EXHIBIT

Exhibit No.:
Issue(s): Response to KCPL's MEEIA application/ Equitable Energy Efficiency Baseline/ WattTime: Automated Emissions Reduction ("AER")/ Pay As You Save ("PAYS®")/ Urban Heat Island Mitigation
Witness/Type of Exhibit: Marke/Rebuttal
Sponsoring Party: Public Counsel
Case No.: EO-2019-0132

REBUTTAL TESTIMONY

OF

GEOFF MARKE

Submitted on Behalf of
The Office of the Public Counsel

KANSAS CITY POWER & LIGHT COMPANY

KCP&L GREATER MISSOURI OPERATIONS COMPANY

CASE NO. EO-2019-0132

** **

Denotes Confidential Information that has been Redacted

August 19, 2019

Non-Proprietary Version

OPC Exhibit No. 200-P
Date 9-23-19 Reporter JLT
File No. EO-2019-0132
EO-2019-0133

EXHIBIT

BEFORE THE PUBLIC SERVICE COMMISSION
OF THE STATE OF MISSOURI

In the Matter of Kansas City Power & Light Company's Notice of Intent to File an Application for Authority to Establish a Demand-Side Programs Investment Mechanism	))))	File No. EO-2019-0132

AFFIDAVIT OF GEOFF MARKE

STATE OF MISSOURI)
) ss
COUNTY OF COLE)

Geoff Marke, of lawful age and being first duly sworn, deposes and states:

1. My name is Geoff Marke. I am a Regulatory Economist for the Office of the Public Counsel.

2. Attached hereto and made a part hereof for all purposes is my rebuttal testimony.

3. I hereby swear and affirm that my statements contained in the attached testimony are true and correct to the best of my knowledge and belief.

Geoff Marke
Chief Economist

Subscribed and sworn to me this 19th day of August 2019.

NOTARY PUBLIC NOTARY SEAL STATE OF MISSOURI

JERENE A. BUCKMAN
My Commission Expires
August 23, 2021
Cole County
Commission #13754037

Jerene A. Buckman
Notary Public

My commission expires August 23, 2021.

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REBUTTAL TESTIMONY

OF

GEOFF MARKE

KANSAS CITY POWER & LIGHT COMPANY
KCP&L GREATER MISSOURI OPERATIONS COMPANY
CASE NO. EO-2019-0132

I. INTRODUCTION

Q. Please state your name, title and business address.

A. Geoffrey Marke, PhD, Chief Economist, Office of the Public Counsel ("OPC"), P.O. Box 2230, Jefferson City, Missouri 65102.

Q. What are your qualifications and experience?

A. I have been in my present position with OPC since 2014 where I am responsible for economic analysis and policy research in electric, gas and water utility operations.

Q. Have you testified previously before the Missouri Public Service Commission?

A. Yes. A listing of the cases in which I have previously filed testimony and/or comments before the Commission is attached in Schedule GM-1.

Q. What is the purpose of your rebuttal testimony?

A. The purpose of this testimony is to respond to Kansas City Power & Light Company ("KCPL-MO") and KCP&L Greater Missouri Operations Company ("KCPL-GMO," or collectively "KCPL" or the "Companies") "Missouri Energy Efficiency Investment Act" ("MEEIA") Cycle III application. This testimony will focus on the following sections within KCPL's Missouri's application including:

- KCPL's Proposed MEEIA in Context
  - Avoided Capacity Costs: "We'd start with zero."
  - Redistribution: Winners & Losers
- Program Modifications
  - Energy Efficiency Programs
  - Demand Response Programs

- Low-Income Programs
- Company proposed Research and Pilot
- Evaluation, Measurement and Verification ("EM&V")

- Alternative Recommendations
  - Default MEEIA Level
  - Urban Heat Island Mitigation
  - Pay As You Save ("PAYS®")
  - WattTime: Automated Emissions Reduction ("AER")
  - Equitable Energy Efficiency Modeling

My silence in regard to any issue should not be construed as an endorsement of KCPL's position.

Q. Could you explain why you are referring to KCPL and GMO as one entity ("KCPL" or the "Companies") for this filing?

A. The short answer is because case No: EO-2019-0133("GMO's MEEIA application") was closed and consolidated into Case No: EO-2019-0132 ("KCPL's MEEIA application"). Effectively, KCPL and GMO are being treated as one MEEIA application in an attempt to make the combined MEEIA applications "better" and to recognize that the Southwest Power Pool ("SPP") looks at KCPL and GMO as one entity for resource planning purposes as of 2018.

It is worth noting that OPC specifically argued in favor of undertaking a consolidation cost study and proposal for consolidation of both KCPL and GMO in their next respective filed rate case. To be clear, we argued that the Company be consistent with its Integrated Resource Plan ("IRP") modeling and SPP reporting. Since that time, the recommendation has only been further substantiated by the Company's actions, notably the consolidation of its MEEIA applications and its justified rationale for prematurely stranding the Sibley 3 power plant twenty-two years before the end of its useful life as argued in case No. EC-2019-0200.

Q. What was the Company's response to OPC's consolidation request?

A. In Case Nos: ER-2018-0145 and ER-2018-0146 Company witness Darrin R. Ives stated:

> While KCP&L and GMO operate on a consolidated basis in many respects, there are numerous instances where KCP&L and GMO are operated and administered separately from one another. Examples include but are not limited to: the Fuel Adjustment Clause ("FAC"), **Missouri Energy Efficiency Investment Act ("MEEIA") programs,** and the Renewable Energy Standard Rate Adjustment Mechanism ("RESRAM", which is in place only for GMO at this time). Consolidation of these cost recovery mechanisms and programs, while possible, needs to be done carefully in order to preserve equity between the KCP&L and GMO customer groups and it is unlikely that consolidating everything could occur in one fell swoop. **The KCP&L and GMO generating fleets remain separate and are identified separately on the books and records of KCP&L and GMO, respectively.** (emphasis added).[1]

Q. Was this issue addressed in a stipulation and agreement from that rate case?

A. Yes. On September 19, 2018 a non-unanimous partial stipulation and agreement settling the revenue requirement, in which OPC was not a signatory but did not oppose was filed with the Commission stating as condition #16.

> CONSOLIDATION STUDY
>
> The Company will perform a study investigating the consolidation of KCP&L and GMO rates and will make a recommendation regarding consolidation of rates in these dockets within two years of the date of approval of this Stipulation. KCP&L and GMO will provide quarterly stakeholder updates concerning the study.[2]

[1] ER-2018-0145 and ER-2018-0146 Rebuttal (Rate Design) Testimony of Darrin R. Ives. pp. 2, 3-13.
[2] ER-2018-0145 and ER-2018-0146 Non-unanimous partial stipulation and agreement p. 9.

Q. It has been eleven months since that stipulation was filed. Has OPC received any quarterly updates concerning the study?

A. No.

Q. Has OPC been contacted by KCPL/GMO for input on the study?

A. No.

Q. In light of that information, do you have any recommendations as it pertains to that topic in this MEEIA application?

A. Regarding the inaction of KCPL/GMO on its agreed to consolidation study, further inquiry is warranted on our part above and beyond this case.

As it pertains to this MEEIA application, I recommend that any future MEEIA approval predicated on treating KCPL and GMO as one entity be conditioned on KCPL and GMO filing a request for consolidation in its next general rate case. Furthermore, the Company should be required to submit quarterly updates (including stakeholder presentation and clear calendar deliverables) in this (or future) MEEIA docket expressly conveying to the Commission that it is adhering to Commission orders.

In the last KCPL and GMO general rate case a similar stipulated study and proposal was at issue—Time-of-Use ("TOU") rates - but failed to fully materialize as stakeholders expected. OPC does not want to see a similar narrative of inaction play out yet again.[3]

Q. Please state your opinion on the direct filing of this case.

A. My primary recommendation is for the Commission to reject KCPL's MEEIA Cycle III application as filed. The application is inappropriate given the low avoided costs, long capacity and other pertinent variables that negate a traditional MEEIA application.

However, as a secondary recommendation, I strongly encourage KCPL to refile an amended application that takes into account an annual "default MEEIA level" which maintains a degree

[3] For further detail on this issue, please see Case Nos: ER-2018-0145 and ER-2018-0146 Rebuttal Testimony of Geoff Marke (Rate Design) pp. 5-15.

of programs and spending at a reasonable level that recognizes both historic sunk costs, the potential need to increase MEEIA funding in the future, and explores alternative deliverables in which a MEEIA could provide equitable benefits to all ratepayers.

The rest of this testimony will provide context for my primary recommendation to reject the application as filed, specific concerns I have regarding proposed program and portfolio design, and will then expand on the secondary recommendation including a "default MEEIA level" and possible alternatives to enhance MEEIA opportunities where none currently exist.

II. KCPL'S PROPOSED MEEIA IN CONTEXT

Avoided Capacity Costs: "We would start with zero."

Q. Why don't you support KCPL's MEEIA filing?

A. Because there is no need for it based on KCPL's current and forecasted operations and based on its planned capital expenditures. The November 15, 2018, Commission Agenda Discussion with the Commission Staff ("Staff") provides a good starting point for understanding the current predicament stakeholders find themselves. The 11/15/2018 Commission Agenda discussing the joint filing of parties involved in the KCPL and KCPL-GMO Triennial Integrated Resource Plan ("IRP") filings (Case Nos: EO-2018-0268 and EO-2018-0269) has been transcribed as follows (beginning at the 34:12 mark of the archived agenda):

> Commissioner Daniel Hall: I do have a question about one of the alleged Staff deficiencies and I guess I will look to Mr. Rogers for that. Its Staff deficiency #2 where KCPL's use of the $116 per kW year drastically overstates KCPL's avoided capacity costs. Could you explain to me Staff's position on that?
>
> John Rogers: Yes. The $116 per kW year.
>
> Commissioner Hall: (points to chair at table) and perhaps you should come to the table so the other commissioners can have the benefit of your wisdom.
>
> Chairman Ryan Silvey: Yeah, that would be helpful.

Mr. Rogers: All right. The $116 per kW year represents the fully levelized cost of a CT. Plus estimates of a…

Commissioner Hall: I'm sorry. Of a CT? What is a CT?

Mr. Rogers: A combustion turbine.

Commissioner Hall: OK

Mr. Rogers. So, this is capacity. This represents the cost of capacity per kW year.

Commissioner Hall: Capacity as opposed to energy?

Mr. Rogers: Yes.

Commissioner Hall: Ok

Mr. Rogers: And it also includes some other forms of capacity. Such as transmission and distribution. What Staff is struggling with is the fact that, Kansas City Power and Light is long on capacity for their entire twenty years of their planning forecast.

Commissioner Hall: Even with the coal retirements?

Mr. Rogers: Yes. In other words, there are no new supply side resources until after the 20 year planning horizon. So, Staff is struggling with using this high avoided costs in year 1 when there are no avoided costs.

Commissioner Hall: When you say "using" the avoided costs, what do you mean?

Mr. Rogers: Well, they are using the avoided costs to value capacity savings, or demand savings from the energy efficiency and demand response programs.

Commissioner Hall: So this is a concern in how this would play out in MEEIA cases?

Mr. Rogers: Yes.

Commissioner Hall: Ok.

Mr. Rogers: The other issue here is that SPP has no capacity market. There is no other form of benefits that the utility and ratepayers would receive from avoided capacity. The utility has all of the capacity it needs for more than

twenty years. There is no capacity market to sell the excess capacity into. And that is our concern.

Commissioner Hall: But there is the ability to sell excess energy.

Mr. Rogers: Yes.

Commissioner Hall: Even on the MISO side, the capacity market does not yield significant dollars. So it is the energy sales that could be significant.

Mr. Rogers: Primarily energy. But when you are valuing demand side resources you value them based on the avoided costs of energy, the avoided costs of capacity and benefits the customers receive from the programs.

Commissioner Hall: What did Staff think the appropriate avoided capacity costs was?

Mr. Rogers: Well, **we would start with zero**.

Commissioner Hall: That is a pretty big discrepancy. Ok. But you don't believe it is significant enough to warrant the Commission requiring KCPL to go back and to do additional work on that?

Mr. Rogers: It is my understanding that they are doing additional work on that in anticipation of the MEEIA Cycle III filing.

Commissioner Hall: Ok. (emphasis added)[4]

To be clear, Staff listed multiple deficiencies associated with demand-side management valuation. These included:

- KCPL's base-case load forecast is based on a cutoff date of June 2017 for all implemented MEEIA Cycle 2 program and does not include the load impacts of implemented MEEIA Cycle 2 demand-side programs ("DSM") through March 2019, the end of MEEIA Cycle 2. This is in violation of 4 CSR 240-22.030(7);

- **KCPL's use of $116 per kW year (2015 dollars) drastically overstates KCPL's avoided capacity cost of generation, transmission, and distribution facilities,**

[4] Missouri Public Service Commission Archived Agenda 11/15/2018, 34:12 to 39:00. https://psc.mo.gov/Archive.aspx

adjusted to reflect reliability reserve margins and capacity losses on the transmission and distribution systems, because Plan KAAHA (No DSM) includes no new non-renewable supply-side resources during the entire 20-years of the planning horizon. KCPL's use of $116 per kW year (2015 dollars) to value avoided capacity cost benefits is in violation of rule 4 CSR 240-20.092(1)(C);

- Because KCPL considered and analyzed alternative resource plans with demand-side resources when it is not in need of any new non-renewable supply-side resources for the entire 20-year planning horizon and **did not consider nor analyze alternative resource plans with new low cost supply-side resources to compete with the new demand-side resources on an equivalent basis**, KCPL did not comply with 4 CSR 240-22.060(1)and 4 CSR 240-22.010(2) (A);

- **Because KCPL has used drastically overstated avoided capacity cost benefits when calculating the total resource cost test (TRC) results** for its demand side programs and portfolio, the programs may not comply with 393.1075.3, RSMo.;

- Because **KCP&L's demand-side programs do not defer any non-renewable supply-side resources during the 20-year planning horizon, it is expected that there will be little, if any, benefits for customers who do not participate in the programs**, resulting in programs which may be in violation of Section 393.1075.3 and .4, RSMo.;

- Because KCPL did not include any analysis required by 4 CSR 240-20.094(4)(C)4 in its 2018 IRP, **Staff is concerned that the earning opportunity component of a DSIM included in the IRP and in the anticipated KCPL MEEIA Cycle 3 application may not be as well informed as it should be**; and

- **KCPL's decision makers may have selected an adopted preferred resource plan which includes a MEEIA RAP portfolio of demand side programs which does not comply with the legal mandate in 393.1075. 4.**, because the RAP programs may not provide benefits to all customers, including those customers who do not participate in the programs. (emphasis added)[5]

Q. Please summarize Staff's alleged deficiencies and their relevance to this filing.

A. KCPL and GMO's (2015 dollar) avoided cost assumptions no longer reflect reality. Consequently, KCPL and GMO's triennial IRP was deficient in 2018 and those same faulty assumptions are even more inaccurate if applied to a portfolio expected to begin in 2020.

Q. Did OPC file comments in the KCPL and GMO triennial IRP filings?

A. Yes. OPC filed comments on August 30th, 2018 in Case No. EO-2018-0269, GMO triennial's case alone.[6] The substance of my comments centered largely on the self-imposed premature retirement of the Sibley 3 power plant twenty-two years before the end of its useful life. That being said, I strongly agreed with Staff's concerns then and would note that the concerns articulated above are only more pronounced today.

Q. What is the status on the 2019 annual IRP update?

A. There will be no 2019 IRP for KCPL or GMO. The Companies are effectively going to "skip" 2019.

Q. Please explain.

A. KCPL and GMO were required to conduct an annual update workshop with stakeholders regarding their IRP planning on or about April 1, with an updated filing no less than 20 days prior to that meeting. Those dates were extended to August 31 pending further MEEIA 3 settlement negotiations. Because settlement talks have failed to materialize an agreed-to

[5] Case Nos: EO-2018-0268 & EO-2018-0269 Joint Filing KCPL and GMO 2018 Triennial Resource Plan. p. 2-5. See also GM-2.
[6] See GM-3.

MEEIA program, both KCPL and GMO have requested and received variance from having to conduct a 2019 IRP entirely and will instead file a 2020 IRP next spring.

Simply put, if KCPL had updated its 2019 IRP, its 2018 MEEIA filing would no longer be accurate. So if no 2019 IRP exists, than KCPL can still argue for its 2018 MEEIA filing.

Unfortunately, there was no sound empirical basis to approve a MEEIA over a year ago and that data has only become more inaccurate with time. Consider for a moment that the 2016 market potential study, which provides the foundation for the cost-effectiveness scores and savings targets in this application, is coming up on being four years old now. For our part, I am confident that a 2016 market potential study should not be the basis for program activity in 2023 let alone in 2020. To be clear, that is only one fault with the current application. The much larger concern centers on the low avoided costs and the lack of benefits for nonparticipants.

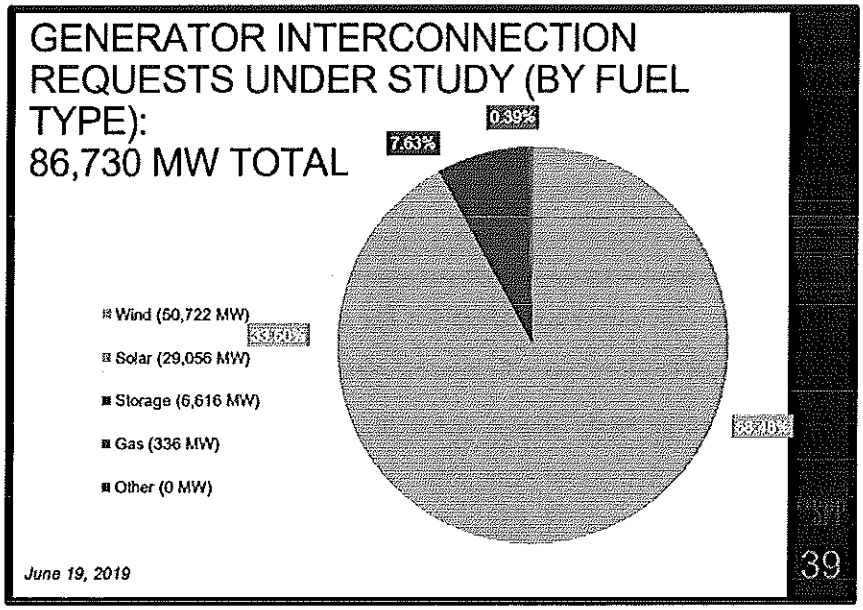
Q. Will any supply-side generation investment be deferred within the 20-year planning period?

A. No.

Q. Will avoided energy costs alone be able to justify a MEEIA investment today?

A. Absolutely not. SPP is flush with energy with more than 86 GW of generation interconnection requests under study as seen in Figure 1.

Figure 1: SPP Generator Interconnection Requests as of June 19, 2019 [7]



According to SPP, today, that would include 9 GW of unbuilt wind with signed interconnection agreements today.[8,9] The 9 GW of signed interconnection agreement wind does not include the most recent Missouri approved 600 MW of Empire wind being sold as a ratepayer-backed merchant generation asset and the 300 MW of state mandated Renewable Energy Standard ("RES") compliance from the Outlaw Wind Farm Ameren Missouri plans on bidding into the SPP market. Neither Empire nor Ameren Missouri's Outlaw projects have obtained SPP interconnection agreements as of this writing but will presumably have those agreements at some point in the future.

Q. Will avoided capacity costs be able to justify a MEEIA investment today?

A. No. Again, there is no deferral of any supply-side generation.

[7] Introduction to SPP p. 39 https://www.spp.org/documents/31587/intro%20to%20spp.pdf
[8] Ibid, p. 123.
[9] I believe this number will likely prove to be understated moving forward. Consider that the Empire "Customer Savings Plan" modeled a "worst-case" scenario of 6.5 GW of wind in the near term. If we assume all 9 GW of wind that already has signed interconnection agreements gets built and the Empire and Ameren projects are introduced into the SPP market, then wind energy alone, in the near-term, would represent 150% of Empire's "high-wind" or "worst-case" scenario.

There is also no capacity market to derive benefits from.

Finally, the 2018 avoided cost assumptions associated with transmission and distribution ("T&D") are also overstated and will need to be adjusted further down to account for the recently announced (and not modeled) planned capital expenditures in T&D related to SB 564's Plant-In-Service-Accounting ("PISA").

As the Commission is well aware, PISA incentivizes the utility to spend money on T&D. GMO for its part, plans on spending $490 million on T&D from 2019-2023 (See Case No: EO-2019-0045) and KCPL-MO (See Case No: EO-2019-0047) plans on spending $416 million across the same period.

Additionally, on August 8, 2019, at Evergy's 2nd Quarter Earnings Call to investors, Evergy CEO Terry Bassham announced further planned capital investment allocations from Kansas to Missouri on top of the aforementioned figures. During the earnings call Mr. Bassham stated:

> Although, we've not completed our work, our team has identified about $150 million of CapEx that we will look to shift from Kansas to Missouri through the 2022 time frame.[10]

Decreasing avoided costs, increasing technology advancement, and PISA legislation undermine the argument for an aggressive MEEIA today. Commission approval of this application will needlessly raise bills on captive customers and increase economic inefficiencies. Because of KCPL's current generation, load profile, and SPP market, the Cycle III application merely functions as a wealth transfer from nonparticipants to participants and the utility. KCPL and the Commission should be mindful of the concept of opportunity costs and consider any and all opportunities to minimize excessive costs and be sure to direct limited resources (capital) to the most optimal outcomes.

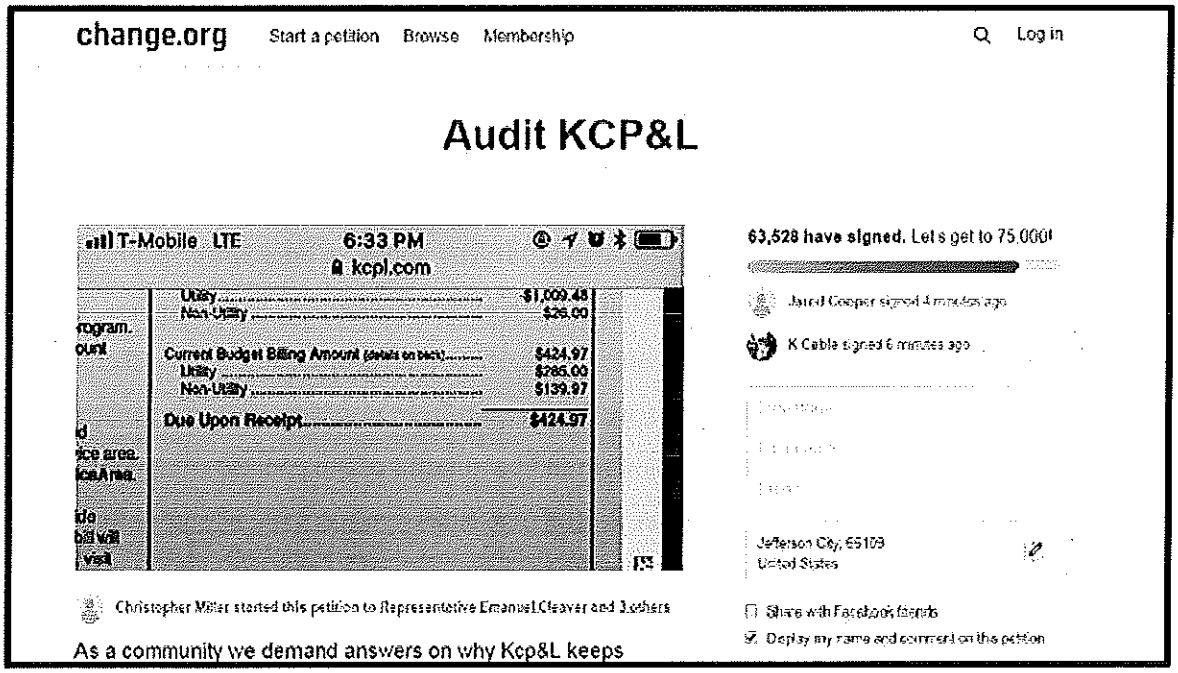
[10] Seeking Alpha. Evergy, Inc. (EVRG) CEO Terry Bassham on Q2 2019 Results—Earnings Call Transcript. https://seekingalpha.com/article/4284701-evergy-inc-evrg-ceo-terry-bassham-q2-2019-results-earnings-call-transcript?part=single

One of the dominant narratives surrounding the recently passed Senate Bill 564 centered on "consumer-friendly rate caps." To be clear, those caps are both temporary and not applicable to the MEEIA surcharge. Customer's bills will be far from consumer-friendly, especially small commercial and residential customer's bills if we pay no heed to upcoming increases in the future.

Q. Are KCPL and GMO customers concerned about increased costs?

A. Yes. Last fall, I testified in Case No: ER-2018-0145 and ER-2018-0146, KCPL-MO and KCPL-GMO rate cases, and pointed to over 68,000 people who had signed a Change.org petition titled "Audit KCP&L" in light of both Companies continued increases in rates and recent budget billing failure as seen in figure 2.

Figure 2: Change.org "Audit KCP&L" [11]



[11] Miller, C. (2018) Audit KCP&L. Change.org https://www.change.org/p/audit-kcp-l

KCP&L-specific data was also included in the aforementioned rate cases that included the results of KCP&L's most recent (at that time) JD Power Survey in which **

**

A copy of the survey in its entirety is included in Schedule GM-4.

Redistribution: Winners & Losers

Q. Won't an increase in spending on energy efficiency help with customer bills?

A. Under today's conditions, it will only benefit ratepayers that participate at the expense of non-participants, in particular low-income tenants. The absence of any supply-side deferral and low avoided costs mean that MEEIA will only serve as a wealth transfer, primarily to higher income households and to utility shareholders. Benefits will not be realized by nonparticipants and will

disproportionately impact those least able to bare the increased costs. To properly understand why this is the case, it is important to realize that energy efficiency can be seen as a form of income redistribution. If it is not managed well or if one just casually assumes it will automatically result in an optimal outcome then the redistribution will largely be regressive in nature.

Q. Ok, so what is the argument for aggressively promoting energy efficiency?

A. It is argued that it is cheaper not to produce electricity (often referred to as a "negawatt") than to produce electricity. That is, the cost per kilowatt hour (kWh) avoided due to the adoption of energy efficiency measures is less than the costs that the utility avoids by not having to produce the next kWh. This is typically calculated as the "avoided costs" of generation or fuel costs (or marginal cost for a utility to produce one more unit of power).

Generation investment tends to be large capital projects whose costs have to be spread out over extended time periods (i.e., "lumpy" investments). Presently, in Missouri, generation capacity is already in place at the margin and thus energy efficiency investments represent a redistribution of fixed costs between participants and non-participants. As time progresses, large-scale adoption of energy efficiency may delay new generation and thus some of the "avoided costs" could include capital costs delayed to a future time.

Q. That is a lot to understand. Could you provide an analogous example?

A. The argument for energy efficiency is similar to the argument for free trade in that they both potentially lead to aggregate economy-wide benefits. However, achieving these net benefits requires some welfare redistribution leading to both winners and losers.

In free trade, at a world price below the domestic (no-trade) price, domestic consumers benefit while domestic producers suffer. The reasoning is fairly straightforward, consumers get to consume more of product at a lower price, while producers with higher production costs end up producing less and receiving a lower price for what they produce.

Aggressive adoption of subsidized energy efficiency produces clear winners and losers as well. The winners are the consumers who adopt the efficient measures. The losers are the utility and the nonparticipants.

The utility (like the inefficient domestic producer in the free trade example) loses because it has lost revenues that would otherwise occur under the non-MEEIA baseline (e.g., incandescent lightbulb uses more energy than a LED lightbulb).[12] To address the utility "loser" issue and encourage energy efficiency adoption, Missouri lawmakers passed the Missouri Energy Efficiency Investment Act ("MEEIA") enabling utilities to have an opportunity to be "winners" by compensating them for both lost revenues and affording an "earnings opportunity" for achieving self-selected targets. The earnings opportunity represents an agreed-to profit that is, in part, equivalent to what, theoretically, would be earned though a needed supply-side investment.[13] In the free trade example, a MEEIA arrangement would be the equivalent of compensating the domestic producer so that they were unharmed *and* even profited with an earnings compensation by international trade.

Q. MEEIA makes utilities and participants' winners. Who loses?

A. Nonparticipants[14] lose as MEEIA program costs and earnings opportunities are increased relative to a baseline forecast (which has some naturally occurring energy efficiency adoption). The nonparticipants lose because they face a higher price for service by subsidizing the paying for the participant's rebates. However, participants can also lose if the utility increasingly continues to seek higher customer charges or proposes new, novel fixed charge recovery.

[12] There is an exception to this argument. For example, the electric utility could be a winner in this scenario if the promotion of that energy efficiency end-use induces a customer to fuel switch. For example, the adoption of an efficient geothermal heat pump enables the house to fuel their heat with electricity as opposed to natural gas or propane. In that scenario the total kWh gains of obtaining a new customer would far outweigh the individual loss in kWh's produced from the geothermal heat pump.

[13] Historically, stakeholders have used a combustion turbine as the default "deferral" in place of earnings investment. Given the historic drop in renewable costs, especially wind, a combustion turbine may no longer be an appropriate earnings opportunity proxy.

[14] Nonparticipants are customers who pay a MEEIA surcharge but do not invest their personal finances in ratepayer subsidized end-use measures. They should not be confused with "opt out" customers. Which are certain commercial and industrial customers who do not have to pay any MEEIA surcharge but do get to receive the benefits.

Increases in fixed cost recovery has been sought by literally every utility in a rate case (with the exception of Spire gas in its most recent rate case) since MEEIA legislation was approved.[15]

Q. What if there was widespread sweeping adoption of energy efficiency?

A. If most ratepayers adopted energy efficiency measures then numerous factors would occur that would erode the original participant's benefits relative to a case where the majority of customers do not participate. Thus, in net terms, each participant would be better off in the case where the aggregate number of participants was low. That is, in a situation where the participant can be subsidized by nonparticipants but does not have to subsidize numerous other participants and/or the utility. If most everyone is a participant than the financial savings or "pay back" of the efficient end-use investment would be would be much smaller and take much longer.

As an aside, *the* most cost effective way to ensure future efficiency would be through the enforcement of strong building codes and standards. That is, build it correctly the first time without the ratepayer subsidies. However, that is a subject largely beyond the scope of this testimony.

Q. Is OPC just against promoting energy efficiency?

A. Based on my recommendations later in this testimony I would hope it is obvious that we are not against promoting sound demand side management strategies. OPC and I have historically supported energy efficiency programs under the premise that the aggregate economy-wide net benefits are worth the redistribution of welfare *if* the adoption of programs leads to meaningful deferral of supply-side investments.[16] Given KCPL's current long capacity position, the current make-up of the SPP market and planned Company capital investments associated with

[15] Seeking increases to fixed cost recovery is not the only means by which a utility can undermine a participant's capital investment in energy efficiency. For example, the City of Kansas City invested millions of dollars in lighting only to have KCPL propose categorical shift in cost recovery from energy to demand for its customer class. In this example, the costs savings associated with lighting were reduced because the energy charge was decreased and demand savings (during non-lighting periods) were increased.

[16] And even in at least one case where that premise was not entirely evident. See also Case No: ER-2016-0023 regarding filings associated with the Empire District Electric PAYS Study.

recently passed legislation, the aggregate economy-wide benefits do not exist to justify approval of this application today.

Stated differently, the rationale for approving a MEEIA is show in Figure 6 which contrasts with KCPL's current application as seen in Figure 7 below:

Figure 6: The intended MEEIA business plan

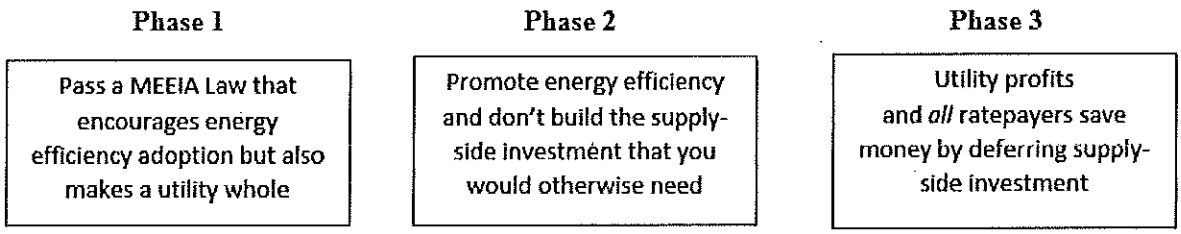
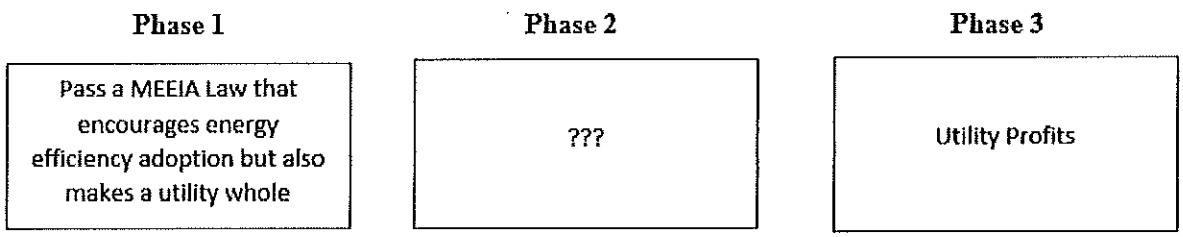


Figure 7: The KCPL MEEIA Cycle III business plan



It is not clear what exactly nonparticipant ratepayers are getting out of Phase 2 in KCPL's application because there is no supply-side investment to defer. That is not to say the benefits of supporting an aggressive MEEIA program will never exist. Rather, the aggressive promotion of energy efficiency and all of its attendant costs will not meaningfully impact the planning period currently in place for KCPL, and will only serve to raise customer bills at a time when costs are already set to be raised through other planned investments (e.g., $1 billion in T&D planned capital expenditures). Increased off-system sales alone cannot justify nor offset the costs that ratepayers will be burdened with. Especially when there are other meaningful investments to be made.

III. PROGRAM MODIFICAITONS

Q. Do you have any comments to make regarding individual programs or measures within KCPL's application?

A. Yes. Putting aside the larger question of whether or not a MEEIA application should be approved, it is important to understand that a MEEIA application is dependent on multiple program offerings in several categories that can be generalized as: energy efficiency, demand response, low-income, EM&V and/or research and pilots. As presently drafted I have many recommended modifications.

Energy Efficiency Programs

Online Home and Business Energy Audit

Q. What is the online home and business energy audit tool?

A. It is effectively a software application that would be added to KCPL's "My Account" portal and allows customers to self-audit their home for energy savings online.

Q. What is your recommendation on KCPL's proposed online energy audit tool?

A. I recommend the Commission reject it. This represents "a low hanging fruit" item that is easily removed from the portfolio to make a future MEEIA application more beneficial. The online home and business energy audit tool is redundant, has been ineffective with other utilities, and is not a prudent expense. Removing it from the MEEIA programs will save ratepayers $800,000.

Q. Why is it redundant?

A. Similar online tools are already available on the internet for free. Moreover, as a result of the over $100 million dollar investment in AMI hardware and AMI billing software, customers should already be getting the best personalized customer experience in the state. Consequently, this additional "education" item suffers from diminishing returns.

Q. There are no energy or demand savings associated with this measure. Why is that?

A. It's an "educational" item. Albeit a passive one on the Company's part.

Q. What has been your experience with online energy audit tools?

A. Customers do not use them or have enough information about their building's make-up to accurately estimate potential savings. Additionally, the savings estimates are highly dependent on a variety of factors (price, weather, occupancy, interactive-effects with natural gas, etc…), all of which can be misleading if not properly accounted for.

Q. Do you support maintaining an online audit tool just for business?

A. No. The same issues exist. For business customers, KCPL should be utilizing whole-building benchmarking data in the U.S. Department of Energy ("DOE") ENERGY STAR Portfolio Manager. Ratepayers should not have to pay additional money for yet another tool. Rather, KCPL should make data available for building managers and owners with the DOE tool.

Home Energy Reports

Q. What is the Home Energy Report?

A. The Home Energy Report is a behavioral modification measure. KCPL utilizes the OPower home energy reports to a large portion of its customers. The basis behind a home energy report is centered on the concept of "shaming."[17] That is, a customer gets a mail insert that not only gives the customer their energy average energy usage but compares their usage against "similar" households. Behavioral research suggests that a person will be more likely to change their behavior based on the power of other people's actions than, say, saving money or helping the environment.[18]

Q. What is your opinion on KCPL's proposed Home Energy Report?

A. I recommend that the Commission reject it. This program represents approximately $4.5 million in program costs. Similar to the online energy audit, the reports have been made redundant as a result of the over $100 million dollar investment in AMI hardware and AMI

[17] Nikiforuk, A. (2011) What saves energy? Shame. *The Tyee*.
https://thetyee.ca/Opinion/2011/07/14/EnergyShaming/

[18] This work is based on the research by Robert Cialdini over hotel towels. A more detailed explanation of experiment can be found at Goldstein, N. (2008) Changing Minds and Changing Towels. *Psychology Today*.
https://www.psychologytoday.com/us/blog/yes/200808/changing-minds-and-changing-towels

billing software. Customers should already be getting the best personalized customer experience negating much of the value of the Home Energy Report.

The reports also suffer from the issue of "persistence." That is, unlike an LED light bulb that literally uses less electricity than an incandescent across the same life-span, behavioral response programs are only good for a limited amount of time and thus are not a "long-life measure."

To date, stakeholders have approved behavioral modification reports and "deemed" the energy savings associated with them. That is, we have not attempted to apply a net-to-gross ratio, rather the Company gets to claim savings and earnings for merely mailing the item.

Given the KCPL's current resource planning status and the hundred million dollar investment in customer experience, this measure can easily be removed without any material impact on savings. OPC has been an active participant in the pending "roll-out" of TOU pilot rates and online customer experience over the past year. The work KCPL has done appears very promising. The customer portal and tailored customer experience is both superior to the home energy report and is already an enormous sunk cost. There is little to no value in the Home Energy Report at this point.

Heating, Cooling and Weatherization

Q. What is the Heating, Cooling and Weatherization program?

A. It is a residential program designed to reduce heating and cooling consumption holistically through audits and rebates (e.g., for efficient HVACs, insulation, etc…).

Q. What is your opinion on the Heating, Cooling and Weatherization program?

A. I strongly support a targeted effort of this program on the real estate market. For several years now, I has advocated for aligning home energy audits with real estate inspections and transactions. For most people, the only time they seriously consider the large scale investment on a heating or cooling system is either upon failure or when they are about to purchase an

existing system—that is, when they purchase a house. The home buying transaction is the perfect time for KCPL to introduce an energy audit and push large capital investment measures.

I recommend that future MEEIA filings provide a more detailed business plan on targeting the real estate segment of its customers.

Q. Are there any other recommendations on this program?

A. Yes. I strongly support introducing a PAYS option with this program. I will discuss that recommendation in greater detail later in this testimony.

Business Process Efficiency

Q. What is the Business Process Efficiency program?

A. It is essentially a ratepayer-funded energy management professional. KCPL contracts with an implementer that serves as an energy management professional for select customers to "hand-hold" them through various energy savings opportunities and assessments.

Q. What is your opinion on the Business Process Efficiency program?

A. Given the KCPL's current resource planning status, I suggest this program be removed. The role of an energy management professional can be met internally by commercial and industrial businesses or can be procured through third-party businesses or organizations (see also the Association of Energy Engineers—Kansas City, Energy Management Association, Kansas Municipal Energy Agency, etc…). Restated, this subsidy can be removed and those energy professionals and the respective groups will still operate in this market.

Demand Response Programs

Business Demand Response

Q. What is the Business Demand Response program?

A. A load curtailment program for select commercial and/or industrial customers that allows them to receive a financial reward by stopping or reducing a significant amount of their energy usage during a "called" peak demand period.

Q. What is your opinion on the Business Demand Response program?

A. Since 2015, KCPL/GMO have called between one and two events a year. That's it.

These events were essentially called to make sure the curtailment program was still operational if it needed to be called. That is, the events have basically functioned as "test runs."

A considerable amount of testimony was filed in the last KCPL and GMO general rate case and my opinion remains the same. I am not opposed to demand response or emergency curtailment options. In fact, I have been vocal in the IRP process about wanting to have a good grasp of the demand response potential that could be called, if the wholesale energy markets ever significantly changed. That being said, to date, events have not been called. There are a variety of reasons why, but it is clear that there has been very little realized energy/demand savings value from the various programs to date.

Moving forward, I strongly oppose opt-out MEEIA customers from participating in MEEIA events. Opt-out MEEIA customers have opted-out and should not be entitled to additional MEEIA benefits or eligible for participation in MEIA programs (including demand response). As it stands, my primary reason for taking this position is my belief that the opt-out provision is categorically unfair to captive ratepayers who cannot opt-out. I am fully conscious that the MEEIA statute can be interpreted to provide this inequity but I believe that if a customer elects to "opt-out" of paying the costs of MEEIA then that customer cannot simultaneously "opt in" to receive the participant benefits. Failure to recognize and rectify this process moving forward will only serve to cannibalize the remaining MEEIA participants by inducing further opt-outs, and lead, at best, to suboptimal MEEIA programs in the future.

Both Companies' current tariffs are designed to allow a curtailable rate separate and aside from MEEIA. I recommend removing the business demand response program from MEEIA unless KCPL can guarantee that events will be called beyond "test runs" and when there is are economic benefits to be realized from an event being called. Otherwise, I recommend that this program remain outside of MEEIA and be used in emergency situations as it has historically operated.

Residential and Small Business Demand Response

Q. What is the Residential and Small Business Demand Response program?

A. A program that provides free smart thermostats (and potentially other control technologies) and financial payments to customers to allow KCPL/GMO to control the device and lower the temperature for an event that could last up to four hours.

Q. What is your opinion on the Business Demand Response program?

A. In 2016 there were eight events called. In 2017 there were three events called. In 2018 there were two events called. I am not aware of any events that have been called during 2019's "extended" Cycle II season. While called events decreased every year, the number of free thermostats increased every year. In short, each year of this program has produced fewer benefits at greater costs.

It should not be lost on the Commission that customers also have the option to "override" a called event and control the temperature of their house if they desire with no penalty.

If no events, or very few events are actually called, there are no additional benefits from subsidizing the full costs of a smart thermostat. It is my understanding that there are now thousands of Company-controlled smart thermostats currently in its service territory. Moving forward, I would recommend that this program be amended to only calling events with existing subsidized smart thermostats. There is no sound reason to continue subsidizing homes with more smart thermostats if events are not being called. At this point, I believe it is incumbent upon KCPL to show value in the existing investment made from Cycle II before further roll-out is warranted. Additionally, KCPL should be required to call a minimum amount of events to satisfy this investment.

Smart Thermostats and Privacy

Q. Do you have any additional concerns regarding smart thermostats?

A. Yes. On September 19, 2019 a non-unanimous partial stipulation and agreement settling the revenue requirement, in which OPC was not a signatory but did not oppose was filed with the Commission stating as condition #18.

> CUSTOMER PRIVACY
>
> The Company will adopt the Green Button platform no later than the second half of 2020. The Company commits to producing a privacy policy statement and frequently asked questions ("FAQ") website section for customers regarding use of customer data. The Company will receive input from OPC, Staff, and DE on the privacy policy statement and FAQs. The Company will hold annual meetings with Staff, OPC, and DE regarding the results of the third party privacy impact assessments. The meetings and any material discussed at the meetings may be designated as confidential by the Company.[19]

Q. It has been eleven months since that stipulation was filed. Has OPC been notified of any action regarding adoption of the Green Button platform?

A. No.

Q. Has OPC been contacted by KCPL/GMO for input on its privacy policy statement or FAQ?

A. No.

Q. Has OPC been contacted by KCPL/GMO for its annual meeting to discuss the results of its third party privacy impact assessment?

A. No.

[19] ER-2018-0145 and ER-2018-0146 Non-unanimous partial stipulation and agreement p. 9.

Q. In light of that information, do you have any recommendations as it pertains to that topic in this MEEIA application?

A. Putting aside yet another example of KCPL and GMO's inability to adhere to the terms of its stipulation and agreement ordered by the Commission for a moment, I continue to have serious concerns about the level of privacy and lack of guidance from the Commission on this issue. Working docket AW-2018-0393 is now over a year old. A July 29th order from the Commission has Staff filing draft rules by September 16th, 2019. However, even under the most optimistic of scenarios, codified rules on the issue of customer data will likely not occur before this issue comes before the Commission in a MEEIA docket.

In Case No. ER-2018-0145 and ER-2018-0146 I testified to the very real threat inherent in third party data access and smart thermostat in particular. My testimony on that is included here:

> **Q. Does OPC have a response to Mr. Johnson's position that other utilities need to opine on KCPL/GMO specific recommendations?**
>
> A. No other utility in Missouri has AMI and supporting software in place. KCPL/GMO is singularly unique in that regard but this is a reality that KCPL/GMO should have fully been aware of when they elected to be first movers on AMI.
>
> **Q. Please provide Mr. Johnson's full quote regarding customer protection criteria with third parties?**
>
> A. Mr. Johnson stated:
>
> > Mr. Marke is correct that it is incumbent on the utility to protect the customers' data. To ensure that happens, customer protection criteria must be specified for third parties to adhere to prior to gaining access to customer data. The utilities will have no control

over treatment of the customer's data once the third party has access.[20]

Q. What is OPC's response?

A. This is a curious comment to make. On the one hand, Mr. Johnson agrees with OPC that customer protection criteria must be in place to ensure third parties do not take advantage of customers, but on the other hand, Mr. Johnson does not follow-up that declarative statement with an affirmation that KCPL/GMO has that essential criteria in place. It's a throw away comment that unexpectedly challenged OPC to consider if there were any potential examples in which KCPL/GMO entered into contracts with third parties in which customer data was obtained by third parties (and by extension, other parties) without full KCPL/GMO ratepayer consent or knowledge.

Q. Did anything come to mind?

A. Yes. In 2017 the *Kansas City Star* published a technology article titled "Digital Life: Real tech payoff that comes with a (remote) risk." The article discusses why the KCPL/GMO Nest thermostat program is both attractive (e.g., hi-tech "learning" thermostat valued at $200 with an additional $50 inducement payment) and successful (more than 16,000 given away at the time of the articles print date). It then discusses the risks:

> Back to that catch. First, you're sharing data about your lifestyle with Nest, meaning Google. Marketer's armed with the patterns of your comings and goings could someday use it as fresh ammunition to tempt you towards their products—likely in ways that you'll be blind to.

[20] ER-2018-0145 & ER-2018-0146 Rebuttal Testimony of Gary Johnson p. 5, 22-23 & p. 6, 1-2.

> Then there's hacker risk. Nest founder Tony Fadell has said the Nest is built with "bank level security" and that the business will fail "if people don't trust it." Yet researchers have said the thing can be cracked by someone who has access to it during delivery or in your home (cough, ex-boyfriend, cough).
>
> Once exploited, scientists from the University of Central Florida said, "what was once a learnings thermostat has been transformed into a spy" able to get into your Wi-Fi network and everything that connects to it.
>
> Such is the dilemma of virtually everything about the digital era and cool things that come from internet connections. Privacy traded for convenience.[21] [22]

The mere fact that the *Kansas City Star* felt compelled to report and opine on this dilemma suggests that many KCPL/GMO customers may not fully be aware of what they consented to when they agreed to "participate" and receive a free smart thermostat (valued at $200.00) and the additional $50.00 incentive.

Q. Has anyone attempted to determine the volume of data created and shared through a Nest thermostat?

A. Yes. Researchers out of the University of Amsterdam produced a report last year on those very questions. A list of the individualized data points collected by the Nest thermostat is included in Figure 1:

[21] Canon, S. (2017) Digital Life: Real tech payoff that comes with a (remote) risk" *Kansas City Star* July 10. https://www.kansascity.com/news/business/technology/article160430799.html see also GM-5.
[22] Hernandez, G. et al (2017) Smart Nest Thermostat: A smart spy in your home. https://www.blackhat.com/docs/us-14/materials/us-14-Jin-Smart-Nest-Thermostat-A-Smart-Spy-In-Your-Home-WP.pdf

Figure 1: Individualized data points collected by a Nest thermostat

Wi-Fi network name (SSID)	Home address (plus ZIP code)
Wi-Fi Password to connect to the Internet	Heating and Cooling (HVAC) system capabilities
IP address	Current temperature
Account associated email Addresses	Humidity
Name	Ambient light in the room
Profile photo	Room movement
Mobile location data	Device setting changes
Bluetooth data	Heating and cooling usage information
Log entries (eg. IP address)	Device model
Technical information (eg browser type and version)	Software version
Thermostat location	Battery charge level
Location information (home or business)	Serial number

The report found 89 unique third-party applications connected to the Nest thermostat that can, in turn, be connected with other applications, devices, and consequently, different companies.[23]

Q. Who would want that kind of information?

A. Many companies would. In fact, "Big Data" has been commonly compared to the equivalent of "Big Oil" for the twenty-first century.[24, 25] However, technology writer, Michael Haupt persuasively argues that the metaphor is both inappropriate and potentially dangerous. Haupt states:

> Yes, big data might be the new oil, but let's remember what data really is: **a natural resource created by, for and because of sovereign human beings.** Let's not allow a new breed of corporations to extract wealth from us, like we've allowed in the past. If we allow privatization of data, as we've permitted with other

[23] Dirkzwger, A. et al (2017) Where does your data go? Mapping the data flow of Nest. Masters of Media, New Media & Digital Culture, University of Amsterdam. https://mastersofmedia.hum.uva.nl/blog/2017/10/25/where-does-your-data-go-mapping-the-data-flow-of-nest/ See also GM-6

[24] The Economists (2017) The world's most valuable resource is no longer oil, but data. *The Economists*. https://www.economist.com/leaders/2017/05/06/the-worlds-most-valuable-resource-is-no-longer-oil-but-data

[25] Haupt, M. (2016) "Data is the new oil"—A ludicrous proposition. *Medium*: Project 2030. https://medium.com/project-2030/data-is-the-new-oil-a-ludicrous-proposition-1d91bba4f294

natural resources in the past, we only have ourselves to blame. (emphasis added)[26]

Q. Does this mean that OPC objects to the Nest thermostat program now?

A. Maybe. But that is an issue beyond the scope of this testimony.

Q. Does OPC have any concluding statements on the issue of One CIS: privacy?

A. There needs to be a robust, honest conversation on the topic of privacy, customer consent and liability. The fact that KCPL/GMO's present position is that they are the sole owner of their customer data is troubling. OPC disagrees with this statement and seeks Commission guidance on minimizing future risk to ratepayers. OPC will provide further recommendations regarding the accounting treatment of One CIS in the conclusion of this testimony.[27]

To date KCPL and GMO have not engaged OPC in a meaningful conversation on the topic of privacy, customer consent and liability. I do not know whether they have engaged Staff or the Division of Energy ("DE"). As it stands, KCPL and GMO's last publically stated position on this topic is that

"customer information remains the sole property of the covered utility."[28]

I disagree.

Until the Company can provide some level of commitment and explicit safeguards ensuring that their captive customer information is not being used or is otherwise susceptible to non-consensual third-party access, or, at a minimum, explicitly states how said data is being used,

[26] Ibid.
[27] ER-2018-0145 & ER-2018-0146 Surrebuttal Testimony of Geoff Marke p. 23, 1 to 25, 13.
[28] AW-2018-0393 Kansas City Power & Light Company's & KCP&L Greater Missouri Operations Company's Comments on proposed new rules regarding treatment of customer information. P. 1. August 24, 2018.

I cannot recommend subsidizing smart thermostats that have proven to be both easily compromised and sources of copious amounts of data collection.

Low-Income Programs

Q. Do you have any recommendations or concerns regarding the proposed low-income programs in KCPL's filed application?

A. Yes. I recommend that KCPL and GMO propose a Business Social Services program similar to the Ameren Missouri MEEIA program. This program specifically targets non-profits and social service facilities. For example, specific targets and extended rebates for soup kitchens, homeless shelters, battered spouse facilities, etc... This is often overlooked market that should be considered moving forward.

Company Proposed Research and Pilot

Q. Do you have any recommendations or concerns regarding the proposed Research and Pilot considerations in KCPL's filed application?

A. I categorically do not support KCPL's Electric Vehicle Charging option. The Company has a two paragraph write-up in its application suggesting exploring the use of demand response options with home and public chargers. To be clear, as seen above, KCPL has not effectively shown they are utilizing demand response with the programs it was approved to implement in Cycle II. EV chargers are not cost effective MEEIA options because they are load building items. It is as simple as that. For whatever benefits EV charging may purportedly have, it simply is not energy efficiency.

I have additional comments to make regarding KCPL's PAYS and/or residential financing pilot option later in this testimony.

Evaluation, Measurement and Verification ("EM&V")

Q. Do you have any recommendations or concerns regarding the proposed EM&V in KCPL's filed application?

A. I do not support the use of non-participant spillover as a net-to-gross ("NTG") ratio factor. The NTG should account for free ridership and spillover. No further breakdown is necessary (e.g., NTG ratio = 1 – Free ridership rate + spillover rate). Furthermore, I do not support KCPL's proposed baseline shift exemption. If the federal government mandates a measure to adhere to certain standards, those are the standards. It is inappropriate to calculate gross and net kWh and kW savings as though those standards did not exist. I would also disagree on maintaining a 0.85 NTG factor for the throughput disincentive net to gross adjustment and instead propose 0.70 NTG to more accurately reflect free ridership. Additionally, the Company's earnings opportunity should be rewarded at the end of the three-year verification of targets, not on an annual basis.

I also strongly suggest that KCPL's future MEEIA application include a discussion with the Company's EM&V consultant prior to submitting its application. Despite the almost one year lapse in when the application was filed and where stakeholders are at today. There was not one technical conference or discussion about EM&V prior to this filing. As such, my recommendations and concerns are certainly understated in regard to what has been filed.

IV. ALTERNATIVE RECOMMENDATIONS

Default MEEIA Level

Q. Do you see merit in having some level of funding and program activity in place?

A. Yes. To be clear, my primary recommendation is to reject what has been filed. That being said, my secondary recommendation would be to approve a default annual MEEIA spending level that could serve as a bridge to a future scenario where demand-side management programs could be ratcheted up if warranted. A default level MEEIA would maintain a degree of program activity and reasonable spending level that would recognize the historic sunk costs,

the potential need to increase MEEIA funding in the future, and explore alternative deliverables in which a MEEIA could provide equitable benefits to all ratepayers.

Q. What would a default MEEIA level look like?

A. A "default MEEIA level" is broken down as follows:

Categories	Annual Costs Range	Class Allocation
• Residential Programs	$791,667 - $875,000	Residential
• Business Programs	$791,667 - $875,000	Business
• Low-Income Programs	$950,000 - $1,050,000	Residential & Business
• Earnings Opportunity	$333,333.33	Residential & Business

I recommend that all Evaluation, Measurement and Verification ("EM&V") be suspended in light of my proposed earnings opportunity mechanism (which is based on annual achieved expenditure thresholds) and that deemed savings be utilized to inform savings assumptions related to the throughput disincentive. Earnings opportunities would be solely dependent on prudently incurred annual spend limited within the proposed cost range. That is, an earnings opportunity would not be realized if annual expenditures for low-income programs were only $500,000. Likewise, the Company would need to seek Commission approval for annual budgets that exceeded any of the program cost ranges.

Additionally, I recommend that the annual "default MEEIA level" be in place until either a new MEEIA application is approved or until the Company(s) next filed rate case. For purposes of cost allocation between utilities, I suggest a 50/50 split between KCPL and GMO for administrative ease.

Q. Is this budget comparable to any other energy efficiency programs by other utilities?

A. Yes. The proposed budget accounts solely for residential, business and low-income annual spend is slightly less than the overall budget currently in place for Empire Missouri scaled up to account for more total customer accounts as seen in Table 1.

Table 1: Comparison between Commission-approved Empire DSM programs and OPC's residential and business budgeted proposal

Utility	Total Customer Accounts	Program Budget Amount	Program cost per year per account[29]
Empire	173,981[30]	$1,250,000[31]	$7.18
KCPL+GMO	615,926[32,33]	$2,700,000	$4.38

Q. What programs/measures would be included or excluded?

A. I recommend removing most of the programs (e.g., OPower, online audit tool, energy savings products, rebating new smart thermostats, etc…). Focus would be placed primarily on heating, cooling and weatherization-like measures for residential customers and a non-lighting Business Standard offerings for commercial and industrial customers. In short, the emphasis would be placed solely on demand-reducing measures.

