City of North College Hill Strategic Energy Plan

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OKI REGIONAL COUNCIL OF GOVERNMENTS

Greater Cincinnati Energy Alliance

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Table of Contents

1. Purpose of Energy Planning

Energy planning investigates issues centered on energy use and delivery in the community; identifies how these issues intersect with land use patterns and transportation choices; and formulates strategies to improve the efficiency of energy use in the community. Energy planning at the local level becomes the convergence of planning for many other issues. Energy planning and initiatives have a large role in quality building standards; emergency management planning (since most community –wide emergency events involve the disruption of power delivery); facility cost and fiscal projections; air quality; and land use.

This Energy Plan was produced through the efforts of the Ohio Kentucky Indiana (OKI) Regional Council of Governments and the Greater Cincinnati Energy Alliance in collaboration with the City of North College Hill. This planning effort was funded through the Duke Class Benefit Fund with the aim of bringing about improved energy efficiency in southwest Ohio.

The goals and objectives included in this plan were drafted in consultation with city officials after reviewing the information included in the associated chapters. A draft version of these goals was posted on the Community Energy Plan website at energy.oki.org.

This plan will serve to organize action by North College Hill, its residents, and businesses to meet the stated goals. This plan should be evaluated periodically to ensure the proposed actions are bringing the desired outcomes, and the stated goals remain relevant to the overall needs and desires of the community.

2. Overview of the North College Hill Energy Plan

The North College Hill energy plan and its associated goals are based on data driven research and the input of city officials. The following mission statement was used to guide the development of the plan:

Mission Statement

The City of North College Hill strives to be a community of well-maintained neighborhoods, which are energy efficient, sustainable, affordable, and attractive for residents and businesses.

With the mission in mind, the following goals were developed for the North College Hill Energy Plan.

Energy Plan Goals

Goal 1	North College Hill will reduce energy consumption in city owned buildings by 10 to 25 percent by identifying and implementing energy and cost saving opportunities.
Goal 2	North College Hill will take simple steps to educate its residents and businesses about the benefits of energy efficiency.
Goal 3	North College Hill will take steps to ensure that zoning regulations and infrastructure projects take energy related issues such as urban heat island, transportation, and other emerging energy topics into consideration.

Strategies

The North College Hill Energy Plan recommends implementing the following strategies to achieve the goals of the plan and to ensure that it becomes an energy efficient, sustainable, affordable, and attractive community for residents and businesses.

Residential Strategies

1	Educate residents about the benefits of installing energy efficiency improvements.
2	Connect low-income residents with information about programs that can assist them with installing energy saving improvements or addressing high energy bills.
3	Develop explicit zoning code language that promotes the placement or use of roof mounted solar arrays.

4	Work with the local business community to identify potential locations for electric vehicle charging stations.

Commercial, Industrial, and Government Strategies

1	Monitor energy usage at city owned facilities.
2	Install energy efficiency improvements at city facilities that provide operational benefits and a return on investment.
3	Explore the benefits of creating an electric and natural gas aggregation program for residents.
4	Contact Duke Energy to determine the costs associated with upgrading the existing streetlights to LED.
5	Work with neighboring governments to create or join an ESID to allow commercial properties in North College Hill to take advantage of PACE financing.
6	Update zoning regulations to require trees in and around parking lots at the rate of one tree for every 5-10 parking spaces.

3. Energy Consumption

A major component of a community energy plan is understanding how much energy the community uses, who is using it, how it is being used, and how much it costs. This information can inform priorities when deciding between efficiency initiatives that target different users while also serving as a baseline to measure the impact of future energy efficiency initiatives in the community.

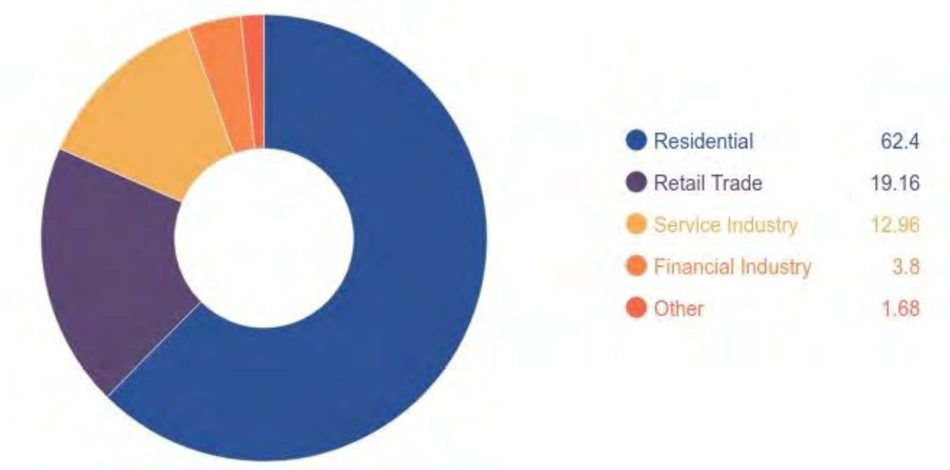
Residential and commercial structures in North College Hill consumed over 490 million kBtus of energy from Duke Energy in 2016 at a total cost of over $8.8 million.[1]

Figure 1: Total Energy Consumption and Cost 2016

	Amount Consumed	Cost
Electricity	53,315,408 kWh	$5.82 million
Natural Gas	3,017,993 CCF	$2.99 million

The residential sector accounted for 62 percent of electricity consumption from Duke Energy in 2016 while the commercial and industrial sectors accounted for 38 percent. Residential usage is likely to remain the largest consumer of electricity in the future even if its overall share of usage declines.

Figure 2: North College Hill Electricity Consumption by Sector, 2016

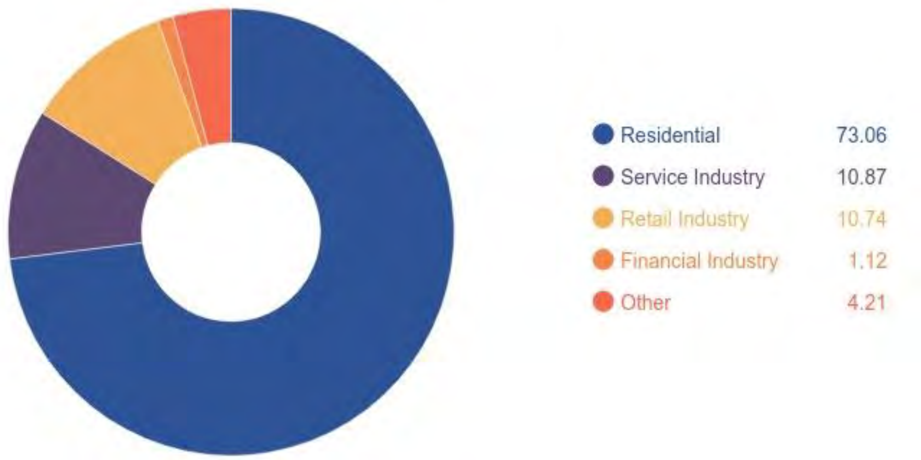


Natural gas is used for space heating, water heating, and some manufacturing processes. In 2016, the residential sector accounted for 73 percent of natural gas consumption while the commercial and industrial sectors accounted for 27 percent. The portion of natural gas usage attributable to the residential

[1] This figure does not include the costs associated with fuel sources such as propane and fuel oil.

sector will likely continue to dominate natural gas usage in North College Hill given the composition of the commercial and industrial sector.

Figure 3: North College Hill Natural Gas Consumption by Sector, 2016



Residential Energy Use

Residential energy use depends on the energy consuming devices used in the home and the efficiency of those devices. Electricity and natural gas are the most-consumed energy sources in residential buildings throughout North College Hill. Figure 4 shows the amount of energy consumed by North College Hill residents and the estimated total cost by energy source. The estimated total annual energy cost of Duke Energy residential customers is $6.1 million and equates to an average cost of $655 per capita or $1,553 per household. Improving the energy efficiency of residential buildings by an average of five percent could save North College Hill residents over $305,000 annually based on 2016 utility rates.

Figure 4: Residential Energy Consumption and Cost[2]

	Amount Consumed	Cost
Electricity	33,271,227 kWh	$4.13 million
Natural Gas	2,204,864 CCF	$1.97 million

Space heating accounts for the largest share of energy use in residential buildings. Natural gas is the most common source of fuel for heating residential buildings in North College Hill followed by electricity.

[2] Duke Energy, 2016

Figure 5: **Residential building fuel consumption by end use.**[3]

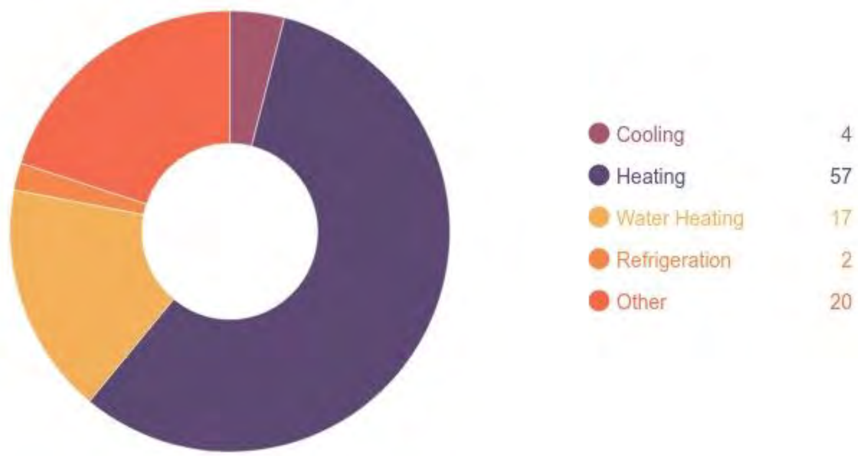


Figure 6 provides a snapshot of residential energy consumption in the community relative to three nearby peer communities (Silverton, Deer Park, and Newtown) that the U.S. Department of Energy has classified in the same population cohort. North College Hill residents appear to consume slightly more electricity per household, but slightly less natural gas per household than the weighted average of the other communities.

Figure 6: **Annual Residential Energy Consumption and Costs, 2016.**[4]

	North College Hill	Peer Communities
Average kWh per household	10,190	10,045
Average annual electricity cost per household	$1,200	$1,185
Average CCF per household	528	576
Average annual natural gas cost per household	$650	$706

Commercial and Industrial Energy Use

Commercial and industrial buildings range in size from small storefronts to larger industrial and retail facilities. In general, commercial and industrial buildings have an energy profile like that shown in Figure 7. However, the actual profile will vary depending on the type of facility.

[3] U.S. Energy Information Administration, 2015
[4] U.S. Department of Energy, 2016

Figure 7: **Commercial building fuel consumption by end use.**[5]

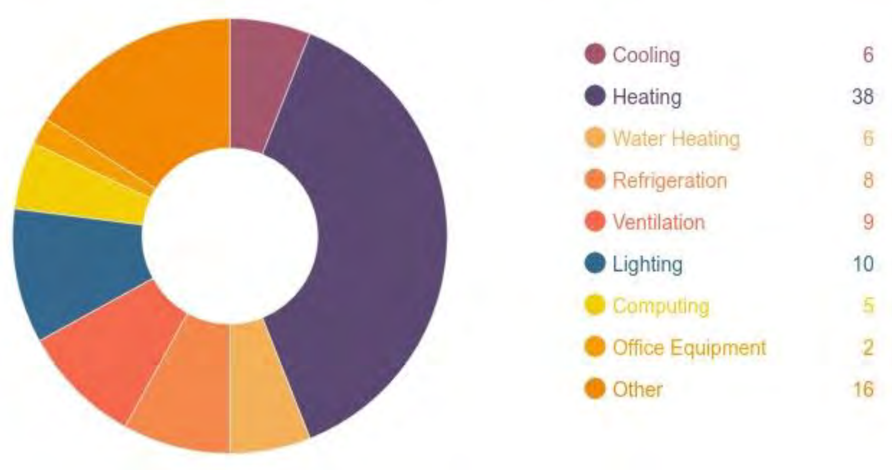


Figure 8 provides a snapshot of commercial and industrial energy consumption in the community relative to the weighted average of several nearby communities (Deer Park, Newtown, and Silverton) that the U.S. Department of Energy has classified in the same population cohort. Commercial and industrial buildings in North College Hill consume almost twice as much electricity and natural gas per square foot as the weighted average of its local peers.

Figure 8: **Commercial and Industrial Energy Consumption and Costs, 2016.**[6]

	North College Hill	Peer Communities
C&I building area (square feet)	1,139,263	927,389
Average kWh per square foot	33.43	17.95
Average CCF per square foot	1.14	0.67

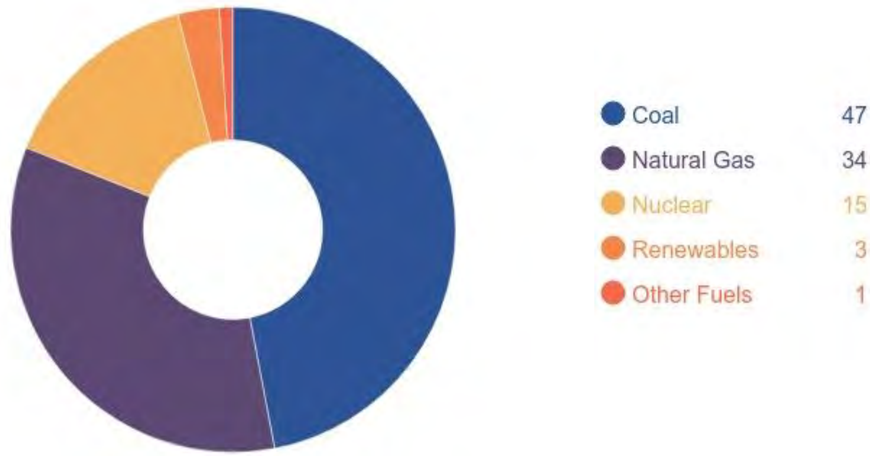
Green House Gas Emissions

Greenhouse gases are gases that emit radiant energy in the Earth's atmosphere and contribute to changes in global temperatures. There are several different greenhouse gases released into the atmosphere including carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O).

The amount of greenhouse gases produced by a community can be traced in part to how its electricity is generated. In Ohio, most of the electricity is generated by coal-fired power plants. Coal plants in Ohio are gradually being replaced by power plants fueled by natural gas which have lower greenhouse gas emissions. A 2014 study by the National Oceanic and Atmospheric Administration found that power plants fueled by natural gas release approximately 40 percent less carbon dioxide than coal-fired plants.[7]

[5] U.S. Energy Information Administration, 2012
[6] U.S. Department of Energy, 2016
[7] de Gouw, J. A., Parrish, D. D., Frost, G. J. and Trainer, M., 2014

Figure 9: **Ohio Electricity Sources, 2018**



The residential and commercial and industrial sectors in North College Hill emitted 76,013 metric tons of greenhouse gases in 2016. This figure includes emissions from electricity production as well as from the burning of natural gas for heating or industrial processes. Figure 10 shows greenhouse gas emissions by source in 2016 for North College Hill as compared to the weighted average emissions of three other communities in the region (Deer Park, Newtown, and Silverton).

Figure 10: **Annual Greenhouse Gas Emissions by Source (metric tons), 2016**

Source	North College Hill	Peer Cities (Avg)
Residential	41,936	22,695
Commercial and Industrial	34,077	14,344
TOTAL Emissions	76,013	37,039
Emissions per Household	18.46	16.84

North College Hill emits more total greenhouse gas than its peers. However, this is not surprising given that the city has a much larger population and a commercial and industrial sector that consumes more energy than the peer communities. To account for the difference in population size, emissions can be viewed from a household level. Based on total annual greenhouse gas emissions per household, North College Hill emits 1.6 metric tons more per household than the weighted average of the peer communities.

4. Transportation, Land Use, and Food Waste

Transportation

Measuring the use of energy for transportation for a local community is a very difficult task. This plan looks to data regarding means of transportation to work gathered by the U.S. Census Bureau as part of the American Community Survey. This data is available for any local political jurisdiction, can be tracked for changes over time, and can be compared with other communities. The peer communities chosen for this comparison are Springfield Township, Mount Healthy, Sharonville, and Reading.

The percentage of workers living in a community who opt to commute in a way which saves energy – by carpooling, riding the bus, biking, walking, or working from home is used as an indicator of the efficient use of energy for transportation. It should be recognized that some workers may commute to work via the above means for reasons other than conserving energy. However, these means of travel are more energy efficient than commuting to work alone in a car.

Figure 11: **Means of Commuting to Work**

	North College Hill	Peer Communities	Hamilton County	Regional Average
By Car	88.5%	92.5%	87.8%	90.8%
Carpooling	9.6%	9.5%	8.0%	8.0%
Public Transportation	6.4%	1.9%	3.8%	2.0%
Walking	1.3%	1.7%	2.9%	2.1%
Bicycle	0.4%	0.1%	0.3%	0.2%
Work from Home	1.7%	3.4%	4.5%	4.2%

As shown in Figure 11, most residents commute alone in their personal vehicles. It is notable that North College Hill has fewer residents commuting by car than the peer communities. The city is about even with peer communities for commuters who carpool.

North College Hill performs better than its peers in public transportation use. The city is served by Routes 15X, 17, and 41. The 15X and 17 routes provide service to downtown Cincinnati, while route 41 is an East-West connector. This relatively high degree of service attracts higher ridership than its peer communities.

Walking and biking comprise a very small percentage of the city's means of commuting to work. North College Hill residents are more likely to bike than its peers. However, the city's residents are less likely to walk than the group of peer communities, the county, or region. North College Hill is a very walkable community, and the school district is an all-walking district. Contributing to the relatively low percentage of commuters who report walking to work is that only 6.7 percent of city residents who work, do so in North College Hill.

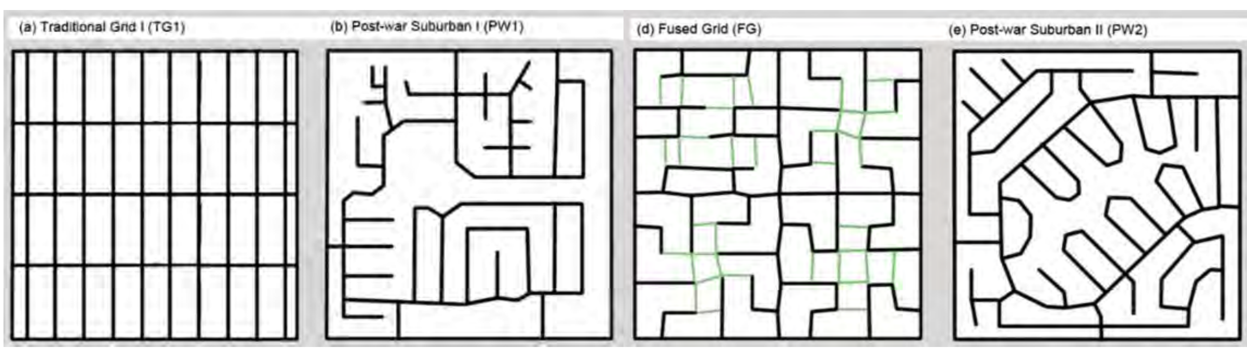
Land Use

With transportation comprising a significant percentage of a community's energy usage, designing roads that accommodate pedestrians, bikes and buses provides an energy saving alternative to cars. Walking for short trips reduces the amount of air pollution and is a good form of exercise. Patterns of development and existing infrastructure can promote walking as an alternative to car travel. A summary of the ample benefits of a capable sidewalk network are listed below.

