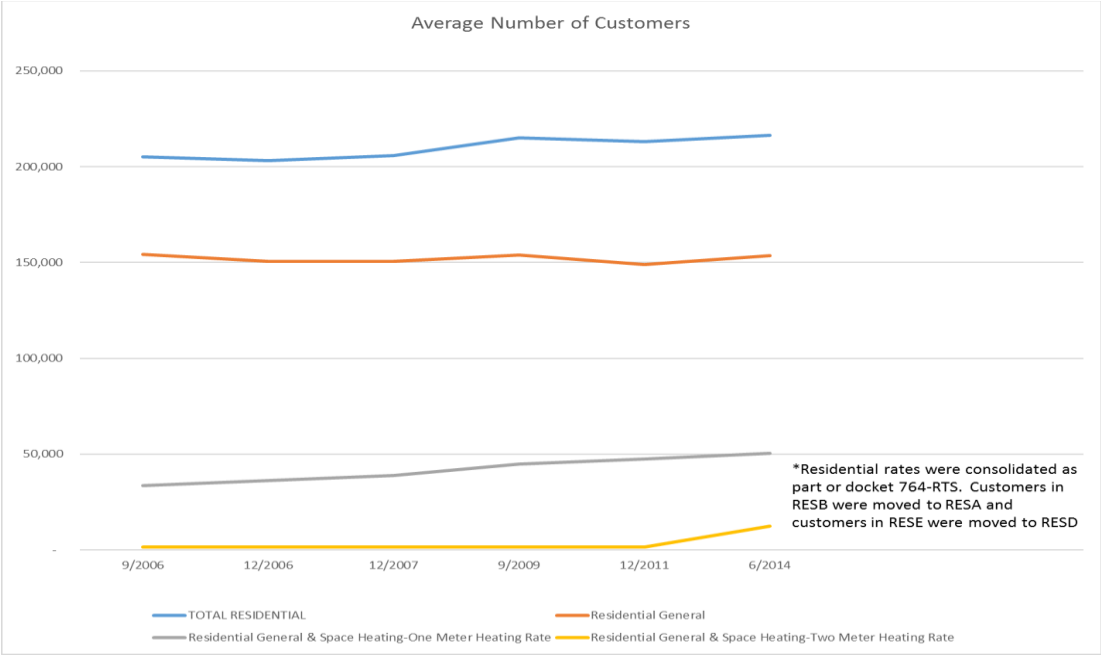
[6] See Appendix B for a copy 2003 Kansas State University report entitled *Comparing Fuel Costs of Heating and Cooling Systems*

CURB's Response to Question No. 2:

Generally, we did not find that KCP&L has a "significantly larger" all-electric heating base, although the approaches to rate design and marketing strategy masks our ability to affirm this finding. Our analysis consisted of reviewing and interviewing electric utilities within Kansas and all the surrounding states. For the most part, many utilities do not offer an all-electric residential rate, per se. Some utilities, like Westar, offer a summer-winter differential which provides a lower price for winter usage periods. A direct comparison is also complicated by the various iterations of space heating and water heating rates such as one or two meter, combined water and space heating, separate water and space heating and similar. Others offer no "discount", but instead, provided cash rebates for high efficiency heat pumps. As a result, the numbers of electric space heating customers are not collected. However, the U.S. Energy Information Administration (EIA) in its 2013 Census report found that of all US households, the split between electric and gas heating was 51/50% (% electric/gas household total households), while in the Midwest it was 42/70% and in Kansas (combined with Nebraska) the split was 50/77%.

We did find that for KCP&L, over the last decade, customers assigned to the two-meter rate have slightly declined from 1,451 customers in 2006 to 1,363 in 2011 while the single meter rate has increased from 33,700 to 47,566 during the same period. In 2014, with some consolidation of rate classes, the percentage of KCP&L's electric heating customers was 41% which is below both the national and regional averages.

Graph 4



Based on information provided by KCP&L per CURB Data Request 3, the numbers of all-electric space heating subscribers have only slightly increased and demonstrates no evidence of mass migration due to real or perceived competitive advantage. In short, our analysis of comparable seasonal heating costs between gas and electricity, the percentage of electric space heating as compared to regional and national data and the lack of a clear trend of customers subscribing to the all-electric rate suggest that the cost based all-electric space heating rate generally provides consumers with the ability to choose either natural gas or electricity heat pumps at a price that is highly competitive.

Our analysis and utility discussions highlight a significant area of concern for the one-meter space heating rate. This concern is centered around the ability to ensure that initial electric resistive installations were in fact the primary source of home heat enabling the consumer to receive the space heating rate. The concern is even greater for insuring that

customers who are once on the electric space heating rate continue to use electric heat as their primary heating source.

KCC Question No. 3: **Quantify the benefits, if any, for having residential all-electric space heating customers on the system as compared to a utility that has not or does not incentivize residential all-electric space heating customers.**

CURB's Response to Question No. 3:

KCP&L is a summer peaking company, which means many, but not all, of its capital investments in T&D plant are dedicated to meeting the peak demand including losses during that summer period. That being said, any increase in consumption during non-peak periods has the effect of increasing its contribution to its capital investments without a commensurate increase in added fixed costs. Clearly, the Company could consolidate the all-electric space heating rate within a General Residential rate with an attendant summer/winter differential and the electric space heating customer would benefit to the extent that the winter rate was less than the summer rate. However, in such a consolidation, the off-season demand and associated higher load factor, would be diluted and fail to fully reflect the system-wide contributions the electric heating demand makes. From a marketing perspective, it can be reasonably assumed that if the all-electric space heating winter differential was reduced, the numbers of participating residential customers would diminish as a degree of competitive edge would be lost.

To quantify this benefit would require an analysis of the marginal contribution of return to fixed costs associated with the tail block of the all-electric space heating rate. However, a "ballpark" assessment, based upon the Company's 2015 Cost of Service Analysis (Average & Peak, 4CP cost of service methodology), the difference in return

was about 1 percentage point higher for the all-electric space heating rate or ~$2.6 million based on the total associated rate base. This represents about 1 percent of KCP&L's General Residential Use rate of $245 M. Conceptually, the quantified benefit of the all-electric space heating rate is $2.6 million. That translates into a $.01/kwh reduction in the 1- meter all-electric space heating rate from $.06527 kWh to $0527 kWh.