Q. Are there any additional ratepayer costs you propose?

A. Yes. I propose an additional $2 million in targeted annual research and development ("R&D") costs to inform alternative MEEIA valuation opportunities. A description of the R&D framework and specific valuation opportunities will be discussed in greater length later in this testimony. However, for cost comparative purposes, the additional $2 million in R&D annual spend breakdown has been included in table 2 along with the per year, per account impact comparison with Empire District Electric.

[29] I am including these estimates merely for comparative purposes. The estimates omit deemed throughput disincentive and the earnings opportunity. Additionally, the actual costs per year per account will also vary based on customer account type and ultimate spend. That is a non-residential or business customer will pay a greater monthly amount than a residential customer due to differences in overall customer account totals and differences between the two utilities. This additional level of complexity has been introduced by the Company (KCPL and GMO) as its MEEIA filing is a joint-filing. OPC is amendable to treating each utility separately in its entirety. Again, for administrative ease, I would propose a 50/50 split in what is articulated above.

[30] BMAR-2019-1971 The Empire District Electric Company Annual Report (MO PSC) for 2018

[31] ER-2016-0023 Stipulation and Agreement p. 5

[32] BMAR-2019-1967 Kansas City Power & Light Company Annual Report for 2018

[33] BMAR-2019-1969 KCP&L Greater Missouri Operations Company Annual Report for 2018

Table 2: Comparison between Commission-approved Empire DSM programs and OPC's residential, business and R&D budgeted proposal

Utility	Total Customer Accounts	Program + R&D Budget Amount	Program + R&D cost per year per account
Empire	173,981	$1,250,000	$7.18
KCPL+GMO	615,926	$4,700,000	$7.63

Q. Would lost revenues associated with the throughput disincentive be recoverable?

A. Yes. However, I am unable to provide an annual bill impact associated with that amount as it would be dependent on the measures rebated.

Q. Is your annual "default MEEIA level" proposal more generous than energy efficiency mechanisms in place for other utilities in Missouri?

A. Yes. It is more generous than all Commission-approved, ratepayer-funded demand side management programs, with the exception of Ameren Missouri. Importantly, my alternative MEEIA default option includes both an earnings opportunity, a throughput disincentive recovery mechanism and an explicit roadmap to explore alternative opportunities to support an amended MEEIA application in light of the lack of supply side deferral opportunities.

Equitable Energy Efficiency Baseline Study

Q. Do you have any further recommendations regarding KCPL's MEEIA application as it pertains to low-income customers?

A. Yes. Similar to what Ameren Missouri agreed to in its MEEIA Cycle III application, I propose that KCPL collect demographic data showing estimated energy use intensity, energy efficiency equitable baseline investment, and energy savings in the KCPL and GMO service territory across various parameters. The goal of this data collection would be to explore residential energy efficiency in order to evaluate the equitable distribution of investments and benefits among customers.

This data should be made available to all parties and the general public in order to better inform future energy efficiency discussions and to aid the Commission's decision-making in this area of regulatory policy. Making this data available would allow researchers to analyze the impact of current MEEIA efforts, and it could assist in preparation for its subsequent MEEIA plan application to the Commission.

KCPL and GMO should also be required to collaborate with an independent academic researcher to provide an analysis of the data regarding energy efficiency utilization by customer income level and by other factors.

Said research should be concluded prior to any future MEEIA application and should include an on-the-record presentation to the Commission prior to any future MEEIA filing.

Q. What specific data should be required?

A. Data provided by KCPL should include, at a minimum, the following:

1. A compilation of annual reconciliation reports (includes annual spending, savings on all residential and income qualified residential programs) from 2012 to 2017, and for ongoing program years;
2. Any data on energy efficiency program utilization by zip code (i.e., dollars, measures, applications); and
3. Aggregate residential consumption data at a spatial level that could be correlated with Census spatial levels (i.e., zip code+4). This includes:
   - Average monthly residential usage for each zip code in the service territory; and
   - A random sample of 2% of household monthly sum usage in each zip code.

Q. What research deliverables would you expect to be provided by an independent academic research authority?

A. The data provided by KCPL would allow the following research deliverables to be performed for the parties and the Commission:

1. Estimate and assess the spatial distribution of mean/median energy use intensity (EUI) in kBTU/ft^2 across the KCPL service territories. The EUI model and maps

may be used for exploring residential energy efficiency disparities across the service territories and for program targeting. This model could be based on 1) data from the Energy Information Administration Residential Energy Consumption Survey or 2) aggregated consumption data from KCPL with additional parcel data from county tax offices to calculate mean/median square footage;

2. Assess program investments between income-qualified and non-income qualified energy efficiency programs and customers. Establish an Equitable Energy Efficiency baseline (E3b) to quantify the gap between equitable, based on territory population demographics (e.g., the proportion of low-income households), and actual annual investments as reported in annual utility filings with the Missouri Public Service Commission; and
3. Assess the equitable distribution of household energy savings between low income and non-low-income customers in the service territory based on utility reported data as filed with the Commission for relative comparisons.

Q. Are you aware of an example of an independent academic analysis performed on the equity of residential energy efficiency utilization?

A. Yes. GM-7 contains 2016 academic article from *Energy Policy* titled "Targeting energy justice: Exploring spatial, racial/ethnic and socioeconomic disparities in urban residential heating energy efficiency" by Dr. Tony Reames of the University of Michigan. The abstract states:

> Fuel poverty, the inability of households to afford adequate energy services, such as heating, is a major energy justice concern. Increasing residential energy efficiency is a strategic fuel poverty intervention. However, the absence of easily accessible household energy data impedes effective targeting of energy efficiency programs. This paper uses publicly available data, bottom-up modeling and small-area estimation techniques to predict the means census block group residential heating energy intensity (EUI), an energy efficiency proxy, in Kansas City, Missouri. Results mapped using geographic information

> systems (GIS) and statistical analysis, show disparities in the relationship between heating EUI and spatial, racial/ethnic, and socioeconomic block group characteristics. Block groups with lower median incomes, a greater percentage of households with poverty, a greater percentage of racial/ethnic minority headed-households, and a larger percentage of adults with less than a high school education were, on average, less energy efficient (higher EUIs). Results also imply that racial segregation, which continues to influence urban housing choices, exposes Black and Hispanic households to increased fuel poverty vulnerability. Lastly, the spatial concentration and demographics of vulnerable block groups suggest proactive, area-and community-based targeting of energy efficiency assistance programs may be more effective than existing self-referral approaches.[34]

Stakeholders are in the unique position of comparing Dr. Reames' pre-MEEIA baseline against the hundreds of millions of dollars of investments from at least two cycles of programs.

Q. Do you want to condition this recommendation on Dr. Reames' involvement?

A. That would be ideal, but I am willing to listen to suggestions on this issue as we have no idea whether or not Dr. Reames would even be interested in conducting the work. Regardless, whether or not Dr. Reames or somebody under his supervision conducts this work is less of a concern for us than making sure an independent research was replicating the 2016 study to see whether or the MEEIA investment to date has been effective and how this information could inform future MEEIA programs. So, at a minimum, the researcher would utilize Dr. Reames' work as the basis for study.

[34] Reames, T.G. (2016) Targeting energy justice: Exploring spatial, racial/ethnic and socioeconomic disparities in urban residential heating energy efficiency. *Energy Policy*. 77: 549-558. See GM-7.

Q. Do you have any privacy concerns over this recommendation in light of your early comments about customer data?

A. No. To be clear, I am not opposed to aggregated data for utility purposes. The intent behind this recommendation is to not use customer usage information for non-utility purposes or as a nonregulated revenue stream.

WattTime: Automated Emissions Reduction ("AER")

Q. Do you have any further recommendations regarding future demand response or customer education programs?

A. Yes. Assuming KCPL adopts and enforces robust customer data protection measures, OPC would recommend that KCPL strongly consider including WattTime's (or a similar software application) Automated Emission Reductions ("AER") technology as a complementary feature for future smart energy efficient devices and/or demand response programs.[35]

[35] See also: DeWitt, Z. & M. Roeschke (2015) Optimal refrigeration control for soda vending machines. *Energy Systems and Control*. U. of California, Berkley https://www.watttime.org/app/uploads/2019/03/Optimal-Refrigeration-Control-For-Soda-Vending-Machines_May_2015.pdf;

Tran, J. et al. (2015) Automated demand response refrigerator project. *Energy Engineering*. U. of California, Berkeley. https://www.watttime.org/app/uploads/2019/03/Automated-Demand-Response-Refrigerator-Project_October-2015.pdf;

Callaway, D., M. Fowlie & G. McCormick (2018) Location, location, location: The variable value of renewable energy and demand-side efficiency resources. U. of Chicago. *Journal of the Association of Environmental and Resource Economists* 5(1): 39-75. https://www.watttime.org/app/uploads/2019/03/Location-location-location-The-variable-value-of-renewable-energy-and-demand-side-efficiency-resources_September-2015.pdf;

Graff Zivin, J.S., M. Kotchen and E. Masur (2014) Spatial and temporal heterogeneity of marginal emissions: Implications for electric cars and other electricity-shifting policies. *Journal of Economic Behavior & Organization*. 107: 248-268. https://www.watttime.org/app/uploads/2019/03/Spatial-and-temporal-heterogeneity-of-marginal-emissions-Implications-for-electric-cars-and-other-electricity-shifting-policies_March-2014.pdf;

Siler-Evans, K., I. Azevedo & M.G. Morgan (2012) Marginal emissions factors for the U.S. electricity system. Environmental Science & Technology. https://www.watttime.org/app/uploads/2019/03/Marginal-Emissions-Factors-for-the-US-Electricity-System_April-2012.pdf; and

Mandel, J. & M. Dyson (2019) WattTime validation and technology primer. Rocky Mountain Institute. https://www.watttime.org/app/uploads/2019/03/Automated-Emissions-Reduction-Primer_RMI-Validation_June2017.pdf

Q. What is an AER?

A. According to the WattTime website the AER technology is:

> Based on real-time grid data, cutting-edge algorithms, and machine learning—provides first-of-its-kind insight into the electricity grid's marginal emissions rate. We're able to "see" when, where, and how the grid is breathing. WattTime's AER technology uses that insight to make smart devices even smarter. Powered by our software, smart devices that control flexible electricity loads use the cloud-based AER signal to automatically, effortlessly, and seamlessly sync their energy use with moments of cleaner energy while avoiding moments of dirtier energy. Most importantly, this happens without sacrificing cost and user experience.[36] . . .
>
> WattTime's AER software pulls information from different power plants and grid operator data to calculate which moments have lower marginal emission rates. It then "talks" via the cloud to individual smart devices that are signed up for AER. The software system lets these devices know when to use electricity—and when not to—reduce emissions, automatically. We simply "move" flexible energy consumption to better times. And we do this seamlessly, without impacting the end use.[37]

Stated differently, in the SPP footprint there should be a strong correlation between increased emissions and peak usage. Using WattTime's grid emission algorithm should help minimize grid intensity, cut emissions and reduce peak usage.[38]

OPC is very interested in exploring this technology not only in MEEIA but also with KCPL's TOU pilot program roll-out. No doubt, there needs to be further dialogue on its applicability with specific devices but the possibilities are promising and worth pursuing. The Commission should note, that Ameren Missouri has recently agreed to explore

[36] WattTime (2019) What is AER? https://www.watttime.org/aer/what-is-aer/
[37] WattTime (2019) AER 101. https://www.watttime.org/aer/how-aer-works/
[38] See GM-8.

WattTime's AER application in its recently filed stipulation and agreement for its EV fast charge rebates.

Pay As You Save ("PAYS®")

Q. Do you have any further recommendations regarding how KCPL can increase its market share of nonparticipants to justify a future MEEIA application?

A. I recommend that KCPL offer a PAYS program.

Q. Did KCPL's independent third party evaluator of PAYS see a market need and recommend pursuing the program?

A. Yes. The recommendation was not an unequivocal endorsement but was predicated on regulatory approval and targeted marketing.

Q. Did OPC take issue with KCPL's independent third party evaluation of PAYS?

A. Yes. Despite the report's general positive conclusions and recommendations, there were some fundamental flaws and misunderstandings in how the evaluators characterized the PAYS tool. Those response comments, authored by the PAYS creators, were filed in this case and are included in GM-9 for reference. In addition to the filed comments, OPC arranged a technical conference in conjunction with this filing to field any questions, concerns, or misunderstanding about PAYS with stakeholders. The stakeholder submitted questions and PAYS responses are included in GM-10 for reference.

Q. What do you propose regarding a PAYS program?

A. My primary recommendation is for KCPL to roll out a full PAYS program with the next MEEIA application; however, I would be amendable to a one-year, proof-of-concept PAYS pilot program with the following seven conditions out of an abundance of caution:

1. <u>One-Year Pilot-Program Goal.</u> The goal should be that within one year of the date of the first completed installation, approximately 1% of the utility's customers (i.e., 5,000 for KCP&L) will complete installation of PAYS projects in their units. Assuming an offer

acceptance rate of 78.1%, this will require at least 6,400 Easy Plans (i.e., offers based on location-specific assessments).

2. Target Market. At least two-thirds of participants must live in neighborhoods designated by the parties as predominantly low- or moderate-income customers or be renters in multifamily housing (5 or more units) where the renter is a customer responsible for paying their energy bills. Owners of multifamily units in participating buildings may also use the PAYS tariff to install upgrades in common areas (e.g., building and parking lighting), but will be allowed to install their own upgrades, and/or use the PAYS charge or their own capital.
3. Earnings Opportunity. A utility's earning opportunity should be tied to the success of its program to ensure the utility's support (e.g., a commitment to 5,000 completed projects and provide customer usage data to target high users, demographic information to target low-moderate income neighborhoods, and identify customers living in multi-family buildings of 5 or more units). For example, there should be a zero-earnings opportunity for a utility that reaches fewer than 50% of the targeted number of customers. For each percent over 50% the utility should receive 2% of the specified earnings opportunity.
4. Program Operator. Since the pilot is a proof of concept, the utility should use the only successful PAYS program operator serving multiple states, EEtility, Inc. and its version of the PAYS system. EEtility's proven model and its license to use the Energy Efficiency Institute, Inc.'s intellectual property will eliminate the need for design and licensing fees.
5. Capital Budget. The program should have a budget for capital of $5,500 per completed project or a total of $27.5 million (see attached spreadsheet), however the utility will not be penalized if the demand for cost effective projects results in the need for additional capital. The utility's earnings opportunity should be tied to its ability to obtain access to capital without carrying costs and an interest rate of no more than 5%. The utility must be assured that if it uses its customary protocols for uncollectables, it will be assured of any uncollectables over its current rate for non-payment.

6. Operational Budget. The operational budget, for planning purposes should be $4.1 million (see attached spreadsheet), however the utility should not be penalized if additional start-up costs associated with the first PAYS pilot results in the need for additions to the operational budget, providing the total operational budget is less than $5 million.
7. Startup Budget. To initiate a program, no less than one month before the first customer contacts, the Program Operator will need to secure and train staff, arrange for leased equipment (e.g., the vehicles, blower doors, other testing equipment and computers), and offices. The estimated start-up costs for a one-year pilot is approximately $180,000. The start-up costs will be one-time costs, providing that the Program Operator receives 90 days-notice prior to termination, extension or expansion of the on-year pilot. EEI did not include a separate startup budget in its response to KCP&L's Cadmus study since startup costs could be amortized over the life of a program.

Q. What is the driving force behind your support for PAYS?

A. PAYS enables deeper, energy efficiency and demand savings to customers that do not have thousands of dollars of disposable income to make energy-related investments, which includes most of the residential customers across KCPL's service territory if key economic indicators are to be believed. If stakeholders are really serious about energy efficiency, they should support a PAYS program.

There have now been three independent third-party studies conducted across each of the major electric utilities. Each one has come back with similar conclusions for the need/potential and recommendations for exploration. Most recently, Ameren Missouri has verbally agreed with stakeholders to send out an RFP for a PAYS pilot program this fall with the hope of operation in 2020.

I can find no compelling reason why KCPL would not make a good faith effort to explore a one-year pilot program. At the conclusion of the one-year, either the PAYS program will be successful and the program can be ramped up or it will not and stakeholders can move on.

Q. Do you have any final comments to make regarding PAYS?

A. I look forward to reading and responding to the rebuttal comments from other stakeholders on this issue in surrebuttal testimony.

Urban Heat Island Mitigation

Q. Do you have any further recommendations regarding alternative means to value future MEEIA applications?

A. Yes. I recommend that KCPL begin investigating how MEEIA could be tailored to address the urban heat island phenomenon in Kansas City.

Q. What are urban heat islands?

A. Many urban and suburban areas experience elevated temperatures compared to their outlying rural surroundings; this difference in temperature is what constitutes an urban heat island.

On a hot, sunny summer day, the sun can heat dry, exposed urban surfaces, like roofs and pavement, to temperatures 50 to 90°F (27 to 50°C) hotter than the air,[39] while shaded or moist surfaces—often in more rural surroundings—remain close to air temperatures. Surface urban heat islands are typically present day and night, but tend to be strongest during the day when the sun is shining.

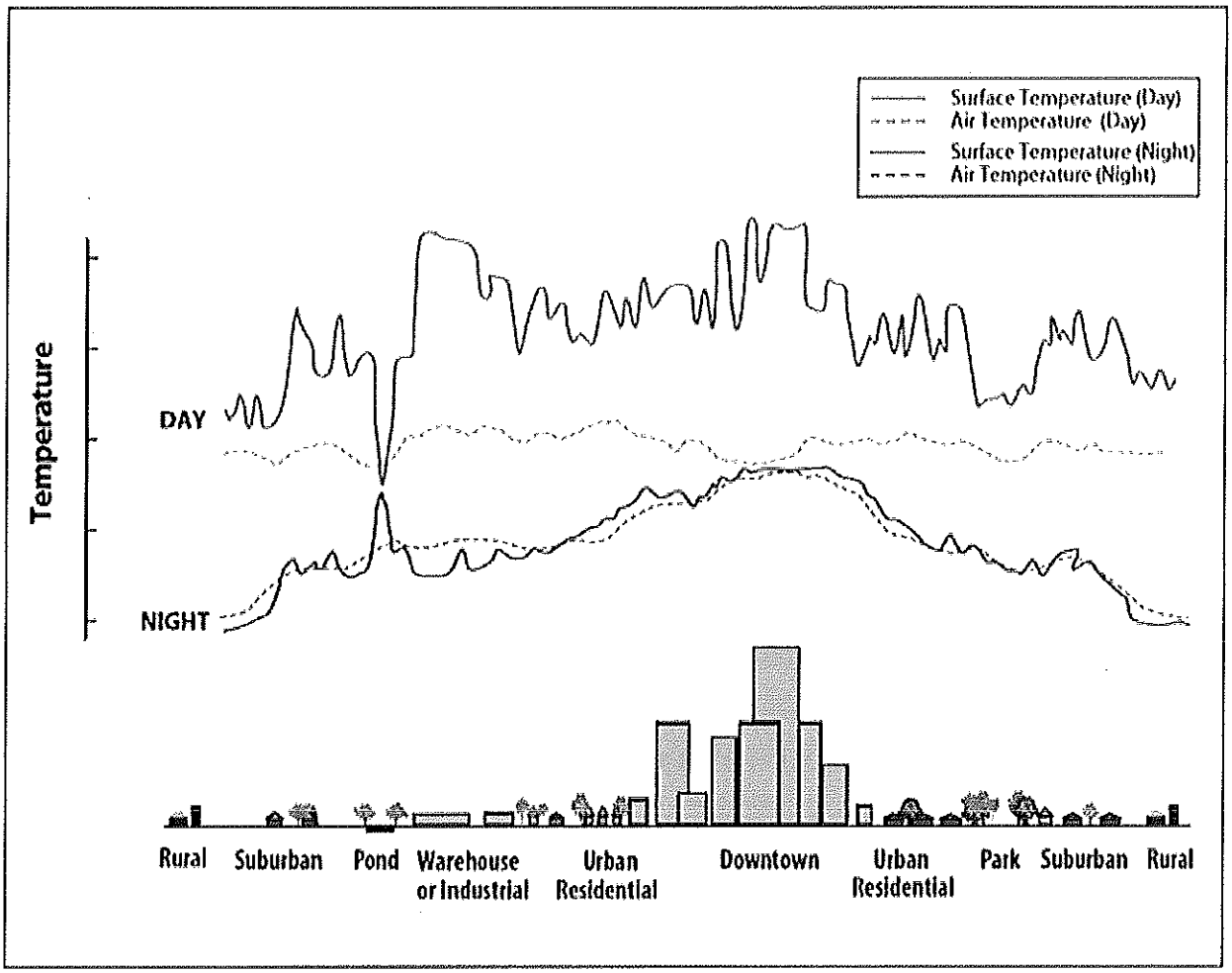
Think about a parking lot in the hot sun—most of us know that if we're walking barefoot, we should stick to the white lines and avoid the black pavement. Now scale that up across a city. The darker the surface, the less vegetation there is, and the more developed the area (e.g., conventional black roofs, sidewalks, roads and parking lots) will result in higher surface and consequently increasers the air temperature.

Surface temperatures have an indirect, but significant, influence on air temperatures. For example, parks and vegetated areas, which typically have cooler surface temperatures, contribute to cooler air temperatures. Dense, built-up areas, on the other hand, typically lead to warmer air temperatures. Because air mixes within the atmosphere, though, the relationship

[39] Berdahl P. and S. Brez. (1997) Preliminary survey of the solar reflectance of cool roofing materials. *Energy and Buildings* 25:149-158.

between surface and air temperatures is not constant, and air temperatures typically vary less than surface temperatures across an area as seen in Figure 8

Figure 8: Variations of surface and atmospheric temperatures



Q. Does the city of Kansas City's urban profile produce an urban heat island?

A. Yes. Kansas City has one of the worst heat islands in the United States and is forecasted to produce more pronounced results into the future if left alone.[40]

[40] The Weather Channel's "climate disruption index" projects Kansas City to be the fifth most impacted city in the future with only New York, Las Vegas, Minneapolis and New Orleans exceeding it. http://stories.weather.com/disruptionindex

Q. Could you provide some basis for the Urban Heat Island problem in regards to Kansas City?

A. Yes. In late 2014, the Kansas City region was named a Climate Action Champion by the White House and the Department of Energy. Area partners, included 119 local governments in the bi-state (Missouri and Kansas) area including over 4,423 square miles committed to developing a regional climate resilience strategy that would assess climate change trends for the Kansas City region, identify potential risks and vulnerabilities, and include alternative mitigation, adaptation and resilience options. A Climate Resilience Workshop series was created that was designed to help decision makers and community partners more intentionally link cross-cutting strategies across multiple sectors, including air quality, ecosystem management, energy, hazard mitigation and emergency planning, environmental justice, land use, public health, transportation and water.

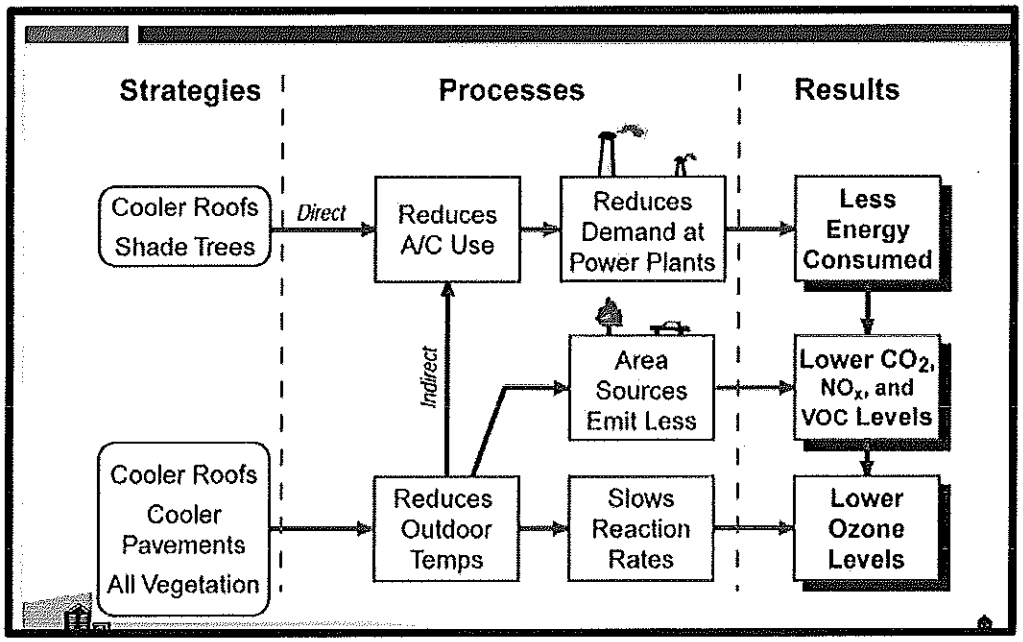
Championed and coordinated by the Mid-American Regional Council ("MARC") two separate independent research studies were conducted on the urban heat island phenomenon for the Kansas City area. The first study was conducted by a third-party research firm, Leidos, and completed in September of 2015. Titled, "Energy Savings of Heat-Island Reduction Strategies for the Kansas City Area" focused solely on the city of Kansas City. A second study was undertaken by Lawrence Berkeley National Laboratory for the greater Kansas City Region (both Missouri and Kansas). I have included the Leidos study in GM-11 and the Berkeley PowerPoint in GM-12. The Berkeley Study is expected to be released publically this fall. Additional work has on this topic that was conducted independently from MARC includes research from the University of Missouri, Kansas City ("UMKC") graduate student Kyle Reed and Climatologist Dr. Sun Fengpeng.[41]

[41] I have included a copy of Kyle Reed and Dr. Sun Fengpeng's findings in a presentation given to KCPL and other stakeholders in GM-13. GM-14 contains the presentation given by the Executive Director of the Global Cool Cities Alliance, Kurt Shickman's also on June 25 2019 at KCPL's headquarters.

Q. Why is this relevant to this MEEIA application?

A. Presently there is no supply-side deferral in the 20-year planning period for KCPL. Consequently, KCPL cannot claim to be producing benefits for all customers that outweigh the projected costs and therefore the application does not conform to MEEIA's statutory requirements for approval. What the urban heat island does is recognize a problem that has historically been overlooked and is forecasted to get much worse if no mitigation efforts are taken. In short, the Kansas City Urban Heat Island presents a problem in which a MEEIA-like tailored effort could help solve; thus producing benefits for all ratepayers. Figure 9, provides a high-level flow-chart of the strategies, process and resulting benefits in mitigating the urban heat island that could be exercised with a coordinated effort:

Figure 9: Strategies, Process and Results



Q. When did OPC get involved in the urban heat island discussion?

A. Shortly after KCPL's MEEIA filing it was evident that a traditional MEEIA could not be justified. In an attempt to find an alternative defense for an approved MEEIA portfolio I read

an article on the benefits of implementing cool roofs.[42] Further research on that topic and its applicability to the Kansas City area led me to the aforementioned work on the urban heat island in Kansas City. I then reached out to representatives from the greater Kansas City area as well as national (and international) experts on the topic. Finally, a dialogue on the potential was broached with the Staff, DE, Renew Missouri and the Company.

Q. Beyond the stakeholders who have intervened in this case, what outside parties have participated in this topic?

A. The following groups in figure 10 have attended and/or actively presented their work to KCPL in the fact-finding, problem-solving collaborative:

Figure 10: Participants in the KCPL Urban Heat Island Mitigation Collaborative to date

- US Environmental Protection Agency
- American Council for Energy Efficient Economy
- Bridging the Gap (environmental non-profit)
- US Green Building Council
- University of Missouri, Kansas City
- Mid America Regional Council
- City of Kansas City
- Global Cool City Alliance
- Lawrence Berkeley National Laboratory
- U.S. Department of Energy
- Sobolt (for-profit, the Netherlands)
- Kansas City Water
- Metropolitan Energy Center

Q. What was the feedback from the MEEIA interveners?

A. I will let those parties speak for themselves in testimony.

Q. Would KCPL be able to mitigate the urban heat island with its present MEEIA application?

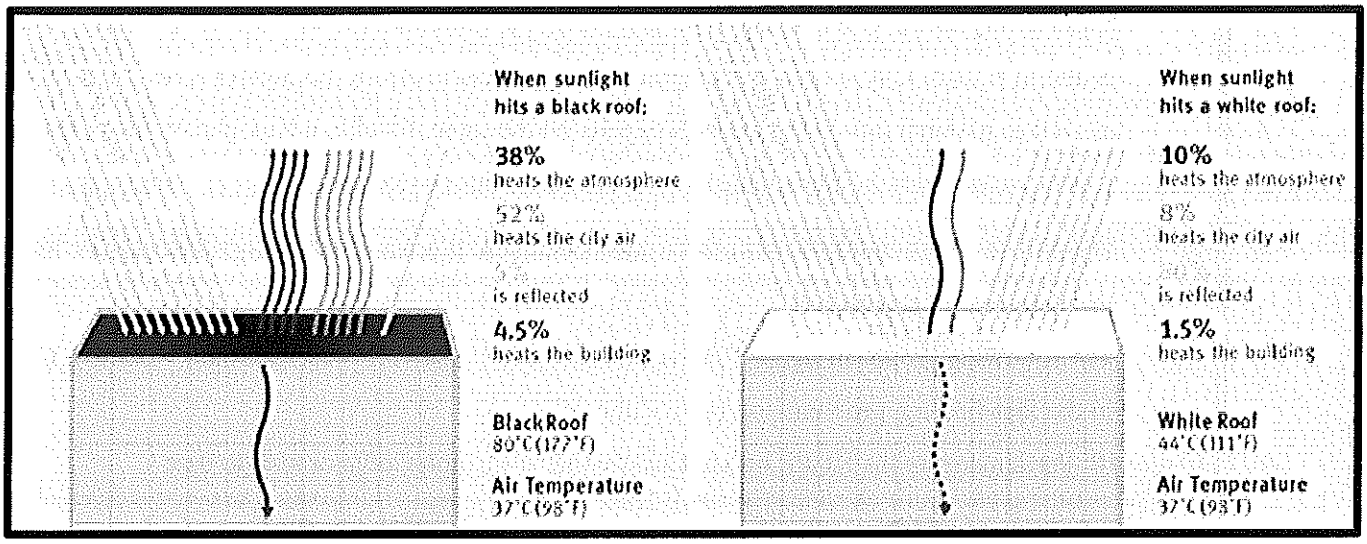
A. No. For a variety of reasons, rebating light bulbs and sending out home energy reports will have no material impact on the urban heat island.

Q. What would be an example of an action that could mitigate the urban heat island?

A. One example is to convert traditional flat rooftops to cool rooftops. Figure 11 provides an illustrative graphic of sunlight on a black and white roof.

[42] Wolfram, C. (2018) How should we use our roofs? Energy Institute at Haas. https://energyathaas.wordpress.com/2018/10/22/how-should-we-use-our-roofs/

Figure 11: How solar energy interacts with dark and highly-reflective urban surfaces



GM-15 contains a write-up titled "Highly Solar Reflective "Cool 'Roofs in Kansas City authored specifically for the KCPL collaborative by Kurt Shickman the Executive Director of the Global Cool Cities Alliance.[43]

Q. Beyond cool roofs, are there other measures?

A. Increased vegetation and increased highly-reflective urban surfaces would all move towards further mitigation.

Q. Will you be able to opine on all of the work that has been done on this topic in this testimony?

A. No. However, much of the information is included as various attachments. This topic is well established and much of the empirical foundation has already been developed by independent researchers. I believe it is a clear problem that KCPL can help mitigate through MEEIA. GM-17 is an academic peer-reviewed article titled "Capturing the true value of trees, cool roofs and other urban heat island mitigation strategies for utilities" and effectively functions as a how-to of various action items that could be utilized. The upcoming Lawrence Berkeley Study will

[43] GM-16 contains a copy of Shickman K. et al (2016) The potential impact of cool roof technologies upon heat wave meteorology and human health in Boston and Chicago. ASTM International Ninth Symposium on Roofing Research and Standards Development.

perhaps be the most useful research item moving forward and will be filed in this docket when it becomes available.

Q. What would be your recommendation regarding this topic moving forward?

A. The urban heat island problem is not an easy fix but will require a lot of coordination and various public-private partnerships. Much of the research needed to justify action has already been conducted. But additional work remains.

I recommend allocating up to $2 million dollars on research and development with funds directed at two deliverables including:

1.) Further empirical justification and coordination with relevant local stakeholders to be incorporated in a future MEEIA; and

2.) The creation of a corporate social responsibility team that actively engages local, state and national actors for funding and help on the urban heat island phenomenon.

Q. Please explain your second deliverable more.

A. As it stands, I do not believe the urban heat island can be mitigated under the traditional MEEIA framework. What I would propose is a specific time period (no more than 18 months) where KCPL would actively seek out alternative funding streams and donations to address Kansas City's Urban Heat Island problem. Ratepayers would fund that R&D and future earnings opportunities could be tied to the amount of money/donations generated from the solicitations. For example, I think it would be more than generous to provide a 10% return on any dollar generated after a certain threshold was met. So, if KCPL were to generate $100 million in grant money to implement cool roofs across Kansas City, then the Company could earn a $10 million earnings opportunity.

Stated differently, the first deliverable is focused on identifying relevant stakeholders and articulating clear and reasonable goals. The second deliverable is focused on allowing the utility and relevant stakeholders the opportunity to present the most cost-effective way to achieve those clear and reasonable goals.

Q. Would mitigating the urban heat island in Kansas City produce benefits for all customers?

A. Yes. I am confident that if left unattended Kansas City's core temperature will increase and translate to increased energy and demand costs for all customers. The proposal on the table in this case is merely a $2 million R&D investment, or literally less than half the amount of money the Company was willing to spend on a home energy report delivered three times a year in the mail for a subset of households. If the R&D investment pays off, that is, if it leads to actionable items and coordinated efforts from local leaders then all ratepayers will be better off and the Company will be in compliance with the MEEIA statute.

Q. Does this conclude your testimony?

A. Yes.

CASE PARTICPATION OF GEOFF MARKE, PH.D.

Company Name	Employed Agency	Case Number	Issues
KCP&L Greater Missouri Operations Company & Kansas City Power and Light Company	Office of Public Counsel (OPC)	EO-2019-0132	**Rebuttal:** Urban Heat Island Mitigation, PAYS, WattTime
KCP&L Greater Missouri Operations Company	OPC	EC-2019-0200	**Surrebuttal:** Deferral Accounting and Stranded Assets
Union Electric Company d/b/a Ameren Missouri	OPC	ED-2019-0309	**Memorandum:** on the "Aluminum Smelter Rate"
KCP&L Greater Missouri Operations Company	OPC	EO-2019-0067	**Rebuttal:** Renewable Energy Credits
Union Electric Company d/b/a Ameren Missouri	OPC	EO-2019-0314	**Memorandum:** Notice of Deficiency to Annual IRP Update
Rule Making	OPC	WX-2019-0380	**Memorandum:** on Affiliate Transaction Rules for Water Corporations
Working Case: Evaluate Potential Mechanisms for Facilitating Installation of Electric Vehicle Charging Stations	OPC	EW-2019-0229	**Memorandum:** on Policy Surrounding Electric Vehicles and Electric Vehicle Charging Stations
Rule Making	OPC	EX-2019-0050	**Memorandum** on Solar Rebates and Low Income Customers
Union Electric Company d/b/a Ameren Missouri	OPC	GR-2019-0077	**Direct:** Billing Practices **Rebuttal:** Rate Design, Decoupling, Energy Efficiency, Weatherization, CHP
Empire District Electric Company	OPC	EA-2019-0010	**Rebuttal:** Levelized Cost of Energy, Wind in the Southwest Power Pool **Surrebuttal:** SPP Market Conditions, Property Taxes, Customer Protections
Empire District Electric Company /Kansas City Power & Light & KCP&L Greater Missouri Operations Company/Union Electric Company d/b/a Ameren Missouri	OPC	EO-2019-0066 EO-2019-0065 EO-2019-0064 EO-2019-0063	**Memorandum:** Additive Manufacturing and Cement Block Battery Storage (IRP: Special Contemporary Topics)
Working Case: Allocation of Solar Rebates from SB 564	OPC	EW-2019-0002	**Memorandum** on Solar Rebates and Low Income Customers
Rule Making Workshop	OPC	AW-2018-0393	**Memorandum:** Supplemental Response to Staff Questions pertaining to Rules

			Governing the Use of Customer Information
Union Electric Company d/b/a Ameren Missouri	OPC	ET-2018-0132	**Rebuttal:** Line Extension / Charge Ahead – Business Solutions / Charge Ahead – Electric Vehicle Infrastructure **Supplemental Rebuttal:** EV Adoption Performance Base Metric
Union Electric Company d/b/a Ameren Missouri	OPC	EO-2018-0211	**Rebuttal:** MEEIA Cycle III Application **Surrebuttal:** Cost Effectiveness Tests / Equitable Energy Efficiency Baseline
Union Electric Company d/b/a Ameren Missouri	OPC	EA-2018-0202	**Rebuttal:** Renewable Energy Standard Rate Adjustment Mechanism/Conservation **Surrebuttal:** Endangered and Protected Species
Kansas City Power & Light & KCP&L Greater Missouri Operations Company	OPC	ER-2018-0145 ER-2018-0146	**Direct:** Smart Grid Data Privacy Protections **Rebuttal:** Clean Charge Network / Community Solar / Low Income Community Solar / PAYS/ Weatherization/Economic Relief Pilot Program/Economic Development Rider/Customer Information System and Billing **Rebuttal:** TOU Rates / IBR Rates / Customer Charge / Restoration Charge **Surrebuttal:** KCPL-GMO Consolidation / Demand Response / Clean Charge Network / One CIS: Privacy, TOU Rates, Billing & Customer Experience
Union Electric Company d/b/a Ameren Missouri	OPC	ET-2018-0063	**Rebuttal:** Green Tariff
Liberty Utilities	OPC	GR-2018-0013	**Surrebuttal:** Decoupling
Empire District Electric Company	OPC	EO-2018-0092	**Rebuttal:** Overview of proposal/ MO PSC regulatory activity / Federal Regulatory Activity / SPP Activity and Modeling / Ancillary Considerations **Surrebuttal** Response to parties **Affidavit** in opposition to the non-unanimous stipulation and agreement
Great Plains Energy Incorporated, Kansas City Power & Light Company, KCP&L Greater Missouri Operations Company, and Westar Energy, Inc.	OPC	EM-2018-0012	**Rebuttal:** Merger Commitments and Conditions / Outstanding Concerns

Missouri American Water	OPC	WR-2017-0285	**Direct:** Future Test Year/ Cost Allocation Manual and Affiliate Transaction Rules for Large Water Utilities / Lead Line Replacement **Direct:** Rate Design / Cost Allocation of Lead Line Replacement **Rebuttal:** Lead Line Replacement / Future Test Year/ Decoupling / Residential Usage / Public-Private Coordination **Rebuttal:** Rate Design **Surrebuttal:** Affiliate Transaction Rules / Decoupling / Inclining Block Rates / Future Test Year / Single Tariff Pricing / Lead Line Replacement
Missouri Gas Energy / Laclede Gas Company	OPC	GR-2017-0216 GR-2017-0215	**Rebuttal:** Decoupling / Rate Design / Customer Confidentiality / Line Extension in Unserved and Underserved Areas / Economic Development Rider & Special Contracts **Surrebuttal:** Pay for Performance / Alagasco & EnergySouth Savings / Decoupling / Rate Design / Energy Efficiency / Economic Development Rider: Combined Heat & Power
Indian Hills Utility	OPC	WR-2017-0259	**Direct:** Rate Design
Rule Making	OPC	EW-2018-0078	**Memorandum:** Cogeneration and net metering - Disclaimer Language regarding rooftop solar
Empire District Electric Company	OPC	EO-2018-0048	**Memorandum:** Integrated Resource Planning: Special Contemporary Topics Comments
Kansas City Power & Light	OPC	EO-2018-0046	**Memorandum:** Integrated Resource Planning: Special Contemporary Topics Comments
KCP&L Greater Missouri Operations Company	OPC	EO-2018-0045	**Memorandum:** Integrated Resource Planning: Special Contemporary Topics Comments
Missouri American Water	OPC	WU-2017-0296	**Direct:** Lead line replacement pilot program **Rebuttal:** Lead line replacement pilot program **Surrebuttal:** Lead line replacement pilot program
KCP&L Greater Missouri Operations Company	OPC	EO-2017-0230	**Memorandum** on Integrated Resource Plan, preferred plan update

Working Case: Emerging Issues in Utility Regulation	OPC	EW-2017-0245	**Memorandum** on Emerging Issues in Utility Regulation / **Presentation:** Inclining Block Rate Design Considerations **Presentation:** Missouri Integrated Resource Planning: And the search for the "preferred plan." **Memorandum:** Draft Rule 4 CSR 240-22.055 DER Resource Planning
Rule Making	OPC	EX-2016-0334	**Memorandum** on Missouri Energy Efficiency Investment Act Rule Revisions
Great Plains Energy Incorporated, Kansas City Power & Light Company, KCP&L Greater Missouri Operations Company, and Westar Energy, Inc.	OPC	EE-2017-0113 / EM-2017-0226	**Direct:** Employment within Missouri / Independent Third Party Management Audits / Corporate Social Responsibility
Union Electric Company d/b/a Ameren Missouri	OPC	ET-2016-0246	**Rebuttal:** EV Charging Station Policy **Surrebuttal:** EV Charging Station Policy
Kansas City Power & Light		ER-2016-0156	**Direct:** Consumer Disclaimer **Direct:** Response to Commission Directed Questions **Rebuttal:** Customer Experience / Greenwood Solar Facility / Dues and Donations / Electric Vehicle Charging Stations **Rebuttal:** Class Cost of Service / Rate Design **Surrebuttal:** Clean Charge Network / Economic Relief Pilot Program / EEI Dues / EPRI Dues
Union Electric Company d/b/a Ameren Missouri	OPC	ER-2016-0179	**Direct:** Consumer Disclaimer / Transparent Billing Practices / MEEIA Low-Income Exemption **Direct:** Rate Design **Rebuttal:** Low-Income Programs / Advertising / EEI Dues **Rebuttal:** Grid-Access Charge / Inclining Block Rates /Economic Development Riders
KCP&L Greater Missouri Operations Company	OPC	ER-2016-0156	**Direct:** Consumer Disclaimer **Rebuttal:** Regulatory Policy / Customer Experience / Historical & Projected Customer Usage / Rate Design / Low-Income Programs

			Surrebuttal: Rate Design / MEEIA Annualization / Customer Disclaimer / Greenwood Solar Facility / RESRAM / Low-Income Programs
Empire District Electric Company, Empire District Gas Company, Liberty Utilities (Central) Company, Liberty Sub-Corp.	OPC	EM-2016-0213	**Rebuttal:** Response to Merger Impact **Surrebuttal:** Resource Portfolio / Transition Plan
Working Case: Polices to Improve Electric Regulation	OPC	EW-2016-0313	**Memorandum** on Performance-Based and Formula Rate Design
Working Case: Electric Vehicle Charging Facilities	OPC	EW-2016-0123	**Memorandum** on Policy Considerations of EV stations in rate base
Empire District Electric Company	OPC	ER-2016-0023	**Rebuttal:** Rate Design, Demand-Side Management, Low-Income Weatherization **Surrebuttal:** Demand-Side Management, Low-Income Weatherization, Monthly Bill Average
Missouri American Water	OPC	WR-2015-0301	**Direct:** Consolidated Tariff Pricing / Rate Design Study **Rebuttal:** District Consolidation/Rate Design/Residential Usage/Decoupling **Rebuttal:** Demand-Side Management (DSM)/ Supply-Side Management (SSM) **Surrebuttal:** District Consolidation/Decoupling Mechanism/Residential Usage/SSM/DSM/Special Contracts
Working Case: Decoupling Mechanism	OPC	AW-2015-0282	**Memorandum:** Response to Comments
Rule Making	OPC	EW-2015-0105	Missouri Energy Efficiency Investment Act Rule Revisions, Comments
Union Electric Company d/b/a Ameren Missouri	OPC	EO-2015-0084	Triennial Integrated Resource Planning Comments
Union Electric Company d/b/a Ameren Missouri	OPC	EO-2015-0055	**Rebuttal:** Demand-Side Investment Mechanism / MEEIA Cycle II Application **Surrebuttal:** Potential Study / Overearnings / Program Design **Supplemental Direct:** Third-party mediator (Delphi Panel) / Performance Incentive

			Supplemental Rebuttal: Select Differences between Stipulations **Rebuttal:** Pre-Pay Billing
The Empire District Electric Company	OPC	EO-2015-0042	Integrated Resource Planning: Special Contemporary Topics Comments
KCP&L Greater Missouri Operations Company	OPC	EO-2015-0041	Integrated Resource Planning: Special Contemporary Topics Comments
Kansas City Power & Light	OPC	EO-2015-0040	Integrated Resource Planning: Special Contemporary Topics Comments
Union Electric Company d/b/a Ameren Missouri	OPC	EO-2015-0039	Integrated Resource Planning: Special Contemporary Topics Comments
Union Electric Company d/b/a Ameren Missouri	OPC	EO-2015-0029	Ameren MEEIA Cycle I Prudence Review Comments
Kansas City Power & Light	OPC	ER-2014-0370	**Direct** (Revenue Requirement): Solar Rebates **Rebuttal:** Rate Design / Low-Income Weatherization / Solar Rebates **Surrebuttal:** Economic Considerations / Rate Design / Cyber Security Tracker
Rule Making	OPC	EX-2014-0352	**Memorandum** Net Metering and Renewable Energy Standard Rule Revisions,
The Empire District Electric Company	OPC	ER-2014-0351	**Rebuttal:** Rate Design/Energy Efficiency and Low-Income Considerations
Rule Making	OPC	AW-2014-0329	Utility Pay Stations and Loan Companies, Rule Drafting, Comments
Union Electric Company d/b/a Ameren Missouri	OPC	ER-2014-0258	**Direct:** Rate Design/Cost of Service Study/Economic Development Rider **Rebuttal:** Rate Design/ Cost of Service/ Low Income Considerations **Surrebuttal:** Rate Design/ Cost-of-Service/ Economic Development Rider
KCP&L Greater Missouri Operations Company	OPC	EO-2014-0189	**Rebuttal:** Sufficiency of Filing **Surrebuttal:** Sufficiency of Filing
KCP&L Greater Missouri Operations Company	OPC	EO-2014-0151	Renewable Energy Standard Rate Adjustment Mechanism (RESRAM) Comments
Liberty Natural Gas	OPC	GR-2014-0152	**Surrebuttal:** Energy Efficiency
Summit Natural Gas	OPC	GR-2014-0086	**Rebuttal:** Energy Efficiency **Surrebuttal:** Energy Efficiency
Union Electric Company d/b/a Ameren Missouri	OPC	ER-2012-0142	**Direct:** PY2013 EM&V results / Rebound Effect **Rebuttal:** PY2013 EM&V results **Surrebuttal:** PY2013 EM&V results **Direct:** Cycle I Performance Incentive **Rebuttal:** Cycle I Performance Incentive

Kansas City Power & Light	Missouri Public Service Commission Staff	EO-2014-0095	**Rebuttal:** MEEIA Cycle I Application testimony adopted
KCP&L Greater Missouri Operations Company	Missouri Division of Energy (DE)	EO-2014-0065	Integrated Resource Planning: Special Contemporary Topics Comments
Kansas City Power & Light	DE	EO-2014-0064	Integrated Resource Planning: Special Contemporary Topics Comments
The Empire District Electric Company	DE	EO-2014-0063	Integrated Resource Planning: Special Contemporary Topics Comments
Union Electric Company d/b/a Ameren Missouri	DE	EO-2014-0062	Integrated Resource Planning: Special Contemporary Topics Comments
The Empire District Electric Company	DE	EO-2013-0547	Triennial Integrated Resource Planning Comments
Working Case: State-Wide Advisory Collaborative	OPC	EW-2013-0519	**Presentation:** Does Better Information Lead to Better Choices? Evidence from Energy-Efficiency Labels **Presentation:** Customer Education & Demand-Side Management **Presentation:** MEEIA: Strengths, Weaknesses, Opportunities and Threats (SWOT) Analysis
Independence-Missouri	OPC	Indy Energy Forum 2014	**Presentation:** Energy Efficiency
Independence-Missouri	OPC	Indy Energy Forum2015	**Presentation:** Rate Design
NARUC – 2017 Winter, Washington D.C.	OPC	Committee on Consumer Affairs	**Presentation:** PAYS Tariff On-Bill Financing
NASUCA – 2017 Mid-Year, Denver	OPC	Committee on Water Regulation	**Presentation:** Regulatory Issues Related to Lead-Line Replacement of Water Systems
NASUCA – 2017 Annual Baltimore,	OPC	Committee on Utility Accounting	**Presentation:** Lead Line Replacement Accounting and Cost Allocation
NARUC – 2018 Annual, Orlando	OPC	Committee on Consumer Affairs	**Presentation:** PAYS Tariff On-Bill Financing Opportunities & Challenges
Critical Consumer Issues Forum (CCIF)—New Orleans	OPC	Examining Polices for Delivering Smart Mobility	**Presentation:** Missouri EV Charging Station Policy in 4 Acts: Missouri Office of the Public Counsel Perspective
Michigan State, Institute of Public Utilities, 2019	OPC	Camp NARUC: Fundamentals	**Presentation:** Revenue Requirement

BEFORE THE PUBLIC SERVICE COMMISSION
OF THE STATE OF MISSOURI

In the Matter of the 2018 Resource Plan of Kansas City Power & Light Company Pursuant to 4 CSR 240-22	)))	File No. EO-2018-0268
In the Matter of the 2018 Resource Plan of KCP&L Greater Missouri Operations Company Pursuant to 4 CSR 240-22	)))	File No. EO-2018-0269

JOINT FILING

Pursuant to 4 CSR 240-22.080(9), Kansas City Power & Light Company ("KCP&L") and KCP&L Greater Missouri Operations Company ("GMO")(collectively "Company"), the Staff of the Missouri Public Service Commission ("Staff"), the Office of the Public Counsel ("OPC"), the Missouri Department of Economic Development—Division of Energy ("DE"), and National Association for the Advancement of Colored People ("NAACP")(collectively, the "Signatories") hereby submit to the Missouri Public Service Commission ("Commission") this Joint Filing that includes a remedy to many alleged deficiencies and concerns expressed by the Signatories of this Joint Filing regarding the compliance filing KCP&L and GMO submitted in this proceeding on April 2, 2018. Additionally, this document also identifies those alleged deficiencies that could not be resolved by the Signatories. The Natural Resources Defense Council ("NRDC"), Renew Missouri Advocates d/b/a Renew Missouri ("Renew Missouri"), the Sierra Club, Dogwood Energy, LLC ("Dogwood"), Missouri Energy Consumers Group ("MECG") and the Missouri Joint Municipal Electric Utility Commission ("MJMEUC") intervened in this case, but they are not Signatories to this Joint Filing.

In support hereof, the Signatories offer as follows related to both the KCP&L and GMO triennial IRP filings:

BACKGROUND

1. On April 2, 2018, KCP&L and GMO submitted their triennial compliance filings related to Chapter 22 of the Commission's regulations concerning the Company's Electric Utility Resource Planning. Absent any extensions approved by the Commission, KCP&L and GMO would submit an annual update report no less than twenty (20) days prior to the annual update workshop to be held on or about April 1, 2019, and will complete its next Chapter 22 triennial compliance filing on April 1, 2021.

2. On August 2, 2018, Staff, OPC, DE and NAACP submitted reports identifying concerns and in some cases alleging certain deficiencies regarding KCP&L's and GMO's 2018 Integrated Resource Plans ("IRP"). Although MECG, Dogwood, MIEC, Renew Missouri, and MJMEUC intervened in the cases, they did not submit reports.

3. The Commission's Electric Utility Resource Planning regulations provide that if the Staff, Public Counsel or any intervenor finds deficiencies in or concerns with a triennial compliance filing, they shall work with the electric utility and the other parties in an attempt to reach a joint agreement on a plan to remedy identified deficiencies and concerns and to describe any deficiencies and concerns for which no remedy was reached. The Signatories have worked together to develop such a Joint Filing. This Joint Filing represents the fruits of those efforts. With regard to the unresolved deficiencies and concerns, the Signatories agree that no hearing is required to resolve the issues, and it is unnecessary for the Commission to resolve the alleged deficiencies and concerns at this time.

AGREED UPON REMEDIES TO ALLEGED DEFICIENCIES AND CONCERNS IN FILING NO. EO-2018-0268

4. Staff's Deficiency 1: KCPL's base-case load forecast is based on a cutoff date of June 2017 for all implemented MEEIA Cycle 2 programs and does not include the load impacts of implemented MEEIA Cycle 2 demand-side programs ("DSM") through March 2019, the end of MEEIA Cycle 2. This is a violation of 4 CSR 22.030(7).

Resolution: KCP&L will comply with 4 CSR 22.030(7) in all future IRP compliance filings by including the expected load impacts of Commission-approved and implemented demand-side programs and rates in the base-case load forecast..

5. Staff Deficiency 2: KCPL's use of $116 per kW year (2015 dollars) drastically overstates KCPL's avoided capacity cost of generation, transmission, and distribution facilities, adjusted to reflect reliability reserve margins and capacity losses on the transmission and distribution systems, because Plan KAAHA (No DSM) includes no new non-renewable supply-side resources during the entire 20-years of the planning horizon. KCPL's use of $116 per kW year (2015 dollars) to value avoided capacity cost benefits is in violation of rule 4 CSR 240-20.092(1)(C).

Resolution: This deficiency is unresolved.

6. Staff's Deficiency 3: Because KCPL considered and analyzed alternative resource plans with demand-side resources when it is not in need of any new non-renewable supply-side resources for the entire 20-year planning horizon and did not consider and analyze alternative resource plans with new low cost supply-side resources to compete with the new demand-side resources on an equivalent basis, KCPL did not comply with 4 CSR 240-22.060(1) and 4 CSR 240-22.010(2) (A).

Resolution: KCP&L will complete integrated resource analysis for a new alternative resource plan with low-cost supply-side resource(s) and no demand-side resources to compete

with the alternative resources plans in this case which vary only the demand-side resources before its next Chapter 22 annual update compliance filing and before the MEEIA 3 filing.[1]

7. Staff's Concern A: Because KCPL has used drastically overstated avoided capacity cost benefits when calculating the total resource cost test (TRC) results for its demand-side programs and portfolio, the programs may not comply with 393.1075.3., RSMo.

Resolution: This concern is unresolved at this time, but the Signatories agree to work toward resolution of this concern as a part of KCP&L's MEEIA 3 application, which is expected to be filed before the end of 2018.

8. Staff Concern B: Because KCP&L's demand-side programs do not defer any non-renewable supply-side resources during the 20-year planning horizon, it is expected that there will be little, if any, benefits for customers who do not participate in the programs, resulting in programs which may be in violation of Section 393.1075.3 and .4, RSMo.

Resolution: This concern is unresolved. KCP&L disagreed with this concern as reflected in the Surrebuttal Testimony of Charles Caisley filed in Ameren Missouri's MEEIA 3, Case No. EO-2018-0211. The remaining procedural schedule in Case No. EO-2018-0211 was suspended due to ongoing efforts to present a complete settlement to the Commission; thus, Mr. Caisley's Surrebuttal Testimony was not further explored at hearing.

Staff's Concern C: Because KCPL did not include any analysis required by 4 CSR 240 20.094(4)(C)4 in its 2018 IRP, Staff is concerned that the earning opportunity component of a DSIM included in the IRP and in the anticipated KCPL MEEIA Cycle 3 application may not be as well informed as it should be.

Resolution: The Company will complete this analysis as part of its next Chapter 22 update compliance filing and as part of its MEEIA 3 application, which is expected to be filed

[1] DE is not in agreement with the Resolution of Staff Deficiency 3 between Staff and the Company.

before the end of 2018.

9. Staff's Concern D: KCPL's decision makers may have selected an adopted preferred resource plan which includes a MEEIA RAP portfolio of demand side programs which does not comply with the legal mandate in 393.1075. 4., because the RAP programs may not provide benefits to all customers, including those customers who do not participate in the programs.

Resolution: The Company will complete this analysis as part of its 2019 IRP annual update filing and as part of its MEEIA 3 application, which is expected to be filed before the end of 2018.

