Hidden Health Care Costs: Energy Demand for Home Medical Equipment

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ABSTRACT

Several utilities in California offer ongoing discount programs within their service territories that assist customers who use medical equipment and need financial assistance with their utility bills. This paper presents the findings from research and estimates of energy consumption of 24 different types of commonly prescribed home medical equipment. ADM researchers conducted a literature review to determine power ratings from manufacturers' specifications. A structured interview guide was used in interviewing healthcare providers to better understand home usage of routinely prescribed devices. These medical professionals provided information on the frequency (e.g., daily) and duration (e.g., minutes or hours per session) of equipment usage and when patients would typically use the home medical equipment. The power rating and operating periods of each type of equipment were used to develop an estimate of the annual energy use, which was combined with the hypothetical time-of-day (TOD) rates to demonstrate estimates of annual energy operating cost for each device.

Some patients are temperature sensitive and may require air-conditioning or may have certain medical conditions requiring controlled environment. Another objective of this research has been to determine the additional energy consumption for maintaining appropriate environmental conditions for the patients with certain medical conditions requiring space cooling and/or heating, because some utilities offer medical baseline allowance for space conditioning as well. ADM performed multiple energy simulations to estimate the energy impacts those changes in cooling and heating temperature setpoints have on residential energy use. The results are provided for several incremental changes in both cooling and heating setpoints to accommodate various environmental conditions. TOD analysis was also performed to determine the cooling and heating energy usage increase contributable to different TOD periods.

INTRODUCTION

Several utilities in California offer discount programs to qualifying customers who utilize medically necessary electrical equipment in their homes and need assistance with their utility bills. Many of these devices consume more power than what the customer normally uses. The discount rates are offered to customers who have medical conditions where their doctor prescribes a temperature setting in the home which will increase their utility cost. Typically, customers must show proof that the device is medically necessary and prescribed by a licensed healthcare professional. Eligible customers are then offered a discount on their utility bill. The main objective of this study is to assess the typical kWh usage of in-home medical equipment and associated operating costs.

This study summarizes the findings from research and estimates of energy consumption of 24 different types of in-home medical equipment that qualify for various utility discount programs (e.g., Southern California Edison, Pacific Gas and Electric, and San Diego Gas and Electric Company). ADM researchers interviewed healthcare providers using a semi-structured interview tool to gain insight about the devices they have prescribed and what time of day the equipment is typically used. The power rating and operating periods of each type of equipment were used to develop an estimated annual energy use. Power ratings came from manufacturers' specifications. The profile of the equipment energy used was combined with time-of-day rates to develop the annual energy operating cost for each device. The medical devices included in this study do not necessarily qualify for all utility sponsored programs but are common across various discount programs. The determination of what equipment qualifies for a specific program was outside the scope of this study.

Some patients may be temperature sensitive and/or have a certain medical condition that require space heating or cooling or modified thermostat setpoints to maintain appropriate environmental conditions, thus impacting residential energy consumption. ADM performed multiple energy model simulations to estimate the incremental energy impacts that changes in cooling and heating temperature setpoints have on residential energy use. The simulations for heating setpoint changes considered heat pumps only. Results are provided for several incremental changes in both cooling and heating setpoints to accommodate various environmental conditions.

For this study, two different size single family homes and a multifamily complex were modeled using eQuest simulation software. The space cooling and heating setpoints were changed in 2 °F increments to quantify the impact on energy usage and cost. The results were averaged across all types of homes.

METHODOLOGY AND DATA COLLECTION

ADM researchers estimated power consumption of medical devices that are commonly prescribed to patients for home use and included in utility sponsored programs. The research was initiated through a broad technical and product analysis. Devices that were restricted to hospital or clinic usage were not considered.

The estimated annual operating cost for each device was calculated and summarized in this study. The costs were based on hypothetical TOD rates for the purpose of calculating monthly or annual electricity costs. These rates apply to non-summer months (October 1 through May 31) and summer months (June 1 through September 30) and provide conservative cost estimates. Additionally, operating costs were calculated for hypothetical peak, mid-peak, and off-peak periods, shown in Table. The actual TOD rates may vary for different utilities.

Table 1. TOD rates used for calculating monthly/annual electricity costs

Period	$/kWh
Summer Peak	$0.30
Summer Mid-Peak	$0.20
Summer Off-Peak	$0.15
Non-summer Peak	$0.15
Non-summer Off-Peak	$0.10

In some cases, a range of estimates was computed based on different operating assumptions. In instances where manufacturers indicated both maximum and typical power consumption ratings of the device, the maximum power rating value was used for calculations. Once the power consumption rating was determined, the typical usage duration of the devices was considered to determine the annual energy consumption.

The researchers developed a semi-structured instrument, consisting of a series of questions by medical device type, to conduct interviews with various healthcare providers (medical doctors, home healthcare nurses/aides, and dialysis clinicians). The purpose of the interviews was to gain more insight about the medical equipment that utility customers may use in their homes. Medical providers were able to provide information about how often various equipment types were utilized, the duration of use, and the time of day that the equipment is used. The medical providers were consulted in determining the usage duration of each device type.