Isolating all-electric space heating customers as a special class helps the company to offer competitive rates with other forms of space heating which might not be apparent if a single or consolidated resident rate were offered. However, as we discuss, many neighboring utilities have chosen to offer a single residential rate with a summer/winter differential which offers similar "discounts" to winter use all-electric heating customers. Similar benefits are also ascribed to winter differentials associated with electric space heating usage. The summer/winter differential also serves to accomplish the same goal without directly addressing how the energy is consumed during the winter off peak months.

KCC Question No. 4: On a Benefit/Cost basis, should KCP&L's residential all-electric space heating customers receive a discount, and if they should, about how large should the discount be? Are residential all-electric space heating customers paying the costs they cause for the system, more than the costs they cause, or less than the costs they cause?

CURB's Response to Question No. 4:

Recognizing the Commission's request that we do not re-litigate Docket No. 15-KCPE-116-RTS, we felt compelled to review the two cost of service studies offered by the

company to assess whether it was reasonable to support an all-electric space heating rate that had a lower cost than the general residential rate. We found, in agreement with the company, that the Average & Peak cost of service methodology provided ample evidence that a seasonal rate for all-electric heating customer was cost justified. Again, this is not a discount, but a reflection of lower costs incurred by the company during the winter period and for higher load factor all-electric heating customers.

In our survey of electric utilities in the Midwest, all respondents indicated that their summer/winter differential, either associated with their general residential or all-electric heating rate class was based upon a cost of service analysis. We further found that utilities that had only a General Residential rate with a summer/winter differential, were competitive with KCP&L's All-Electric Heating Rate which reinforces our finding that supports a lower marginal rate for all-electric space heating customers. Recalling that the utilities surveyed for this study included those within Kansas and the surrounding states, our attempt was to compare systems with roughly similar topography, meteorological characteristics (i.e., similar heating requirements) and access to sources of generation.

As to how large the all-electric space heating rate differential should be, in general, whatever it is, it should be cost based. Our cursory review of the cost of service study results suggest that the current discount is reasonable, but there may be some additional room for further winter differential price reduction in the tail block of the all-electric space heating rate.

KCC to Question No. 5: Alternatively, if KCP&L's residential all-electric space heating customers were to convert to an alternative heating source such as

geothermal, solar, natural gas or propane, what would be the cost to KCP&L's system and what would be the cost to KCP&L's other residential customers?

CURB's Response to Question No. 5:

This question essentially has two components. The first is the impact on the system and rates if residential all-electric space heating customers were to convert to any other means of space heat regardless of fuel source or technology. However, as a second aspect of the question, the practical and economic considerations of converting to another heating source should be considered given current and projected technologies and associated costs.

As a general principle, if the tail block of the residential rate structure approximates the marginal cost of electricity, then minor scale reductions in electric usage should have no impact on either the company's ability to earn a fair return on its investments or cause cross subsidization within the residential class.

With most residential customers choosing either natural gas or electricity heat pumps, the other forms of heating serve niche markets, e.g., propane, geothermal heat pumps, etc. and are either too costly to operate or too expensive to install. As demonstrated in our response to Question 1, the close comparative costs of natural gas and the electricity heat pump will not likely result in a dramatic shift in choice as long as the relevant costs remain constant or the rate at which natural gas utilities can extend service feeders to high growth residential markets in the Kansas City area remains constant.

CURB notes that its study shows that many of the alternative primary space heating options are either minimal in actual application or infeasible. Although the question is

posed as hypothetical, the premise that KCP&L all-electric heating customers can freely leave KCP&L for alternative heating sources in substantial numbers may not be realistic. On the contrary, the practical captivity of all-electric customers (at least in the short term) would be a factor which could be urged to support gradualism or other equitable measures in rate design.

As to the event should KCP&L's all-electric space heating customers shift to other forms of heating systems, the impact on sales and earnings is impacted by two opposing forces:

- On the one hand and as noted earlier, winter space heating loads occur during the off-peak period, meaning that utility investments required to meet peak load conditions, are more fully utilized and generate added revenues and earnings to meet the company's cost of capital obligations. The loss of this load would result in a disproportionate decline in revenues relative to fixed cost recovery.
- However, because residential rates do not include a demand charge component, and the fact that fixed costs are loaded on the initial block of KCP&L's residential rates[7], reductions in heating usage, at the margin, will be mitigated by the fact that a majority of the incremental heating usage falls above 1,000 kWh which is the threshold when the tail block begins.

Consequently, it is difficult assess exactly what might happen with a mass migration to other forms of heating, however, the impact will be softened by the way rates are currently designed.

[7] See Rebuttal testimony of Bradley Lutz (KCP&L) Docket No. 15-KCPE-116-RTS, page 19, lines 1 - 14

6. *Recommendations for Future Action*

Our Findings and Recommendations

1. We found no evidence in our investigation that the concept of an all-electric space heating rate is not cost justified. In fact, when compared to natural gas heating, the electric-space heating rate is highly competitive.
2. We further believe that the reduction in the price differential between the all-electric space heating rate and the general residential rate approved by the KCC in 2010 was too great and based on KCP&L's 2015 cost of service analysis the tail block should be further reduced by as much as $.01/kwh.
3. Finally, we found that even if those reductions were based on cost causality principles, cost of service analysis is not an exact science, and the KCC, on the side of fairness and equity should have phased-out the differential substantially more gradually than an immediate sixty percent increase that left consumers ill- prepared to mitigate those higher prices. At the least, revisiting this issue is of extreme importance to the genuine application of the principles of gradualism and equity in this docket.

For those reasons, we offer the following recommendations:

1) *We recommend that the all-electric space heating rate classification be maintained.* Residential customers that are not provided natural gas service are provided a highly competitive alternative with an electric heat pump.

2) *We urge the KCC to consider further decreasing the Winter tail block of the AllElectric Space Heating rate based on KCP&L's 2015 Cost of Service analysis*. While the revised

rate that we suggest will not return the all-electric space heating to the level they enjoyed pre-2010, it will go a long way in restoring some of those same benefits.

3) *As a matter of fairness and equity, the KCC should reopen for its consideration Docket No. 16-KCPE-325-TAR to allow the parties to litigate or seek a settlement of KCP&L's rate mitigation proposal for those all-electric space heating customers adversely affected by the 2010 rate increase authorized in Docket No. 10-KCPE-415-RTS.* In these regards, the Commission can provide some guidance from this docket as to what concerns the Commission has, if any, with respect to the amount of gradualism that can still be built into the rate design approved in 10-KCPE-415-RTS. CURB believes that the Commission understands the impact that a 60% increase in rates meant to all-electric customers who were essentially captives to these higher rates, especially those customers who are low-income or fixed income.