- Increases the opportunity for physical activity thus positively impacting public health by combating inactivity.
- Increases property values.
- Forges a better sense of community.
- Improves air quality and decreases energy use by reducing vehicle trips.

The advent of the automobile and post-war development changed the complexion of American streets. The traditional grid pattern is now typically reserved for high density areas while suburban developments adopted patterns similar to (b) and (e) below.

Figure 12: **Residential Development Patterns**[8]



All four patterns have a direct impact on the daily decisions of travel. The decision between walking versus driving us dependent on multiple variables such as distance and traffic volume. Both post-war development models (b and e) prioritize car travel over walking. There are limited incentives for pedestrians in these patterns. The fused grid pattern (d) incentivizes walking by providing more direct routes for pedestrians. The fused grid also maintains the suburban hierarchy of cul-de-sacs and collectors for cars.

North College Hill's neighborhoods and street pattern is largely fixed in place. One potential opportunity to put these ideas into practice would be if any of the commercial buildings along Goodman Ave were to be redeveloped into residential housing.

[8] Jin, Xiangbing and White, Roger

Urban Heat Island Effect

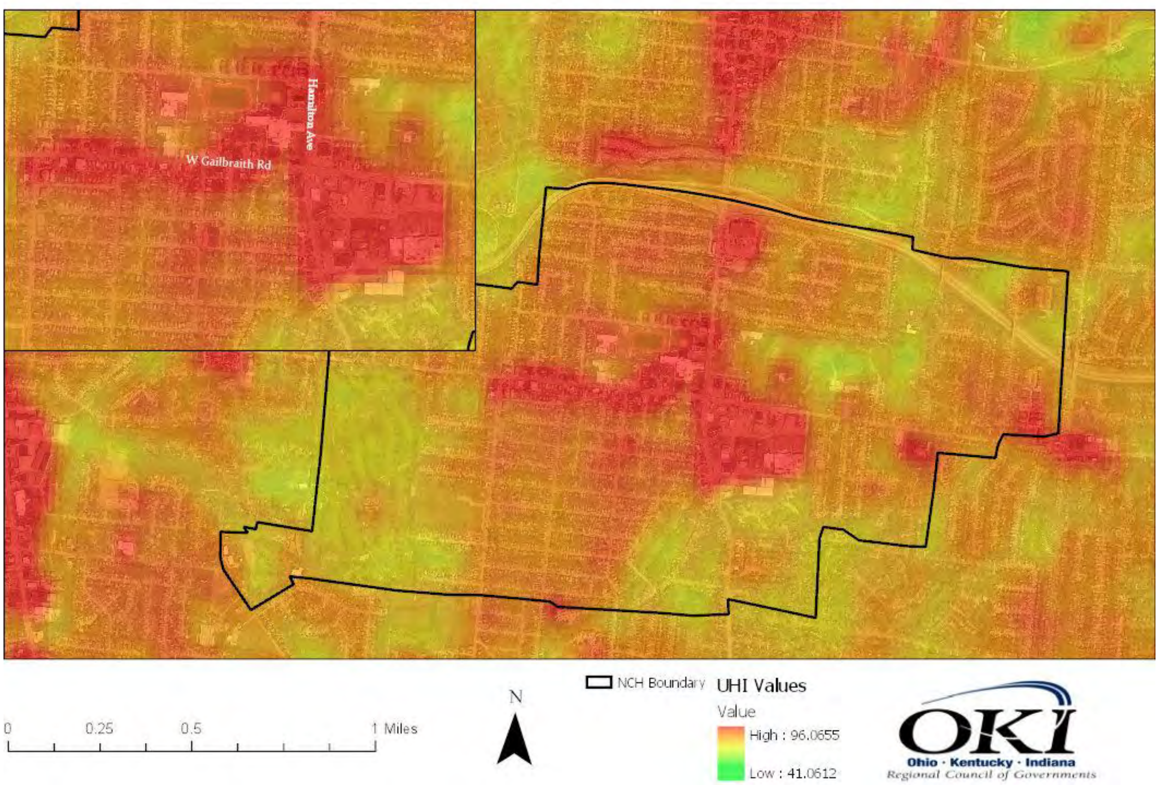
Asphalt streets, parking lots, and large black roofs absorb heat from the sun during the day, and release that heat at night, keeping temperatures higher during the summer. In urbanized areas, this creates a dome of hot air that causes air conditioners to run harder and longer – called the urban heat island effect. Impervious surfaces that contribute to increased heat values include:

- Dark roofing material
- Parking lots
- High concentration of buildings
- Lack of tree canopy

The urban heat island phenomenon impacts energy use, particularly in the summer months, when air conditioners are forced to run more often, and for longer periods of time due to the increased air temperatures.

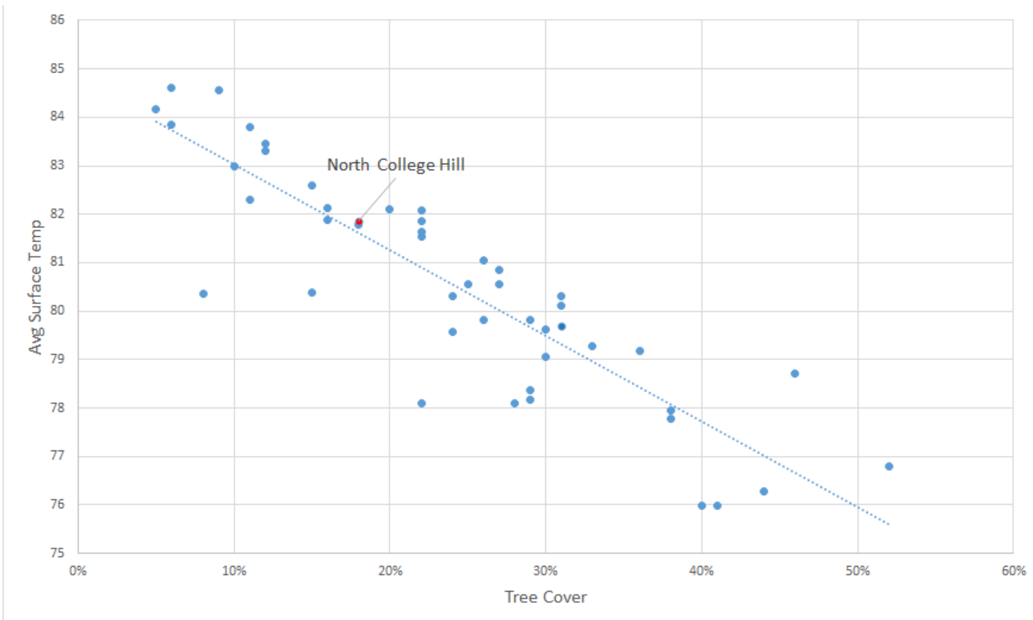
The impacts from the urban heat island effect are extremely high in North College Hill. As shown in Figure 13, the UHI values are toward the upper end of the spectrum throughout the city. They are extremely high along the West Galbraith Road and Hamilton Avenue corridors where there are large commercial buildings. The other hotspots are the parking lot surrounding the Lifespring Christian Church as well as the Four Worlds Apartments.

Figure 13: North College Hill Urban Heat Island Analysis



Tree canopy is shown to be the strongest determinant of the heat island effect's impact on a community. The higher the percentage of tree canopy, the lower the surface temperatures found within the community. Figure 14 shows this relationship for municipalities in Hamilton County. North College Hill has less than 20 percent tree cover and an average surface temperature of approximately 82° Fahrenheit. This places it in the bottom third of Hamilton County municipalities.

Figure 14: Average Surface Temperature in Hamilton County Municipalities



It is also important that the tree canopy be located strategically near buildings, parking lots and roadways, as these development features have some of the largest impacts on the heat island effect. With their shade, trees can significantly reduce the amount of heat these features absorb during the day and lessen their heat island impact.

Zoning regulations play a key role in mitigating the heat island effect. Many communities require developers to place trees in and around new parking lots for aesthetic reasons. However, these trees also provide shade to the parking areas and lessen the development's contribution to the heat island effect. Street tree requirements perform the same functions, shading the streets throughout the day, improving aesthetics, and providing more pleasant conditions for pedestrians.

Currently, the City of North College Hill does not require parking lot trees or street trees as part of new development. The only requirement that provides any opportunity for trees in non-residential development is the requirement in the B-1 and B-2 districts that caps impervious surface coverage on lots at 90 percent. The B-3 district allows 100 percent impervious surface coverage. Commercial lot sizes in North College Hill are generally small so giving up space in parking lots for trees seems like a big sacrifice. However, the aesthetic and energy saving benefits of the trees are also good for the local business community and may outweigh the benefits of a few extra parking spaces.

Most zoning codes in the Greater Cincinnati area require trees in and around parking lots at the rate of one tree for every 5-10 parking spaces. It is recommended that North College Hill conduct an analysis using several commercial lots in the city to test which rate of required parking lot trees creates the best results. The redevelopment of the big box retail along Goodman Ave. also presents an opportunity to incorporate the use of trees and landscaping in the development plan.

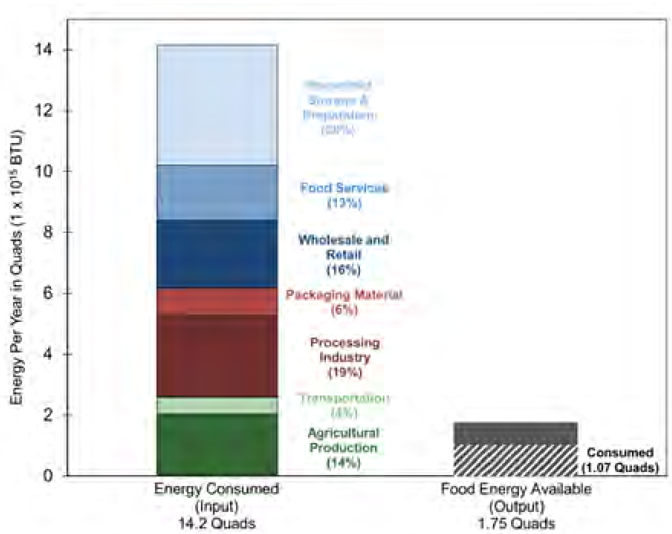
Street trees were added along the Galbraith Rd. corridor west of Hamilton Ave. in the early 2000s. This was accomplished by reducing travel lanes to one lane in each direction while adding tree islands and permanent on-street parking in the curb lanes. Redevelopment along Goodman Ave. presents another opportunity to provide street trees in the community.

Food Waste

While it might be difficult to see the connection between food and energy, food is the physical manifestation of many layers of added energy. Food must be grown or raised, processed and/or packaged, transported and distributed, adding more layers of energy. According to the USDA, food related energy use accounts for nearly 16 percent of total energy use in the United States. It takes over eight calories of energy to deliver one calorie of food to the customer. Some products, like beef, requires ten times as much energy.

With so much energy required to produce food in the U.S., it should be viewed as a precious commodity. However, estimates show that about 40 percent of the food produced is wasted.[9] Some of this waste occurs as a byproduct of food processing, bulk storage, or transportation before it reaches store shelves. Unfortunately, most of the waste can be attributed to food bought by consumers that is thrown away instead of eaten.[10] Accounting for waste, we spend 14 times more energy producing food than we derive from it.

Figure 15: Energy Flow in the U.S. Food System



Food waste is the single largest component going into municipal landfills, composing 22 percent of total municipal solid waste generated.[11] Once it reaches the landfills, food waste begins to decompose and create methane gas. Food waste is responsible for eight percent of global emissions of this potent greenhouse gas. If food waste was a country, it would rank third in the world for GHG emissions behind China and the United States.[12]

[9] National Resource Defense Council
[10] Buzby, Jean C., Hodan F. Wells, and Jeffrey Hyman. 2014
[11] U.S. Environmental Protection Agency. 2015
[12] Food and Agriculture Organization of the United Nations. 2015

There are simple actions that can be taken to reduce the energy impact of food and reduce the amount of food waste.

Eat Local
Food products in the U.S. travel increasingly long distances before they land on the shelf in the local supermarket. Buying locally grown produce can save a significant amount of energy through cutting transportation.

Eat Less Meat
A meat-based diet (28 percent of calories from animal products) uses twice as much energy to produce as a vegetarian diet.[13] Also, meat and dairy products are among the highest contributors to food waste in production and spoilage.

Eat Organic
Organic produce does not use chemicals that require lots of energy to produce.

Use Less Refrigeration
Home refrigeration accounts for 13 percent of the total energy cost used by the U.S. food system.[14] Processed and convenience foods typically require refrigeration, but whole foods, like beans, rice, produce, and cereals do not.

Reduce Waste
Most household food waste is due to spoilage. This can be avoided by buying smaller amounts, planning meals, and freezing or canning extra produce. Also, most discarded foods are still safe to eat, but are tossed due to confusion over “sell by” or “use by” dates.[15]

Even with careful planning, excess food still occurs. The diagram below illustrates the hierarchy of preferred ways to dispose of excess or spoiled food.

Figure 16: **Food Recovery Hierarchy**

[13] Heller, M. and Keoleian, G. 2000
[14] Center for Sustainable Food Systems, University of Michigan. 2018
[15] U.S. Department of Agriculture Economic Research Service. 2016

5. Utility Aggregation and Energy Resiliency

Duke Energy Ohio is the utility responsible for the delivery of electricity and natural gas services for residents and businesses in North College Hill. It is responsible for maintaining the electric and natural gas infrastructure that delivers energy throughout the city. However, residents and businesses can choose their own energy provider. This section reviews how North College Hill can educate its residents and businesses about their utility bill and how it can use utility aggregation to secure a competitive electricity and natural gas rate for its residents. It also provides an overview of different considerations related to the resiliency of the energy grid.

Understanding Energy Usage

One key component to helping residents understand the benefits of energy efficiency is equipping them with the skills necessary to read their monthly utility bill. The ability of residential and commercial utility users in Ohio to select their own energy suppliers has resulted in an influx of companies trying to obtain new customers. In some cases, companies offer very low energy rates that either are accompanied by a hefty monthly fee or escalate rapidly over time. Customers that do not read the agreement closely and do not know how to read their utility bill may find that they are ultimately paying more per kWh of electricity or CCF of natural gas than they were with their previous provider.

As the local utility provider responsible for the delivery or transmission of electricity and natural gas in North College Hill, Duke Energy is also responsible for billing customers. It has a number of resources on its website to help customers understand how to read their utility bill.[16] A sample Duke Energy bill highlighting the key places to review is also provided in Appendix A. By knowing the correct place to find the rate that they are paying for natural gas or electricity, customers can determine if they are paying more than the local "Price to Compare" rate. In addition, the Public Utilities Commission of Ohio's "Energy Choice Ohio" website at www.energychoiceohio.gov allows customers to compare the rates and programs offered by different electricity and natural gas suppliers operating in their area.

Utility Aggregation

Ohio's deregulated energy market enables property owners to select their own electricity and natural gas providers. Communities are permitted to aggregate their residents together to buy electricity and/or natural gas as a group to gain buying power in the marketplace. According to the Public Utilities Commission of Ohio, North College Hill does not offer an aggregation program to its residents.

Ohio law allows local governments to create a utility aggregation program using either an opt-in or opt-out methodology. The opt-in program allows each resident to sign up individually for the aggregation program created by the local government. The local government must hold a minimum of two hearings on the program and pass a resolution supporting its creation. This type of aggregation program often results in minimal savings to residents because the program does not have an established pool of participants to increase its buying power.

An opt-out program requires voter approval to implement and often results in lower utility rates because all residents in the community are automatically enrolled in the program. This type of aggregation program must be approved by a majority of voters in the community during a primary or general election.

[16] Information on reading your utility bill can be found at https://www.duke-energy.com/home/billing/reading-your-bill

Once approved by voters, the local government must hold two public hearings to review the aggregation program. Once the local government has adopted the plan, residents must be notified that they will be automatically enrolled in the aggregation program unless they elect not to participate. This notification must also state the rates, charges, and other terms and conditions of enrollment in the program.[17]

Regardless of the type of aggregation program that North College Hill may decide to implement, it is important to educate residents about the program and its benefits. Information about the program should appear on the city's website and in other government communication channels such as newsletters or social media. Residents that want to determine if they can save money by opting out of any future aggregation program offered by North College Hill should visit the Public Utilities Commission of Ohio's "Energy Choice Ohio" website at www.energychoiceohio.gov. The website allows users to compare the rates and programs offered by different electricity and natural gas suppliers operating in their area.

Energy Resiliency

Resiliency is how susceptible a community is to threats, and how capable they are in overcoming threats when they do occur. One of the factors that goes into determining a community's resiliency is the condition of its energy infrastructure. North College Hill has an above ground electrical infrastructure, although some below ground infrastructure may exist.

There are several types of events that may test the resiliency of the energy infrastructure. The most common are weather events, such as wind and ice events, that can impact above-ground power and communications networks.

There are three primary components to a resilient energy system: prevention, recovery, and survivability.[18]

Prevention
This focuses on preventing damage to the distribution system. Damage can occur in numerous ways, including from weather incidents or traffic accidents. The utility works to minimize the risk of damage through design standards, inspection procedures, and maintenance routines. The utility will periodically trim trees and vegetation in the vicinity of transmission or distribution lines to reduce the risk of damage in a weather event. The distribution network is designed to provide multiple pathways to deliver electricity in the event of damage to a portion of the network.

Recovery
This component centers on how the community and the utility can work together to quickly assess and repair damage to the energy utility network. In the aftermath of a major weather event that causes significant damage to the energy utility network, communication between local emergency responders and utility companies is essential to identifying and assessing locations where disruption of the network occurred and dispatching utility crews to those locations. Coordination is often required between local responders and utility crews on dealing with downed trees or accident scenes.

The Hamilton County Emergency Management Agency (EMA) maintains an emergency response plan and provides information to local governments to prepare their own emergency response plans. The county emergency response plan designates the local community as the party responsible for addressing energy related issues. It must assess local conditions, identify areas affected by shortages or outages, communicate and coordinate with utilities regarding outages and facilities of high priority, and communicate with residents and businesses. North College Hill coordinates with the Hamilton County EMA and is equipped to perform the necessary functions in the event of a significant energy outage.

[17] Public Utilities Commission of Ohio (https://www.puco.ohio.gov/be-informed/consumer-topics/governmental-energy-aggregation-local-community-buying-power/)
[18] Electric Power Research Institute (www.epri.com)

Survivability
The survivability component refers to a community's ability to continue to provide essential functions and service through an energy shortage or outage. Essential functions typically include communications, public order and safety, potable water, and essential power to certain health care facilities. The role of ensuring these core functions typically fall to local governments and institutions.

A new aspect to the survivability function involves distributed generation (privately owned solar panels and wind turbines). Most distributed generation systems are designed to shut down in the event of a power outage. This is to prevent power lines from being energized while utility crews are attempting to repair them. If certain safeguards are installed, then distributed generation systems can be temporarily isolated from the grid and used to provide power in the event of an outage to the property where they are installed.