ADM developed several simulations to estimate the increase in residential energy use due to the reduction of cooling temperature setpoints and the increase of heating temperature setpoints. Certain medical conditions require specific indoor temperatures that countermand energy efficiency or conservation. The evaluators were able to simulate different scenarios to understand the various prescribed conditions. Energy simulations were run for various residential homes as described in the section titled “Residential Energy Simulations.”

In addition to the interviews and the residential energy simulation, the researchers collected information about the medical equipment commonly used by customers. Keywords like “top” and “best” were used to target the more popular models of each device using Google’s search engine. An example of the electrical specifications of each device was examined based on information obtained from specifications in an owner’s manual or operating manual found online.

MEDICAL PROVIDER INTERVIEWS

The objective of the medical provider interviews was to gather professional opinions to assess the range of hours for device usage (in particular, related to time-of-day rate periods) and low, typical, and high usage by equipment type. Medical provider interviews offered ADM with additional professional insight into how customers often use equipment in the home and the typical duration. ADM contacted various medical providers (e.g., home healthcare providers, home dialysis clinics, pulmonary medicine, etc.) to participate in interviews.

Using a semi-structured instrument, ADM conducted eight interviews with a range of healthcare providers. ADM interviewed an orthopedic surgeon, a hospice nurse, a home health nurse, a home dialysis medical technician, two pediatricians, a family healthcare provider, and a medical doctor who owns a private practice. Conducting interviews with a range of healthcare professionals provided a diversity of opinions on varying equipment types. Medical professionals were asked how often patients use the equipment (daily, weekly, as needed) and what time of day the equipment is used. ADM asked medical professionals to estimate how often customers used medical equipment during the peak, mid-peak, and off-peak hours.

Medical providers had varying experience with the medical equipment, with some indicating many patients utilizing the type of equipment being investigated or had knowledge of home usage. Commonly prescribed medical equipment for home use or that medical providers were most familiar with included oxygen support equipment, dialysis equipment, mobility equipment, and pain relief equipment. According to the interviewed medical providers, the frequency and duration that medical equipment is used is highly dependent on the condition of the patient and varies significantly. The duration that equipment is used varied from a few hours up to 24 hours per day. The frequency of equipment use varied from a few times per week up to daily, with some equipment being used on an as-needed basis. An example of this variability are patients who require dialysis or oxygen. There are two types of home dialysis patients (hemodialysis and peritoneal). The dialysis needs and usage varies making it a challenge to estimate typical usage. Some patients who require oxygen may only need it overnight while others may need oxygen throughout the day (e.g., chronic obstructive pulmonary disease, post-surgical oxygen requirements, or emphysema).

The information gathered from the medical provider interviews was used to estimate the energy consumption of the in-home medical devices. Hours per day were averaged across the various interviews for equipment that providers prescribed for patients or was familiar with home use. When estimating peak, mid-peak, and off-peak usage, ADM relied on assessments from medical professionals and/or consulted literature for internal estimates. The full range of medical equipment energy consumption is presented in the following section.

ENERGY CONSUMPTION OF IN-HOME MEDICAL DEVICES

ADM projected energy usage of medical equipment that is commonly used in residential housing environments. ADM conducted a literature review of 24 various medical devices to identify the power ratings and used the findings from the medical provider interviews on when equipment is most likely to be used and how often the patient may use the devices to estimate energy use for the TOD rate periods.

The evaluated medical devices that have in-home applications are listed in Table 2. All devices vary in size, utility and how they use energy in residential homes. Mode of operation ranges from intermittent to continuous. Power and energy consumption varied greatly by device. While some medical devices are required to stay plugged in to an electrical outlet, others need to be charged periodically. Charging duration ranged from one to ten hours depending on the device. The power rating for some devices was provided by some manufacturers. The power of other devices was calculated based on rated voltage and amps and multiplied by estimated power factor for the load type. To calculate the annual and monthly energy consumption, the evaluators considered the nature of each device by consulting literature and accounted for estimated duty cycle of the device. Based on when the energy is expected to be used and the cost of electricity by period, the annual operating cost of each medical device were calculated and are presented in Table 2. The breakdown between non-summer and summer average operating costs by device category is also included in the table.

