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Strategies for Financing Efficiency in District Energy Systems

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Executive Summary

End users do not understand energy efficiency strategies for district energy systems as well as they for as well as they do for electricity. Utility commissions and other organizations have successfully educated many end users and the general public about the value of the "negawatt." There has not, however, been a similar effort to educate district energy users about energy efficiency. Frequently, end users do not know what technologies might be available, how to deploy them if they knew about them, or how to pay for them.

Cleveland State University surveyed end users for a downtown Cleveland, Ohio district energy system to ascertain their level of knowledge of and interest in adopting energy efficiency programs. The survey was distributed to 39 customers, with 16 responses received. Questions sought to gauge interest in energy efficiency programs, demand side management, demand response programs, energy mix and strategies for paying for efficiency. Interviews with some of responds further clarified the need for education.

The survey provided some useful insights for development of energy efficiency in thermal systems. The most important take away is that while over half of end users understand basic energy efficiency technologies, they do not have a good sense of how valuable they could be, nor what strategies might be available to pay for them. Further, while respondents expressed an interest in undertaking efficiency upgrades to improve their carbon emission footprint, their appetites for this wane considerably when it means increasing payouts beyond 3-5 years. The most popular strategies for energy efficiency were temperature controls, capture and use of residual heat, steam traps, building envelope improvements and energy audits. Onsite heat pumps were among the least popular strategies, most likely reflecting a general lack of knowledge about this technology. The preferred strategy to pay for efficiency programs was split between self-financed (37.5%), energy service company contracts (37.5%), and tariffs (25%).

Related programs, such as demand side management, demand response and microgrids, generated little enthusiasm. This is very likely because they are poorly understood. Most respondents did not think they could reduce load during periods of peak system usage. Further, while respondents did not oppose participation in demand response programs, they had little interest in them, except when explained during the follow up interviews. The same was true for participation in a microgrid, where respondents indicated significantly more interest than in the survey after hearing an explanation of how they will work.

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Table of Contents

1.0 Introduction/Background.

1.1 Efficiency Policy for District Energy Systems.

Energy efficiency for the electrical grid has, for a number of years, been addressed by policy makers and public utility commissions. The value of the "negawatt" is generally well understood economically, if not environmentally, at least by end users in commercial settings. Ohio, for instance, passed an energy efficiency portfolio standard in 2008 that encouraged significant "behind the meter" efficiency investments by end users (i.e. at the site of the end user). This led to a significant push by the Ohio Manufacturer's Association and others to educate end users as to the value of behind the meter energy efficiency measures. That in turn led to a lengthy campaign by Ohio utilities, led by FirstEnergy, to initially freeze (2014), and eventually overturn (2019)[2] the mandates. Ohio's utilities apparently did not believe in "Jevon's Paradox" – the notion that energy efficiency measures inevitably lead to more consumption by end users, not less.[3]

But there are no similar understandings by policy makers or end users in Ohio about the value of efficiency for thermal systems, and there have been no similar mandates put into effect to encourage efficiency measures in those systems. This is due principally to the fact that thermal systems are normally not part of a regulated grid in Ohio, where energy efficiency upgrade costs can be readily socialized to ratepayers. Instead, most district energy systems are contract-based and operate in a competitive market, making it easier for the customers to seek and the operator to provide customer-specific efficiency upgrades. As a result, there has been no push in the Ohio General Assembly or at the Ohio Public Utility Commission to understand whether efficiency measures might be valuable in district energy systems, or how they can be implemented if they are. Accordingly, this study has been undertaken to examine the efficacy of strategies to implement district energy efficiency. For the most part, there are thermal system behind the meter counterparts for nearly all the behind the meter electric grid efficiency measures.

1.2 Defining District Energy Systems.

District Energy Systems are described by the utilization of community energy sources to provide energy services to multiple end users. Such a system can be used to replace individual building-based furnaces, boilers, chillers and air conditioner. District Energy Systems are characterized by one or more central plants producing hot water, steam, or chilled water, which then flows through a network of pipes to nearby buildings.[4] There are three major components to a district energy system: (1) thermal energy

[2] The bill that eventually ended the energy efficiency mandates in Ohio was the now infamous Ohio HB 6, which turned out have been passed through a bribery and dark money scheme that FirstEnergy eventually pled guilty to. Before it was passed, the American Council for Energy Efficient Economy had identified over a billion of dollars in economic and health care savings from the actions taken to date under the mandate. *See, e.g.:* https://www.aceee.org/blog/2019/04/aceee-debunks-myths-behind-ohio-bill. HB 6 was never fully repealed, despite the corruption, and the efficiency mandates were never put back into place.

[3] Jevon's Paradox was originally identified by the economist William Jevon through his observation in 1865 that improvements in coal burning technologies served to drive down the price of steam, driving up its consumption, leading in turn to more consumption of coal. *See, e.g.* https://rethinkdisruption.com/rethinking-jevons-paradox/

[4] https://www.energy.gov/sites/default/files/2021/03/f83/District_Energy_Fact_Sheet.pdf

generating plant, (2) distribution piping and (3) building interconnections, including meters, valves and pumps.

About three quarters of U.S. district energy systems use natural gas as the fuel to supply a central plant to generate thermal energy. Coal provides around 16% of the fuel, and the rest are run by fuel oil, renewables, biomass, biogas, geothermal, solar thermal and electricity. District Energy Systems tend to be highly resilient and are frequently used with mission-critical facilities for this reason. They also offer considerable promise to enable resilient and cost effective microgrids. There are around 660 district energy systems in operation in the United States.[5]

There are likely many more than 660 systems, depending upon how you define district energy. In the sense that is being used in this research, district energy is defined as a thermal system that supports multiple buildings. There are two models for deployment of district energy in the United States: single customer, multiple building campus energy (behind the meter) and multi-customer utility (in front of the meter -- also sometimes referred to as "downtown" or "utility" district energy systems). By far the most common form of district energy in the United States is the single customer, campus energy system.[6] Such systems are far easier to manage and generally do not require public utility commission oversight. Multi-customer, in front of the meter systems are more common in Europe and Asia, where densely populated cities make thermal distribution more attractive, both for financial and spatial reasons.[7] The need for efficiency in district energy in Europe has taken on new urgency in response to Russian aggression in Ukraine. Currently 73% of heating in Europe comes from fossil fuels, most of which is supplied by Russia. This will need to be curtailed significantly in the coming months, leading to a likely infusion of money into energy efficiency projects and the replacement of fossil fuels with heat pumps, biogas and renewable natural gas and other strategies.[8]

The United States is also likely to see a surge in interest in efficient operation of district energy, both for campus energy and for multi-customer systems. However, it will be more likely to be in response to efforts to decarbonize than in response to national security. Decarbonization will include a fuel switch for district energy companies from natural gas to natural gas/hydrogen blends. A significant movement toward a hydrogen economy is underway in the U.S., including an August 2022 bill recently signed into law (Inflation Reduction Act) that includes a clean hydrogen generation production tax credit.[9] But fuel switching will not happen quickly, and district energy companies can reduce carbon emissions now

[5] *Id.* This number is of course highly dependent upon how you define district energy.

[6] For a map of district energy systems in the United States*, see* https://www.districtenergy.org/resources/resources/system-maps. The International District Energy Association's 2015 map identifies a variety of single customer, behind-the-meter systems, including those found at airport, university, government, industrial, and medical facilities. The most common district energy systems are those found at colleges and universities, which alone greatly outnumber the downtown/utility systems. *Id.*

[7] Around 60 million Europeans get their heat from district energy systems. *See,* S. Stefanini, "District Heating Roundtable: Policy across RED, EED and EPD," February 17, 2022, found at: https://energypost.eu/district-heating-roundtable-policy-across-red-eed-and-epbd-must-take-account-of-conditions-in-all-member-states/

[8] "District Heating is Necessary to Repower EU's Heating Sector," June 24, 2022, https://energypost.eu/district-heating-roundtable-policy-across-red-eed-and-epbd-must-take-account-of-conditions-in-all-member-states/

[9] *See, e.g.* G. Zorpette, "2022: The Year the Hydrogen Economy Was Launched," https://spectrum.ieee.org/hydrogen-economy-inflation-reduction-act, August 17, 2022. Production tax credits of up to $3.00/kg will be available for reduced carbon emission hydrogen generation. This could make clean hydrogen competitive as a blend with natural gas.

through energy efficiency. This, too, has been incentivized by the Inflation Reduction Act. Because system efficiency is the easiest near-term way to reduce natural gas demand, US district energy companies will be watching how their European counterparts respond to the Russian natural gas boycott.

This study is focused on the customer interest in energy efficiency for an in-front-of-the-meter district energy system in Cleveland, Ohio. Customers were surveyed generally to identify interest in energy efficiency, but more specifically to identify financing strategies and payout requirements. Customers were also surveyed to determine their interest in some related clean energy strategies, such as adopting microgrids, using hydrogen fuel mixes, and participating in demand response programs.

2.0 Energy Efficiency Survey of District Energy End Users.

2.1 Survey Strategy and Deployment.

Techno-economic energy efficiency strategies are fairly well understood for behind the meter applications on electric utility companies, where utility commissions and other organizations have sought to educate the public about its value. It is less well understood for district energy systems, however. This is especially so for district utilities that use distribution systems with multiple customers. Frequently, such end users do not know what technologies might be available, or how to deploy them if they knew about them.

To survey end user interest and knowledge about energy efficiency, the Study Team focused on one District Energy Utility – Cleveland Thermal – based in downtown Cleveland, Ohio. The Study Team surveyed 39 of Cleveland Thermal's customers, most attached to an underground steam distribution system, and some to a chilled water distribution system. Cleveland Thermal generates most of its thermal load at its plant on Hamilton Avenue in downtown Cleveland and distributes it to the community therefrom. Its tariff is subject to review and approval by the Public Utility Commission of Ohio. As is typical for electric utility billing strategy used in Ohio, Cleveland Thermal's tariff has two parts: (1) a generation (energy) cost, and (2) a distribution cost.

Unlike as commonly found for electricity tariffs, Cleveland Thermal does not deploy "demand" or "capacity" charges, which are frequently used by electric utilities. The goal of demand and capacity charges is for the utility to recoup the cost of standby generation or distribution.[10]

The goal of the survey was to better understand the state of end user practices for and interest in energy efficiency deployment in district energy systems. To better understand the knowledge, needs, and ideas of the average district energy customer, the Study Team developed a comprehensive survey to gather key information relating to decisions by end users to deploy energy efficiency. This survey was created with support from Cleveland Thermal, the district energy provider, and it covered topics such as demand, resiliency, cost, and strategies for paying for efficiency upgrades. The survey was distributed to 85 executives among a subset (39) of customers within Cleveland Thermal's district energy system. The Study Team felt that no financial incentive was necessary to generate responses, as is commonly done

[10] In the FirstEnergy electrical system common for Northeast Ohio, ratepayers pay a capacity charge based upon generation that is bid into the PJM Regional Transmission Organization auction for standby power and pay a demand charge for distribution line capacity the distribution company must have available for peak demand.

with surveys, since this topic was believed to be of considerable interest to most end users, thereby generating responses. A total of 16 responses were received. After the survey results were collected and analyzed, five customers agreed to be interviewed to better understand the responses. A copy of the survey is set forth below in Appendix A. Surveys took approximately 20-30 minutes to complete.

The survey questions were generally about demand, resiliency and strategies for how to pay for upgrades. They were set forth in the following categories:

- Background Information (3 Questions)
- Your Facility (3 Questions)
- Energy Demand Management (2 Questions)
- Efficiency (10 Questions)
- Management of District Energy (8 Questions)
- Energy Mix and Renewables (5 Questions)
- Microgrid Electricity Generation (5 Questions)

The questions were crafted to enable the Study Team to effectively analyze the information gathered, including some basic quantitative analysis. For example, the demand related questions first establish the respondent's familiarity with demand side management. Thereafter, the respondents' interest in the financial opportunities of demand side management was polled. Finally, the survey asked about the specific capabilities of the respondent's business to see if they would be able to participate in any demand response event. This general format was used elsewhere in the survey where the respondent's knowledge of the topic was polled: first establish knowledge, second establish level of interest, and third identify capabilities to participate in energy efficiency programs.

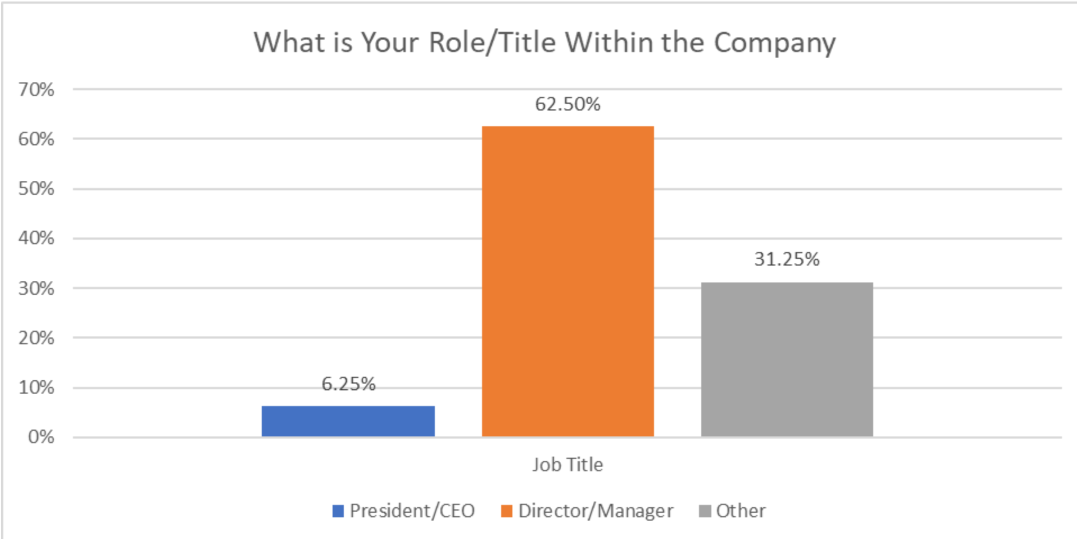
The survey was conducted on the Qualtrics platform, and it was disseminated by Cleveland Thermal on behalf of the Study Team to its end users. Cleveland Thermal also helped the Study Team follow up with its users to encourage them to complete the survey. These results were received from Qualtrics, assimilated, and then compiled into an excel spreadsheet.

2.2 Survey Results and Interpretation.

2.2.1 Background Information (Section 3 in Survey).

The Study Team was interested in understanding the respondent's position within his or her respective company. From these results we can see that half of the respondents identified themselves as operational managers. The rest were executive level decision makers, including Presidents or CEOs, or otherwise reported to management. These last titles included positions such as Commissioner of Property Management, counsel and agent.