10. DE Deficiency 1: Preferred plan includes less-than-RAP-level DSM programs, along with demand-side rates. The failure to include true-RAP-level DSM programs in multiple alternative resource plans does not result in the equivalent valuation of demand-side and supply-side resources since KCP&L cannot present a comparative analysis to justify a reduced level of DSM programs as an alternative to at least RAP-level DSM investments. This falls short of the MEEIA statute policy of achieving all cost-effective demand-side savings (p. 4).

Resolution: This issue is unresolved for purposes of this IRP filing. However, KCP&L will include other scenarios with full RAP in its 2019 IRP Update filing and will work to address this issue with DE in its MEEIA 3.

11. DE Deficiency 2: Income-eligible DSM programs are screened for cost-effectiveness in IRP which is not required by statute. DE recommends that the Commission order the Company to provide more information on how it performed this analysis and to modify its DSM portfolio appropriately (p.5).

Resolution: This issue is unresolved for purposes of this IRP filing. However, this item may be considered as a part of the Missouri Energy Efficiency Advisory Collaborative (MEEAC) Working Group for Cost-Effectiveness.

12. DE's Deficiency 3: As part of the IRP, the Company was ordered by the Commission to, "describe and document the benefits and detriments for integrated resource planning to require achievement of targets under MEEIA." In its IRP, the Company responded by stating that the targets were "unachievable and unrealistic." The order from the Commission did not specify which targets the Company was meant to evaluate. Therefore, DE recommends that an evaluation be performed by KCP&L with the goal of determining targets that are both achievable and realistic. The Company should perform this analysis as part of the current IRP (p.7).

Resolution: This issue is unresolved for purposes of this IRP filing. However, KCP&L agrees to address the issue in its next DSM potential study.

13. DE's Deficiency 4: Demand-side technologies, storage technologies, and DERS are all at the level of commercialization where they are being implemented in the state of Missouri and across the country. Asserting that these technologies are not to a point where they could have a material impact on the selection of alternative resource plans is not supported. DE requests the Commission order the Company to evaluate these technologies in greater detail (p. 7-8).

Resolution: This concern is related to DE Deficiency 1 and is unresolved for purposes of this IRP filing, but may be potentially resolved as part of the IRP DER rulemaking process.

14. DE's Concern 1: DE believes that the values of the variables in the analyses performed were not differentiated enough to demonstrate the variety of the alternative resource plans available (p. 1).

Resolution: This concern is related to DE Deficiency 1, and is unresolved for the purposes of this IRP filing. The Company will review this concern, but at this point, the Company disagrees.

15. DE's Concern 2: There appears to be a heavy reliance on combustion turbines should capacity be needed in most of the alternative resource plans. DE provides some recommendations on evaluating additional DSM savings, PPAs and renewable resources (p.2-3).

Resolution: This concern is related to DE Deficiency 1, and is unresolved for the purposes of this IRP filing.

16. DE's Concern 3: DE encourages the analysis of greater variability in demand-side program levels and types when paired with varying levels and types of supply-side resources (p. 3).

Resolution: This concern is related to DE Deficiency 1 and remains unresolved for the purposes of this IRP filing. KCP&L will consider this concern, but notes that its IRP included more variability in DSM programs than required by the IRP Rules.

17. DE's Concern 4: Analysis is incomplete without a full evaluation of DSM in the context of how such payouts correlate to helping customers use energy more efficiently under MEEIA. The Company should conduct a complete analysis of the impacts of DSM on its customers' ability to save energy, including varying levels of participation rates and total savings to participants (p. 3).

Resolution: This concern is related to DE Deficiency 1, and remains unresolved for the purposes of this IRP filing. The Company asserts that this analysis was completed in the DSM potential study.

18. DE's Concern 5: DE does not support including DSR in the Company's plan. AMI and a new CIS system have already been deployed by the Company. Customers are already paying for these technologies in their rates, so they should be able to utilize the full extent of these technologies and their capabilities and reap the benefits without paying duplicative costs covered under MEEIA (p. 5)

Resolution: This concern has been addressed as a part of the recent KCP&L rate case. With the deployment of AMI and a new CIS, DE anticipates further DSR considerations and actions in the future in appropriate settings.

19. DE Concern 6: DE encourages the Company to strive for full utilization of AMI and CIS capabilities for DSM programs (p. 5).

Resolution: This concern has been addressed as a part of the recent KCP&L rate case. With the deployment of AMI and a new CIS, DE anticipates further DSR considerations and actions in the future in appropriate settings.

20. DE Concern 7: During EM&V process, DE recommends that the Company consider three points that are currently not listed in its procedure. First, certain DSM programs may require more than a 3-year lifespan to reach their full benefits; consequently, these programs should be allowed to develop without premature termination due to initial EM&V results. Secondly, DE notes that the statewide TRM is available to aid in the EM&V process (p. 5-6).

Resolution: This issue is resolved for purposes of this IRP filing. The Signatories agree to address this issue as a part of KCP&L's MEEIA 3 filing which is expected before the end of 2018.

21. DE Concern 8: While conducting this EM&V process, DE advises the Company to incorporate NEBs. Without the inclusion of all participants' avoided costs in the cost effectiveness tests, the test results are inaccurate (p. 6).

Resolution: This issue remains unresolved, but may be further explored through a Missouri Energy Efficiency Advisory Collaborative working group.

22. DE Concern 9: When ordered to analyze integrated distribution planning within the context of grid-modernization, the Company provided very little detail. Company also included a statement that it could not include DSM, EE, DERS, AMI, DSR, EVs and energy

storage in the analysis and would instead need to invest in its GIS system in order to do so. The Company should provide the Commission and other interested parties with information on the GIS upgrade process (p. 8).

Resolution: This concern is resolved for the purposes of this IRP filing.

23. DE's Concern 10: Company has not explained how the CCN will be implemented as part of a DR program with late-night, off-peak charging. Company should be ordered to provide both an outline of the proposed program and a thorough analysis of how it plans on implementing this program (p. 8).

Resolution: This issue is resolved for purposes of this IRP filing. The Signatories agree to address this issue as a part of KCP&L's MEEIA 3 filing which is expected before the end of 2018.

24. DE's Concern 11: Since the Company didn't provide a detailed explanation of how it plans to encourage off-peak charging, it should model some EV charging during system peak (p. 9).

Resolution: This issue is resolved for purposes of this IRP filing. The Signatories agree KCP&L will continue to refine its model related to EV charging as part of its 2019 Chapter 22 update compliance filing.

25. DE's Concern 12: As part of the IRP's Executive Summary, the Company lists a number of studies that it is working on. DE requests that copies of the AMI studies, EV study, and DSM/DER studies be made available to DE when finished. The Company should also provide an update on its progress, along with a timeline for completion of the studies, in its next IRP annual update (p. 9).

Resolution: The Company will work with DE to provide such documentation. This matter is has been resolved for the purposes of this IRP filing.

26. DE's Concern 13: DE requests that the Company review and update its analysis of EVs taking the Court of Appeals ruling into account and provide this information in its next IRP annual update (p.10).

Resolution: This concern has been addressed as a part of the recent KCP&L rate case.

27. DE's Concern 14: The Company should include information on how SB 564 affects its preferred plan as part of its next IRP update (p. 10).

Resolution: This issue is resolved. The Company will include such information in its 2019 Chapter 22 compliance filing.

28. DE's Concern 15: The Company should be ordered to evaluate the implications of its recent merger with Westar on KCP&L systems and include these results in its next IRP annual update (p. 10).

Resolution: This issue has been resolved. The Company will include such information in its 2019 Chapter 22 compliance filing.

29. NAACP Concern 1: The IRP is deficient because it is contrary to the requirement to provide the public with energy services which are safe and in a manner which serves the public interest. It does not in any manner prioritize or otherwise consider access to affordable, renewable energy for persons who reside in low income or minority communities; consider air quality benefits in low-income or minority communities; and, consider minimizing localized air pollutants and greenhouse gas emissions in low-income or minority communities. Over-reliance on coal-fired power is an assault on the health and wellbeing of people of color in this state.

Resolution: KCP&L and NAACP agree to work together to identify opportunities to provide affordable, renewable energy to persons who reside in low income or minority communities within KCP&L's Missouri service territory.

AGREED UPON REMEDIES AND RESPONSES TO ALLEGED DEFICIENCIES AND CONCERNS
IN FILING NO. EO-2018-0269

Staff raised two deficiencies and OPC raised concerns related to GMO's IRP filing (EO-2018-0269), all of which are addressed below. Otherwise DE and NAACP raised the same alleged deficiencies and/or concerns in the GMO filing as in the KCP&L filing. The same resolutions of the KCP&L alleged deficiencies and concerns, as discussed above, apply equally to GMO, and will not be repeated herein. The following addresses the deficiencies and concerns raised related to the GMO filing:

1. Staff Deficiency 1: GMO's base-case load forecast is based on a cutoff date of June 2017 for all implemented MEEIA Cycle 2 programs and does not include the load impacts of the implemented demand-side programs through March 2019, the end of MEEIA Cycle 2. This is a violation of 4 CSR 240-22.030(7).

Resolution: GMO will comply with 4 CSR 22.030(7) in all future IRP compliance filings by including the expected load impacts of Commission-approved and implemented demand-side programs and rates in the base-case load forecast.

2. Staff Concern A: Because GMO did not include any analysis required by 4 CSR 240-20.094(4)(C)4 in its 2018 IRP, the earning opportunity component of a DSIM included in the IRP and in the anticipated GMO MEEIA Cycle 3 application may not be as well informed as it should be.

Resolution: The Company will complete this analysis as part of its next Chapter 22 update compliance filing and as part of its MEEIA 3 application, which is expected to be filed before the end of 2018.

3. OPC Concerns: OPC is concerned that GMO's resource planning may not fully account for the high uncertainty in both future energy policies and energy markets—policies and

markets that are highly interdependent—and, therefore, the planned premature plant retirements in GMO's preferred plan, especially of the Sibley 3 generating unit, raises prudency issues related to stranded costs, increased risk exposure to market volatility and less reliable energy supply. OPC states that with GMO's preferred plan, GMO will increasingly rely on the capacity and energy of others.

Resolution: These concerns are unresolved.

WHEREFORE, the Signatories submit this Joint Filing for consideration by the Commission.

Respectfully submitted,

/s/ Casi Aslin

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CERTIFICATE OF SERVICE

I do hereby certify that a true and correct copy of the foregoing document has been hand-delivered, transmitted by e-mail, or mailed, First Class, postage prepaid, this 26th day of October, 2018, to counsel for all parties on the Commission's service list in this case.

/s/ James M. Fischer

James M. Fischer

BEFORE THE PUBLIC SERVICE COMMISSION
OF THE STATE OF MISSOURI

In the Matter of KCP&L Greater Missouri Operations Company's 2018 Triennial Compliance Filing Pursuant to 4 CSR 240-22	)))	Case No. EO-2018-0269

COMMENTS OF THE OFFICE OF THE PUBLIC COUNSEL

COMES NOW the Office of the Public Counsel and pursuant to Commission Rule 4 CSR 240-22.080(8), offers the following comments on KCP&L Greater Missouri Operations Company's ("GMO") 2018 Triennial Compliance Filing.

1. As described in the Commission's regulations, the fundamental objective of the Commission's Electric Utility Resource Planning process for electric utilities is to provide the public with "energy services that are safe, reliable, efficient, at just and reasonable rates, in compliance with all legal mandates, and in a manner that serves the public interest and is consistent with state energy and environmental policies." Commission Rule 4 CSR 240-22.010(2).

2. In their triennial filings Missouri electric utilities are required to document compliance with the objectives of the resource planning rules, and stakeholders are permitted to offer comments. Rule 4 CSR 240-22.080(8).

3. GMO's 2018 triennial report continues material changes from its last annual update, in particular the announced plan to accelerate retirement, between GMO and Kansas City Power & Light Company, of nearly 900 MW of base-load generation capacity. As described in the attached *Memorandum*, OPC is concerned the premature retirements, especially of the Sibley 3 generating unit, creates significant risk by not fully accounting for the highly uncertain, interdependent energy market and policy arena in which the utility now operates. More

specifically, the premature closure of base load-serving generation in favor of unknown capacity contracts through the SPP energy market raises prudency concerns moving forward by potentially producing significant stranded costs, increased risk exposure from market volatility and future reliability concerns. With this preferred plan, GMO would increasingly rely on the capacity and energy of other utilities.

4. OPC remains concerned with the degree in which GMO's preferred plan deviates from its previous Triennial filing and that it may not fully account for the highly uncertain, interdependent energy market and policy arena the revised "preferred" plan would operate in. As such, the early forced retirement of base load generation[1] raises prudency concerns moving forward by potentially producing significant stranded costs and future liabilities. OPC has raised these concerns in GMO's currently contested rate case (Case No: ER-2018-0146) and believes that venue is the proper forum for further dialogue at this point.

WHEREFORE, Public Counsel submits these Comments included in the attached *Memorandum.*

Respectfully,

/s/ Nathan Williams

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[1] There are 891 MW of "base load" generation planned for retirement between GMO and KCPL.

CERTIFICATE OF SERVICE

I hereby certify that copies of the foregoing have been mailed, hand-delivered, transmitted by facsimile or electronically mailed to all counsel of record this 30th day of August 2018.

/s/ Nathan Williams

MEMORANDUM

To: Missouri Public Service Commission Official Case File,
Case No. EO-2018-0269

From: Geoff Marke, Chief Economist
Office of the Public Counsel

Subject: OPC response to triennial KCP-GMO IRP

Date: August 30, 2018

Overview:

Kansas City Power and Light Greater Missouri Operations ("GMO" or "the Company") 2018 triennial IRP filing has continued to maintain material changes carried over from its last annual update. Most notably, the preferred plan includes both earlier retirement dates and additional units, most notably the inclusion of Sibley 3 (364 MW). A breakdown of 2016's retirements compared to the preferred plan in its triennial IRP can be seen in figure 1 below.

Figure 1: 2016 and 2018 triennial IRP preferred plan generation plant retirements

2016 IRP Generation Plant	MW	Retirement Date
Sibley 1 & 2	97	2019
Lake Road 4/6	96	2021

2018 IRP Generation Plant	MW	Retirement Date
Sibley 1	50	Retired
Sibley 2 & 3	411	2018
Lake Road 4/6	96	2019

The Company cites associated environmental compliance costs, long term forecasts of low natural gas prices and changes to SPP's reserve margins as the primary drivers for early retirement.

OPC's Response:

Based on OPC's review of the triennial IRP, the Company has met the minimum filing requirements for the plan and is in compliance with 4 CSR 240-22. ("IRP Rule"). However, OPC is again concerned with the degree in which GMO's preferred plan deviates from its previous Triennial filing and may not fully account for the highly uncertain, interdependent energy market and policy arena the revised "preferred" plan would operate in. As such, the early forced retirement of base load generation[1] raises prudency concerns moving forward by potentially producing significant stranded costs and future liabilities. OPC has raised these concerns in

[1] There are 891 MW of "base load" generation planned for retirement between GMO and KCPL.

GMO's currently contested rate case (Case No: ER-2018-0146) and believes that venue is the proper forum for further dialogue at this point.

BEFORE THE PUBLIC SERVICE COMMISSION
OF THE STATE OF MISSOURI

AFFIDAVIT OF GEOFF MARKE

STATE OF MISSOURI)
) SS.
COUNTY OF COLE)

COMES NOW GEOFF MARKE and on his oath declares that he is of sound mind and lawful age; that he contributed to the foregoing *COMMENTS;* and that the same is true and correct according to his best knowledge and belief.

Further the Affiant sayeth not.

Geoff Marke
Chief Economist

JURAT

Subscribed and sworn before me, a duly constituted and authorized Notary Public, in and for the County of Cole, State of Missouri, at my office in Jefferson City, on this 30th day August 2018.

NOTARY PUBLIC NOTARY SEAL STATE OF MISSOURI

JERENE A. BUCKMAN
My Commission Expires
August 23, 2021
Cole County
Commission #13754037

Jerene A. Buckman
Notary Public

My Commission expires August 23, 2021.

Case No. EO-2019-0132

Schedule GM-4 to

Geoff Marke's Rebuttal

Testimony has been deemed

"Confidential" in its entirety

Digital Life: Real tech payoff that comes with a (remote)risk

BY SCOTT CANON
scanon@kcstar.com

https://www.kansascity.com/news/business/technology/article160430799.html
July 10, 2017 07:00 AM
Updated July 10, 2017 11:31 AM

Let's get you started on a smart home. While we're at it, how 'bout we save you some money? Maybe ease up on the carbon dioxide your house belches into the atmosphere. And we can do this while making the temperature in your castle more regularly comfy.

Now get the power company to pay for the new gadgetry that makes it all possible. Better yet, pocket 50 clams if you knock out the sub-30-minute job of swapping in the hockey puck-sized Nest thermostat for your old model.

You get a nifty gadget in your house worth about $200 that should cut your gas and electric bills while making it easier to adjust the temperature in your house, including by letting the magic of machine learning do it more efficiently than you would.

If you live in Missouri, Kansas City Power & Light Co. *wants* you to take them up on the offer, *wants* to pay you $50 for the simplest of wiring jobs.

What's the catch? It's theoretical and probably worth the trade-off. We'll circle back to that.

Why the high-tech giveaway? KCP&L has two chief incentives: complying with a state law on energy efficiency and keeping up with power demands.

Missouri demands that power companies take action to limit power consumption and the pollution it creates. That's partly why utilities are investing in wind turbines and solar panels. Kansas regulators have not approved a similar thermostat giveaway.

The company contends it can save customers and shareholders money if it can keep peak energy demands down. KCP&L reasons use of the Nest, for instance, will help it avoid building another coal- or natural gas-burning plant.

To qualify for the program (try 888-864-3923 or nest.com/kcpl), you need central air conditioning and home Wi-Fi.

The Wi-Fi matters because it allows the utility to seize control of the thermostat on the steamiest of days and turn up the temperature three degrees. It did that three times last year. But customers get a warning when it happens, on the Nest thermostat and on their phones if they've installed an app. You can override, chilling yourself as much as you want.

KCP&L has given away about 16,000 smart thermostats in the past 15 months. This year, it expects the Nests planted in homes to cut electricity consumption by 7.4 million killowatt hours, enough to power more than 6,000 homes for a year.

The wall-mounted wonder was invented by two former Apple engineers and purchased by Google for $ 3.2 billion. Programmable thermostats have been on the market for decades. They allow users to set a different temperature for the evenings, another for the workday, another for the weekends.

Smart thermostats do that for you, but with more savvy. They check the internet for weather reports and adjust accordingly. They learn your patterns of your life and adapt. If you're too lazy to get up from the couch, you can tweak the heat from your smartphone (although you don't need one for the thermostat to work).

Back to that catch. First, you're sharing data about your lifestyle with Nest, meaning Google. Marketers armed with the patterns of your comings and goings could some day use it as fresh ammunition to tempt you toward their products — likely in ways that you'll be blind to.

Then there's hacker risk. Nest founder Tony Fadell has said the Nest is built with "bank level security" and that the business will fail "if people don't trust it" Yet researchers have said the thing can be cracked by someone who has access to it during delivery or in your home (*cough, ex-boyfriend, cough*).

Once exploited, scientists from the University of Central Florida said, "what was once a learning thermostat has been transformed into a spy" able to get into your Wi-Fi network and everything that connects to it.

Such is the dilemma of virtually everything about the digital era and cool things that come from internet connections. Privacy traded for convenience.

The Nest poses a pretty small risk. Buyer beware, even when something's free.

The most recent "Deep Background" podcast discusses the Nest and whether technology is worth its trade-offs.

Where does your data go? Mapping the data flow of Nest

mastersofmedia.hum.uva.nl/blog/2017/10/25/where-does-your-data-go-mapping-the-data-flow-of-nest/

October 25, 2017

Introduction

With this research project, we set out to investigate the volume of data created and shared from smart home devices.

Intrigued by the claim that our homes are getting smarter and more connected, we aimed to find out where the data and what type of data of such connected devices end up. We chose to use Nest, a leading company in the smart homes sector, as a means to investigate the data flows of connected devices. Google bought Nest Labs for $3.2bn in 2014. It is likely that Google's motivations for the purchase lay not with the business of home automation as much as the data that these smart home devices, entangled with the growing Internet of Things, have the potential to collect. IBM's CEO Ginni Rometty has labelled big data as "the new oil" (Deutscher), and Google is a platform that knows this like no other.

In October 2011, Nest Labs introduced their smart, a self-learning thermostat connected to the Internet that improves climate control of homes and businesses to save energy. The user has to normalize the thermostat in order to provide his personal reference data set. Nest studies the timetable of this user and learns, for instance, his preferred house temperature. Using integral sensors and mobile geotracking the Nest moves into energy saving mode when it comprehends that the user is not home. Nest also produces the Nest Protect smoke and carbon monoxide detector, the Nest Cam with night vision, two-way talk, sound and motion alerts, as well as optional Nest Aware cloud services. The Nest App brings together all devices, potentially allowing access to the Thermostat, Cam, Protect and other devices in a user's pocket.

On the Nest website we found 116 other third-party devices that work with Nest (Works With Nest). They range from baby cams to smart fridges and light bulbs. These devices track numerous data points from users, including device usage metrics, IP addresses, contact and payments details, and more. This study aims to map the possible data flows between these devices, and to show which companies and entities can potentially make use of the user information from Nest activities. We also propose a creating a public website to highlight this information flow to Nest users.

It is interesting to examine how much data is gathered by all these devices and what companies have access to it. We will look into the specific data that the Nest collects, the details of which may not be clear to consumers that extensive personal information is assembled and potentially shared with third parties. We focused on smart home technology. This technology consists of "applications like security systems and remote monitoring that adapt to a user's presence and habits" (Zeng 2).

Relevance: The internet of things

The Internet of Things, defined as a global Internet-based technical architecture is the concept of connecting any device to the Internet to provide smarter insights on their usage. This can include a large number of appliances, for example, fridges, coffee machines, lamps and thermostats (Morgan). The main focus of the Internet of Things is that everything that can connect, will be connected. To illustrate, the number of devices connected to the Internet by 2021 is estimated to be around 46 billion (Juniper Research). Alongside the increase in devices comes an increase in the volume of data being collected by such technology.

The connection to the World Wide Web allows one to live life just a bit easier, but these devices, often full of sensors and cameras, raise privacy related questions and critique. For example, what happens with the data that is inevitably gathered and with whom is it shared (McDonald)? A debate about the security of these devices is also prevalent (Weber 24). However, this paper will only focus on the debate about sharing of information. We are moving towards a world in which more and more devices and products are connected to the internet, making them remotely accessible from other devices. It is unclear however who receives all the data that is gathered by these devices, and what is done with this data. That leaves us with one important question: who is actually the true owner of that information?

Methodology: Data Gathering

In setting out to analyse the data flows associated with Nest technologies, we identified two relevant strands to our research. The first was the data and information that Nest devices tracked themselves from the user. For this, we were interested in the information captured by the devices themselves.

Secondly, it was necessary to gather information about all the third party integrations and devices that could potentially be connected to Nest devices. To do this, we consulted the Works With Nest website, which provides product descriptions of all 116 devices that can be connected to Nest products (Works With Nest). Using a website scraper, we compiled a spreadsheet of all the names and descriptions of these devices, which we manually tidied and added additional context to, such as detailing the Nest products they related to. As one of the questions we were hoping to answer in this research looked to connect the links in corporate ownership between the manufacturers of the devices sharing and making use of the data, we also conducted research into the parent owners of each device. Once all this information was displayed in the spreadsheet, we were able to proceed to visualising the data flows.

1. Data collected by Nest devices

First, we looked at the information and data utilised by Nest. To find the complete list, we consulted the legal terms and conditions of Nest technologies, and itemised each data point listed on the site (Nest). We made note of every piece of personal information and data that users consented to submitting once they purchased a Nest device and created their online profile and compiled a document with all the information we could gather on these data points. Some of the data relevant to all devices, such as the IP address and mobile location data of

users, comprises of 'indexical data', which potentially allows for identification. According to Rob Kitchin, indexical data is important because it "enable(s) large amounts of non-indexical data to be bound together and tracked through shared identifiers, and enable discrimination, combination, disaggregation and re-aggregation, searching and other forms of processing and analysis" (10). Flagging this in the context of security vulnerabilities is important.

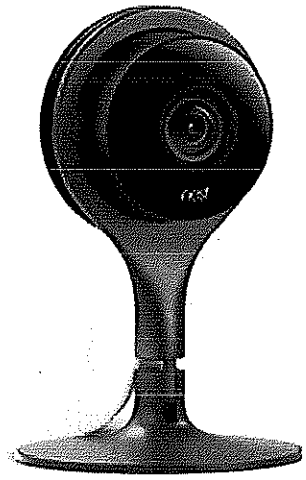
Other information was specific to the device, such as smoke and carbon monoxide levels (Nest Protect), and access to video content (Nest Cam). In total, these were the number of data points collected by each Nest device.

Device	Thermostat	Cam	Protect
No. of data points captured	24	25	26

Next, we created graphics illustrating all the information tracked and stored by individual devices, taking the information from obscured legalese on the terms and conditions section of the Nest website and placing it alongside the devices themselves.

Nest Cam Data Capture

Wi-Fi password
IP Address
Account email addresses
Name
Profile photo
Mobile location data
Bluetooth data
Log entries
Technical information
Smoke levels
Current temperature
Humidity
Room movement



Wi-Fi network name (SSID)
Home address
Device location
Carbon monoxide levels
Ambient light
Sensor status
Profile photo
Device model
Serial number
Software version
WiFi signal strength
Battery charge level
Microphone audio

A full list of individualised data points per device can be seen here. From here, we proceeded to analyse the data connections between the Nest devices and third party integrations.

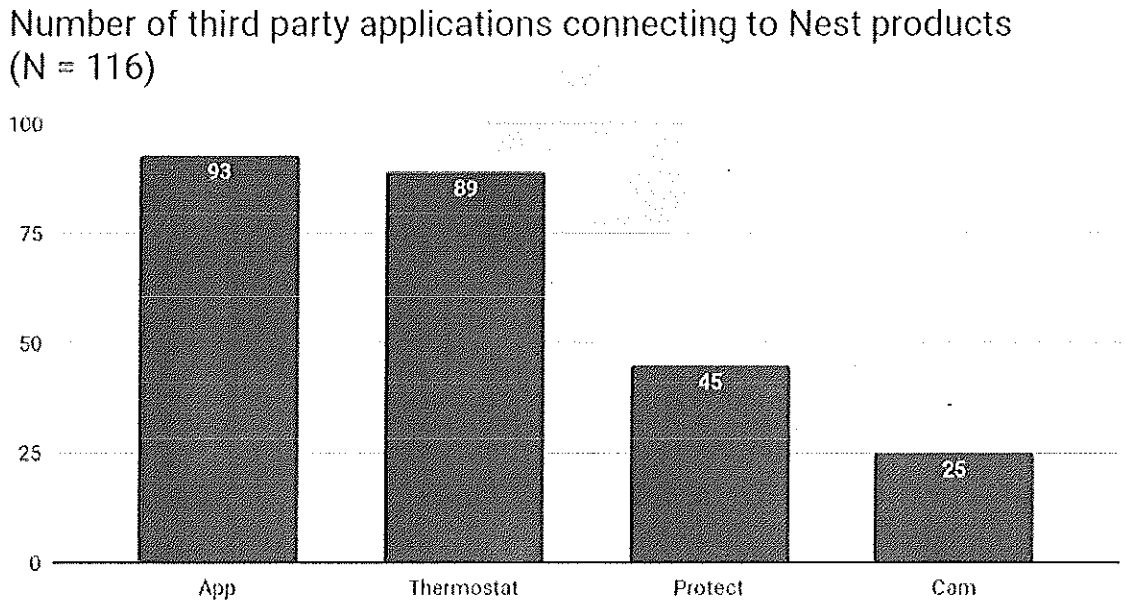
2. Sharing of data with third party integrations and devices

This section will mainly deal with the different visualisations and what they could bring to light. For this, the visualisation is was inspired by Dodge and Kitchin's visualisation in abstract space, to show how different applications connect to Nest products (42).

A step-by-step guide of the data gathering and visualisation can be found overhere. As previously discussed, third parties are able to integrate their products with the Nest using its API. Users give their consent to Nest to share their data to the third party applications they use by accepting the terms and conditions. Our use of mapping techniques was informed by Dodge and Kitchin's view that mapping can be used to "exploit the mind's ability to more readily see complex relationships in images, providing a clear understanding of a phenomenon, reducing search time, and revealing relationships that may otherwise not have been noticed" (2).

To provide a greater insight on the possible data flows that come with integrating third party applications into Nest products, we set out to map the hypothetical flow of data between devices. An important sidenote to this, is that it is not possible to map out the actual data flows, since we are limited to the descriptions of possible data flows.

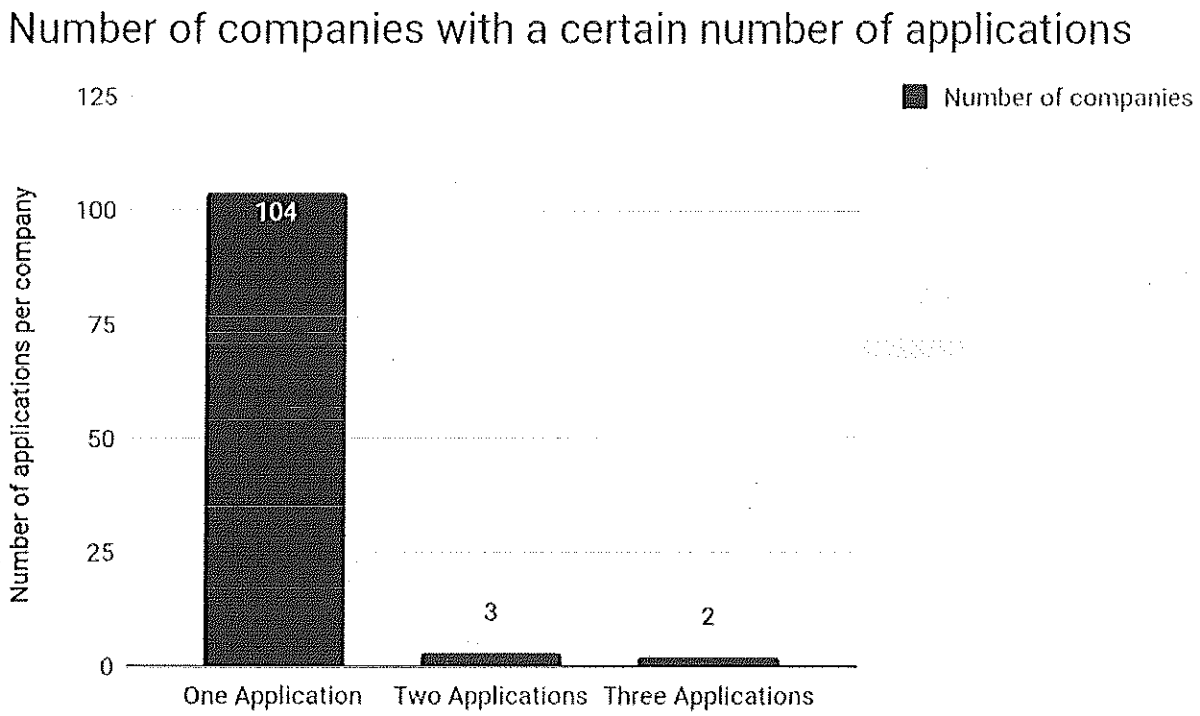
Firstly, an overview was created of the number of different third party applications that connect to each of the Nest applications (Thermostat, App, Cam and Protect). This is because each different Nest product collects different data, even though a lot of it is similar. Nest provides info on what applications use which products and one application can be used with multiple devices. To visualize this, we had to manually go through each webpage of third party applications and note down what each application used. The dataset can be found over here. This resulted in the following graph.



As shown in the graph the Nest app and Thermostat are easily the most connected devices. This can be explained by the fact that the Thermostat and the App were the first Nest products to come out.

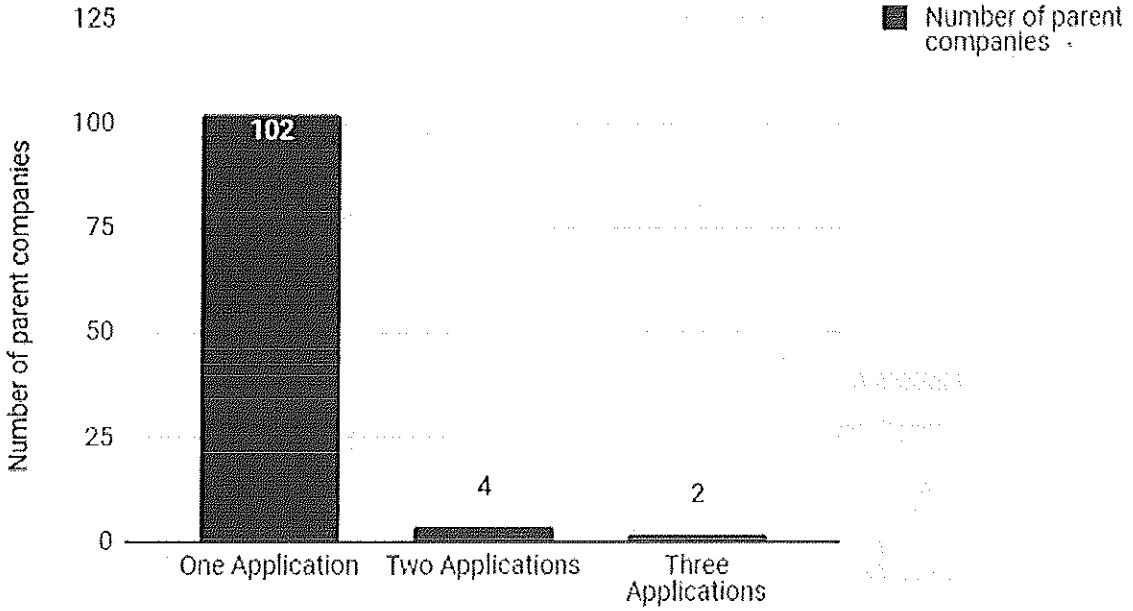
Even though this provides an overview of the number of third party applications connecting to Nest products, this does not necessarily provide an answer to the question of whether these third party applications are owned by a number of large companies, or by a large number of independent companies.

By creating an overview of each different company that owns one of these applications, we were able to assess if some companies have a large number of applications. This provided us with the following graph.



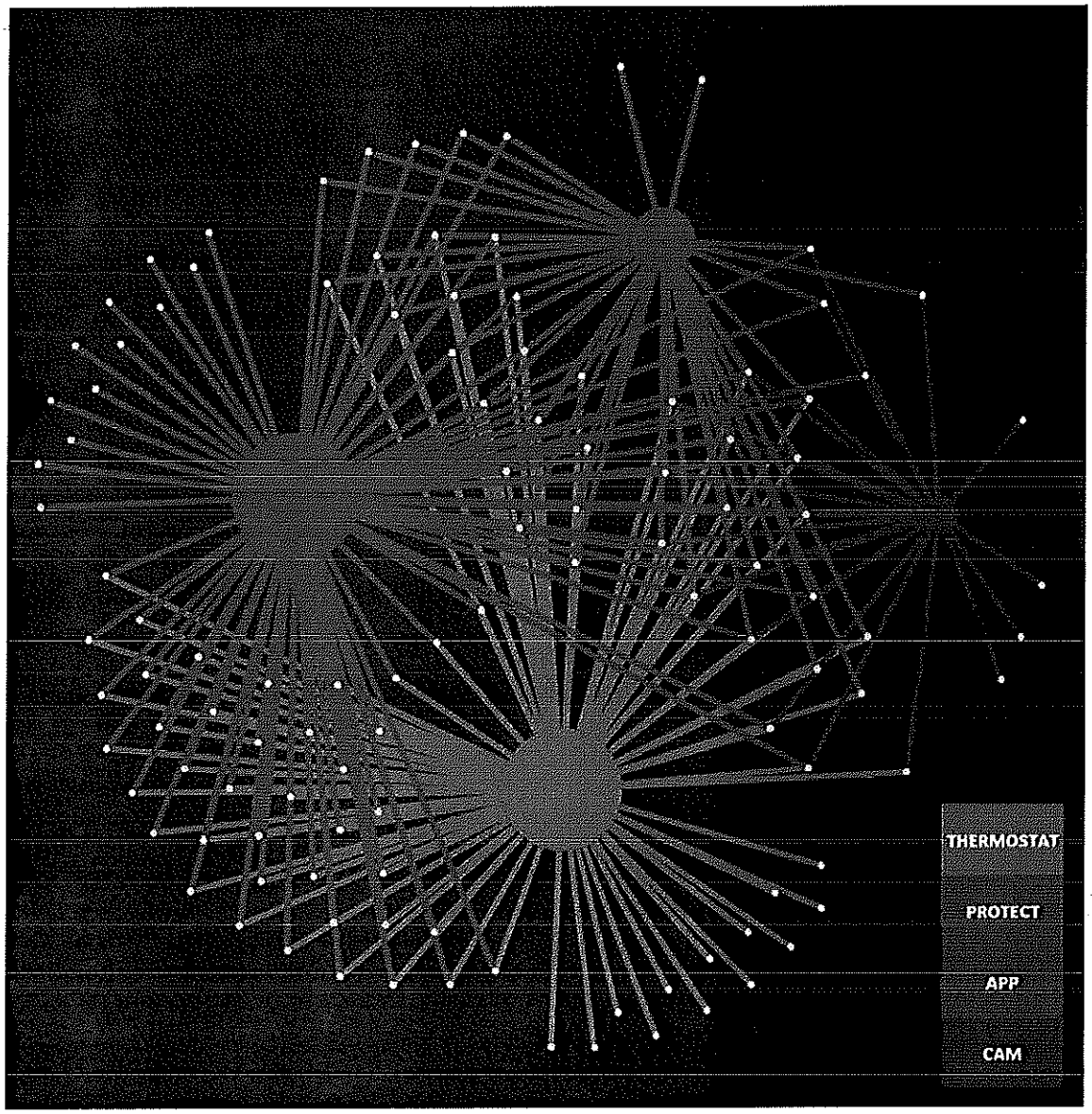
As shown in the graph, only a few of the companies have more than one application, however, no company has more than 3 (Deviate, 2; MaaDoTaa, 2; Roomie Remote, 2; Google, 3; IFTTT, 3). This shows that so far there are no clusters of companies dominating the manufacture of integrations connected to Nest.

However, a large number of companies are owned by parent companies – for example, Nest and Google are owned by Alphabet. Consequently, a number of the companies in the previous graph could be owned by the same company, to assess whether this is true, we created another graph, where each company is replaced by its parent company. This led to the graph below, which interestingly only added one extra company (Whirlpool) that has 2 or more applications, the other companies have either changed ownership.

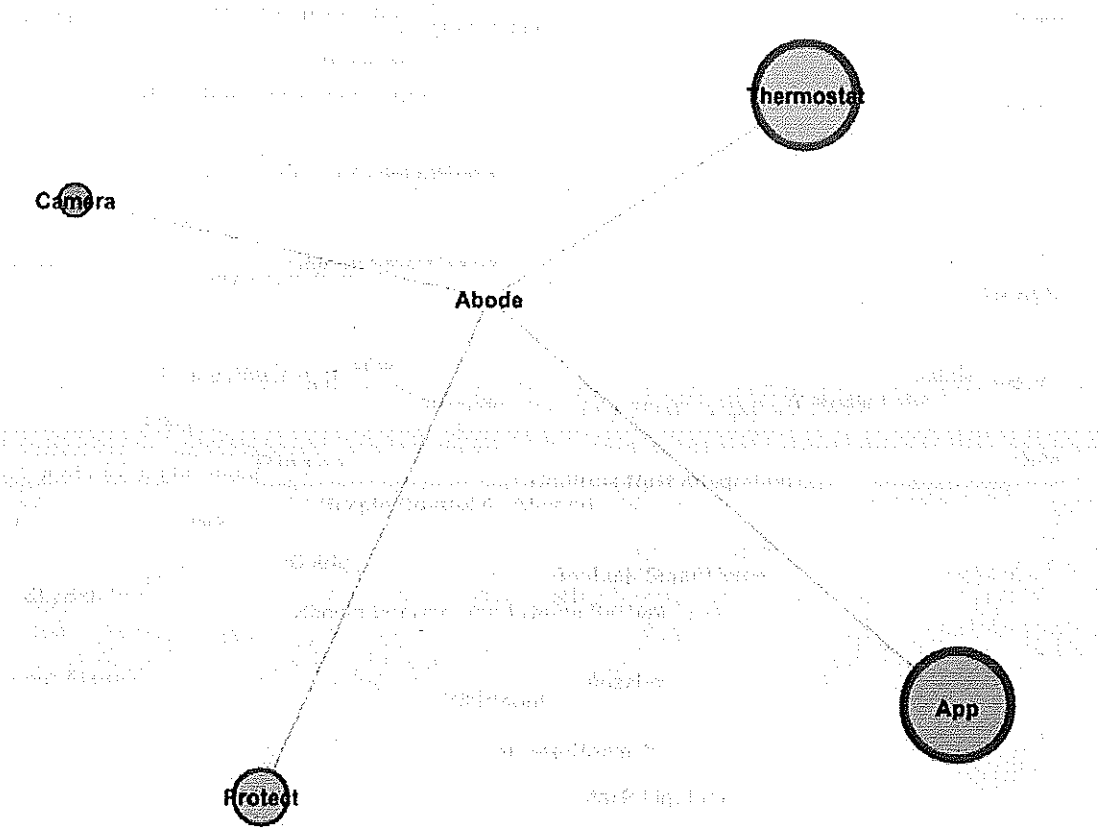


This is interesting because it was possible that there would be a small number of large companies that would have the biggest share in the number of applications. This visualisation however, shows that this is not the case.

Lastly, a visualisation could also be made of the different connection each different application makes with the different Nest products. For example, an application that links with the Cam and the Thermostat, will be clustered towards those two, while being further from the App and Protect. Furthermore, each outgoing edge will be coloured as it's target. This shows the different connections the third party applications make and also shows what data could be shared between devices.



This could be used to further provide insight to consumers to where their data could possibly go. An idea for this would be to provide an app, or a website, where people can fill in the applications they use. After this, they could see to which Nest product the application is connected, after which it is possible to show which data could possibly be shared. An example is shown below.



This way, consumers could be informed about the amount of data they share, consciously or unconsciously, and that could prove to be useful possibly.

Utilising new media: Illustrating data flows for Nest consumers

Armed with this information about the huge volume of potential data collection and sharing via Nest devices, we would propose creating a simple website which Nest customers could use to review exactly what information and data they are potentially making available to Nest and their partners, even at aggregate level. Using menus, the user would be able to select the Nest device(s) that they use in their home, and add on any integrations that they also use. This would create a visualisation using the information we have gathered to show all data points that could be stored and shared by their single device. The goal is to improve visibility around the issue of data sharing from smart home devices, and provide some insight into the nature of data capitalism as practiced by technology companies such as Nest. With the smart homes industry blossoming, this is an area with potentially huge big data privacy concerns. As Nissenbaum and Baracos have argued, informed consent by way of tick box and mass anonymity alone are "ineffective against the novel threats to privacy posed by big data" (32). Arming the consumer to make better decisions about the use of their data is one way of ensuring greater transparency around the issue.

Conclusions

In concluding, we have gained an insight in the type of data that one of the leading companies

in the growing smart home space is collecting and sharing with partners. While their collection of the data is perfectly legitimate, much of the information is largely 'buried' in the legal terms and conditions on their site. By placing this information in clearer terms, we are able to demonstrate the data collection capabilities of each of the Nest devices. We have also demonstrated the potential overall reach of third party sharing of data with other companies, illustrating the connection between the devices and their sharing of data.

Further questions arise as a result of this research. The most relevant relate to the implications that such big data harvesting has on users, and the potential uses of aggregate levels of such information. With all the benefits of connected devices also come risks concerning security and privacy violations with the vulnerability of hacking being one of the most urgent.

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Targeting energy justice: Exploring spatial, racial/ethnic and socioeconomic disparities in urban residential heating energy efficiency

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HIGHLIGHTS

- Develops statistical model to predict block group (BG) residential heating energy use intensity (EUI), an energy efficiency proxy.
- Bivariate and multivariate analyses explore racial/ethnic and socioeconomic relationships with heating EUI.
- BGs with more racial/ethnic minority households had higher heating EUI.
- BGs with lower socioeconomics had higher heating EUI.
- Mapping heating EUI can facilitate effective energy efficiency intervention targeting.

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ABSTRACT

Fuel poverty, the inability of households to afford adequate energy services, such as heating, is a major energy justice concern. Increasing residential energy efficiency is a strategic fuel poverty intervention. However, the absence of easily accessible household energy data impedes effective targeting of energy efficiency programs. This paper uses publicly available data, bottom-up modeling and small-area estimation techniques to predict the mean census block group residential heating energy use intensity (EUI), an energy efficiency proxy, in Kansas City, Missouri. Results mapped using geographic information systems (GIS) and statistical analysis, show disparities in the relationship between heating EUI and spatial, racial/ethnic, and socioeconomic block group characteristics. Block groups with lower median incomes, a greater percentage of households below poverty, a greater percentage of racial/ethnic minority headed-households, and a larger percentage of adults with less than a high school education were, on average, less energy efficient (higher EUIs). Results also imply that racial segregation, which continues to influence urban housing choices, exposes Black and Hispanic households to increased fuel poverty vulnerability. Lastly, the spatial concentration and demographics of vulnerable block groups suggest proactive, area- and community-based targeting of energy efficiency assistance programs may be more effective than existing self-referral approaches.

1. Introduction

Climate change concerns highlight a number of serious social and environmental inequalities that can be traced to energy consumption. These concerns form the foundation of a growing field of scholarship, and activism, on energy justice. For instance, Hernández (2015) issued "*A Call for Energy Justice*," which acknowledged four basic human rights to energy: the right to a healthy, sustainable energy production; the right to best available energy infrastructure; the right to affordable energy; and the right to uninterrupted energy service. For the many US households suffering in fuel poverty, nearly 14 million with unpaid utility bills and 2.2 million with disconnected utilities, these rights are unfulfilled promises (Seibens, 2013). Fuel poverty (also known as energy poverty or energy insecurity) is the inability of households to afford energy services for adequate heating and cooling resulting in uncomfortable indoor temperatures, material deprivation, and accumulated utility debt (Li et al., 2014, Hernández 2013, Buzar, 2007; Boardman, 2012). More than a matter of mere comfort, indoor temperatures that are too cold in winter or too hot in summer have detrimental mental and physical health impacts, including death, for vulnerable populations like children, the elderly, and racial/ethnic minorities (Anderson et al., 2012; Liddell

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0301-4215/

and Morris, 2010, Howden-Chapman et al., 2009, Howden-Chapman et al., 2007, Klinenberg, 2002; Taylor et al., 2001). A key measurement of fuel poverty is the proportion of gross income spent on home energy costs, or the energy burden. Low-income US households have an average heating energy burden of 4.7% that is more than double the 2.3% national average and more than four times the 1.1% average burden for high-income households (US Department of Health and Human Services [HHS] 2011). Analysts consider a heating energy burden greater than 2% unaffordable (Fisher et al., 2014).

However, fuel poverty is more than a straightforward relationship between household income and energy costs. The concept became prominent in the 1980s and has been well-studied in the UK (see special issue Volume 49 of this journal) and even codified in law with the passage of the Warm Homes and Energy Conservation Act of 2000. Investigations of fuel poverty, including those beyond the UK, demonstrate that a pure financial assessment of its prevalence does not account for the variety of factors and relationships that produce and sustain it. Buzar (2007) advocated a "relational approach" to studying fuel poverty, one that combines understanding energy policy, housing infrastructures, and the lived experience of the fuel poor. Hernandez and Bird (2010) found the incidence of high inner-city energy burdens was due in part to a lack of energy assistance funding, a lack of housing and energy policy coordination, and a lack of understanding the social and economic benefits of energy conservation and efficiency. Harrison and Popke (2011) suggested fuel poverty be understood "as a geographical assemblage of networked materialities and socioeconomic relations" determined by household socioeconomic characteristics, material conditions of the home, and the structure that defines the provision of energy.

The conceptualization of fuel poverty as an energy justice concern speaks to the energy-related distribution, procedure, and recognition of "what constitutes the basic rights and entitlements of sufficient and healthy everyday life" (Walker and Day, 2012). Consequently, fuel poverty violates the basic principle of distributive justice. Distributive justice is the idea that all members of society have the right to equal treatment, and that outcomes should be fairly distributed, and provides moral guidance for the political processes and structures that affect the distribution of economic benefits and burden across and within society (Rawls, 1971; Sen, 1999 Schlosberg, 2013). As a distributive injustice, fuel poverty results from three interconnected inequalities: income inequality, inequality in energy prices, and inequalities in housing and energy efficiency (Walker and Day, 2012). Although fundamentally, fuel poverty is a problem of distributional injustice, its production and persistence are also the result of an injustice in recognition of the specific energy-related needs of vulnerable populations, and procedural injustice related to access to information, meaningful participation in decision-making, and access to legal processes for achieving redress or challenging decision-making processes (Walker and Day, 2012).

Addressing the distributive injustice of fuel poverty requires first determining what should be fairly distributed. Since inequalities in income and energy prices require larger social and economic solutions, residential energy efficiency retrofits have become a key fuel poverty intervention strategy (Howden-Chapman et al., 2007, Howden-Chapman et al., 2009, Bird and Hernández 2012, Gibson et al., 2011, Harrison and Popke, 2011). However, the absence of easily accessible data on individual household energy consumption and efficiency, and an incomplete understanding of the spatial distribution of vulnerability presents an impediment to effectively targeting those most in need (Walker et al., 2013; Sefton, 2002). Recently, scholars have conducted small-scale, area-based studies using readily available public data and geographic information systems (GIS) to offer visualizations of spatial disparities in the distribution of fuel poverty vulnerability and energy consumption to facilitate policymaking and intervention targeting (Pereira and de Assis, 2013; Walker et al., 2013; Fahmy et al., 2011; Morrison and Shortt, 2008).

In the US, while fuel poverty is neither recognized colloquially or politically, a few studies have modeled the spatial distribution of residential energy consumption, including socioeconomic and demographic control variables in their models (Howard et al., 2012; Min et al., 2010; Heiple and Sailor, 2008). Others have explored the socioeconomic and demographic relationships of national residential energy consumption patterns (Health and Human Services [HHS] 2011; Steemers and Yun, 2009; Ewing and Rong, 2008; Adua and Sharp, 2011; Newman and Day, 1975). Generally, these studies concluded that, all else being equal, low-income households consume less energy. This broad assessment of consumption rather than efficiency, tends to mask fuel poverty vulnerability. Instead, when analyzing energy use intensity (EUI), or energy consumption normalized by building square area, as a proxy for energy efficiency, national data from the US Energy Information Administration (EIA) show that low-income household, on average, are less efficient, with an EUI 27% greater than high-income households. The spatial distribution of energy efficiency is further complicated by a persistent system of racial and income residential segregation that defines housing development and consumption patterns in many US metropolitan areas. A substantial amount of research is aimed at understanding the causes and consequences of residential segregation, primarily from the fields of sociology and public health (Sampson, 2012; Sharkey, 2011; Anthopolos et al., 2011; Sampson and Wilson, 1995; Wilson, 1987). But very little of this research is connected to energy-related research in meaningful ways that illustrates the critical importance of place to the presence of energy efficiency disparities and fuel poverty vulnerability.

This paper uses publicly available data to model residential heating energy efficiency, as a function of various housing and household characteristics for a tri-county metropolitan area. The study extends previous energy consumption and social justice oriented research by predicting small-area estimation of end use energy efficiency, and then examining racial/ethnic and socioeconomic relationships. This analysis not only furthers our understanding of the dynamics and distribution of energy efficiency disparities, it has practical applications that may assist policymakers and practitioners with developing and implementing more equitable, efficient, and effective targeting of energy assistance programs and weather-related vulnerability prevention activities. This study seeks to answer two research questions. First, does residential heating energy efficiency vary within a metropolitan area? And if so, what are the spatial characteristics of that variation? Second, what are the patterns of association between residential heating energy efficiency and racial/ethnic, and socioeconomic characteristics? The remainder of the paper summarizes the modeling and mapping of residential heating energy efficiency and analysis of the spatial, racial/ethnic, and socioeconomic patterns. Section 2 describes the study area, and methods for developing a model for heating energy efficiency and small-area predictions. Section 3 presents the results of the geographic and statistical analyses. Section 4 concludes with policy implications.

2. Methodology

2.1. Description of study area

Kansas City is the largest city in the State of Missouri and lies mostly in Jackson, Clay, and Platte counties (see Fig. 1). This tri-county region also represents the service area for United Services,

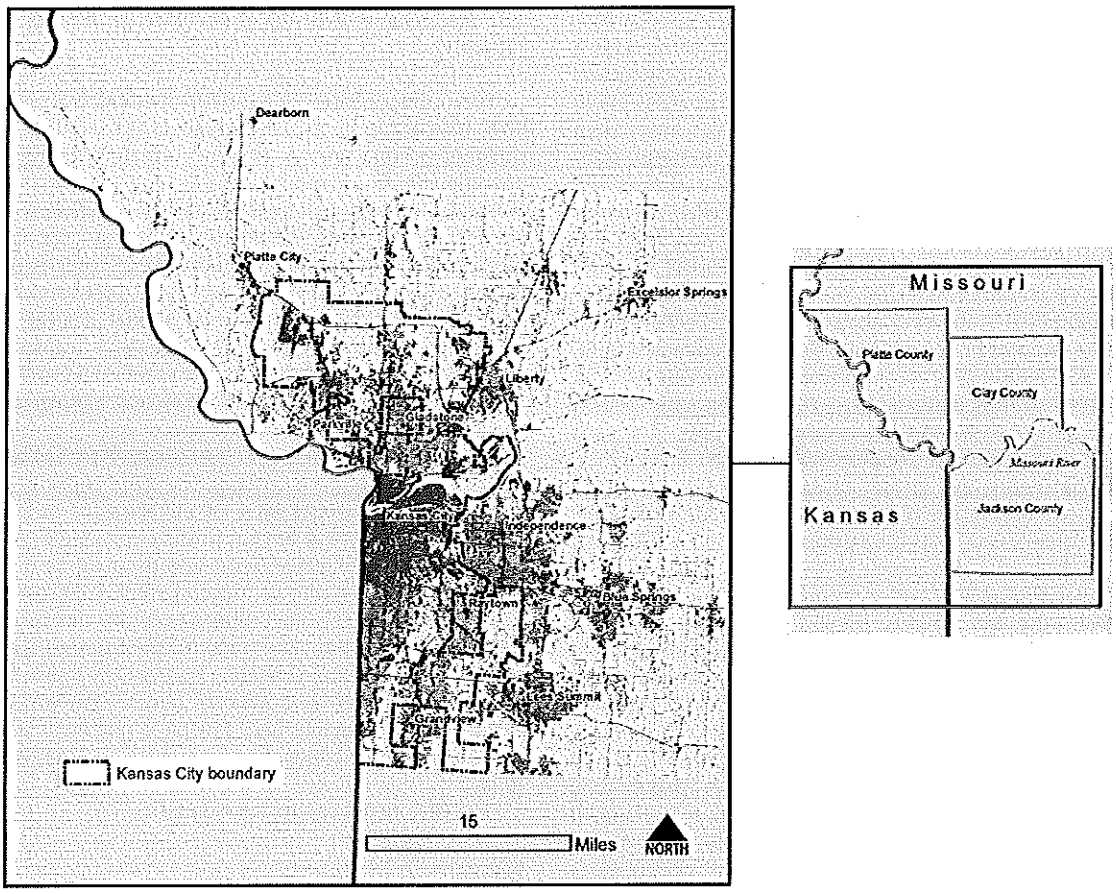

Fig. 1. Study area: Kansas City, Missouri (Jackson, Clay and Platte counties).

one of nation's roughly 1000 Community Action Agencies (CAAs). CAAs are mostly nonprofit, anti-poverty social service organizations covering nearly 96% of US counties. CAAs are responsible for administering federal low-income energy assistance programs, such as, the Department of Health and Human Services Low-income Home Energy Assistance Program which provides utility bill assistance and the Department of Energy Weatherization Assistance Program which provides no-cost energy efficiency retrofits. According to Building America, which determines building practices based on climate zones to achieve the most energy savings in a home, the counties are located in Climate Zone 4, which has a range of 4000–5499 heating degree days (HDDs) annually, and where the average monthly outdoor temperature drops below 47 °F (7 °C) during the winter (U.S. Department of Energy, 2015).[1] Hence, homes in the area exhibit relatively high usage of heating equipment. In fact, space heating accounts for 41% of total household energy consumption in Missouri. The main heating fuel sources are natural gas (52%) and electricity (35%). Overall, the average Missouri household total energy consumption is roughly 100 million BTUs per year, approximately 12% more than the national average (EIA, 2013a).