Table 2. Electricity consumption and operating costs of medical devices

Medical Equipment	Annual kWh	Monthly kWh	Non-summer operating costs, ($/Year)	Summer operating costs, ($/Year)	Annual operating costs, ($/Year)
Aerosol Tent	1,354	113	$93.96	$79.71	$173.67
Apnea Monitor	32	3	$2.10	$1.70	$3.80
Compressors (Limb Pressure Support)	18	1	$1.27	$1.12	$2.38
CPAP Portable w/o Humidifier	79	7	$5.36	$4.53	$9.89
CPAP Standard w/o Humidifier	190	16	$12.90	$10.90	$23.80
CPAP Standard with Humidifier	248	21	$16.87	$14.25	$31.12
Dialysis Cycler Portable	1,150	96	$85.21	$75.50	$160.70
Dialysis Cycler Full Size	1,937	161	$143.56	$127.19	$270.75
Electric Spinal Cord Stimulator	32	3	$2.28	$2.04	$4.32
Electric Wheelchair	690	57	$47.04	$38.60	$85.64
Electric Hospital Bed	53	4	$3.90	$3.45	$7.35
Feeding Pump	49	4	$3.58	$3.19	$6.78
Hydroven Pump	13	1	$1.13	$1.08	$2.20
Infusion Therapy Pumps	153	13	$10.42	$8.58	$19.00
IPPB Machine	112	9	$8.29	$7.34	$15.63
Iron Lung	438	37	$30.40	$25.79	$56.18
Low Air Loss Mattress	11	1	$0.73	$0.62	$1.35
Nebulizer (Jet/Standard)	52	4	$3.62	$3.37	$6.99
Nebulizer (Ultrasonic)	9	1	$0.61	$0.57	$1.17
Oxygen Concentrator Portable	641	53	$46.27	$39.58	$85.86
Oxygen Concentrator Full Size	3,066	256	$212.78	$180.50	$393.28
Pressure Pads	12	1	$0.87	$0.73	$1.61
Respirator	357	30	$24.80	$21.04	$45.84
Suction Machine	10	1	$0.70	$0.62	$1.32

The in-home medical devices with the largest electrical demand include the full-size oxygen concentrators (3,066 kWh per year), followed by full-size dialysis cyclers (1,937 kWh per year), aerosol tents (1,354 kWh per year), and portable dialysis cyclers (1,150 kWh per year). Full-size oxygen concentrators and full-size dialysis cyclers had the highest operating costs at $393.28 and $270.75 per year, respectively. Suction machines and ultrasonic nebulizers had the lowest operating costs per year compared to all other medical equipment at $1.32 and $1.17 per year, respectively.

Of the 24 medical equipment included in this study, operating costs depend on complexity of equipment and duration of use. Estimated low, typical, and high use of the qualifying medical equipment varied based on the number of hours used per day and what time of day the equipment would most likely be in use. For example, aerosol tents ranged from $78/year for low use to $173/year for high use and an electric hospital bed ranged from $2.15/year for low use and $7.35/year for high use.

RESIDENTIAL ENERGY SIMULATIONS

Some medical conditions may require patients to use space conditioning or result in modified thermostat setpoints to maintain appropriate environmental conditions. ADM performed several simulations to estimate the impacts that changes in cooling and heating temperature setpoints may have on residential energy use. Results are provided for several incremental changes in both cooling and heating setpoints to accommodate various prescribed conditions.

The intent of a prescribed thermostat setpoint is to maintain ongoing (and constant) temperature control for chronic conditions. Therefore, each of the simulations maintained a constant temperature profile (i.e., the thermostat is set to the same temperature for all 24 hours). Six different setpoints were simulated for cooling in 2 °F decrements (i.e., 80 °F, 78 °F, 76 °F, 74 °F, 72 °F, and 70 °F) and seven were simulated for heating in 2 °F increments (i.e., 68 °F, 70 °F, 72 °F, 74 °F, 76 °F, 78 °F, and 80 °F). The weather conditions used to assess the conditioning loads were representing central California.

The buildings simulated included two different size single-family homes and a multifamily complex. These buildings were simulated at two different orientations and the results for each building type were averaged. This was done to eliminate the impact of home orientation on the simulation results.

A summary of the modeling assumptions is presented in Table 3 below. In the initial simulations, we discovered that the energy use increases between the two-story single family and single-story single-family homes was minor. Therefore, the results for single family are averaged across all of the single-family homes in the simulation model.

Table 3. Summary of model construction

Construction	Square Footage (ft^2)
Single Family (Single Story)	1,887
Single Family (Multi-Story)	2,904
Multi Family (2-Story w/ 24 units)	912 each Unit
All Single Family (Weighted Average)	2,396
All Residential	1,901

Figure 1 and Figure 2 below present the annual energy usage increases due to cooling setpoint and heating setpoint changes, respectively, which represent weighted average values for all modelled homes. It should be noted that in each case, the energy increase for different setpoints is calculated compared to the baseline, which is 80 °F for cooling and 68 °F for heating. The corresponding cost increases are shown in Figure 3 and Figure 4.