Figure 1. Respondent's Role within Company

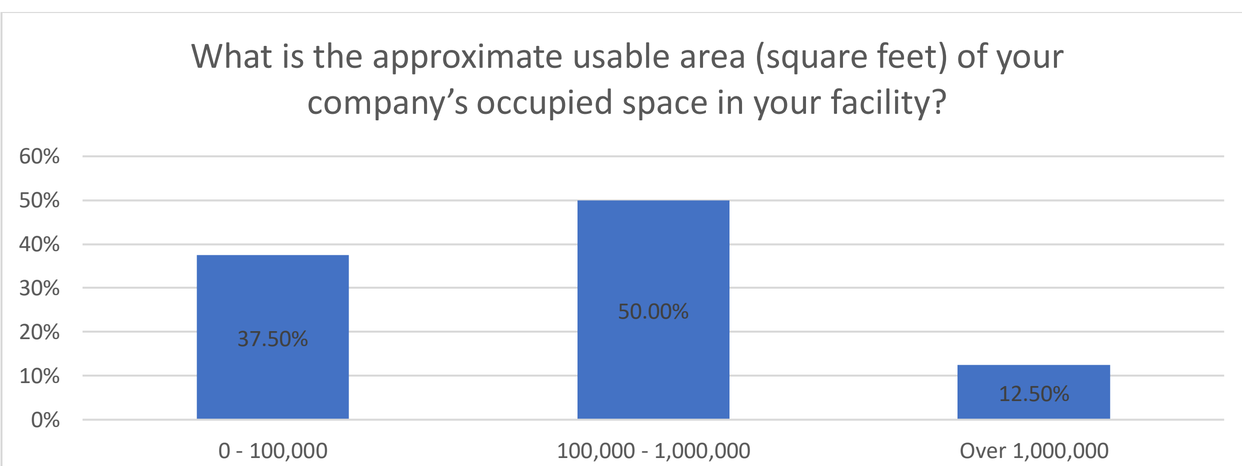


Next the survey asked the respondents to identify their role in energy purchasing decisions for the company. About 1/3 of respondents were the sole decision maker on energy procurement, and over half of the respondents indicated that they are part of a team that evaluated energy procurement. A few indicated that they supervise others that made recommendations to them.

2.2.2 Facility Description.

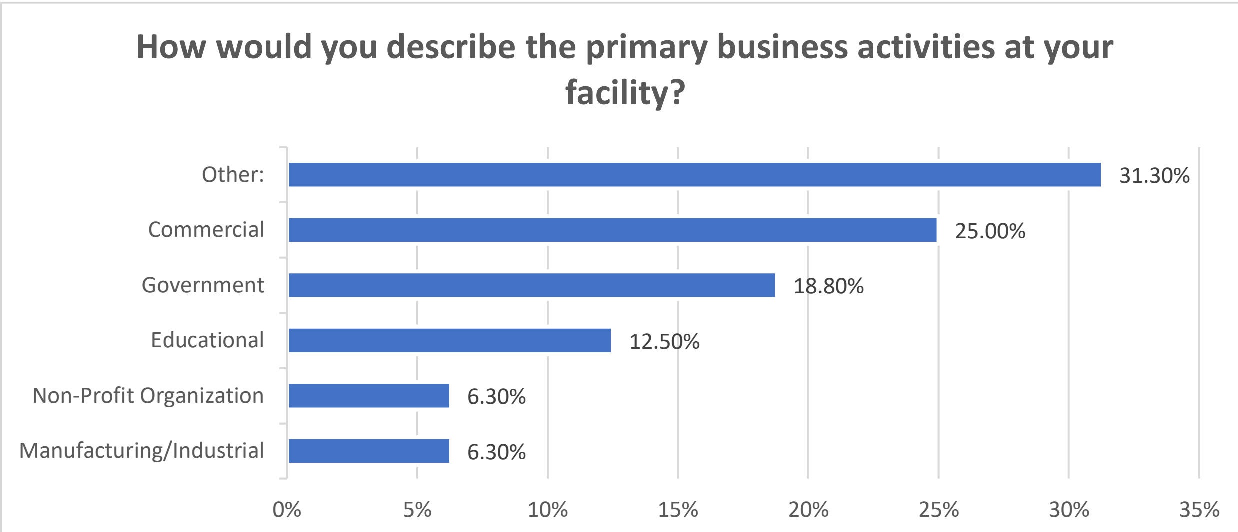
The next set of questions sought information about the facilities connected to Cleveland Thermal's system. The first question in this section looked to establish the average area served by the district utility for each respondent. Usable areas varied considerably, from as small as 4500 square feet to over 5,000,000 square feet (Cleveland State University). The mean respondent customer size of 830,000 square feet was skewed heavily by Cleveland State. The average size was 210,000 square feet. The respondent answers below are from a subset of Cleveland Thermal customers and do not necessarily reflect the views of all of its customers.

Figure 2. Size of Respondent's Facility



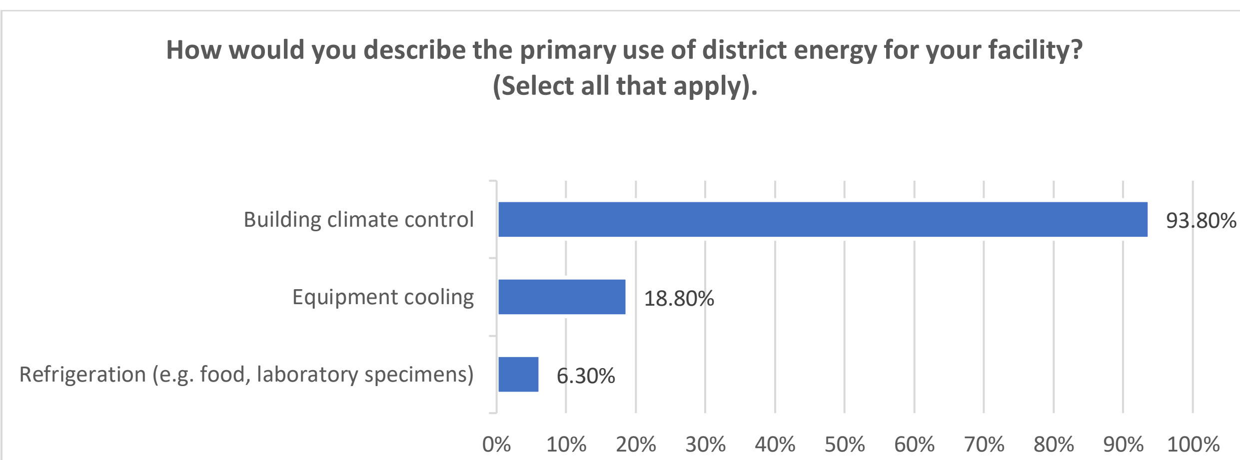
The survey next asked respondents to identify their primary business activity. Respondents indicated that their businesses included education, government, commercial and manufacturing. No respondents indicated they were in the business of healthcare.

Figure 3. Primary Business Activity



While the business of district energy users varied considerably, their purpose in using thermal energy did not. End users were encouraged to choose more than one primary use if they had more than one. Over 90% of users identified a principal use for thermal energy as building climate control. Other uses identified included equipment cooling (18%) and refrigeration (6%). No respondents identified manufacturing, laundry, turbine or other processes as the use for the thermal energy (these are all end uses supplied by Cleveland Thermal, but companies using thermal load for these purposes were either not part of the survey or did not respond).

Figure 4. Primary Use of Facility

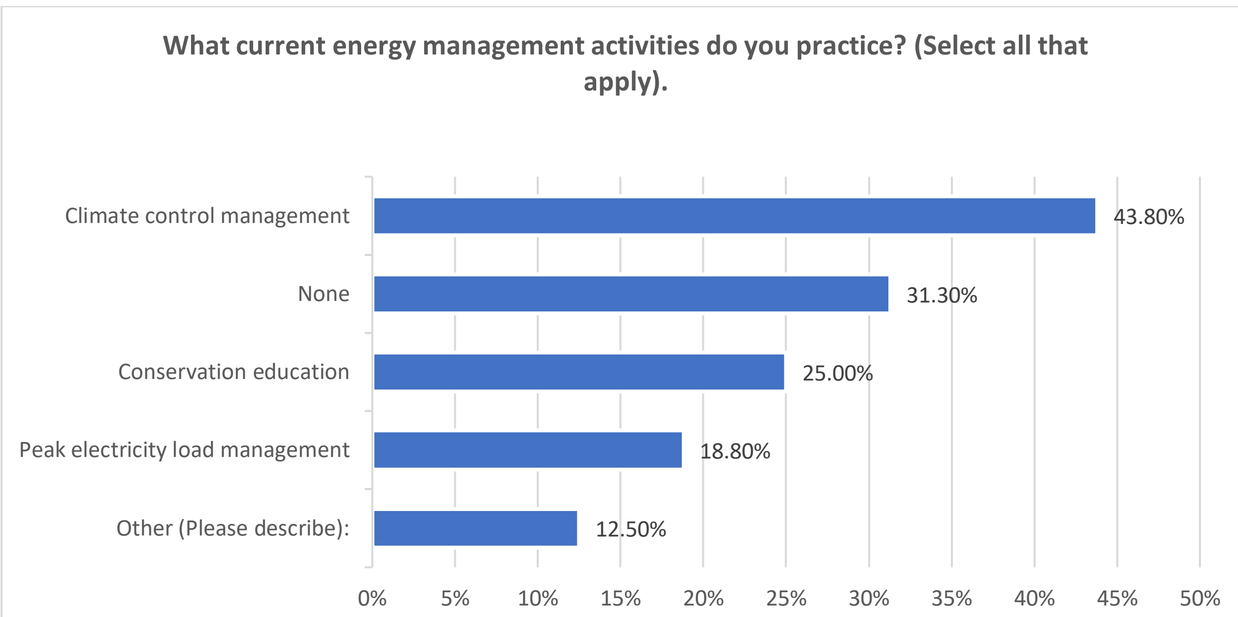


2.2.3. Energy Demand Management (Section 4 of survey).

The next group of questions sought to understand energy demand management practices among end users. The first question looked for insights as to existing management practices. Respondents were asked to choose from among a list of practices, allowing the respondent to choose more than one practice, or none at all. Climate control management was the most frequently selected strategy, with nearly 45% of respondents selecting this response. Conservation education (25%) was also selected. However, the second most popular response (31%) was no energy management practices at all.

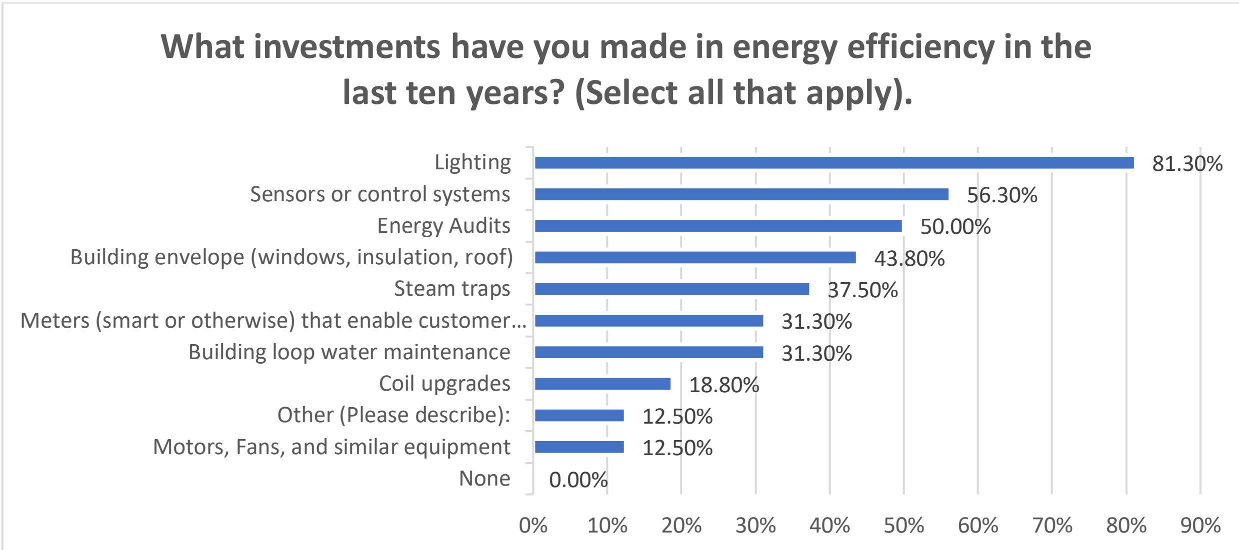
Around 18% of respondents indicated that they undertook peak load electricity management. This question was designed as a prelude to gauging interest in thermal system peak load management, which is the subject of later questions. Incentives for peak load management are not available under current tariff designs for thermal loads. However, they could be, if there was sufficient interest.

Figure 5. Current Energy Practices



A follow up question asked the respondents to select from a list of energy efficiency measures that they have undertaken in the past ten years. End users were encouraged to pick multiple answers. Lighting upgrades were the most popular response (over 80%), followed by control system upgrades (56%), energy audits (50%) and building envelope upgrades (43%). Respondents also identified investment in other areas, including steam traps, motors, coils and fans. Figure 6 below sets forth the responses.

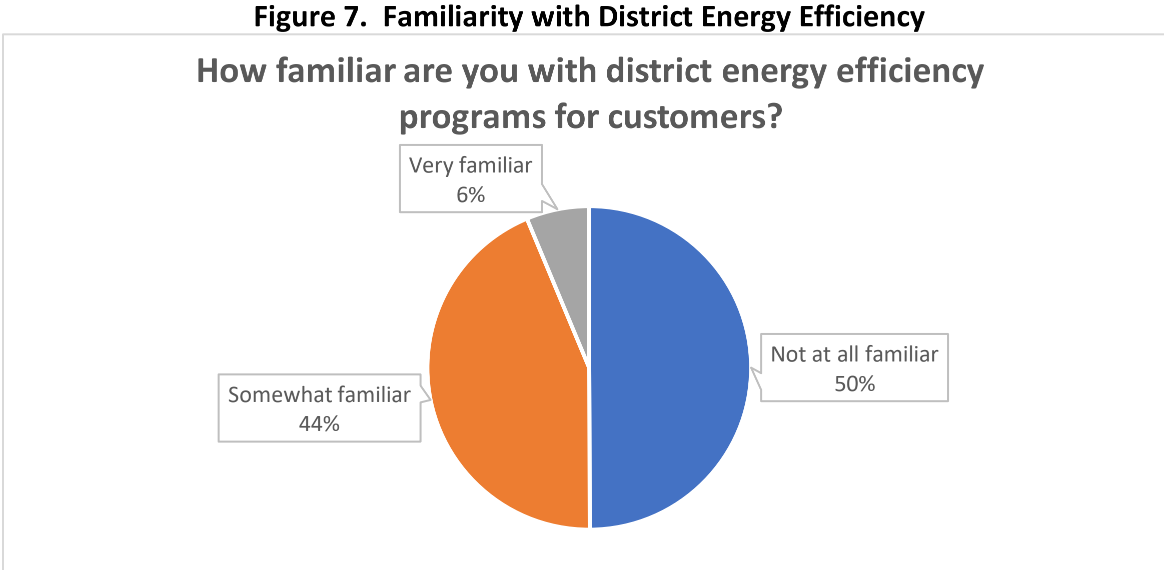
Figure 6. Types of Investment into Efficiency



2.2.4 Energy Efficiency (section 5).

Having examined the state of existing efficiency measures among CT customers, the survey next sought to establish interest in new measures, and how such measures can be financed. The first question seeks to establish customer familiarity with district energy improvements. The short answer is that while most customers generally understood energy efficiency measures could be valuable, there is ample room for educating customers about energy efficiency in thermal systems. Half the customers responded that they were "not at all familiar" with district energy efficiency, with the rest indicating they were "somewhat familiar" [percentage] or "very familiar" [percentage]. This survey was the first opportunity to begin an educational process for many of the respondents.