4) *As a furtherance of Docket* No. *16-GIME-576-GIE, the KCC should direct the Company to analyze and present alternative rate structures that can also offer residential all-electric space heating customers rates that reflect their cost of service.* We offer the following suggestion for illustration[8]:

a) A U-shaped general residential rate with three energy blocks: 1) up to 750 kwh that represents the base usage (exclusive of space heating) for all residential customers, 2) from 750 kwh to 1500 kwh that represents the average incremental usage for electric space heating, and 3) above 1500 kwh. The first block would include, as it does now, energy and assigned fixed costs; the second block (at the lowest unit price) reflecting the short run marginal cost to serve; and the third block reflecting the long run avoided

[8] The rate blocks are illustrative only.

costs. The third block should discourage consumption that will drive average unit costs upward.

5) *KCP&L is best positioned to analyze such proposals to test the sensitivity of alternative rate structures to varying levels of consumption and usage patterns (i.e., load shapes). As a result, we further propose that the company in collaboration with KCC Staff and CURB perform a scenario analysis of such alternative rate structures to determine if they offer consumers prices that are more reflective of their usage and usage patterns.*

CURB recognizes that utilities sometimes advocate for demand charges as part of their rates. From the perspective of a utility, the introduction of a residential seasonal rate structure that introduces a demand charge to address the recovery of fixed, demand-related, costs could be urged as a potential means to reduce the rates of all-electric customers.

Yet, from the perspective of an all-electric customer, it may offer some help. Here, a two-tiered energy rate would include a first tier that reflects the short run marginal to serve and the second block reflecting the long run avoided costs. This inverted rate structure would encourage the efficient use of electricity by fostering usage that consumes surplus or available capacity, yet discourages usage that will require future capital investment in T&D or production plant. In combination, higher load factor customers would benefit from lower unit fixed costs and short run marginal costs.

From CURB's perspective, all the benefits and detriments of demand rates should be fully analyzed before demand rates are implemented. Moreover, from CURB's perspective, even if a demand charge were explored in this docket, no demand charge should ever be implemented without a sufficient educational and facilitation strategies being implemented both in advance and coincidentally. Finally, to obviate rate shock, gradualism is an imperative in the

implementation of demand rates where residential class of customers are concerned. However, it should be noted that this approach may lead to larger regulatory issues than the ones it potentially resolves. For example, low and fixed income consumers faced with a severe winter could find that by conserving to meet other financial obligations, their bills may no longer be proportionate to their usage as a greater percentage is fixed via the demand charge.

7. *About the Authors*

Dr. Howard J. Axelrod is President of Energy Strategies, Inc. and has more than 45 years of experience with regulated electric and natural gas utilities. Having served as a special assistant to nationally renowned regulatory leaders, NYSPSC Chairmen Joseph Swidler and Dr. Alfred Kahn, Dr. Axelrod led in the early development of performance based rates and nuclear phase-in mechanisms. He has performed numerous studies and led in the development of strategies addressing such issues as competitive restructuring, strategic business and market planning, organizational development, and business risk analysis. Dr. Axelrod has performed best practice assessments relating to strategic and business planning, utility outage preparedness and enterprise risk management. He has testified before numerous state regulatory agencies and FERC on such topics as resource planning, power contract management, utility research & development programs, and productivity.

As Director of Utility Intervention for the New York Consumer Protection Board, Dr. Axelrod managed the nation's largest consumer advocacy organization overseeing the intervention on behalf of residential rate payers in over 300 electric, natural gas, water and telephone rate proceedings.

Dr. Axelrod was received his doctorate from Rensselaer Polytechnic Institute in Managerial Economics, an MBA from the State University of New York and BSEE and MSEE degrees in Power Systems from Northeastern University. He was a Licensed

Professional Engineer registered in New York (retired) and is a Senior Life Member of the Institute of Electrical and Electronic Engineers.

Mr. Mark D. Fowler has more than 30 years of experience with regulated electric, natural gas, telecommunications, water and wastewater utilities. He also has experience in nonregulated pipeline, generation and cogeneration experience. He has performed numerous studies and led in the development of strategies addressing such issues as competitive restructuring, market competitiveness, emergency restorations, organizational structure, and reliability. Mr. Fowler has performed best practice assessments relating to work management, emergency restoration times, utility outage preparedness and construction and maintenance practices. Mr. Fowler has testified before numerous state regulatory agencies and the FCC on such topics as rate structures, customer service, competition, and productivity. He has assisted clients throughout North and Central America, the Caribbean and the Pacific Rim.

Mr. Fowler received his MBA and BS degrees from the University of Tulsa.

VERIFICATION

STATE OF GEORGIA)
) ss:
COUNTY OF FULTON)

I, Howard Axelrod, of lawful age and being first duly sworn upon my oath, state that I am a consultant for the Citizens' Utility Ratepayer Board; that I have read and am familiar with the above and foregoing document and attest that the statements therein are true and correct to the best of my knowledge, information, and belief.

Howard Axelrod

SUBSCRIBED AND SWORN to before me this 5th day of July, 2017.

Notary Public

My Commission expires:

JEFF FRANZ NOTARY PUBLIC FULTON COUNTY GEORGIA EXPIRES May 16, 2021

Appendix A:

Computation of Annual Energy Bills for Competitive Space Heating Systems

Natural Gas

$/mmbtu

2000	1000 btu/sq ft	Lo efficient	Average	Hi efficient	Lo efficient	Average	Hi efficient
Current	40	15.38	12.82	10.53	$ 1,230	$ 1,026	$ 842
Code	29	15.38	12.82	10.53	$ 892	$ 744	$ 611
Hi Efficient	23	15.38	12.82	10.53	$ 707	$ 590	$ 484

Elecrticity Heat Pump

$/mmbtu

2000	1000 btu/sq ft	Lo efficient	Average	Hi efficient	Lo efficient	Average	Hi efficient
Current	40	16	11.76	8.51	$ 1,280	$ 941	$ 681
Code	29	16	11.76	8.51	$ 928	$ 682	$ 494
Hi Efficient	23	16	11.76	8.51	$ 736	$ 541	$ 391