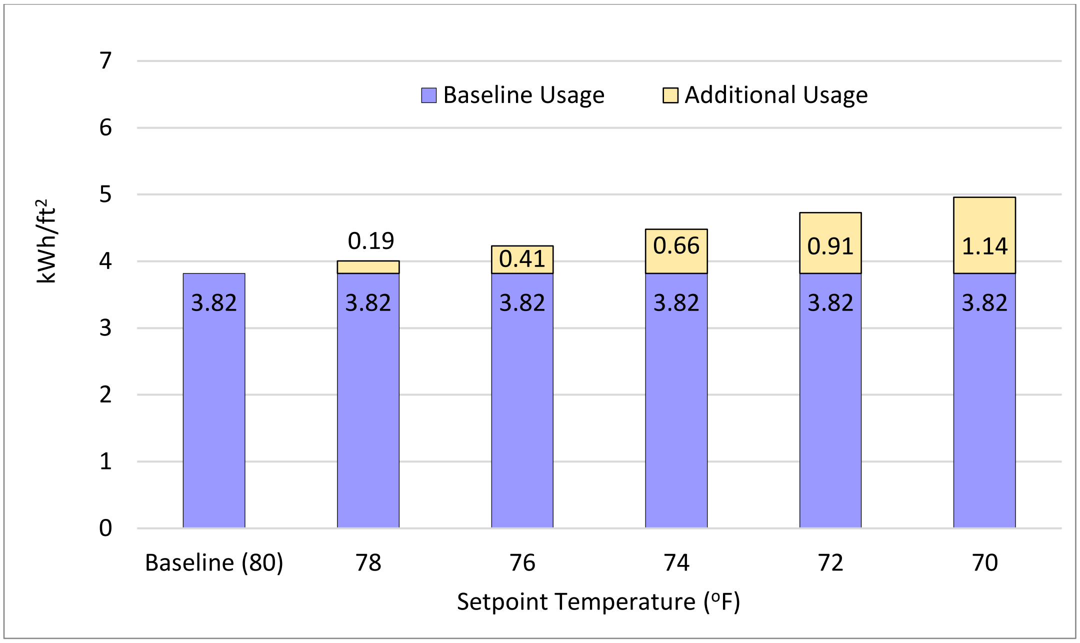

Figure 1. Estimated increase in annual energy use (kWh/ ft^2) due to changes in cooling setpoints.

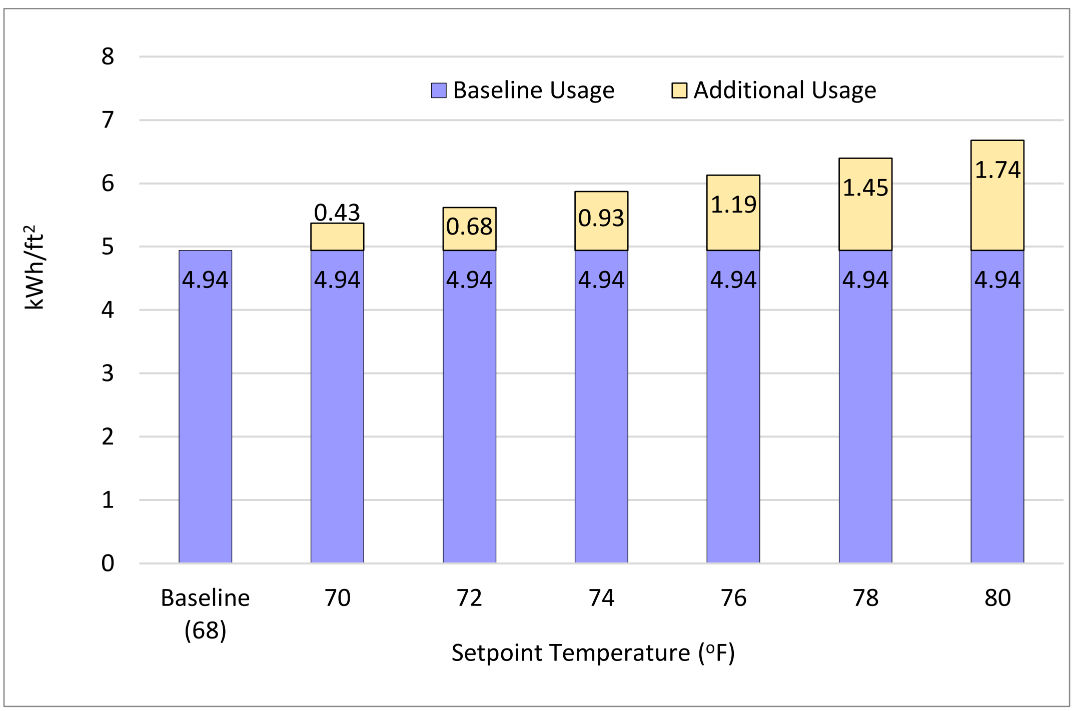

Figure 2. Estimated increase in annual energy Use (kWh/ ft^2) due to changes in heating setpoints.