According to the 2010 decennial census, the counties had a total population of 985,419 in 398,124 households. The area covers urban, suburban, and rural landscapes. In addition to the urbanization gradient, socioeconomic characteristics in the area vary greatly. Median block group income ranged from $14,250 to $154,250. The household racial composition included 77.1% White households, 17.3% Black households, and 5.2% Hispanic households, as identified by the head of household. Kansas City is consistently identified as one of the nation's twenty-five most racially segregated metropolitan areas due to its high placement on a range of housing segregation indices, most recently ranking 23rd based on black-white segregation (Logan and Stults, 2011; Denton, 1994; Massey and Denton, 1993). Kansas City also exhibits a high, and increasing, level of residential segregation by income. According to Pew Research on Social and Demographic Trends, Kansas City's Residential Income Segregation Index score increased from 38 in 1980 to 47 in 2010 (Fry and Taylor, 2012).

2.2. Data

In the absence of detailed individual household energy data, the EIA's Residential Energy Consumption Survey (RECS) provides household-level energy consumption data for a representative sample of occupied, primary residences in the US. The RECS employs a multi-stage area probability design to ensure the selection of a representative sample of housing units, carefully controlled at specified levels of precision, to allow analysis of housing unit characteristics and energy consumption and expenditures at the following geographic levels: national, census region, census division, groups of states within a census division, and individual

[1] Climate zones range from 1 (warmest) to 7 (coldest). Heating degree days (HDDs), commonly used in calculations relating to the energy consumption required to heat buildings, is a measurement of the difference in temperature between the mean outdoor temperature, over a 24-h period, and a given base temperature for if a building's indoor temperature fell below would require heating, typically 65 °F (18 °C) in the US. For example, if the mean outdoor temperature for a day is 35 °F, the HDDs measurement for that day is 65−35=30. Essentially, areas with a larger number of HDDs have colder outdoor temperatures and require more energy for heating.

states (EIA, 2013b). The RECS, first conducted in 1978, collects data on energy consumption, expenditure and behavior along with a number of household demographics and housing unit characteristics. In the past, the RECS sample size has not been particularly useful for analyzing energy patterns at spatial scales lower than the census region, except for the most populous US states; California, Texas, New York, and Florida. The 13th iteration of the survey, conducted in 2009 and released in 2013, nearly tripled in sample size to 12,083 housing units (up from 4382 in 2005) representing the US Census Bureau's statistical estimate of 113.6 million occupied primary residences. Subsequently, the 2009 RECS allows for additional state-level analysis with the collection of representative samples in 12 additional states, including Missouri. A sample of 686 households were surveyed to represent the 2.35 million occupied housing units in Missouri. For geographic domain estimation purposes, base sampling weights were applied to each housing unit, which was the reciprocal of the probability of selection into the sample and is the number of households in the population each observation represents (EIA, 2013b). Each sampling weight value was used as a weighting factor in the weighted regression model.

Data for spatial modeling and mapping of the study area were obtained from the U.S. Census Bureau 2006–2010 American Community Survey (ACS) 5-year estimates. The census block group was used as the unit of analysis for this research. Census block groups are a contiguous cluster of blocks within a census tract and generally consist of between 600–3000 people. The census block group is the smallest spatial resolution for which household and housing unit characteristics similar to RECS variables are publically available from the U.S. Census Bureau. In addition, it is assumed that physical and social homogeneity are more likely at the smaller block group level than larger spatial levels, such as, census tracts or zip codes. A GIS data layer of census block groups for the study area was created by clipping data from the U.S. Census Bureau TIGER/Line Shapefiles with demographic and economic data from the 2006–2010 ACS 5-year estimates. Block groups were retained for analysis only if data values for both population and number of occupied housing units were greater than zero. Subsequently, 757 of 763 block groups in the three-county study area were included in this analysis.

The RECS microdata set can be used to develop a bottom up statistical model. Bottom up statistical models use input data at a granular level, such as a sample of individual households, for extrapolation to a geographic area of interest. These statistical models have been used to establish relationships between various characteristics of household energy consumption (i.e. specific end use consumption, total consumption, energy use intensity) while controlling for exogenous variables such as housing unit characteristics, household characteristics, urban form and climatic conditions (Min et al., 2010; Ewing and Rong, 2008; Tso and Yau, 2007). Min et al. (2010) developed a statistical framework for modeling residential space heating (and other end use) consumption at a zip code- level resolution using the 2005 RECS microdata. Their results were validated against residential energy sales data. This study extends their framework to estimate residential heating efficiency by creating a state-level regression model using the Missouri sample of housing units in the 2009 RECS microdata set and exploring small-area spatial, racial/ethnic, and socioeconomic patterns. Since many of the variables identified in the RECS can also be found in the Census ACS, relationships derived from the statistical model, known as direct estimators, can be applied to the block group level dataset as indirect estimators for constructing small-area estimates, under the assumption that the small areas have the same characteristics as the large areas (Rao and Molina, 2015). The next two sections detail this process.

2.3. Specifying a robust regression model for heating energy efficiency

The ordinary least square (OLS) method was used to analyze how housing unit and household characteristics influence residential heating energy efficiency. Heating energy efficiency is operationalized as annual heating energy use intensity (EUI). Generally, a lower EUI signifies relatively efficient performance. The EUI is defined as the quantity of energy used in producing a given level of service, expressed as energy consumed per unit of output. The heating EUI (kBtu/m^2) was calculated for each RECS observation by dividing the total annual heating consumption (kBtu) by the housing unit square area (m^2). Trained interviewers use a standardized method for measuring and collecting the dimensions of the housing unit. Total annual heating consumption is the aggregation of a household's space heating consumption from all fuel types (i.e. natural gas, electricity, liquefied petroleum gas (LPG), fuel oil, and/or kerosene). The RECS captures consumption data from actual utility bills. Of the Missouri RECS sample, 676 observations had total annual heating consumption greater than zero kBtu. Another observation was dropped as it was the only housing unit in the sample reporting fuel oil/kerosene as the primary heating source. Fuel oil/kerosene are not major sources of heat in the tri-county area; only 0.09% of homes use fuel oil/kerosene as their primary heating source (US Census 2016). Upon testing for outliers, an additional observation was dropped that exhibited an extremely high EUI for a relatively small footprint. The final data set consisted of a sample of 674 Missouri housing units.[2]

The OLS model can be formulated as,

$$\ln E = \beta_0 + \sum_{i}^{n} \beta_i^* \chi_{i,RECS} + \varepsilon$$

where E is the annual heating EUI, and $\chi_{i,RECS}$ is the predictor variable χ_i from the RECS dataset (Min et al., 2010). The dependent variable was natural logged to better fit the nonlinear relationship between heating EUI and the independent variables (Min et al., 2010; Ewing and Rong, 2008).

Since many of the predictors of heating EUI are themselves correlated, it is important to consider their simultaneous effects using multivariate analysis techniques. This approach therefore requires determining the best subset of predictors of heating EUI. Initial selection of independent variables was guided by previous studies using OLS to understand residential energy consumption. The two major themes on factors that contribute to residential energy consumption are categorized as the physical-technical-economic model (PTEM) and the lifestyle and social-behavior tradition (LSB) (Adua and Sharp, 2011). Many models include variables from the PTEM perspective which explains energy consumption as a result of housing unit characteristics, or the building's physical structure and equipment characteristics, and economic and environmental factors. These variables include: type of home, year home built, home size, household income, price of energy, geographic location, and climate variables (Ewing and Rong, 2008; Min et al., 2010; Adua and Sharp, 2011, Valenzuela et al., 2014). The LSB tradition draws on the importance of human occupants to energy consumption, or household characteristics. LSB-related variables often include: race/ethnicity, household size, age of householder, and sex of householder (Ewing and Rong, 2008; Min et al., 2010; Adua and Sharp, 2011, Valenzuela et al.,

[2] A sample size of 674 can predict with accuracy at a 95% confidence interval and ± 4 confidence level, for 2,339,684 housing units (population size). Based on the assigned sampling weights, the final sample represents 2,286,868 housing units.

Table 1
OLS regression model for small-scale heating EUI estimation.

DV = ln (EUI_{heat})	Coeff.	Robust Std. Err.
Type of Housing		
Multi-Family	Reference	
Mobile Home	0.68***	0.09
Single Family Dettached	–	
Single Family Attached	–	
Decade Constructed		
Before 1950	Reference	
1950s	–	
1960s	-0.24***	0.07
1970s	-0.18**	0.07
1980s	-0.34***	0.08
1990s	-0.26***	0.07
2000s	-0.29***	0.07
Primary Heat		
Natural Gas	Reference	
Electricity	-1.10***	0.05
Wood	-2.07***	0.23
Liquid Petroleum Gas	–	
Control Variables		
Household Income	-0.03*	0.01
Home ownership	-0.15**	0.05
No. of rooms	-0.09***	0.01
Model Statistics		
Intercept	6.57***	0.08
N	674	
F (11, 662)	85.9***	
Adjusted R^2	0.62	
RMSE	0.523	

-dropped from stepwise regression
* Significance $p < 0.05$.
** Significance $p < 0.01$.
*** Significance $p < 0.001$.

2014). For this model, variables representing housing unit characteristic included three dummy-coded variables for housing type (mobile home, single family detached, and single family attached, with multifamily as the reference category), six dummy-coded variables for decade constructed (1950s through 2000s, with homes built before 1950 as the reference category), and three dummy-coded variables for primary heating fuel (liquid petroleum gas (LPG), electricity, and wood, with natural gas as the reference category). Household characteristic variables included one interval variables for number of rooms, one categorical variable for household income (divided into eight categories), and one dummy-coded variable for home ownership coded as "1", otherwise "0". Final model selection of independent variables was based upon backward stepwise selection.

2.4. Utilizing census data for small area heating EUI estimation

Since the goal of this study is to explore heating energy efficiency at a geographical domain smaller than the RECS microdata (collected with adequate precision at the state-level), the second step involves using the model above to estimate and map heating EUI for Kansas City. This technique, known as small-area estimation, combines individual level data (i.e. household surveys) and spatial characteristic estimates (i.e. Census data). There have been significant theoretical advances in small-area estimation methodologies for modeling and mapping (Fay and Herriot, 1979; Fahmy et al., 2011; Rao and Molina, 2015). To accomplish this, resultant weights derived from the regression model are applied to spatial data (e.g., housing units by type, housing units built in each decade, housing units using each fuel type for heating, median household income), from the US Census 2006–2010 ACS 5-year estimates. The derived regression weights are therefore intended to reflect the observed pattern of influence at the household level, which is essential to the small area estimation. Regression coefficients β_i are applied to block group level data, $x_{i,CENSUS}$, for each of the 757 block groups in the study area (Min et al., 2010), using ARCMap (v.10.3.1) software (ESRI, Inc) to predict block group level heating EUI estimates $\hat{E}$:

$$\hat{\ln}E = \hat{\beta}_0 + \sum_i \hat{\beta}_i * x_{i,CENSUS}.$$

Since this modeling approach involves matching two different datasets (RECS and ACS), these sources must first be harmonized with respect to their measurement and weighting. Each census variable was weighted by the percentage (or ratio) of its presence in the Census block group. For example, if the number of housing units heated by electricity in census block group 1 is 100 and the block group has 200 housing units, the variable is standardized as 100/200=0.5, which is comparable to the binary variable for whether or not an observation in the RECS data set uses electricity as its primary heating source. The ratio for each block group is then multiplied by the coefficient for electricity from the regression model.

Lastly, to simply exponentiate the log-linear model, $\hat{\ln}E$, will systematically underestimate the expected value of EUI, thus the scaling value $exp\left(\frac{RMSE^2}{2}\right)$ is needed (Wooldridge, 2009: 211). RMSE is the root mean square error of the model. From the estimated log values $\hat{\ln}E$, the actual estimated EUI is obtained by the equation

$$\hat{E} = \exp\left(\frac{RMSE^2}{2}\right) * \exp(\hat{\ln}E).$$

2.5. Statistical analysis

The relationships between the predicted mean block group heating EUI and measures of race/ethnicity, and socioeconomic status are examined using bivariate and multivariate analyses. First, correlation analysis was conducted between heating EUI and demographic and socioeconomic characteristics. Next multivariate regression was used to explore the relationship between predicted heating EUI and block group racial/ethnic and socioeconomic characteristics. Lastly, logistic regression was used to model how the proportion of racial/ethnic minority headed households, and other block group socioeconomic characteristics affect the probability of block group vulnerability, thus prime for energy efficiency intervention targeting.

3. Results

The final regression model for estimating annual heating EUI, expressed as natural log, is presented in Table 1. The final model consisted of 11 statistically significant variables representing housing unit type, decade housing unit was constructed, primary heating fuel, and control variables for household income, home ownership, and housing unit size. The model explained a considerable proportion of variability in heating EUI (R^2=0.62, F(11, 662)=85.9, $p < 0.001$). Based on the F value of the model, the final sample size of 674 is large enough to make the model significant. Cross-sectional studies are at greater risk of exhibiting heteroskedasticity. Weighted regression is one method to correct residuals and the model's residual versus fit plot exhibits a constant variance and shows no evidence of heteroskdasticity. Additionally, robust standard errors were used and are reported in Table 1

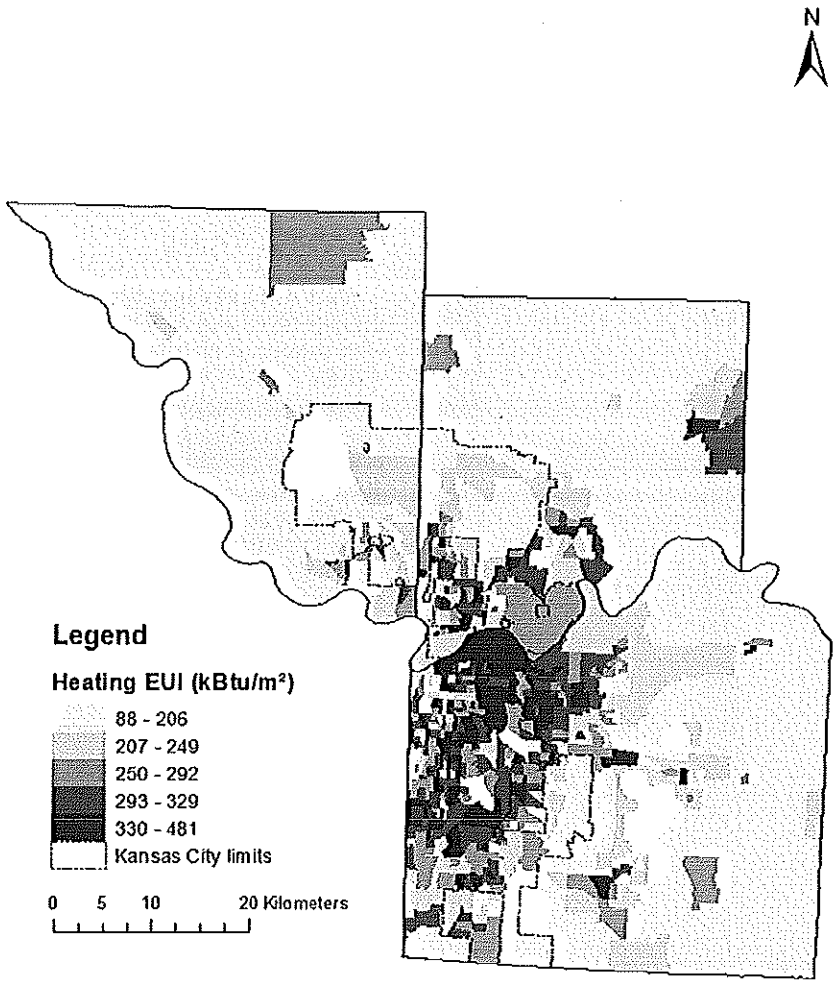

Fig. 2. Predicted block group mean annual heating EUI (kBtus/m^2).

(Wooldridge, 2009). Multicollinearity can also be a major problem for statistical models of residential energy use, and can result in poor predictions of certain end uses (Swan and Ugursal, 2009). Multicollinearity commonly arises with variables that tend to be correlated, such as household income and housing unit size. However, correlations between any two variables in the final model did not exceed 0.45, and the variance inflation factor is 1.32. Thus, the model did not indicate a noticeable presence of multicollinearity.

Fig. 2 illustrates the spatial distribution, in quintiles, of the predicted mean annual heating EUI for each block group, darker shading represents higher predicted heating EUI. The six uninhabited block groups were left uncolored. It is important to note that predicted values reflect the mean heating EUI of all housing units in the block group rather than any specific house (Min et al., 2010). Among the 757 block groups there was significant difference in values of heating EUI, ranging from 88 to 481 kBtus/m^2. The metropolitan mean heating EUI, 269.6 kBtu/m^2 (SD=66.7 kBtus/m^2), was higher than the state mean heating EUI, 218.9 kBtus/m^2. The heating EUI variation, nearly 400 kBtus/m^2, is quite large. This means that within the same metropolitan region, homes in some areas were far less efficient than others. While block groups with higher heating EUIs are scattered throughout the three counties, the majority of block groups with the highest EUIs were concentrated within the Kansas City limits and its urban core. Of the 151 block groups with the highest (fifth quintile) predicted heating EUI, 119 (78.8%) were located within the city limits.

Table 2
Pearson's correlation between race/ethnicity, socioeconomics and predicted heating energy use intensity (EUI).

Category	Description	Pearson's correlation
Economic status	Median household income	-0.62
	Percent households below poverty level	0.47
Education	Percent population with less than high school diploma	0.51
Age	Percent households with householder aged 65+	0.12
Race/Ethnicity	Percent white householders	-0.37
	Percent black householders	0.32
	Percent Hispanic householders	0.31
Tenure	Percent renters	0.40

All coefficients significant at $p < 0.001$

Pearson correlations, shown in Table 2, revealed statistically significant relationships between socioeconomics, race/ethnicity and predicted heating EUI ($p < 0.001$). Heating EUI is positively correlated with block groups with a higher number of adults without a diploma (0.51), higher number of households in poverty (0.47), more renters (0.40), more Black householders (0.32), more Hispanic householders (0.31), and more senior householders (0.12). Furthermore, heating EUI was negatively correlated with median household income (−0.62) and percentage of White

Table 3
Relationship between estimated heating EUI and block group race/ethnicity, segregration and socioeconomic characteristics.

	Model 1		Model 2		Model 3		Model 4	
	b	S.E.	b	S.E.	b	S.E.	b	S.E.
Percent black householders	0.75***	0.07	0.19*	0.09				
Percent Hispanic householders	2.58***	0.29	0.71*	0.32				
Percent households below poverty level			1.24***	0.20				
Percent population with less than high school diploma			1.47***	0.28				
Percent households with householder aged 65+			0.75***	0.17				
Black residential segregation					90.93***	7.19	37.09***	9.19
Hispanic residential segregation					238.68***	22.03	94.27**	29.92
Proportion households below poverty level							98.37***	22.87
Proportion population with less than high school diploma							146.14***	29.97
Proportion households with householder aged 65+							64.32***	16.89
Intercept	240.13***	3.29	210.56***	4.75	232.34***	3.39	210.09***	4.82
N		757		757	757			757
R^2		0.21		0.33	0.23			0.33

* Significance $p < 0.05$.
** Significance $p < 0.01$.
*** Significance $p < 0.001$.

householders (−0.37). Thus, census block groups with lower socioeconomics, lower median household incomes, and higher percentages of Black or Hispanic households are more likely to have higher heating EUIs. Additionally, Kruskal-Wallis tests were conducted to determine if heating EUI was different among block groups divided into quintiles by the socioeconomic and race/ethnicity variables of interest. Individual Kruskal-Wallis tests showed there were statistically significant differences in heating EUI between the quintiles of median household income (χ^2=330.9), percent poverty (χ^2=171.1), percent less high school education (χ^2=195.2), percent senior headed households (χ^2=20.2), percent renters (χ^2=168.2), percent White householders (χ^2=78.1), percent Black householders(χ^2=97.2), and percent Hispanic householders (χ^2=94.7), (DF=4, $p < 0.001$).

Regression models examining how race/ethnicity are related to heating EUI are shown in Table 3. Model 1 in Table 3 shows this relationship when socioeconomic characteristics of the block group are not taken into account. This model reveals a strong relationship between race/ethnicity and heating EUI. The model shows that as the percentage of Black households and Hispanic households in a block group increase, heating EUI increases by 0.75 and 2.58 kBtu/m^2, respectively.

The second model in Table 3 (Model 2) shows how race/ethnicity are related to heating EUI when the effects of socioeconomic characteristics of the block group (percent poverty, percent less than high school diploma and percent senior householders) are held constant. In this model, while the positive relationship between race/ethnicity and heating EUI remain, as in Model 1, the effects are moderated by the socioeconomic characteristics of the block group with percent of households below poverty, percent of population with less than a high school diploma, and percent senior headed households having a larger effect on heating EUI, 1.24 (t=6.3), 1.47 (t=5.4), and 0.75 (t=4.5) kBtu/m^2, respectively. After controlling for socioeconomics, the effect of a percent increase in Black or Hispanic households increasing a block group's heating EUI drops to 0.19 (t=2.2) and 0.71 (t=2.2) kBtu/m^2, respectively.

The final two models reported in Table 3 (Models 3 and 4) exchange the percentage of Black and Hispanic households in the block group with a measure of the block group's level of Black and Hispanic racial residential segregation (RRS). The RRS, a measure of the geographic isolation of race/ethnicity from other racial groups (Massey and Denton, 1993, Reardon and O'Sullivan, 2004, Anthopolos et al., 2011). RRS has received increased attention as a major social determinant in poor outcomes (i.e. health effects) and may be a proxy for concentrated neighborhood disadvantage, including exposure to socio-physical environmental stressors in the built environment (Anthopolos et al., 2011). Model 3 shows that RRS has a strong positive relationship with heating EUI. Each unit increase in Black isolation increases heating EUI by roughly 91 kBtu/m^2. Hispanic isolation has an even greater effect on heating EUI. Every unit increase in Hispanic isolation increases heating EUI 239 kBtu/m^2. In Model 4 the relationship between segregation and heating EUI remains strong even after controlling for the socioeconomic characteristics of the block group. Given that the isolation index is a value between 0 and 1, the socioeconomic block group characteristics in Model 4 are in proportions rather than percentages. The Black and Hispanic isolation indexes maintain a strong positive relationship with heating EUI but are slightly moderated by block group socioeconomic characteristics. Once socioeconomic characteristics- poverty (t=4.3), less high school (t=4.9), senior households (t=3.8)- are taken into account, the effect that a unit increase in Black and Hispanic isolation increases heating EUI drops to 37 (t=4.0) and 94 (t=3.2) kBtu/m^2, respectively.

Fig. 3 illustrates the spatial distribution of high-risk block groups, which would be prime candidates for energy efficiency interventions. High-risk block groups are defined as those where predicted heating EUI was greater than study area mean (269.6 kBtu/m^2), median year home built was less than the study area mean (1966.5), and median household income was less than the study area mean ($51411.50). There were 263 block groups meeting these criteria (34.7% of block groups). More than a quarter of the area's population (26.6%) resided in high-risk block groups. The racial composition included 49.7% of the Black population, 46.9% of the Hispanic population, and 18.7% of the White population. Black and Hispanic households within the high-risk block groups are highly overrepresented compared to their representation within the entire study area (29.6% Black, and 8.6% Hispanic), while White households are underrepresented (62.4%). If there were no disparities in heating EUI this would not be the case.

To understand the odds that the racial/ethnic and socioeconomic characteristics of a block group contribute to that block group's likelihood of being high-risk, logistic regression results are presented in Table 4. Table 4 suggests that a 10% difference in percent households in poverty increased the odds by 2.7% ($p < 0.01$) that the block group is high-risk. Racial/ethnic characteristics (percentages of Black and Hispanic households) are significant predictors of high-risk block groups ($p < 0.001$). For instance, a 10% increase in Hispanic households increased the high-risk odds by a factor of 10.8. Logistic regression results showed that high-risk block groups are poorer, have less educational attainment, have more households headed by seniors, and

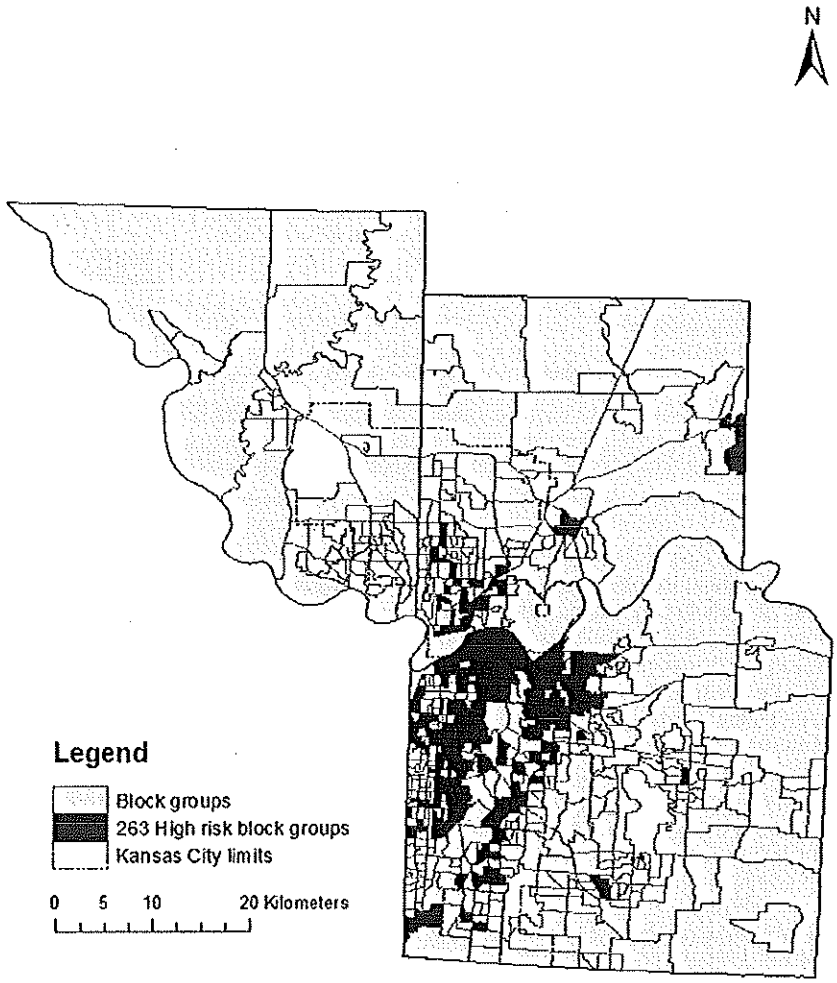

Fig. 3. High-risk block groups. High-risk block groups are defined as those where heating EUI, median age of home, and median household income were worse than the study area average. There are 263 high-risk block groups identified.

Table 4
Logistic regression – high-risk block groups.

	Odds ratio	S.E.
Percent black householders	1.014***	0.004
Percent Hispanic householders	1.079***	0.023
Percent households below poverty level	1.027**	0.010
Percent population with less than high school diploma	1.050***	0.013
Percent households with householder aged 65+	1.021**	0.008
Intercept	0.060***	
Pseudo R^2	0.24	
N	757	

*Significance $p < 0.05$
** Significance $p < 0.01$.
*** Significance $p < 0.001$.

have greater percentages of Black and Hispanic households.

4. Conclusion and policy implications

This study estimated the mean heating EUI for 757 census block groups in Kansas City, Missouri (Jackson, Clay, and Platte counties). The findings demonstrate that disparities exist in the relationships between the spatial, racial/ethnic, and socioeconomic characteristics of census block groups and the estimated mean block group heating EUI (kBtu/m^2), a proxy for energy efficiency where a higher EUI signals relatively less efficiency when compared to similar sized homes. Predictions reveal that block groups with lower median incomes, a greater percentage of households below poverty, a greater percentage of racial/ethnic minority headed households, and a larger percentage of the population with less than a high school education experienced higher mean heating EUIs. Essentially, homes in block groups exhibiting these demographic and socioeconomic characteristics are more likely to be less energy efficient when compared to other block groups in the region.

This analysis also reveals an association between the enduring effects of residential racial and income segregation and the distribution of residential energy disparities. The figures above illustrate that past institutionalized residential segregation continues to influence urban housing consumption and translates directly to energy-related disparities. Urban sociologists often associate residential segregation with concentrated social and economic disadvantage (Sharkey, 2013; Sampson, 2012; Klinenberg, 2002). The results of this study follow decade-old reports by two major African American organizations about the relationship between Blacks, energy and climate change. Both the Congressional Black Congress Foundation and the American Association of Blacks in Energy released reports in 2004 assessing the disproportionate effects of energy inequities on Blacks. Since these reports, there has been little research conducted on this issue and virtually no policy advances. Recognizing that the uneven development

patterns and high levels of residential segregation evident in Kansas City occur in other US urban areas, such as St. Louis and Detroit, this study should be replicated to explore if similar energy disparity patterns exist and determine the need for a national urban energy justice policy.

Space heating remains the largest, single end use, accounting for 41% of residential energy consumption (EIA, 2013c). Modeling the efficiency of residential space heating (and cooling) is important because of its responsiveness to weather. Prioritizing heating energy efficiency and targeting building envelope retrofits, before appliance and lighting efficiency, may have greater potential as the lifespan of a housing unit most likely outlasts the current occupant and appliances. Additionally, in dominant discussions on climate change, global warming specifically, winter weather and cold conditions receive far less attention. Nevertheless, recent studies have found that the effects of global warming (i.e. the loss of Arctic sea ice) can be linked to extreme and prolonged cold weather patterns in mid-latitudes, such as the cold spells experienced by northeastern and Midwestern states during the polar vortex of winter 2014 (Peings and Magnusdottir, 2014, Tang, 2013, Francis and Vavrus, 2012). Subsequently, as climate change adaptation discourse becomes more prevalent, it is necessary to understand the material experience of changing environmental conditions, the effect on everyday life, and the potential ways in which communities are threatened (Schlosberg, 2013).

Furthermore, energy related disparities increase the sensitivity of low-income and other vulnerable households to extreme temperature exposure resulting in detrimental health implications (Noe, Jin and Wolkin, 2012; Centers for Disease Control [CDC], 2006; Taylor et al., 2001). The Centers for Disease Control (CDC) found that between 2006 and 2010, 63% of weather-related deaths were attributed to extreme cold exposure, compared to 31% attributed to heat-related causes (Berko et al., 2014). Weather-related death rates varied by age, race/ethnicity, sex, location, and income (Berko et al., 2014). For vulnerable populations like the elderly, extremely cold temperatures can be deadly, even indoors. Elderly patients admitted to the intensive care unit for hypothermia are more severely affected and die more frequently when found indoors compared to those found outside with equivalent body temperatures (Mégarbane et al., 2000). In another study, almost half of hypothermia-related deaths occurred indoors, with death rates particularly high among Blacks aged 80 years or older (Taylor et al., 2001). Despite these findings, there is a lack of recognition of the magnitude of problems associated with dangerous indoor temperatures when homes are not adequately heated. Instead, public health agencies often issue broad cold-weather injury risk reduction precautions primarily focused on outdoor protection, like layering clothes and keeping emergency kits and blankets in the car (CDC, 2006). Mapping heating energy efficiency can be combined with hypothermia health data for additional analysis on the connection between efficiency and winter-related injuries and death.

To the disadvantage of the millions of Americas who struggle to access and maintain affordable heating energy services, the consequence of not identifying distinct forms of social inequality in residential energy efficiency means more broad-based energy policies that fail to serve those with the greatest need. For instance, the passage of the 2009 economic stimulus bill created various residential energy efficiency programs across the country. Most programs, however, were market-based interventions in the form of low-interest loans and tax rebates which limited participation by low-income households who often lack adequate credit worthiness to qualify for loans and rarely earn enough annual income to file for tax rebates. Although $5 billon was committed to the Department of Energy's Weatherization Assistance Program, the rollout was slow and inconsistent (Grunwald, 2012). In part, the lack of comprehensive accounting of local energy consumption and efficiency disparities, forced weatherization agencies to rely on prevailing practices of first-come, first-served self-referral operating procedures (Fuller et al., 2010; Madrid and James, 2012). A growing body of research demonstrates that the spatial concentration of fuel poverty risk factors, justifies taking proactive, targeted, area- or community-based approaches for implementing energy assistance programs to overcome participation barriers, including those that are social and cultural, and to more efficiently and effectively deliver services in vulnerable communities (Reames, 2016; Walker et al., 2013; Hallinan et al., 2012).

Moreover, modeling energy use intensity rather than total energy consumption provides more meaningful information for analyzing disparities and targeting the most appropriate intervention to the appropriate location. The residential sector has made energy efficiency progress, continuing a three-decade decline in average consumption per home even as the number and average size of housing units increase. This trend is primarily a result of efficiency improvements for newer homes. While aggregate residential sector statistics and analyses are useful for policy and program development, they often mask the heterogeneity of energy users, resulting in a lack of equity considerations. The use of bottom-up statistical models and mapping, extrapolated to smaller-scale spatial areas allows a more nuanced analysis of energy consumption. While several energy-mapping projects are in various stages of development and implementation across the nation (e.g., Twin Cities Energy Mapping Tool in Minnesota), a barrier to more of these projects remains the proprietary nature of individual energy data, as utilities express concerns about customer privacy, or have little incentive to participate in projects that have the potential reduce revenue. In the meantime, using readily available public data and the methodological procedures presented in this study, offer an alternative for community energy mapping when local utility energy data are unavailable.

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GM-7
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Case No. EO-2019-0132

Schedule GM-8

31 pages

WattTime Validation and Technology Primer

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Transforming global energy use to create a clean, prosperous, and secure low-carbon future.

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Purpose of this document

- WattTime is a nonprofit organization that invented a novel means to reduce GHG and other emissions, known as Automated Emissions Reduction (AER).
- Rocky Mountain Institute (RMI), an independent third-party with a 35-year history of leadership in efficiency and renewable energy, evaluated WattTime's technique and AER's impact potential and found it to be a uniquely powerful, additional means of driving large amounts of environmental benefit.
- Unlike most high-impact sustainability technologies, AER can scale in the cloud, and has the potential to rapidly and automatically reduce emissions from an estimated 23 billion devices.
- Driven by this unique opportunity, RMI decided to offer to incorporate WattTime as a subsidiary organization after careful vetting to drive rapid adoption of this technology.
- This document reflects key findings from RMI's due diligence process and, also serves as an introduction to AER technology.
- Additional information about WattTime is available at www.WattTime.org.

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About WattTime

- Nonprofit tech startup spinning out of UC Berkeley research
- Built by > 200 volunteers from MIT, Climate Corp, DOE, etc.
- Technology lets customers source more electricity from cleaner power plants, automatically
- Works in any building, any utility, any type of energy contract

greentechmedia: Clean Technica Forbes Chicago Tribune

FAST COMPANY Co.EXIST the guardian Union of Concerned Scientists

ENERGY INSTITUTE AT HAAS ecHOING GREEN

Executive Summary

WattTime, a technology nonprofit, has developed a fundamentally new approach to significantly reduce emissions from power plants using software known as *Automated Emissions Reduction (AER).*

What is AER?

AER enables internet-enabled, electricity consuming devices to seamlessly reduce emissions by combining:

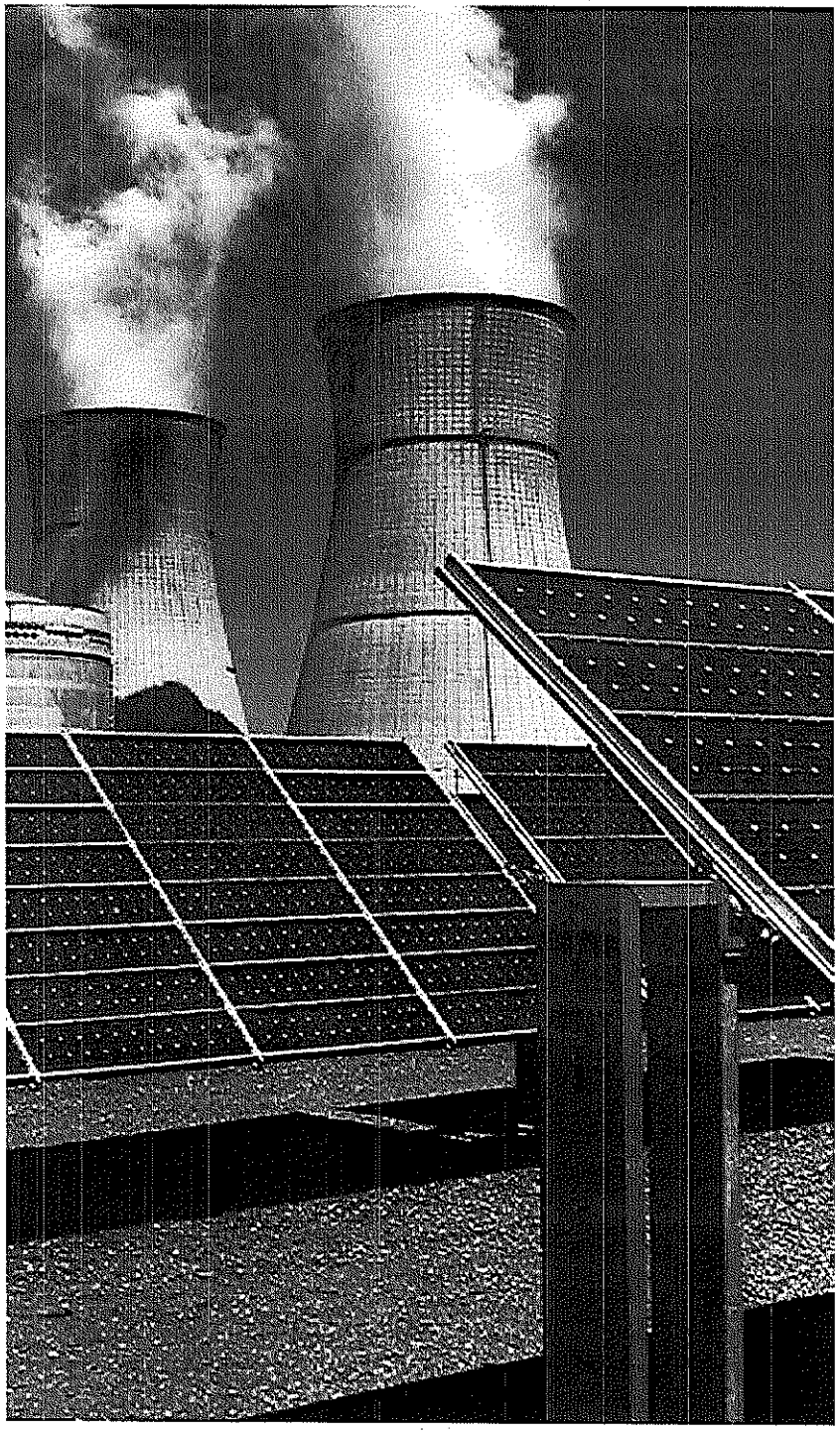
- real-time grid data on power plant emissions, and
- internet-enabled control of electricity-consuming devices using new comfort and cost algorithms

Customer demand and technology trends create an emerging opportunity

- With 23 billion "smart" devices expected worldwide by 2020, a rapidly growing share of electricity consumption is capable of supporting AER
- Current-generation AER has the capability to reduce CO_2 emissions by the equivalent of 1 million cars
- As technology matures, impacts per device will grow

AER can create value across multiple sectors

- AER offers institutional and residential energy users a new source of rapid, low-cost emissions reductions
- AER also offers ancillary benefits to numerous other energy sector actors
- Strong potential for new entrants and business models



Overview:

What is Automated Emissions Reduction?

Defining Automated Emissions Reduction

Automated emissions reduction (AER) combines leading-edge research on grid emissions with new algorithms to seamlessly shift loads in response, thus minimizing grid emissions associated with loads without reducing performance

Marginal emissions research

- New data analytics approach allow an accurate estimate of the marginal emissions intensity of the grid, at a specific location and time
- This approach can provide, for the first time, accurate visibility into the impacts of individual or institutional decisions about energy use on total emissions

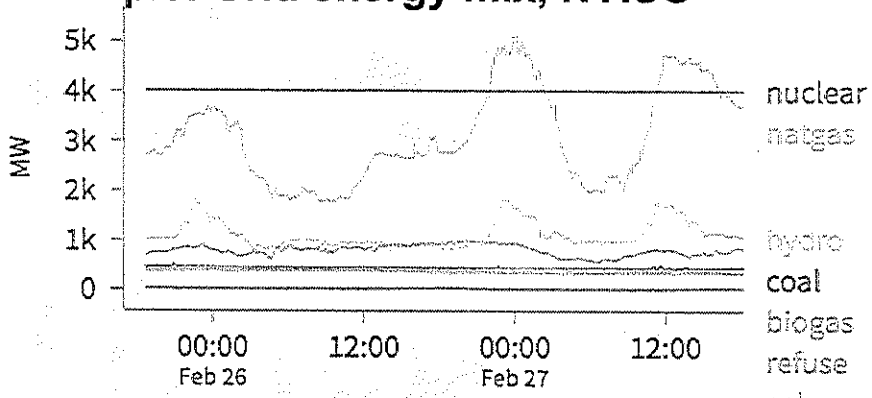
Internet-connected control of load timing

- The increasing prevalence of Internet-connected devices and building systems mean that many loads can be controlled in response to marginal emissions data
- Sophisticated control algorithms let users minimize the emissions associated with their load automatically and seamlessly

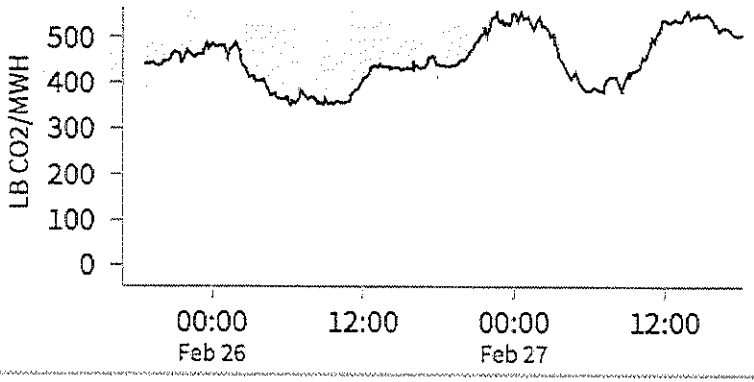
WattTime software monitors grid operations in real-time, allowing users to identify variations in marginal emissions

The fuel mix and emissions factors in regional grids can be calculated every 5 minutes

Example: Grid energy mix, NYISO



Average carbon intensity, NYISO



Marginal emissions provide detailed insight into a user's actual impact

Average emissions: Average emissions are calculated by dividing total emissions by total energy output, and are generally used today to measure carbon footprints.

However, if a user turns on or off a particular device, in reality only one or two power plants would increase or decrease production; thus the average value is not the most accurate or relevant figure.

Marginal emissions: In contrast, WattTime can now calculate the marginal emissions, which more precisely represent the change in overall emissions if load increases or decreases at any given time.

Source: WattTIme.org

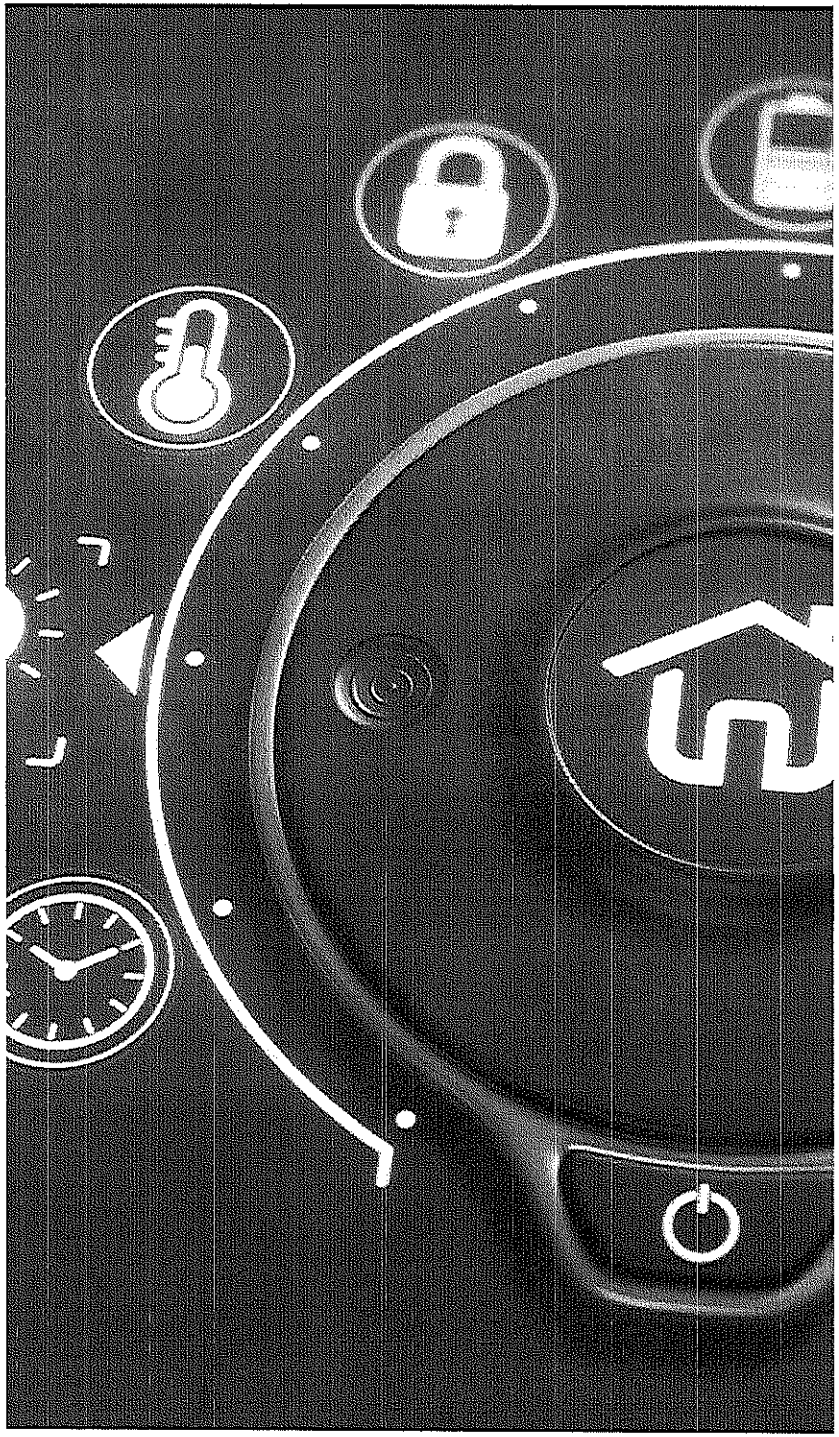
Real-time emissions signals enable load shifting for seamless, cheap, and measurable emissions reductions

Loads with flexibility or energy storage mechanisms can moderate their electricity usage with little or no impact on performance

- **HVAC and refrigeration systems** can slightly pre-cool or temporarily delay running in order to reduce energy-related emissions.
- **Electric water heaters** can use their storage tank like a battery, enabling flexible operation.
- **Electric vehicles** charging overnight can fluctuate the timing of their to take advantage of low-emissions periods.

Providers can take advantage of the flexible nature of loads and the scalable nature of software to enable programs that are:

- **Seamless:** Program operators can take advantage of natural flexibility to reduce emissions without impacting customer satisfaction.
- **Low cost:** Programs can offer these benefits at minimal incremental cost, given that control capability is often already present.
- **Measurable:** The environmental benefits gained can be quantified using widely accepted methodologies.



Impact:

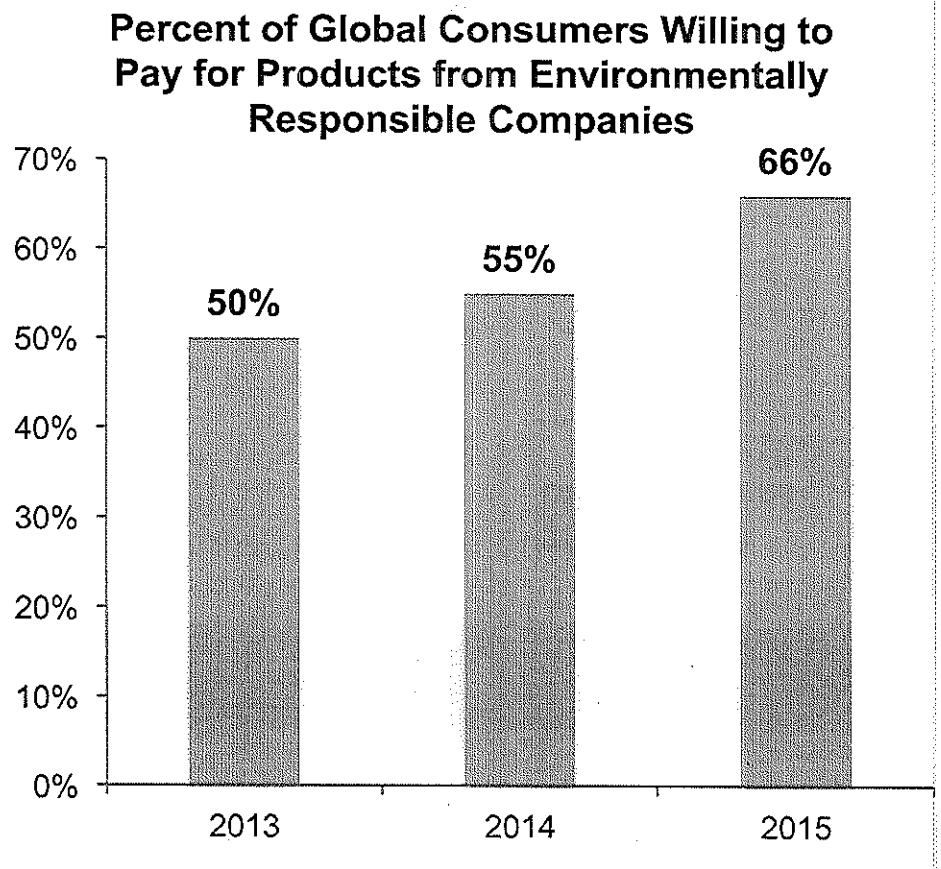
What is the potential for AER to reduce emissions?

Individual consumers are expecting more environmentally friendly options, and are willing to pay for them

Consumers in America want and expect more sustainable solutions

- A survey of 1,500 customers conducted by SmartEnergy IP found that 32% expect their utility to adopt automation technologies to save energy[1]
- A 2016 Gallup poll revealed that 73% of Americans want to emphasize alternative energy instead of oil and gas production[2]

Consumers are increasingly willing to pay for environmentally conscious brands[3]



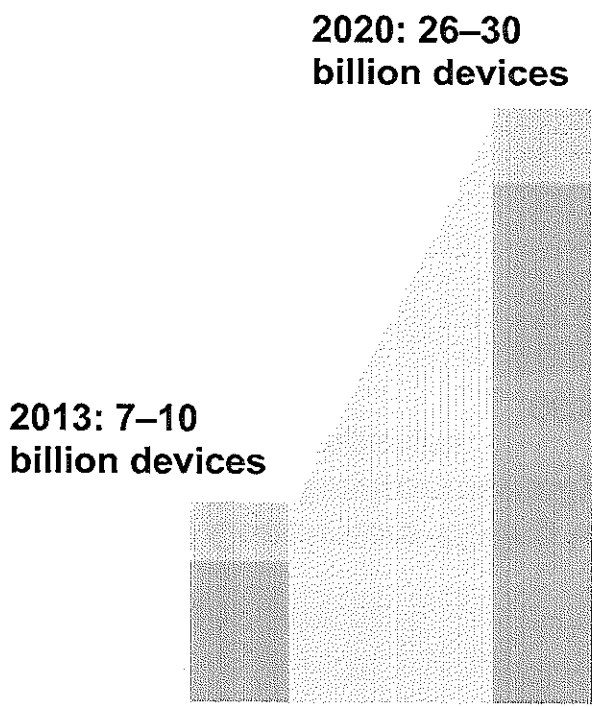
Source: [1] Navigant Research; [2] Gallup; [3] Nielsen.

Customers are also increasingly demanding communicating, controllable, and "smart" devices and control systems

Smart devices, appliances, and controls are growing in availability and popularity

- The smart thermostat market is projected to quadruple in size, reaching a $4.4 billion dollar industry by 2025.[1]
- Large consumer technology companies are now competing for market share in the growing "smart home" space.
- In institutional, commercial, and industrial facilities, business priorities are driving customers to demand connected, intelligent control systems to manage loads.

Some 30 billion devices may be connected to the Internet of Things (IoT) by 2020[2]



Source: [1] Navigant Consulting; [2] McKinsey, December 2014

As the IoT expands, greater connectivity offers new opportunities to capture value from connected devices

Connectivity and control allow energy-using devices to be optimized against several criteria. Devices can be programmed to:

Existing capabilities

- **Reduce peak demand** by shifting the timing of electricity usage to non-peak hours. Existing programs in the United States are already capable of reducing peak loads by up to 32 GW.
- **Lower energy costs** by scheduling load to take advantage of relatively low-cost electricity at different times of day. U.S. utilities currently have over 7.5 million customers enrolled in some form of dynamic pricing program, which directly incentivize this temporal flexibility.

Emerging opportunity

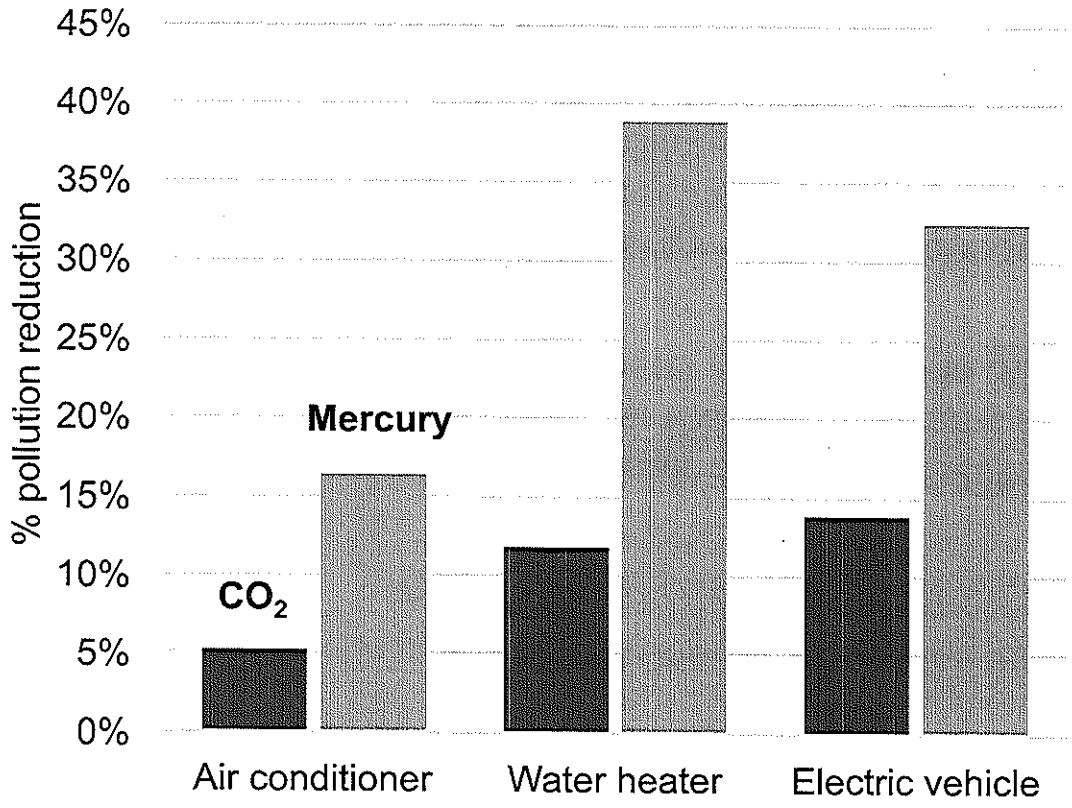
- **Reduce emissions** by shifting load to coincide with renewable energy production, or cleaner, more-efficient conventional generators.