Electricity Resistive

2000	1000 btu/sq ft	Lo efficient	Average	Hi efficient	Lo efficient	Average	Hi efficient
Current	40		23.46		$ -	$ 1,877	$ -
Code	29		23.46		$ -	$ 1,361	$ -
Hi Efficient	23		23.46		$ -	$ 1,079	$ -

Electricity Ground Water Heat Pump

2000	1000 btu/sq ft	Lo efficient	Average	Hi efficient	Lo efficient	Average	Hi efficient
Current	40	7.08	6.2	5.41	$ 566	$ 496	$ 433
Code	29	6.14	6.07	5.05	$ 356	$ 352	$ 293
Hi Efficient	23	6.14	6.07	5.05	$ 282	$ 279	$ 232

Propane

2000	1000 btu/sq ft	Lo efficient	Average	Hi efficient	Lo efficient	Average	Hi efficient
Current	40	23.67	19.23	16.19	$ 1,894	$ 1,538	$ 1,295
Code	29	23.67	19.23	16.19	$ 1,373	$ 1,115	$ 939
Hi Efficient	23	23.67	19.23	16.19	$ 1,089	$ 885	$ 745

Corn

2000	1000 btu/sq ft	Lo efficient	Average	Hi efficient	Lo efficient	Average	Hi efficient
Current	40	11.78	11.78	11.78	$ 942	$ 942	$ 942
Code	29	11.78	11.78	11.78	$ 683	$ 683	$ 683
Hi Efficient	23	11.78	11.78	11.78	$ 542	$ 542	$ 542

Appendix B:

Comparing Fuel Costs of Heating and Cooling Systems

Comparing Fuel Costs of Heating and Cooling Systems

June 2003

Introduction

One of the most common questions posed to energy specialists at Engineering Extension asks for a comparison between costs to operate different heating and cooling systems. It might be a comparison of a furnace to a heat pump, a regular furnace to a high-efficiency furnace, or a wood burning stove to a pellet stove.

There are two components to cost, the initial cost to purchase and install the system, and the ongoing fuel cost. In general, higher efficiency equipment costs more initially but saves operating costs. To determine the purchase price, get bids from one or more contractors. Be certain bids included all costs to make the system fully functional including duct work, thermostats, and chimneys. This fact sheet will help you compare the cost of fuel for several types of heating and cooling systems.

Annual cost of delivering heating and cooling to a home depends on cost of the fuel, how efficiently the system converts the fuel source into heating or cooling energy, and the quantity of heating and cooling required. The following section, "Estimating the cost of heating or cooling", allows you to estimate the cost of one million Btus for several fuels and system types. However, if you want to compare annual estimated costs for two or more fuels, then you will also need to estimate the heating load of your home. This process is explained in "Estimating annual costs" on page 7.

What is the price of fuel?

Fuel prices vary between suppliers, may change seasonally, and are affected by world events. To estimate fuel costs, you can either contact your local utility or supplier or you can use past billings.

To estimate natural gas costs from your utility bill, divide the monthly charge by the consumption, usually measured in MCF. The cost should be between $3 and $12 per MCF. Use a winter bill so meter charges are spread out over several units of gas. If your bill shows gas consumption in CCF, you will need to multiply the gas cost by 10 to get it in $ per MCF.

To obtain an average $ per kilowatt hour (kWh), divide the total monthly cost by the consumption in kWh. Use a mid-winter bill if you want to estimate heating costs and a mid-summer bill if you want to estimate cooling costs. The cost for electricity in Kansas varies from $.04 to $.15 per kWh.

Propane, fuel oil, wood, and pellets are sold in simple units and should be easy to determine.

Estimating the cost of heating or cooling

If you just want to compare operating costs of different systems, you can use Tables 1 through 7 to directly determine the cost of delivering one million Btus (MBTUs) of heating and Table 8 for one MBTU of cooling. For example, you could compare the cost of delivering one MBTU to your home from a high-efficiency natural gas furnace to the cost of

delivering one MBTU from wood in a modern wood stove. There are several measures of system efficiency. A brief explanation is provided in the description of the tables.

Table 1 is for natural gas furnaces and boilers. There are three efficiency levels and gas prices range from $5 to $15 per thousand cubic feet (MCF). If your furnace was installed before about 1985, use the "older equipment" column. If you have a modern but normal-efficiency unit, use the 78 percent column. The last column is for high-efficiency (condensing) equipment.

Tables 2 and 3 are similar to Table 1, but are for propane and fuel oil, respectively.

Modern natural gas, propane, and fuel oil furnaces and boilers receive an annual fuel-utilization efficiency (AFUE) rating. Older units were not rated but an assumed performance of 65 percent is reasonable.

Table 1. Natural gas heating costs — $ per MBTU delivered for three appliance efficiencies.

	Furnace or boiler efficiency		
Gas price $/MCF.	65% (low) older equipment	AFUE = 78% (average) current minimum	AFUE = 95% high efficiency
$5.00	$7.69	$6.41	$5.26
$5.50	$8.46	$7.05	$5.79
$6.00	$9.23	$7.69	$6.32
$6.50	$10.00	$8.33	$6.84
$7.00	$10.77	$8.97	$7.37
$7.50	$11.54	$9.62	$7.89
$8.00	$12.31	$10.26	$8.42
$8.50	$13.08	$10.90	$8.95
$9.00	$13.85	$11.54	$9.47
$9.50	$14.62	$12.18	$10.00
$10.00	$15.38	$12.82	$10.53
$10.50	$16.15	$13.46	$11.05
$11.00	$16.92	$14.10	$11.58
$11.50	$17.69	$14.74	$12.11
$12.00	$18.46	$15.38	$12.63
$12.50	$19.23	$16.03	$13.16
$13.00	$20.00	$16.67	$13.68
$13.50	$20.77	$17.31	$14.21
$14.00	$21.54	$17.95	$14.74
$14.50	$22.31	$18.59	$15.26
$15.00	$23.08	$19.23	$15.79

Table 2. Propane heating costs — $ per MBTU delivered for three appliance efficiencies.