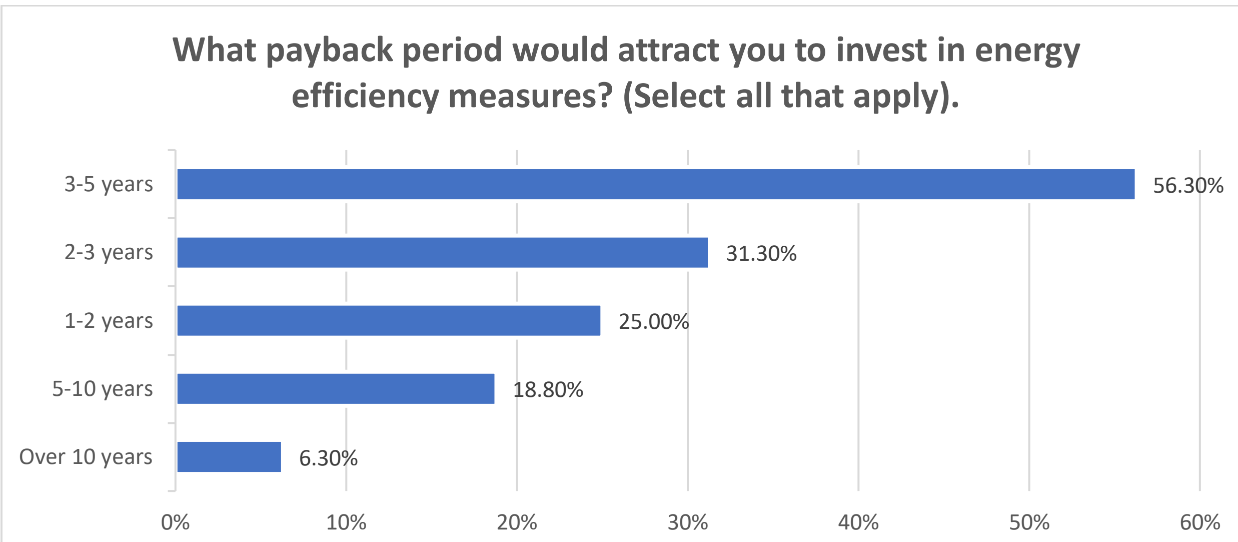
Figure 7. Familiarity with District Energy Efficiency



The next question attempted to discover the preferred payback period for investment into energy efficiency measures. Respondents were asked to identify all the payback periods they would be willing to consider.   Accordingly, we cannot cumulate the responses (i.e. we cannot assume that if they chose 3-5 years, we should add 1-2 and 2-3 years, since they would have also selected those separately).

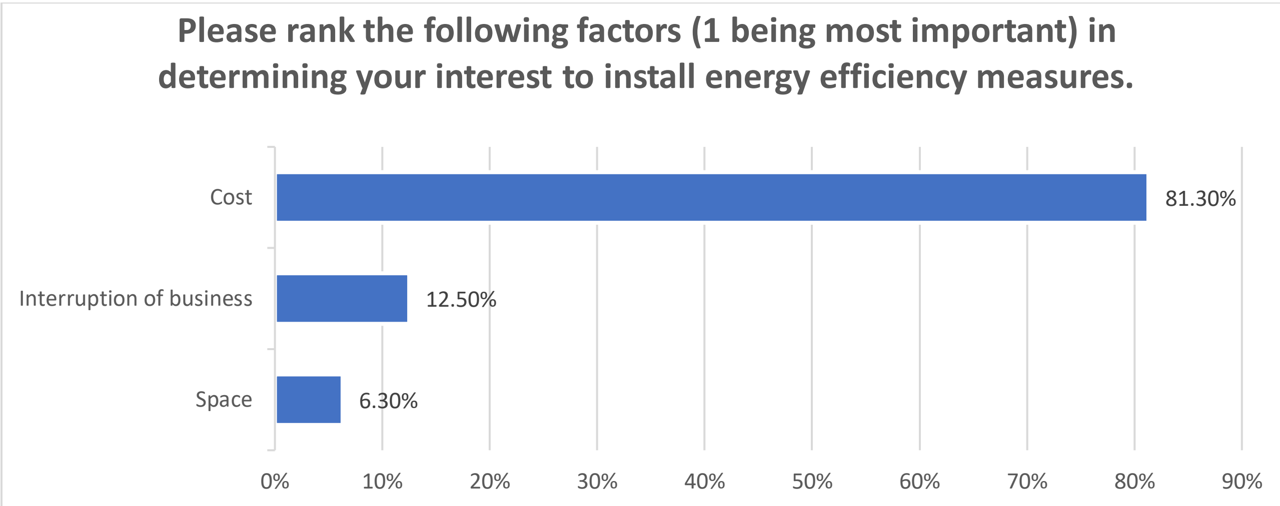
This was a key finding from the survey: the most common response from companies indicated that they expected payback in five years or less.   Even so, a significant number of respondents 25% were willing to tolerate paybacks of over five years.   This may be enough to drive energy efficiency improvement measures for district energy systems.   Further, rising natural gas prices are likely to lead to many efficiency measures to pay off more quickly than they have in the past.

Figure 8. Required Payback Periods for Efficiency Investments



Another important survey question looked for respondents to identify the relative importance of factors controlling implementation of energy efficiency measures. For this question, the respondents were asked to rank three factors from most important (1) to least important (3). It turns out that cost is far more important to respondents than space and business interruption.   Over 80% of respondents indicated that cost was the number 1 consideration, while none indicated cost was the number 3 consideration.   The bar graph below lists the results of the rankings for the most important factor.

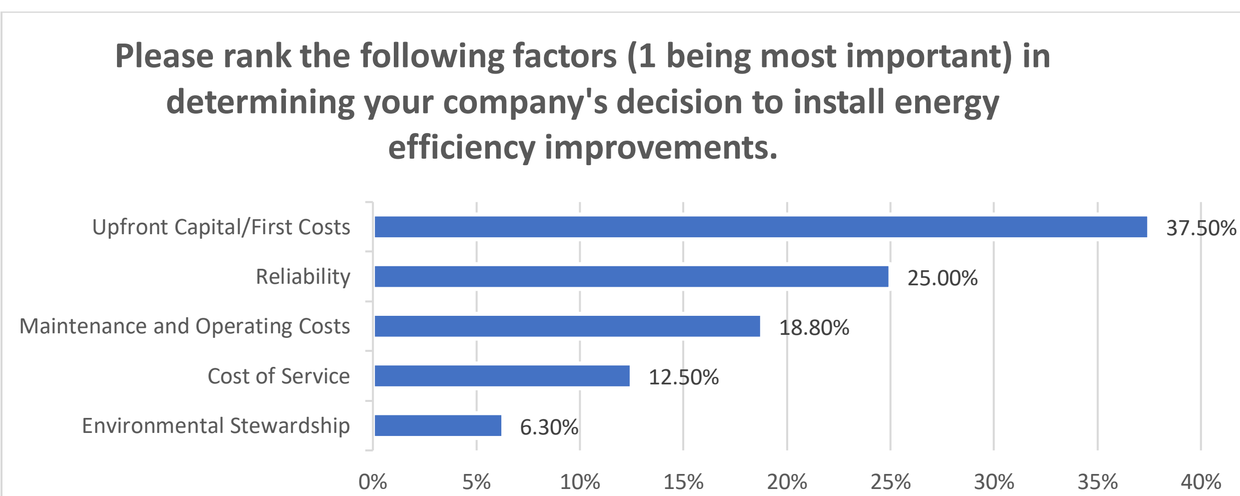
Figure 9. Factors Controlling Interest in Thermal System Efficiency Measures



The next question asked respondents to rank a series of specific factors that determined their company's prior decisions to install energy efficiency improvements. The results are set forth in Figure 10. From these results we can see that the most important consideration for end users is the upfront cost of improvements. After that, they rank reliability and maintenance/operating costs of the improvements as most important. All the available responses were chosen by at least one company as "most important" except for price variability. For that reason, it is not included in Figure 10 below, which sets forth the response percentages for "most important."

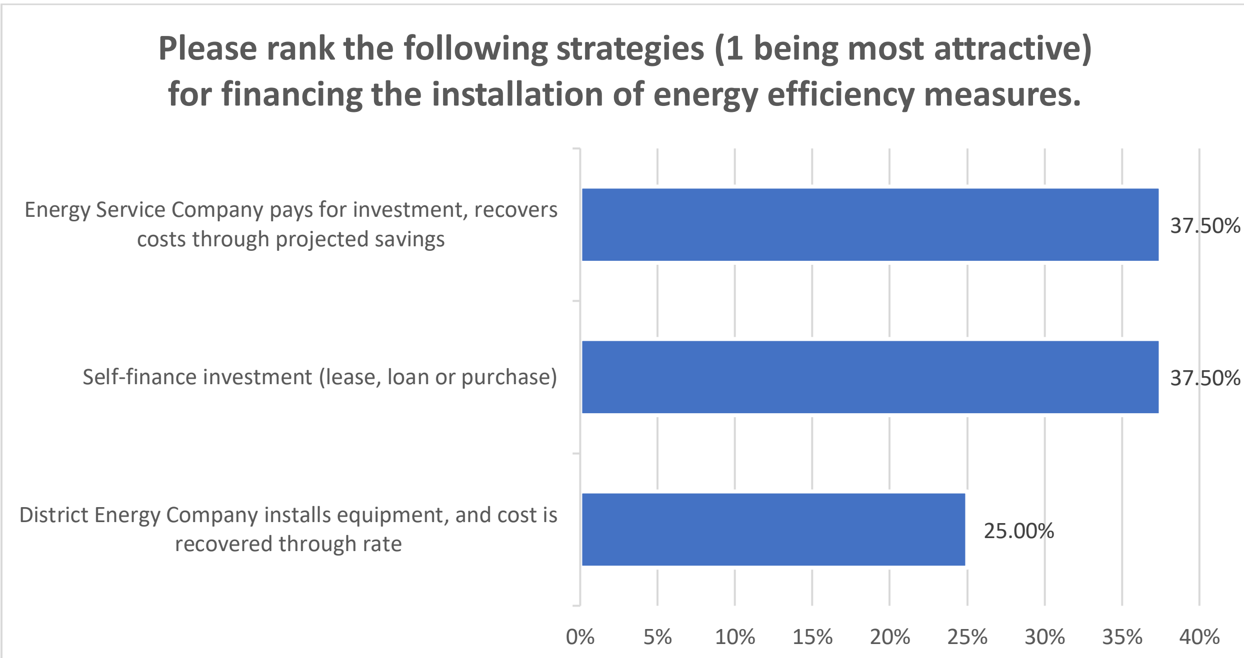
While price variability was not selected as most important by any respondent, for most companies, environmental stewardship was lowest among their priorities. This is also an unsurprising, but key, finding: environmental stewardship, alone, will not justify investment into efficiency for most companies and institutions. If society wants to encourage large scale investment into thermal system efficiency, it will require economic incentives to do so. Rising natural gas prices might be the first such incentive.

Figure 10. Considerations Determining Installations of Efficiency



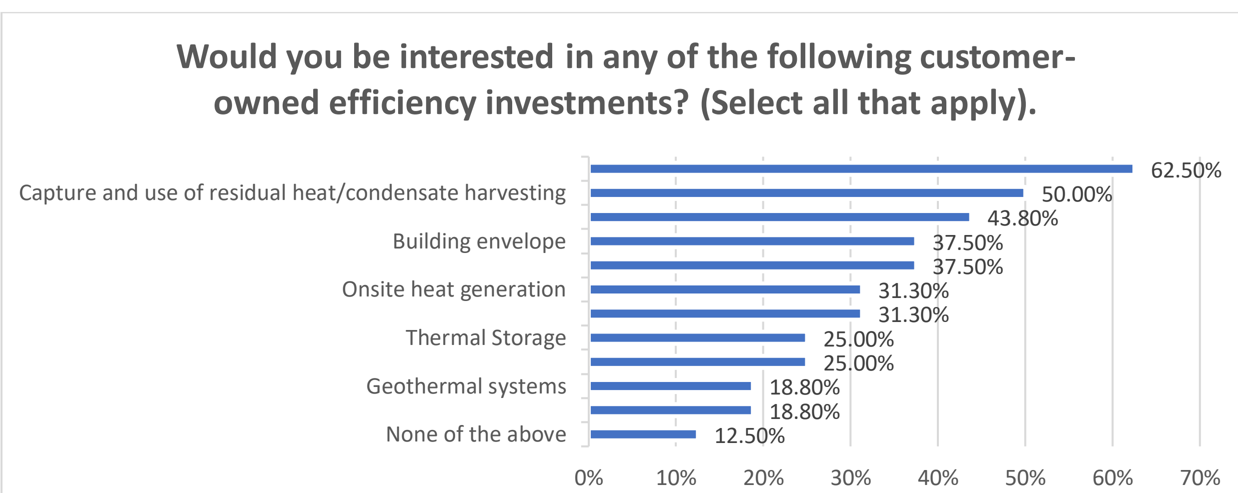
It is unsurprising that cost would rank very highly in respondents' considerations in investing in energy efficiency improvements. Accordingly, respondents were asked to identify their preferred financial strategies for investment, ranking them in order of preference. The results indicate that about one third preferred to self-finance their projects, one third preferred energy service contracts, and one third preferred to pay for the projects through their tariff.