Using current technology, **it is possible to stack the value of these use cases**, achieving both cost reductions for capacity and energy, as well as emissions reductions.

Source: EIA

Adjusting loads to minimize CO_2 and mercury emissions can reduce pollution by 5–40%, using current generation data

Simulated emissions impact of AER using residential loads in Chicago with negligible impact on service quality

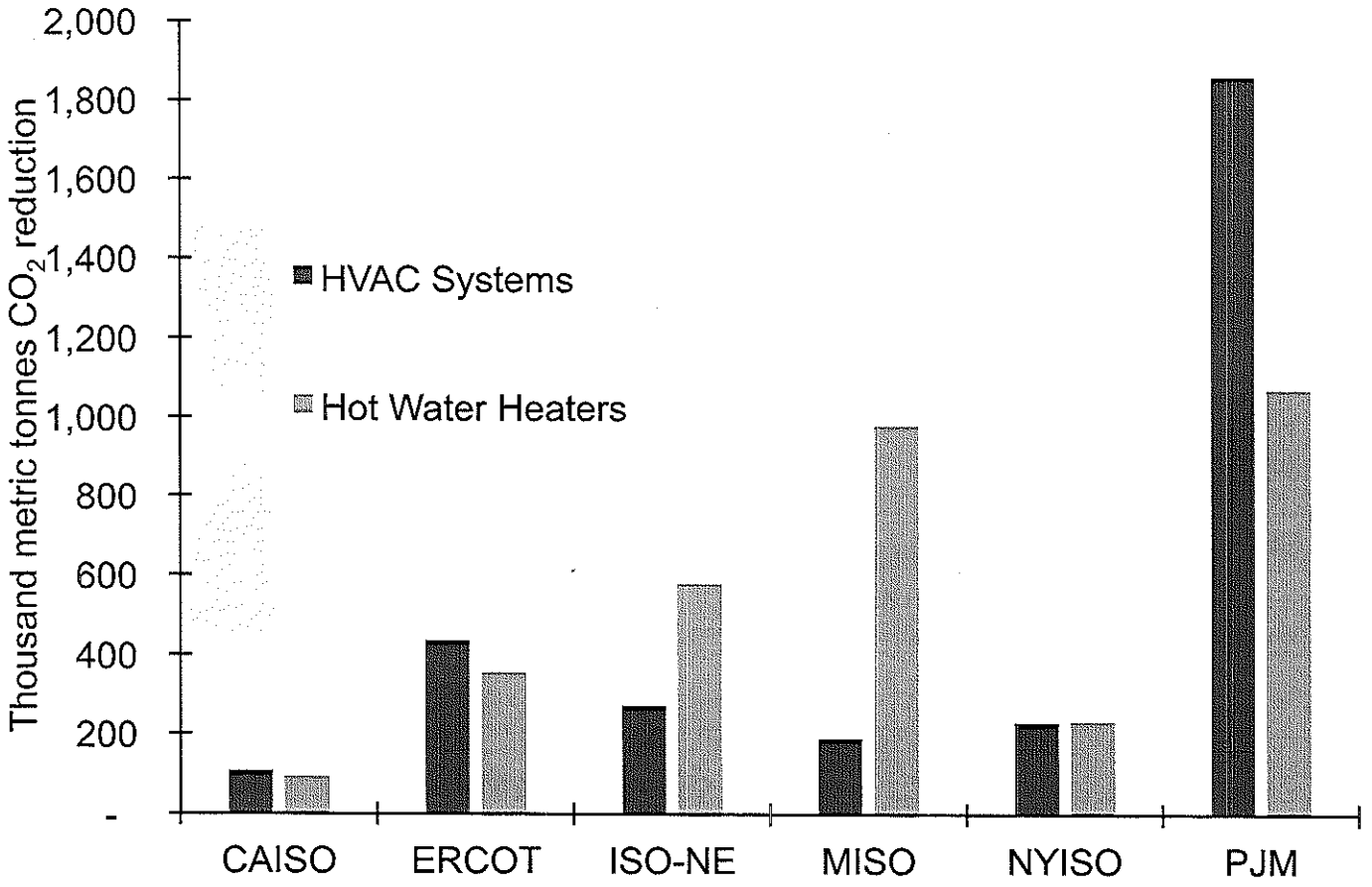


- Strategies to reduce emissions rely on flexibility and/or physical storage inherent in end-use loads.
- Electric water heaters and electric vehicles have flexibility over longer time scales, and thus greater emissions savings potential than air conditioning loads.

Source: WattTime and E2i emissions data, RMI simulation

Residential AC and water heating in six markets in the U.S. can reduce emissions by the equivalent of 1 million autos

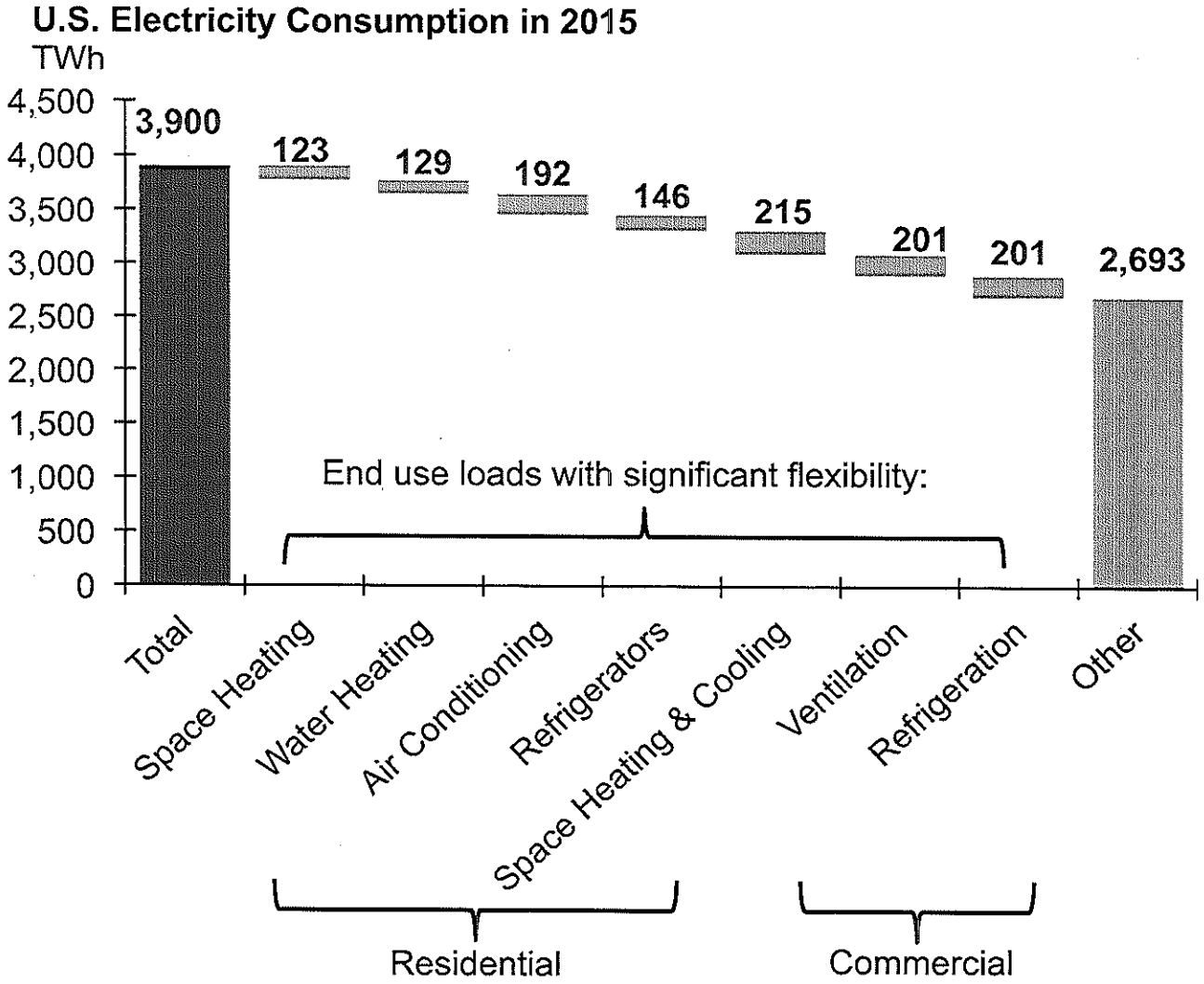
Estimated annual impact of AER technology in residential buildings across six U.S. ISO/RTOs



- Savings potential depends on both the patterns of marginal carbon intensity in regional grids, and the number of flexible devices in each region.
- Non-wholesale market regions and non-residential loads would lead to greater savings potential.

Source: RMI analysis; WattTime and E2i emissions data; EPA; EIA

AER technology can expand to additional loads with flexibility and use newly-available data to amplify its impact

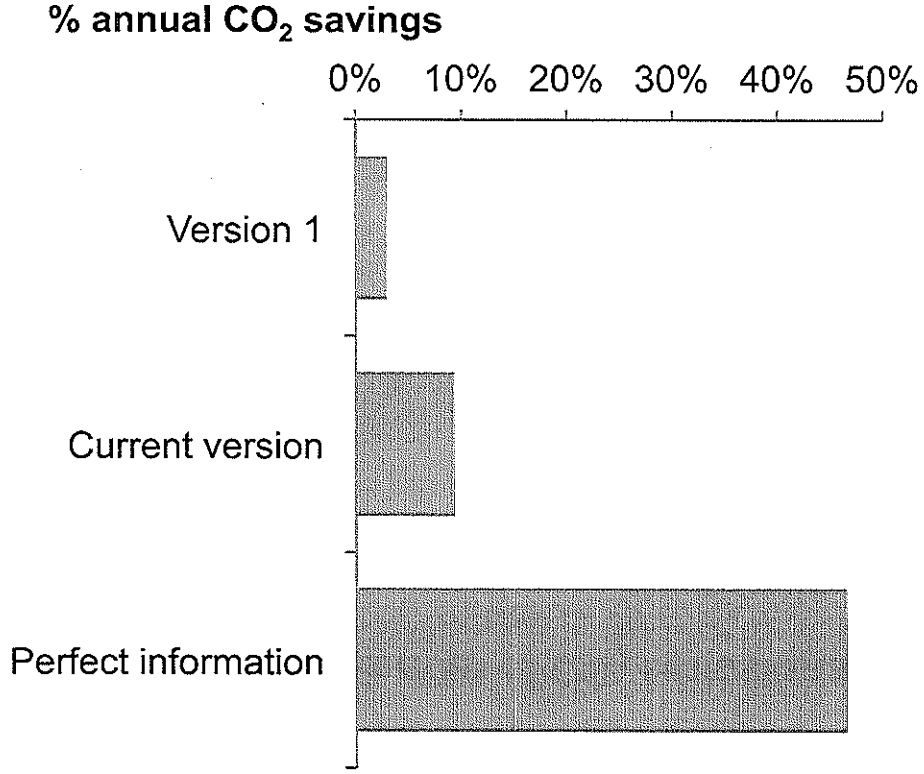


- At least 30% of total U.S. load has significant inherent flexibility appropriate for AER
- There is likely significant untapped flexibility potential in the remaining 70% (e.g. some industrial loads, behavioral response)

Source: EIA; RMI analysis

Emerging data sources can lead to more dramatic emissions reductions

Comparison of emissions savings possible for water heaters in MISO using different generations of marginal emissions data

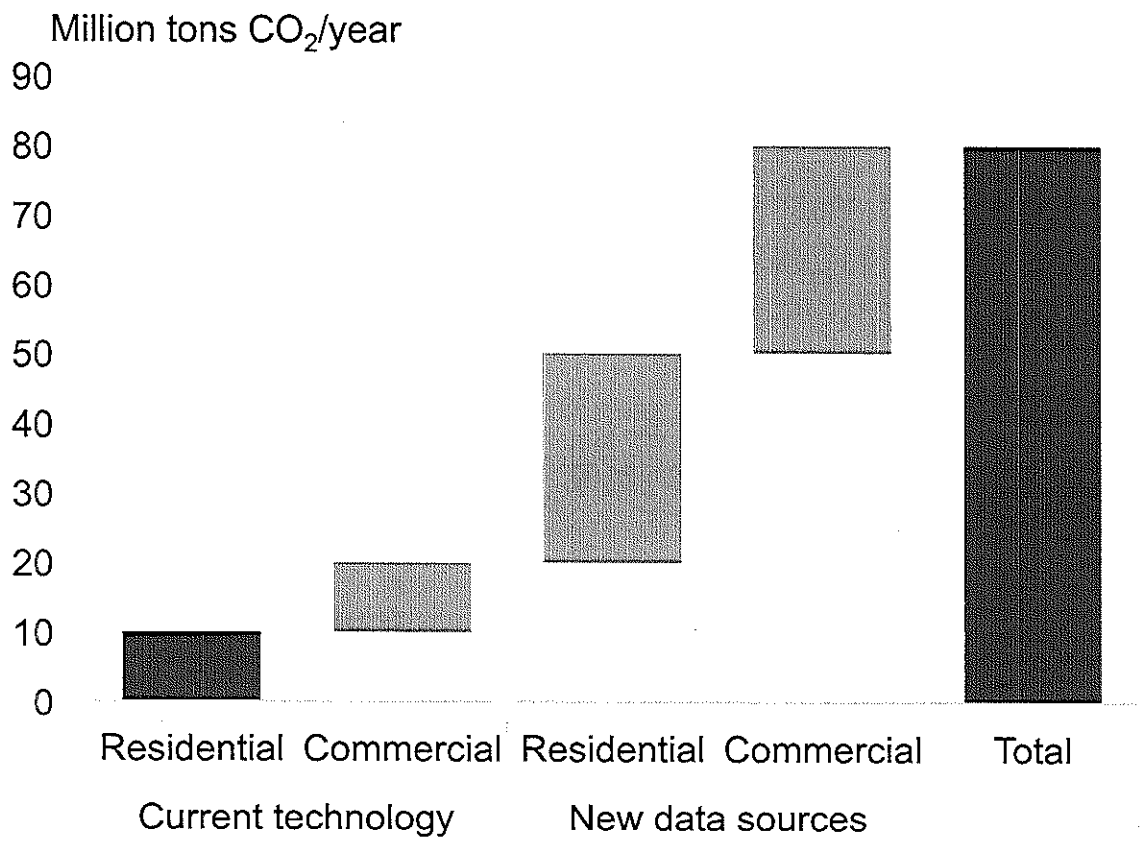


- The first generation of marginal emissions data allowed a 3% CO_2 reduction.
- Current-generation models, using more and different data sources, increase savings potential to ~10%.
- With emerging data sources (e.g. direct integration with system operators), it may be possible to measure marginal CO_2 perfectly, reducing annual emissions by an estimated 40%.

Source: WattTime, E2i, MISO, RMI simulation

AER can provide significant savings if deployed at scale with increased access to refined data sources

Estimated US potential of CO_2 emissions reduction from AER



- Current AER technology, used in just well-suited residential loads (AC and water heating), could save on the order of 10 $MTCO_2$/y
- Expanding to commercial loads could double that savings potential
- Incorporating new data sources to capture larger swings in marginal emissions rates would approximately quadruple the savings

Source: RMI analysis

The impact of small changes on the margin today can add up to major emissions reductions over time

Planning for next kilowatt-hour…

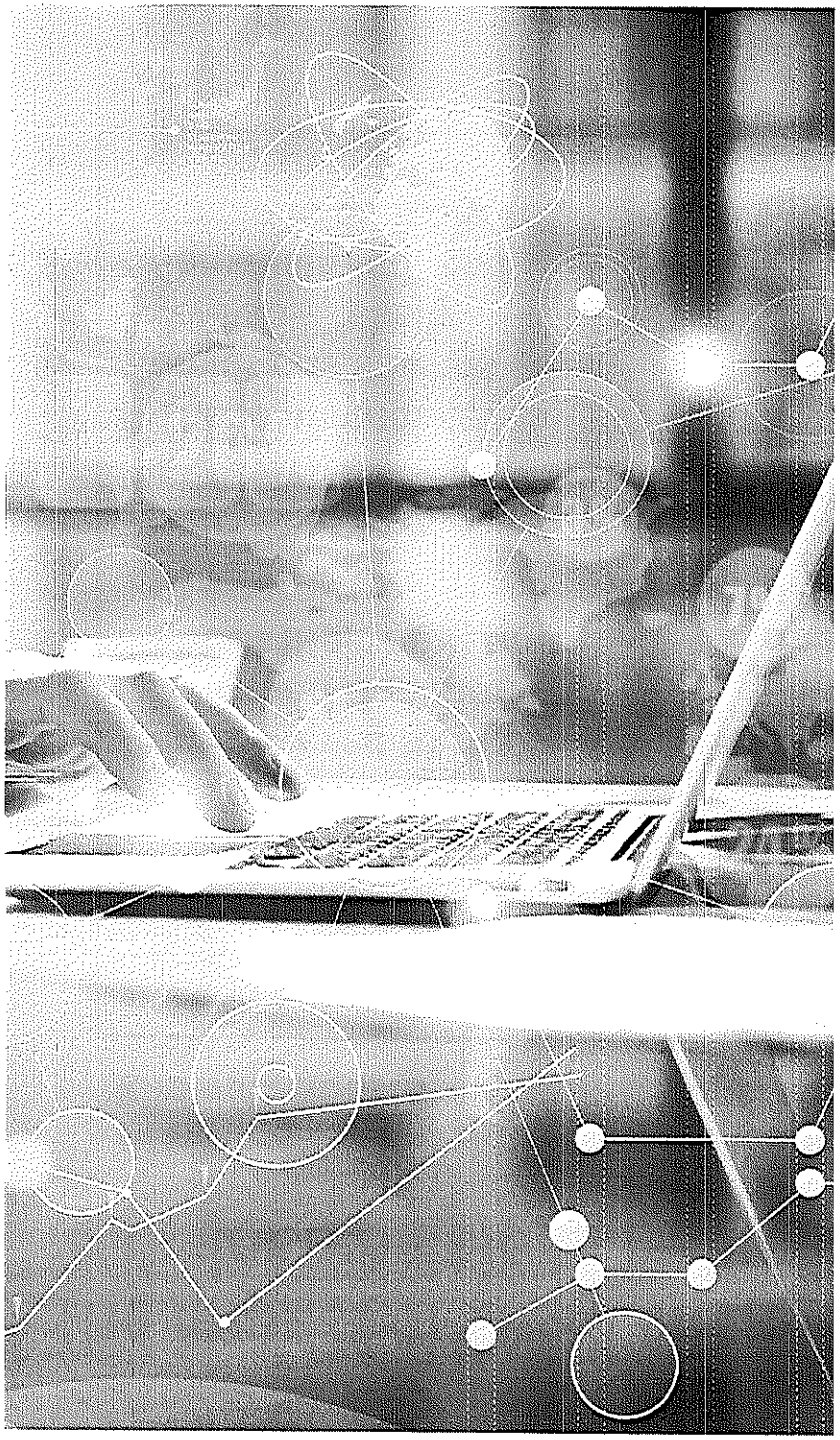
- Using current technology and data about marginal emissions, individual customers are **empowered to make informed decisions about their next unit of energy consumption.**
- These immediate emissions savings are verifiable, easily demonstrated, and simple to quantify.

... leads to grid operational changes …

- As more customers make incremental changes to their usage, there will be an **emerging opportunity to adjust the control signals and directly impact power plant operational decisions** (i.e., unit commitment).
- While harder to quantify, these savings can be much greater (e.g., targeted shifting to eliminate the need for coal plant operation).

… and eventually impacts resource investment

- As these operational impacts are reflected in system operations, spot prices, and forward capacity prices, **emissions-aware load shifting can drive emissions-reducing investment decisions.**
- These impacts are difficult to forecast, but could materially increase investment in renewable energy resources.



Data Validation:
RMI's evaluation of WattTime's algorithms

RMI independently evaluated WattTime's marginal emissions algorithms

- WattTime's algorithms to determine the marginal emissions rate in real time have been built on peer-reviewed academic research, but have gone significantly further to provide additional granularity and real-time capabilities.
- The resulting algorithms are proprietary IP.
- As part of its due diligence, RMI staff conducted a deep technical verification of the validity of the WattTime algorithms.
- RMI staff found the WattTime algorithms to not only be accurate, but to be likely *underestimating* the emissions savings resulting from deploying them for AER.
- Based on this finding, RMI decided to incorporate WattTime as a subsidiary organization.

Source: RMI assessment of proprietary WattTime methodology

Finding 1: WattTime algorithms rely on empirical methods, not structural models

Theory is a bad predictor

- Observed historical data do not match predictions from economic theory-based models (e.g. economic dispatch based on marginal supply curves)
- In public power grid data identified by WattTime, neither emissions rates nor renewable curtailment data match expected behavior

Empirical advantages

- WattTime's empirical approach is still capable of capturing the structural drivers of marginal emissions, but does not rely on theory-based models to do so
- Using a rich historical data set, it is possible to derive estimates of marginal emissions rates that are well-constrained by real data

Source: RMI assessment of proprietary WattTime methodology

Finding 2: WattTime's approach is a statistically accurate approach to estimating marginal emissions

Empirical basis

- The core statistical approach uses validated empirical techniques that improve on leading-edge research
- The WattTime approach relies on vetted data sets from providers of record

Conservative approach

- WattTime combines historical and real-time data to identify a robust estimate for marginal emissions
- The WattTime approach adds new data to core model only when their inclusion can be empirically justified

Roadmap for improvement

- The empirical approach using historical data captures the vast majority of variation that causes changes in marginal emissions intensity
- Accuracy will increase with additional testing and incorporating additional data sources already in the WattTime product roadmap

Source: RMI assessment of proprietary WattTime methodology

Finding 3: Due to the conservative nature of WattTime's approach, AER is a robust emissions reduction tool

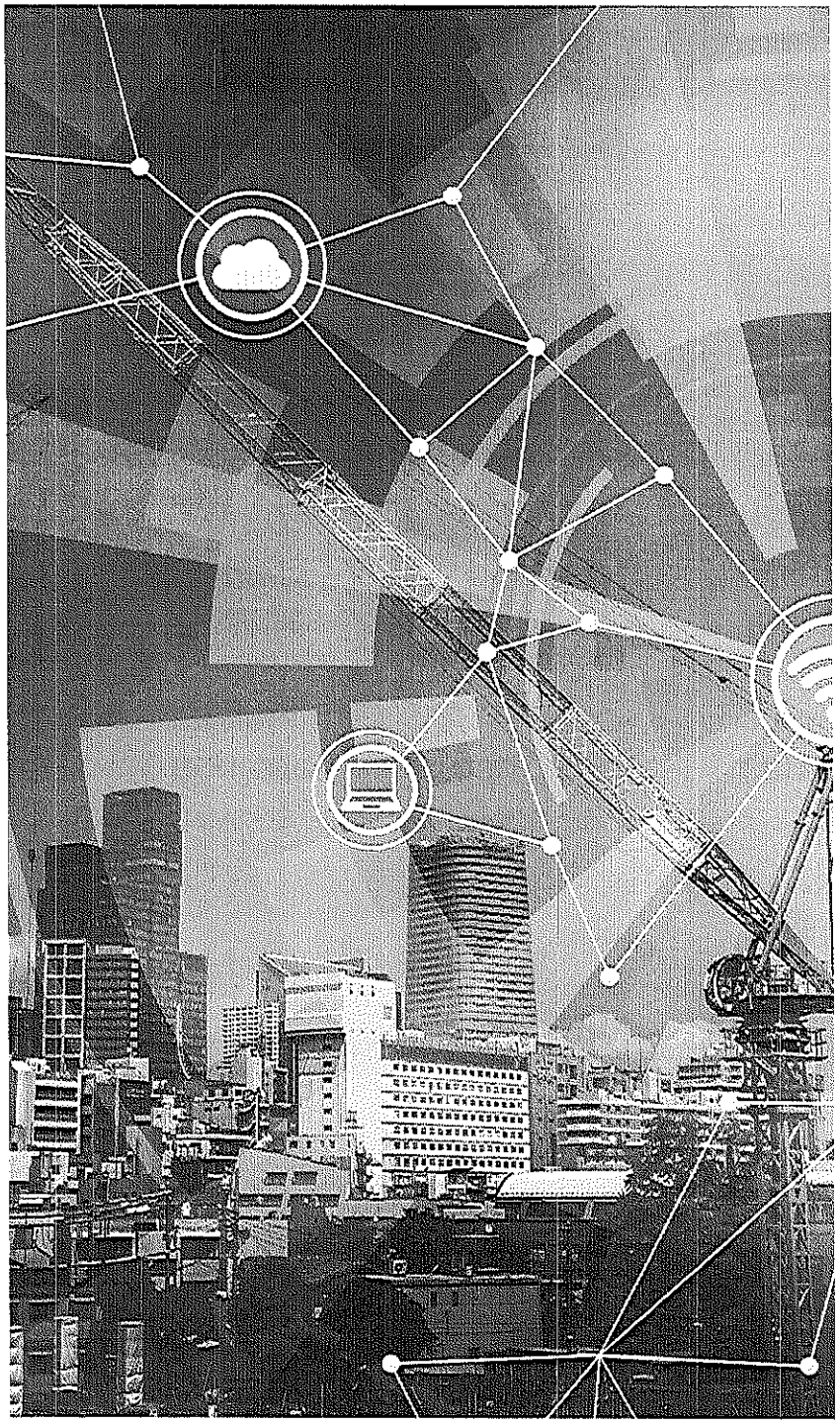
Emissions savings are statistically certain

- The design of the marginal emissions model ensures that identified changes in time of the emissions intensity are statistically robust
- Therefore, control signals that use these estimates are virtually certain to reduce emissions

Emissions reductions are likely higher than reported

- The conservatism of the WattTime data feed results in a estimates of marginal emissions that likely vary much less than the true variation on the grid
- Thus, because WattTime-enabled devices outputs are robust in their identification of changes, the actual savings associated with WattTime's control signal are likely higher than estimated by WattTime itself

Source: RMI assessment of proprietary WattTime methodology



Use Cases:

How AER drives value for adopters

Institutional and residential energy users: sources of value

Financial savings	Public relations and marketing benefits	Customer experience
• Lowest-cost method to achieve GHG reduction targets • Enables optimization of GHG impacts per dollar	• ***External:*** Company can publicize corporate stewardship effort • ***Internal:*** Improves employee health and happiness	• ***Residential*****:** feeling of control increases consumer engagement • ***Institutional:*** control rests with facility manager, providing greater reliability than with conventional DR

Institutional and residential customers: use cases

Energy-smart buildings

- AER integrated directly into building-level controls can enable the whole building to minimize emissions
- Unlocks additional savings from the buildings' existing equipment installations

Technical integration into existing devices

- Integration of AER into existing smart devices makes technology available at zero incremental cost
- Survey data finds consumers are more likely to purchase a smart device if it includes AER capability

Integration with demand response

- For "dumb" buildings, combining AER with automated demand response (ADR) mitigates equipment costs
- Same financials as conventional ADR, but greater environmental impact

Utilities and policy: sources of value

Improving customer engagement

- Lower customer acquisition costs
- Increase satisfaction
- Increase scale of demand side management programs

Meeting utility-level sustainability objectives

- Sell emissions credits
- Mitigate operational challenges
- Avoid renewable energy curtailment

Achieving emissions goals

- AER can be a low-cost lever to reach goals of existing policy
- For example, state-level renewable portfolio and air quality standards can be bolstered by AER

AER providers: use cases

Utilities: integration with demand response

- AER adoption can deliver cost savings per program participant greater than those of real-time pricing
- Survey data suggest that AER can reduce customer acquisition costs for utility demand response
- Integration with an existing program would limit overhead costs of a new implementation

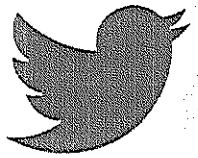
Policy: emissions reductions

- Policy can direct deployment of AER towards specific cases where it will have the greatest impact
- Deploying AER at small (~1-2%) participation levels, if targeted well, could reduce local pollutants by ~40%

Key Conclusions and Next Steps

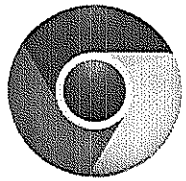
- We are confident that WattTime's cutting-edge technology is proven and validated thanks to early adopters and RMI analysis
- RMI and WattTime expect this technology to be more broadly used to accelerate corporate sustainability efforts, improve the profitability of distributed energy resource companies and retail energy providers by lowering customer acquisition costs, and improving the way that carbon emissions are measured worldwide.

Follow Us



@RockyMtnInst
@wattTime

@RockyMtnInst
@wattTimeApp



www.rmi.org
www.wattime.org

Or contact Jamie Mandel, Rocky Mountain Institute, jmandel@rmi.org

BEFORE THE PUBLIC SERVICE COMMISSION
OF THE STATE OF MISSOURI

In the Matter of Kansas City Power & Light Company's Notice of Intent to File an Application for Authority to Establish a Demand-Side Programs Investment Mechanism	))))	File No. EO-2019-0132
In the Matter of KCP&L Greater Missouri Operations Company's Notice of Intent to File an Application for Authority to Establish a Demand-Side Programs Investment Mechanism	))))	File No. EO-2019-0133

RESPONSE TO PAY AS YOU SAVE (PAYS) FEASIBILITY STUDY

COMES NOW, the Office of the Public Counsel (OPC), by and through counsel, to submit this Response to Pay as You Save (PAYS) Feasibility Study and state as follows:

1. In its Report and Order from a prior general rate case for Kansas City Power & Light (KCPL) and KCP&L – Greater Missouri Operations (GMO), the Public Service Commission (Commission) ordered the companies to consider incorporating PAYS into a Missouri Energy Efficiency and Investment Act demand-side management program.[1]

2. KCPL and GMO contracted with the Cadmus Group LLC to complete a feasibility study.

3. Cadmus Group completed the study on September 28, 2018, and found that a PAYS program could support KCPL and GMO customers without other means of accessing capital, but that KCPL and GMO must address implementation barriers to realize the PAYS' full potential. Cadmus Group recommended that KCPL and GMO consider a PAYS program that targets low-

[1] *Report and Order*, File No. ER-2016-0285 (May 3, 2017).

income and multifamily populations. KCPL and GMO submitted the study alongside their latest application for a demand-side management program.

4. In response to KCPL and GMO's feasibility study, the Energy Efficiency Institute, Inc. (EEI), the proprietary owner of PAYS, reached out to the OPC with concerns regarding Cadmus Group's methodology.

5. The EEI provided the OPC with documentation of its concerns, and the OPC attaches said document hereto as **OPC-1**.

WHEREFORE, the OPC respectfully submits this Response to PAYS Feasibility Study and tenders **OPC-1** for the Commission's future consideration regarding the PAYS program. The OPC does not request any particular action of the Commission at this time.

Respectfully,

OFFICE OF THE PUBLIC COUNSEL

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Caleb.hall@ded.mo.gov

Attorney for the Office of the Public Counsel

CERTIFICATE OF SERVICE

I hereby certify that a true and correct copy of the foregoing was served, either electronically or by hand delivery or by First Class United States Mail, postage prepaid, on this 8th day of January, 2019, with notice of the same being sent to all counsel of record.

/s/ Caleb Hall

Response to

PAYS[1] Feasibility Study prepared for Kansas City Power & Light by Cadmus

prepared by the Energy Efficiency Institute, Inc.

for Missouri Office of the Public Counsel

Given recent interest in the Pay As You Save® (PAYS®) system in Missouri, it is vital that decision makers assess whether PAYS should be implemented in Missouri based on accurate information about how PAYS works and experiences in other states.

The Energy Efficiency Institute, Inc. (EEI) is not only the originator of the Pay As You Save system, it has also been involved to varying degrees in the regulatory approval, design, and implementation of all 17 programs in the seven states where the PAYS system has been implemented.

EEI reviewed the Cadmus "PAYS Feasibility Study" (sic) prepared for Kansas City Power and Light (KCP&L), which was delivered September 28, 2018.

The Cadmus report is based on a survey of KCP&L residential customers intended to assess "*...whether the Pay As You Save (PAYS) program model could contribute to increased energy efficiency uptake among KCP&L residential customers, and whether offering the program would be administratively feasible for KCP&L.*" (p. 1)

Generally, the report's conclusions and recommendations are positive about the appropriateness of PAYS for KCP&L residential customers. The report notes, for example, that "*...potentially a reasonably large subset of homes in KCP&L territory that could provide significant savings opportunity and be good candidates for PAYS.*" (p. 3) And Cadmus acknowledges the unique aspects of the PAYS offer to customers on page 17 when it writes, "*PAYS incorporates several unique features that most people are not accustomed to considering when thinking about payment or financing options.*"

At the same time, this report evidences a troubling misunderstanding of PAYS and unfortunately that can leave readers (including KCP&L decision makers) confused about what PAYS is, how it works, and the attractiveness of the offer to customers. And that misunderstanding has not only impacted the survey and its results, it undermines the report's positive conclusions and

[1] The report title should include the registered trademark symbol. In 2003 (PAYS®) and 2005 (Pay As You Save®), the U.S. Trademark and Patent Office awarded EEI trademarks for its system and its acronym. As of those dates, there is no PAYS-like program or a generic Pay As You Save program. Using the name or its acronym must refer to EEI's system (i.e., has all the essential elements and meets all the minimum program requirements) and should be accompanied by the registration mark. It must also be used when utilities receive permission to use PAYS as part of their branding. EEI has never charged a program for using the mark. EEI has asked numerous persons with relationships with Cadmus (e.g., Dr. Holmes Hummel at Clean Energy Works and Jennifer Greene the City of Burlington Vermont's Sustainability Office) to point out that PAYS is a trademarked system and U.S. Patent and Trade Mark law requires the use of the registered mark symbol. Cadmus acknowledges on page 5: "*PAYS is a trademarked program model used in a number of energy efficiency programs around the country,*" however, they do not use the registered trademark symbol in the report as required by U.S. Patent and Trademark law.

recommendations. We are especially concerned because this study repeats many of the same errors that EEI found in the studies Cadmus published earlier this year for Empire District and Ameren Missouri.[2]

We have cited excerpts from this study and provided clarifications that we think are necessary as well as recommendations that we think would help KCP&L meet its operational goals for efficiency programs through implementing a successful and cost effective PAYS program that serves all customers including renters and low- moderate- income and other hard-to-reach customers. As we did with our response to Cadmus' report for Empire District, we have also included in this response an addendum listing examples of misinformation in the Cadmus report for KCP&L that should be corrected.

We have organized this response into five sections plus an addendum: 1. PAYS background and key distinctions; 2. Unrealistically high cost estimates; 3. Low penetration targets and few eligible measures; 4. Survey flaws; and 5. Recommendations.

1. PAYS® background and key distinctions

The PAYS system was developed in the mid-1990s. Rebates, low- or no-interest loans, and on-bill financing were used as incentives to customers to purchase and install energy efficiency measures in their homes and businesses. But none of these efforts produced robust customer acceptance.

EEI's assessment was that these incentives failed to produce widespread building energy efficiency because they were not focused on customers, the people who make the decisions about whether or not to install building upgrades. In fact, these programs required participants to accept most of the risk that the purchase might not deliver as promised (e.g., problems with contractors, insufficient savings to justify the cost, upgrade failure, shoddy products or installations, leaving premises before upgrades repaid their cost through savings, unaffordability that excluded participation of more than half of utilities' customers, that is, renters and low- moderate- income customers). As a result, the customer take-up rates for most utility programs have been very low.

While the PAYS system includes elements of rebate and loan programs, it takes a different approach to achieving widespread building energy efficiency: making an offer to customers that is too good to refuse. Because PAYS is focused on the offer to the customer, it is often misunderstood or mischaracterized by analysts used to thinking about programs using rebates or financing incentives, which also appears to be the case with Cadmus.

In this section of the response, we look at some key distinctions between PAYS and other types of programs and how misunderstanding these distinctions has led Cadmus to erroneous conclusions in its report for KCP&L that put PAYS in an unrealistically negative light.

Utility investment, not consumer loans:
PAYS involves no consumer purchases or loans. The participating utility customer does not take on new debt, and therefore, there is no need to go through a credit check. In the PAYS system, the

[2] Missouri Office of Public Counsel. 2018. Response to Notice of Completion of PAYS Study. https://www.efis.psc.mo.gov/mpsc/commoncomponents/view_itemno_details.asp?caseno=ER-2016-0023&attach_id=2018021923. EEI communicated to the Missouri Office of the Public Counsel that there was no need to respond to Cadmus' feasibility study for Ameren because it cited similar costs and faulty conclusions as its Empire study.

utility places no lender lien on the property, and there is no loan balance to be paid off by when a utility customer vacates the premises. In short, customers are not borrowers under PAYS programs.

Instead, PAYS involves utilities investing in upgrades on the customer side of the meter and then collecting payments through a tariff to recover their investments from customer(s) at the locations where the upgrades were installed. If any money needs to be borrowed, it is borrowed by the utility. And payment obligations are tied to the location, so whoever is a customer at a location where upgrades are installed makes the payments for only as long as they are a customer there.

Cadmus represents PAYS as a consumer financing program throughout this study, introducing confusion with loan programs. For example, immediately following the Executive Summary on page 1, the report states: "*...the study examined whether any on-bill financing program would be a beneficial addition to KCP&L's residential energy efficiency portfolio...*". Financing in this context typically means a consumer loan that includes debt on the participant's balance sheet as the borrower, a lien placed on the property by the lender, and the need for the participant to pay off the loan when they vacate the premises. Since PAYS is not a consumer loan, it includes none of those barriers to customer participation; it is a very different kind of offer to the customer. At best, the report is ambiguous about whether on-bill financing involves a loan to the participant.

In the scenarios that Cadmus uses to describe PAYS to survey participants, it describes it as a consumer loan. In scenario two on page 18 (and in scenario three on page 19), for example, the report states: "*You would repay the loan as an extra $40 charge each month on your electric bill ($480 per year) for about 14 years.*" It's no surprise that the percentage of respondents who selected rebate and financing options was lower (54%) than the percentage selecting rebates only (84%). We know that customers do not want to take on more debt. That's one of the barriers to participation that PAYS was designed to eliminate. Customers incur no new debt with PAYS upgrades.

In fact, none of the four scenarios (pp. 17-21) describe PAYS. Many of the survey questions do not address information that might be helpful to any Missouri utility considering implementing a PAYS program. The KCP&L customers in the sample surveyed by Cadmus are asked to comment on differences that are never clearly or fully explained to them in Cadmus' questions. Findings related to non-PAYS on-bill finance programs have no relevance to well-designed PAYS programs in terms of operations costs, upgrade costs, installation costs, and offer acceptance rates. It is a mistake to use such information to inform conclusions about the viability of PAYS at KCP&L.

PAYS® is a system:

In the Willingness to Accept PAYS Features section (pp. 17- 21), Cadmus examines customer interest in individual features of the PAYS system, such as "...the *'tied to the meter' tariff aspect, the guaranteed positive cash flow and the utility endorsement.*"

A significant problem in this section is that it leaves out other features that, in concert with the cited features, combine to create an offer that works. PAYS works as a system with each element of the system designed to help create an offer that customers find too good to refuse. The offer is not effective unless all of the features are included. Cadmus should have asked the KCP&L customers in the sample about the desirability of a PAYS offer with all of its customer benefits.

The first scenario in this section of the study by Cadmus for KCP&L has nothing to do with PAYS features. Cadmus writes, "The first scenario presented a rebate-only option... The majority of

respondents (84%) selected the rebate option, as shown in Figure 9." Rebates are not a requirement of PAYS though many utilities have continued their rebates when implementing PAYS.

Rebates were originally designed to provide the least possible subsidy to get customers to purchase items they would not otherwise purchase that would benefit the utility and all of its customers. EEI is not familiar with and cannot comment on the efficacy of KCP&L's rebate programs. However, since more than half of all customers receiving a PAYS offer accepted it (80% in neighboring Arkansas' HELP PAYS® program and more than 70% in Kansas' Midwest Energy's How$mart® program), implementing a PAYS program would provide utilities the opportunity to reevaluate the amount of the rebates required to get customers to purchase efficiency upgrades.

Without any justification, on page 47, Cadmus writes, "*Due to its strict requirements for eligible projects, PAYS will prove unattractive to customers with access to other financing options.*" As noted elsewhere in this response, Cadmus never presents its sample of KCP&L customers with a PAYS offer that includes all of its benefits, so the survey provides little insight into whether those surveyed would like or dislike a PAYS offer. The choice to ask questions about features of PAYS in isolation (and not all of the features) rather than about the actual PAYS offer and its benefits for customers undermines the survey. There is no basis for the conclusion from the Cadmus survey that PAYS will prove unattractive, since the sample of KCP&L customers were not presented a PAYS offer.

2. Unrealistically high cost estimates

Loan loss reserves:
On pages 39 and 40, Cadmus writes, "*Research for other PAYS feasibility studies has found several PAYS administrators, including the MACED program in Kentucky, use loss reserves to fully protect ratepayers from participant nonpayment. Loss reserve funds typically are set equal to a certain percentage of the program's outstanding loan volume, just above the expected nonpayment rate. This limits the funding amount needed in reserve, but protects the administrator (and ratepayers) from absorbing the cost of unrecovered investments.*"

In three and four years of program operation respectively, neither Ouachita Electric (Arkansas) nor Roanoke Electric (North Carolina) Cooperatives has filed a claim against their reserve fund. Actual PAYS programs that report uncollectables average less than a 0.1 percent loss. MACED, cited above by Cadmus, has less than a 0.2 percent nonpayment rate. According to MACED program manager Chris Woolery, since How$mart®KY program design changes and a revised tariff were put in place in August 2013, only one of MACED's utilities filed a claim against the risk mitigation fund.[3] Nevertheless, Cadmus assumes a five percent charge on project funding to be paid by program participants for a reserve fund (Table 9, p. 41), 25 times the nonpayment rate at MACED.[4] Since PAYS uncollectables average 0.1 percent and the Illinois Energy Efficiency Loan Program (EELP) had uncollectables of 0.16 percent (p. 39) and both are lower than average uncollectables for KCP&L, there is no need to require participants to pay for a costly loss reserve fund, which makes fewer upgrades qualify for installation.

[3] Based on a Jan. 3, 2019 phone call with Harlan Lachman.
[4] MACED was required by the implementing utilities to fund a reserve fund through participant fees based on 5% of their upgrades' cost. This was not a design recommendation, nor has the amount been reduced in spite of the performance of collections at PAYS upgraded locations.

IT upgrades:
The report states, "*Upgrades to IT systems that manage billing may be a significant cost – in the low hundreds of thousands as a base estimate...*" (p. 41).

Cadmus provides no credible source for this estimate. The only utility that we know of that commissioned an add-on module to its information and billing system software system to comply with EEI's (and its own staff's) recommendations spent less than $40,000 for the upgrade (c.f., p. 3 of the Cadmus Process Evaluation Report of the Windsor Efficiency PAYS® program). Before the estimate in the report for KCP&L is taken seriously, Cadmus should share the bids that justify an estimate that is five to 10 times an actual expenditure noted in a previous Cadmus evaluation.

Origination and servicing for consumer loans:
On pages 41 and 42, in Table 8. Estimated KCP&L Costs for Annual PAYS Implementation, Cadmus estimates a servicing cost of $900 per participant, an origination cost of $600 per participation, and a $700 - $1000 cost per participant for implementation.

Origination and servicing are terms related to consumer loans, and they refer to activities like underwriting and debt collections. These activities are not applicable to PAYS investments with on-bill cost recovery and, therefore, those costs are not necessary.

EEI does not dispute an estimate of a one-time $700 - $1000 per-participant cost for implementation by the program operator although in most PAYS weatherization programs, participants reimburse their utility approximately $325 of these costs which are rolled into the participant's project cost (c.f., Roanoke, Ouachita, and Appalachian Electric). The one-time implementation cost includes the work to visit the site, develop a proposal, discuss the proposal with the customer, get a signature, inspect the installation, and communicate to the utility that it should begin to collect the monthly charge.

None of the 17 utilities, including the two IOUs that have operated programs based on PAYS, have reported one-time or annual per-participant costs for servicing of $900, and similarly, none have reported one-time or annual per-participant costs for origination of $600. These costs should be eliminated from the Cadmus estimate of total costs.

Unnecessary staffing:
In the second of four conclusions in the Executive Summary (p. 3) and again in the Conclusions section (p. 46) the report states, "*While a significant number of customers accepted the PAYS offer, survey responses indicated a significant information barrier for many customers when evaluating this unique program.*" Cadmus goes on to write, "*KCP&L intends to add additional staff to manage its pilot programs. Cadmus expects that this staff will be critically important to ensuring the program delivers a clear, strong message...*"

These additional staff are unnecessary and needlessly inflate the costs for implementing a PAYS program. Since not only have a significant number of customers accepted offers, but a very high percentage of customers receiving offers accepted them, it is unlikely that there is a "significant information barrier." More than 80% of customers in neighboring Arkansas and approximately 70% of customers in neighboring Kansas who have received PAYS offers said yes to those offers. These are unprecedented customer acceptance levels for utility efficiency programs that contradict the notion that there is a significant information barrier that requires the addition of expensive new

staff, which will reduce funding available for efficiency upgrades that the program can offer to customers.

3. Low penetration targets and few eligible measures

Renters:
On page 43, Cadmus wrote, "*In interviews conducted for the Ameren Missouri PAYS feasibility study, a PAYS implementer reported that, in most cooperative PAYS programs in the Midwest and South, the majority of participants were single-family home owners.*"

While it is true that most participants have been single-family home owners, it's noteworthy that Arkansas' HELP PAYS® reached 100 percent of the customers in the service territory living in multifamily housing and responsible for their energy bills. And just a few years ago, Kansas' How$mart® program reported that 15 percent of its participants were renters. These are significant achievements in this hard-to-reach market and should be used as the basis for setting minimum goals for penetration levels that utilities initiating programs should be expected to reach with renters.

Overall program participation:
In its presentation of Estimated Costs Paid by Participants (Table 9, p. 42), Cadmus assumes a program of 250 customers in a year. That scale is smaller than the sample size for Cadmus' survey for its report for KCP&L.

In citing Participation in PAYS Programs (Table 10, p. 43), the report lists the number of participants in several programs that are based on PAYS without noting the percentage of each utility's customers served by the program. In a revised version of Table 10 below, EEI shows the level of participation that could be assumed for KCP&L if it served the same percentage of its residential customers as the utilities cited by Cadmus. This table shows that it would not be unreasonable to expect KCP&L to implement a program serving 21,000 customers in three years, since the HELP PAYS® program reached 4% of Ouachita Electric Cooperative's customers in only two years.

By using a number as low as 250 participants in a year, the Cadmus report sets a very low bar for KCP&L program participation compared to programs operated in other states.

Residential Program	Number of Utility Customers	Participants	Years of Operation	Comparable KCP&L Participants*
HELP PAYS®	6,500	278	2016–2017	22,000
Upgrade to $ave	14,000	400	2014–2017	15,000
How$mart®	50,293	1915	2010-2018	20,000
Windsor Efficiency PAYS®	8,000	242	2012-2014	16,000
How$mart®KY	139,230	289	2011–2017	1,100

* KCP&L has 522,032 residential customers.[5] These numbers are derived by applying the percentages of residential customers that are program participants for the other listed utilities to the number of KCP&L residential customers.

[5] This estimate was provided to EEI by the Office of the Consumer Counsel.

Eligible measures:

• On page 9, the report states, "*Cadmus relied on recently completed feasibility studies for PAYS in Ameren Missouri's and Empire District's territories for acquiring basic information on the requirements to launch and operate PAYS, and findings from currently implemented PAYS and on-bill financing programs. As the author, Cadmus could access these unpublished reports and the primary data collection informing them.*"

Cadmus evaluated the feasibility of implementing a PAYS program for Empire District and Ameren primarily on its assessment of the costs and economics. EEI reviewed Empire District Feasibility Study by Cadmus and wrote a detailed assessment noting: "There are a number of assumptions included in the Cadmus analysis, however, that significantly reduce the reported cost effectiveness of implementing PAYS in Missouri…" The Office of the Public Counsel filed EEI's response with the Missouri Public Service Commission (https://www.efis.psc.mo.gov/mpsc/commoncomponents/view_itemno_details.asp?caseno=ER-2016-0023&attach_id=2018021923).

• On page 19, the report for KCP&L states, "*In other analyses of PAYS feasibility, replacing working electrical heating equipment with a high efficiency heat pump was the only project that generated sufficient savings to allow administrators to finance full project costs under PAYS guidelines.*"

Two utilities in neighboring states achieved the high offer acceptance rates described above (80% of customers receiving an offer in neighboring Arkansas' HELP PAYS® program and more than 70% in Kansas' Midwest Energy's How$mart® program) even while installing comprehensive residential upgrades such as air and duct sealing, gas fired heating upgrades, high efficiency heat pumps, attic insulation, LEDs, low flow showerheads, and ground water heat pump systems. In EEI's response to the Cadmus study for Empire District, EEI discusses some of the reasons why Cadmus arrived at this faulty conclusion distorting PAYS potential in Missouri.

On page 25, the report for KCP&L states, "*Other PAYS feasibility studies have shown that project savings must be extremely high to generate saving necessary for PAYS to cover most or all upfront project costs. Upgrading working electric furnaces to high-efficiency heat pumps is one of a few project types likely to consistently provide sufficient savings to support full project funding.*" And, on page 44, Cadmus writes, "*At the same time, analysis for Ameren Missouri and Empire District found that PAYS, if limited to projects offering sufficient savings for the program to fund full project costs, potentially could be cost-effective with fewer than 300 participants.*"

Midwest Energy in Kansas, with only 50,293 electric customers (https://www.mwenergy.com/assets/uploads/pages/2017_Annual_Report.pdf), has fewer than 10% of KCP&L's customers (and a small percentage of the cited number of customers for both Ameren and Empire District), yet it has completed 1,915 projects. While these projects involved some copayments, it would seem reasonable that if Midwest Energy is able to report that more than 70% of offers have been accepted, Cadmus' presumption that a program needs to operate with no copayments is unnecessarily limiting eligible measures.

An independent February 2018 evaluation of Ouachita Electric Cooperative's HELP PAYS® program performed by OptiMiser LLC, reported that 92% of participants installed air sealing, 75% installed duct sealing, 88% installed LEDs, 79% added attic insulation, and 80% installed HVAC

upgrades. Recent results at a utility in an adjacent state serving one of the most economically distressed regions in the country shows that most customers accept offers to install comprehensive energy efficiency upgrades in both owner-occupied and rental housing.

Finally, it is important to note that in all three of the feasibility studies prepared by Cadmus to date for investor-owned utilities in Missouri, in addition to using incorrect assumptions about operations and upgrade costs, Cadmus excludes customers' gas savings as a program benefit. Excluding gas savings from customers' upgrade cost-effectiveness calculations reduces the number of eligible upgrades that will qualify for the tariff. For at least half of the programs not targeted to a single upgrade (e.g., Hawaii's Solar$aver pilot replaced electric water heaters with solar water heaters), the PAYS tariff allowed customers' gas savings to be included in the cost-effectiveness screening to determine which upgrades could be installed.

Cadmus' focus on targeting replacement of electric furnaces with heat pumps is viable, although other upgrades should be included in those homes as has been the case in the Kansas and Arkansas PAYS programs. In its previous studies of the PAYS system for two other investor-owned utilities in Missouri, Cadmus examined only savings from the utility's perspective and ignored savings from the customer's perspective. This error appears to be the basis for the exclusion of heat pumps that replace gas and propane HVAC systems from the list of eligible measures.

In the PAYS system, the determination of which upgrades qualify for a PAYS tariff considers all the savings that will accrue to participants, excluding societal costs and energy rate inflation. Due to the efficiency of propane-fired heating systems and the high cost for propane, the savings for customers who heat with propane may be even higher than those who heat with electricity. In its study noted above, OptiMiser LLC wrote that the HELP PAYS® program includes upgrades that result in fuel switching: "The participants included 4 apartments, and 6 homes where the HVAC measure resulted in fuel switching." (p. 9) In Kentucky, fuel switching is also permitted. MACED's six utilities allow gas heating customers to fuel switch to heat pumps, but it is only cost effective when customers use propane for heating.

4. Survey flaws

The Cadmus study for KCP&L has discussed the viability of PAYS in its report based primarily on survey data. The challenge with surveys is sample size (i.e., whether the sample is large enough to make generalizations to the total population), sample selection (i.e., whether the sample represents the same characteristics of the total population), response rate (i.e., whether enough respondents respond to a question to ensure accuracy), and question wording (i.e., whether the questions were clearly worded in an unbiased way so responses can be trusted).

There are approximately 522,032 KCP&L residential customers including customers served by KCP&L Missouri and by KCP&L Greater Missouri Operations.[6] Based on estimates provided by Cadmus (p. 25), EEI assumes approximately 65% are in owner-occupied houses (339,000 homeowners) and 35% are in rental units (182,000 renters).

In its study for KCP&L (p. 7), Cadmus' sample size for homeowners was 321 and for renters 62 for a total of 383, which is a little more than .07 percent of residential customers. However, some of its findings were based on a fraction of those numbers. For example, in Figure 6 relating to interest

[6] Information provided by the Missouri Office of Public Counsel.

rates, findings were based on the responses of 58 homeowners, just 18 percent of the sample size or less than 0.02 percent of single-family customers. The sample size for renters is only 16 percent of the total sample size though renters account for 35 percent of the KCL&P's residential customers. Inadequate sample size, non-representative sample selection, low response rate, and poorly framed questions may be responsible for the anomalies discussed below.

• On page 24 Cadmus writes, *"As shown in Figure 16, renters accepting the utility offer in the second scenario dropped to 42%. Of 36 respondents selecting Option A in Scenario 1, 14% (five respondents) said they were not sure if they would accept Option A in Scenario 2, and 31% (11 respondents) selected Option B. Of 26 respondents that did not select Option A in Scenario 1, 23% (six respondents) selected Option A in Scenario 2."*

Cadmus has reported findings here as if they provide significant information for utility planners to consider in developing a PAYS program. The number of respondents is so small that the findings do not provide a basis for decision making.

• On page 14, the authors write, *"Three respondents (4%) indicated that they wanted their monthly energy savings to be more than their monthly payments."* On page 16, they write, *"The ability to qualify for a loan was the least likely to be rated for a significant concern, with only 16% of the respondents ranking this barrier a 4 or a 5."*

On its face, Cadmus reports that only 4 percent of the customers in the sample indicated that they wanted their savings to exceed their payments, so 96 percent did not have this concern. Implicit with the second quote is that if only 16 person percent indicated they were concerned about being able to qualify for a loan, the rest of the KCP&L customers in the sample either had the money or did not doubt their ability to obtain credit at acceptable terms. Both of these observations raise questions about whether the sample of customers was representative of one of the customer market segments that KCP&L would want to reach with a PAYS offer.

In **Figure 4. Homeowner Alternative Purchase Decision,** Cadmus notes that of those homeowners who responded to the survey, 152 paid cash and only 71, less than half, used some form of financing. In **Figure 3. Homeowner Payment Method by Project Costs,** Cadmus showed the range of costs for these projects. Most projects cost more than $3,000 and some respondents financed projects up to $48,000. At no project cost amount did more than half of Cadmus' respondents choose financing.

This sample is supposed to be representative of KCP&L's residential customers, at least half of whom are likely to be low- to moderate- income customers and approximately 35% of whom are renters (p. 47). It is not credible that 96 percent of this population was unconcerned about having positive cash flow or that 84 percent were unconcerned about their ability to qualify for a loan. The report does not provide adequate information to discern how Cadmus' conclusions were affected by the sample selection, the number of respondents, questions asked, or how the questions were worded.

The validity of the sample size for renters surfaces as an issue again in the study for KCP&L on page 22: *"Nine renters reported paying for a home improvement project, with project costs ranging from $793 to $5,000, with an average cost of $1,666. This question was not limited to the energy-related projects in Figure 13, but one respondent purchased a water heater, one purchased a major*

household appliance, and two said they purchased all or part of an HVAC system. The nine respondents that reported paying for a project used a variety of payment methods."

The split incentive between property owners and renters is acknowledged as a barrier to installing improvements in rental housing and especially multifamily housing. "*The two respondents paying cash or using their credit cards reported doing so as the cost was too small to finance, and they had the cash available.*" There is no explanation why these renters opted to make improvements to their landlord's buildings costing as much as $793 - $5,000. It is not typical for renters to pay for expensive improvements to a building they don't own. These responses without explanation should not influence how a PAYS or any program can best reach KCP&L's hard to reach customers.