	Furnace or boiler efficiency		
Propane price $/gal.	65% (low) older equipment	AFUE = 78% (average) current minimum	AFUE = 95% high efficiency
$0.60	$10.14	$8.24	$6.94
$0.65	$10.99	$8.93	$7.52
$0.70	$11.83	$9.62	$8.10
$0.75	$12.68	$10.30	$8.68
$0.80	$13.52	$10.99	$9.25
$0.85	$14.37	$11.68	$9.83
$0.90	$15.22	$12.36	$10.41
$0.95	$16.06	$13.05	$10.99
$1.00	$16.91	$13.74	$11.57
$1.05	$17.75	$14.42	$12.15
$1.10	$18.60	$15.11	$12.72
$1.15	$19.44	$15.80	$13.30
$1.20	$20.29	$16.48	$13.88
$1.25	$21.13	$17.17	$14.46
$1.30	$21.98	$17.86	$15.04
$1.35	$22.82	$18.54	$15.62
$1.40	$23.67	$19.23	$16.19
$1.45	$24.51	$19.92	$16.77
$1.50	$25.36	$20.60	$17.35
$1.55	$26.20	$21.29	$17.93
$1.60	$27.05	$21.98	$18.51

Table 3. Fuel oil heating costs — $ per MBTU delivered for three appliance efficiencies.

	Furnace or boiler efficiency		
Oil price $/gallon	65% (low) older equipment	AFUE = 78% (average) current minimum	AFUE = 86% high efficiency
$0.70	$7.76	$6.47	$5.87
$0.75	$8.32	$6.93	$6.29
$0.80	$8.87	$7.39	$6.71
$0.85	$9.43	$7.86	$7.13
$0.90	$9.98	$8.32	$7.55
$0.95	$10.54	$8.78	$7.96
$1.00	$11.09	$9.24	$8.38
$1.05	$11.65	$9.71	$8.80
$1.10	$12.20	$10.17	$9.22
$1.15	$12.76	$10.63	$9.64
$1.20	$13.31	$11.09	$10.06
$1.25	$13.87	$11.55	$10.48
$1.30	$14.42	$12.02	$10.90
$1.35	$14.97	$12.48	$11.32
$1.40	$15.53	$12.94	$11.74
$1.45	$16.08	$13.40	$12.16
$1.50	$16.64	$13.87	$12.58
$1.55	$17.19	$14.33	$12.99
$1.60	$17.75	$14.79	$13.41
$1.65	$18.30	$15.25	$13.83
$1.70	$18.86	$15.71	$14.25

Table 4 is for electric heat. The price per MBTU for electric resistance heat includes both baseboard and central resistance heating systems. Sections for air-source heat pumps, ground-water heat pumps, and ground-loop heat pumps are provided and each contains three performance levels.

Air-source heat pumps are the most common heat pump. They have an inside blower and coil with an outside compressor and coil, and look like a conventional air conditioner. Use an air-source heat pump heating seasonal performance factor (HSPF) of 5 for older heat pumps, 6.8 for an average-performance unit, and 9.4 if you have or plan to buy a superior-performance unit.

Ground-loop and ground-water are both geothermal heat pump systems. A ground-loop heat pump, Figure 1, circulates water through buried piping loop. Coefficient of performance (COP) is the measure of performance for geothermal heat pumps. A COP of 3.1 would be appropriate for an older or low-performance system; a COP of 3.5 is representative of average equipment sold today; and a system with a COP of 4.2 would represent superior performance.

Unlike a ground-loop system that circulates water in a piping system, a ground-water heat pump, Figure 2, draws water from a well, extracts heat from the water in the winter or rejects heat to it in the summer, and then discharges the water, typically to another well. The heat pump is normally located inside, but there will be one or two wells associated with its operation. Ground-water heat pumps also use COP as a measure of performance with a COP of 3.2 for an older or low-performance system, 4.1 for average performance, and 4.7 for superior performance. In many cases, the same equipment is used for both ground-loop and ground-water systems. They are rated with different COPs because of the differences between ground-loop and ground-water temperatures.

Table 4. Electric heating costs — $ per MBTU delivered for several appliances and performance levels.

	Electric resistance	Air-source heat pump performance			Ground-loop heat pump performance			Ground-water heat pump performance		
Electricity $/kWh	Electric resistance	HSPF=5.0 (low) older equipment	HSPF=6.8 (average) current minimum	HSPF=9.4 (superior)	COP=3.1 (low)	COP=3.5 (average)	COP=4.2 (superior)	COP=3.6 (low)	COP=4.1 (average)	COP=4.7 (superior)
$0.040	$11.73	$8.00	$5.88	$4.26	$4.21	$3.74	$3.11	$3.54	$3.10	$2.70
$0.045	$13.20	$9.00	$6.62	$4.79	$4.74	$4.21	$3.49	$3.98	$3.49	$3.04
$0.050	$14.66	$10.00	$7.35	$5.32	$5.26	$4.67	$3.88	$4.42	$3.88	$3.38
$0.055	$16.13	$11.00	$8.09	$5.85	$5.79	$5.14	$4.27	$4.87	$4.26	$3.72
$0.060	$17.60	$12.00	$8.82	$6.38	$6.32	$5.61	$4.66	$5.31	$4.65	$4.05
$0.065	$19.06	$13.00	$9.56	$6.91	$6.84	$6.07	$5.05	$5.75	$5.04	$4.39
$0.070	$20.53	$14.00	$10.29	$7.45	$7.37	$6.54	$5.43	$6.19	$5.43	$4.73
$0.075	$21.99	$15.00	$11.03	$7.98	$7.89	$7.01	$5.82	$6.64	$5.81	$5.07
$0.080	$23.46	$16.00	$11.76	$8.51	$8.42	$7.48	$6.21	$7.08	$6.20	$5.41
$0.085	$24.93	$17.00	$12.50	$9.04	$8.95	$7.94	$6.60	$7.52	$6.59	$5.74
$0.090	$26.39	$18.00	$13.24	$9.57	$9.47	$8.41	$6.99	$7.96	$6.98	$6.08
$0.095	$27.86	$19.00	$13.97	$10.11	$10.00	$8.88	$7.38	$8.41	$7.36	$6.42
$0.100	$29.33	$20.00	$14.71	$10.64	$10.53	$9.35	$7.76	$8.85	$7.75	$6.76
$0.105	$30.79	$21.00	$15.44	$11.17	$11.05	$9.81	$8.15	$9.29	$8.14	$7.09
$0.110	$32.26	$22.00	$16.18	$11.70	$11.58	$10.28	$8.54	$9.73	$8.53	$7.43
$0.115	$33.72	$23.00	$16.91	$12.23	$12.11	$10.75	$8.93	$10.18	$8.91	$7.77
$0.120	$35.19	$24.00	$17.65	$12.77	$12.63	$11.21	$9.32	$10.62	$9.30	$8.11
$0.125	$36.66	$25.00	$18.38	$13.30	$13.16	$11.68	$9.70	$11.06	$9.69	$8.45
$0.130	$38.12	$26.00	$19.12	$13.83	$13.68	$12.15	$10.09	$11.50	$10.08	$8.78
$0.135	$39.59	$27.00	$19.85	$14.36	$14.21	$12.62	$10.48	$11.95	$10.47	$9.12
$0.140	$41.06	$28.00	$20.59	$14.89	$14.74	$13.08	$10.87	$12.39	$10.85	$9.46