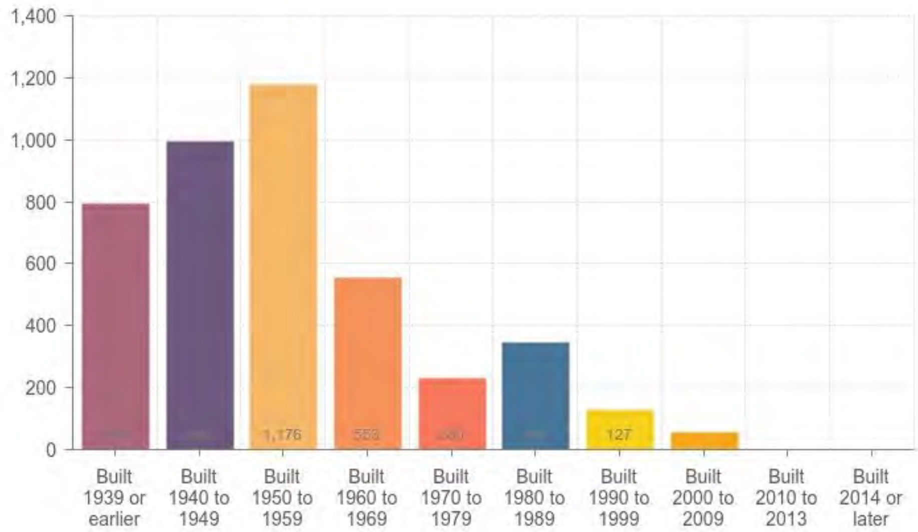
6. Residential Energy Efficiency

The City of North College Hill contains over 3,900 residential housing units according to the American Communities Survey. These buildings offer significant opportunities to reduce energy waste and save money on annual utility costs.

Residential Building Stock

North College Hill contains a diverse housing stock that has developed over time. Approximately 98 percent of residential buildings in North College Hill were built before 2000 when energy efficiency was not an integral component of construction methods. Energy code requirements for insulated windows, higher R-rated insulation in the walls and ceilings, and a tighter building envelope began after the year 2000. Appendix B shows the predominate building age type for both residential and commercial buildings.

Figure 17: North College Hill Residential Building Age by Decade Built[19]



Residential Energy Improvements

Buildings built within the same decade share characteristics that impact their overall energy efficiency. Older homes were not designed with energy efficiency in mind, so they present significant opportunities to reduce energy usage and improve comfort. A study conducted by the Joint Center for Housing Studies of Harvard University found that homes in the Midwest built prior to 1970 use 20 percent more energy per square foot than homes built since 1990.[20]

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[19] U.S. Census Bureau, 2017, *Year Structure Built (ID B25034)*

[20] Joint Center for Housing Studies of Harvard University, 2007

The amount of energy consumed by a household is determined by a variety of factors including those outlined in the table below. Energy consumption is dictated not only by the age and construction of the home, but also by the behaviors and purchasing decisions of its residents.

Figure 18: **Factors impacting household energy consumption**

Electricity	Natural gas
Square footage	Square footage
Presence and efficiency of air conditioning	Building age
Efficiency of lighting	Building envelope efficiency
Efficiency of appliances and systems	Efficiency of heating system
Occupant behavior	Occupant behavior
	Systems operation and maintenance

While elements of construction, such as insulation, are not constant among homes of the same era, they can help define the general energy efficiency of a home and dictate the type of improvements required to improve efficiency. The improvements listed below represent five of the most common energy efficiency improvements for homes in North College Hill.

Attic insulation
Older homes were not constructed with attic insulation, but small levels may be present in homes built from the 1960s onward. If old insulation is present, then it has likely lost most if not all its insulating value and should be evaluated by a professional. In homes with a Cape Cod style attic, it is important to properly insulate the attic floor, knee walls, slopes, and ceiling. ENERGY STAR recommends that attics in this region have insulation levels between R49 and R60.

Air sealing
Most older homes have significant issues with air infiltration. Special attention should be paid to sealing penetrations into the home to reduce drafts and improve comfort. Penetrations and gaps in the attic plane such as electrical boxes, plumbing stacks, ductwork, chimneys, and chases should be sealed prior to adding additional insulation. All penetrations in the foundation, including the rim joists if present, should be properly air sealed.

Heating systems
Older furnaces should be replaced with an ENERGY STAR high efficiency unit. If natural gas is not available, then an air source heat pump should be installed. Duct work should be sealed with mastic and insulated if located in unconditioned space.

Cooling systems
Many older homes did not originally have cooling systems. Ductless mini-split heat pumps provide an energy efficient alternative to a window air conditioning unit if forced air is not present. Older air conditioning units should be replaced with an ENERGY STAR high efficiency unit or an air source heat pump.

Windows
Homes built in the late 1940s through the 1950s had steel or aluminum single pane windows. Neither of these types of windows were designed to prevent air infiltration or to provide any insulation value. If steel or aluminum windows are present, the best option is to replace them with ENERGY STAR rated replacement windows. Simple repairs to older wood or vinyl windows can be made to make them

more energy efficient. Windows should be properly sealed and caulked to reduce infiltration. Storm windows should also be installed to provide additional insulating properties for some types of older windows.

Appendix C provides an overview of the different types of energy efficiency improvements needed by residential properties in North College Hill based on age.

Energy Burden

Energy burden is defined as the percentage of a household's annual gross income that goes toward payment of annual utility costs (electric, natural gas, or other heating fuel). This measure illustrates how the impact of high energy prices and inefficient housing are disproportionately felt by different population groups or households in different parts of the community. Energy costs that may be affordable to a middle-class household, may not be affordable to a low-income household. In fact, low-income households spend three times more of their income on energy bills than higher income households.[21]

$$\text{Energy Burden} = \frac{\text{Total Annual Energy Utility Spend}}{\text{Total Gross Household Income}}$$

Households that face high energy burdens experience many negative long-term economic and health related burdens. Research has found that there are three separate but interrelated consequences of energy burden: (a) illness and stress, (b) financial challenges, and (c) housing instability.[22]

Figure 19: **Drivers of household energy burden**[23]

Type of Driver	Examples
Physical	Inefficient and poorly maintained HVAC systems Poor insulation, leaky roofs, and inadequate air sealing Weather extremes that raise the need for heating and cooling
Economic	Chronic economic hardship due to persistent low income Sudden economic hardship Inability to afford the up-front costs of energy efficiency improvements
Policy	Insufficient or inaccessible policies and programs
Behavioral	Lack of access to information about bill assistance or energy efficiency programs Increased energy use due to age or disability

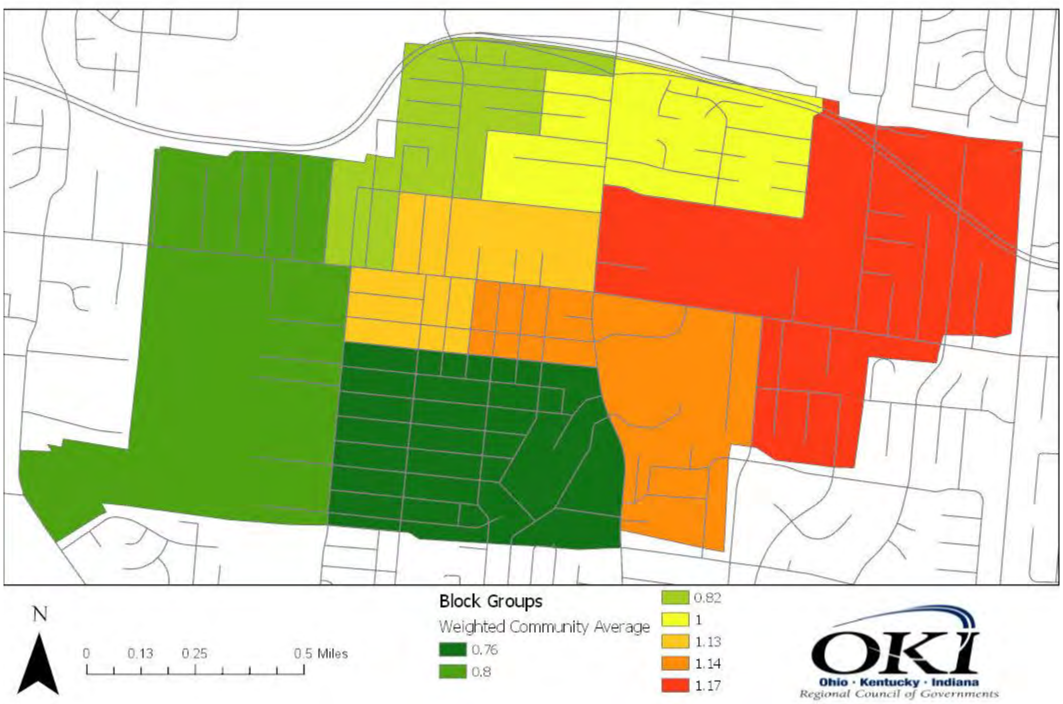
[21] Drehobl and Ross, 2016
[22] Hernandez and Bird, 2010
[23] Drehobl and Ross, 2016

Residential utility data from 2016 was obtained from Duke Energy and used to determine average annual utility cost per household at the census block group level. The utility data provided included the total number of residential accounts in each census block group as well as the total amount spent on residential utilities. In order to determine the average annual household utility cost, the total amount spent on utilities was divided by the number of accounts. The average annual household utility cost per census block group includes all applicable fees and riders as well as generation and distribution costs.

The U.S. Census Bureau's American Communities Survey was used to obtain median household income data at the census block group level. Energy burden was calculated at the census block group level by dividing the average annual utility cost per household by the median household income.

Census block groups with high energy burden levels in North College Hill are represented by the red and orange colors on Figure 20. The median energy burden across all census block groups in North College Hill is 3.73 percent. The census block group with the highest energy burden is on the eastern side of the city. It has an energy burden of 5.17 percent which is slightly below the energy poverty threshold of 6 percent. This census block group contains several large apartment complexes and single-family homes built in the 1950s. The information shown in the map can be used to guide efforts to identify areas with a high energy burden and provide them with programs that can improve energy efficiency and reduce costs.

Figure 20: Relative Energy Burden by Census Block Group



With only seven census block groups in North College Hill, the analysis of energy burden is not particularly nuanced. It is important to recognize that even if the energy burden values are below the energy poverty threshold, there are likely residents experiencing issues related to high energy burden. As a result, it is important to make residents aware of the resources that are available to assist them. The three strategies outlined below can be implemented at the local level to educate and inform residents.

Leverage community-based organizations to implement energy related programs
Low-income households nationwide may not trust government agencies, utilities, or energy efficiency contractors. It is important to work with community-based organizations that are viewed as trusted sources of information and who advocate for residents. These organizations can be utilized to host or sponsor programs designed to educate community members about energy efficiency related topics.

Conduct outreach and education programs to increase energy literacy
Low-income homeowners and tenants can be better positioned to act if they understand how to save energy in their dwelling. Programs that promote greater energy literacy and teach energy saving strategies that households can implement on their own, can help to decrease energy burden.[24]

Connect residents with existing energy programs
In many cases low-income households lack access to communication channels that can inform them about the variety of programs designed to address energy related issues. It is important to provide residents with information about programs available in the community that could assist them with addressing high energy bills or installing energy saving improvements.

Rental Housing and Energy Efficiency

Rental housing poses a unique challenge to improving the energy efficiency of residential buildings. This stems from the fact that owners of rental housing do not have an economic incentive to improve the energy efficiency of their buildings since they will not reap the financial benefits of the improvements. This results in what is known as a split incentive. It occurs when one party owns the property and can make significant investments in its energy efficiency; but the benefits of those improvements go to another party (the renter). This situation results in neither party having a significant interest in investing in the energy efficiency of rental properties.

While there are several solutions that can be pursued to address the split incentive issue, most research has focused on the three strategies listed below.

Incentives
Designed to encourage investment by offering grants, loans, or rebates to offset the costs of energy efficiency improvements. The value of the incentive needed to overcome the split incentive problem is extremely high. While incentives are a popular mechanism to encourage investment in energy efficient improvements among homeowners, they have not shown to be effective when applied to rental housing.

Transfer of Benefits Agreements
Allows a share of the utility savings experienced by the renter to flow back to the landlord, thus providing an economic incentive to invest in energy efficiency. This provides the renter with a more comfortable and efficient space and the landlord with a return on their investment. However, it is difficult to predict the value of the resulting energy savings, so a high level of trust is required between the two parties.

Residential Energy Conservation Ordinance
An ordinance passed by a local or state government that requires the owner of an applicable residential property to document a minimum standard of energy efficiency when a property is sold. The benefits of a RECO ordinance is that it sets and enforces a minimum standard of energy efficiency.

More information about each strategy to overcome split incentives is available in Appendix D.

[24] Hernandez and Bird, 2010

Overcoming the split incentive problem is key for North College Hill to make significant strides in boosting residential energy efficiency. Over 50 percent of the city's housing units are rentals. North College Hill requires all owners of multi-family dwellings of more than four units to register with the city. There are a few exceptions to this, but this means that the city has the contact information of most apartment landlords. This information can be used to conduct outreach and dialogue which could encourage energy saving improvements in the city's apartment buildings. Addressing energy efficiency in rental housing is also important to reducing energy burden in the community.

Programs to Boost Residential Energy Efficiency

North College Hill should educate residents about existing programs designed to assist them with improving the energy efficiency of their home. These programs range from utility incentives and loan programs to low income weatherization programs. A listing of these programs is available in Appendix E.

In addition to leveraging existing programs, North College Hill should consider developing new programs to assist its residents with reducing energy consumption. It is important to ensure that new programs are designed to meet the specific needs of the community in order for them to produce their desired outcomes.

Education and Outreach

North College Hill should work to improve the energy literacy of its residents. The city can leverage its communication channels such as newsletters and social media to provide residents with energy saving tips and information designed to educate them about the benefits of improving the efficiency of their homes. In addition, the city could partner with local groups to host energy efficiency workshops in the community. The workshops would focus on steps that both property owners and renters could take to reduce their energy usage and improve comfort.

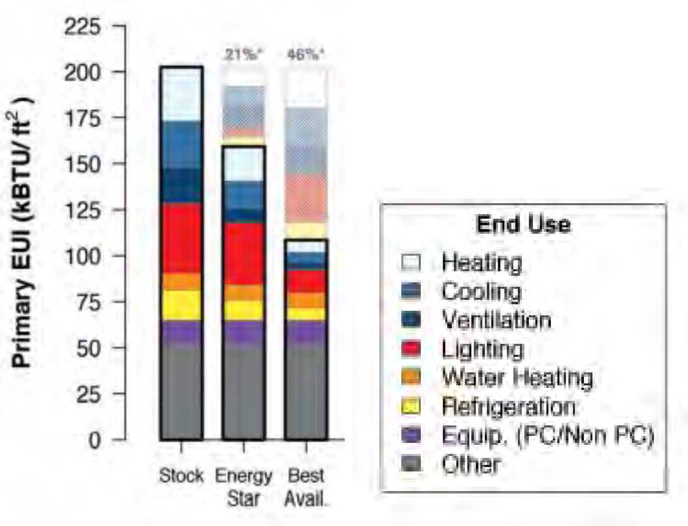
7. Commercial, Industrial, and Governmental Energy Efficiency

The City of North College Hill has approximately 230 commercial and industrial buildings with a total building area of over 1.1 million square feet.[25] These buildings offer significant opportunities to reduce energy waste and save money on utility costs.

Commercial and Industrial Buildings

According to the U.S. Department of Energy, improving heating and cooling related building components in commercial buildings such as windows, walls, roofs, controls, and HVAC equipment to ENERGY STAR recommended levels can decrease energy consumption by 21 percent. Upgrading to the best available technologies could reduce energy consumption even further, saving property owners up to 46 percent.

Figure 21: **Potential Commercial Energy Savings.[26]**



Understanding the composition of its building stock can help North College Hill assess the impacts of different policies and programs that it may implement. Of the 230 commercial and industrial buildings in the city, only three are larger than 5,000 ft^2.

Nursing homes and residential care facilities are the largest consumers of electricity in the commercial and industrial sectors. They use almost four times more electricity than the next closest user.

[25] U.S. Department of Energy, 2016
[26] U.S. Department of Energy, 2015

Figure 22: **Largest commercial and residential consumers of electricity**[27]

	Category	Number of Establishments	Total Electricity Use (MWh)
Nursing and residential care facilities	Commercial	4	3,290
Food services and bars	Commercial	12	734
Ambulatory health care services	Commercial	11	392

While the commercial and industrial buildings in North College Hill vary in age and use, there are several improvements that property owners can make to reduce energy usage.

Lighting
Many commercial and industrial buildings continue to rely on incandescent or florescent bulbs for lighting. Switching to high efficiency LED bulbs can reduce energy usage for lighting by up to 70 percent. In some cases, it may be necessary to switch out the fixture or remove the ballast prior to installing a LED bulb.

Building Controls
While most commercial and industrial buildings have set hours of operation, they often do not have systems in place to effectively manage their lighting or heating and cooling systems. Installing proper building controls can ensure that the building operates in an efficient manner. Controls can range from a simple programmable thermostat in a small commercial storefront to a more advanced computer-based system in larger facilities. On the lighting front, property owners can utilize occupancy sensors, timers, and other controls to ensure they are not lighting areas that are not in use.

Heating and Cooling Systems
Commercial and industrial property owners should develop a plan to replace heating and cooling equipment rather than waiting until failure. This will reduce costs associated with emergency repairs and/or rental chillers that would be required to keep the system operational until a new unit could be obtained. Property owners should install high efficiency equipment to maximize energy savings.

Local Government Energy Usage

North College Hill relies on electricity and natural gas to power governmental functions ranging from heating and cooling to lighting. An analysis of the utility usage for the Administration Building and the Public Services Building revealed that most of the energy consumed is utilized for heating. The large amount of energy used for heating is an indicator that there are significant opportunities for energy efficiency improvements in the two buildings.

Figure 23: **North College Hill governmental energy consumption by end use**

[27] U.S. Department of Energy, 2016

	Public Service Building	Administration Building	Combined Energy Usage
Electricity (lighting, plug loads, etc.)	26.6%	15.4%	19.4%
Space Heating and Cooling	70.9%	83.4%	78.9%
Water Heating	2.5%	1.2%	1.7%

Based on the data, the amount of energy used for heating and cooling is 15 to 25 percentage points higher than the average for our census division according to the U.S. Energy Information Administration's 2012 Commercial Buildings Energy Consumption Survey (CBECS). In the Administration Building, this is likely due to the fact that there is no electricity usage in the unoccupied portion of the building to offset the large amount of energy used to heat that area. In the Public Safety Building, this discrepancy is potentially due to low-plug loads and decreased lighting hours in portions of the building that are heated and cooled even when they are not occupied.

Another way to compare the amount of energy used in each building is to look at its site energy usage intensity, or EUI. The EUI expresses a building's energy use as a function of its size and other characteristics.

Figure 24: **Energy Usage Intensity**

	kBtu Consumed	Area (ft^2)	EUI ($kBtu/ft^2$)
Administration Building	1,790,273	30,768	58.19
Public Safety Building	1,010,900	12,146	83.23

The Environmental Protection Agency has determined median EUIs in the United States for different building classifications.[28] The median EUI for a police and fire station is 63.5 $kBtu/ft^2$. The Public Safety Building has an EUI of 83.23 $kBtu/ft^2$ which is 30 percent higher than the median. The EUI for the Administration Building is 10 percent higher than the median EUI for an office building of 52.9 $kBtu/ft^2$.