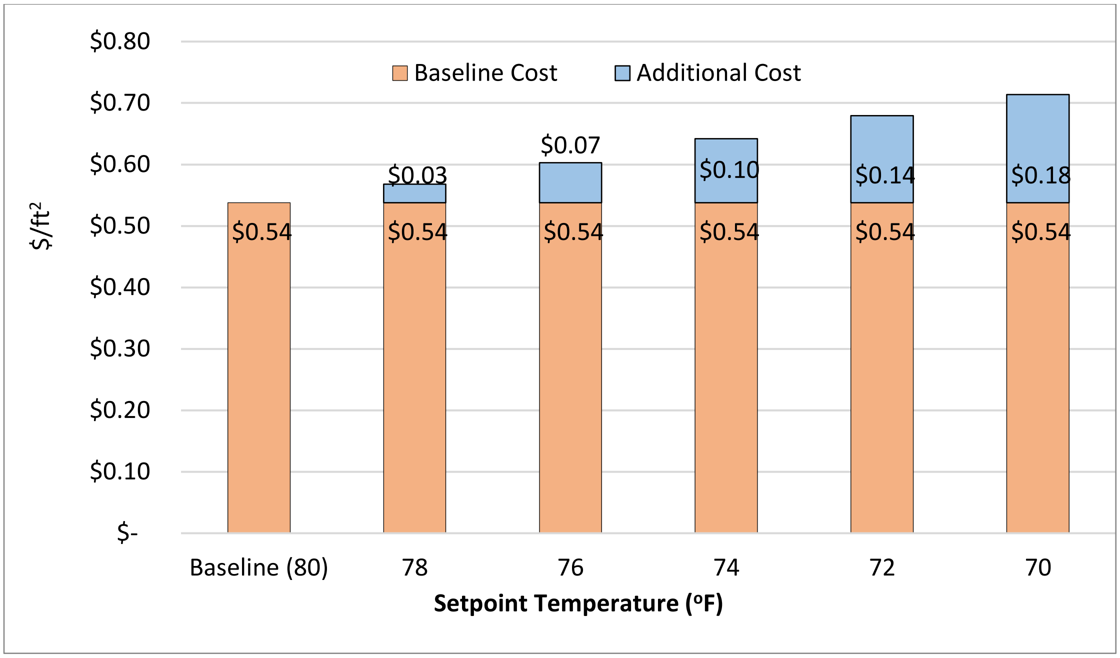

Figure 3. Estimated increase in annual energy cost ($/ ft²) due to changes in cooling setpoints.

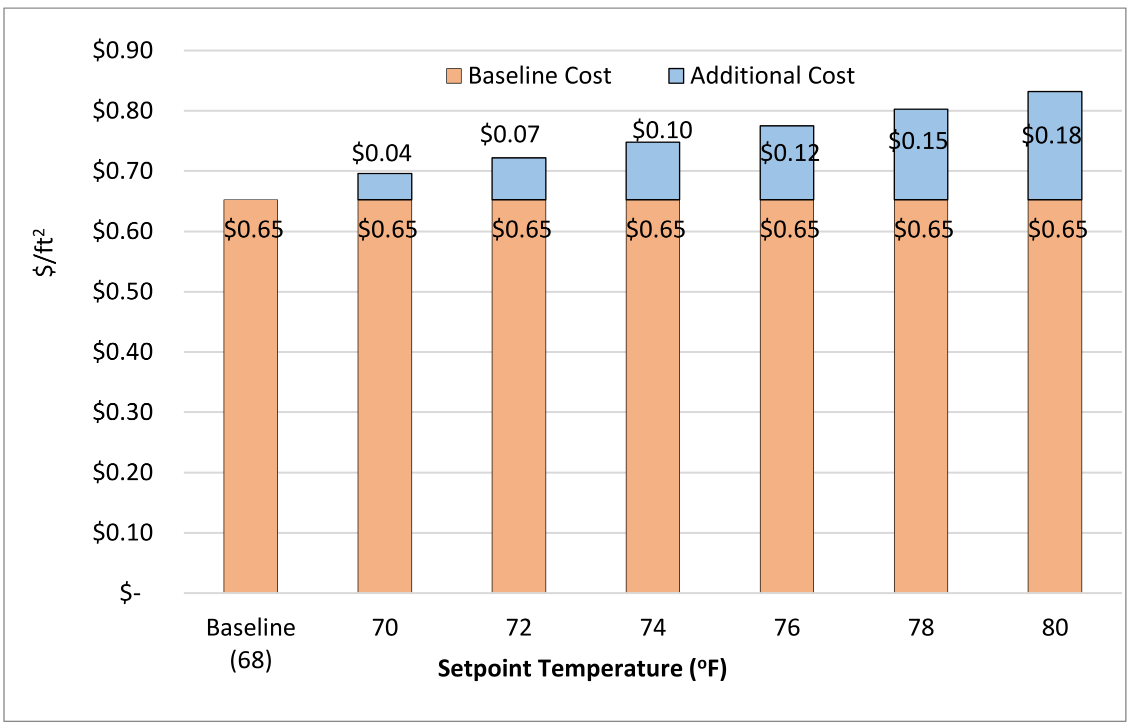

Figure 4. Estimated increase annual energy Cost ($/ ft²) due to changes in heating setpoints.

Time-of-Day Usage and Cost Analysis

The time-of-day (TOD) analysis was done using hypothetical rates, shown in Table 1 above, for the purpose of calculating monthly or annual electricity costs. The results are presented in Figure 5 through Figure 8.