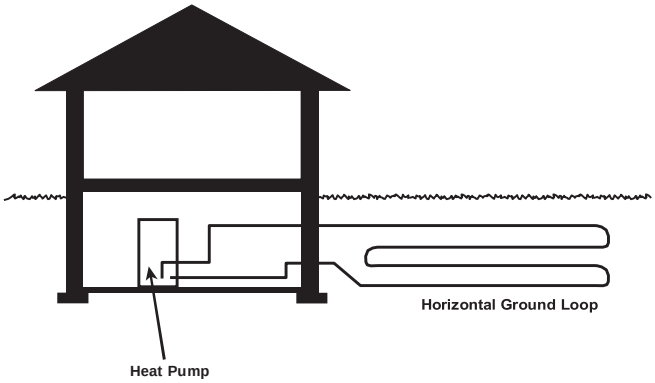


Figure 2. Ground-loop heat pump.

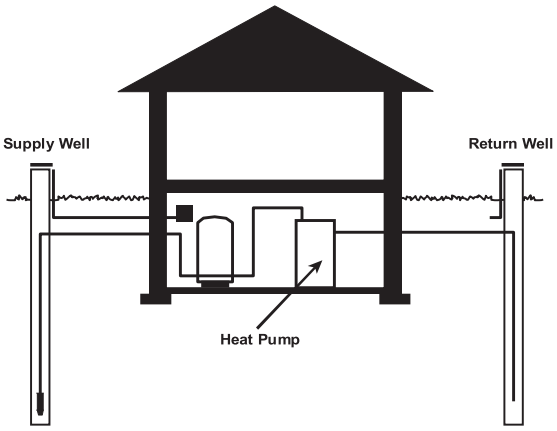


Figure 1. Ground-water heat pump.

Table 5 is used to estimate the cost per MBTU for unvented kerosene heaters. They are 100 percent efficient because all of the heat is delivered to the home. If you are using a vented kerosene appliance, use Table 3.

Table 5. Kerosene heating costs — $ per million MBTU delivered.

Unvented kerosene heater	
Kerosene price $/gallon	Unvented equipment
$1.00	$7.56
$1.10	$8.31
$1.20	$9.07
$1.30	$9.83
$1.40	$10.58
$1.50	$11.34
$1.60	$12.09
$1.70	$12.85
$1.80	$13.61
$1.90	$14.36
$2.00	$15.12
$2.10	$15.87
$2.20	$16.63
$2.30	$17.38
$2.40	$18.14
$2.50	$18.90
$2.60	$19.65
$2.70	$20.41
$2.80	$21.16
$2.90	$21.92
$3.00	$22.68

Estimate the cost of delivered heating energy

Example: Compare the cost of heat from a propane furnace to the cost of heat from an air-source heat pump.

First, you will need to know the cost of both fuels and efficiencies of the systems. Follow this example to learn how to use Tables 1 through 8.

Table 2 is for propane appliances. Assuming you have an old propane furnace, the efficiency will be about 65%. If you pay $.90 per gallon for propane, the cost per million Btus (MBTUs) will be $15.22.

Table 4 is for electric appliances. Compare this to the cost of heating with an average-efficiency, air-source heat pump with electricity costing $.07 per kilowatt hour (kWh). The cost per MBTU will be about $10.29.

Delivered heat from the heat pump costs about two-thirds that of propane.

Table 6 will allow you to estimate the cost per MBTU for several wood heating appliances. The specie of wood, cost per cord, and appliance efficiency are all important to getting an accurate estimate. The efficiency ratings provided are typical but may vary between manufacturers. Several common wood species are listed with cord costs ranging from $80 to $140. There are sections of the table for open fireplaces; pre-1980 wood stoves; masonry heaters; and post-1980, EPA-certified wood stoves. For more details on solid-fuel heating appliances, obtain a copy of *Solid-Fuel Heating Appliances* online at *www.engext.ksu.edu/*. Look under publications.

Table 6. Wood heating costs — $ per million BTU for several wood species, heating appliance efficiencies, and cord wood costs.

	Wood heating appliance efficiency							
	10% — typical open fireplace				50% — typical central boiler, furnace, or pre-1980 wood stove			
Price per cord	$80	$100	$120	$140	$80	$100	$120	$140
Species								
Cottonwood	$50.63	$63.29	$75.95	$88.61	$10.13	$12.66	$15.19	$17.72
Elm, American	$40.00	$50.00	$60.00	$70.00	$8.00	$10.00	$12.00	$14.00
Hackberry	$37.74	$47.17	$56.60	$66.04	$7.55	$9.43	$11.32	$13.21
Honeylocust	$29.96	$37.45	$44.94	$52.43	$5.99	$7.49	$8.99	$10.49
Maple, Silver	$42.11	$52.63	$63.16	$73.68	$8.42	$10.53	$12.63	$14.74
Oak,Red	$32.52	$40.65	$48.78	$56.91	$6.50	$8.13	$9.76	$11.38
Osage Orange	$24.32	$30.40	$36.47	$42.55	$4.86	$6.08	$7.29	$8.51

	60% — typical masonry heater				70% — typical EPA-certified wood stoves and inserts			
Price per cord	$80	$100	$120	$140	$80	$100	$120	$140
Species								
Cottonwood	$8.44	$10.55	$12.66	$14.77	$7.23	$9.04	$10.85	$12.66
Elm, American	$6.67	$8.33	$10.00	$11.67	$5.71	$7.14	$8.57	$10.00
Hackberry	$6.29	$7.86	$9.43	$11.01	$5.39	$6.74	$8.09	$9.43
Honeylocust	$4.99	$6.24	$7.49	$8.74	$4.28	$5.35	$6.42	$7.49
Maple, Silver	$7.02	$8.77	$10.53	$12.28	$6.02	$7.52	$9.02	$10.53
Oak,Red	$5.42	$6.78	$8.13	$9.49	$4.65	$5.81	$6.97	$8.13
Osage Orange	$4.05	$5.07	$6.08	$7.09	$3.47	$4.34	$5.21	$6.08

Table 7 provides heating cost estimates for pellet- and corn-burning appliances.