Facility Audit

Graphet Data Mining conducted an energy audit of the North College Hill Administration Building and the Public Safety Building to identify potential energy conservation opportunities. The study completed a review of the building's energy usage patterns as well as its heating and cooling equipment, lighting, and control systems.

The administration building used just under $24,610 in natural gas and electricity during the twelve-month period examined. Electricity represents the largest utility cost. An analysis of the data showed that North College Hill is paying $0.09 per kWh for electricity which is competitive for a commercial user. On the

[28] ENERGY STAR Portfolio Manager, 2018

natural gas side, the city paid an average of $0.89 per CCF during the period examined which is a competitive rate.

Table 25: **North College Hill Administration Building Energy Usage**

	Amount Consumed	kBtu Equivalent	Cost
Electricity	152,477 kWh	520,273	$13,540
Natural Gas	12,451 ccf	1,270,002	$11,070

The administration building's occupancy varies throughout the day due to its mixed uses. The portion of the building that houses the administrative offices are used primarily during traditional business hours. In addition, meeting spaces are used in the evenings and on weekends. This results in a building dynamic that must be properly managed to maximize energy efficiency.

The Public Safety Building used just over $19,000 in natural gas and electricity during the twelve-month period examined. Electricity represents the largest utility cost. An analysis of the data showed that the city is paying $0.09 per kWh for electricity, which is a competitive rate for a commercial user. On the natural gas side, the city is paying $1.17 per CCF which is not a competitive rate.

Table 26: **North College Hill Public Safety Building Energy Usage**

	Amount Consumed	kBtu Equivalent	Cost
Electricity	145,627 kWh	496,900	$13,209
Natural Gas	5,039 ccf	513,978	$5,884

A complete version of energy audit report prepared by Graphet can be found in Appendix H. The report identified the following energy conservation opportunities (ECO) as high to medium priorities:

Adjust temperature settings on the HVAC units at the Public Safety Building
The HVAC units in the building are adjusted by users daily which can result in the HVAC units operating at inefficient temperatures during unoccupied hours. While large portions of the Public Safety Building are used around the clock, there are portions that are utilized during specific hours. Adjusting temperature settings based on occupancy can result in significant energy savings. The city should determine what hours it feels are acceptable to adjust thermostats to an unoccupied set point and program the new and existing thermostats appropriately. This ECO is estimated to save between $596 to $745 annually.

Interior and exterior lighting
Both the Administration Building and the Public Safety Building currently use fluorescent bulbs to light interior spaces. The city should begin the process of upgrading to LED bulbs for all interior fixtures. If the ballasts in the existing fixtures are old, then the city should use Type B LED bulbs in the interior spaces. Type B LED bulbs bypass the ballast and are connected directly to the existing electrical wiring. By converting all interior bulbs to Type B LEDs, the city could save an estimated $1,975 to $2,469 in electricity costs annually.

The exterior wallpacks and metal halide lamps at both buildings should also be replaced with LED fixtures. This will improve the visibility around the buildings and reduce the amount of energy spent on exterior lighting. By converting to LED fixtures, the city could save an estimated $272 to $341 annually.

Thermostat optimization in the Administration Building
The HVAC units in the building are adjusted by users daily which can result in the units operating at inefficient temperatures during unoccupied hours. Installing programmable thermostats with setpoints based on occupancy can result in significant energy savings. The city should determine what hours it feels are acceptable to adjust thermostats to an unoccupied set point and program the existing thermostats. This ECO is estimated to save between $124 to $155 annually.

Identify new heating solution for the unoccupied portion of the Administration Building
The boiler in the unoccupied portion of the Administration Building continues to operate during the winter months at a considerable cost to the city. The water main for the building enters through the unoccupied portion so decommissioning the boiler is not a feasible solution. The city should determine if there are ways to heat the areas through which the pipes pass rather than heating the entire unoccupied portion. This could be accomplished by installing pipe insulation with heat tape or a smaller furnace focused on heating the area where the pipes are located.

Replace Mueller Climatrol furnace in the Administration Building
The Mueller Climatrol furnace that currently serves the council chambers and caucus room is original to the building and is estimated to have a heating efficiency of 68 percent. The city should replace this unit in the near term with an ENERGY STAR rated furnace or air source heat pump. The increased efficiency of the new unit would yield immediate savings estimated to be $1,447 annually resulting in a relatively fast payback period.

The table below provides a basic overview of the major ECOs identified by Graphet.

Figure 27: Energy Conservation Opportunities for North College Hill

ECO	Priority	Investment Required	Estimated Annual Cost Savings
Implement temperature setbacks in Public Safety Building	High (Operational)	Minimal	$596 - $745
Optimize thermostats at Administration Building	Medium	Minimal	$124 - $155
Retrofit interior and exterior lighting at Public Safety Building	Medium	Medium	$1,218 - $1,523
Retrofit interior lighting at Public Works Garage	Medium	Medium	$244 - $305
Retrofit interior and exterior lighting at Administration Building	Medium	Minimal	$958 - $1,168
Retrofit HVAC at Public Safety Building	Long	High	$774 - $929

Streetlighting

Streetlighting plays an important role in economic growth and community safety. On average, streetlighting accounts for as much as 40 percent of a municipality's electric bill.

Switching to energy efficient streetlighting that utilizes LED technology could help North College Hill reduce its electricity demand for lighting. LED bulbs last longer and offer significant maintenance and operational benefits when compared to existing high-intensity discharge (HID) sources. In addition, LED bulbs provide a more uniform light coverage that increases visibility for pedestrians and improves public safety.

Decision-makers often cite the upfront costs of LED technology as the most significant roadblock toward prospective streetlighting conversions. Conversions to LED technology should be evaluated using a full life cycle cost/benefit analysis. The U.S. Department of Energy offers a lighting retrofit analysis tool though its Better Buildings Outdoor Lighting Accelerator to assist local governments with this process.[29]

The Outdoor Lighting Accelerator created the decision tree shown in Appendix F to help local governments determine the best way to pursue lighting projects. One of the first steps is to determine who owns the streetlights. Currently all streetlights in North College Hill are owned and maintained by Duke Energy. This means that the city would need to work directly with Duke Energy to purchase and install the fixtures.

Programs to Boost Commercial and Industrial Energy Efficiency

The following programs are available to encourage investment in energy saving improvements by commercial and industrial property owners.

Duke Energy Smart $aver
Rebates are available to help offset the costs associated with installing certain approved energy efficiency measures. As of 2020, Duke Energy offers rebates for lighting, HVAC, and commercial and industrial equipment.

PACE Financing
Property Assessed Clean Energy (PACE) is a financing mechanism available to commercial and industrial properties for energy efficiency and renewable energy improvements. PACE provides financing for 100 percent of an energy project's cost and offers terms of up to 25 years with a voluntary special assessment added to the property's tax bill. It enables property owners to increase the value of their building and reduce energy costs with no down payment or personal guarantee. PACE is a simple and effective way to finance new construction and upgrades to buildings.

[29] U.S. Department of Energy, 2016. *Outdoor Lighting Accelerator Toolkit*.

8. Emerging Energy Trends

Approximately 80 percent of the energy used in Ohio is currently derived from power plants fueled by coal or natural gas. While these forms of energy production are relatively cheap, they generate air pollution and greenhouse gases which negatively impact public health in our region. In the American Lung Association's 2019 State of the Air report, Hamilton County received an F for its number of high ozone days while the Cincinnati metropolitan area was ranked the 13th worst for annual particulate pollution out of over 200 metropolitan areas.[30]

These impacts, coupled with rising energy costs, are leading more and more homeowners and businesses to look for alternative energy options. Renewable energy offers a clean, sustainable, and increasingly cost-competitive sources of energy.

Distributed Generation

Distributed generation refers to electricity that is generated, and in many cases fed to the electric grid, from sources that are dispersed throughout the community. The most common example of this are privately owned solar panels that provide energy for individual homes or businesses, but also feed excess power back to the grid through net metering. Distributed generation is also becoming a larger portion of the nation's energy generating capacity. In 2017, the U.S. Energy Information Agency projected a 400 percent increase in solar distributed generation capacity by 2040, making it the fastest growing sector of new electric generation capacity.

Distributed generation offers several key benefits to a community. First, most sources of distributed generation are renewable like solar or wind and provide power with little to no emissions. Secondly, distributed generation facilities improve the resiliency of the utility network because they lessen the chance of an event knocking out a critical portion of generating capacity on the grid. Finally, distributed generation reduces line losses from the transmission of electricity over longer distances.

Solar Photovoltaics

Solar photovoltaics have been available for decades, but only recently gained widespread popularity due to lower costs. Ten years ago, the cost of a solar panel installation was $8.82 per Watt. Today, a similar installation would cost less than $3.00 per Watt. These price declines have shortened the payback on a solar PV system and made them more affordable to homeowners in the region.

Most solar installations remain connected to the electrical grid even though they have solar panels. Any excess electricity produced by the solar panels that cannot be used by the property at the time it is produced is sent to the grid. Under the current regulatory structure in Ohio, property owners are compensated for any excess electricity produced through a process known as net metering.

According to the Public Utilities Commission of Ohio (PUCO), the North College Hill High School and four residences in the city are registered as certified solar facilities. However, because property owners are not required to register their solar installations with PUCO, there could be additional commercial or residential properties in the city that have installed solar panels.

[30] American Lung Association, 2019

There are several steps that North College Hill can take to make it easier for property owners to invest in solar in the future.

Launch a Solar Campaign
Solar campaigns create a group purchasing and community outreach program to accelerate demand and reduce individual costs for solar installations in a community. They also seek to increase awareness of solar energy and financing options, thereby helping to build sustained growth of the local solar market. Solar United Neighbors works with local governments to conduct a community based solar campaigns.

Develop a Permit Checklist
A permit checklist can help guide a solar installer or other interested party through the permitting process by clearly stating the necessary types of plan reviews and required permits for a solar installation. A basic permit checklist outlines the sequential steps of the permitting process while a more comprehensive checklist also includes applicable standards for each step in the review process.

Update Zoning Regulations
The current North College Hill Planning and Zoning Code is silent on roof and ground mounted solar installations. North College Hill should develop explicit language regarding the placement or use of roof and ground mounted systems. One of the biggest potential barriers to solar energy use is a lack of clarity in the local zoning code about what types of solar energy systems are permitted and where they can be placed. This will prevent any future interpretations of the code that might prohibit roof mounted solar installations. Sample language is provided in Appendix G.

Electric Vehicles

Electric vehicles (EVs) are vehicles that use motors fueled by electric energy for propulsion. There are three types of EVs: hybrid electric, plug-in hybrid electric, and battery electric vehicles. EVs provide a number of benefits including higher fuel efficiency than internal combustion (gasoline) systems, lower operating costs, and reduced air pollution. Over the past eight years, U.S. plug-in electric vehicle sales have continued to increase, with sales nearly doubling from 2017 to 2018.

Figure 28: Growth of U.S. Electric Vehicle Sales 2011-2019[31]

[31] EVAdoption.com, 2020

There are two main ways of fueling electric vehicles. The most popular is with batteries that are charged by connecting the car to a source of electricity. There are two major disadvantages to cars of this type. First, the batteries add considerable weight to the vehicles which causes them to consume more energy and limits travel range. Second, battery electric vehicles currently require considerable time to recharge.

The other less common type of electric vehicle uses a hydrogen fuel cell (HFC) to generate power. HFC vehicles use a fuel cell that mixes air with pure hydrogen to create an electric current. There are no batteries to charge so HFC vehicles can be refueled in five minutes and have a travel range similar to a traditional gasoline powered vehicle. Unfortunately, the infrastructure for refueling HFC vehicles needs to be developed before they become a viable option.

There are currently over 1,000 electric charging stations in Ohio. Depending on the type of battery and the charger, the battery can take a full day to charge (Level 1 chargers), several hours (Level 2 chargers), or 30 minutes (DC Fast Chargers). Chargers can be located at residential properties, workplaces, and public destinations. There no public EV charging stations in North College Hill currently. The nearest public charging stations are at car dealerships in Colerain Township and Arlington Heights as well as at the Cincinnati State main campus in Clifton.

There are equity considerations that must be kept in mind when siting charging stations and other alternative fuel stations. In the future, this is could be a topic relevant to land use and zoning regulatory action. As the use of electric vehicles and their charging stations increase, local communities will need convenient access to a charging infrastructure. This is especially relevant to residents who rent and are unable to install private chargers at their homes. While the popularity and affordability of EVs has not yet reached a level where that is a concern, there may be a time in the near future when the city will need to consider how to provide equitable access to charging infrastructure for its residents.

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10. Appendix

Appendix A: Sample Duke Energy Bill

This section provides an overview of some of the important sections that appear on your Duke Energy bill. The letter next to each description corresponds to the red circled letter on the attached sample Duke Energy bill.

A. Billing Summary

Perhaps the most important section on the first page is the billing section. It shows the previous amount due as well as any payments that were received. If there is a remaining balance, then it will be noted as well. The bottom portion of the section shows the current charges for the billing period as well as the total amount due.

B. Your Usage Snapshot

The usage snapshot located on the first page is a useful tool that shows a 13-month summary of electricity and natural gas usage. The line graph provides a visual interpretation of monthly usage. Homes with natural gas should have higher usage in the winter months and lower in the summer months.

For electricity, usage should be lower in the winter months with a peak in the summer as more electricity is used for air conditioning. However, if electricity is used for heating, then the usage chart should be higher in the winter months than the summer.

The table under each graph shows the amount of energy used in the current month verses that same month a year ago. Those values may be similar, but they may differ significantly depending on what the weather was like during that month each year.

C. Billing details

The Billing details section on the third page provides a detailed overview of your natural gas and electric charges. The first charge listed will be the fixed charges. These are charges that are paid to Duke Energy regardless of how much energy is used each month.

Below the fixed charges will be the distribution charges which are based on the amount of natural gas or electricity that Duke Energy delivered. The next item listed are any riders set by the Public Utility Commission of Ohio.

The generation charges for electric and gas cost recovery charges for natural gas appear below the riders line item. This is where the name of the electric and natural gas supplier appears if it is not Duke Energy. This section also shows the price per unit of energy that the user is paying.

D. Notes section

On the right-hand side of the third page is the Price to Compare section. This shows the price that Duke Energy is charging per kilowatt hour (kWh) of electricity. That price can be compared to the price the user is paying per kWh which appears in the Billing details - Electric section under Generation charges.

DUKE ENERGY

duke-energy.com
800.544.6900

Your Energy Bill

Service address
123 Sample St
City OH 00000

Bill date Oct 23, 2020
For service Sep 21 – Oct 22
31 days

Account number **999 999 999**

Thank you for your payment.

Billing summary

A

Previous amount due	$ 198.29
Payment received Oct 15	- 198.29
Current electric charges	100.35
Current gas charges	50.02
Total amount due Nov 14	**$ 150.37**

Your usage snapshot

B

	Current Month	Oct 2019	12-Month Usage	Average Monthly Usage
Electric (kWh)	849	928	11,373	948

12-Month usage based on most recent history

	Current Month	Oct 2019	12-Month Usage	Average Monthly Usage
Gas (CCF)	19	10	568	47

12 Month usage based on most recent history

Mail your payment at least 7 days before the due date or pay instantly at *duke-energy.com/billing.*
Late payments are subject to a 1.5% late charge.

Please return this portion with your payment. Thank you for your business.

DUKE ENERGY
P.O. Box 1326
Charlotte NC 28201-1326

Account number **999 999 999**

Amount due

$ 150.37 by Nov 14	*After Nov 14, the amount due will increase to $152.63.*

$ ________ *Add here, to help others with a contribution to HeatShare*

$ ________ **Amount enclosed**

000549 0000024295

Sally Sample
123 Sample St
City OH 00000-1234

P.O. Box 1326
Charlotte NC 28201-1326

09880389 0 9752709 1 0000011588 6 0000011588 6 0000011588 6 page 3 of 6

DUKE ENERGY

duke-energy.com
800.544.6900

Account number 999 999 999

Your usage snapshot - continued

Current electric usage for meter number 999999999

Actual reading on Oct 22	80793	
Previous reading on Sep 21	– 79944	
Energy used	849	kWh

A kilowatt-hour (kWh) is a measure of the energy used by a 1,000-watt appliance in one hour. A 10-watt LED lightbulb would take 100 hours to use 1 kWh.

Current gas usage for meter number 999999999

Actual reading on Oct 22	3962	
Previous reading on Sep 21	– 3943	
Energy used	19	CCF

One centum cubic foot (CCF) is the amount of gas in a 100-cubic-foot space. If you have a standard oven, it would take about 20 hours to use 1 CCF of gas.

Billing details – Electric

C

Customer charge	$6.00	
Delivery charges		
Energy charges		
849 kWh @ $0.02534200	21.52	
Delivery riders	22.01	
Generation riders	0.73	
Generation charges		
Rider RC	17.63	
Rider RE	33.76	
Rider AERR	0.25	
Rider SCR	-1.55	
Current electric charges		**$100.35**

Billing details – Gas

Fixed delivery service charge	$33.03	
Usage-based charge		
19 CCF @ $0.03272800	0.62	
Gas delivery riders	8.17	
Gas cost recovery		
19 CCF @ $0.43183210	8.20	
Current gas charges		**$50.02**

D

Your current rate is Residential Service, Winter (RS).

The charges for the current billing period include the following amounts to meet each of these Ohio requirements: Energy Efficiency = $2.34, Peak Demand Reduction = $0.58, Renewable Energy = $0.61

Price to compare: In order for you to save money, an electric supplier must offer you a price lower than 5.90 cents per kWh for the same usage that appears on this bill. To review competitive offers from electric suppliers, visit the Public Utilities Commission of Ohio's "Energy Choice Ohio" website at www.energychoice.ohio.gov. To learn more about Price to Compare, visit duke-energy.com or contact Duke Energy for a written explanation.