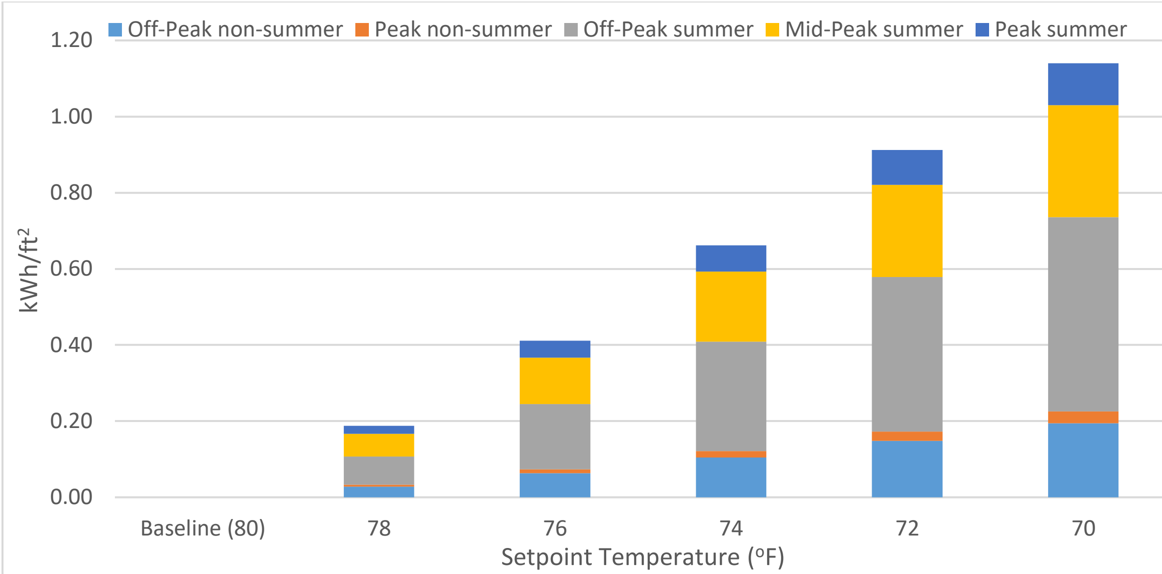

Figure 5. Estimated annual increase in energy usage (kWh/ ft^2) due to changes in cooling setpoints.

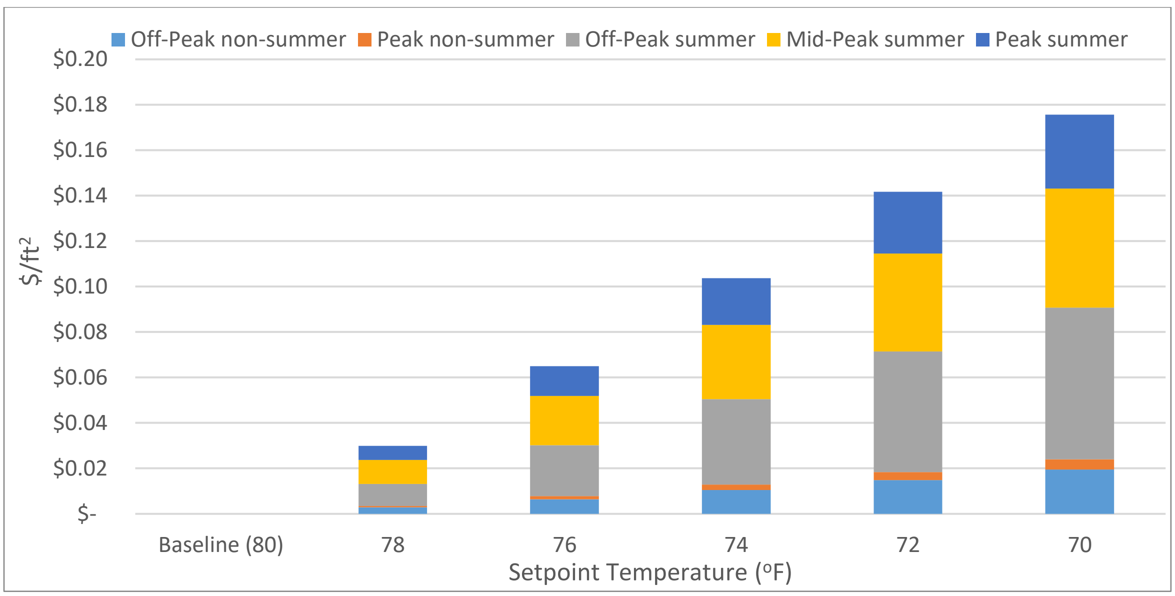

Figure 6. Estimated Annual increase in energy Cost ($/ ft^2) due to changes in cooling setpoints.

Incorporating a typical residential time-of-day rates into the analysis was the primary factor in determining energy costs impacting medical patients. The annual electric energy operating costs and typical usage for the 24 medical devices was the primary focus of this study.