Table 7. Pellet and corn heating costs — $ per MBTU.

Pellet price		Typical pellet stove	Corn price	Typical corn stove
Price per 40-pound bag	Price per ton		Price per bushel	
$2.50	$125	$9.77	$1.50	$5.05
$3.00	$150	$11.73	$2.00	$8.42
$3.50	$175	$13.68	$2.50	$11.78
$4.00	$200	$15.63	$3.00	$15.15

Table 8 will estimate the cost of providing one MBTU of cooling for air conditioners and heat pumps. A seasonal energy efficiency rating (SEER) is the performance measure for modern air conditioners and air-source heat pumps. Older units may not be rated, and a SEER of 7 is reasonable for estimating operating costs.

Table 8. Electric cooling costs — $ per MBTU cooling for several appliances and performance levels.

	Air conditioner or air-source heat pump performance			Ground-water heat pump performance			Ground-loop heat pump performance		
Electricity $/kWh	SEER = 7 (low) older equipment	SEER = 12 (average)	SEER = 15 (superior)	EER = 16 (low)	EER = 19 (average)	EER = 24 (superior)	EER = 13 (low)	EER = 16 (average)	EER = 20 (superior)
$0.040	$5.71	$4.00	$2.67	$2.61	$2.22	$1.78	$3.18	$2.62	$2.13
$0.045	$6.43	$4.50	$3.00	$2.93	$2.50	$2.00	$3.58	$2.95	$2.39
$0.050	$7.14	$5.00	$3.33	$3.26	$2.78	$2.22	$3.98	$3.28	$2.66
$0.055	$7.86	$5.50	$3.67	$3.58	$3.06	$2.44	$4.38	$3.61	$2.92
$0.060	$8.57	$6.00	$4.00	$3.91	$3.33	$2.67	$4.78	$3.94	$3.19
$0.065	$9.29	$6.50	$4.33	$4.23	$3.61	$2.89	$5.18	$4.27	$3.46
$0.070	$10.00	$7.00	$4.67	$4.56	$3.89	$3.11	$5.57	$4.59	$3.72
$0.075	$10.71	$7.50	$5.00	$4.89	$4.17	$3.33	$5.97	$4.92	$3.99
$0.080	$11.43	$8.00	$5.33	$5.21	$4.44	$3.56	$6.37	$5.25	$4.25
$0.085	$12.14	$8.50	$5.67	$5.54	$4.72	$3.78	$6.77	$5.58	$4.52
$0.090	$12.86	$9.00	$6.00	$5.86	$5.00	$4.00	$7.17	$5.91	$4.78
$0.095	$13.57	$9.50	$6.33	$6.19	$5.28	$4.22	$7.56	$6.23	$5.05
$0.100	$14.29	$10.00	$6.67	$6.51	$5.56	$4.44	$7.96	$6.56	$5.32
$0.105	$15.00	$10.50	$7.00	$6.84	$5.83	$4.67	$8.36	$6.89	$5.58
$0.110	$15.71	$11.00	$7.33	$7.17	$6.11	$4.89	$8.76	$7.22	$5.85
$0.115	$16.43	$11.50	$7.67	$7.49	$6.39	$5.11	$9.16	$7.55	$6.11
$0.120	$17.14	$12.00	$8.00	$7.82	$6.67	$5.33	$9.55	$7.87	$6.38
$0.125	$17.86	$12.50	$8.33	$8.14	$6.94	$5.56	$9.95	$8.20	$6.65
$0.130	$18.57	$13.00	$8.67	$8.47	$7.22	$5.78	$10.35	$8.53	$6.91
$0.135	$19.29	$13.50	$9.00	$8.79	$7.50	$6.00	$10.75	$8.86	$7.18
$0.140	$20.00	$14.00	$9.33	$9.12	$7.78	$6.22	$11.15	$9.19	$7.44

Estimating annual costs

Once you have determined the cost per MBTU for any fuel, you can estimate annual heating or cooling costs. It is important to remember these are estimates only; lifestyle, actual housing conditions, house configuration, and other factors can greatly influence heating and cooling costs.

Table 9[1] provides estimates of heating and cooling requirements of homes in Kansas. Three levels of home efficiency are listed. Standard practice represents homes as they have generally been constructed in Kansas, energy code compliant applies to a home that would meet modern energy codes, and energy efficient represents homes where high performance was a major design goal. There are also three climate areas listed.

Based on the type of home and location, choose the appropriate index. Multiply it by the size of your home (square feet of living space) and the cost of your fuel in $ per MBTU, then divide by 1,000 to estimate annual costs. If you live in an older, poorly insulated and weatherized home, your heating costs will be higher than those estimated by this method. To estimate savings for using higher performance equipment or other fuels, calculate the costs for each and compare.

Table 9. Annual heat and cooling indices — 1000 Btus/square foot.

	Heating			Cooling		
	Northwest	Central	Southeast	Northwest	Central	Southeast
Current practice	50	45	40	11	13	14
Energy code compliant	36	32	29	10	11	12
Energy efficient	28	25	23	9	10	11

Estimating annual costs

Example: Estimate the annual cost of heating a 2,000-square-foot home in rural Sedgwick County. The home was built in the 1960s. The home owner is considering both propane and an air-source heat pump. Fuel costs were determined in the previous example to be $15.22 /MBTU for propane and $10.29/MBTU for a heat pump.

The heating index for the home would be 45. Annual heating costs would be

$\frac{2{,}000 \times 45 \times 15.22}{1{,}000}$ = $1,370 for propane, and

$\frac{2{,}000 \times 45 \times 10.29}{1{,}000}$ = $925 for the heat pump.

[1] Ground-Source Heat Pumps, An Efficient Choice for Residential and Commercial Use, J. Mark Hannifan, Joe E King, AIA, 1995.