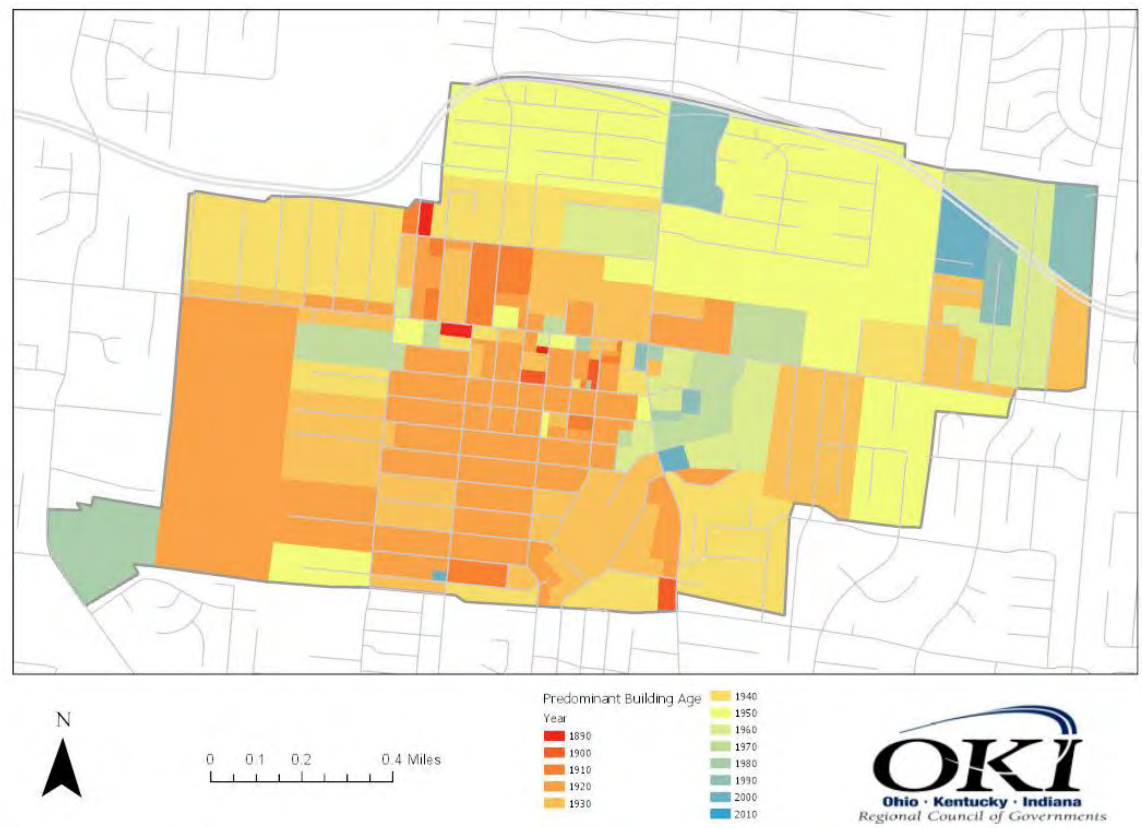
Riders are costs the Public Utilities Commission of Ohio has approved to cover investments in improving the energy infrastructure or other additional expenses.

Your current delivery rate is Residential Service (RS).

This month's Gas Cost Recovery (GCR) charge for customers purchasing their natural gas from Duke Energy is **$0.4318321** per CCF, which includes a base GCR of $0.4117 and Ohio excise tax of $0.0201321.

For a complete listing of all Ohio rates and riders, visit duke-energy.com/rates.

Appendix B: North College Hill Predominate Building Age



Appendix C: Residential Energy Efficiency Improvements

The table below provides an overview of the different types of energy efficiency improvements needed by residential properties in North College Hill based on their age.

	Cost	Savings Impact	1900-1940s	1950s	1960s	1970s	1980s - 1990s	2000 and beyond
Air Sealing	Low	High	✓	✓	✓	✓	✓	
Rim Joists	Low	High	✓	✓	✓	✓		
Attic Insulation	Low	High	✓	✓	✓	✓	✓	
Basement Insulation	Medium	Medium	✓	✓	✓	✓		
Crawlspace Insulation	Low	High	✓	✓	✓	✓		
Wall Insulation	High	High	✓	✓	✓			
Heating Systems	High	Medium/ Low	✓	✓	✓	✓	✓	✓
Cooling Systems	High	Medium/ Low	✓	✓	✓	✓	✓	✓
Windows	High	Low	✓	✓	✓	✓	✓	
Areas above unconditioned spaces	Low	High	✓	✓	✓	✓	✓	
Knob and tube wiring	Medium	NA	✓					
Asbestos	High	NA	✓	✓	✓			
Vermiculite	High	NA		✓	✓			

Appendix D: Strategies to Address Split Incentive Issue

Incentives

Incentives are a standard practice to encourage energy efficient investments for both homeowners and businesses. Incentives can be offered through utilities, non-profits, or government to encourage investments in energy efficiency. However, the amount of incentive needed to overcome the rental housing split incentive problem is reportedly very high. A 2008 study found that an incentive covering 80 percent of the cost of an improvement was necessary to spark interest from 50 percent of landlords eligible for the program.[32]

Other factors impact the market penetration of incentive programs beyond the dollar amount offered. The type of incentive can be a significant factor. Incentives can be offered as grants, where money is provided up front. Another type of incentive is a rebate, where the customer must pay the total cost of the improvement before being reimbursed. Finally, incentives can take the form of loans, which do not reduce the principal cost, but can help those who do not have cash on hand for the improvement.

Another factor in the success of any incentive program is how effectively the program is marketed to its intended target population. To achieve success, an incentive program must effectively reach and drive the targeted population to make desired energy efficient improvements. If the population is not aware of the incentive, or the incentive is not enough to drive action, the incentive will not be successful.

While incentives are a popular mechanism to encourage investment in energy efficient improvements among homeowners, they have not shown to be effective when applied to rental housing.

Transfer of Benefits Agreements

Another strategy to combat the split incentive problem is using agreements to create a bridge between landlords and renters over which the benefits of energy efficient improvements can flow. When a landlord invests in energy efficient improvements, the renter realizes an economic benefit in the form of lower utility bills. A Transfer of Benefits Agreement (TBA) allows a share of that economic benefit to flow back to the landlord, thus providing an economic incentive to making the investment in energy efficiency.

A literature review uncovered two ways a TBA program can be structured.[33] One way, dubbed Pay-As-You-Save, or PAYS, is organized through the utility. The other, called a Green Lease, is an agreement between tenant and landlord that adjusts the rent to share the economic benefits of the improvements.

Pay-As-You-Save (PAYS) offers loans to landlords to make energy efficient improvements. This loan is then repaid through a surcharge the tenant agrees to have placed on their utility bill. The amount of the surcharge is set so that the tenant still sees a net reduction in their utility bill. The surcharge remains on the utility bill until the loan is paid off, even if the tenants change. This type of program requires the close cooperation of the utility company to handle billing. It is also unclear what mechanism ensures that the tenant's utility bill achieves a net decrease. Without this assurance, a tenant likely would not be comfortable with the program.

A Green Lease is where the landlord and tenant(s) enter into a more direct agreement with one another, through the help of an energy consultant. The energy consultant certifies the expected savings the tenant will see on their utility bill due to the improvements. A portion of that expected savings is paid each month to the landlord. Again, the tenant sees a net reduction in total costs of rent plus utilities while most of the savings from reduced utility bills flow to the landlord who paid for the improvements. However, since this

[32] Nexus Market Research, Inc., 2005.
[33] Williams, 2008.

is an agreement between the landlord and a particular tenant or set of tenants, if the tenant(s) move out, the payments to the landlord cease. There is a significant risk that the landlord might not recoup his or her investment.

Transfer of Benefit Agreements directly address the root of the split incentive problem by creating a mechanism of transferring most, but not all the immediate economic benefit of lower utility bills to the landlord, who pays for the improvements. Some of the benefit is retained for the tenants to provide both parties with an interest in energy efficient improvements. Where the TBAs tend to fall short is the relative transience of tenants and the reliance on a high level of trust and transparency between landlords and tenants.

Residential Energy Conservation Ordinance

A Residential Energy Conservation Ordinance (RECO) is an ordinance passed by a local or state government that requires the owner of an applicable residential property to document a minimum standard of energy efficiency at such time when the property is extensively renovated or right before the property is sold. The documentation is provided by a certified inspector or licensed engineer and typically documents the amount and condition of insulation, the efficiency of heating systems, and the level of air infiltration.

Of the communities reviewed that have passed a RECO ordinance, most are in northern climates where energy use for heating is more significant than average. There were no examples of a RECO found in Ohio, and therefore cannot be sure that such an ordinance would be deemed a valid use of a community's police powers.

One example – Burlington, VT – specifically targeted rental properties in its RECO ordinance. The Burlington ordinance contains a few key compromises: first, if a property is not found to be in compliance with the ordinance at the time of transfer, the new owner has one year to make the improvements (extensions may be granted due to cost or financing issues), and second, the ordinance sets a cap to the cost of the required improvements. However, once the transfer of the property is done, there are no other enforcement mechanisms to ensure the promised improvements are made by the new owner.

The benefits of a RECO ordinance is that it sets, and somewhat firmly enforces a minimum standard of energy efficiency. Through this, all renters can be assured of dwellings that are reasonably comfortable and efficient with low utility bills. Also, it also alerts buyers of a property if it did not pass inspection, which contributes to an informed marketplace.

Because the main triggering mechanism to a RECO is the sale of a property, North College Hill would require the Hamilton County Auditor's Office to enforce the ordinance by not allowing sales to be executed without documentation of compliance. It would be logical that landlords and real estate professionals would be opposed to legislation that added additional barriers to the transfer of properties.

Appendix E: Residential Energy Efficiency Programs

Duke Energy Residential Programs

Smart $aver
Rebates are available to help offset the costs associated with installing certain approved energy efficiency measures. As of 2020, Duke Energy offers rebates for heat pump water heaters, insulation and air sealing, variable-speed pool pumps, and high efficiency air conditioners and heat pumps.

Home Energy House Call
Homeowners may request a free in-home energy assessment that will identify ways to improve energy efficiency. The program is only available to homeowners.

LED Program
Duke customers can receive up to 15 LED bulbs every 5 years. In addition, Duke offers an online lighting stores where customers can purchase various types of LED bulbs at discounted prices.

Income Qualified Programs

The Community Action Agency – Cincinnati | Hamilton County and People Working Cooperatively offer programs supported by the State of Ohio and Duke Energy to assist qualifying households with reducing their energy usage. Participants qualify for the programs based on their income level. As a result, potential participants must provide a variety of documentation, including proof of income, to determine their eligibility. Examples of some of the documentation required are listed below.

Required Documentation

- Valid picture ID
- Current Duke Energy bill
- Proof of citizenship
- Proof of income for past 30 days
- Social Security card for all household members

Proof of Income

- Paycheck stubs
- Social Security check
- Pension or retirement letter
- Housing Assistance Payment contract
- Unemployment, disability, workers compensation, child support

Check with the program provider for a complete list of required documentation.

Community Action Agency – Cincinnati | Hamilton County

The Community Action Agency - -Cincinnati | Hamilton County offers the following energy related programs for homeowners and renters.

Home Energy Assistance Program (HEAP)

Provides eligible households assistance with their home energy bills. This one-time benefit is applied directly to the customer's utility bill. The Winter Crisis Program (HEAP Winter Crisis Program) helps income eligible households maintain their utility service if they are threatened with disconnection or have been disconnected. The program runs from November 1 until March 31. The Summer Crisis Program (HEAP Summer Crisis Program) provides bill payment assistance for persons 60 years of age and older or those with a certified medical condition. The program runs from July 1 until August 31.

Percentage of Income Payment Program Plus (PIPP Plus)

Helps households manage their energy bills by establishing consistent monthly payments based on a percentage of household income. Monthly payments range from 10% to 12% of household income depending on how the home is heated. The balance of a household's utility bill is subsidized by the State of Ohio. There is a minimum monthly payment of $10.00. Paying 24 on-time and in-full payments eliminates any outstanding balance with the utility company that a household may have.

People Working Cooperatively

People Working Cooperatively offers the following energy related programs for homeowners and renters.

Home Weatherization Program (HWAP)

Provides eligible individuals with assistance to improve the energy efficiency of their homes and reduce their energy costs. HWAP provides a home inspection to identify energy saving improvements and the installation of cost-effective improvements. The most common types of improvements are insulation, air sealing, windows, and doors. It is available to homeowners and renters, although renters will need permission from their landlord to participate.

Duke Energy Weatherization Program

Helps eligible households save energy and reduce expenses through the installation of energy saving improvements and by providing education on energy saving behaviors the household can adopt. The program is available to single-family and multi-family units.

Electric Partnership Program (EPP)

Assists households in reducing their electricity usage. EPP provides in-home audits and installs electric energy efficiency measures to reduce electric usage. Customers also receive information on how they can reduce their electric use and improve their home's efficiency. Households are eligible for EPP if they are on or eligible for the Percentage of Income Payment Plan Plus (PIPP) and must have 12 months of electric usage at their current address and an annual electric baseload usage of at least 5,000 kWh.

Duke Energy Refrigerator Replacement Program

Provides eligible households with a replacement for inefficient refrigerators as determined by a two-hour metering test. The program is available to homeowners and renters. However, participants must show verification of refrigeration ownership.

Local resources

Program	Weatherization Assistance	Utility Bill Assistance	Renters Eligible	Program Provider
Home Energy Assistance Program (HEAP)		✓	✓	Community Action Agency
Percentage of Income Payment Program Plus (PIPP Plus)		✓	✓	Community Action Agency

Home Weatherization Program (HWAP)	✓		✓	People Working Cooperatively
Duke Energy Weatherization Program	✓		✓	People Working Cooperatively
Electric Partnership Program (EPP)	✓		✓	People Working Cooperatively
Duke Energy Refrigerator Replacement	✓		✓	People Working Cooperatively

For more information contact:

- Community Action Agency – Cincinnati | Hamilton County 513-569-1850
- People Working Cooperatively 513-351-7921

Other Energy Efficiency Programs

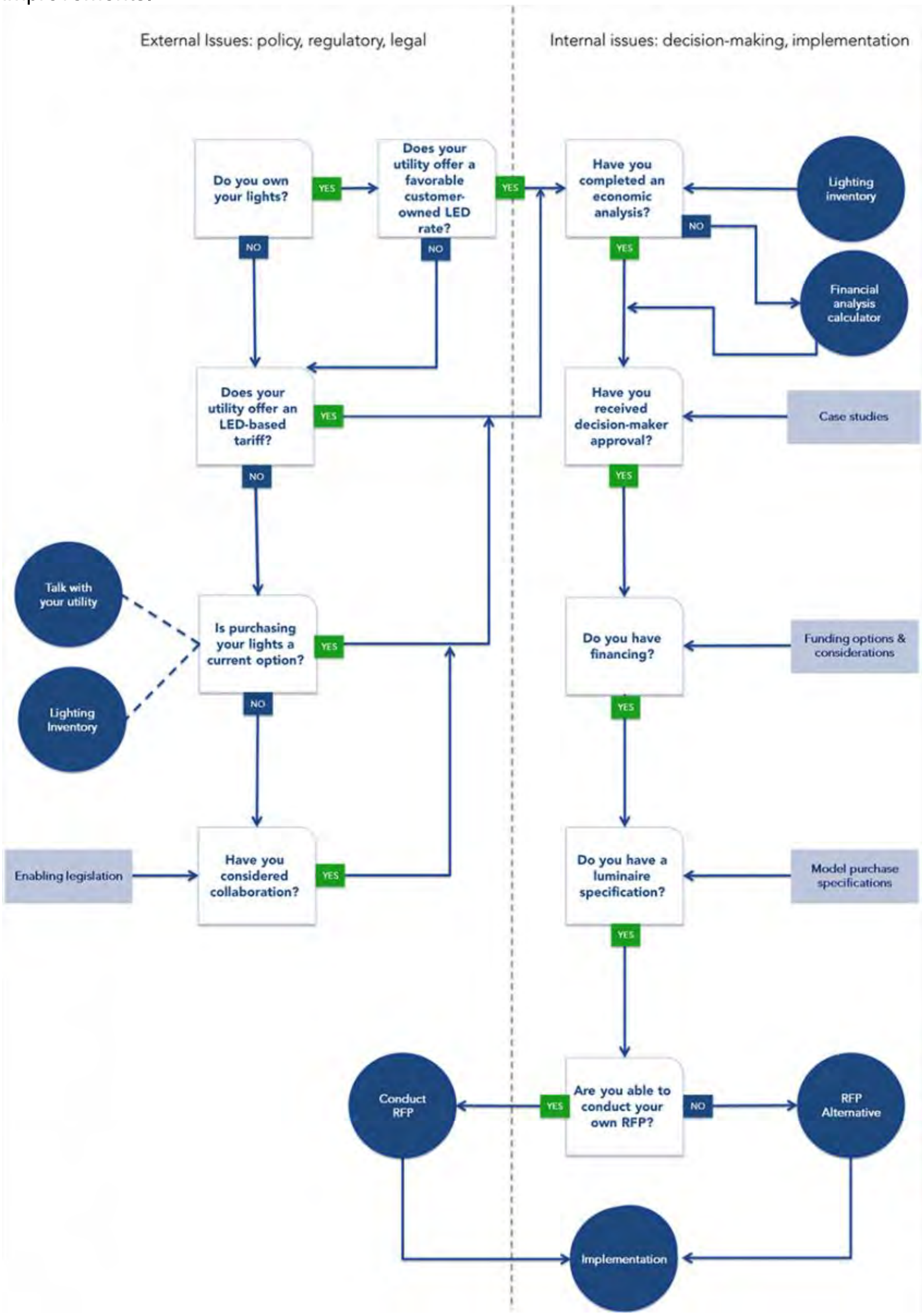
Federal Income Tax Credit
Residential property owners are eligible to receive a federal tax credit for renewable energy products installed prior to December 31, 2021. The tax credit is limited to solar water heat, solar photovoltaics, geothermal heat pumps, and small wind turbines. The tax credit is equal to 26 percent of the project cost for projects installed by the end of 2020 and 22 percent for projects installed by the end of 2021. The tax credit is scheduled to expire at the end of 2021.

State of Ohio ECO-Link Loan Program
The Office of the Ohio Treasurer of State works local lending partners to provide up to a 3 percent interest rate reduction for loans that are used to fund energy efficiency improvements. Additional information is available at www.ECOLink.ohio.gov.

Zonolite Attic Insulation Trust
Homeowners that have asbestos-containing vermiculite insulation in their attic may qualify to receive financial compensation to offset the costs associated with removing the hazardous substance. Homeowners who think they may have asbestos-containing vermiculite insulation should visit www.zonoliteatticinsulation.com for additional information.

Appendix F: Lighting Accelerator Decision Chart

The U.S. Department of Energy through its Better Buildings Outdoor Lighting Accelerator designed the decision tree below to assist local governments with implementing energy efficient streetlighting improvements.



Appendix G: Sample Zoning Language

Roof-Mounted Solar Energy Systems

i. Roof-mounted solar panels that are integrated with the surface layer of the roof structure or are mounted flush with the roof structure may be permitted on any roof surface of a principal building or accessory building.

ii. Roof-mounted solar panels that are mounted at an angle to the roof structure shall only be permitted on roof surfaces that face the side or rear lot.

iii. Solar panels may be mounted on flat roofs provided there is a parapet wall or other architectural feature that screens the view of the panels. Such panels may be mounted on an angle provided they do not extend more than five feet above the roof surface.

iv. A certificate of zoning compliance shall not be required for roof-mounted solar energy systems.

Appendix H: Energy Audit Report

Ohio Development Services Agency

Sustainable Energy Efficiency Program

Energy Plan Report

for

NORTH COLLEGE HILL
the center of it all

Cincinnati, Ohio

Attn: Ron Mosby and North College Hill Staff

March 2020

Graphet
DATA MINING
<Empowering Energy Efficiency>

Telephone (513) 474-4870 www.graphet.com

Contents

1.0- EXECUTIVE SUMMARY

The City of North College Hill is interested in reducing the energy consumption of the Public Safety Building (PSB) and Administration Building (AB). This study presents energy conservation opportunities (ECOs) to be considered for both the PSB and AB buildings. The total building(s) area is approximately 32,050 ft^2 . The site annual electric consumption is 298,104 kWh/year and annual natural gas consumption is 1,722 MMBtu/year with an energy cost of $43,703/year.