• A subtle problem with Cadmus' study for KCP&L is that the questions, at least as represented by this report, appear flawed. For example, in scenario 2 on page 18, the monthly payments are presented in one sentence while the estimated savings are provided in the following sentence — with no mention that the savings exceed costs by 25 percent. One might legitimately question whether the sample customers understood the relationship between costs and savings. If this information had been in one sentence that identified the percent by which savings exceed costs, there might have been a different response.

5. Recommendations for KCP&L implementation of a PAYS® program

EEI is including recommendations in this response to show how PAYS could be implemented in KCP&L service territories in a way that is in line with the company's stated preferences, avoids licensing and design costs, eliminates the need for new staff, and is delivered by a proven program operator.

KCP&L preferences

On page 35, Cadmus reports five KCP&L's preferences for its efficiency programs and two assumptions about such programs that are not in alignment with its preferences:

1. "*KCP&L staff confirmed that the typical KCP&L energy efficiency program is designed for implementation by a third party, with minimal management required by internal staff.*"

2. "*As required by the Missouri Energy Efficiency Investment Act (MEEIA), all programs must pass a cost-effectiveness test, except for programs targeting low-income or multifamily markets.*"

3. "*KCP&L generally selects programs based on their ability to deliver cost-effective energy savings at scale; so the utility meets its energy efficiency targets at the least cost to ratepayers.*"

4. "*Because of the multiyear timeframe, the utility favors field-tested program models to incur the least risk possible to the portfolio's ability to achieve its goals.*"

5. "*For the coming year, KCP&L staff reported it will place greater priority on programs that target hard-to reach markets that historically have not participated in existing programs in large numbers: low-income and multifamily.*"

    - "*KCP&L staff expect that programs targeting hard-to-reach markets will present challenges that the utility has not faced with its more mainstream programs. For example, staff expect pilot programs specifically targeting these harder-to-reach markets to require a dedicated*

internal staff to identify opportunities, coordinate pilot implementation, and provide customer support."

- "*Another issue may be achieving scale; staff expect to pilot multiple new program models, and then focus on scaling up pilots that show potential for increased participation.*"

EEI proposes an approach that meets all five criteria and does not require adding additional program staff to reach harder-to-reach markets or multiple pilots that unnecessarily waste utility resources on anything other than the best possible program. The program that EEI recommends:

- Will be implemented by a third party so no new staff need to be hired by KCP&L. Existing managers may be able to oversee program operations using data management tools provided by the vendor.

- Will pass any utility cost-effectiveness test since participants pay almost all costs for their upgrades even though the program can be targeted to harder-to-reach customers as it has been in Arkansas and North Carolina.

- Can reach four percent of KCP&L's residential customers (i.e., approximately 21,000 customers) in three years after a three- to five-month start-up period following approval by the Public Service Commission.

- Will incur the largest investment in resource efficiency upgrades for the least possible impact on KCP&L's budget for ratepayer funded spending on energy efficiency resources.

- Can reach large numbers of renters and low- moderate-income, hard-to-reach customers.

- Will not require a dedicated internal staff to address the challenges assumed in serving hard-to-reach customers.

- Has been field tested and produced outstanding results in several states, including two adjacent states for several years.

EEI recommends that KCP&L implement a residential PAYS program by hiring a third-party operator, such as EEtility, Inc. EEtility operates the successful programs in Arkansas and North Carolina. The program should have the funding and capital to reach at least 21,000 customers including hard-to-reach customers. EEI has consulted with EEtility management and they are prepared to operate a program for KCP&L at this scale. This recommendation will achieve all of the bulleted claims noted above and eliminate the need for KCP&L to pay EEI for a license for its intellectual property, hire new staff to fulfill new duties, or to pay what Cadmus estimates as "*PAYS program design and marketing*" of *$50,000* (**Table 7. Start-up Costs for PAYS**. 41).

This recommendation should also result in the greatest likelihood of Missouri Public Service Commission approval for a PAYS program. Since five commissions and other oversight bodies (e.g., Tennessee Valley Authority) have approved PAYS programs targeting investor-owned, cooperative, and municipal utilities, these Commissions have established precedents that would facilitate Missouri Public Service Commission approval, especially when two of those states border Missouri. The success of the seventeen programs in seven states would also seem to facilitate Missouri Public Service Commission approval. Finally, if KCP&L seeks approval for a program

implemented by a proven PAYS program operator, that would also seem to facilitate Missouri Public Service Commission approval.

In order to illustrate what a PAYS program that would enable 21,000 customers in three years to implement projects averaging $5,500, based on EEI's recommendation, we have used the categories shown in Cadmus' Tables 7 and 8 to compare Cadmus' to EEI's estimates.

Revised Tables 7 & 8 Showing KCP&L Costs for a 3-year program serving 21,000 customers based on Cadmus' estimates and EEI estimates for an EEtility-operated program

Category	Cadmus Estimated Cost	EEI Estimated Cost
PAYS design & licensing	$50,000	$0 licensing; $20,000 assistance with testimony and capital
Utility Administration (program staff)	$240,000	$240,000 (or $0 if existing personnel are assigned)
Implementation $700 to $1,000 per participant	$15.4 – $21.0 million	$20,450,000 ($975 per participant)
Participants Fees	-$0	-$6,825,000 ($325 each)
Marketing/outreach $25,000 per yr.	$75,000	$75,000 (or less)
Evaluation $24,000 per yr.	$72,000	$72,000 (or less)
Servicing (10-year term) $900 per participant	$18,900,000	$0 No loans to be serviced
Origination $600 per participant per year for each year of tariff duration (12 yr. per)[7]	$12,600,000	$0 One loan to utility
Call Center ($61 per participant)	$1,281,000	$0 (Program Operator handles most calls; Utility handles remainder)
Subtotal	**$54,218,000**	**$14,057,000**
Capital Costs (interest to be paid by participants) $5,500 per project	**$115,500,000**	**$115,500,000**
Utility Cost Recovery 15 years (12-year tariff and 3 years of implementation)	Uncollectables offset by participant funded loss reserve	**$115,384,500**
Net Capital Costs	**$0**	**$115,500**
Total Utility Costs	**$54,218,000**	**$14,172,500**

EEI's recommended approach would cost KCP&L only 26 percent of the total cost of this sized program using Cadmus' assumptions. KCP&L's total costs would be less than 12.3 percent of its total investment in efficiency upgrades.

Tables 7 and 8 do not show that for a program of this size, Cadmus' is proposing that KCP&L charge participants a one-time five-percent fee of their project's costs to fund a loss reserve fund. In the above example, Cadmus would charge participants $5,775,000 (i.e., .05 X $115,500,000) to protect against estimated uncollectables likely to be less than $115,500.

[7] The sentence describing Origination costs could be interpreted in two ways. EEI interprets the Origination costs to mean $600 per participant for every year there are participants.

Addendum

Misinformation in the report by Cadmus for KCP&L that should be corrected

In this Cadmus report for KCP&L, as in the Cadmus report for Empire District, there is information presented as fact and used as the basis for assumptions that is not correct.

Since Cadmus published *The Empire District Electric Company PAYS Feasibility Study* (May 31, 2018), new information has been published about the field experience with PAYS that would have prevented a repeat of many of the errors Cadmus made in that study. Instead, Cadmus repeatedly cites the Empire report in its KCL&P report and repeats many of its errors.

Here are links to three documents published between the date of Cadmus' study for Empire District and this one for KCL&P:

- The Missouri Office of Public Counsel submitted EEI's response to Cadmus' Empire District report on the public record on June 28, 2018 (https://www.efis.psc.mo.gov/mpsc/commoncomponents/view_itemno_details.asp?caseno=ER-2016-0023&attach_id=2018021923);
- Jessica Lin wrote a *The Pay As You Save Program in Rural Arkansas: An opportunity for rural distribution cooperative profits* published in the Electricity Journal (Volume 31, Issue 6, July 2018, Pages 33-39, payment required without a subscription https://www.sciencedirect.com/search?pub=The%20Electricity%20Journal&volume=31&issue=6&show=25&sortBy=relevance&origin=jrnl_home&zone=search&cid=272016)
- Dr. Holmes Hummel and Harlan Lachman wrote a piece entitled *What is inclusive financing for energy efficiency, and why are some of the largest states in the country calling for it now?* published by ACEEE on September 4 (https://aceee.org/files/proceedings/2018/index.html#/paper/event-data/p401)

While we have not noted every error in Cadmus' report, we highlight below a number of them to illustrate the nature of these errors, each of which can be corrected in this and future feasibility studies of the PAYS system. In this section, we have copied statements from the Cadmus study for KCP&L and then explained the apparent error.

1. On page 36, the report states, "*Although a trademarked concept, in practice, PAYS programs are typically customized to a program administrator's needs, as long as it includes the basic features (e.g., the energy audit, capped monthly tariff, no credit score requirement). Most PAYS programs conform to a common organizational structure, as shown in* ***Figure 21 PAYS Program Design***."

None of the seventeen utilities that have or are operating PAYS programs use the model illustrated in Figure 21. In the myriad presentations given about PAYS by knowledgeable people, many of which are available on the web (e.g., http://www.cleanenergyworks.org/about-pays/) none have used this model. We have no idea where the image in Figure 21 came from, but it confuses PAYS with a loan program by including an Origination Provider and a Servicer, both roles associated with consumer loans. Since PAYS does not involve consumer loans, neither role is needed for a PAYS program.

Also the "basic features" noted in the quote above do not correspond to PAYS Essential Elements and Minimum Program Requirements, which all PAYS programs must include, noted on EEI's website (http://www.eeivt.com/?page_id=48).

2. On page 38, the report states, "*No investor-owned utilities (IOUs) currently implement PAYS.*"

Eversource, an IOU, is operating the longest running PAYS program, Smart$tart, in New Hampshire and has been since 2002. https://www.eversource.com/content/nh/business/save-money-energy/manage-energy-costs-usage/smart-energy-solutions/municipal-smart-start-program.

3. On page 38, the report states, "*IOUs, as regulated entities, face strict requirements for protecting ratepayers from unnecessary expenses.*" Again, on page 40, it states, "*Cooperatives and municipal utilities, which are not regulated and do not answer to shareholders, have greater leeway for accepting financial risk to ratepayers through an energy efficiency program used by only a minority of customers. IOUs face much tougher restrictions on types of financial risk they can incur.*"

There are two issues raised by these statements. First, there is a suggestion that energy efficiency expenses are an unnecessary expense. Commissions in five states (and oversight bodies in three other states, including the Tennessee Valley Authority) have approved the use of a PAYS tariff with disconnection for nonpayment because regulators consider efficiency investments to be part of basic service that the utility is obligated to provide to its customers. These are not unnecessary expenses.

Second, there is an implication that the financial risk related to operating a PAYS program is significant enough that an IOU might not able to tolerate it. As is noted in Section 2 Unrealistically high cost estimates in this response, of the utilities with PAYS programs that have reported rates of uncollectables for participants, the average nonpayment rate is less than 0.1 percent, which is lower than most utilities' prevailing rate for uncollectable charges. Further, because installation of efficiency upgrades lowers customers' bills, PAYS programs actually reduce risk to utilities because customers are better able to pay their bills, which is consistent with the low rate of nonpayment observed among PAYS participants.

4. On page 38 Cadmus writes, "*Most private sector investors have very little appetite for alternative screening methods, such as the bill payment history used by most PAYS programs, despite that most PAYS programs—like most energy efficiency financing programs—offer nonpayment rates below 2%.*"

PAYS does not involve consumer loans. The only loan that might be part of a PAYS program is a capital provider's loan to the utility to capitalize its PAYS investment portfolio. A loan to the utility is made based on the strength of the utility's own balance sheet, and not based on the creditworthiness of customers determined by any screening methods. Since any private sector investor putting up capital for a PAYS program would be making a loan to the utility, not to an individual customer, the screening methods used by the utility with its customers should be of little concern to the investor.

Even if a private sector investor was concerned about the prospects of utility default on its commercial paper (i.e. corporate debt), PAYS programs require that utilities make payments to capital providers on the schedule set out in the loan agreement regardless of a utility's collections from its customers. Additionally, since PAYS requires that the utility have access to disconnection for unpaid PAYS charges, applying the same protocols as apply to all other utility charges, the utility is assured of its normal high rate of cost recovery. And, finally, since PAYS requires that a utility treat PAYS uncollectables the same as all other uncollectables, all ratepayers will pay to offset any small losses that may occur.

Since PAYS makes it easier, not harder, for participants to pay their bills, there is no requirement that PAYS programs do any screening of customers except based on whether they have cost-effective upgrade opportunities in their homes. In our experience, utility managers typically want to build in a review of a customer's bill payment history as a screening tool and not invest in efficiency at a location where a customer chronically misses payments. This is not a screening method that is required for a PAYS program.

5. Cadmus writes that one of its objectives for its study is to answer, "*...whether PAYS or another on-bill financing program offers the best approach to address unmet financing needs.*" (Executive Summary, Objectives, p1).

First, PAYS is not a consumer loan program. Second, loan programs by design do not reach more than half of a utility's customers (i.e., low- moderate- income customers and renters), and they do not achieve comparable offer acceptance rates in the field. Therefore, framing a question about whether on-bill loan programs or the PAYS system offers the best approach to addressing unmet financial needs raises the question as to why this question was even asked.

6. Cadmus listed its fourth conclusion in its executive summary (p. 3) and conclusion (p. 47), "*The primary PAYS barrier for KCP&L will be obtaining regulatory approval for appropriate credit enhancements to attract investors willing to provide low-cost capital.*"

There is no basis in this report for this conclusion. First, there is no need to enhance consumer credit because the creditworthiness of a customer does not put capital at risk. Second, investors routinely provide large amounts of low-cost capital to utilities with sound balance sheets, and these transactions typically occur without regulatory approval of subsidies to attract investors. If the utility is willing to guarantee repayment of principal and interest to a capital provider regardless of collections, as PAYS requires, no subsidy on the cost of capital would be warranted. (See http://www.eeivt.com/?page_id=48)

7. On pages 29 through 34, Cadmus compares various financing products (e.g., credit card, PACE, OBF) to PAYS.

PAYS is not a financing product, but rather it is a utility investment system with cost recovery via tariffed charges over time paid by customers residing at a location where upgrades have been installed. In Table 5 on page 32, Cadmus summarizes its perceived differences between financing products and PAYS:

- Overall Cost. The ratings for the overall cost estimates of OBF, PACE, and PAYS are backwards. No OBF or PACE program includes control of upgrade or installation pricing. All of the recent PAYS weatherization programs have included mechanisms to ensure fair prices for participants (e.g., RFPs, maximum price paid, etc.). OBF programs require credit enhancements, especially if a utility has any interest in providing financing to customers with low eligible credit scores. PAYS needs no credit enhancements. The "Excellent" rating for OBF and the "Okay" rating for PAYS should be switched.

- Available Loan Amounts. This category should refer to "available capital amounts," without specifying the financing mechanism. The ratings for the overall available loan amounts for financing products and PAYS are also backwards because it appears that Cadmus presumes

larger amounts of capital are better. Most cost-effective efficiency projects in the residential sector range from several hundred dollars to $9,000. Many PACE and OBF programs have minimum loan amounts that prohibit installation of moderate-cost upgrades (e.g. less than ~$5,000) for anyone who lacks the disposable income to install them. PAYS does not involve loans to participants, and most PAYS programs do not have minimum project cost limits. More of these projects can be addressed by PAYS than by loan products that have high minimums (e.g., $5,000). By looking at amounts needed for reaching cost-effective efficiency improvements in the residential sector, the "Excellent" ratings for home equity lines of credit (HELC) and OBF should be switched with the "Poor-Okay" rating for PAYS.

- Outcome When Borrower Moves. Every category in Table 5 has an understandable rating, even though some of the ratings are wrong. This category has no ratings. The rating for HELC and OBF when the borrower moves should be "Poor" since the borrower must pay off the obligation when they move from the home. For any participant that leaves their residence before the cost recovery period is complete, the requirement to make all future payments in one lump sum is almost guaranteed to leave them with negative savings from their efficiency improvements. The rating for PACE should be poor-good. PACE also requires the borrower to pay off the balance due unless a successor customer agrees to assume the payment obligation (without any assurances the upgrades will last as long as the payments and with the leverage of being able to force the seller to pay off the obligation). Given these alternatives, PAYS is the best option for the original participant (who is not a borrower) and should be rated "Excellent".

8. On page 32 Cadmus writes, "*States do regulate some aspects of the financing market, such as licensing lenders, and rules vary from state to state. However, from the consumer perspective, differences in available financing products are modest even across state lines.*"

PAYS does not involve any consumer loans.

9. On page 33, the report states, "*PAYS was rated Poor-Okay due to its strict formula for determining available funding, which will cover the full project cost of only a handful of measures.*"

Some experts consider the fact that PAYS highlights which portion of the cost of an upgrade will provide immediate net savings and which portion will not to be one of the major benefits of the PAYS system. This feature is a consumer protection. PAYS has not encountered consumer advocates' attacks such as those regarding predatory practices in the credit card industry. PAYS has not experienced rejection such as those by California municipalities seeking to ban PACE in their municipalities (c.f., http://www.governing.com/topics/transportation-infrastructure/gov-california-cities-clean-energy-loans-pace.html or https://www.latimes.com/business/la-fi-pace-bakersfield-20170720-story.html) because of problems with foreclosure caused by high lending costs for equipment that is no longer working or not producing sufficient savings to offset their costs.

10. Cadmus writes on page 36 that, "*While a utility may operate a tariff or financing program using internal resources and capital, most IOUs choose to partner with organizations that specialize in this function. The origination provider may serve as a liaison with a capital provider.*"

Neither of the two IOUs that have implemented PAYS programs have used origination providers.

BEFORE THE PUBLIC SERVICE COMMISSION
OF THE STATE OF MISSOURI

AFFIDAVIT OF HARLAN LACHMAN

STATE OF VERMONT)
) SS.
CHITTENDEN COUNTY)

COMES NOW HARLAN LACHMAN and on his oath declares that he is of sound mind and lawful age; that he contributed to the foregoing *RESPONSE TO CADMUS' "PAYS' FEASIBILITY STUDY";* and that the same is true and correct according to his best knowledge and belief.

Further the Affiant sayeth not.

Harlan Lachman
President, Energy Efficiency Institute, Inc.

JURAT

Subscribed and sworn before me, a duly constituted and authorized Notary Public, in and for the Chittenden County, State of Vermont, at my office in the Town of Colchester, on this 8th day January, 2019.

Signature Erin Hogan #157-00001348
Print Name Erin Hogan
Notary Public

My Commission expires 1/31/2021.

BEFORE THE PUBLIC SERVICE COMMISSION
OF THE STATE OF MISSOURI

AFFIDAVIT OF PAUL CILLO

STATE OF VERMONT)
) SS.
COUNTY OF CALEDONIA)

COMES NOW PAUL A. CILLO and on his oath declares that he is of sound mind and lawful age; that he contributed to the foregoing *RESPONSE TO CADMUS' "PAYS' FEASIBILITY STUDY";* and that the same is true and correct according to his best knowledge and belief.

Further the Affiant sayeth not.

Paul A. Cillo
Vice-President, Energy Efficiency Institute, Inc.

JURAT

Subscribed and sworn before me, a duly constituted and authorized Notary Public, in and for the County of Caledonia, State of Vermont, at my office in Hardwick, on this 7th day January, 2019.

Notary Public

My Commission expires 2-10-2019.

PAYS® Questions for KCPL MEEIA

January 10, 2019

Q. An overview of PAYS® would be appreciated, how long in business, where it operates etc.?

- The Energy Efficiency Institute, Inc. (EEI) was incorporated in 1988 by Harlan Lachman and Paul A. Cillo. Each of them has 40 years of experience in the resource efficiency field, including program implementation, design, expert witness testimony, and management assistance.
- Work on the development of the PAYS® system started in 1998. The system was first presented in a NARUC commissioned paper in 1999.
- The New Hampshire Public Utilities Commission approved the first PAYS tariff in 2001.
- The first PAYS program was started by Public Service Company of New Hampshire, an IOU, now Eversource in 2002 and they are still running their program.
- A number of questions EEI was asked to address appear to make two assumptions:
  1. That PAYS is an entity, and
  2. That PAYS involves loans to individual customers.
- EEI wants to address both of these now very clearly:
  1. There is no PAYS entity. PAYS is a system developed by the Energy Efficiency Institute, and EEI holds the trademark to the name of that system: PAYS® and Pay As You Save®.
  2. PAYS does not involve loans to individuals. PAYS is a system that allows utilities to invest in efficiency upgrades on the customer side of the meter and recover their costs through a tariffed charge on the participant's bill. It does not involve consumer loans, no individual debt, and not credit checks.

Q. Is there a customer income level profile that PAYS® believes is most effective for targeting for achieving energy savings?

- No. The PAYS system has been designed for all customer classes and types of customers.
- It has been implemented at Investor Owned, Cooperative, and Municipal utilities, and by electric, gas and water utilities.
- Programs based on the PAYS system have been targeted to municipal customers and residential customers (both single family and multifamily).
- Participants in Arkansas and North Carolina live in some of the most economically distressed service territories in the country; other programs have primarily served middle-income to upper-income families.
- The most important criteria is that the customer have cost-effective savings opportunities.

- If I were a utility manager, I would probably run a residential program with funds allocated to multifamily homes where customers pay utility bills and single family customers (with some funds allocated to customers in economically distressed neighborhoods). The no-debt and immediate net savings features of PAYS are also especially attractive to customers managing public buildings and to industrial customers.

Q. Can and is the PAYS® model utilized by customers across multiple classes i.e. low income, middle income etc.? Please discuss any examples, experiences.

- Yes, No PAYS programs have been implemented with income criteria, although some marketing has been targeted to economically distressed neighborhoods and service territories.
- To be clear, PAYS has served all types of customers.

Q. Can and is PAYS® utilized by small businesses/small commercial customers?

- Yes.
- However, depending on your definition of small business/small commercial customers, this is the most challenging market to serve. Unlike all residential customers who live in homes, with some heating and often cooling systems, refrigeration, hot water, and televisions and computers, there are very different types of customers and usages often classified as small business/small commercial.
- For that reason, if I were starting a program, I would not start with small commercial customers.
- That said, in the second PAYS program implemented, a tiny program at a cooperative utility, the utility upgraded HVAC systems for customers operating a health club and retail stores.

Q. What types of energy saving purchases do customers make by availing themselves of PAYS®? (furnaces, insulation etc?)

- PAYS is a utility investment program in resource efficiency on the customers' side of the meter.
- Participants do not purchase items, they receive none of the benefits of ownership. They allow upgrades to be installed and allow the utility to recover its costs through a tariffed charge. The utility "owns" the upgrades through the cost recovery period. Ownership is transferred to the owner of the location when cost recovery is completed.
- Generally, any upgrade that is a proven technology, that produces a reliable savings stream that can pay for the upgrade and provide immediate net savings to the customer, can and has been installed.
- Upgrades installed in PAYS programs include, solar water heaters, street lighting, room lighting, water saving showerheads, toilets, insulation, air and duct sealing, dry summer drought tolerant landscaping, HVAC improvements, heat pump systems, and ground water source heat pumps.

- In 2004, EEI produced a study for Missouri showing more than 50 Industrial projects identified by Missouri's Industrial Assessment Center that would qualify as PAYS upgrades with an investment of $2 million dollars. All had less than three-year paybacks and had not been implemented. For any jurisdiction interested in economic development, offering PAYS to industrial customers would make a lot of sense.

Q. What efficiency projects remain or cannot be accomplished under the PAYS® model? Does PAYS® perform periodic evaluations of additional energy efficiency projects it may decide to finance?

- Projects with long paybacks (e.g., ten years or more such as new windows) cannot be accomplished using the PAYS system unless rebates are available to bring the payback down to approximately six years or less. Unproven technologies should not be included in a PAYS program because savings must be uncertain. To qualify, upgrades must produce immediate, reliable savings for the customer.
- Utilities or program operators who are using or considering using PAYS review new technologies and proven technologies all the time as installation costs, rates, and technologies change to determine whether they can produce sufficient reliable savings to qualify for installation. For example, this year there will be a study about qualifying rooftop solar photovoltaics and efforts to qualify electrification of buses using PAYS tariffs.

Q. How has credit worthiness criteria been established in other PAYS® programs/ jurisdictions? (ie.: a specific credit score/ reliance on specific credit agencies e.g.,. Experian, TransUnion, Equifax or other criteria (such as presented in PSC Rules 13.030(1)(C). etc.)

- No program based on the PAYS system has used credit scores or credit agency reports to determine customer eligibility. Some utilities require customers to be current in their utility billing, some require no more than 2 late payments in the preceding year, and some do not require any eligibility standard.
- One of PAYS requirements for residential programs is that on an annual basis, estimated savings to the participant must exceed program services charges by 25%. All customers currently have to pay their bills and risk disconnection if they fail to do so. It should be easier for all customers to pay lower bills.
- Without customer credit checks, uncollectables relating to PAYS upgrades across the country have averaged less than 0.1%. This is a fraction of utilities' typical rate of uncollectables for all other charges.

Q. How has credit worthiness been demonstrated ie: tools such as automated credit risk scoring conducted by the utility, other tools, mechanisms?

- I believe the answer I provided for the previous question addressed this question.

Q. Is underwriting a component in the PAYS ®model and if so how does it work? Who is responsible for defaulted PAYS® financing/loans?

- PAYS involves no loans to participating customers so there is no underwriting needed for PAYS transactions with customers. Customers at a location agree to allow their utility to invest in upgrades at that location and the tariffed program services charges are assigned to the location.

Q. What are the program costs? Is a flat fee or percent of loan charged? What interest rates are applied? Are the interest rates subject to being adjusted? Do participants sign 'Know Before You Owe' documentation?

- PAYS program services charges are fixed monthly amounts based on the upgrades installed at a location and are significantly less than a reliable estimate of customer savings for that specific location.
- Program costs vary and depend on the size and quality of the program. In EEI's response to Cadmus' PAYS (sic) feasibility study filed by the Office of the Consumer Counsel, EEI recommends one way to implement a PAYS program and provides a budget for planning purposes.
- If a utility borrows capital to use to pay the upfront costs for investments, it recovers its interest costs by rolling them into the program services charges. We have seen program services charges that include interest rates between zero and 7%.
- PAYS program costs are much less than on-bill financing (OBF) programs and unlike these loan programs PAYS programs can reach hard-to-reach customers (low- moderate-income customers and renters) and have much higher offer acceptance rates.
- Customers receive offers. Once the offer is made to the customer, the interest rate used to determine the program services charge cannot be changed. Interest rates can be changed during a program.
- EEI has developed and licenses agreements that provide clear statements to participants of program benefits and their responsibilities (and building owners' responsibilities if the customer does not own the building).
- EEI has developed a new system for providing notice of PAYS upgrades at a location that ensures successor customers who purchase or rent a location which had PAYS upgrades installed – learn of PAYS benefits and obligations prior to their taking occupancy.
- Utilities have no responsibility to provide notice and are not liable for a failure to provide notice of PAYS benefits and obligations at a location.

Q. Has on-bill financing typically been included on utility bills?

- On bill financing (OBF) has typically been defined as making loans to help customers purchase resource efficiency upgrades. By definition, OBF programs involve charges on the bill.
- PAYS does not involve loans to customers. PAYS uses a voluntary tariff. Program services charges are on the utility bills at a location at which PAYS upgrades were installed until the utility receives full cost recovery for its investments.

Q. What opportunities and challenges have arisen with integrating PAYS® into utility billing systems?

- One of the eighteen utilities implementing PAYS programs upgraded its billing and information system based on EEI's recommendations and those of its billing staff. The module cost less than $40,000.
- The seventeen other utilities used existing capabilities, likely those associated with rental or financed technologies, supplemented by program CRM software, and have operated their programs without making changes. EEI recommends any utility committing to the PAYS system investigate the real cost of an EEI approved billing system upgrade.

Q. How many utility clients does PAYS® serve and how many customers are served by PAYS®?

- As of June 30, 2019, eighteen utilities in eight states had operated programs using the PAYS system. The first program started in 2002. As of June 30, 2019, customers at more than 4,900 locations accepted offers for upgrade installations at their locations totaling more than $40 million.

Q. What are various utility and or PAYS® processes utilized to handle customer arrearages?

- Since PAYS charges must be treated the same as all other utility charges for essential services, the same processes the utility uses for other arrearages is used.
- Some utilities have established loss reserve funds. Uncollectables have averaged less than 0.1% for all reporting utilities operating PAYS programs. Only 1 charge against the three loss reserve funds in three states has been made in the past 5 years. EEI does not recommend incurring the cost of setting up reserve funds but that utilities use the same mechanisms they currently use to recover their investments.

Q. What are the 'ranges' of arrearage rates that PAYS® sees from its various utility partners/their customers? How are arrearages handled? Are they tied to service disconnection? What are the up and downsides of tying arrearages to service disconnection?

- Uncollectables related to PAYS upgrades are a fraction of all reporting utilities' average rate of uncollectables.

- Utilities implementing PAYS programs are required to use their same processes for collections of arrearages, including disconnection if necessary, as they currently use for all other charges.
- No utility implementing a PAYS program has ever reported disconnecting a PAYS participant or successor customer for non-payment.

Q. Have defaulted loans led to any evictions or foreclosures? If so, what data does PAYS® maintain and have in its possession on such occurrences?

- No. No defaulted tariffs have led to eviction or foreclosures.
- Some homes in California were subject to foreclosure for reasons other than the PAYS tariff as a result of the financial collapse in 2008 - 2009. The tariff is designed to survive foreclosure or extended vacancy.

Q. What data does PAYS® have regarding loans that have transferred ownership? Did transfers result in accelerations of early pay-offs? Does repayment transfer seamlessly to new customers? Please explain how loan transfers work between customers/households.

- There are no loans with the PAYS system.
- Tariffed charges remain at the location and are binding upon any successor customer taking service at a location.
- Some utilities have waived program services charges at times for customer service reasons. These do not represent a PAYS related expense.
- Based on anecdotal information, EEI has revised its intellectual property (i.e., the forms, agreements and worksheets alluded to above) to provide for tariffs that will not be subject to early pay-offs but that assure that all successor customers who purchase locations will learn about the PAYS upgrades at that location and the tariff's benefits and obligations.

Q. Has PAYS® had any complaints filed against it by ie: state attorney general offices, by consumer advocacy groups, utility commission staffs, Better Business Bureaus etc?

- No. There have been no complaints filed against an implementing utility in the 18 years programs have been operated.
- There have been no challenges to the PAYS system elements (i.e., that PAYS charges represent an essential utility service, that PAYS uncollectables shall be treated the same as all other essential utility charges, including disconnection in accordance with existing rules governing disconnection for non-payment, that charges may be assigned to a location and are binding on successor customers who apply for service at an upgraded location, etc.).

Q. Does PAYS® guarantee monthly savings greater than the monthly tariffed repayment? If not, how do low-income customers participate given that some months customers could receive higher bills.

- There are no savings guarantees.
- There is a guarantee that annual savings estimates for each specific location based on current rates will significantly exceed annual program services charges for that location. Most utilities use EEI's 80% rule. This ensures that solid annual savings estimates will exceed annual program services charges by 25% (i.e., providing a healthy margin of error).
- There is also a guarantee that if upgrades fail and are not repaired, program services charges will cease.
- This offer to customers has resulted in more than 50 percent, and sometimes as high as 90 percent, of customers accepting PAYS offers.

Q. If PAYS® projects under-perform' and the energy savings are not what was projected/ calculated what if anything occurs or what recourse does the customer/utility have?

- PAYS uses only proven technologies. Contractor requirements such as insurance and bonding, quality control mechanisms, mechanisms to ensure high quality upgrades and fair prices, along with other design features have kept under-performance from being a problem.
- Additionally, verification protocols alert implementing utilities to anomalies at PAYS locations that enable investigation prior to complaints. Most of the time, higher than anticipated usage results from increased occupancy. Other times higher than expected usage results from customer purchase and use of new energy using technologies.
- Finally, every implementing utility has reported increased customer satisfaction when they have switched to using the PAYS system.

Q. Who bears the burden of making repairs on PAYS® funded projects should they be required during the course of payback?

- If an upgrade fails as a result of contractor error, substandard products, or poor installation, even problems not identified by a post installation inspection, the contractor or product supplier is required to repair the upgrades.
- If the building owner fails to maintain upgrades as per their agreement or if occupants damage the upgrade, causing its failure, they will be made responsible for repairs and the program services charges will continue, assuring utility cost recovery.
- If the upgrade just failed, the utility or its program operator can determine if it is financially viable to pay for a repair and extend the charges (another required PAYS design feature) or to just terminate the charges.
- The use of proven technologies, high quality contractors and contractor requirements has resulted in no utility using the PAYS system reporting the need for upgrade repairs or to waive charges due to upgrade failure.

Energy Savings of Heat-Island Reduction Strategies for the Kansas City Area

Mid-America Regional Council

September 2015

leidos

Energy Savings of Heat-Island Reduction Strategies for the Kansas City Area

Table of Contents

Background

The Greater Kansas City Clean Air Action Plan, originally adopted in 2005 and updated in 2011, outlines voluntary measures for reducing ground-level ozone in the Kansas City metro area. Strategies for implementing the Plan include heat-island reduction (HIR) strategies like high albedo surfaces and shade trees. The heat island effect is known to increase ambient temperatures in urban areas and contribute to increased ozone formation. The Mid-America Regional Council (MARC) funded this study, which focuses on building energy impacts of HIR measures specific to the Kansas City region. Specifically, this study analyzed the direct building energy impacts of high albedo roofs, nearby high albedo ground cover, and nearby tree shading measures on commercial and residential building energy consumption.

Methodology

Leidos used a parametric energy model approach to determine the energy impacts of the HIR measures. The U.S. Department of Energy developed energy models for several commercial and residential prototype buildings. Leidos adapted a set of these prototype models to represent prevalent building types in the Kansas City region. In addition to the building type, several other significant building features were also varied in the parametric study. Tables 1 & 2 show the parameters and values that were varied in order to represent the Kansas City area building stock in this study. Many other building model inputs were used as developed for the prototypes and were not varied parametrically (e.g., building geometry, schedules). Appendices C & D include further details about the building characteristics of each energy simulation model used in this study. Tables 3 & 4 show the HIR measures that were analyzed for commercial and residential buildings, respectively.

The parametric energy model results provide energy impacts for every combination of the model input parameters. Recent average Missouri utility rates and emissions factors for electricity and natural gas were applied to determine utility cost and emissions impacts of each measure for each building. Leidos also estimated implementation costs and put together a simple payback and cost-benefit analysis for each measure. Tables 5 & 7 show the values of important calculation inputs that can be varied interactively as needed. Default values are included along with associated references.

The parametric results have been put together as interactive spreadsheets for both commercial and residential building types. The spreadsheets include dynamic pivot charts to display results, which can be filtered as needed. Appendices A & B include versions of these pivot charts that represent results for each measure using building characteristics that could be considered typical. Tables 6 & 8 indicate the building characteristic combinations that correspond to the charts displayed in Appendices A & B.

The spreadsheets that were developed through this project present the results in several ways. All of the measures are included in a spreadsheet that normalizes results on the basis of conditioned floor area. This provides a convenient way to compare results across building types. This database can also be used in combination with a breakdown of building types in the Kansas City region to determine the aggregate impact of any or all of these measures for the region. The results of the ground cover

Table 1. Commercial Building Parametric Variable Assignments

Parameter	# of Iterations	Iteration 1	Iteration 2	Iteration 3	Iteration 4	Iteration 5	Iteration 6
Building Type	6	Medium Office	Large Office	Primary School	Hospital	Stand-Alone Retail	Mid Rise Apartment
Construction Vintage	10	Pre-1980	Post-1980	New Construction	-	-	-
Roof R-Value		10, 15, 20, 25	15, 20, 25	15, 20, 25	-	-	-
Window Solar Reflectance[1]	2	~0.15	~0.3	-	-	-	-
Economizer	2	Fixed (No Economizer)	Dry Bulb	-	-	-	-
Roof Material	4	Light Gravel on Built-Up Roof	Black EPDM Membrane or Smooth Bitumen	White EPDM Membrane	Paint-On Reflective Coating	-	-
Emissivity (ε) & Reflectance (ρ)[2]		ε = 0.9 ρ = 0.34	ε = 0.86 ρ = 0.06	ε = 0.9 ρ = 0.64	ε = 0.86 ρ = 0.55		
Ground Cover Material	2	Asphalt	Portland Cement Concrete or Vegetation	-	-	-	-
Emissivity (ε) & Reflectance (ρ)[2]		ε = 0.9 ρ = 0.1	ε = 0.9 ρ = 0.25				
Exterior Shading[3]	4	None	25% Tree Cover	50% Tree Cover	75% Tree Cover	-	-
Total Runs:	**7,680**						

Notes

1. Windows were chosen from the window library to meet IECC code requirements and approximate reflectance value of interest. Glass reflectivity is ~0.15 for clear glass and ~0.3 for reflective glass.
2. Infrared emissivity and solar reflectance represent 3 year aged values.
3. The % Tree Cover indicates what percentage of the building South, East, and West walls have seasonal tree coverage as represented by representative trees as described in the methodology section.

Table 2. Residential Building Parametric Variable Assignments

Parameter	# of iterations	Iteration 1	Iteration 2	Iteration 3	Iteration 4	Iteration 5
Building Type	4	Single Family Gas Furnace DX Cooling	Single Family Heat Pump	Multi Family Gas Furnace DX Cooling	Multi Family Heat Pump	-
Construction Vintage Attic R-Value	10	Pre-1980[1] 10, 20, 38, 49	Post-1980[1] 20, 38, 49	IECC 2006 38, 49	IECC 2012 49	-
Window Solar Reflectance[2]	2	~0.15	~0.3	-	-	-
Roof Material Emissivity (ε) & Reflectance (ρ)[4]	5	Composition Shingles Standard - Black ε = 0.91 ρ = 0.04	Composition Shingles Standard - Tan ε = 0.91 ρ = 0.14	Composition Shingles CRCM Material[3] ε = 0.92 ρ = 0.3	Metal Roof Standard - Dark ε = 0.85 ρ = 0.1	Metal Roof CRCM Material[3] ε = 0.87 ρ = 0.43
Ground Cover Material Emissivity (ε) & Reflectance (ρ)[4]	2	Asphalt ε = 0.9 ρ = 0.1	Portland Cement Concrete or Vegetation ε = 0.9 ρ = 0.25	-	-	-
Exterior Shading[5]	4	None	25% Tree Cover	50% Tree Cover	75% Tree Cover	-
Total Runs:	**3,200**					

Notes

1. Values for Pre-1980 and Post-1980 construction based on engineering judgment.
2. Windows were chosen from the window library to meet IECC code requirements and approximate reflectance value of interest. Glass reflectivity is ~0.15 for clear glass and ~0.3 for reflective glass.
3. CRCM = cool roof color material; engineered for higher solar reflectance.
4. Infrared emissivity and solar reflectance represent 3 year aged values.
5. The % Tree Cover indicates what percentage of the building South, East, and West walls have seasonal tree coverage as represented by representative trees as described in the methodology section.

Table 3. Commercial HIR Measures

Measure Code	Component	Baseline	Revised	Measure Type[1]	Measure Life (yrs)[2]	Cost	Cost Basis	Cost Note
CR-1	Roof	Light Gravel on Built-Up Roof	Applied Coating	Retrofit	30	$ 2.10	per SF Roof Area	4
CR-2		Smooth Bitumen Roof	Applied Coating	Retrofit	30	$ 1.83	per SF Roof Area	5
CR-3		Black EPDM	White EPDM	New Upgrade	30	$ 0.13	per SF Roof Area	6
CG-1	Ground Cover	Asphalt	Concrete	New Upgrade	50	$ 1.60	per SF Covered Area	7
CS-1	Exterior Shade	None	25% Tree Cover	Retrofit	50	$ 100	per Tree[3]	8
CS-2		None	50% Tree Cover	Retrofit	50	$ 100	per Tree[3]	8
CS-3		None	75% Tree Cover	Retrofit	50	$ 100	per Tree[3]	8

Notes

1. Retrofit measures can be applied to existing buildings at any time; retrofit cost is the cost to apply the retrofit. New upgrade measures represent use of the revised building component instead of the baseline building component in new construction or at the end-of-life for an existing building; incremental cost for the revised component over the baseline component applies to this measure type.
2. Roofs: Based on median manufacturer's warranty seen in CRCC products database (by product type); Concrete: https://www.fanniemae.com/content/guide_form/4099f.pdf; Trees: Engineering judgement.
3. Each tree is assumed to have a canopy that begins five feet from the ground, extends to fifteen feet above ground, and is fifteen feet in width.
4. Average of the range (1.45-2.75) found by Lawrence Berkeley National Laboratory (LBNL-49638).
5. Average of the range (1.25-2.40) found by Lawrence Berkeley National Laboratory (LBNL-49638).
6. Average of the range (0.10-0.15) found by Lawrence Berkeley National Laboratory (LBNL-49638).
7. RS Means Incremental Cost of Concrete (320610100310) over Asphalt (321216140500 & 321216140900).
8. Tree cost estimates range from approximately $1 to $1000 per tree depending on many factors; especially initial tree size.

Reference Report LBNL-49638: "Energy Savings of Heat-Island Reduction Strategies in Chicago and Houston (Including Updates for Baton Rouge, Sacramento, and Salt Lake City)", S. Konopacki and H. Akbari, Heat Island Group - Environmental Energy Technologies Division - Lawrence Berkeley National Laboratory - University of California, February 2002.

Table 4. Residential HIR Measures

Measure Code	Component	Baseline	Revised[1]	Measure Type[2]	Measure Life (yrs)[3]	Cost	Cost Basis	Cost Note
RR-1	Roof	Black Composition Shingles	CRCM Shingles	New Upgrade	50	$ 0.55	per SF Roof Area	4
RR-2		Tan Composition Shingles	CRCM Shingles	New Upgrade	50	$ 0.55	per SF Roof Area	4
RR-3		Standard Dark Metal Roof	CRCM Metal Roof	New Upgrade	35	$ 0.50	per SF Roof Area	5
RG-1	Ground Cover	Asphalt	Concrete	New Upgrade	50	$ 1.60	per SF Covered Area	6
RS-1	Exterior Shade	None	25% Tree Cover	Retrofit	50	$ 100	per Tree[4]	7
RS-2		None	50% Tree Cover	Retrofit	50	$ 100	per Tree[4]	7
RS-3		None	75% Tree Cover	Retrofit	50	$ 100	per Tree[4]	7

Notes

1. CRCM = Cool Roof Color Material.
2. Retrofit measures can be applied to existing buildings at any time; retrofit cost is the cost to apply the retrofit. New upgrade measures represent use of the revised building component instead of the baseline building component in new construction or at the end-of-life for an existing building; incremental cost for the revised component over the baseline component applies to this measure type.
3. Roofs: Based on median manufacturer's warranty seen in CRCC products database (by product type); Concrete: https://www.fanniemae.com/content/guide_form/4099f.pdf; Trees: Engineering judgement.
4. Each tree is assumed to have a canopy that begins five feet from the ground, extends to fifteen feet above ground, and is fifteen feet in width.
5. Average of the range (0.35-0.75) found by Lawrence Berkeley National Laboratory (LBNL-49638).
6. Average of the range (0.00-1.00+) found by Lawrence Berkeley National Laboratory (LBNL-49638).
7. RS Means Incremental Cost of Concrete (320610100310) over Asphalt (321216140500 & 321216140900).
8. Tree cost estimates range from approximately $1 to $1000 per tree depending on many factors; especially initial tree size.

Reference Report LBNL-49638: "Energy Savings of Heat-Island Reduction Strategies in Chicago and Houston (Including Updates for Baton Rouge, Sacramento, and Salt Lake City)", S. Konopacki and H. Akbari, Heat Island Group - Environmental Energy Technologies Division - Lawrence Berkeley National Laboratory - University of California, February 2002.

Table 5. Commercial Building HIR Measure Analysis Inputs

Value	Default Value	Units	Description	Default Reference
0.093	0.093		Commercial Electricity ($/kWh)	http://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_a
0.86965	0.86965		Commercial Gas ($/therm)	http://www.eia.gov/dnav/ng/ng_pri_sum_a_EPG0_PCS_DMcf_a.htm
2.1	2.1	$/SF of Roof	Applied Coating over Smooth Surface	Average of the range (1.45-2.75) found by Lawrence Berkeley National Laboratory (LBNL-49638)
1.825	1.825	$/SF of Roof	Applied Coating over Rough Surface	Average of the range (1.25-2.40) found by Lawrence Berkeley National Laboratory (LBNL-49638)
0.125	0.125	$/SF of Roof	Incremental Cost of Cool EPDM vs Black EPDM	Average of the range (0.10-0.15) found by Lawrence Berkeley National Laboratory (LBNL-49638)
1.6	1.6	$/SF of Cover	Incremental Cost of Concrete vs Asphalt	RS Means Incremental Cost of Concrete (320610100310) over Asphalt (321216140500 & 321216140900)
100	100	$/Tree	Deciduous Tree[1]	Tree cost estimates range from approximately $1 to $1000 per tree depending on many factors; especially initial tree size
5%	5%		Discount Rate[2]	
1758	1758	lb/MWh	CO2 Emissions for Electricity Generation	2013 KCP&L figure
1.9186	1.9186	lb/MWh	NOx Emissions for Electricity Generation	http://www.epa.gov/cleanenergy/documents/egridzips/eGRID_9th_edition_V1-0_year_2010_Summary_Tables.pdf
2.5511	2.5511	lb/MWh	SOx Emissions for Electricity Generation	http://www.epa.gov/cleanenergy/documents/egridzips/eGRID_9th_edition_V1-0_year_2010_Summary_Tables.pdf
11.639	11.639	lb/therm	CO2 Emissions for Natural Gas	Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2002, EPA430-R-04-003, U.S. EPA, Washington, DC, April 2004.
0.009126	0.009126	lb/therm	NOx Emissions for Natural Gas	http://www3.epa.gov/ttnchie1/conference/ei12/area/haneke.pdf
5.83E-05	5.83E-05	lb/therm	SOx Emissions for Natural Gas	http://www3.epa.gov/ttnchie1/conference/ei12/area/haneke.pdf

Notes

1. Each tree is assumed to have a canopy that begins five feet from the ground, extends to fifteen feet above ground, and is fifteen feet in width.
2. Discount rate is used to determine the present value of utility cost savings over the life of the measure.

Reference Report LBNL-49638: "Energy Savings of Heat-Island Reduction Strategies in Chicago and Houston (Including Updates for Baton Rouge, Sacramento, and Salt Lake City)", S. Konopacki and H. Akbari, Heat Island Group - Environmental Energy Technologies Division - Lawrence Berkeley National Laboratory - University of California, February 2002.

Table 6. Commercial Building "Typical" Values Chosen for Overall Results Presentation (Appendix A)

Building Type	Window Reflectivity	Reference	Economizer	Reference
Hospital	High	Engineering Judgement	Dry Bulb	Engineering Judgement
Large Office	High	Engineering Judgement	Dry Bulb	Engineering Judgement
Medium Office	Both	Engineering Judgement	Dry Bulb	Engineering Judgement
Mid Rise Apartment	Low	Engineering Judgement	Fixed	Engineering Judgement
Primary School	Both	Engineering Judgement	Dry Bulb	Engineering Judgement
Stand-Alone Retail	Low	Engineering Judgement	Both	Engineering Judgement

Construction Vintage	Roof R-Value	Reference
Pre 1980	10	Engineering Judgement
Post 1980	15	Commercial IECC 2006
New Construction	25	Commercial IECC 2012

measures (CG-1 and RG-1) are presented on the basis of conditioned building area (expressed in units of kSF or thousand square feet of conditioned floor area) in Appendices A & B.

In addition to the spreadsheets that normalize results based on conditioned area, two other normalization bases are provided. For the roof measures, spreadsheets are provided that normalize results on the basis of roof area (in units of kSF or thousand square feet of roof area). For the tree shading measures, spreadsheets are provided that normalize results per tree.

Table 7. Residential Building HIR Measure Analysis Inputs

Value	Default Value	Units	Description	Default Reference
0.1186	0.1186	$/kWh	Residential Electricity	http://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_a
1.027237	1.027237	$/therm	Residential Gas	http://www.eia.gov/dnav/ng/ng_pri_sum_a_EPG0_PRS_DMcf_a.htm
0.55	0.55	$/SF of Roof	CRCM[1] Composite Shingle	Average of the range (0.35-0.75) found by Lawrence Berkeley National Laboratory (LBNL-49638)
0.5	0.5	$/SF of Roof	CRCM[1] Metal Roof	Average of the range (0.00-1.00+) found by Lawrence Berkeley National Laboratory (LBNL-49638)
1.6	1.6	$/SF of Cover	Incremental Cost of Concrete vs Asphalt	RS Means Incremental Cost of Concrete (320610100310) over Asphalt (321216140500 & 321216140900)
100	100	$/Tree	Deciduous Tree[2]	Tree cost estimates range from approximately $1 to $1000 per tree depending on many factors; especially initial tree size
5%	5%		Discount Rate[3]	
1758	1758	lb/MWh	CO2 Emissions for Electricity Generation	2013 KCP&L figure
1.9186	1.9186	lb/MWh	NOx Emissions for Electricity Generation	http://www.epa.gov/cleanenergy/documents/egridzips/eGRID_9th_edition_V1-0_year_2010_Summary_Tables.pdf
2.5511	2.5511	lb/MWh	SOx Emissions for Electricity Generation	http://www.epa.gov/cleanenergy/documents/egridzips/eGRID_9th_edition_V1-0_year_2010_Summary_Tables.pdf
11.639	11.639	lb/therm	CO2 Emissions for Natural Gas	Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2002, EPA430-R-04-003, U.S. EPA, Washington, DC, April 2004.
0.009126	0.009126	lb/therm	NOx Emissions for Natural Gas	http://www3.epa.gov/ttnchie1/conference/ei12/area/haneke.pdf
5.83E-05	5.83E-05	lb/therm	SOx Emissions for Natural Gas	http://www3.epa.gov/ttnchie1/conference/ei12/area/haneke.pdf

Notes

1. CRCM = Cool Roof Color Material.
2. Each tree is assumed to have a canopy that begins five feet from the ground, extends to fifteen feet above ground, and is fifteen feet in width.
3. Discount rate is used to determine the present value of utility cost savings over the life of the measure.

Reference Report LBNL-49638: "Energy Savings of Heat-Island Reduction Strategies in Chicago and Houston (Including Updates for Baton Rouge, Sacramento, and Aslt Lake City)", S. Konopacki and H. Akbari, Heat Island Group - Environmental Energy Technologies Division - Lawrence Berkeley National Laboratory - University of California, February 2002.

Table 8. Residential Building "Typical" Values Chosen for Overall Results Presentation (Appendix B)

Building Type	Window Reflectivity	Reference
Single Family	Low	Engineering Judgement
Multi Family	Low	Engineering Judgement

Construction Vintage	Roof R-Value	Reference
Pre 1980	10	Engineering Judgement
Post 1980	20	Engineering Judgement
IECC 2006	38	Residential IECC 2006
IECC 2012	49	Residential IECC 2012

Measure Descriptions

Roof Measures

The urban heat island effect is reduced when any building exterior surface is high albedo; meaning that it reflects a higher percentage of solar energy back away from the surface. Since roofs face generally upward, they receive solar energy directly, and high albedo roofs can effectively reflect a higher portion of that energy back into space than more conventional options. Also, in an urban environment the building roof area can represent a significant fraction of total area.

ENERGY STAR keeps a database of certified roof products[1]. This database lists roofing products in several categories along with initial and 3-year aged solar reflectance, emissivity, and warranty. For the purposes of this study, the 75th percentile aged solar reflectance and emissivity were used to represent high albedo roof products. A spreadsheet file of the ENERGY STAR product database that was current at the time of this study has been provided to accompany the report.

Baseline roof reflectance ranges from 0.04 to 0.34, and high albedo roofing reflectance ranges from 0.3 to 0.64. For commercial roofing, high albedo coatings can be applied over an existing roof in good repair as a retrofit. Measures CR-1 and CR-2 examine the impacts of applying such a coating over a light gravel covered built-up roof and a smooth bitumen roof, respectively. Measure CR-3 examines the incremental cost and energy impact of choosing a high albedo EPDM membrane roof instead of a conventional black EPDM roof. Residential roof measures examine the use or cool roof color material (CRCM) shingles instead of either black (measure RR-1) or tan (measure RR-2) composition shingles. Measure RR-3 examines the use of CRCM metal roofing instead of conventional dark metal roofing. Cool roof color materials are specially engineered to provide high solar reflectance even with a visual color that may appear relatively dark. The need for CRCMs arises in part from a consumer acceptance perspective; medium or darker colors are preferred over white roofing in residential applications.

In addition to reflectance, a secondary surface property that relates to the urban heat island effect is emissivity. Emissivity is a measure of how efficiently a surface emits thermal energy. A so-called "black body" is a perfect emitter with an emissivity of 1. Most non-metallic surfaces have thermal emittance between 0.80 and 0.95. All of the roofs considered in this analysis have emissivity ranging from 0.85 to 0.92.

Ground Cover Measure

High albedo ground cover is another heat island reduction measure. The urban hardscape often consists of relatively dark asphalt pavement (reflectance of 0.1) that absorbs solar energy. Lighter ground cover options exist such as concrete or vegetation; both with a reflectance of about 0.25. Higher reflectance

[1] http://www.energystar.gov/productfinder/product/certified-roof-products/

ground cover will reduce ambient temperatures in an urban environment; however, the direct effect upon nearby buildings is to reflect more ground-incident solar energy back toward the buildings. This increases solar heat gain, which is beneficial in the winter but not in the summer.

The commercial (CG-1) and residential (RG-1) ground cover measures both examine the effect of Portland cement (or vegetation) as a ground cover instead of asphalt. For the purposes of cost estimation, a ground cover area with a width of four feet surrounding the West, South, and East perimeters of each building was considered. The incremental cost of Portland cement over asphalt ground cover was used in the analysis.

Tree Shading Measures

Trees are another HIR strategy; they reduce the amount of solar energy that reaches buildings and the ground and can cool the air through evapotranspiration. This study examines the direct effect of strategically placed trees that shade buildings. The effect and the cost of the shade trees depend on many factors, including the tree size, placement, and amount of sunlight penetration (including any seasonal differences). Based on a similar study[2], the tree shade measures considered mature box-shaped trees that are 15 feet wide with foliage that extends from 5 feet above ground to 15 feet above ground. The trees extend to within 5 feet of the building and are planted along the West, South, and East building facades (see Figure 1). The solar transmittance is modeled as 0.1 for April 1 through October 31 and as 0.9 the rest of the year (to mimic deciduous tree foliage). The commercial building tree shade measures CS-1, CS-2, and CS-3 consider 25%, 50%, and 75% tree coverage along the three facades, respectively. Residential tree shade measures RS-1, RS-2, and RS-3 are similarly defined for residential building types. Tree cost can be highly variable depending on the size, location, and type of tree. The literature show cost estimates ranging from approximately $1/tree to $1000/tree. A cost of $100/tree was used in this study, although the measure cost is something that can be adjusted in the provided spreadsheets.

[2] LBNL-49638: "Energy Savings of Heat-Island Reduction Strategies in Chicago and Houston (Including Updates for Baton Rouge, Sacramento, and Salt Lake City)", S. Konopacki and H. Akbari, Heat Island Group - Environmental Energy Technologies Division - Lawrence Berkeley National Laboratory - University of California, February 2002.

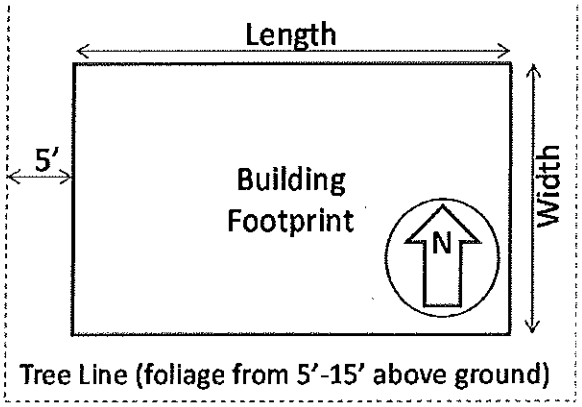


Figure 1. Tree Shading Diagram (Plan View)

Results

Comprehensive results are provided in Appendices A & B for the commercial and residential building HIR measures studied. Any number of combinations can be examined using the results database spreadsheets provided. To summarize the results further, Tables 9-14 indicate the range of energy impacts observed for each measure. In each case a range is seen due to the different building characteristics based on vintage. For example, older buildings with lower roof insulation levels exhibit different savings for a high albedo roof than a new building with more roof insulation.