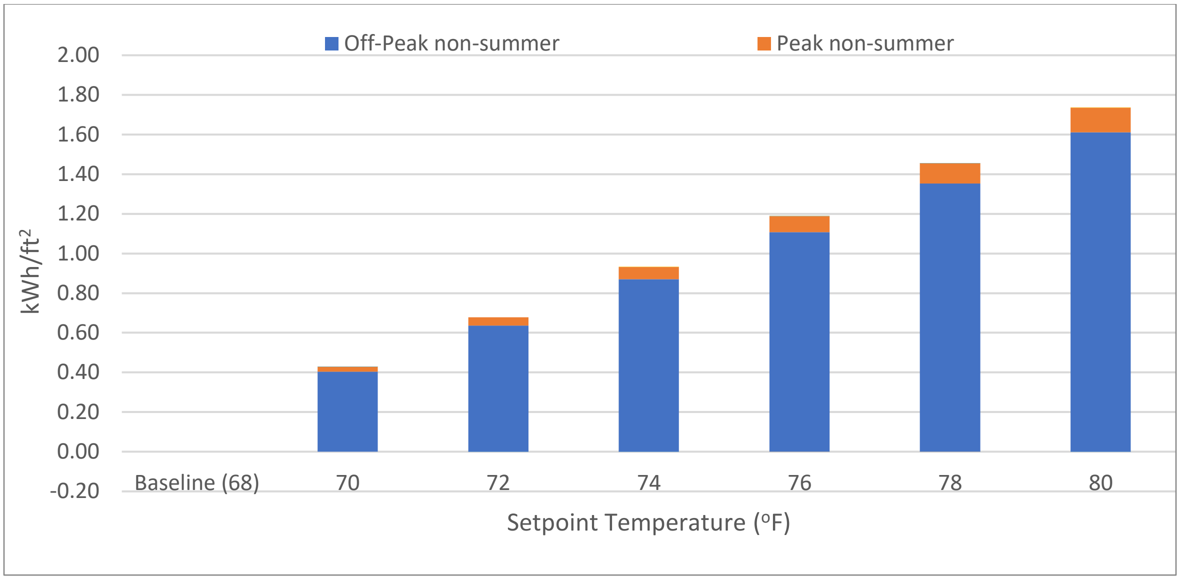

Figure 7. Estimated annual increase in (TOD) energy usage (kWh/ ft^2) due to changes in heating setpoints (weighted Average).

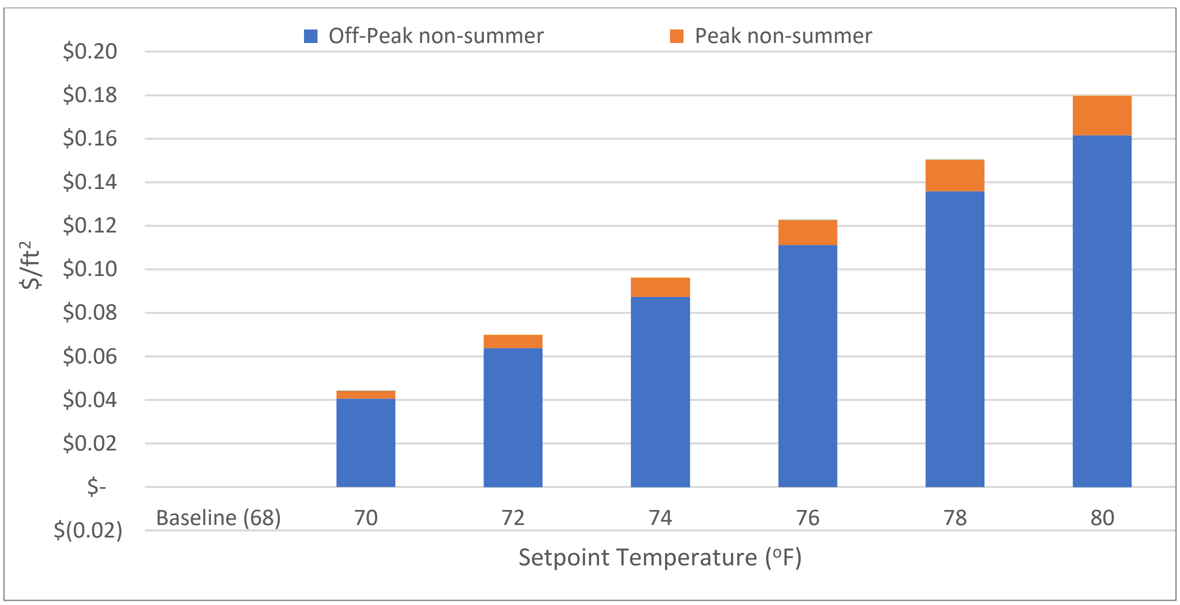

Figure 8. Estimated annual Increase in energy Cost ($/ ft^2) due to changes in heating setpoints.

The annual additional operating costs per square foot of living space for maintaining prescribed temperatures is provided in Table 4. For example, a customer living in a 1,500 square foot house whose doctor has prescribed a constant temperature of 76° F year-round will have an additional annual cooling energy operating cost of $90 per year and an additional annual heating energy operating cost of $180 per year, for a total of $270 per year.