It is possible for the City of North College Hill Township to reduce energy consumption by an estimated 21 to 34%, or $9,213 to $14,924 per year.

1.1- Energy Goals and Objectives

Past studies, brainstorming of ideas for energy conservation, and available utility and operating data were used to develop an understanding of potential energy conservation opportunities (ECOs). These opportunities were identified and evaluated with a focus on setting priorities for implementation. Suggested energy goals for the City North College Hill PSB and AB buildings were developed relative to baseline energy consumption and rates. These energy goals are categorized below as operational, short-term, mid-term, and long-term goals. Rebates include Duke Energy rebates.

1.1.1- Operational Goals (Low Cost / No Cost Opportunities)

Energy conservation projects categorized as operational priorities have simple paybacks of one year or less. The proposed ECOs in this category are:

- **HVAC: ECO 1a:** Decommission Unoccupied Portion of AB
- **HVAC: ECO 1b:** Thermostat Optimization at PSB (Police Department)

By implementing operational improvement projects, the City North College Hill PSB and AB buildings can improve efficiency and reduce energy costs by $5,137 to $9,828 or 12 -22% of the total energy cost.

1.1.2- Short-Term Goals

Energy conservation projects categorized as short-term priorities have a simple payback of less than two years, would provide a substantial upgrade in ease of building control, or are deemed as critical equipment replacements. The proposed short-term energy conservation measures are:

- **Lighting:** ECO 2d: Retrofit Exterior Lighting to LED at PSB

By investing $20, the City of North College Hill PSB and AB buildings can improve efficiency and reduce energy costs by $13. Simple payback for this opportunity is approximately one and half years.

1.1.3- Mid-Term Goals

Energy conservation projects categorized as mid-term priorities have a simple payback of greater than two years and less than five years. The proposed mid-term energy conservation measures are:

- **HVAC:** ECO 1c: Thermostat Optimization at AB
- **Lighting:** ECO 2a-i: Retrofit Interior Lighting to Type A LED at PSB
- **Lighting:** ECO 2c-i: Retrofit Interior Lighting to Type A LED at Public Works Garage
- **Lighting:** ECO 23: Retrofit Exterior Lighting to Type B LED at AB

By investing $8,325 to $10,647, the City of North College Hill PSB and AB buildings can improve efficiency and reduce energy costs by $1,838 to $2,298, or 4 to 5% of total energy cost. Simple payback, including Duke Energy rebates, for this group is approximately 4 years.

1.1.4- Long-Term Goals

Energy conservation projects categorized as long-term priorities have a simple payback of greater than five years. The proposed long-term energy conservation measures are:

- **HVAC:** ECO 1d: Replacement Strategy for Air Source Heat Pumps at PSB (Police)
- **HVAC:** ECO 1e: Replacement Strategy for RTUs at PSB (Fire Department)
- **HVAC:** ECO 1f: Replacement Strategy for HVAC at AB
- **HVAC:** ECO 1g: Replace Break Room Spot Cooler and Space Heater w/ Window Unit (AB)

By investing $48,836 to $79,187, the City of North College Hill PSB and AB buildings can improve efficiency and reduce energy costs by $2,228 to $2,785, or 5 to 6% of total energy cost. Simple payback, including Duke Energy rebates, for this group is greater than 10 years.

Table 1-1 and Table 1-2 provide details on energy savings and associated cost savings, potential project costs, and rebates for each ECO.

Table 1-1: Energy Conservation Opportunities – Cost Benefit Analysis

											Payback, yrs			
			Selected		Project Cost		Energy Cost Savings		Rebates		With Rebates		Without Rebates	
ECO	System	Opportunity	(Y/N)	Priority	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
1a	HVAC	Decommission Unoccupied Portion of AB	Y	Operational	$240	$480	$4,541	$9,083	$0	$0	0.05	0.05	0.05	0.05
1b	HVAC	Thermostat Optimization at PSB (Police Department)	Y	Operational	$110	$220	$596	$745	$0	$0	0.18	0.30	0.18	0.30
1c	HVAC	Thermostat Optimization at AB	Y	Mid	$320	$640	$124	$155	$0	$200	2.58	2.84	2.58	4.13
1d	HVAC	Replacement Strategy for Air Source Heat Pumps at PSB (Police Department	Y	Long	$13,398	$21,086	$558	$697	$0	$347	24.01	29.75	24.01	30.25
1e	HVAC	Replacement Strategy for RTUs at PSB (Fire Department)	Y	Long	$18,000	$36,000	$186	$232	$0	$0	96.77	155.17	96.77	155.17
1f	HVAC	Replacement Strategy for HVAC at AB	Y	Long	$16,688	$20,861	$1,358	$1,698	$0	$0	12.29	12.29	12.29	12.29
1g	HVAC	Replace Breakroom Spot Cooler and Space Heater with Window Unit (AB)	Y	Long	$750	$1,240	$126	$158	$0	$0	5.95	7.85	5.95	7.85
2a	Interior Lighting	Retrofit Interior Lighting to LED at PSB	Y	Mid	$5,579	$6,974	$1,208	$1,510	$1,024	$1,281	3.77	3.77	4.62	4.62
2a-i	↑	*Retrofit Interior Lighting to Type A LED at PSB*	*A*	*Mid*	*$5,579*	*$6,974*	*$1,208*	*$1,510*	*$1,024*	*$1,281*	*3.77*	*3.77*	*4.62*	*4.62*
2a-ii	↑	*Retrofit Interior Lighting to Type B LED at PSB*	*N*	*Mid*	*$7,174*	*$8,967*	*$1,279*	*$1,599*	*$1,024*	*$1,281*	*4.81*	*4.81*	*5.61*	*5.61*
2a-iii	↑	*Retrofit Interior Lighting to LED Fixtures at PSB*	*N*	*Long*	*$12,300*	*$15,375*	*$1,411*	*$1,764*	*$2,824*	*$3,530*	*6.72*	*6.71*	*8.72*	*8.72*
2b	Interior Lighting	Retrofit Ineterior Lighting to LED at AB	N	Long	$0	$0	$0	$0	$0	$0				
2b-i	↑	*Retrofit interior lighting to Type A LED at AB*	*N*	*Long*	*$7,538*	*$9,424*	*$658*	*$822*	*$1,384*	*$1,731*	*9.35*	*9.36*	*11.46*	*11.46*
2b-ii	↑	*Retrofit Interior Lighting to Type B LED at AB*	*N*	*Long*	*$8,309*	*$10,387*	*$696*	*$870*	*$1,384*	*$1,731*	*9.95*	*9.95*	*11.94*	*11.94*
2b-iii	↑	*Retrofit interior lighting to LED Fixtures at AB*	*N*	*Long*	*$39,147*	*$48,934*	*$860*	*$1,075*	*$3,586*	*$4,483*	*41.35*	*41.35*	*45.52*	*45.52*
2c	Interior Lighting	Retrofit Interior Lighting to LED at Public Works Garage	Y	Mid	$1,411	$1,764	$244	$305	$259	$324	4.72	4.72	5.78	5.78
2c-i	↑	*Retrofit Interior Lighting to Type A LED at Public Works Garage*	*A*	*Mid*	*$1,411*	*$1,764*	*$244*	*$305*	*$259*	*$324*	*4.72*	*4.72*	*5.78*	*5.78*
2c-ii	↑	*Retrofit Interior Lighting to Type B LED at Public Works Garage*	*N*	*Long*	*$1,814*	*$2,268*	*$258*	*$323*	*$259*	*$324*	*6.03*	*6.02*	*7.03*	*7.02*
2c-iii	↑	*Retrofit Interior Lighting to LED Fixtures at Public Works Garage*	*N*	*Long*	*$2,995*	*$16,784*	*$244*	*$305*	*$273*	*$342*	*11.16*	*53.91*	*12.27*	*55.03*
2d	Exterior Lighting	Retrofit Exterior Lighting to LED at PSB	Y	High	$15	$20	$10	$13	$0	$0	1.50	1.54	1.50	1.54
2e	Exterior Lighting	Retrofit Exterior Lighting to Type B LED at AB	Y	Mid	$1,015	$1,269	$262	$328	$168	$210	3.23	3.23	3.87	3.87
		All Projects			$57,526	$90,554	$9,213	$14,924	$1,451	$2,362	6.09	5.91	6.24	6.07
		Percent of Present Energy Costs					21%	34%						
		Operational Priority Projects			$350	$700	$5,137	$9,828	$0	$0	0.07	0.07	0.07	0.07
		Percent of Present Energy Costs					12%	22%						
		High Priority Projects			$15	$20	$10	$13	$0	$0	1.50	1.54	1.50	1.54
		Percent of Present Energy Costs					0%	0%						
		Mid Priority Projects			$8,325	$10,647	$1,838	$2,298	$1,451	$2,015	3.74	3.76	4.53	4.63
		Percent of Present Energy Costs					4%	5%						
		Long Priority Projects			$48,836	$79,187	$2,228	$2,785	$0	$347	21.92	28.31	21.92	28.43
Percent of Present Energy Costs							5%	6%						

All the numbers in red are estimates at this time

Cells in red signify ECOs which need more development

*** CO2 emissions are calculated using the updated eia.gov state carbon factors**

Total Annual Energy Costs	
Electric	$26,749
Gas	$16,954
Total	$43,703

Table 1-2: Energy Conservation Opportunities – Energy Savings Analysis

ECO	System	Opportunity	Selected (Y/N)	Priority	Electric Savings Breakdown: Demand, kW Min	Demand, kW Max	Energy, kWh Min	Energy, kWh Max	Gas Savings Breakdown: Energy, MMBtu Min	Energy, MMBtu Max	CO2 Reduction*: lectric, M.Ton Min	lectric, M.Ton Max	Gas, M.Tons Min	Gas, M.Tons Max
1a	HVAC	Decommission Unoccupied Portion of AB	Y	Operational	0	0	25,235	50,469	264	528	16	31	14	28
1b	HVAC	Thermostat Optimization at PSB (Police Department)	Y	Operational	0	0	0	0	22	28	0	0	1	1
1c	HVAC	Thermostat Optimization at AB	Y	Mid	0	0	1,154	1,443	0	3	1	1	0	0
1d	HVAC	Replacement Strategy for Air Source Heat Pumps at PSB (Police Department	Y	Long	0	0	6,150	7,688	0	0	4	5	0	0
1e	HVAC	Replacement Strategy for RTUs at PSB (Fire Department)	Y	Long	0	0	2,048	2,561	34	43	1	2	2	2
1f	HVAC	Replacement Strategy for HVAC at AB	Y	Long	0	0	3,380	4,222	92	115	2	3	5	6
1g	HVAC	Replace Breakroom Spot Cooler and Space Heater with Window Unit (AB)	Y	Long	0	0	1,426	1,783	0	0	1	1	0	0
2a	Interior Lighting	Retrofit Interior Lighting to LED at PSB	Y	Mid	0	0	15,104	18,880	0	0	10	13	0	0
2a-i	↑	*Retrofit Interior Lighting to Type A LED at PSB*	*A*	*Mid*	*0*	*0*	*15,104*	*18,880*	*0*	*0*	*10*	*13*	*0*	*0*
2a-ii	↑	*Retrofit Interior Lighting to Type B LED at PSB*	*N*	*Mid*	*0*	*0*	*15,991*	*19,989*	*0*	*0*	*11*	*14*	*0*	*0*
2a-iii	↑	*Retrofit Interior Lighting to LED Fixtures at PSB*	*N*	*Long*	*0*	*0*	*17,643*	*22,054*	*0*	*0*	*12*	*15*	*0*	*0*
2b	Interior Lighting	Retrofit Ineterior Lighting to LED at AB	N	Long	0	0	0	0	0	0	0	0	0	0
2b-i	↑	*Retrofit interior lighting to Type A LED at AB*	*N*	*Long*	*0*	*0*	*8,255*	*10,281*	*0*	*0*	*6*	*7*	*0*	*0*
2b-ii	↑	*Retrofit Interior Lighting to Type B LED at AB*	*N*	*Long*	*0*	*0*	*8,708*	*10,886*	*0*	*0*	*6*	*7*	*0*	*0*
2b-iii	↑	*Retrofit interior lighting to LED Fixtures at AB*	*N*	*Long*	*0*	*0*	*10,752*	*13,441*	*0*	*0*	*7*	*9*	*0*	*0*
2c	Interior Lighting	Retrofit Interior Lighting to LED at Public Works Garage	Y	Mid	0	0	3,055	3,819	0	0	2	3	0	0
2c-i	↑	*Retrofit Interior Lighting to Type A LED at Public Works Garage*	*A*	*Mid*	*0*	*0*	*3,055*	*3,819*	*0*	*0*	*2*	*3*	*0*	*0*
2c-ii	↑	*Retrofit Interior Lighting to Type B LED at Public Works Garage*	*N*	*Long*	*0*	*0*	*3,234*	*4,044*	*0*	*0*	*2*	*3*	*0*	*0*
2c-iii	↑	*Retrofit Interior Lighting to LED Fixtures at Public Works Garage*	*N*	*Long*	*0*	*0*	*3,055*	*3,819*	*0*	*0*	*2*	*3*	*0*	*0*
2d	Exterior Lighting	Retrofit Exterior Lighting to LED at PSB	Y	High	0	0	133	167	0	0	0	0	0	0
2e	Exterior Lighting	Retrofit Exterior Lighting to Type B LED at AB	Y	Mid	0	0	3,281	4,102	0	0	2	3	0	0
		All Projects			0	0	60,966	95,134	412	717	39	61	22	38
		Percent of Present Energy Costs												
		Operational Priority Projects			0	0	25,235	50,469	286	556	16	31	15	30
		Percent of Present Energy Costs												
		High Priority Projects			0	0	133	167	0	0	0	0	0	0
		Percent of Present Energy Costs												
		Mid Priority Projects			0	0	22,594	28,244	0	3	15	19	0	0
		Percent of Present Energy Costs												
		Long Priority Projects			0	0	13,004	16,254	126	158	8	10	7	8

Percent of Present Energy Costs

All the numbers in red are estimates at this time

Cells in red signify ECOs which need more development

*** CO2 emissions are calculated using the updated eia.gov state carbon factors**

2.0- UTILITY DATA ANALYSIS

Procurement strategies employed for energy sources determine the unit costs for energy, the rate structures, and contract terms. Utility data analysis begins with an understanding of:

- How much energy is used and what it costs (bills and usage information – typically monthly billed data and,
- A preliminary understanding of the impact weather has on energy usage

This section provides an analysis of the Duke Energy supplied electricity and natural gas. Additional utilities used by the site are not included in the scope of this analysis, which is done under the sponsorship of the Ohio Developmental Services Agency (ODSA) Energy Efficiency Program.

2.1- Billed Data

The available monthly billed data with respective account and procurement information is summarized in Table 2-1 for PSB and Table 2-2 for AB below.

Table 2-1: PSB Available Billing Data Account Information

Utility	Distributor / Supplier	Account	Meter	Service Address	Date Range
Electric	Duke / IGS	0840-0073-21	108160225	1646 Galbraith Rd W	2/8/2018 - 2/10/2020
Electric	Duke / IGS	0840-0073-21	108153340	1646 Galbraith Rd W	2/8/2018 - 2/10/2020
Natural Gas	Duke	0840-0073-21	000793989	1646 Galbraith Rd W	2/8/2018 - 2/10/2020

Table 2-2: AB Available Billing Data Account Information

Utility	Distributor / Supplier	Account	Meter	Service Address	Date Range
Electric	Duke / IGS	5940-0264-21-4	108260929	1500 Galbraith Rd W	2/7/2018 - 2/7/2020
Electric	Duke / IGS	5940-0264-21-4	Outdoor Lighting	1500 Galbraith Rd W	2/7/2018 - 2/7/2020
Natural Gas	Duke	5940-0264-21-4	000579073	1500 Galbraith Rd W	2/7/2018 - 2/7/2020
Electric	Duke / IGS	9330-3727-01-7	328175416	1500 Galbraith Rd W, Misc Rear	2/7/2018 - 2/7/2020
Natural Gas	Duke	6040-3734-01-5	000997650	1500 Galbraith Rd W, Misc Garage	2/7/2018 - 2/7/2020

The most recent year of valid data available for all utilities is chosen as a baseline period for analysis. The baseline period for the utility billed considered below is February 2019 through January 2020.

2.1.1- Total Utilities Breakdown

PSB

A pie chart of the total utility costs from February 2019 through January 2020 are shown in Figure 2-1. Electricity costs account for 69% of total utility cost and natural gas costs account for 31% of total utility costs. Total annual utility costs are $19,093. A more detailed summary of the monthly billing data is shown in Table 2-3.

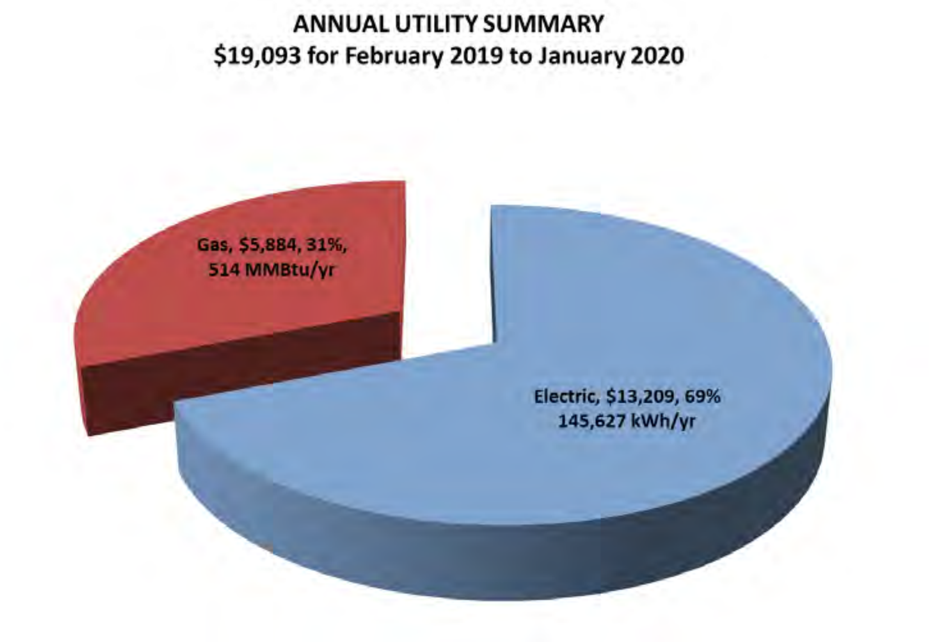


Figure 2-1: PSB Total Utility Cost Breakdown

Table 2-3: PSB Annual Utility Cost Summary

Electric

Billing Period	Annual Cost, $	Annual Consumption, kWh	Unit Cost, $/kWh	Peak Demand, kW Min	Peak Demand, kW Max	Peak Demand, kW Avg	Consumption Per Day, kWh/day Min	Consumption Per Day, kWh/day Max	Consumption Per Day, kWh/day Avg
Feb'19 - Jan'20	$13,209	145,627	$0.09	30.6	40.7	35.1	325	512	399

Gas

Billing Period	Annual Cost, $	Annual Consumption, mmBtu	Unit Cost, $/mmBtu	Usage Per Day, mmBtu/dy Min	Usage Per Day, mmBtu/dy Max	Usage Per Day, mmBtu/dy Avg
Feb'19 - Jan'20	$5,884	514	$11.46	0.2	4.0	1.4

Total Annual Cost
$19,093

AB

A pie chart of the total utility costs from February 2019 through January 2020 are shown in Figure 2-2. Electricity costs account for 55% of total utility cost and natural gas costs account for 45% of total utility costs. Total annual utility costs are $24,610. A more detailed summary of the monthly billing data is shown in Table 2-4.