A detailed look at the roof measure data show, as expected, that high albedo roofs save summer cooling energy but also increase the required winter heating energy. For the building types with multi-zone reheat systems (hospital, large office, medium office, and primary school), some net heating energy savings can be seen. This is because the high albedo roof reduces the difference in cooling requirements between the zones with roof exposure and those without. The result is that the zones without roof exposure require less reheat during the cooling season. Tables 9 & 12 show net energy cost savings for all of the commercial and residential roof measures, although the magnitude of the savings is not compelling enough to justify the investment in most cases. Measure CR-3 (white EPDM instead of black EPDM) does have reasonable payback for buildings with relatively low roof insulation, however additional roof insulation would generally be recommended at the time of roof replacement anyway.

The high albedo ground cover measures cause increased solar gains to nearby buildings, as expected. This does save some heating energy, but it also increases cooling energy. The net result is increased energy cost for the buildings; the one exception being older mid rise apartments, which show a small net energy cost savings.

Table 9. Commercial Building Roof Measures

	Energy Cost Savings ($/Roof kSF)			Simple Payback (Years)		
Measure	CR-1	CR-2	CR-3	CR-1	CR-2	CR-3
Hospital	1.2 to 30	2.8 to 58	3.1 to 61	71 to >100	31 to >100	2.0 to 40
Large Office	2.3 to 13	6.3 to 26	7.6 to 25	>100	70 to >100	5.0 to 17
Medium Office	2.2 to 11	5.6 to 27	6.6 to 32	>100	69 to >100	3.9 to 19
Mid Rise Apartment	2.1 to 4.3	5.0 to 10	5.4 to 11	>100	>100	11 to 23
Primary School	3.7 to 20	9.7 to 44	12 to 55	>100	43 to >100	2.3 to 11
Stand-Alone Retail	2.4 to 14	8.1 to 42	9.8 to 44	>100	42 to >100	2.9 to 13

Table 10. Commercial Building Ground Cover Measure

	Energy Cost Savings ($/Conditioned kSF)	Simple Payback (Years)
Measure	CG-1	CG-1
Hospital	-40 to -6.8	Note 1
Large Office	-4.8 to -1.5	
Medium Office	-16 to -5.8	
Mid Rise Apartment	-1.0 to 1.8	
Primary School	-27 to -15	
Stand-Alone Retail	-5.4 to -1.9	

Notes

1. Direct energy impacts to the buildings are a net energy cost for all but older apartments, which have a small savings but a long (35+ year) payback.

Table 11. Commercial Building Tree Shade Measures

	Energy Cost Savings ($/Tree)			Simple Payback (Years)		
Measure	CS-1	CS-2	CS-3	CS-1	CS-2	CS-3
Hospital	14 to 35	14 to 35	12 to 31	2.8 to 7.1	2.9 to 7.4	3.2 to 8.7
Large Office	17 to 30	7.2 to 13	6.5 to 11	4.7 to 6.1	7.7 to 15	11 to 16
Medium Office	28 to 64	27 to 60	26 to 57	1.6 to 3.5	1.7 to 3.7	1.8 to 3.9
Mid Rise Apartment	5.7 to 9.0	4.9 to 7.8	4.2 to 7.1	11 to 18	13 to 21	14 to 24
Primary School	18 to 25	20 to 30	20 to 31	4.7 to 5.6	3.5 to 5.0	3.3 to 5.0
Stand-Alone Retail	4.5 to 7.4	4.3 to 7.1	4.0 to 6.6	15 to 26	15 to 27	16 to 29

Table 12. Residential Building Roof Measures

	Energy Cost Savings ($/Roof kSF)			Simple Payback (Years)		
Measure	RR-1	RR-2	RR-3	RR-1	RR-2	RR-3
Single Family w/ Furnace	1.9 to 16	1.2 to 10	2.0 to 20	35 to >100	56 to >100	25 to >100
Single Family w/ Heat Pump	1.4 to 12	0.8 to 7.5	1.6 to 16	65 to >100	>100	41 to >100
Multi Family w/ Furnace	1.7 to 14	1.1 to 8.3	2.2 to 17	41 to >100	66 to >100	29 to >100
Multi Family w/ Heat Pump	1.7 to 5.7	1.1 to 3.7	2.3 to 7.6	96 to >100	>100	66 to >100

Table 13. Residential Building Ground Cover Measure

	Energy Cost Savings ($/Conditioned kSF)	Simple Payback (Years)
Measure	RG-1	RG-1
Single Family w/ Furnace	-25 to -4.3	Note 1
Single Family w/ Heat Pump	-15 to -2.0	
Multi Family w/ Furnace	-19 to -5.1	
Multi Family w/ Heat Pump	-7.5 to -3.9	

Notes

1. Direct energy impacts to the buildings are a net energy cost, which explains the negative simple paybacks.

Table 14. Residential Building Tree Shade Measures

	Energy Cost Savings ($/Tree)			Simple Payback (Years)		
Measure	RS-1	RS-2	RS-3	RS-1	RS-2	RS-3
Single Family w/ Furnace	8.5 to 17	7.7 to 16	7.0 to 15	5.9 to 12	6.4 to 14	6.9 to 14
Single Family w/ Heat Pump	8.6 to 14	7.9 to 14	7.1 to 14	7.3 to 12	7.0 to 13	7.4 to 14
Multi Family w/ Furnace	21 to 29	21 to 30	19 to 29	3.4 to 4.7	3.3 to 4.8	3.5 to 5.2
Multi Family w/ Heat Pump	19 to 28	20 to 28	18 to 25	3.6 to 5.2	3.6 to 5.1	4.0 to 5.8

The tree shade measures generally show the most promise for significant energy savings at reasonable payback. This is true for both the commercial and residential buildings studied. The range of savings occurs mainly because of different window solar heat gain coefficients (SHGCs) that are modeled for different vintages. As expected, more savings occurs from shading an older window with a higher SHGC than occurs from shading a new window with a low SHGC. For any given building type, Tables 11 and 14 show very similar numbers across the measures (CS-1 through CS-3 and RS-1 through RS-3). This is because the savings results are expressed on a per tree basis. The savings are roughly linear then for additional shade trees in this model. Simple payback scales roughly linearly as well because the savings per tree is roughly linear and the cost per tree is linear.

Of course, for any given building the tree placement will significantly affect the results. In this study trees were placed within a reasonable distance of the building (canopy within 5 feet) and along the best

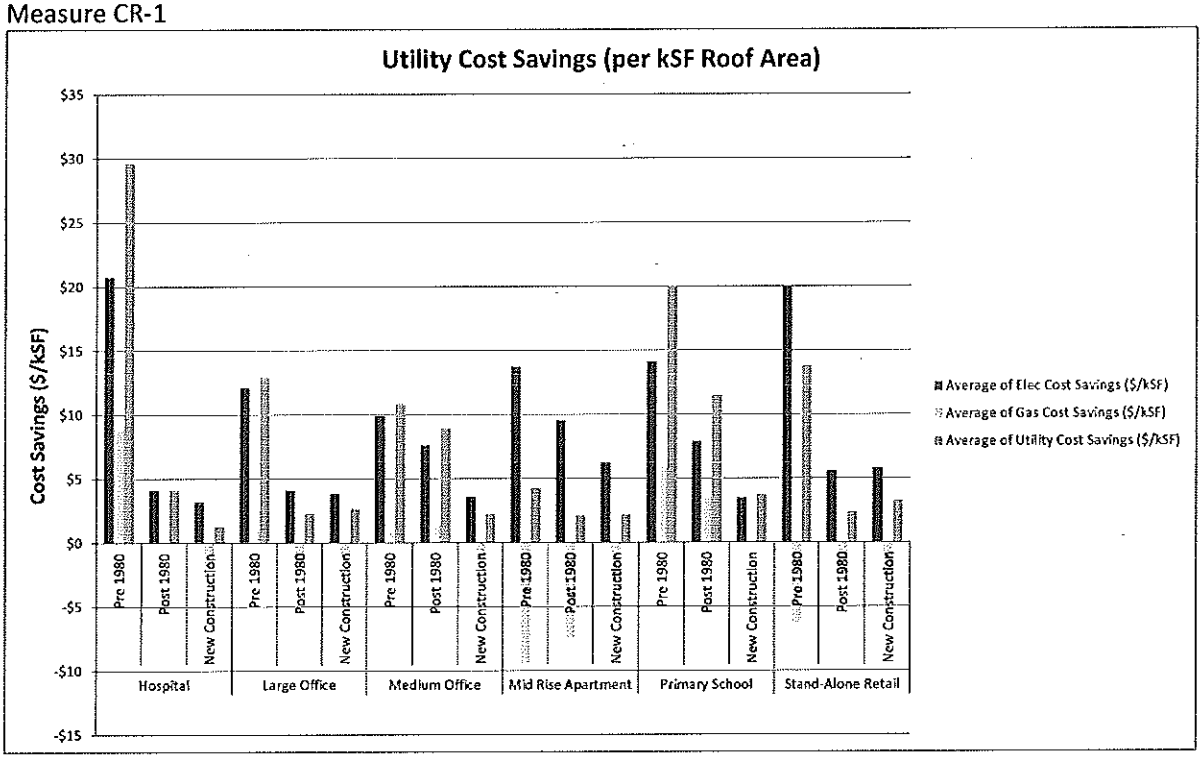
building exposures (West, South, and East). This methodology averages out the effect of a shade tree planted somewhere on that tree line (see Figure 1). More or less benefit could be realized depending on the exact tree placement. This means that careful regard for tree placement with respect to building glazing will show even better savings per tree and better payback than average.

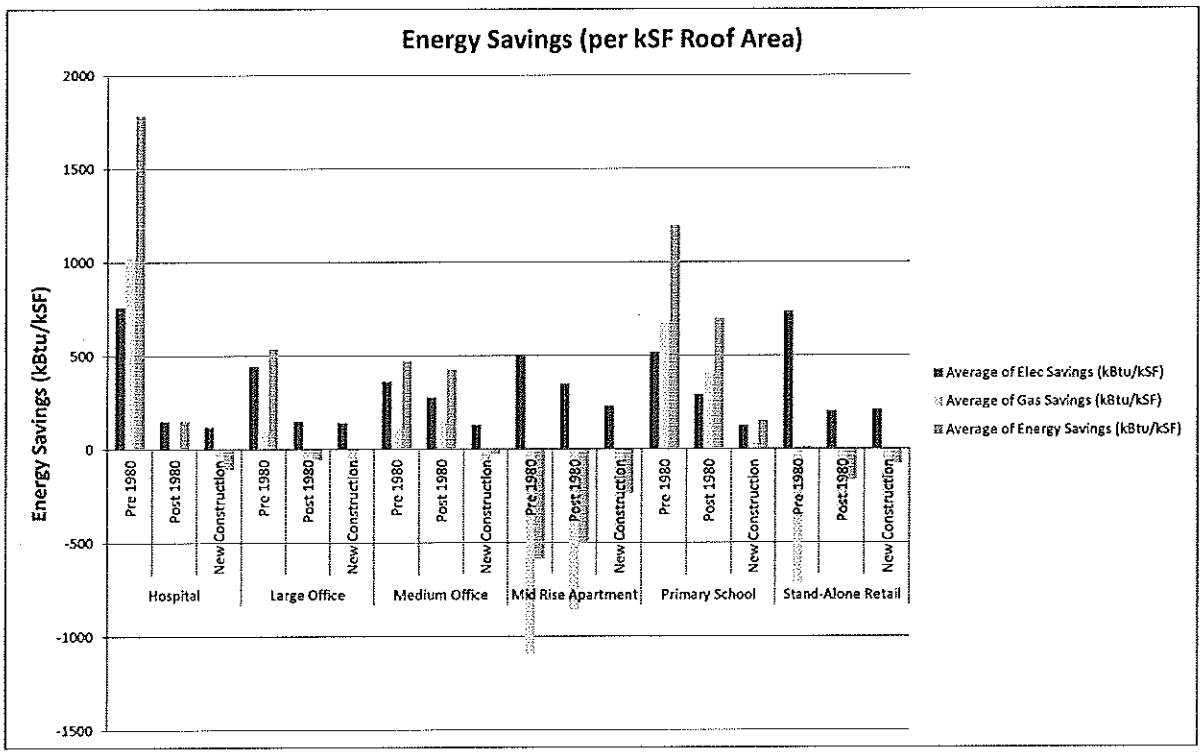
Conclusions

The purpose of this study was to determine the direct energy impacts to buildings from implementation of heat island reduction measures in the Kansas City region. The parametric energy model approach provided a wealth of data to examine the energy impacts on various building types and with various building characteristics common to the region. Implementation cost estimates were also developed. The high albedo roof measure savings show significant dependence on the roof insulation level, as expected. Overall, the net energy cost savings of high albedo roofs could not reasonably support the additional cost. High albedo ground cover results in a net energy cost increase when only direct building impacts are considered. Tree shading measures show significant promise for both the commercial and residential buildings studied. Careful consideration of tree placement relative to the building can further improve the savings per tree and the payback beyond the average results obtained in this study.

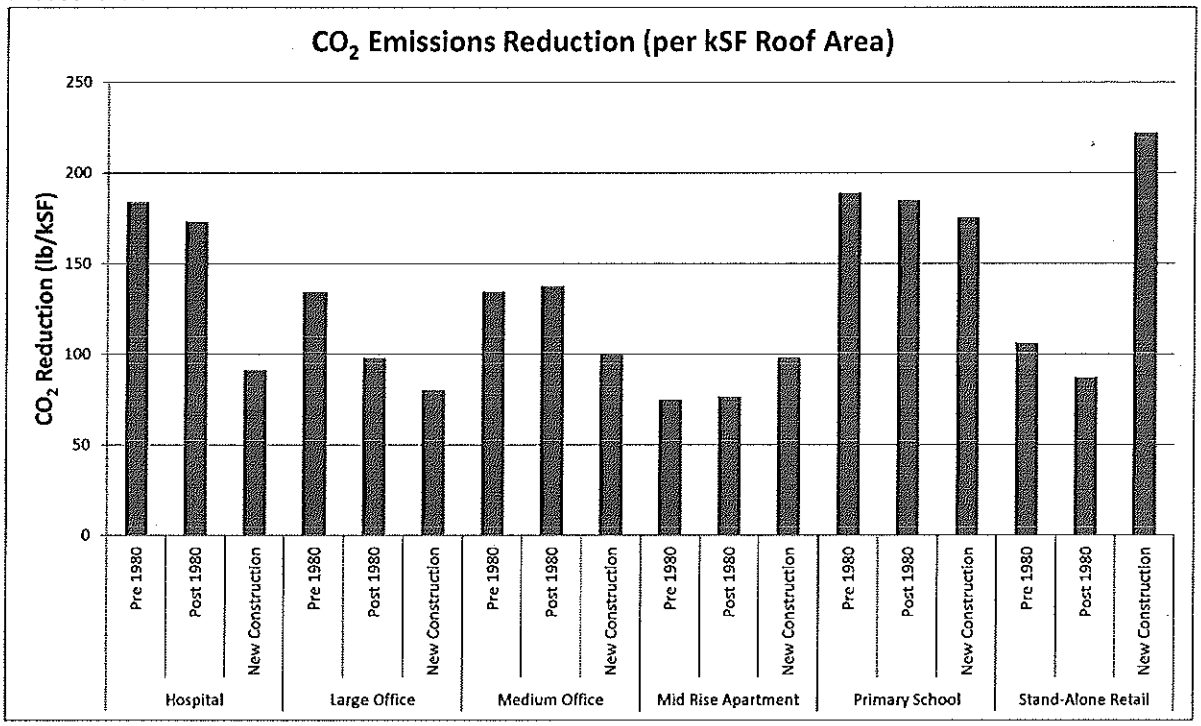
Appendix A: Commercial Measure Results

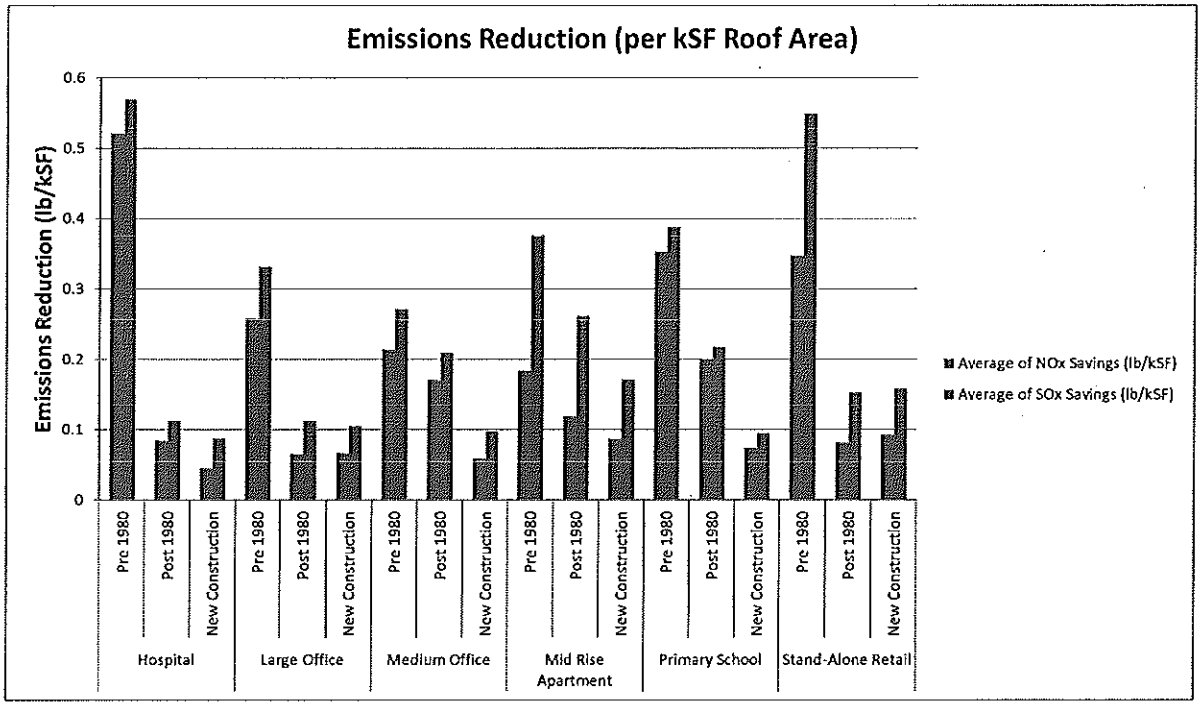
Measure CR-1


Utility Cost Savings (per kSF Roof Area)
Cost Savings ($/kSF)
$35
$30
$25
$20
$15
$10
$5
$0
-$5
-$10
-$15
Pre 1980
Post 1980
New Construction
Hospital
Large Office
Medium Office
Mid Rise Apartment
Primary School
Stand-Alone Retail
Average of Elec Cost Savings ($/kSF)
Average of Gas Cost Savings ($/kSF)
Average of Utility Cost Savings ($/kSF)

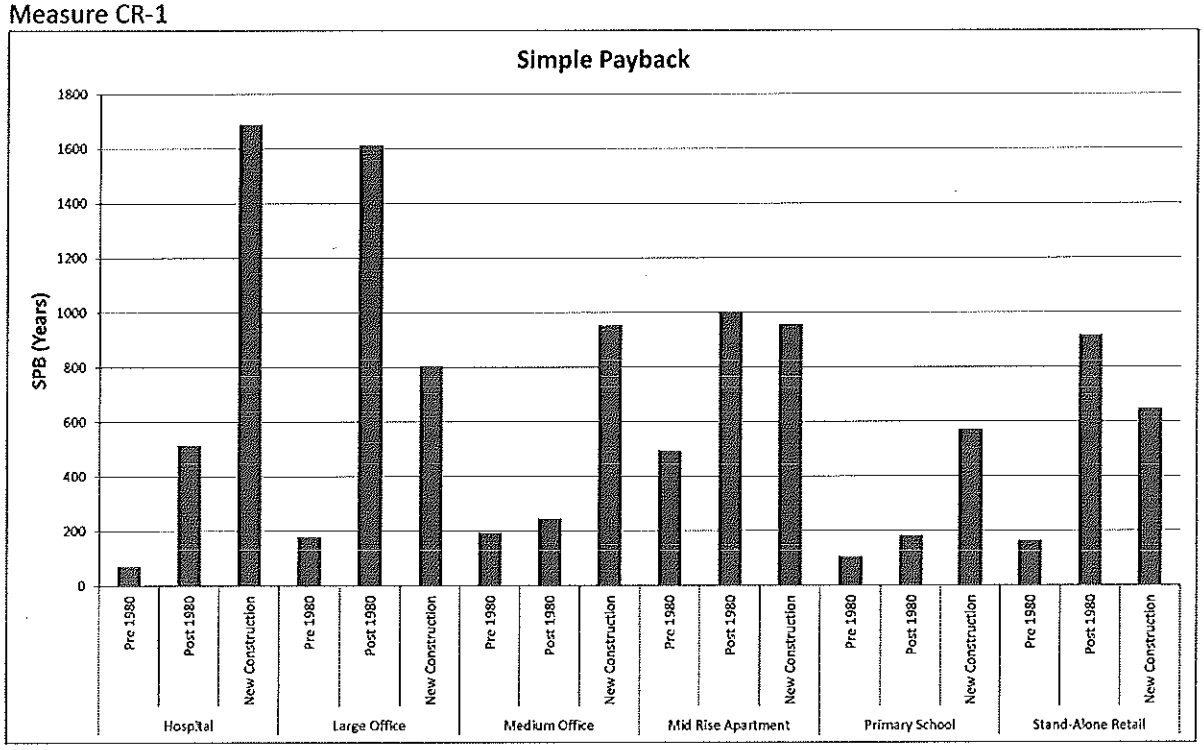

Energy Savings (per kSF Roof Area)
Energy Savings (kBtu/kSF)
2000
1500
1000
500
0
-500
-1000
-1500
Pre 1980
Post 1980
New Construction
Hospital
Large Office
Medium Office
Mid Rise Apartment
Primary School
Stand-Alone Retail
Average of Elec Savings (kBtu/kSF)
Average of Gas Savings (kBtu/kSF)
Average of Energy Savings (kBtu/kSF)

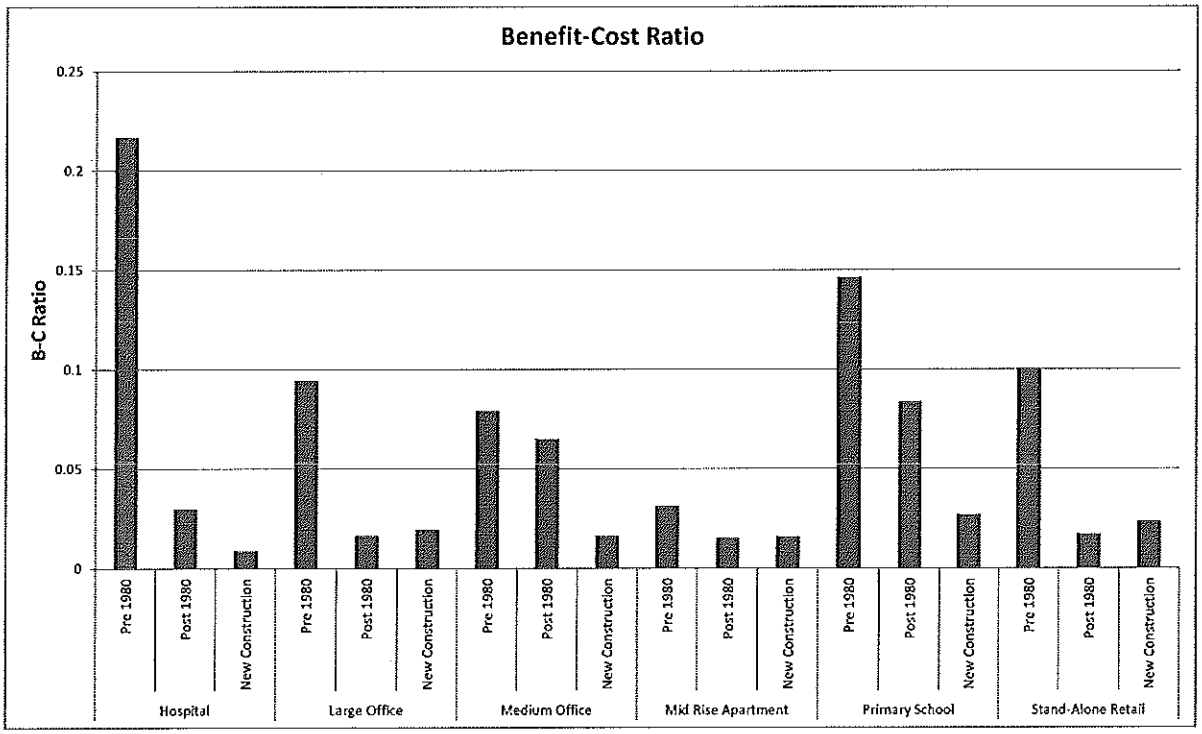
Measure CR-1


CO_2 Emissions Reduction (per kSF Roof Area)
CO_2 Reduction (lb/kSF)
250
200
150
100
50
0
Pre 1980
Post 1980
New Construction
Hospital
Large Office
Medium Office
Mid Rise Apartment
Primary School
Stand-Alone Retail

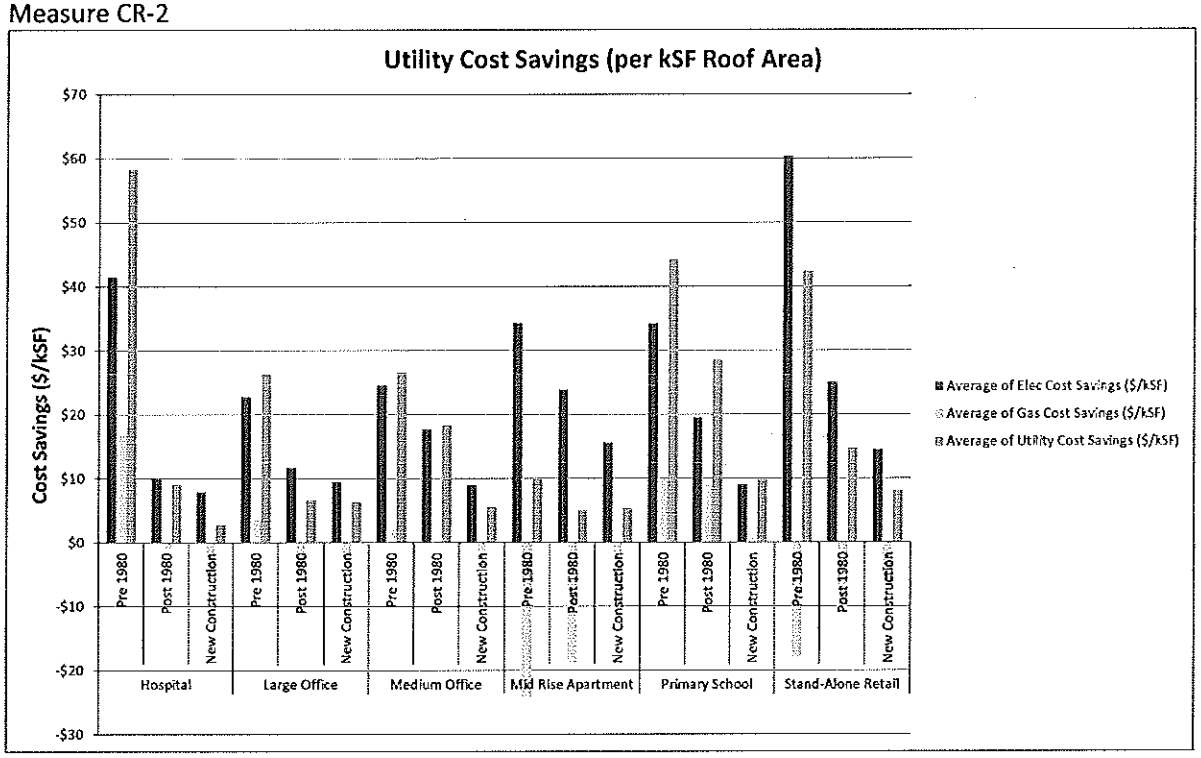

Emissions Reduction (per kSF Roof Area)
Emissions Reduction (lb/kSF)
0.6
0.5
0.4
0.3
0.2
0.1
0
Pre 1980
Post 1980
New Construction
Hospital
Large Office
Medium Office
Mid Rise Apartment
Primary School
Stand-Alone Retail
Average of NOx Savings (lb/kSF)
Average of SOx Savings (lb/kSF)

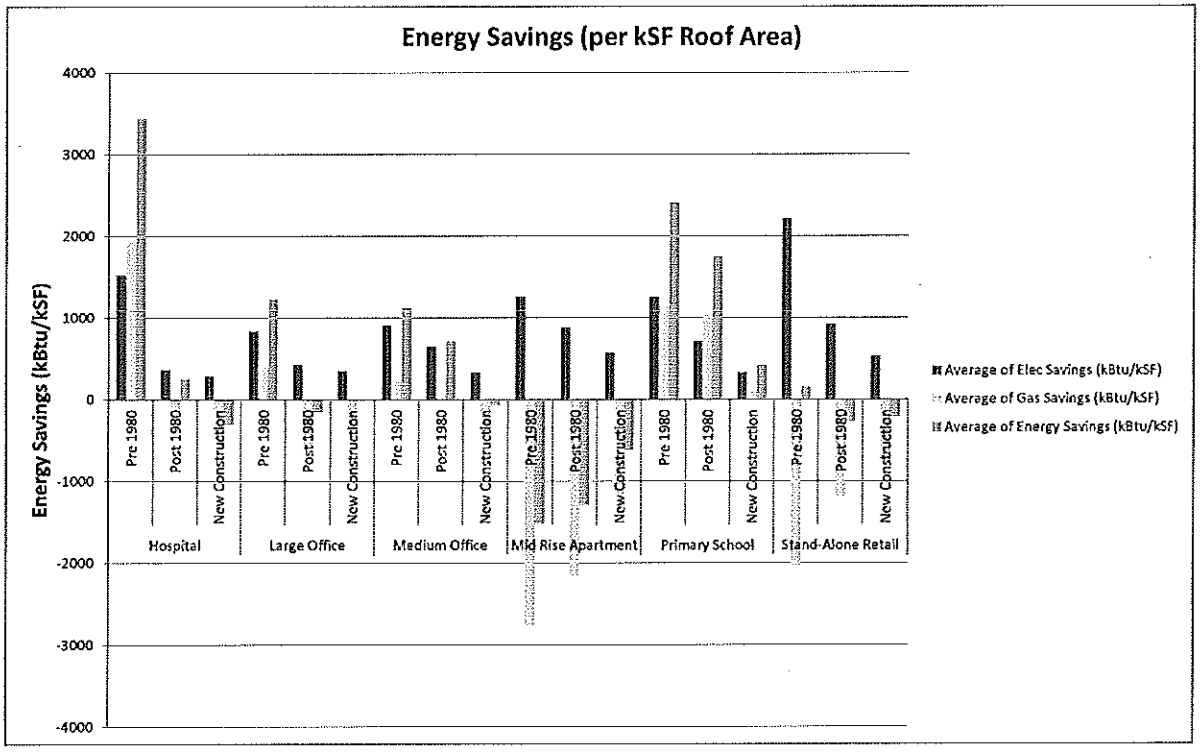
Measure CR-1


Simple Payback
SPB (Years)
1800
1600
1400
1200
1000
800
600
400
200
0
Pre 1980
Post 1980
New Construction
Hospital
Large Office
Medium Office
Mid Rise Apartment
Primary School
Stand-Alone Retail

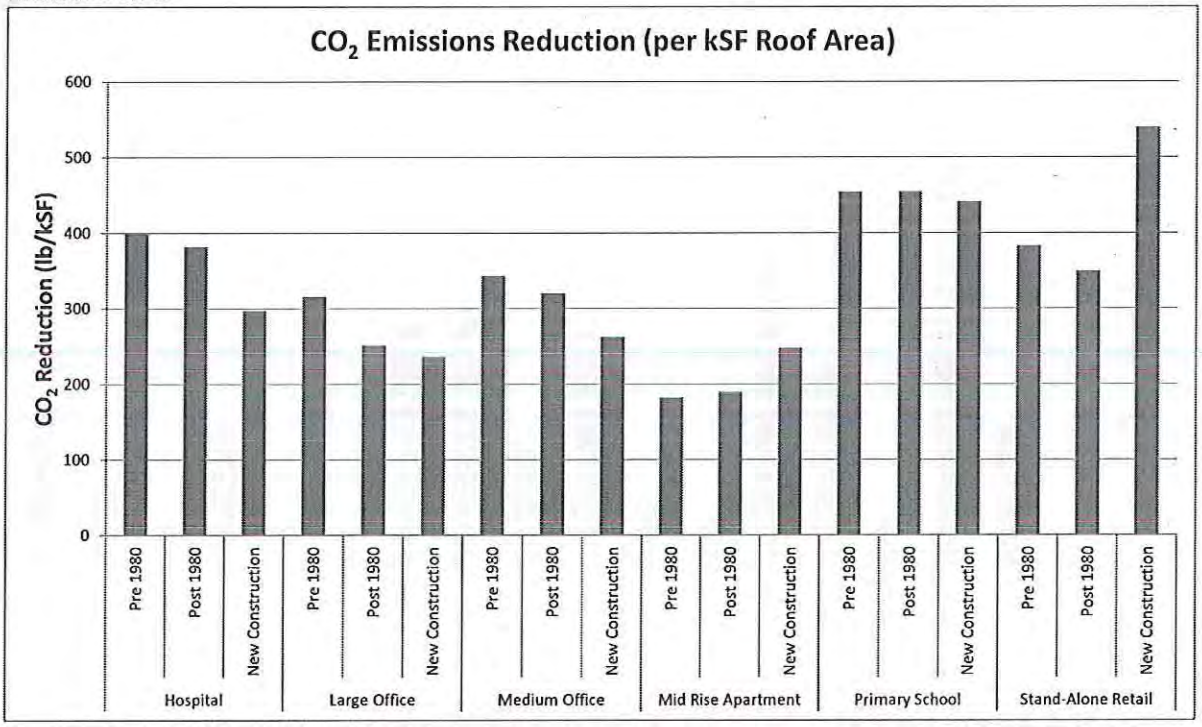

Benefit-Cost Ratio
B-C Ratio
0.25
0.2
0.15
0.1
0.05
0
Pre 1980
Post 1980
New Construction
Hospital
Large Office
Medium Office
Mid Rise Apartment
Primary School
Stand-Alone Retail

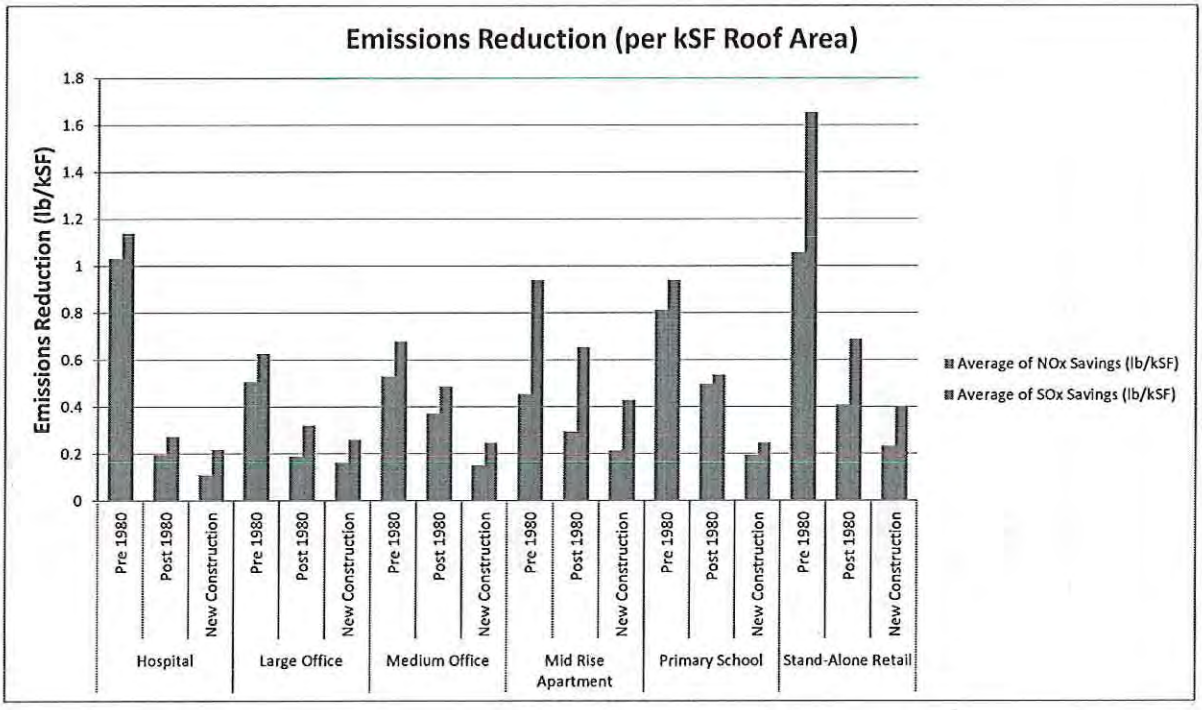
Measure CR-2


Utility Cost Savings (per kSF Roof Area)
Cost Savings ($/kSF)
$70
$60
$50
$40
$30
$20
$10
$0
-$10
-$20
-$30
Pre 1980
Post 1980
New Construction
Hospital
Large Office
Medium Office
Mid Rise Apartment
Primary School
Stand-Alone Retail
Average of Elec Cost Savings ($/kSF)
Average of Gas Cost Savings ($/kSF)
Average of Utility Cost Savings ($/kSF)

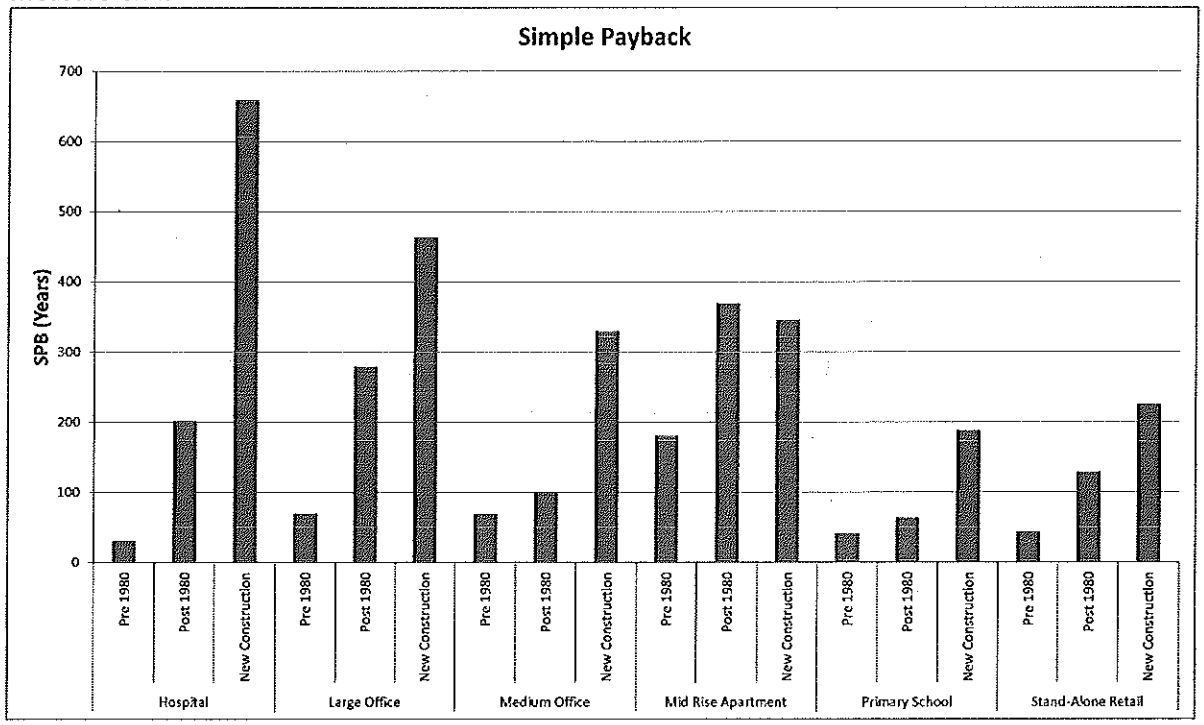

Energy Savings (per kSF Roof Area)
Energy Savings (kBtu/kSF)
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
Pre 1980
Post 1980
New Construction
Hospital
Large Office
Medium Office
Mid Rise Apartment
Primary School
Stand-Alone Retail
Average of Elec Savings (kBtu/kSF)
Average of Gas Savings (kBtu/kSF)
Average of Energy Savings (kBtu/kSF)

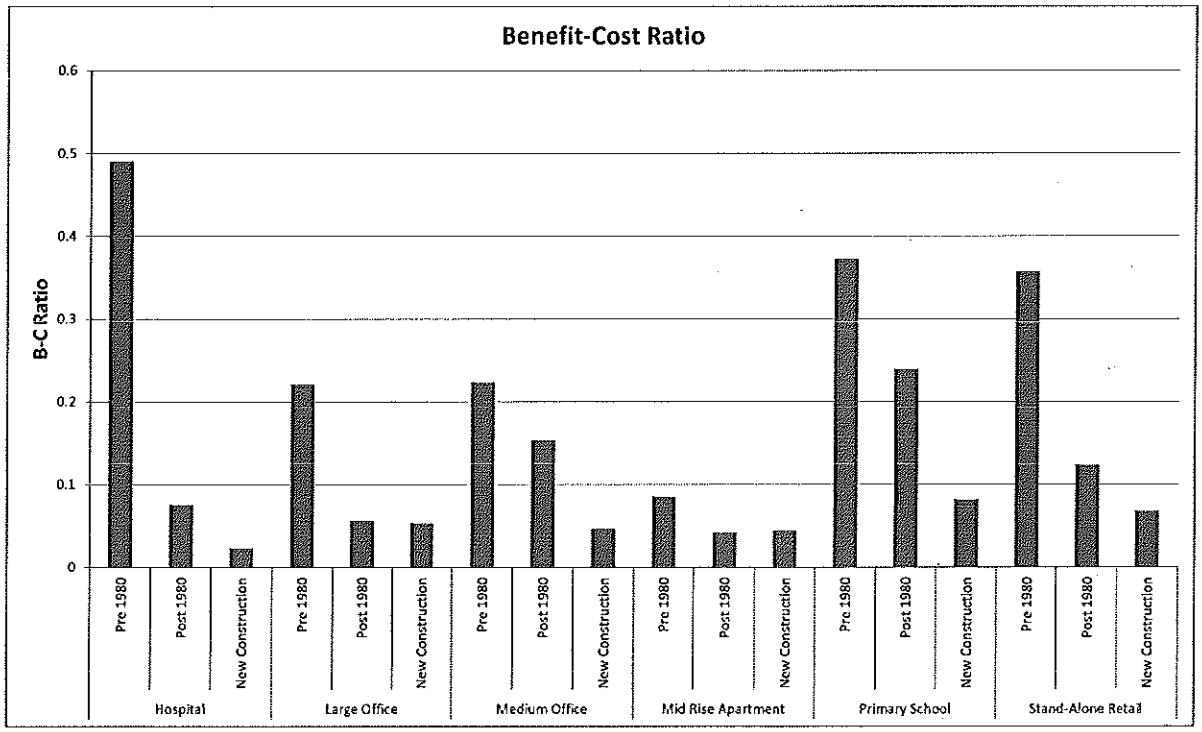
Measure CR-2


CO_2 Emissions Reduction (per kSF Roof Area)
CO_2 Reduction (lb/kSF)
600
500
400
300
200
100
0
Pre 1980
Post 1980
New Construction
Hospital
Large Office
Medium Office
Mid Rise Apartment
Primary School
Stand-Alone Retail

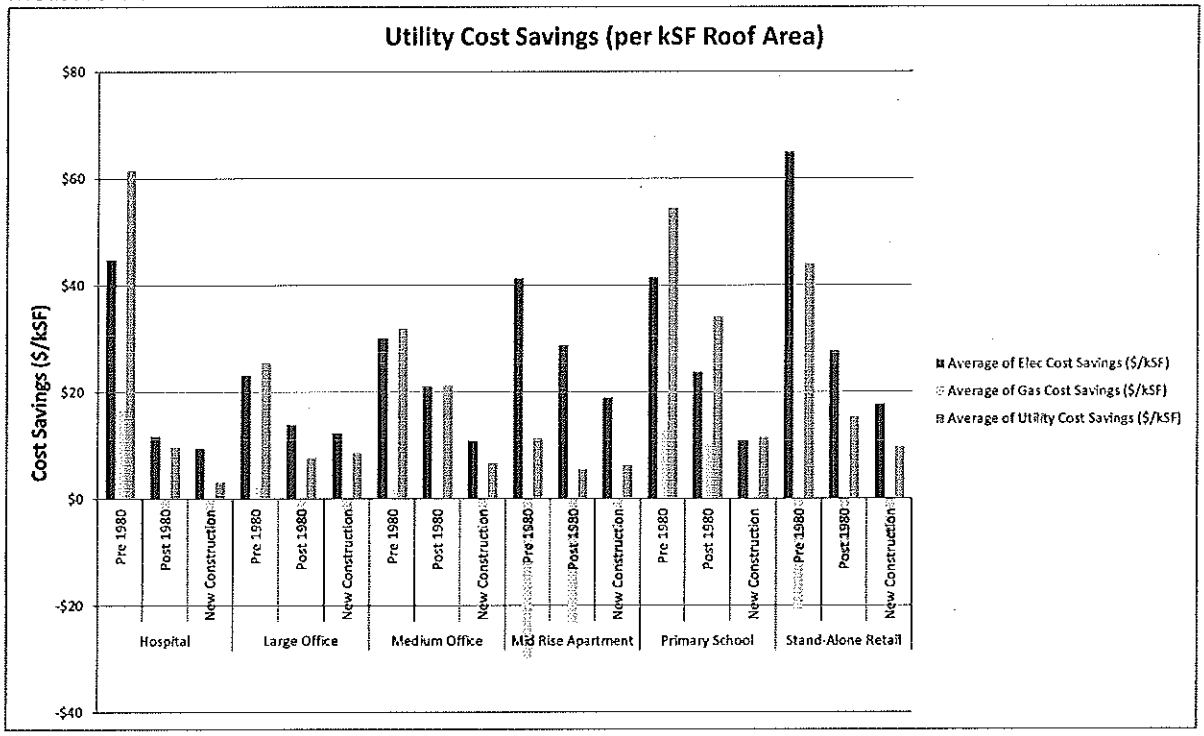

Emissions Reduction (per kSF Roof Area)
Emissions Reduction (lb/kSF)
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Pre 1980
Post 1980
New Construction
Hospital
Large Office
Medium Office
Mid Rise Apartment
Primary School
Stand-Alone Retail
Average of NOx Savings (lb/kSF)
Average of SOx Savings (lb/kSF)

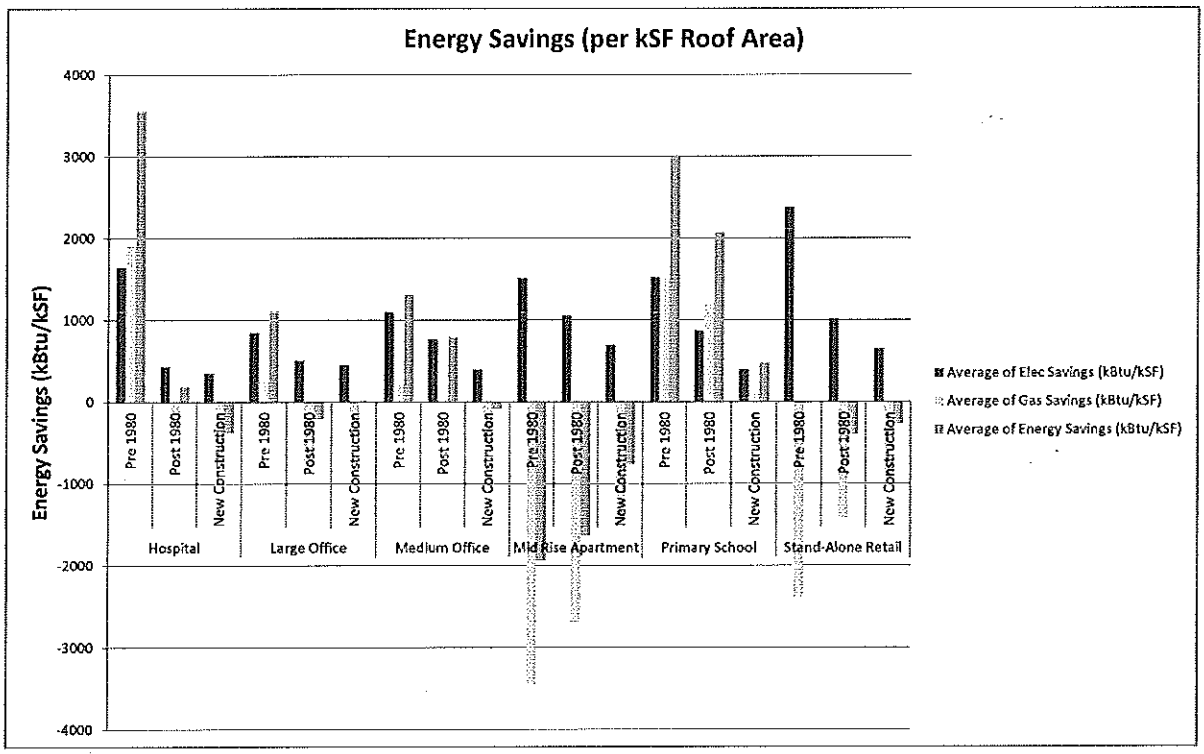
Measure CR-2


Simple Payback
SPB (Years)
700
600
500
400
300
200
100
0
Pre 1980
Post 1980
New Construction
Hospital
Large Office
Medium Office
Mid Rise Apartment
Primary School
Stand-Alone Retail

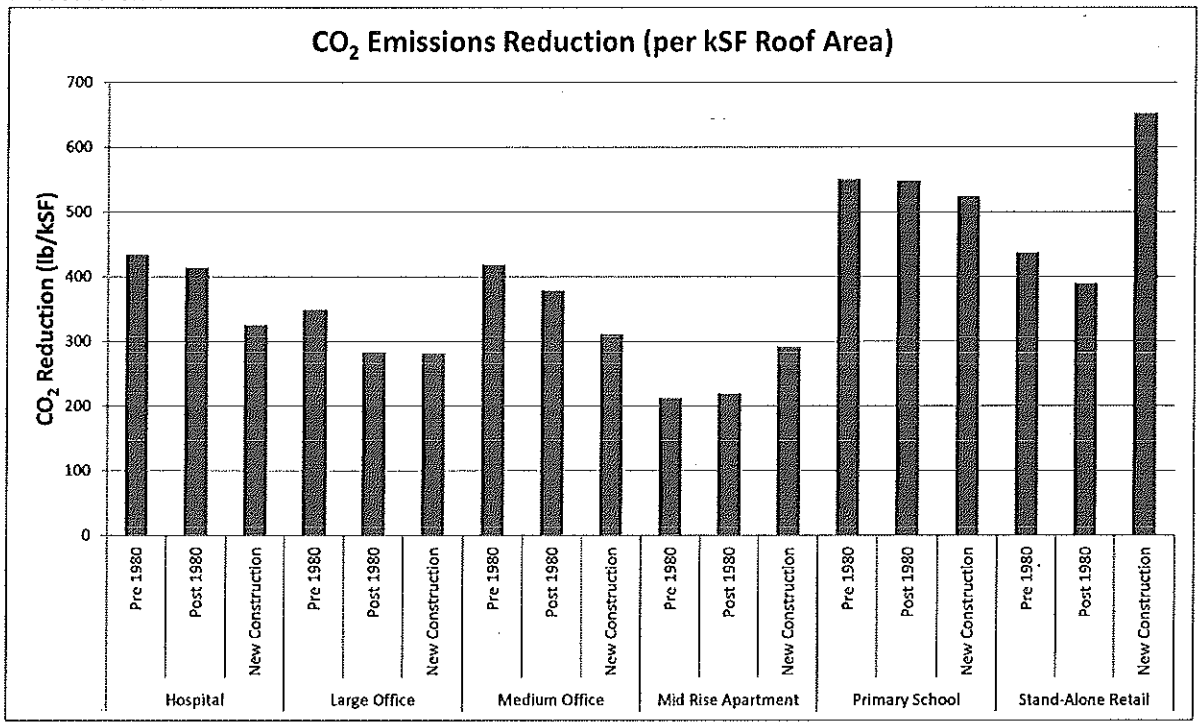

Benefit-Cost Ratio
B-C Ratio
0.6
0.5
0.4
0.3
0.2
0.1
0
Pre 1980
Post 1980
New Construction
Hospital
Large Office
Medium Office
Mid Rise Apartment
Primary School
Stand-Alone Retail

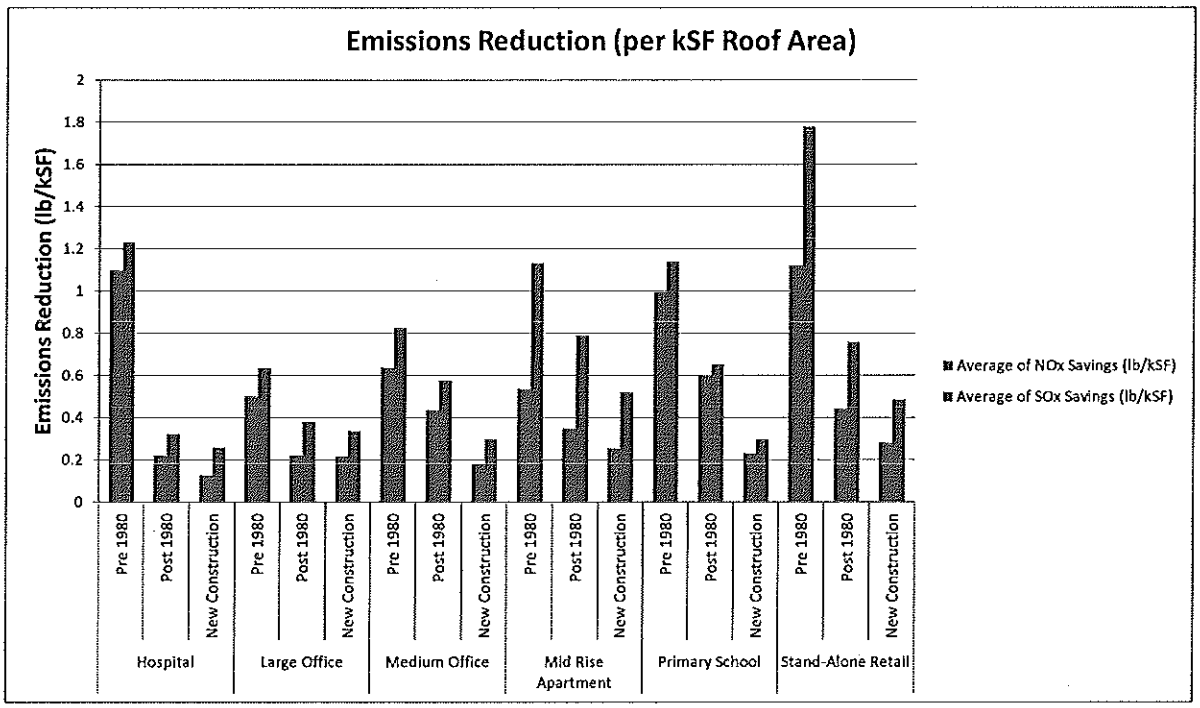
Measure CR-3


Utility Cost Savings (per kSF Roof Area)
Cost Savings ($/kSF)
$80
$60
$40
$20
$0
-$20
-$40
Pre 1980
Post 1980
New Construction
Hospital
Large Office
Medium Office
Mid Rise Apartment
Primary School
Stand-Alone Retail
Average of Elec Cost Savings ($/kSF)
Average of Gas Cost Savings ($/kSF)
Average of Utility Cost Savings ($/kSF)