Figure 11. Preference for Financing Strategies



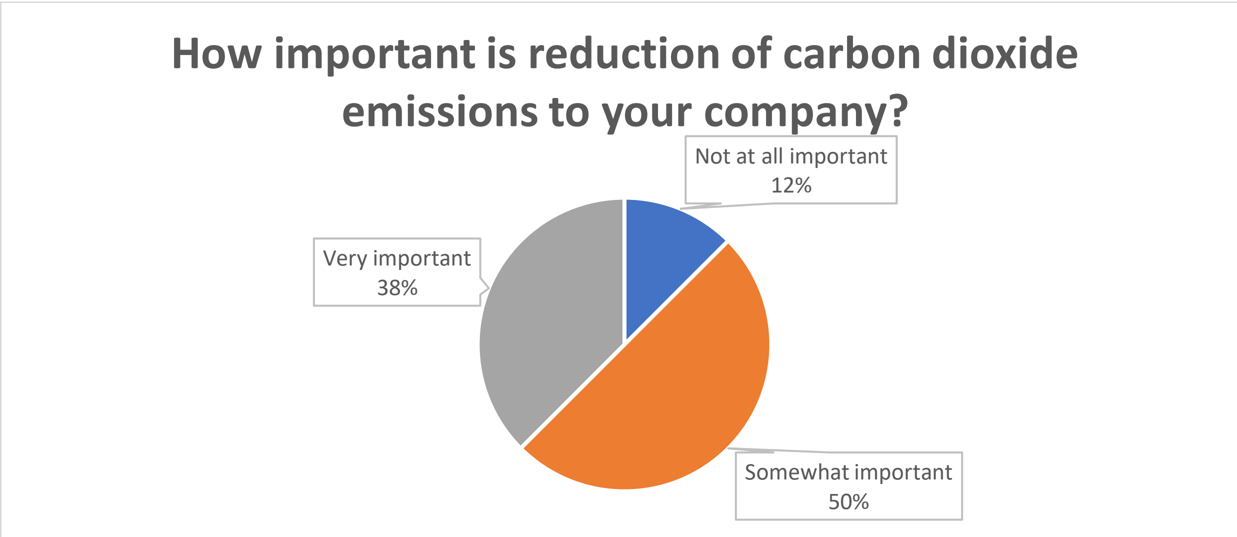
The respondents were then asked to indicate, from a list of efficiency technologies, which technologies were of interest to them. There was broad interest in a variety of efficiency strategies. About 10% indicated no interest in any of the specified plans, while as many as 60% indicated an interest in temperature control systems.

Figure 12. Interest in Specific Efficiency Investments



Even though companies placed carbon dioxide savings below cost savings as a priority, companies do have an interest in reducing carbon dioxide emissions. Over 1/3 of companies considered carbon dioxide emission reduction to be “very important” to their business, and another half considered it to be “somewhat important.” Only 12% considered it to be not important at all.

Figure 13. Importance of Carbon Dioxide Emission Reduction



Likewise, from the survey we found that over 50% of companies are willing to increase the payback period for those energy efficiency investments that significantly reduce carbon emissions. But the survey also showed that about 2/3 of respondents would be willing to increase payback by only one to two years. Another third was willing to go as high as 5 years, but none were willing to increase payback further. See Figures 14 and 15 below.

Figure 14. Willingness to Pay for Carbon Dioxide Emission Reduction

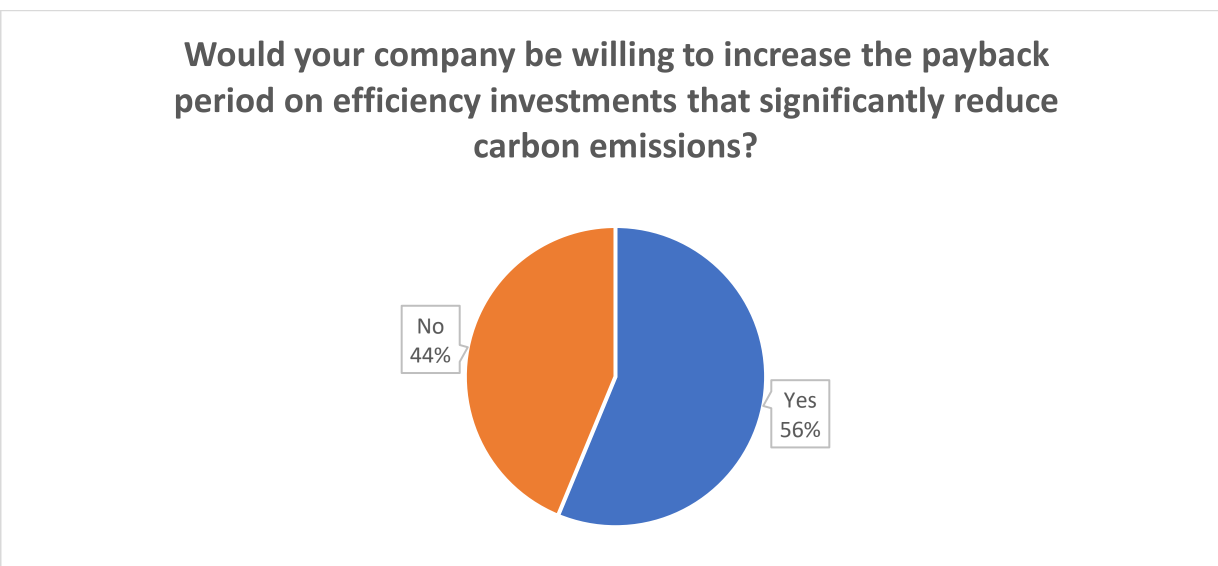
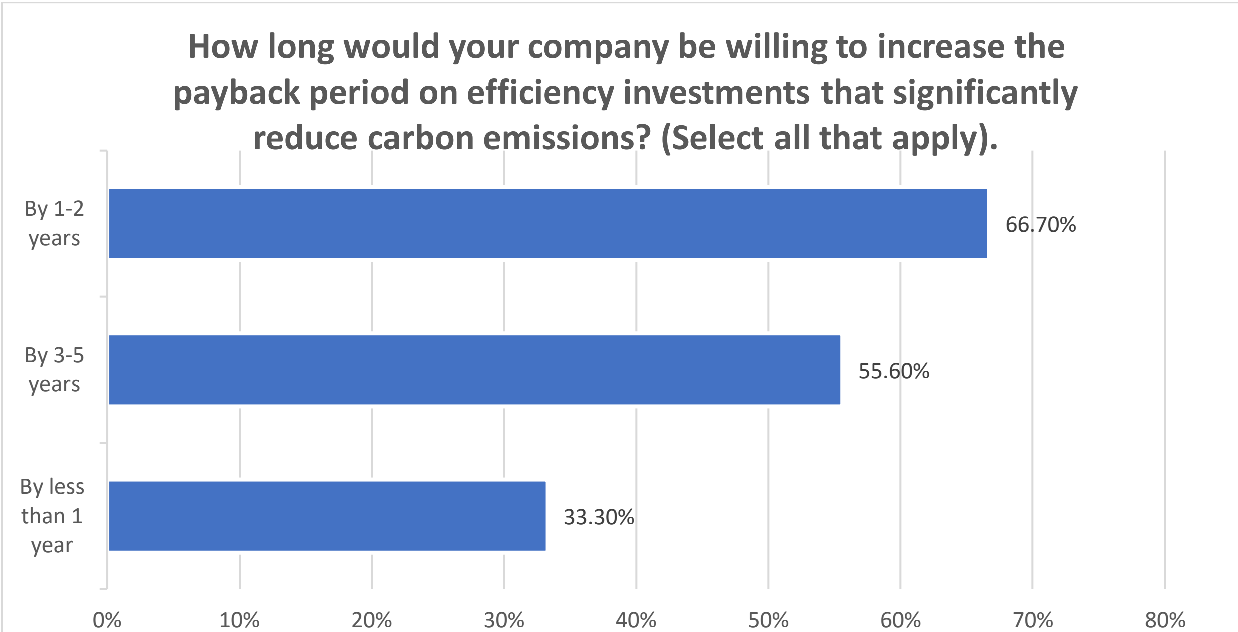


Figure 15. Length of Time for Payback on Carbon Reducing Efficiency

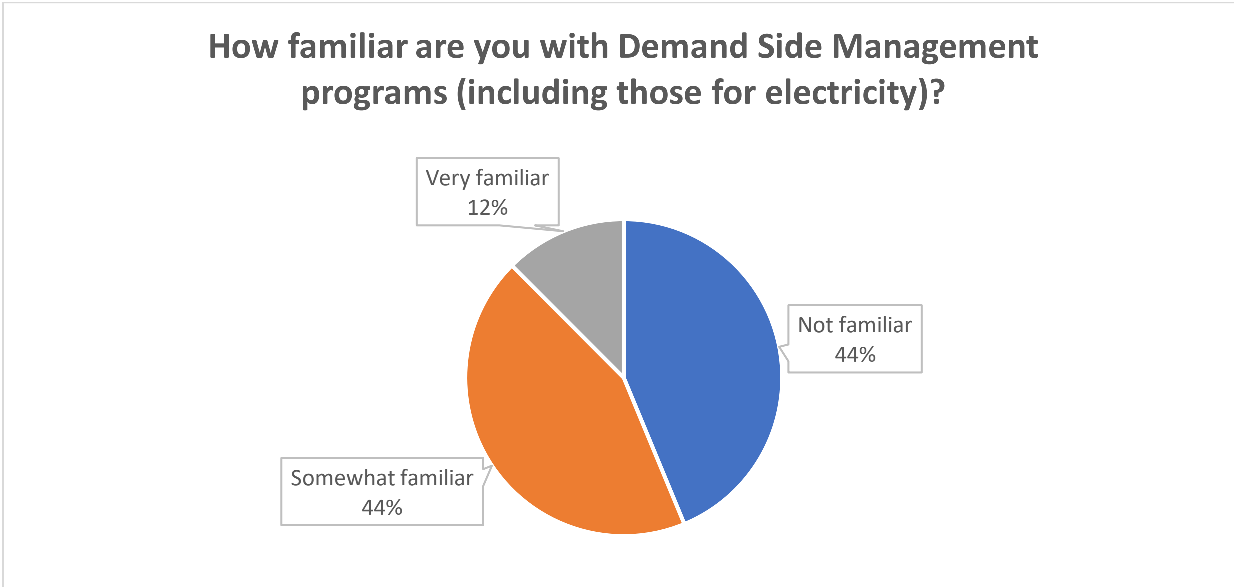


2.2.5 Demand Side Management.

The next topic that the survey focused on was demand side management. Generally, district energy systems do not currently offer demand side management incentives. Customers see savings from reducing demand simply by reducing the volume of purchase; there are no incentives to manage load during peak system usage.

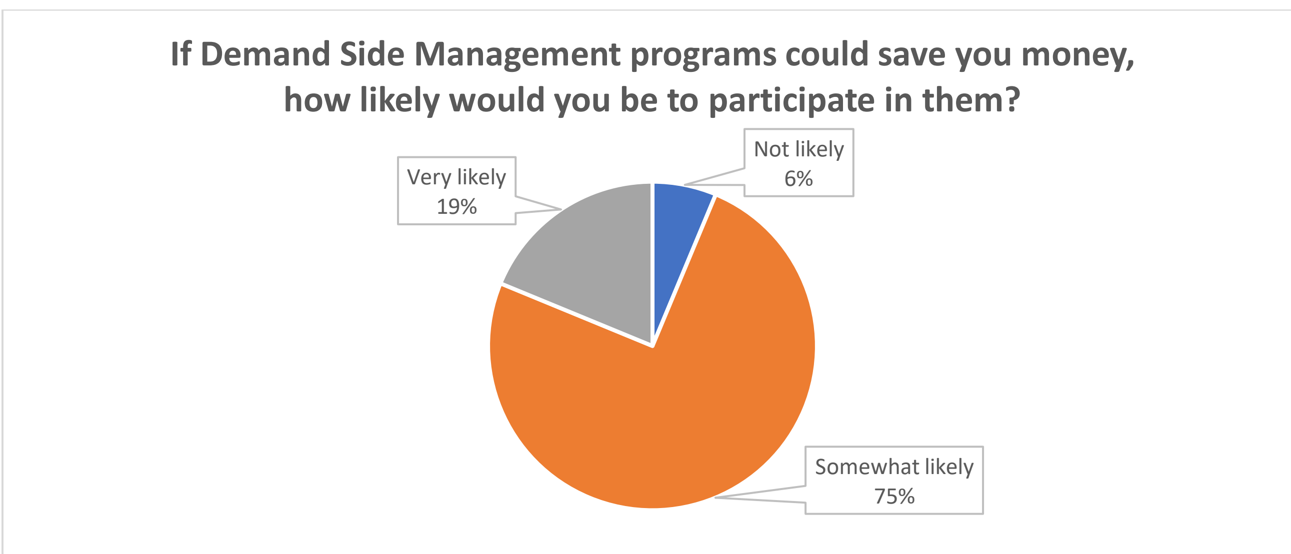
The first question on this topic was to establish their familiarity with the concept of demand side management. Only 12% of respondents indicated they were familiar with demand side management programs (consistent with the earlier response that around 18% participated in electricity demand side management programs. The rest of respondents were either somewhat or not at all familiar with demand side management.

Figure 16. Familiarity with Demand Side Management



Despite this lack of familiarity, the companies indicated in interest in participation in such a program if it saved them money. Not surprisingly, this enthusiasm was tempered by the lack of familiarity: 75% indicated they were "somewhat likely" to participate if it saved them money. Only 6% said they were unlikely to participate even if it saved them money.

Figure 17. Interest in Participation if Demand Response Could Save Money



Despite this interest, 63% of companies indicated they could not reduce demand during a demand response event. Still, over 1/3 of companies indicated they could reduce load during heating demand response events, and nearly identical results were obtained from the same question regarding the cooling load during peak demand.