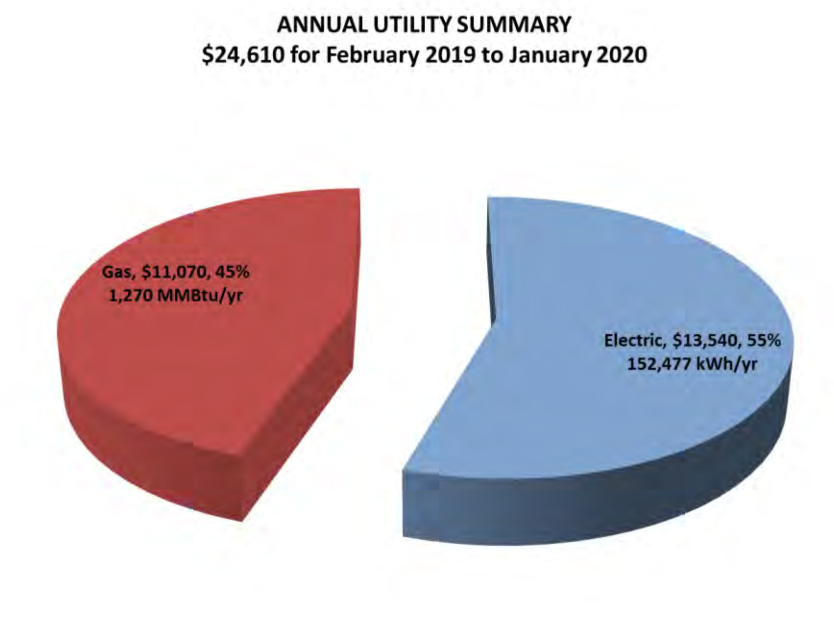


Figure 2-2: AB Total Utility Cost Breakdown

Table 2-4: AB Annual Utility Cost Summary

Electric

Billing Period	Annual Cost, $	Annual Consumption, kWh	Unit Cost, $/kWh	Peak Demand, kW Min	Peak Demand, kW Max	Peak Demand, kW Avg	Consumption Per Day, kWh/day Min	Consumption Per Day, kWh/day Max	Consumption Per Day, kWh/day Avg
Feb'19 - Jan'20	$13,540	152,477	$0.09	21.6	30.4	27.3	334	516	418

Gas

Billing Period	Annual Cost, $	Annual Consumption, mmBtu	Unit Cost, $/mmBtu	Usage Per Day, mmBtu/dy Min	Usage Per Day, mmBtu/dy Max	Usage Per Day, mmBtu/dy Avg
Feb'19 - Jan'20	$11,070	1,270	$8.71	0.1	14.7	3.6

Total Annual Cost
$24,610

2.1.2- Electric Cost Breakdown

PSB

The cost components for electric are shown in Figure 2-3. About 59% of the total electric cost is associated with supplier charges, and the remaining 41% is associated with distribution charges. The distribution charge is further broken down into delivery riders (19%), delivery demand charges (18%), and delivery customer charges (4%). The delivery demand charge consists of a $/kW charge for the larger meter (108153340) and a $/kWh charge for the smaller meter (108160225). The smaller meter does not have a $/kW charge.

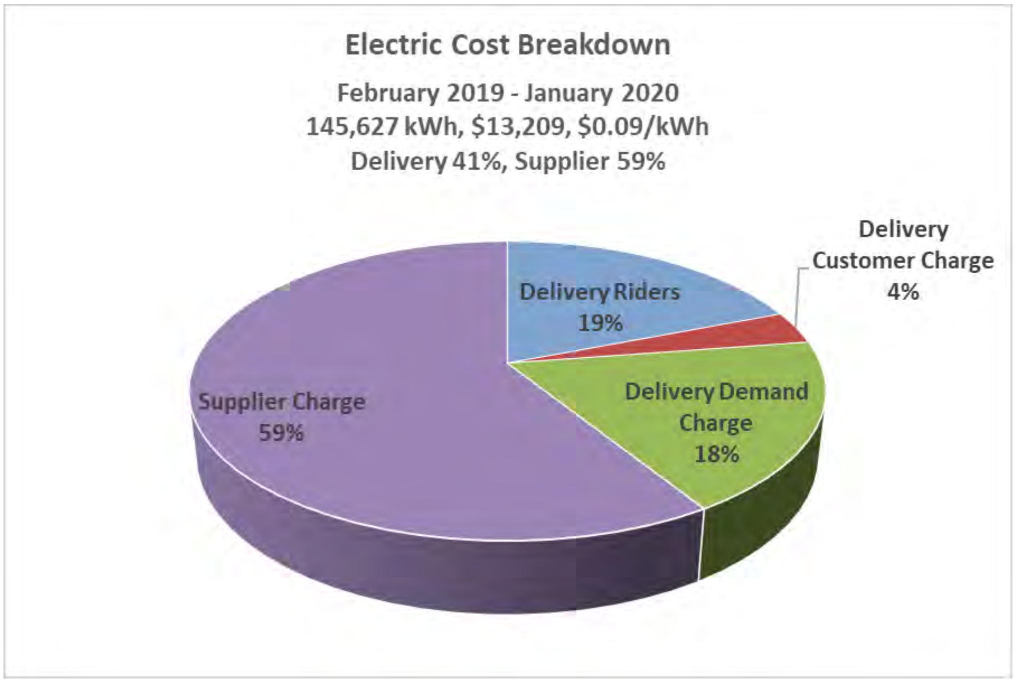


Figure 2-3: PSB Electric Cost Breakdown

AB

The cost components for electric are shown in Figure 2-4 and Figure 2-5 for AB. The two electric meters associated with the building (108260929 and 328175416) are represented in Figure 2-4, and the outdoor lighting meter is represented in Figure 2-5.

For the Administration Building, 61% of the total electric cost is associated with supplier charges, and the remaining 39% is associated with distribution charges. The distribution charge is further broken down into delivery riders (19%), delivery demand charges (17%), and delivery customer charges (3%).

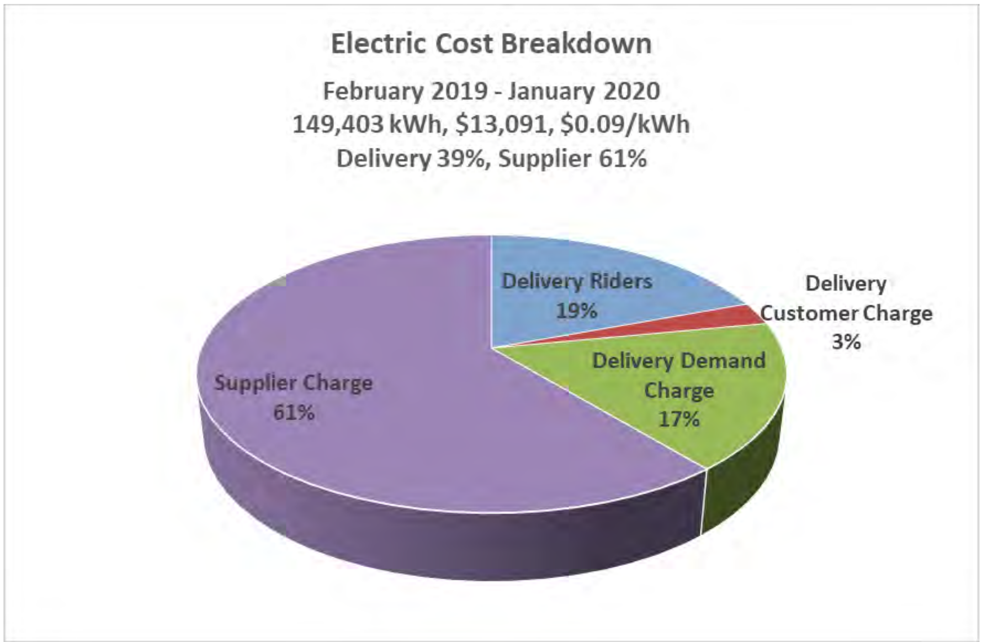


Figure 2-4: AB Electric Cost Breakdown

For the AB Outdoor Lighting meter, 37% of the total electric cost is associated with supplier charges, and the reamining 63% is associated with distribution charges. The distribution charge is further broken down into delivery riders (7%), delivery energy charges (4%), and OLE special lighting maintenance charges (52%).

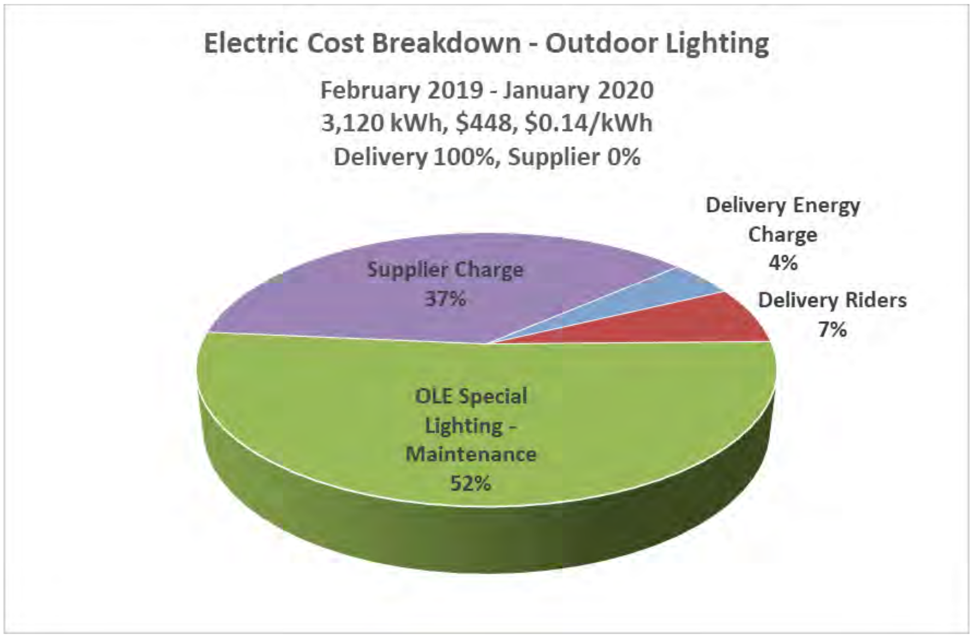


Figure 2-5: AB Outdoor Lighting Electric Cost Breakdown

2.1.3- Natural Gas Cost Breakdown

PSB

The cost components for natural gas are shown in Figure 2-6. About 31% of the total natural gas cost is associated with commodity charges, and the remaining 69% is associated with delivery charges. Note that the delivery service charge is a fixed amount of $226/month, and this charge corresponds with what type of meter the facility has.

The PSB is currently on a General Service Large (GSL) natural gas meter. This meter is for facilities with a yearly natural gas consumption of more than 4,000 CCF. If the PSB decreases the annual natural gas usage to below 4,000 CCF, then they could potentially move to a different rate category and pay less each month for the fixed delivery service charges.

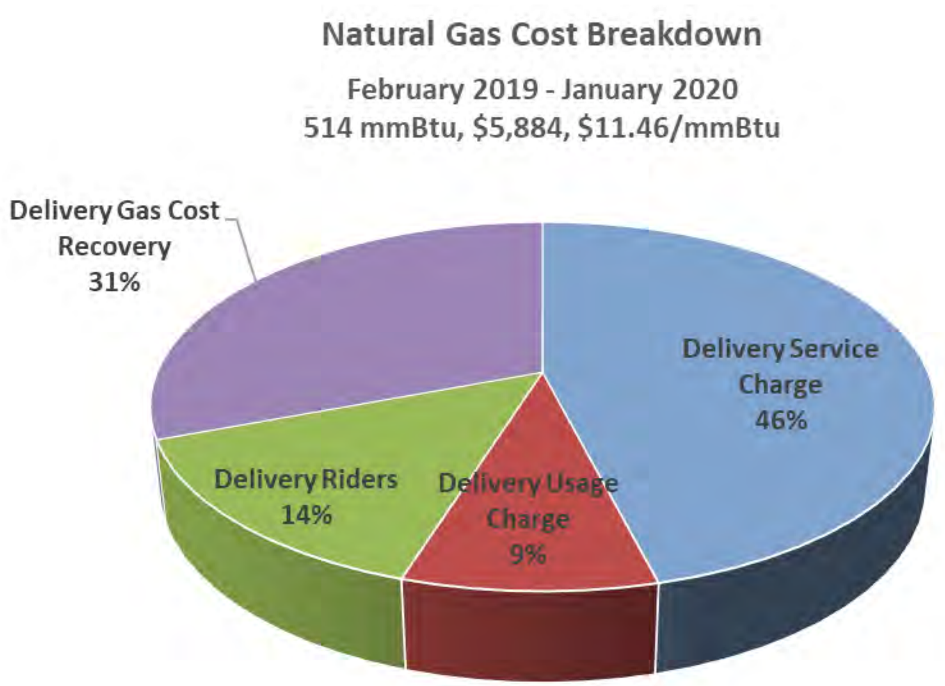


Figure 2-6: PSB Natural Gas Cost Breakdown

AB

Figure 2-7 provides a breakdown of the natural gas charges. About 40% of the total natural gas cost is associated with commodity charges, and the remaining 60% is associated with delivery charges.

AB currently has two natural gas meters. The 000579073 meter is on the General Service Large (GSL) rate, and the 000997650 meter is on the General Service Small (GSS) rate. As in the PSB, if the 000579073 meter was able to reduce its yearly natural gas consumption to less than 4,000 CCF, the meter could potentially move to a different rate category and pay less each month for the fixed delivery service charges.

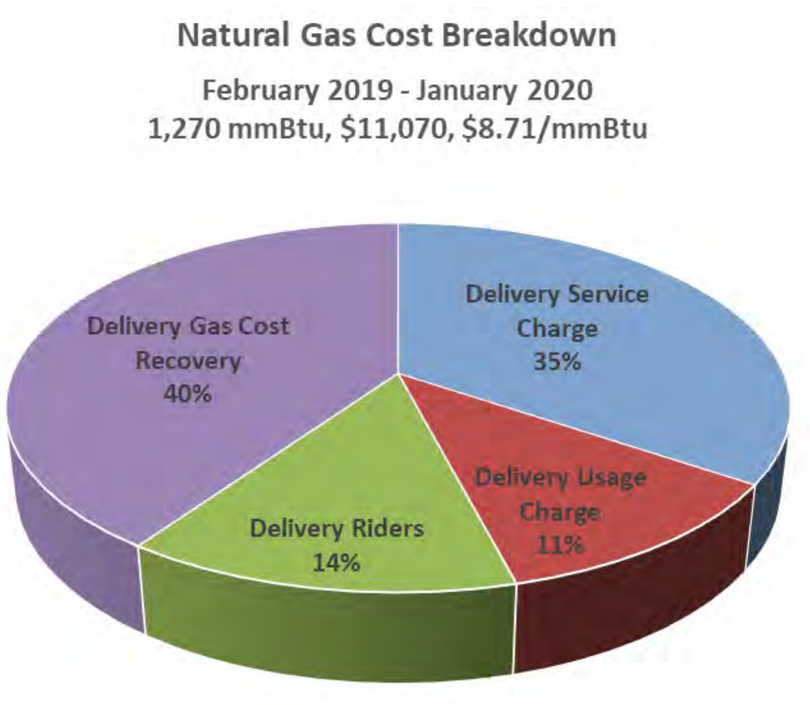


Figure 2-7: AB Natural Gas Cost Breakdown

3.0- UNDERSTANDING OF PERFORMANCE AND OPPORTUNITIES

The allocation of energy consumption to various operations and utilities requires an understanding of the building systems and equipment, operating schedules, and trended historical data. This information was gathered from facility walkthroughs on site. Understanding of performance and opportunities begins with the development of an energy flow map to classify utility energy consumption by systems, equipment and functions. The energy flow map is an organization tool which:

- Identifies purchased and generated utilities
- Assists in understanding current energy performance by systems and equipment
- Establishes a reasonable baseline of existing conditions
- Helps identify potential areas for energy conservation opportunities
- Promotes systems optimization to maximize facility energy efficiency

The purchased utilities for the City of North College Hill PSB and AB buildings are:

- Electricity
- Natural Gas

The generated utilities for these sites are:

- Domestic Hot Water
- Compressed Air (Fire Department)
- Heating Hot Water

The energy flow maps can be found in Appendix A, Figure 4-1 and Figure 4-2.

3.1- Electrical Energy Consumption

Available equipment data, operating parameters, and monitored data were used to determine major electric users and their expected contributions to peak load and average electric use. Baseline energy consumption calculations are shown in Appendix B.

PSB

Figure 3-1 shows a breakdown of electric energy consumption by system type, and Figure 3-2 shows a breakdown of electric energy consumption by equipment type. The top energy intensive systems for this building are shown in Figure 3-1 and listed below.