Table 4. Additional electric operating cost per year for prescribed thermostat settings

Thermostat Setpoint	Cooling Cost Per SQFT Per Year	Heating Cost Per SQFT Per Year
68 °F	NA	$ 0.00
70 °F	$ 0.17	$ 0.04
72 °F	$ 0.13	$ 0.07
74 °F	$ 0.10	$ 0.10
76 °F	$ 0.06	$ 0.12
78 °F	$ 0.03	$ 0.15
80 °F	$ 0.00	$ 0.18

CONCLUSIONS AND RECOMMENDATIONS

This study estimated the energy consumption of 24 different types of medical equipment that are typically included in utility sponsored discount programs. To better understand the devices that are often prescribed to patients and what time of day the equipment is typically used, ADM researchers interviewed healthcare providers. Additionally, researchers developed annual energy use by collecting data from the manufacturers' power ratings and operating periods of each type of equipment. The profile of the equipment energy used was combined with time-of-day rates to develop the annual energy operating cost for each device.

The medical providers who were interviewed had differing levels of experience with medical equipment. According to the interviewed medical healthcare providers, the medical equipment most commonly used in the home included oxygenators, CPAP machines, dialysis equipment, electric wheelchairs, hospital beds, and pain relief equipment. The operating costs of the medical equipment included in this study ranged widely. The in-home medical devices with the largest electrical demand include the full-size oxygen concentrator (3,066 kWh per year), the full-size dialysis cycler (1,937 kWh per year), and aerosol tent (1,354 kWh per year). Among the 24 medical equipment that were analyzed, operating costs depend on complexity of equipment and duration of use. Estimated low, typical, and high use of the qualifying medical equipment varied based on the number of hours used per day and what time of day the equipment would most likely be in use. For example, aerosol tents ranged from $78/year for low use to $173/year for high use and an electric hospital bed ranged from $2.15/year for low use and $7.35/year for high use.

The operating costs for space cooling and heating increased as the temperature setting moved away from the recommended energy conservation setpoints. The environment control inside the home, recommended by a doctor due to a patient's certain medical conditions, may have an impact on the home's energy usage and cost. The space cooling and heating setpoints were changed in 2 °F increments to quantify the impact on energy usage and cost. The results were averaged across all types of homes. It is estimated that on average, every 2 °F reduction in cooling setpoint temperature increases the cooling energy usage by 5.4% and cooling energy operating cost by 6%. Similarly, every 2 °F increase in heating setpoint temperature increases the heating energy usage by 5.2% and heating energy operating cost by 4.4%.

The time of the day when electricity is being used for space conditioning has an impact on the energy costs to the customer. The time-of day analysis concludes that on average, about 16% of the cooling energy usage increase is contributable to off-peak non-summer, 3% to peak non-summer, 43% to off-peak summer, 28% to mid-peak summer, and 10% to peak summer period. However, that additional 10% energy use during the peak summer period costs the customer 21% of the total cost increase, due to the high rate during this period. For the heating season, 93% of heating energy usage increase is contributable to off-peak non-summer, 7% to peak non-summer, and none to other periods. The scope of this research, involving increase in energy use due to certain medical conditions, can be expanded in the future to include other climate regions in the country and actual residential billing rates for several utilities.

Additional research is needed to better assess the accuracy of operating costs for utility sponsored medical device discount programs. One consideration for similar programs would be to collect more data and information about usage from participants. This study utilized interview findings from healthcare providers to assess usage, however, patients can provide the most accurate information about what time of day they are using specific devices and the frequency. Program administrators could request that participants log their daily or weekly usage of medical equipment in a diary or online form. This type of data would be valuable to researchers and program administrators to ensure that operating costs are accurately calculated and to improve the delivery of program services to customers. Moreover, program administrators can provide educational materials to program participants about on- and off-peak hours. Discount programs offer utilities a touchpoint with customers to help them better understand how they can reduce their energy consumption when using at-home medical equipment. When feasible, patients can choose to use or charge their medical devices during off-peak hours and increase their understanding of energy usage in their homes.

Medical device programs may have broad policy implications and considerations because they provide non-energy benefits to an underserved population. As the US population ages and the burden of chronic disease grows, the use of home medical equipment will increase annually (National Resource Council, 2010). Further, the costs of healthcare are projected to increase annually in all sectors (Centers for Medicare and Medicaid Services). As such, the need for medical device discount programs may also increase. Utility companies who sponsor medical device discount programs may consider working with their local and state health authorities to explore partnership opportunities to increase awareness of such programs and improve outreach to underserved communities. Additionally, there may be opportunities to increase funding for the programs and increase participation through Medicaid waivers or other state-sponsored programs.

Utility companies who offer medical device discount programs benefits customers who use medical equipment and need financial assistance with their utility bills. These types of programs offer a valuable service to customers who may struggle to pay the increased costs associated with the equipment. Medical device discount programs can improve customer relations by offsetting increasing healthcare costs for underserved populations.

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