Figure 18. Ability to Reduce Load During Heating Demand Response Event

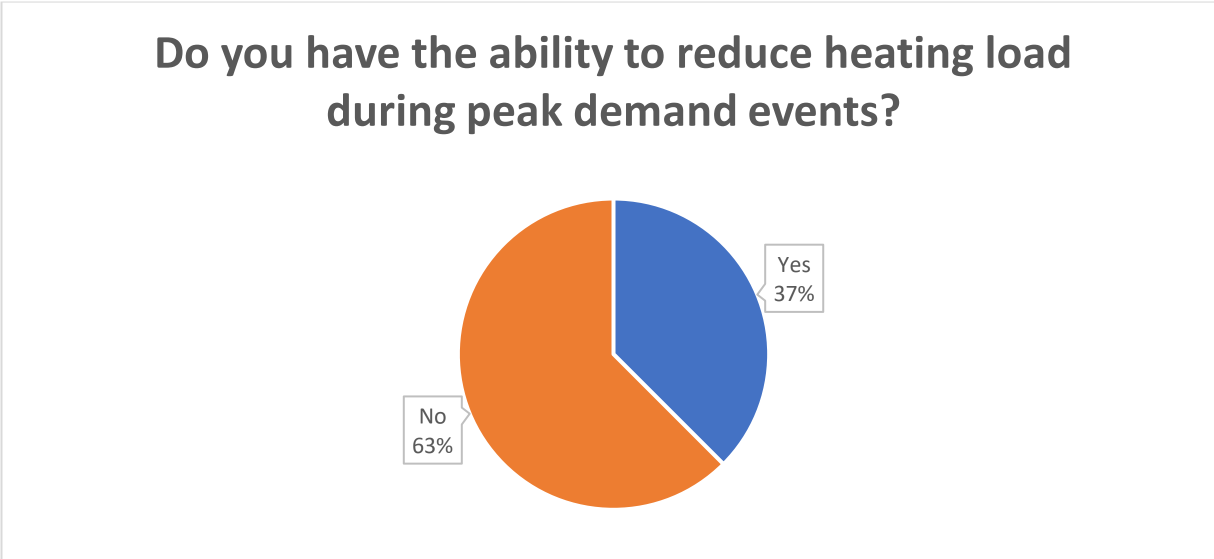
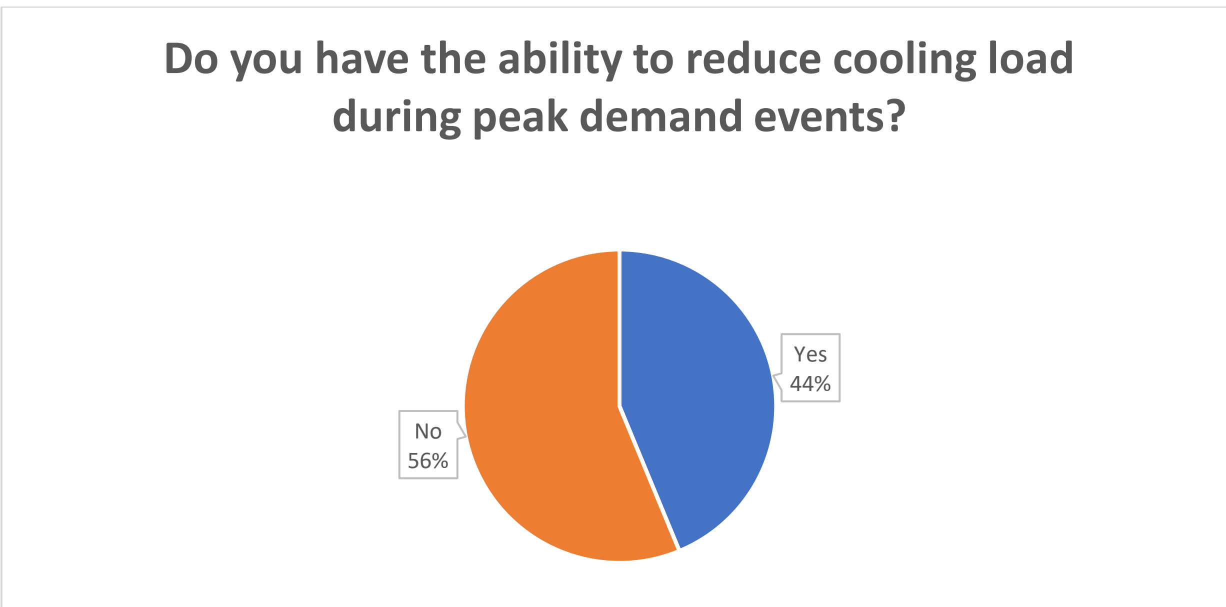
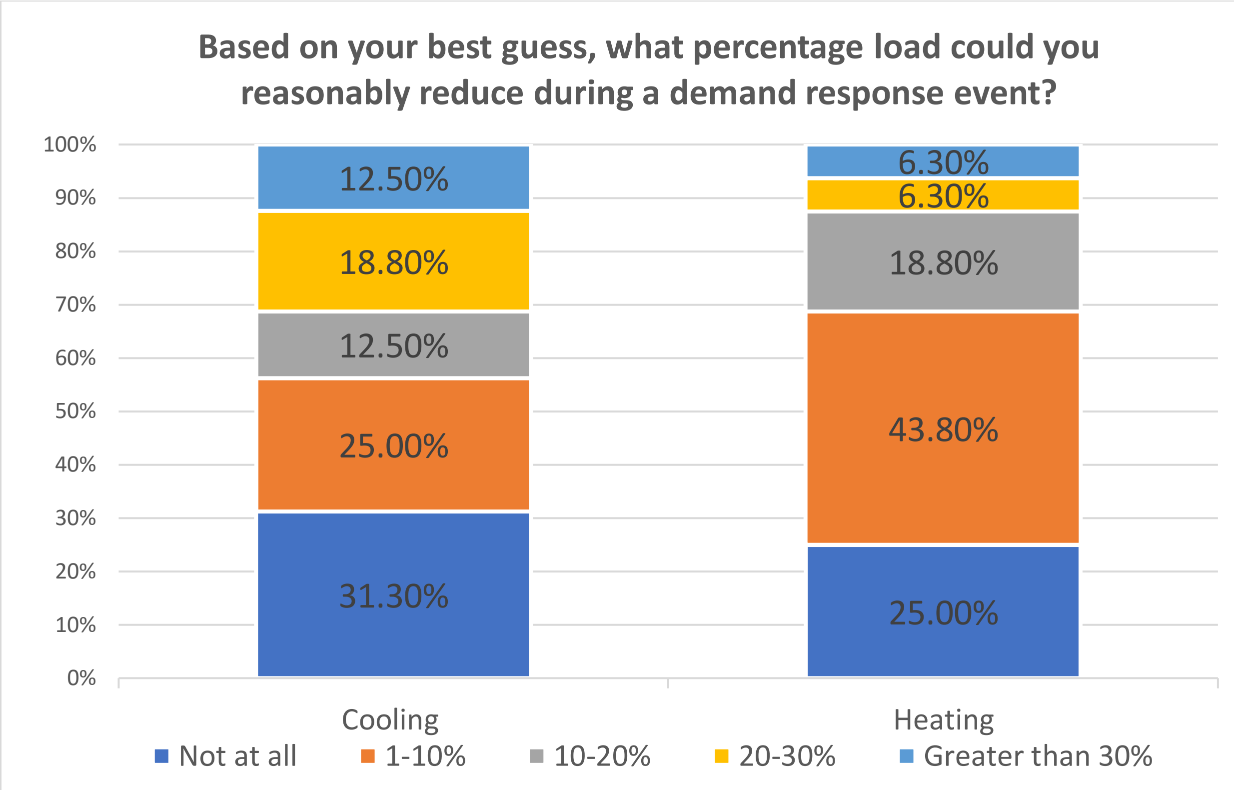


Figure 19. Ability to Reduce Load During a Cooling Demand Response Event.



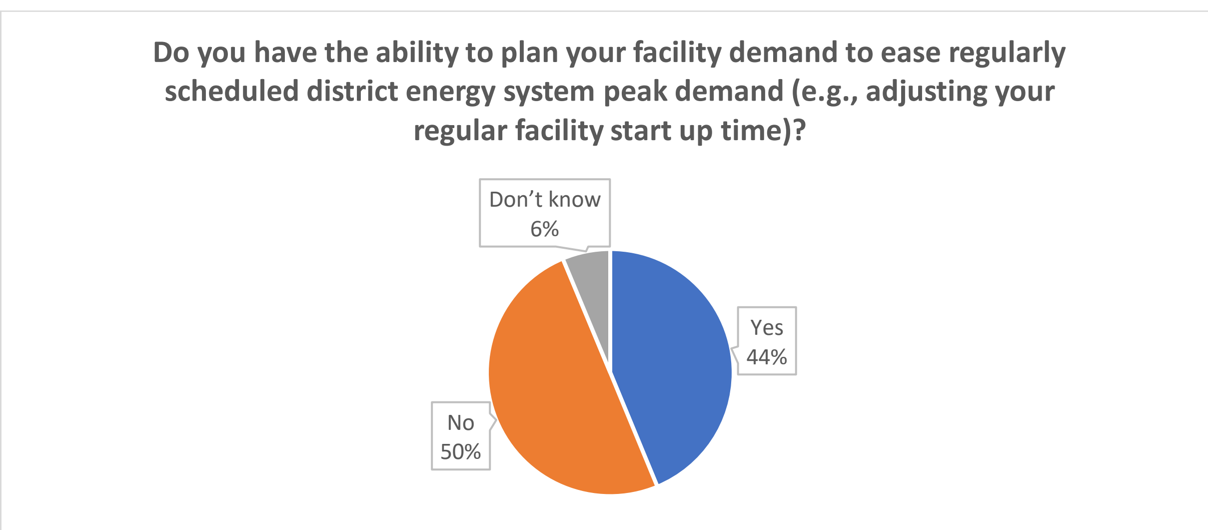
However, a subsequent question suggested that companies could reduce heating or cooling during peak demand, notwithstanding that only 44% indicated they could do so in the prior question. Only 25% said they could not reduce heating, and 33% said they could not reduce cooling. Among the rest of respondents, answers varied as to the amount of heating and cooling load they would be able to reduce. Of all respondents, 30% indicated they would be able to reduce up to 20% for heating, and 10% for cooling.

Figure 20. Percentage of Load That Can Be Reduced



Additionally, respondents were asked to indicate their companies' ability to change their start or end time to enable district energy utility capacity management (thereby enabling utilities to ramp up and down more smoothly). About half of companies were unable to change the times that they operated to help utilities manage capacity costs. But 44% of companies indicated they could – identifying a potentially significant source of savings for utilities that could be passed through to customers.

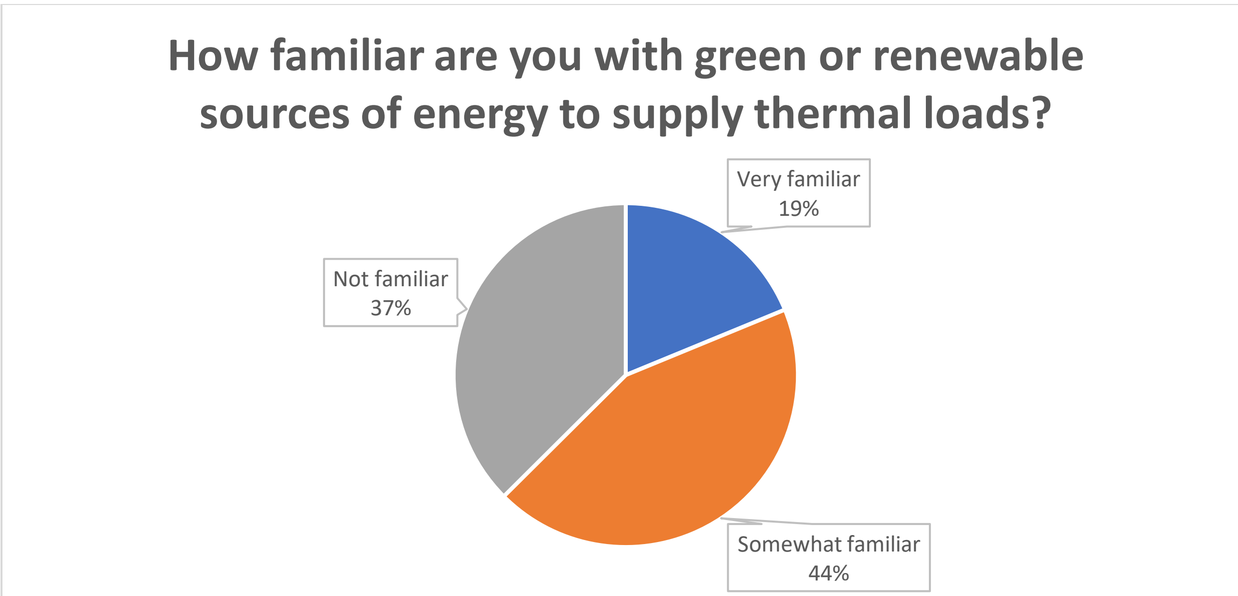
Figure 21. Ability to Manage Company Operation Start and End Times



2.2.6 Energy Mix and Renewables (Section 7 of survey).

The questions next asked about interest in sustainability. The first question sought to gauge the respondent's familiarity with green or renewable sources of energy to supply thermal loads. Most respondents were somewhat or very familiar with these concepts, but over a third of respondents indicated that they were not at all familiar.

Figure 22. Familiarity with Clean Fuel Sources for Thermal Systems



Next the survey sought to determine whether the customers would be interested in the district energy companies using a percentage of green or renewable sources to create its thermal energy. Nearly 70% of respondents indicated an interest in having a portion of their thermal load coming from renewable sources. Among those interested, 18% indicated that they would support more than half the thermal power coming from renewable sources. However, when asked if they would consider paying more for energy produced from a green or renewable source, a majority (63%) indicated that they would not be willing to pay more. Among the minority of respondents who indicated that they would pay more, 60% said they would pay up to 5% more, and 40% up top 10% more. No one responded they would pay more than 10%.