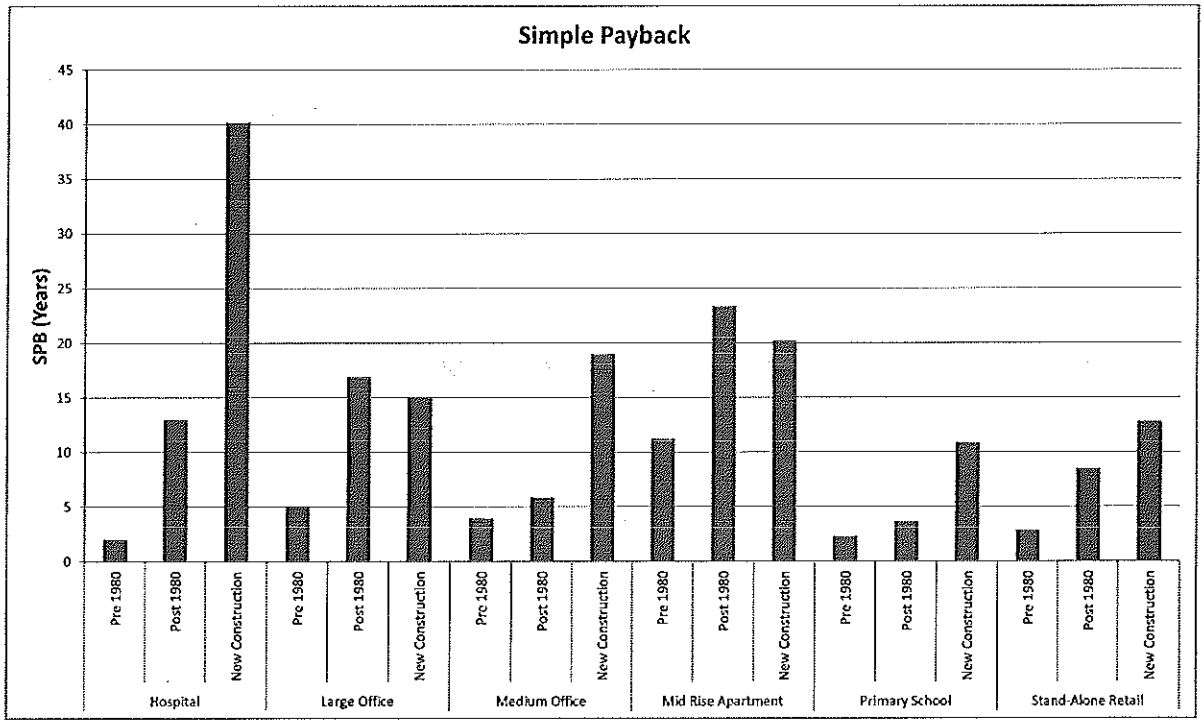

Energy Savings (per kSF Roof Area)
Energy Savings (kBtu/kSF)
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
Pre 1980
Post 1980
New Construction
Hospital
Large Office
Medium Office
Mid Rise Apartment
Primary School
Stand-Alone Retail
Average of Elec Savings (kBtu/kSF)
Average of Gas Savings (kBtu/kSF)
Average of Energy Savings (kBtu/kSF)

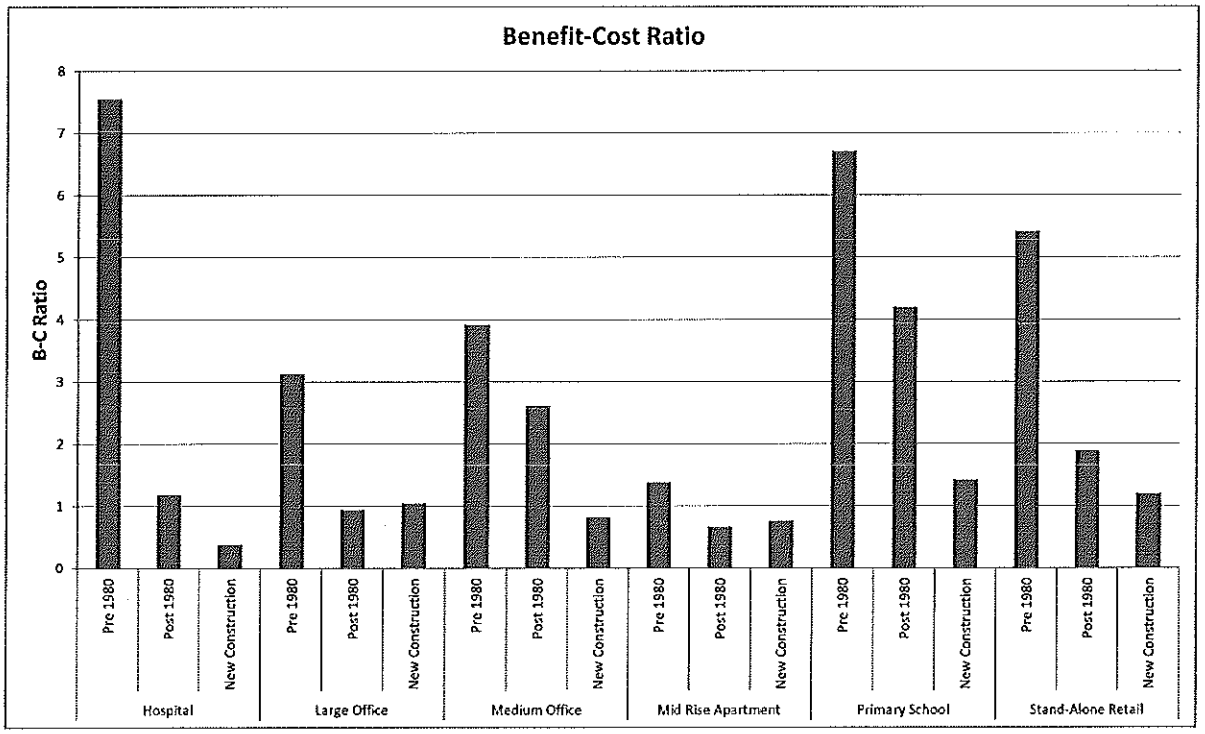
Measure CR-3


CO_2 Emissions Reduction (per kSF Roof Area)
CO_2 Reduction (lb/kSF)
700
600
500
400
300
200
100
0
Pre 1980
Post 1980
New Construction
Hospital
Large Office
Medium Office
Mid Rise Apartment
Primary School
Stand-Alone Retail

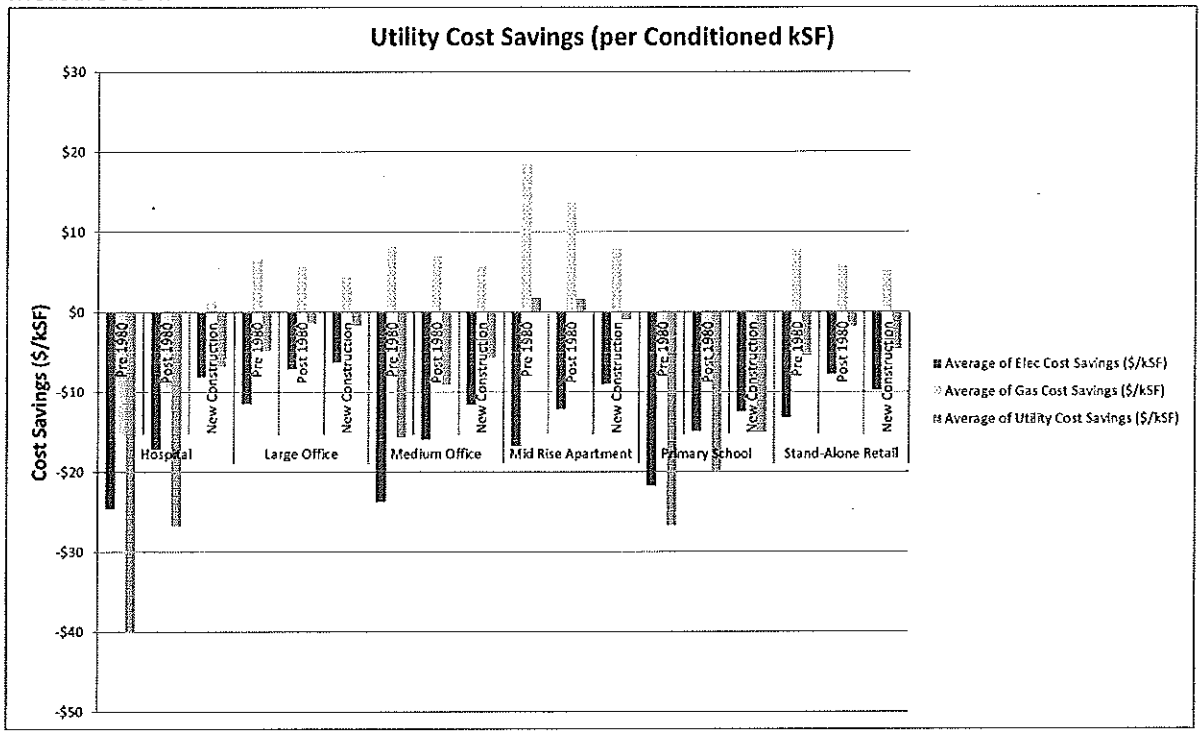

Emissions Reduction (per kSF Roof Area)
Emissions Reduction (lb/kSF)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Pre 1980
Post 1980
New Construction
Hospital
Large Office
Medium Office
Mid Rise Apartment
Primary School
Stand-Alone Retail
Average of NOx Savings (lb/kSF)
Average of SOx Savings (lb/kSF)

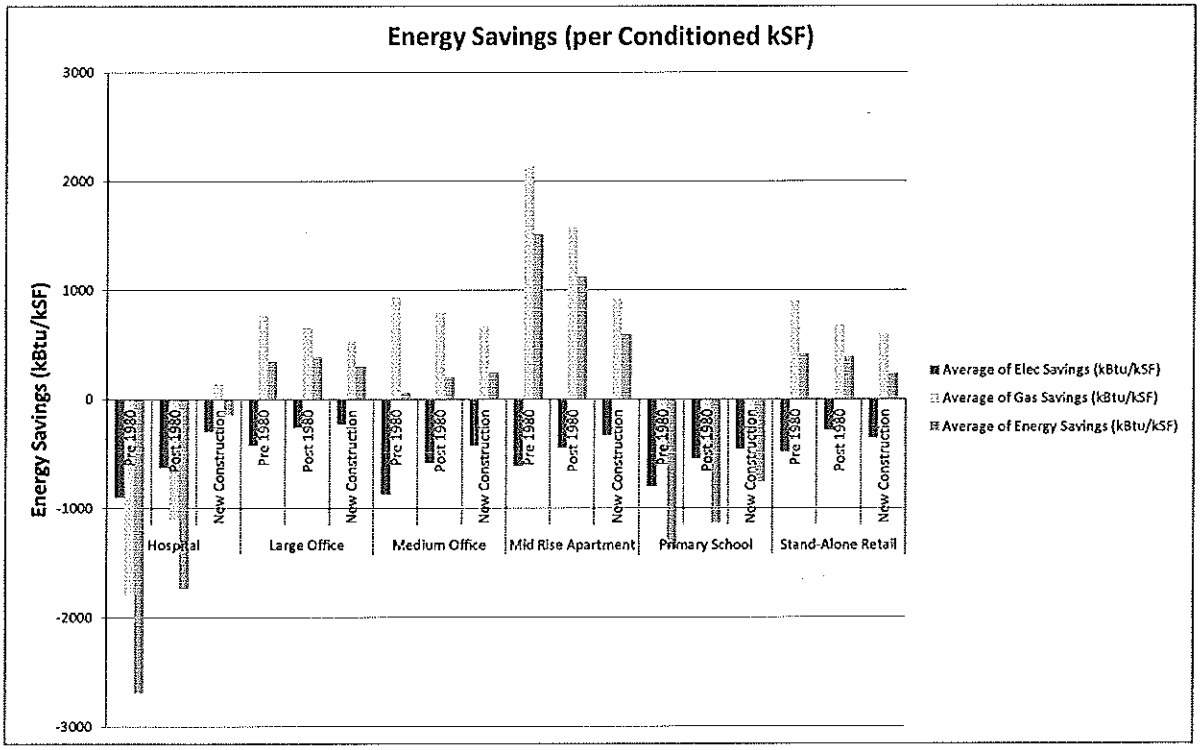
Measure CR-3


Simple Payback
SPB (Years)
45
40
35
30
25
20
15
10
5
0
Pre 1980
Post 1980
New Construction
Hospital
Large Office
Medium Office
Mid Rise Apartment
Primary School
Stand-Alone Retail

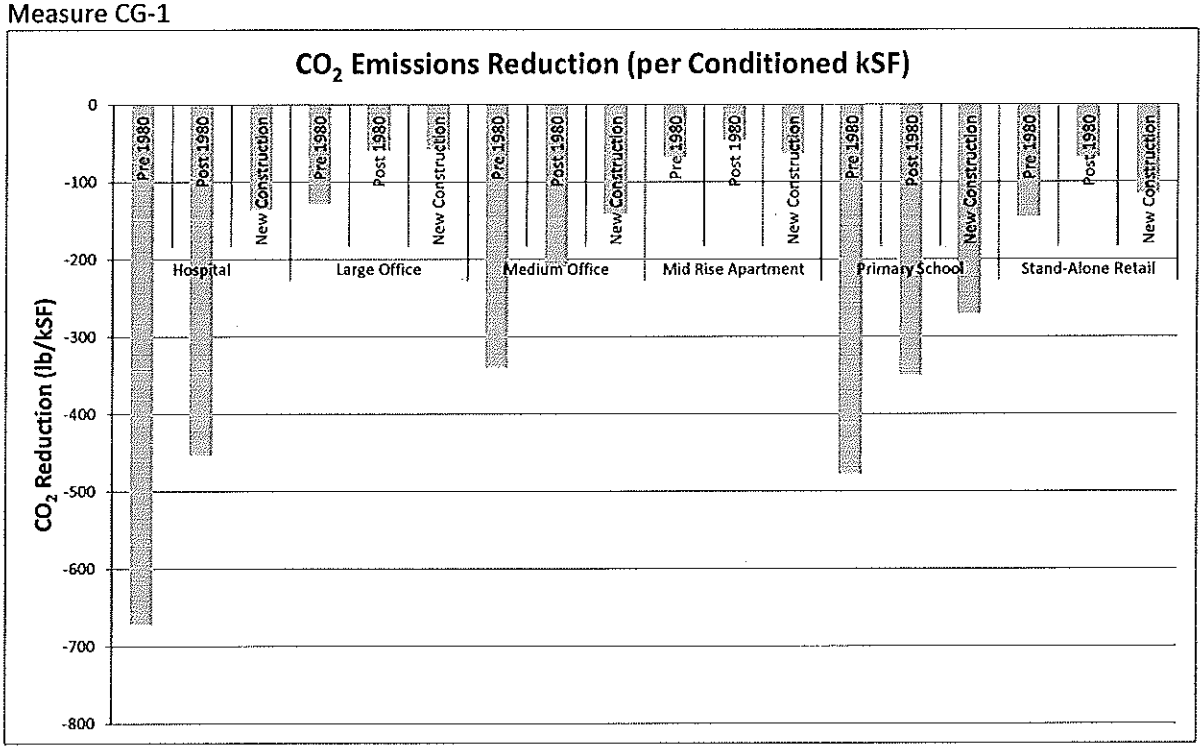

Benefit-Cost Ratio
B-C Ratio
8
7
6
5
4
3
2
1
0
Pre 1980
Post 1980
New Construction
Hospital
Large Office
Medium Office
Mid Rise Apartment
Primary School
Stand-Alone Retail

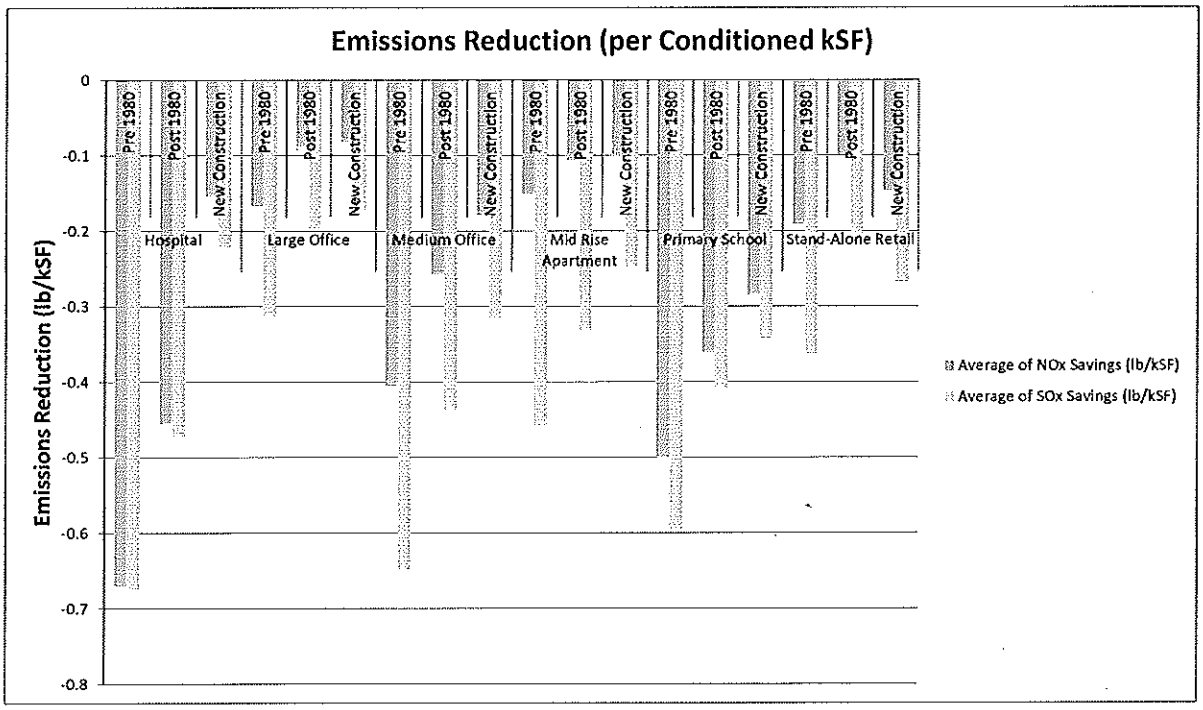
Measure CG-1


Utility Cost Savings (per Conditioned kSF)
Cost Savings ($/kSF)
$30
$20
$10
$0
-$10
-$20
-$30
-$40
-$50
Pre 1980
Post 1980
New Construction
Hospital
Large Office
Medium Office
Mid Rise Apartment
Primary School
Stand-Alone Retail
Average of Elec Cost Savings ($/kSF)
Average of Gas Cost Savings ($/kSF)
Average of Utility Cost Savings ($/kSF)

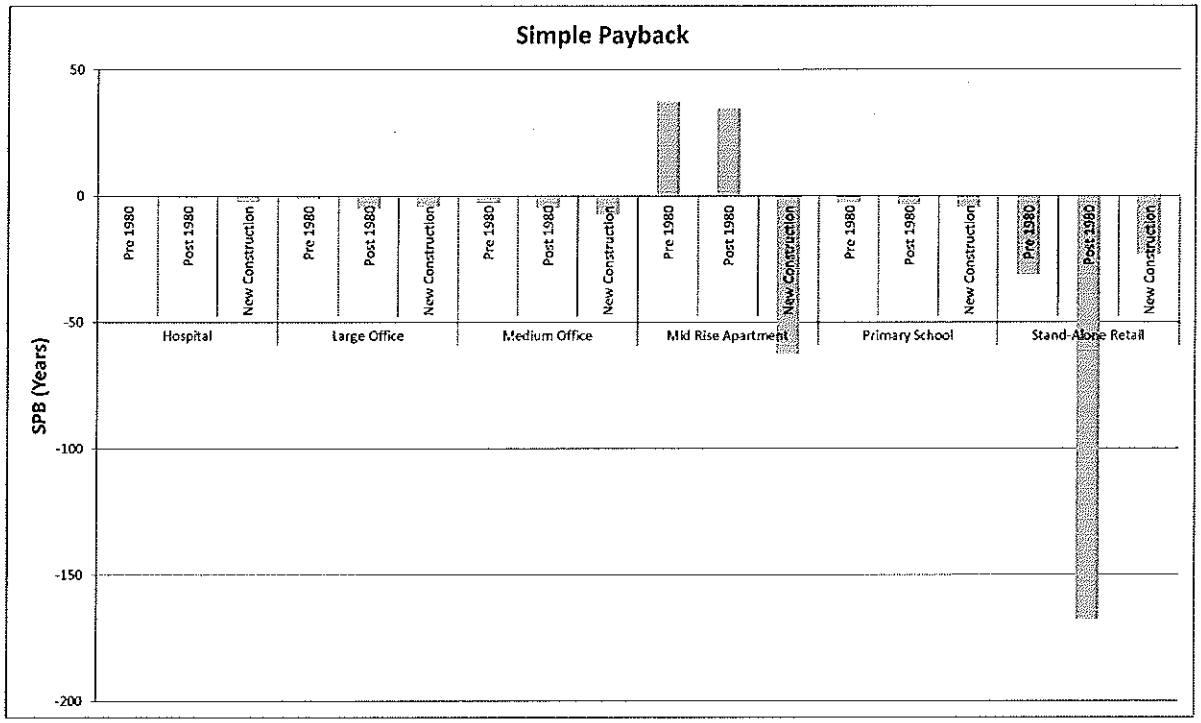

Energy Savings (per Conditioned kSF)
Energy Savings (kBtu/kSF)
3000
2000
1000
0
-1000
-2000
-3000
Pre 1980
Post 1980
New Construction
Hospital
Large Office
Medium Office
Mid Rise Apartment
Primary School
Stand-Alone Retail
Average of Elec Savings (kBtu/kSF)
Average of Gas Savings (kBtu/kSF)
Average of Energy Savings (kBtu/kSF)

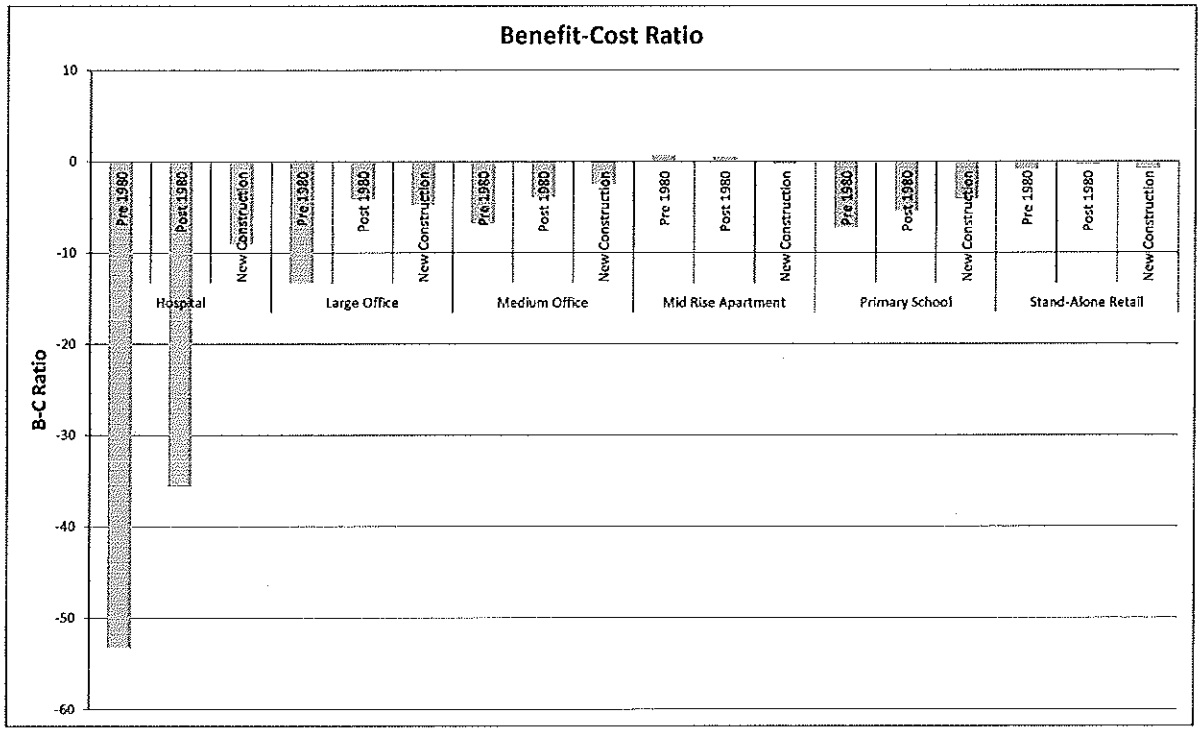
Measure CG-1


CO_2 Emissions Reduction (per Conditioned kSF)
CO_2 Reduction (lb/kSF)
0
-100
-200
-300
-400
-500
-600
-700
-800
Pre 1980
Post 1980
New Construction
Hospital
Large Office
Medium Office
Mid Rise Apartment
Primary School
Stand-Alone Retail

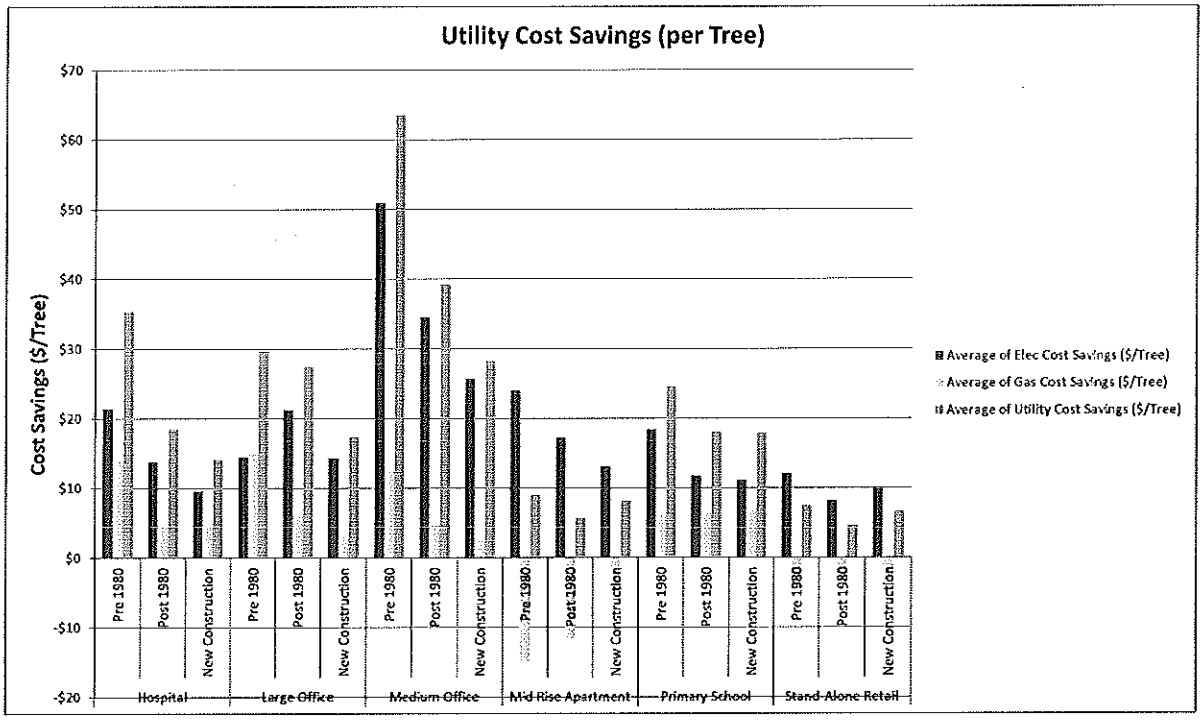

Emissions Reduction (per Conditioned kSF)
Emissions Reduction (lb/kSF)
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
Pre 1980
Post 1980
New Construction
Hospital
Large Office
Medium Office
Mid Rise Apartment
Primary School
Stand-Alone Retail
Average of NOx Savings (lb/kSF)
Average of SOx Savings (lb/kSF)

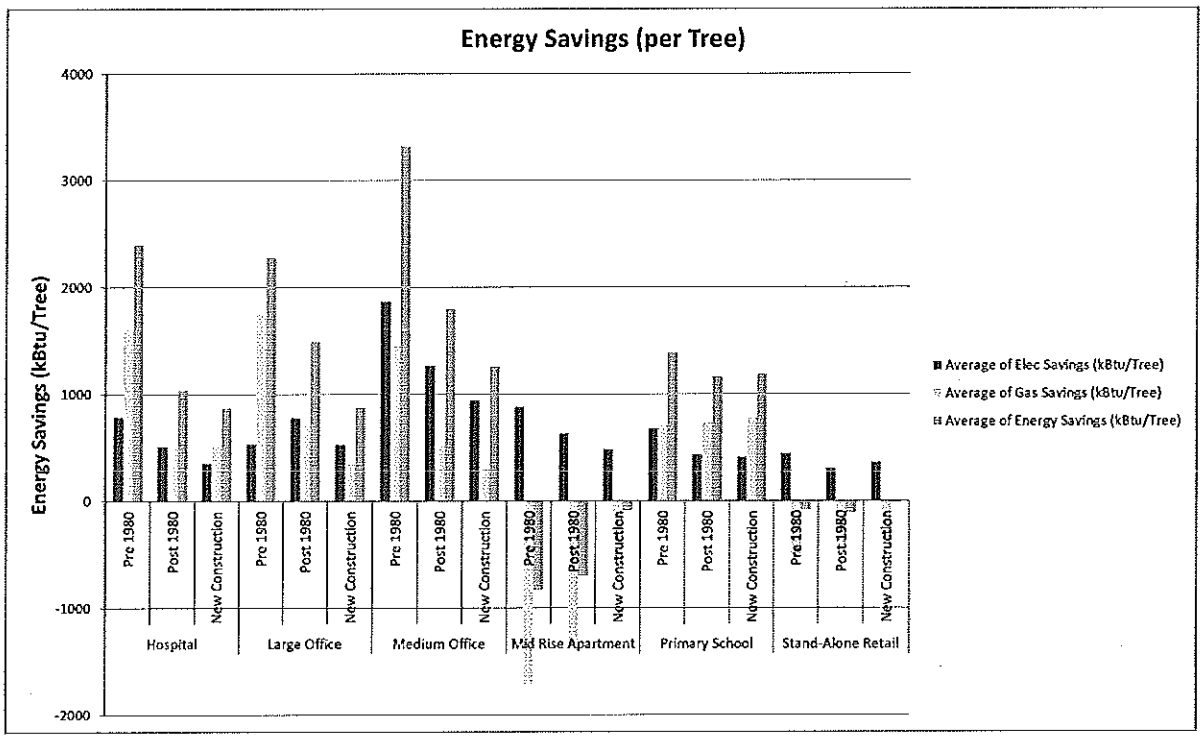
Measure CG-1


Simple Payback
SPB (Years)
50
0
-50
-100
-150
-200
Pre 1980
Post 1980
New Construction
Hospital
Large Office
Medium Office
Mid Rise Apartment
Primary School
Stand-Alone Retail

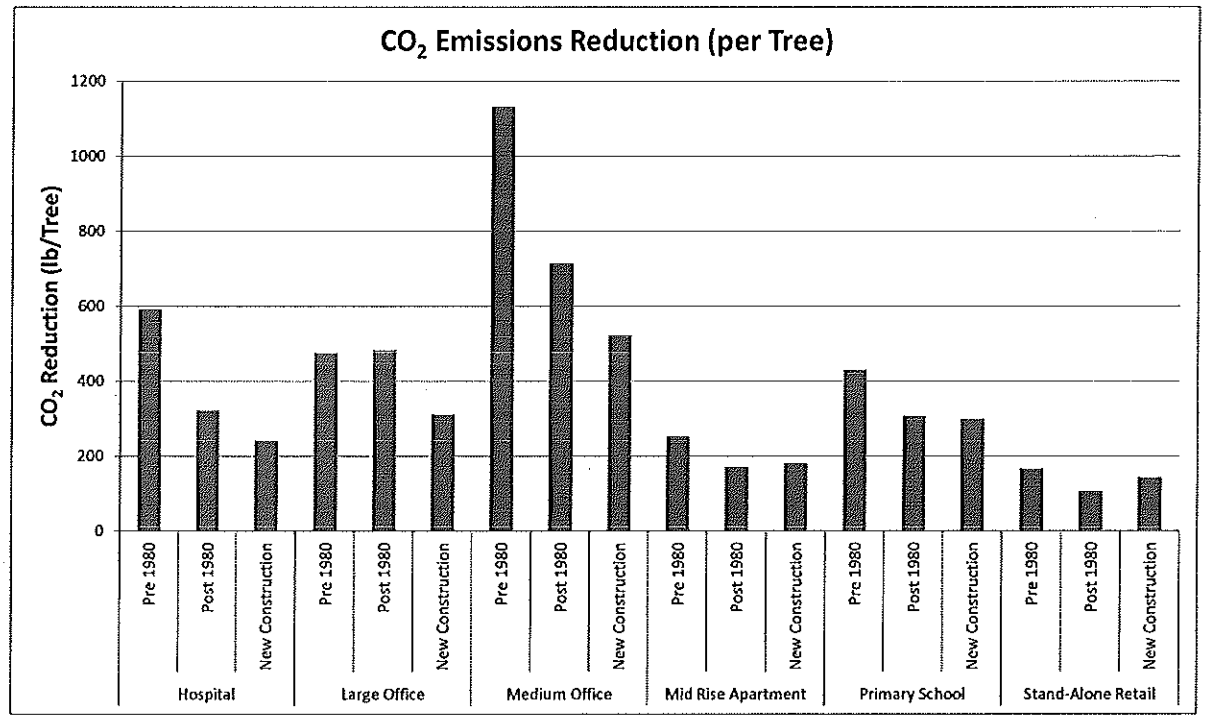

Benefit-Cost Ratio
B-C Ratio
10
0
-10
-20
-30
-40
-50
-60
Pre 1980
Post 1980
New Construction
Hospital
Large Office
Medium Office
Mid Rise Apartment
Primary School
Stand-Alone Retail

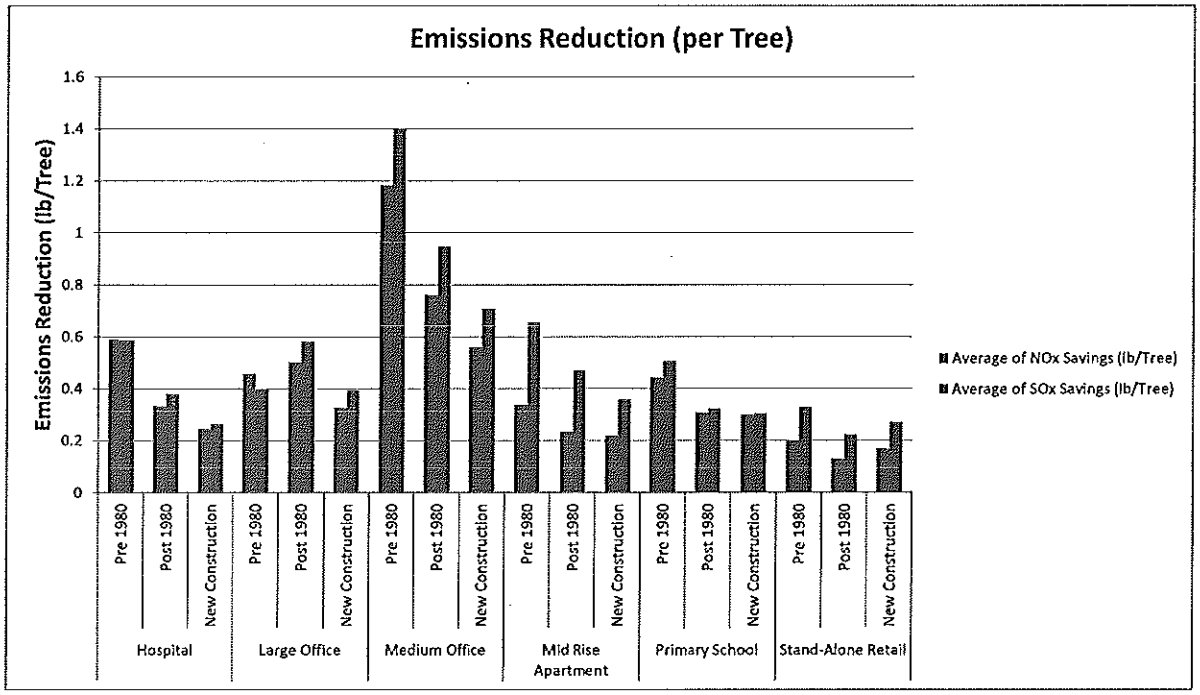
Measure CS-1


Utility Cost Savings (per Tree)
Cost Savings ($/Tree)
$70
$60
$50
$40
$30
$20
$10
$0
-$10
-$20
Pre 1980
Post 1980
New Construction
Hospital
Large Office
Medium Office
Mid Rise Apartment
Primary School
Stand-Alone Retail
Average of Elec Cost Savings ($/Tree)
Average of Gas Cost Savings ($/Tree)
Average of Utility Cost Savings ($/Tree)

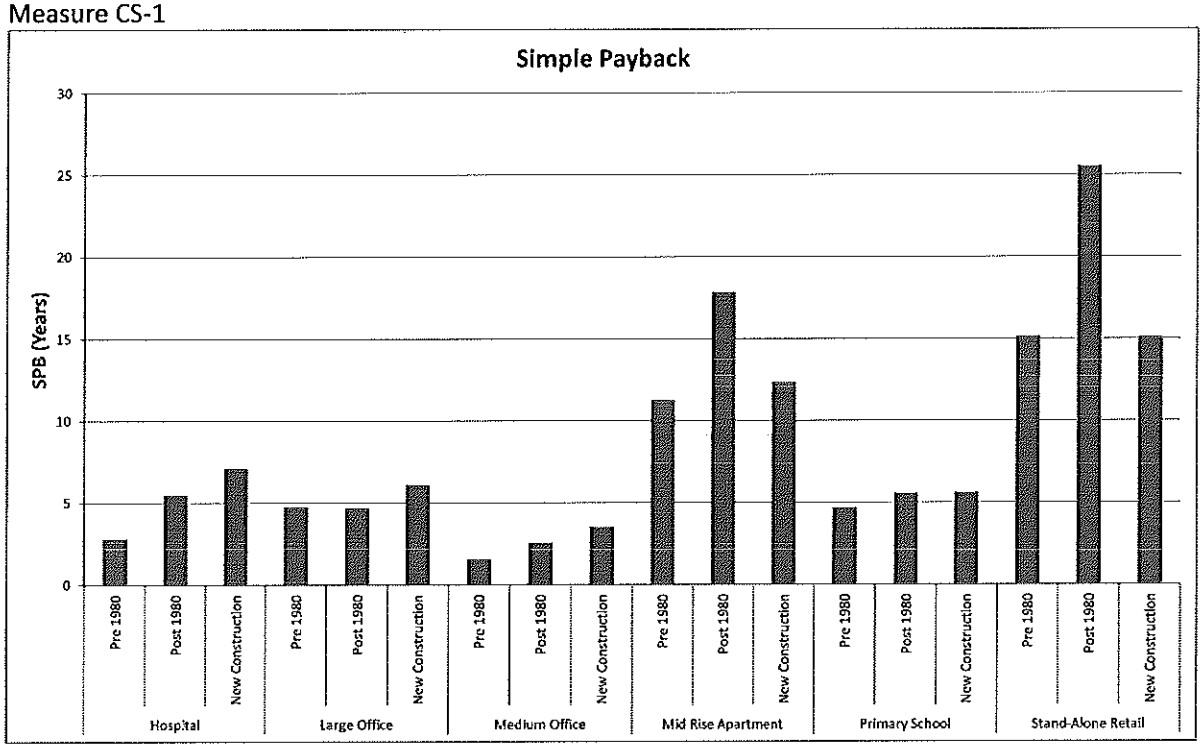

Energy Savings (per Tree)
Energy Savings (kBtu/Tree)
4000
3000
2000
1000
0
-1000
-2000
Pre 1980
Post 1980
New Construction
Hospital
Large Office
Medium Office
Mid Rise Apartment
Primary School
Stand-Alone Retail
Average of Elec Savings (kBtu/Tree)
Average of Gas Savings (kBtu/Tree)
Average of Energy Savings (kBtu/Tree)

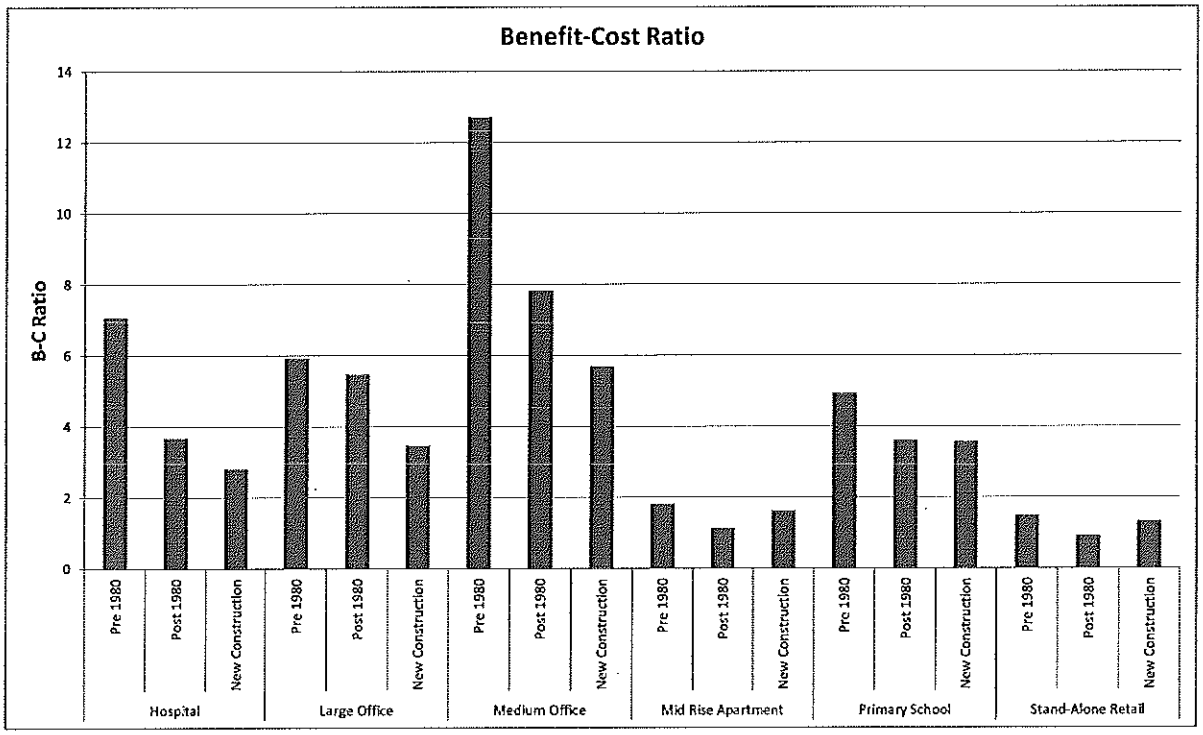
Measure CS-1


CO_2 Emissions Reduction (per Tree)
CO_2 Reduction (lb/Tree)
1200
1000
800
600
400
200
0
Pre 1980
Post 1980
New Construction
Hospital
Large Office
Medium Office
Mid Rise Apartment
Primary School
Stand-Alone Retail

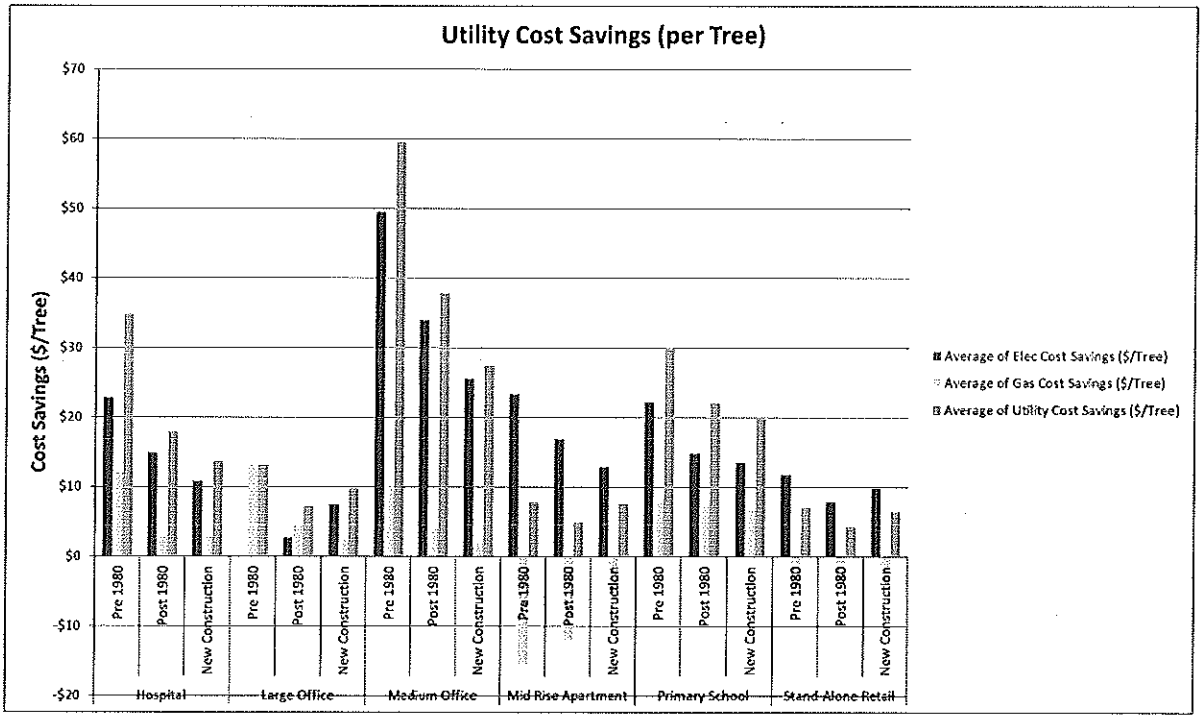

Emissions Reduction (per Tree)
Emissions Reduction (lb/Tree)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Pre 1980
Post 1980
New Construction
Hospital
Large Office
Medium Office
Mid Rise Apartment
Primary School
Stand-Alone Retail
Average of NOx Savings (lb/Tree)
Average of SOx Savings (lb/Tree)

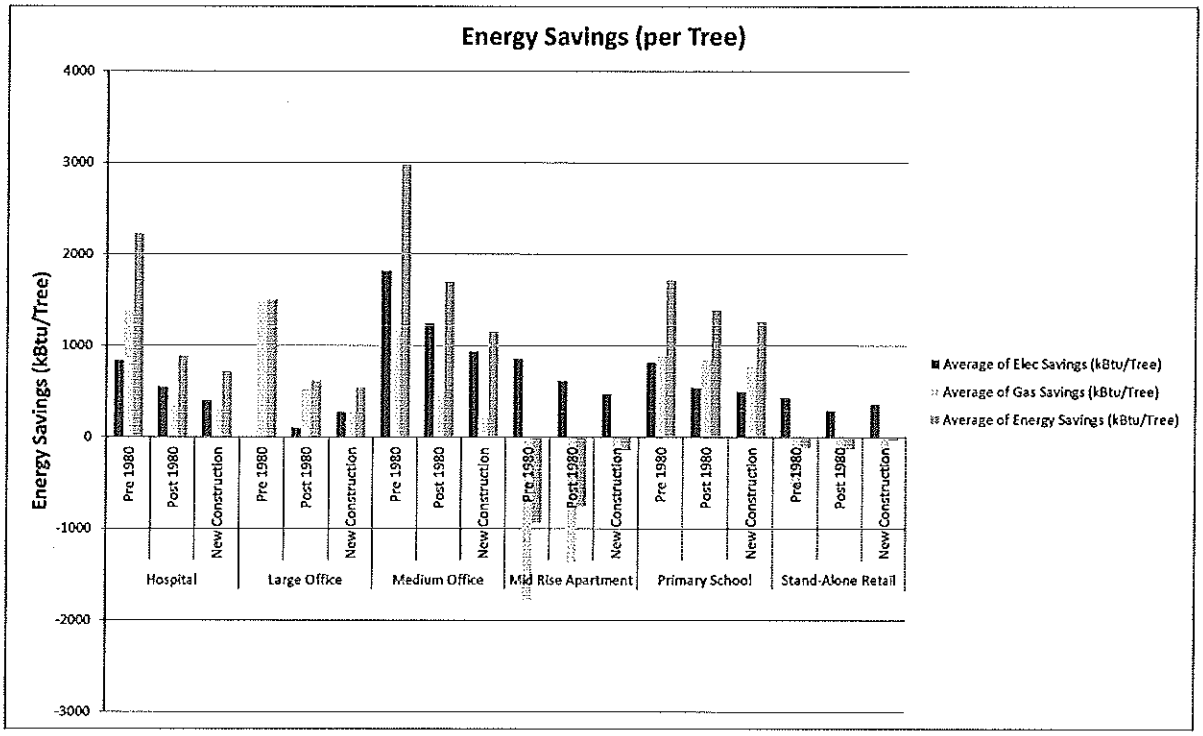
Measure CS-1


Simple Payback
SPB (Years)
30
25
20
15
10
5
0
Pre 1980
Post 1980
New Construction
Hospital
Large Office
Medium Office
Mid Rise Apartment
Primary School
Stand-Alone Retail

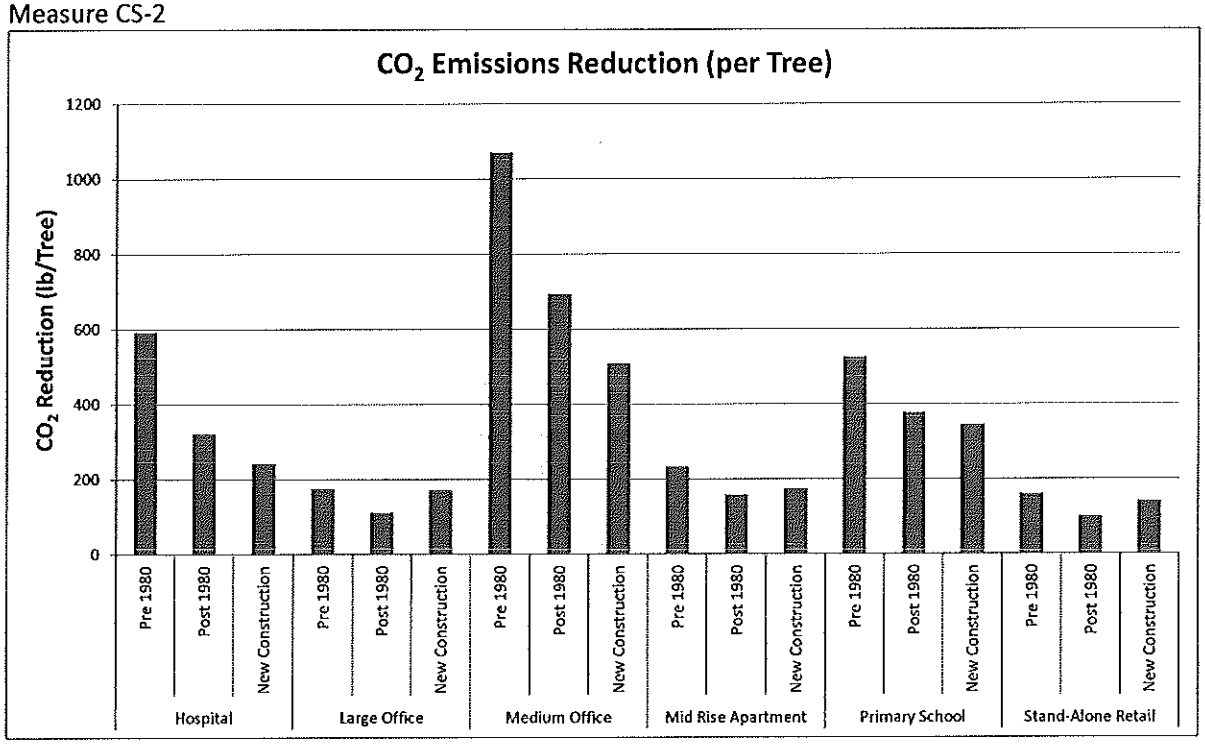

Benefit-Cost Ratio
B-C Ratio
14
12
10
8
6
4
2
0
Pre 1980
Post 1980
New Construction
Hospital
Large Office
Medium Office
Mid Rise Apartment
Primary School
Stand-Alone Retail

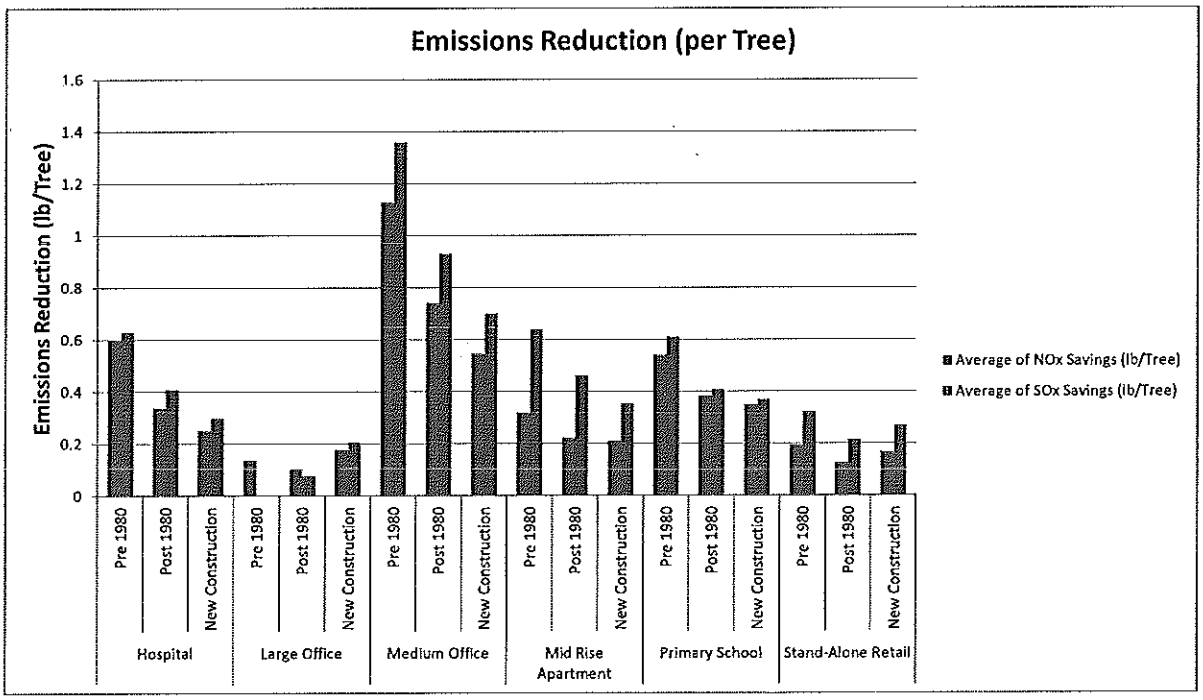
Measure CS-2


Utility Cost Savings (per Tree)
Cost Savings ($/Tree)
$70
$60
$50
$40
$30
$20
$10
$0
-$10
-$20
Pre 1980
Post 1980
New Construction
Hospital
Large Office
Medium Office
Mid Rise Apartment
Primary School
Stand-Alone Retail
Average of Elec Cost Savings ($/Tree)
Average of Gas Cost Savings ($/Tree)
Average of Utility Cost Savings ($/Tree)


Energy Savings (per Tree)
Energy Savings (kBtu/Tree)
4000
3000
2000
1000
0
-1000
-2000
-3000
Pre 1980
Post 1980
New Construction
Hospital
Large Office
Medium Office
Mid Rise Apartment
Primary School
Stand-Alone Retail
Average of Elec Savings (kBtu/Tree)
Average of Gas Savings (kBtu/Tree)
Average of Energy Savings (kBtu/Tree)

Measure CS-2


CO_2 Emissions Reduction (per Tree)
CO_2 Reduction (lb/Tree)
1200
1000
800
600
400
200
0
Pre 1980
Post 1980
New Construction
Hospital
Large Office
Medium Office
Mid Rise Apartment
Primary School
Stand-Alone Retail


Emissions Reduction (per Tree)
Emissions Reduction (lb/Tree)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Pre 1980
Post 1980
New Construction
Hospital
Large Office
Medium Office
Mid Rise Apartment
Primary School
Stand-Alone Retail
Average of NOx Savings (lb/Tree)
Average of SOx Savings (lb/Tree)