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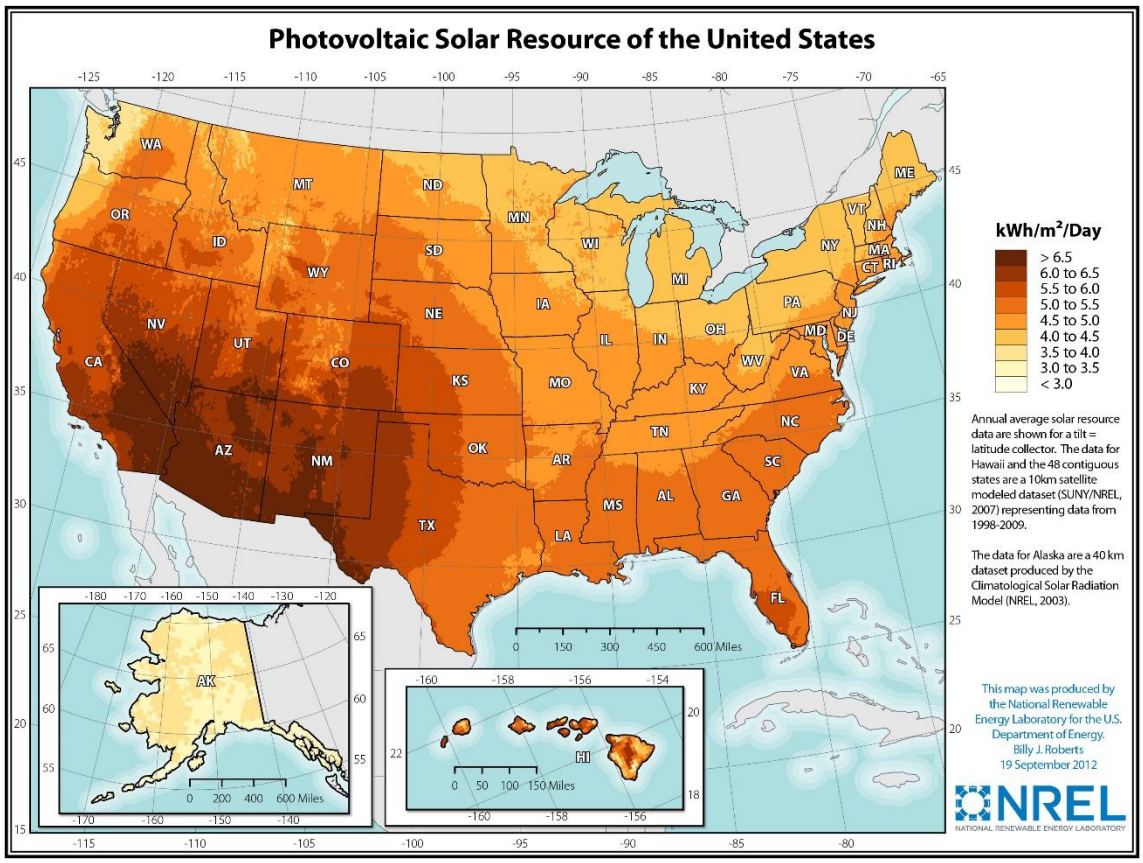
Appendix C

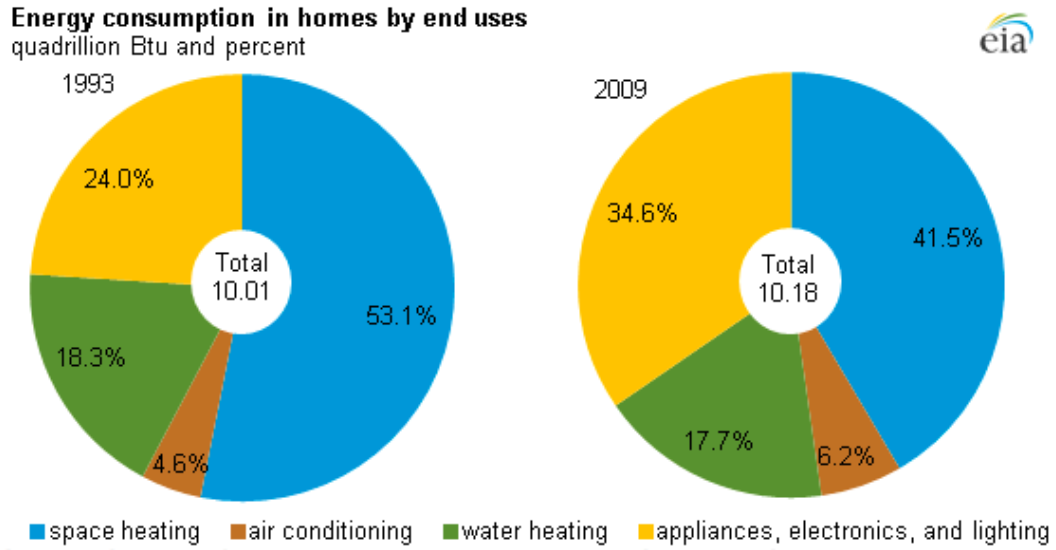

Photovoltaic Solar Resource of the United States
kWh/m²/Day
> 6.5
6.0 to 6.5
5.5 to 6.0
5.0 to 5.5
4.5 to 5.0
4.0 to 4.5
3.5 to 4.0
3.0 to 3.5
< 3.0
Annual average solar resource data are shown for a tilt = latitude collector. The data for Hawaii and the 48 contiguous states are a 10km satellite modeled dataset (SUNY/NREL, 2007) representing data from 1998-2009.
The data for Alaska are a 40 km dataset produced by the Climatological Solar Radiation Model (NREL, 2003).
This map was produced by the National Renewable Energy Laboratory for the U.S. Department of Energy.
Billy J. Roberts
19 September 2012
NREL
NATIONAL RENEWABLE ENERGY LABORATORY
0 150 300 450 600 Miles
0 200 400 600 Miles
0 50 100 150 Miles

Appendix D

Space Heating Continues to Decline as an Overall Component of Household Energy Use

MARCH 7, 2013

Heating and cooling no longer majority of U.S. home energy use



Source: U.S. Energy Information Administration, Residential Energy Consumption Survey.
Note: Amounts represent the energy consumption in occupied primary housing units.

CERTIFICATE OF SERVICE
16-GIME-576-GIE

I, the undersigned, hereby certify that a true and correct copy of the above and foregoing document was served by electronic service on this 5th day of July, 2017, to the following parties:

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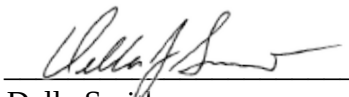

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