Figure 23. Interest in Using Clean Fuels Sources for Thermal Energy

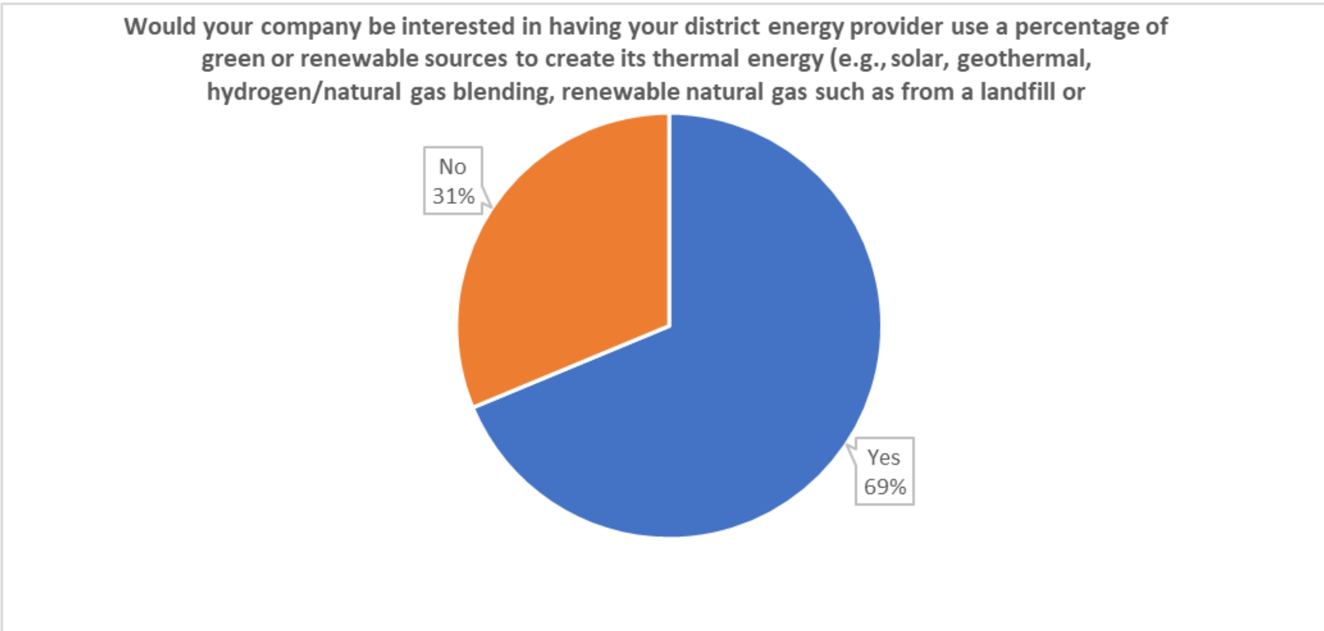


Figure 24. Percentage of Thermal Energy from Renewable Sources

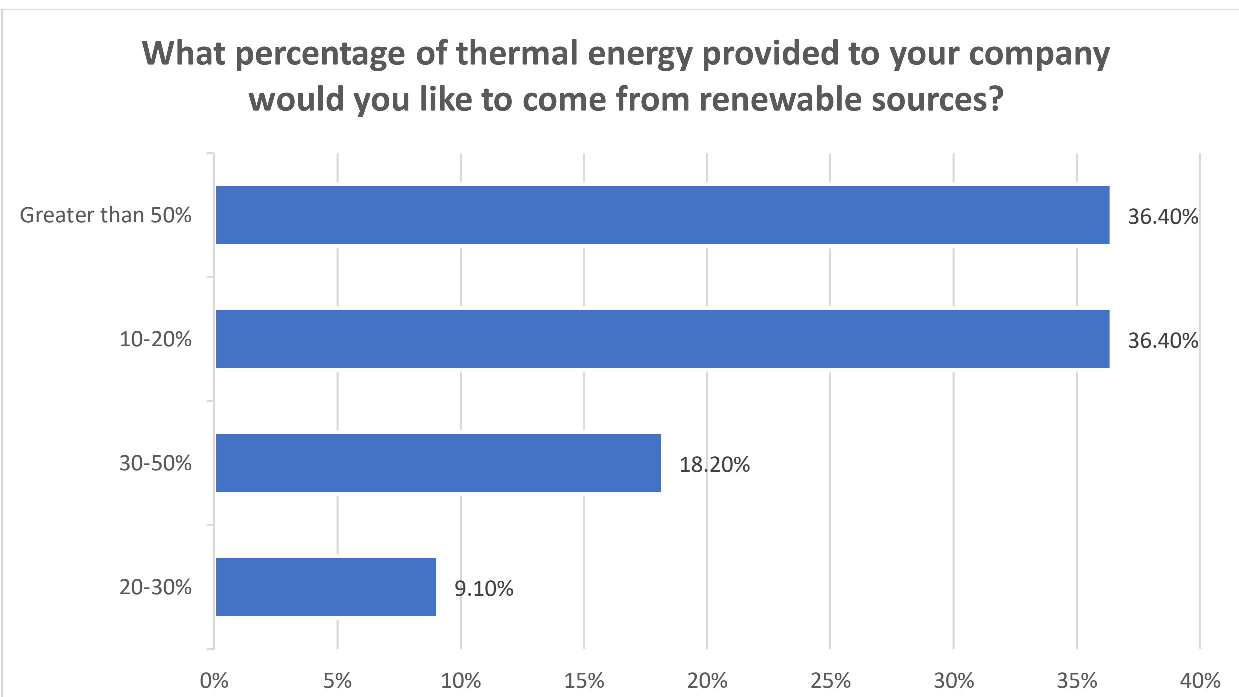


Figure 25. Willingness to Pay More for Clean Sourced Thermal Energy.

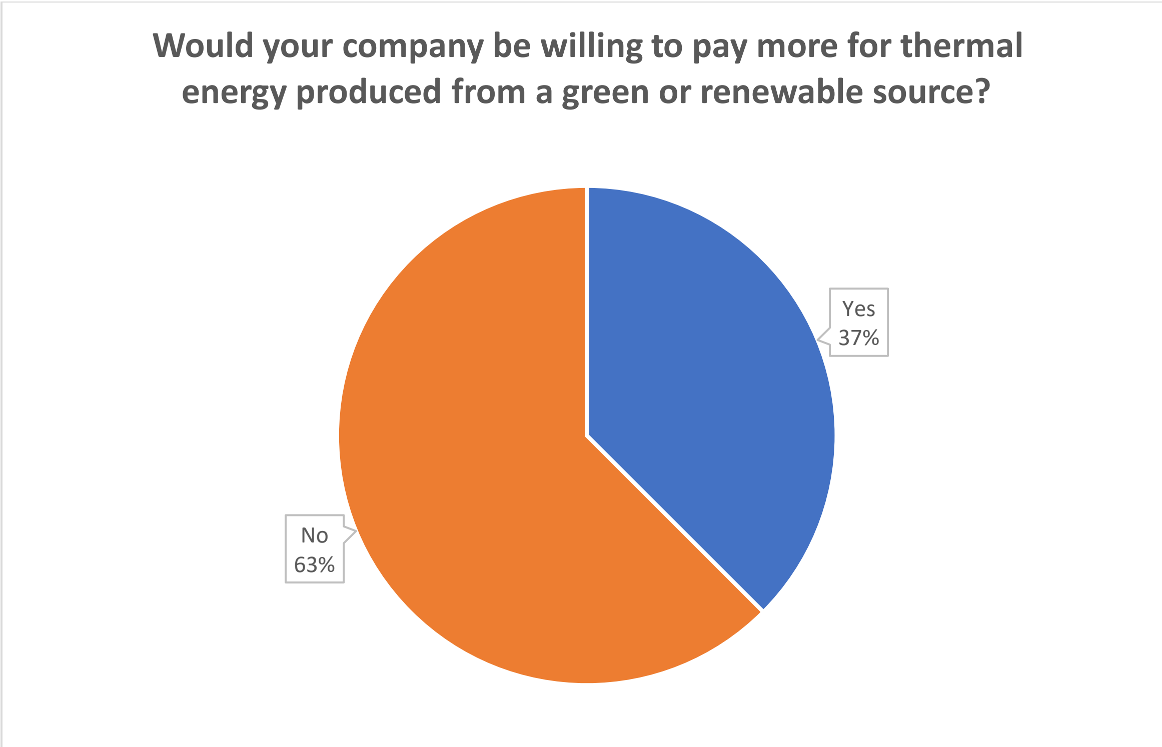
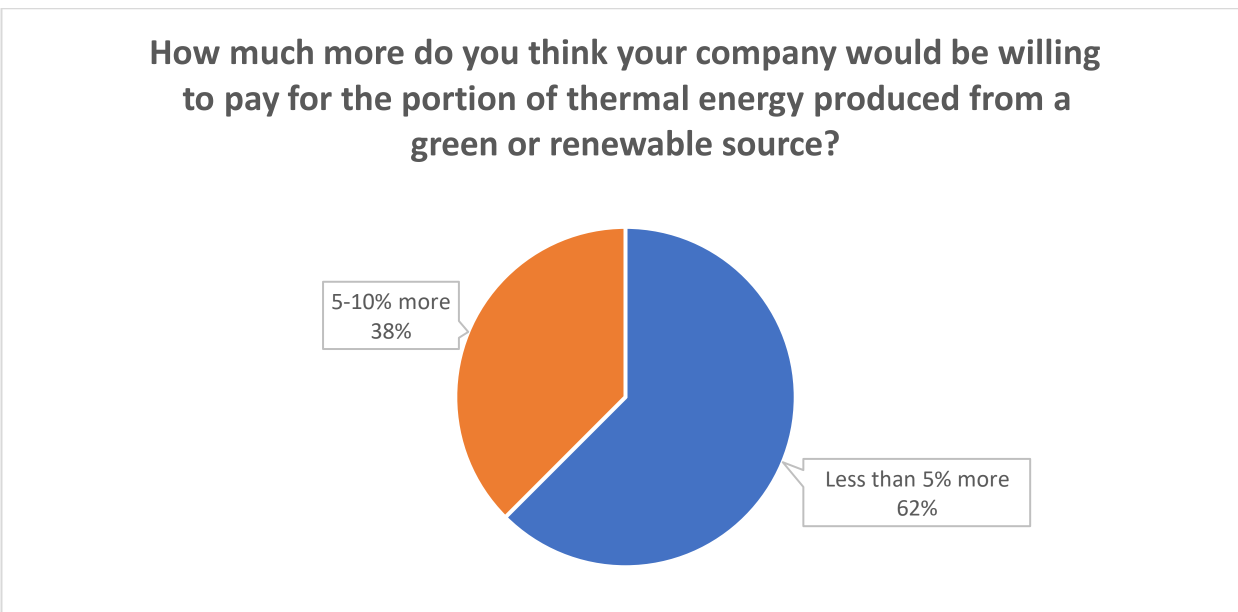


Figure 26. How Much More Company Will Pay for Clean-Sourced Thermal Energy



2.2.7 Microgrid Electricity Generation (section 8 of survey).

Finally, and in anticipation of the follow up research to this project, the last set of questions dealt with the respondents interest in microgrids. The first questions dealt with the respondent's familiarity with microgrids. About a third of respondents indicated moderate familiarity, one third some familiarity and one third no familiarity at all. The extremely familiar option was not selected by any of the participants. Those who did indicate familiarity were not, however, sold on the usefulness of them. The next question established that only a third of respondents believed that microgrids would be very or moderately useful that their companies. This suggests that district energy customers are not overly concerned about their electric grid resiliency, or otherwise will need more information to understand the value proposed by microgrids. This will be the subject of the next phase of the study – establishing the need to education end users of the value of microgrids in support of district energy systems.

Figure 27. Familiarity with Microgrid Design and Operation

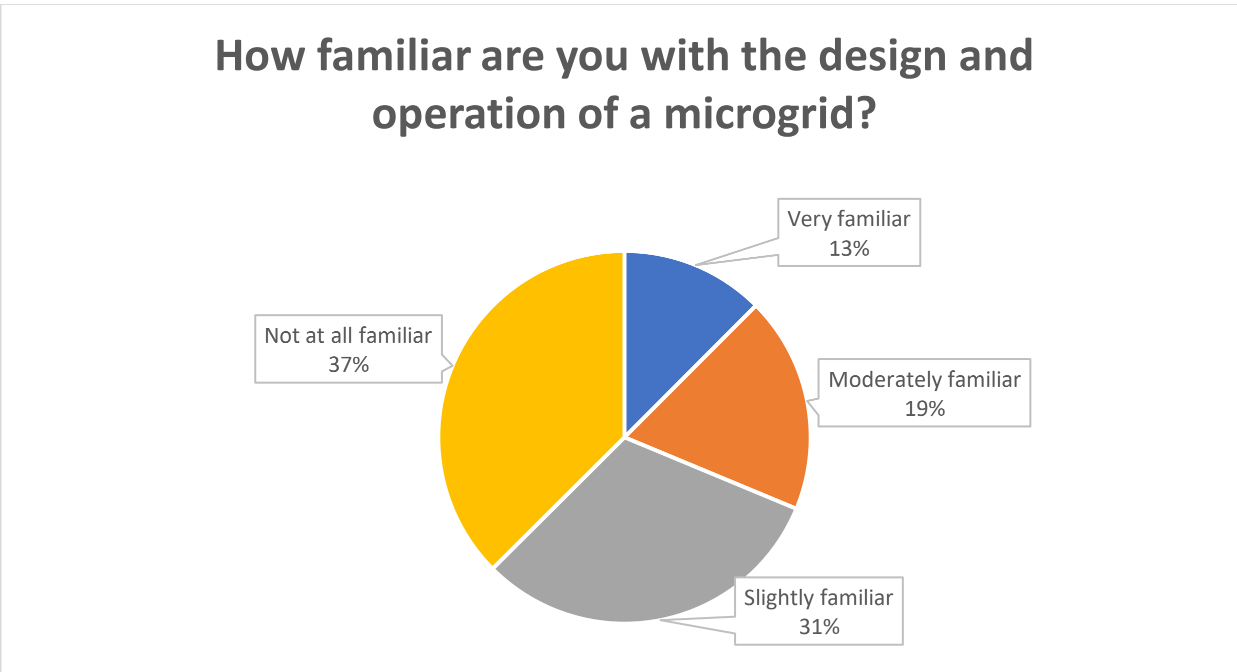
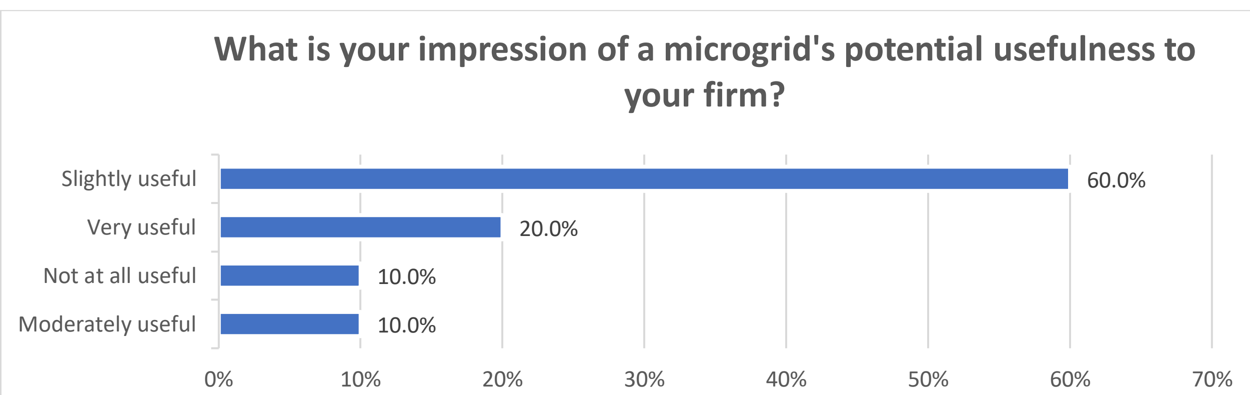


Figure 28. Usefulness of Microgrids to Customers



Those companies who thought microgrids might be useful did not identify a specific reason, therefore. When prompted to identify reasons, respondents split about equally among the choices: fewer power outages, reduction in emissions, improvement of power quality, quick recovery from outages and reduction in total energy cost. However, when asked about the price per kilowatt-hour (kwh) that they would pay to join a microgrid, a majority of the companies would not be willing to pay more than then-current commercial rates of around 11 cents to 12 cents per kwh. Forty percent said they would not consider joining at any rate, and another 50% would not pay more than 11 cents. This suggests either a general distrust of the technology or a misunderstanding of the prices (e.g. the fact that 20% of respondents would not be willing to pay more than 7 cents suggests they may think that this would only be a component of their price). This should be a focus of follow up interviews for the next phase of the study.

Figure 29. Reasons for Why Microgrids May be Useful to Customers

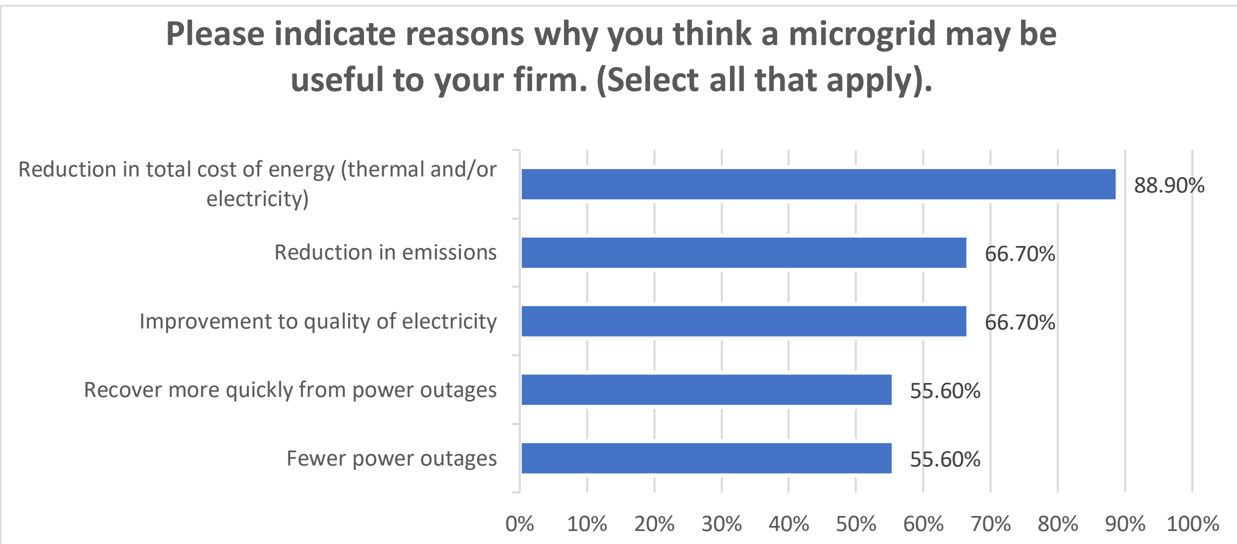
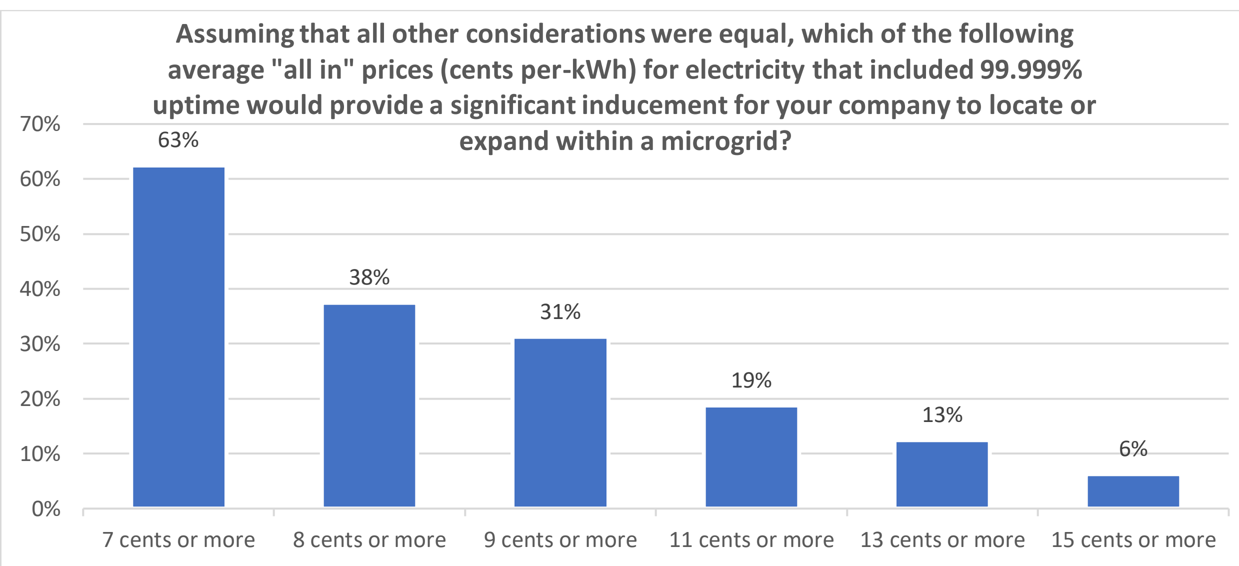


Figure 30. Willingness to Pay More for Improved System Uptime



2.3 Follow Up Interviews of Respondents.

The Survey Team was interested in discussing the survey results with respondents and learning more about the sorts of energy efficiency programs in which they might be interested. Accordingly, respondents were contacted to see if they would be willing to participate in an interview discussing the topics from the survey. Five respondents agreed to an interview. An outline was created for the interviews seeking additional information on six main talking points. These were as follows:

1. Interest in and knowledge of district energy efficiency systems.
2. Ability to participate in load management programs.
3. Importance of carbon dioxide emission reduction to the company.
4. The company's preferred method of financing for efficiency projects.
5. Investment payback the customer may require for investment in efficiency.
6. The customer's interest in and knowledge about microgrids.

Based upon the interviews, it appears that some companies could not participate in load management due the requirements of their business, even though they may find the concept intriguing. However, it was also clear from the interviews that load management was something that most companies have heretofore not considered, beyond the usual practice of "adjusting the thermostat" to conserve costs, and they did not really understand its benefits. The notion of a program to incentivize load management in response to system-wide demand was new to them. Accordingly, more education will be required for customers to engage in a demand response or peak load contribution program.

The interviews confirmed the view identified in the survey held by most respondents that they are keen to reduce carbon dioxide emissions. However, while carbon emission reduction may be very important to their institutions, few were willing to pay more to reduce them. This was also consistent with the survey results.

We also confirmed that the respondents did not have a strong preference for a financing method. When asked about what method of financing, the interviewees indicated that they were open to all types of financing, so long as the total cost was competitive. This was also true when the participants were questioned about the company's payback preference. Some additional tariff structures, such as a return temperature-based plan, were explained to the participants. They expressed willingness to consider working within some of these plans but indicated they would need to learn more. =

While the responses in the survey seemed to indicate that a majority of the participants were at least somewhat familiar with the concept of a microgrid, the Study Team interviews with the respondents suggest that this may not be the case. Once the concept of a microgrid was explained to the participants, they showed significant interest in being a part of such a network. Reliability was a major selling point for the system overall and companies were enthusiastic about a supply of electricity that had a 99.999% uptime. It is apparent that microgrid integration with district energy systems will require significant education among system end users before they will fully embrace this strategy.

Finally, several interviewees offered up some additional considerations for district energy companies. One respondent suggested that the district energy company could help customers better understand the efficacy of pipes in their buildings to ensure a more uniform distribution of thermal load within the building. Another commented on the lack of government programs incentivizing district energy companies and their customers to develop efficiency programs. This interviewee suggested that the district energy companies could help customers identify programs that do exist.

3.0 Best Strategies to Encourage Energy Efficiency Deployment.

District Energy can under many circumstances be the most efficient strategy for heating and cooling systems, especially when end users are relatively close to each other. However, even systems in congested areas must compete with onsite thermal system options. The best way for district energy systems to remain competitive with customer-owned onsite systems (and to attract new customers) is to improve system efficiencies. Some of these efficiencies can be undertaken by the district energy company in front of the meter. These costs are generally shared among the end user's pro rata based upon their consumption. But many of the more effective efficiency measures must be taken behind the meter, and as such are controlled by the customer.

This survey sought to assess customer interest in "behind the meter" projects – those projects that are installed at the customer's location. Costs for behind the meter efficiency cannot be socialized into the rate base and must as a result be paid for by the customer. The survey specifically focused on best strategies for customers to pay for such projects. Of course, many behind the meter efficiency projects, such as improving building insulation, work just as well for either district energy or onsite thermal generation. In this regard, those who do not want to commit long term to district energy use might still tolerate longer pay back periods. More likely, however, end users who have a low tolerance for long term payouts do so because they are not committed long term to their facilities.

The results of the survey suggest that customers will be receptive to a variety of behind the meter projects, provided that the payout is sufficiently attractive and that financing options were available. Overall, about one third of respondents preferred to pay for the projects through their tariff, about one third through an energy service company contract, and the remaining third through self-financing. Additional ideas were formulated through interviews with the respondents. These different options are discussed below.

3.1 Energy Efficiency Development through Tariff Design.

Although one third of the system end users surveyed preferred to pay for behind the meter efficiency through tariffs, it is unclear how readily district systems can use this method to pay for such measures. Most tariffs are set as costs that are socialized throughout the rate base, and approved by a Public Utility Commission. So behind the meter efficiencies that benefit specific customers cannot be readily passed through to those specific end users under a tariff. Even so, tariffs can be designed to encourage efficiency.

In several European countries, district energy systems have used tariff design to encourage end users to invest in their own efficiency. This can be accomplished through "intelligent rate design" – a system that rewards efficiency. One example of this is through what is described as a "low temperature tariff." In some tariff structures the rate a customer is charged for a unit of hot water consumption is based on the return temperature of the hot water. The customer tariff can be set up collect in one of two ways: (1) based upon a rate that assumes the average return temperature to the district energy company or (2) based upon a rate the measures the actual return temperature. Under the low temperature tariff, those customers that deploy efficiency measures could see additional savings not only by reducing their steam intake, but also by returning condensate to the district energy provider at a higher temperature. Such a tariff strategy, if available, could motivate customers to invest in energy efficiency improvements. For many systems, especially older ones, this option might not be available.

Another example of intelligent rate design that could improve efficiency would be to set costs based upon time of use. End users can be incentivized to change their operations to reduce load during peak system demand. Electricity tariffs commonly account for this through capacity or demand charges. In the PJM regional transmission organization (regulates interstate power transmission), end users can save money by managing their loads to ensure that their peak demand does not coincide with system peak demand (called "peak load contribution" or PLC management). This reduces waste by ensuring that excess capacity is not built. District energy systems can also offer end users PLC management to encourage efficiency.

Reducing the number of demand events over the course of a year by spreading out the time different businesses operate would help with the overall efficiency of the plants. Additionally, spreading the hours of operation out over the course of a day would increase the daily efficiency of the plant since one of the main contributors to plant efficiency is the temperature and amount of steam generated. A more constant load over the course of the day, shaving the peaks, would improve system efficiency, save the district energy provider as well. These would be in front of the meter efficiencies that can be realized by both individual customers and the utility through rate design.

Respondents to the survey did not express great enthusiasm for changing start and stop times to accommodate peak load management. Nevertheless, in the interviews with certain respondents of the survey, all the respondents were clear that the principal concern is finding the least cost option available. End users also do not much care for changing operations to manage their electricity loads, but they do it when they save money.

Still another intelligent rate design would be to charge more per unit of use as consumption increases. Most district energy companies already vary rates based upon volume – but do the exact opposite, decreasing costs per unit with increased volume. This works in a manner to actually discourage efficiency. The reason utilities offer the volume discount is closely tied to the fundamental value proposition provided by district energy companies: scale reduces costs for the district energy. This is a savings the district energy company is keen to pass on to its end users. Even so, rate design that discourages, rather than encourages, increased use should be considered. Jevon's Paradox has demonstrated the fallacy of assuming that increased efficiency leads to lower income streams to the utilities.

Finally, another way to increase the efficiency of the district energy system is to increase the number of customers on the system, or their total consumption. The boiler may, depending upon the design, operate more efficiently when running at higher temperatures and pressures. In such cases, more customers on the district energy system would allow the boilers to operate with more steam at higher pressures to serve a greater area. When there is excess capacity in the distribution system (more common among urban, legacy district energy systems), certainly more customers using more load would increase system efficiencies. These sorts of efficiencies are in front of the meter, and difficult to incentivize for end users, since they do not see a direct savings. As a result, creative strategies may be required to socialize the costs (and the savings) for these kind of efficiency upgrades.

One way to increase customer subscription is through government assistance. This can be accomplished through incentives to switch to district energy, such as subsidized rates for an initial transition period. The Public Utility Commission of Ohio could establish a lower 'introduction" tariff for new system users. Further, subsidies to district energy utilities to pay for efficiency programs also could increase customer subscription by lowering costs among all customers. Heretofore, the major investments into in front of the meter efficiency programs have been on the electricity grid, and not on the thermal grids. New state and federal programs that encourage efficiency will attract new customers. This is also true for behind the meter efficiency investments – such programs could be important to maintaining existing customers in the district energy system, which is just as important for distribution system efficiency as is new customers.

3.2 Energy Service Company Agreements.

Perhaps the easiest way to finance behind the meter efficiency upgrades is to have the utility company conduct the work under an Energy Service Company (ESCO) contract. ESCO contracts are generally performance-based: such contracts can be written in a way to be paid for by operational savings. Under an ESCO agreement, the Energy Service Company commits to install the necessary equipment, provide a performance guarantee, and to pay for the upfront costs. Those costs are recovered over time in accordance with a schedule, and only upon meeting performance targets. This may be especially attractive to customers who seek to avoid additional traditional indebtedness, since such agreements are typically treated as an "off balance sheet" operational obligation rather than capital obligation.

ESCO agreements do not, however, have to be between the customer and the District Energy utility. Third parties, including engineering firms, often offer ESCO contracts to customers of district energy utilities. End users interested in using an ESCO to undertake efficiency upgrades are wise to interview these companies and to get bids. But the District Energy Utility is in a particularly strong position to know what efficiencies will work to generate savings for customers. As such, the Utility should be able to offer an aggressive ESCO strategy that is transparent and relatively easy to monitor. Most ESCO agreements will need some sort of independent auditing if the customer cannot do its own audits.

One third of the end user respondents surveyed on the Cleveland Thermal system preferred this strategy. Based upon an interview with Seth Whitney, President of Cleveland Thermal (the District Energy provider for the surveyed end users), district energy utilities preferred contracting the work through the unregulated side of the utility rather than passing the costs through under a tariff. Redesigning tariffs requires explaining the changes to customers and getting Public Utility Commission permission – both time consuming and unpredictable processes. But contracts, such as the ESCO agreement, can be readily set up to create guaranteed savings and to provide sufficient transparency to the customer. Further, successful efficiency programs are likely to attract new customers to the system, as the District Energy Utility demonstrates it is able to constrain costs.

3.3 Customer Financed Infrastructure.

One third of the district energy end user respondents to the survey indicated that their preferred strategy for financing efficiency is self-financing. End users can contract directly with providers of efficiency systems. Many companies that undertake building envelope, geothermal and other thermal improvements can sell or lease their equipment to the facility owner, or can provide financing, therefore. The principal risk for end users is that they may not have the knowledge to predict the savings from such investments, and salesmen from the equipment provider may be more interested in selling equipment than recommending best practices. Engagement of a third-party energy auditor or consultant can mitigate some of this risk.

4.0 Conclusions and Planned Follow Up Strategies

The survey provided some useful insights for development of energy efficiency in thermal systems. The most important take away is that while over half of end users understand basic energy efficiency technologies, they do not have a good sense of how valuable they could be, or what the best strategies are to pay for them. Further, while respondents expressed an interest in undertaking efficiency upgrades to improve their carbon emission footprint, their appetites for this wane considerably when it means increasing payouts beyond 3-5 years.

The interviews, however, confirmed some key suspicions about the survey responses. First, while respondents did not oppose participation in demand response programs, it appears that the end users will need more education about the merits of such programs. Upon explanation of how demand response programs would work, interest went up significantly. The same was true for participation in a microgrid, where respondents indicated significantly more interest than in the survey after hearing an explanation of how they will work.

This suggests that follow up research needs to focus on how to educate end users on the value of energy efficiency, demand response and microgrids. In particular, the follow up research under this study should look at how district energy systems can catalyze adoption of microgrids and vice versa. Optimization of district energy with microgrids could lead to significant savings on both carbon emissions and money. And it can also produce uptimes that are conducive to economic development in the digital economy, which requires extreme uptime.

Appendix A. Survey of End Users on Cleveland Thermal District Energy System

Q2.2 - What is your role/title within your company?

#	Answer	%	Count
1	Chief Executive Officer	6.3%	1
2	Chief Financial Officer	0.0%	0
3	Director/Manager of Operations	50.0%	8
4	Director/Manager of Utilities	0.0%	0
5	Director/Manager of Sustainability	12.5%	2
6	Other:	31.3%	5
	Total	100%	16

Q2.3 - What is your involvement in energy purchasing decisions for your company?

#	Answer	%	Count
1	Primary evaluator on procurement	31.3%	5
2	Member of procurement evaluation team	56.3%	9
3	Supervise others who make procurement recommendations	12.5%	2
4	Other (Please describe):	0.0%	0
	Total	100%	16

Q3.1 - What is the approximate usable area (square feet) of your company's occupied space in your facility?

#	Answer	%	Count
4500	4500	6.3%	1
8500	8500	6.3%	1
25000	25000	6.3%	1
50000	50000	6.3%	1
65000	65000	6.3%	1
80000	80000	6.3%	1
100000	100000	6.3%	1
110000	110000	6.3%	1
190000	190000	6.3%	1
200000	200000	12.5%	2
456700	456700	6.3%	1
500000	500000	6.3%	1
1000000	1000000	6.3%	1
5000000	5000000	6.3%	1
5400000	5400000	6.3%	1
	Total	100%	16

Q3.2 - How would you describe the primary business activities at your facility?

#	Answer	%	Count
1	Manufacturing/Industrial	6.3%	1
2	Commercial	25.0%	4
3	Government	18.8%	3
4	Educational	12.5%	2
5	Non-Profit Organization	6.3%	1
6	Healthcare	0.0%	0
7	Residential	0.0%	0
8	Other:	31.3%	5
	Total	100%	16

Q3.3 - How would you describe the primary use of district energy for your facility? (Select all that apply).

#	Answer	%	Count
1	Process (e.g. turn turbine, laundry services or other processes)	0.0%	0
2	Building climate control	93.8%	15
3	Equipment cooling	18.8%	3
4	Refrigeration (e.g. food, laboratory specimens)	6.3%	1
5	Other (Please describe):	0.0%	0
	Total	100%	16

Q4.1 - What current energy management activities do you practice? (Select all that apply).

#	Answer	%	Count
1	Peak electricity load management	18.8%	3
2	Conservation education	25.0%	4
3	Climate control management	43.8%	7
4	Other (Please describe):	12.5%	2
5	None	31.3%	5
	Total	100%	16

Q4.2 - What investments have you made in energy efficiency in the last ten years? (Select all that apply).

#	Answer	%	Count
1	Energy Audits	50.0%	8
2	Building envelope (windows, insulation, roof)	43.8%	7
3	Building loop water maintenance	31.3%	5
4	Coil upgrades	18.8%	3
5	Lighting	81.3%	13
6	Motors, Fans, and similar equipment	12.5%	2
7	Steam traps	37.5%	6
8	Meters (smart or otherwise) that enable customer management	31.3%	5
9	Sensors or control systems	56.3%	9
10	Other (Please describe):	12.5%	2
11	None	0.0%	0
	Total	100%	16

Q5.2 - How familiar are you with district energy efficiency programs for customers?

#	Answer	%	Count
1	Not at all familiar	50.0%	8
2	Somewhat familiar	43.8%	7
3	Very familiar	6.3%	1
	Total	100%	16

Q5.3 - What payback period would attract you to invest in energy efficiency measures? (Select all that apply).

#	Answer	%	Count
1	1-2 years	25.0%	4
2	2-3 years	31.3%	5
3	3-5 years	56.3%	9
4	5-10 years	18.8%	3
5	Over 10 years	6.3%	1
	Total	100%	16

Q5.4 - Please rank the following factors (1 being most important) in determining your interest to install energy efficiency measures. Use your mouse to drag and drop each item.

#	Question	1		2		3	
1	Cost	81.3%	13	18.8%	3	0.0%	0
2	Space	6.3%	1	25.0%	4	68.8%	11
3	Interruption of business	12.5%	2	56.3%	9	31.3%	5
	Total	Total	16	Total	16	Total	16

Q5.5 - Please rank the following factors (1 being most important) in determining your company's decision to install energy efficiency improvements. Use your mouse to drag and drop each item.

#	Question	1		2		3		4		5		6	
1	Reliability	25.0%	4	12.5%	2	43.8%	7	18.8%	3	0.0%	0	0.0%	0
2	Maintenance and Operating Costs	18.8%	3	56.3%	9	6.3%	1	18.8%	3	0.0%	0	0.0%	0
3	Upfront Capital/First Costs	37.5%	6	12.5%	2	18.8%	3	25.0%	4	6.3%	1	0.0%	0
4	Cost of Service	12.5%	2	12.5%	2	12.5%	2	31.3%	5	25.0%	4	6.3%	1
5	Price Variability Over Time	0.0%	0	6.3%	1	12.5%	2	0.0%	0	62.5%	10	18.8%	3
6	Environmental Stewardship	6.3%	1	0.0%	0	6.3%	1	6.3%	1	6.3%	1	75.0%	12
	Total	Total	16	Total	16	Total	16	Total	16	Total	16	Total	16

Q5.6 - Please rank the following strategies (1 being most attractive) for financing the installation of energy efficiency measures.   Use your mouse to drag and drop each item.

#	Question	1		2		3	
1	Self-finance investment (lease, loan or purchase)	37.5%	6	18.8%	3	43.8%	7
2	Energy Service Company pays for investment, recovers costs through projected savings	37.5%	6	43.8%	7	18.8%	3
3	District Energy Company installs equipment, and cost is recovered through rate	25.0%	4	37.5%	6	37.5%	6
	Total	Total	16	Total	16	Total	16

Q5.7 - Would you be interested in any of the following customer-owned efficiency investments? (Select all that apply).

#	Answer	%	Count
1	Energy audits	37.5%	6
2	Steam traps (device utilized to trap and release moisture from the steam system)	43.8%	7
3	Temperature controls	62.5%	10
4	Building envelope	37.5%	6
5	Coil upgrades	31.3%	5
6	Building Loop Water maintenance	25.0%	4
7	Capture and use of residual heat/condensate harvesting	50.0%	8
8	Onsite heat generation	31.3%	5
9	Onsite heat pumps	18.8%	3
10	Geothermal systems	18.8%	3
11	Thermal Storage	25.0%	4
12	None of the above	12.5%	2
	Total	100%	16

Q5.8 - How important is reduction of carbon dioxide emissions to your company?

#	Answer	%	Count
1	Not at all important	12.5%	2
2	Somewhat important	50.0%	8
3	Very important	37.5%	6
	Total	100%	16

Q5.9 - Would your company be willing to increase the payback period on efficiency investments that significantly reduce carbon emissions?

#	Answer	%	Count
1	Yes	56.3%	9
2	No	43.8%	7
	Total	100%	16

Q5.9b - How long would your company be willing to increase the payback period on efficiency investments that significantly reduce carbon emissions? (Select all that apply).

#	Answer	%	Count
1	By less than 1 year	33.3%	3
2	By 1-2 years	66.7%	6
3	By 3-5 years	55.6%	5
4	By more than 5 years	0.0%	0
	Total	100%	9

Q6.2 - How familiar are you with Demand Side Management programs (including those for electricity)?

#	Answer	%	Count
1	Not familiar	43.8%	7
2	Somewhat familiar	43.8%	7
3	Very familiar	12.5%	2
	Total	100%	16

Q6.3 - If Demand Side Management programs could save you money, how likely would you be to participate in them?

#	Answer	%	Count
1	Not likely	6.3%	1
2	Somewhat likely	75.0%	12
3	Very likely	18.8%	3
	Total	100%	16

Q6.4 - Do you have the ability to reduce heating load during peak demand events?

#	Answer	%	Count
1	Yes	37.5%	6
2	No	62.5%	10
3	Don't know	0.0%	0
	Total	100%	16

Q6.5 - Do you have the ability to reduce cooling load during peak demand events?

#	Answer	%	Count
1	Yes	43.8%	7
2	No	56.3%	9
3	Don’t know	0.0%	0
	Total	100%	16

Q6.6 - Based on your best guess, what percentage load could you reasonably reduce during a heating demand response event?

#	Answer	%	Count
1	Not at all	25.0%	4
2	1-10%	43.8%	7
3	10-20%	18.8%	3
4	20-30%	6.3%	1
5	Greater than 30%	6.3%	1
	Total	100%	16

Q6.7 - Based on your best guess, what percentage load could you reasonably reduce during a cooling demand response event?

#	Answer	%	Count
1	Not at all	31.3%	5
2	1-10%	25.0%	4
3	10-20%	12.5%	2
4	20-30%	18.8%	3
5	Greater than 30%	12.5%	2
	Total	100%	16

Q6.8 - Do you have the ability to plan your facility demand to ease regularly scheduled district energy system peak demand (e.g., adjusting your regular facility start up time)?

#	Answer	%	Count
1	Yes	43.8%	7
2	No	50.0%	8
3	Don’t know	6.3%	1
	Total	100%	16

Q7.1 - How familiar are you with green or renewable sources of energy to supply thermal loads?

#	Answer	%	Count
1	Very familiar	18.8%	3
2	Somewhat familiar	43.8%	7
3	Not familiar	37.5%	6
	Total	100%	16

Q7.2 - Would your company be interested in having your district energy provider use a percentage of green or renewable sources to create its thermal energy (e.g., solar, geothermal, hydrogen/natural gas blending, renewable natural gas such as from a landfill, or biomass)?

#	Answer	%	Count
1	Yes	68.8%	11
2	No	31.3%	5
	Total	100%	16

Q7.3 - What percentage of thermal energy provided to your company would you like to come from renewable sources?

#	Answer	%	Count
1	Less than 10%	0.0%	0
2	10-20%	36.4%	4
3	20-30%	9.1%	1
4	Greater than 50%	36.4%	4
5	30-50%	18.2%	2
	Total	100%	11

Q7.4 - Would your company be willing to pay more for thermal energy produced from a green or renewable source?

#	Answer	%	Count
1	Yes	37.5%	6
2	No	62.5%	10
	Total	100%	16

Q38 - How much more do you think your company would be willing to pay for the portion of thermal energy produced from a green or renewable source?

#	Answer	%	Count
1	Less than 5% more	62.5%	10
2	5-10% more	37.5%	6
3	10-20% more	0.0%	0
4	Greater than 20% more	0.0%	0
	Total	100%	16

Q8.2 - How familiar are you with the design and operation of a microgrid?

#	Answer	%	Count
1	Extremely familiar	0.0%	0
2	Very familiar	12.5%	2
3	Moderately familiar	18.8%	3
4	Slightly familiar	31.3%	5
5	Not at all familiar	37.5%	6
	Total	100%	16

Q8.3 - What is your impression of a microgrid's potential usefulness to your firm?

#	Answer	%	Count
1	Extremely useful	0.0%	0
2	Very useful	20.0%	2
3	Moderately useful	10.0%	1
4	Slightly useful	60.0%	6
5	Not at all useful	10.0%	1
	Total	100%	10

Q8.4 - Please indicate reasons why you think a microgrid may be useful to your firm. (Select all that apply).

#	Answer	%	Count
1	Fewer power outages	55.6%	5
2	Recover more quickly from power outages	55.6%	5
3	Improvement to quality of electricity	66.7%	6
4	Reduction in total cost of energy (thermal and/or electricity)	88.9%	8
5	Reduction in emissions	66.7%	6
6	Other (Please explain)	0.0%	0
	Total	100%	9

Q8.5 - Assuming that all other considerations were equal, which of the following average "all in" prices (cents per-kWh) for electricity that included 99.999% uptime would provide a significant inducement for your company to locate or expand within a microgrid?

#	Answer	%	Count
40	7 cents	25.0%	4
41	8 cents	6.3%	1
42	9 cents	12.5%	2
43	10 cents	0.0%	0
44	11 cents	6.3%	1
45	12 cents	0.0%	0
46	13 cents	6.3%	1
47	14 cents	0.0%	0
48	15 cents	6.3%	1
49	16 cents	0.0%	0
50	17 cents	0.0%	0
51	Would not consider at any price	37.5%	6
	Total	100%	16