1. **HVAC** contributing 47%
2. **Plug Loads & Other Unaccounted Loads** contributing 27%
3. **Lighting** contributing 26%

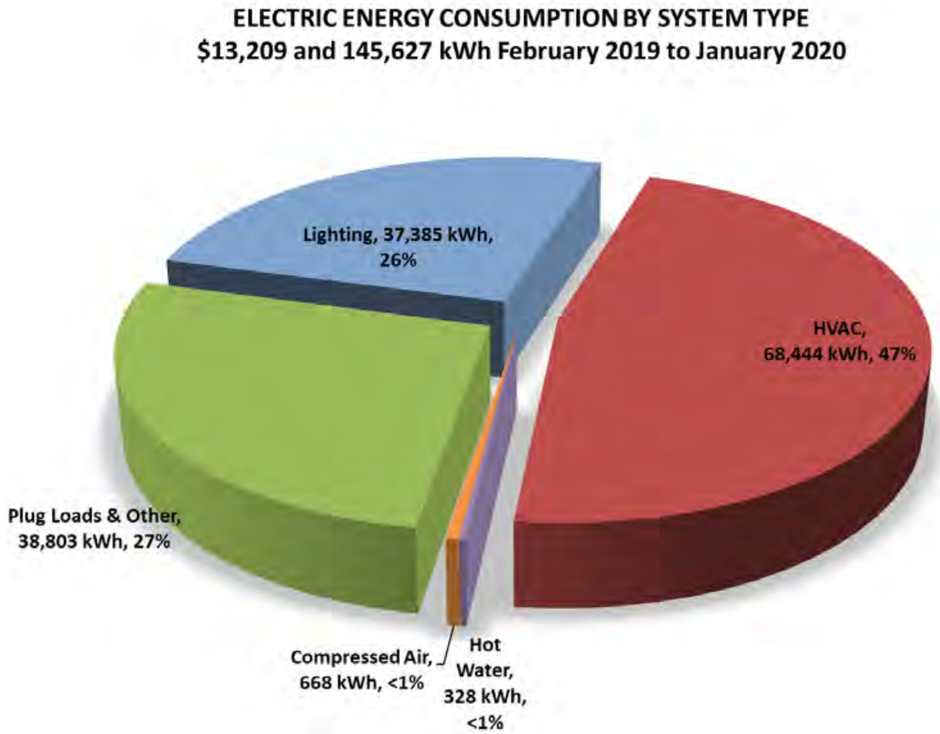


Figure 3-1: PSB Electric Energy Consumption by System

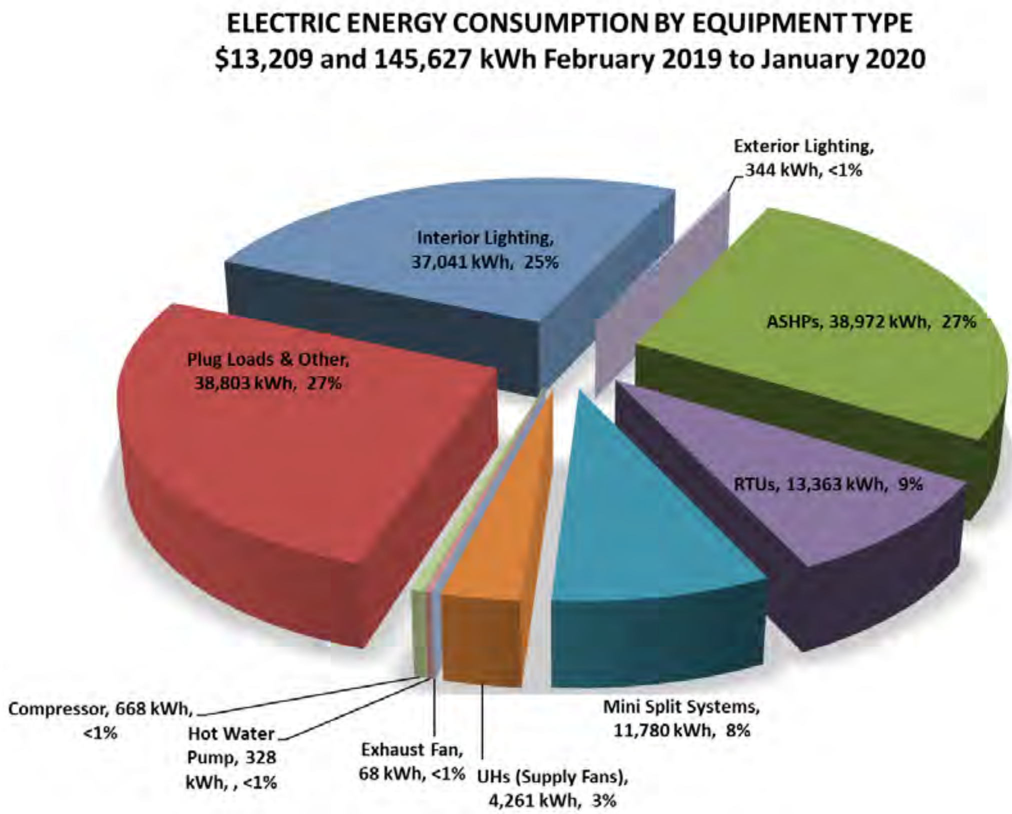


Figure 3-2: PSB Electric Energy Consumption by Equipment

AB

Figure 3-3 shows a breakdown of electric energy consumption by equipment type, and Figure 3-4 show a breakdown of electric energy consumption by system type. The top energy intensive systems for this building are shown in Figure 3-3 and listed below.

1. **HVAC** contributing 38%
2. **Plug Loads** contributing 30%
3. **Interior and Exterior Lighting** contributing 23%

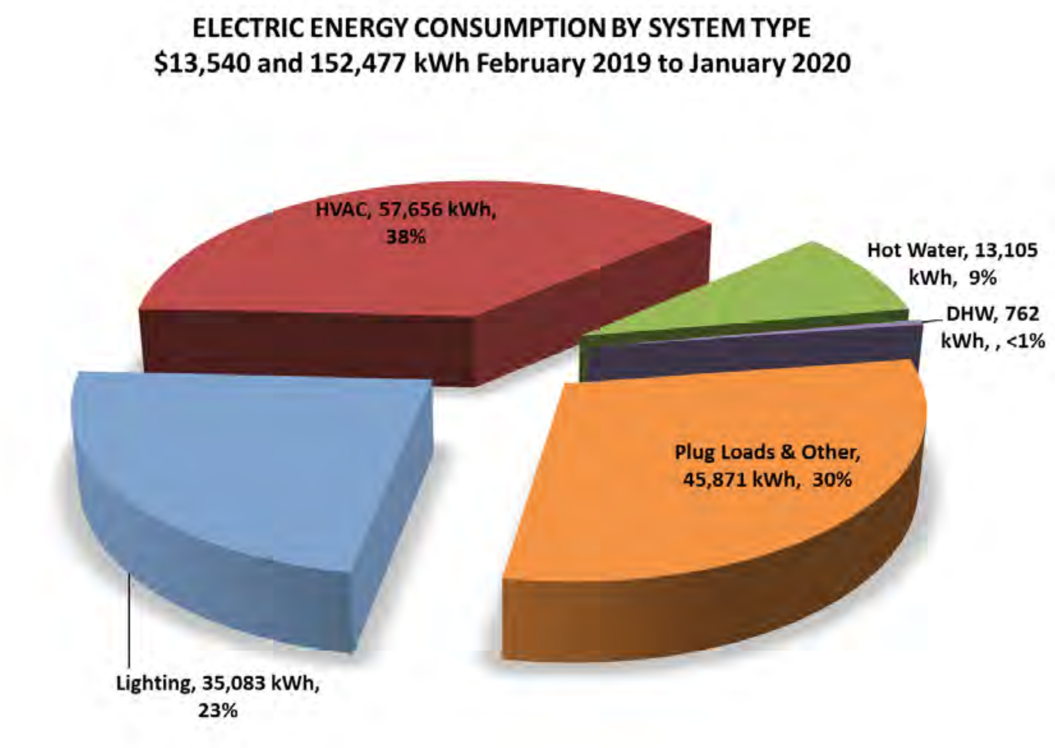


Figure 3-3: AB Electric Consumption Breakdown by System Type

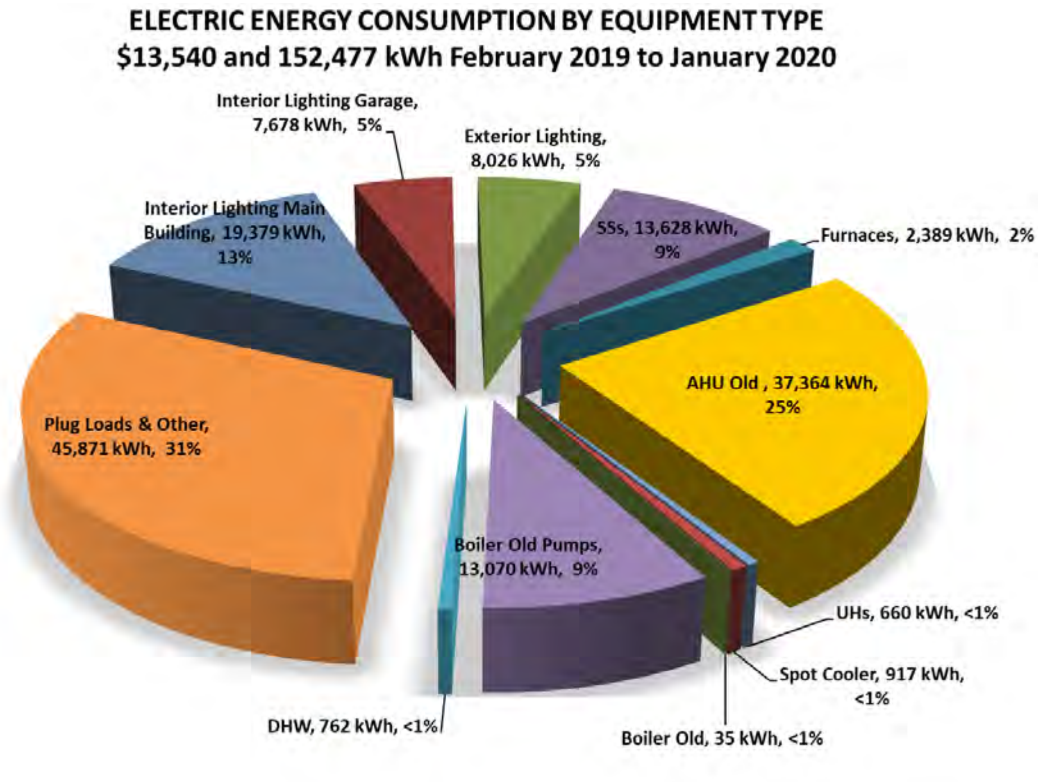


Figure 3-4: AB Electric Consumption Breakdown by Equipment Type

Note the AHU in the unoccupied portion of the AB is currently consuming 25% of the yearly electricity consumption. This assumes the supply fan is rated at 5HP and is constantly running throughout the year.

3.2- Natural Gas Energy Consumption

Available equipment data and operating parameters were used to determine major natural gas users and their expected annual natural gas use. Baseline energy consumption calculations are shown in Appendix B.

PSB

Figure 3-5 shows a breakdown of natural gas energy consumption by system type, and Figure 3-6 shows a breakdown of natural gas energy consumption by equipment type. The top energy intensive systems for this building are shown in Figure 3-5 below and listed below.

1. **Hot Water** contributing 48%
2. **HVAC** contributing 43%

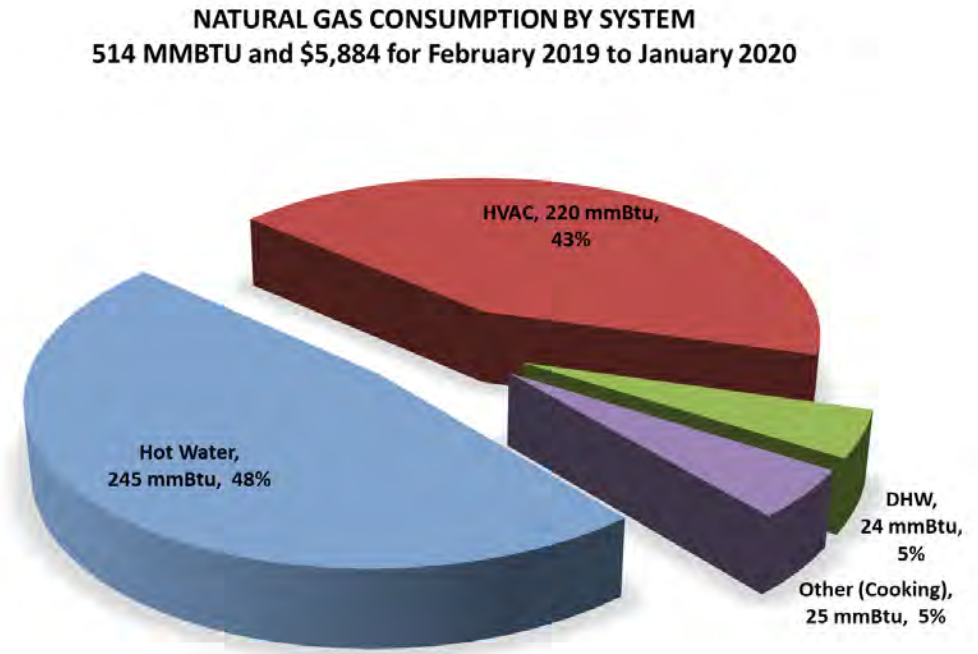


Figure 3-5: PSB Natural Gas Energy Consumption Breakdown by System

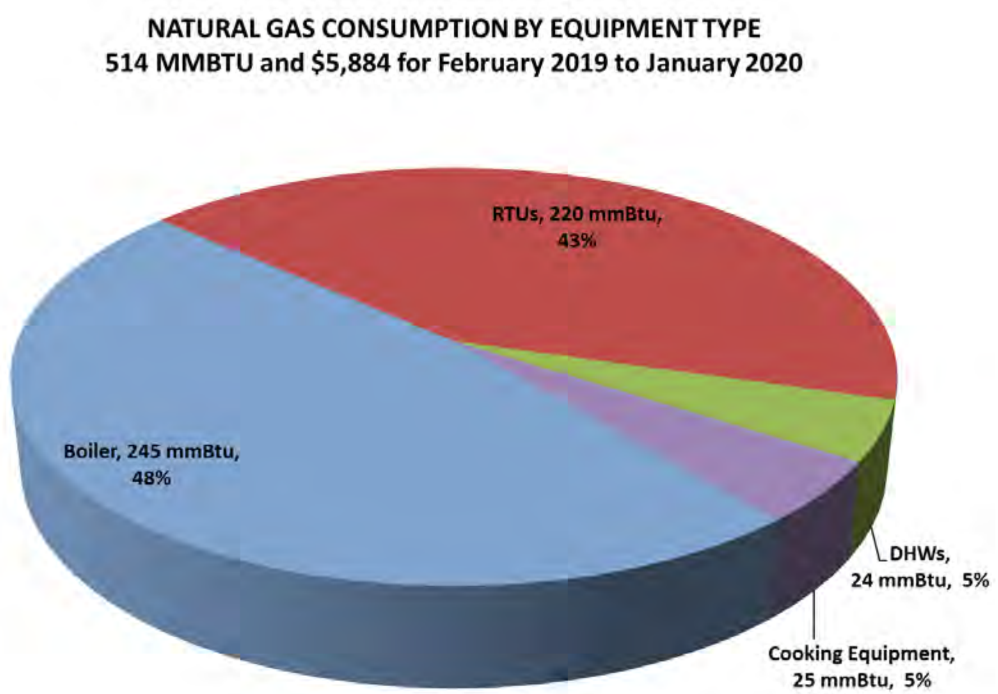


Figure 3-6: PSB Natural Gas Energy Consumption Breakdown by Equipment

AB

Figure 3-7 shows a breakdown of natural gas energy consumption by system type, and Figure 3-8 shows a breakdown of natural gas energy consumption by equipment type. The top energy intensive systems for this building are shown in Figure 3-7 below and listed below.

1. **HVAC** contributing 67%
2. **Hot Water** contributing 31%
3. **DHW** contributing 2%

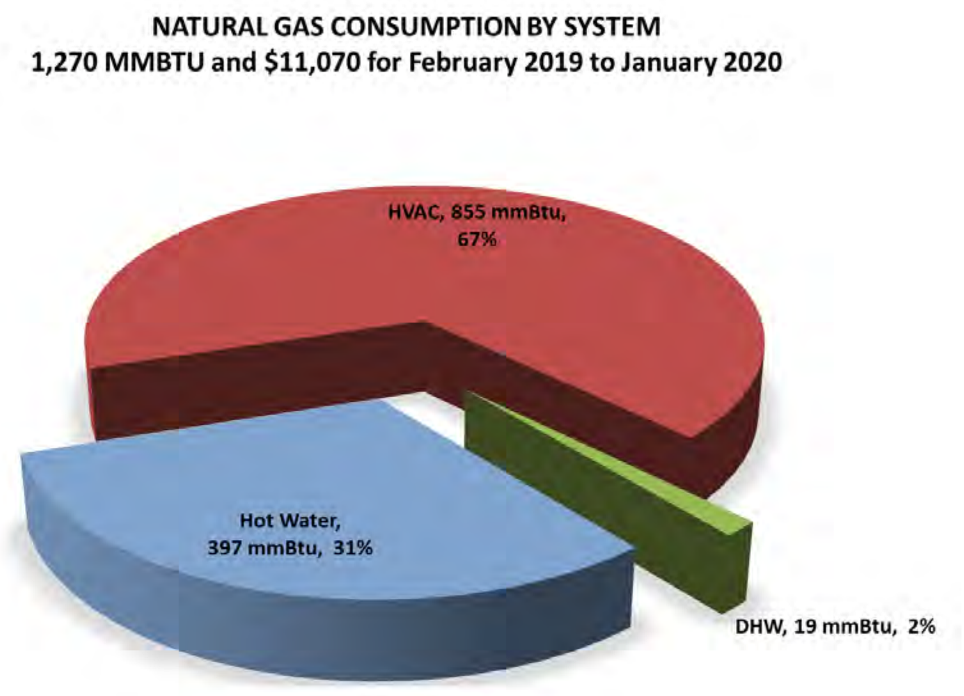


Figure 3-7: AB Natural Gas Energy Consumption Breakdown by System

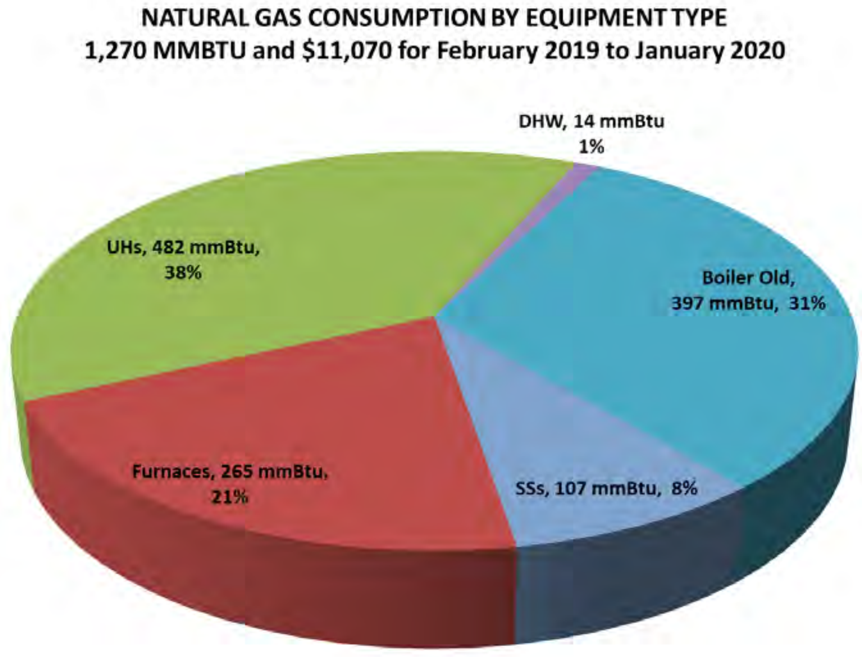


Figure 3-8: AB Natural Gas Energy Consumption Breakdown by Equipment

3.3- Baseline Energy Consumption

3.3.1- HVAC

PSB

The PSB's HVAC system is largely decentralized, with 12 individual forced-air units providing cooling and heating to the building and a central hot water, radiant heat system providing heat to half of the Police Department building. Table 5-1 in Appendix B provides a detailed list of the forced-air equipment, and below is a summary list of units by space.

Police Department

- (3) Carrier air source heat pumps (3, 3.5, 4 Tons, 15 SEER)
- (2) Sanyo min-split heat pump systems (2 Tons, 13 SEER)
- (1) Reznor UDAP60 natural gas fired unit heater (49,800 Btuh)
- (1) Lochinvar KBN286 natural gas condensing boiler (259,000 Btuh)

Fire Department

- (3) ICP Roof-top units: DX-cooling (3, 3, 5 Tons at 15 SEER); NG-heating (49, 93, 88 kBtuh)
- (1) Reznor UDAP100 unit heater (87kBtuh)
- (2) Reznor UDAP150 unit heaters (124.5 kBtuh)

For the Police Department cooling is provided using three Carrier air source heat pumps (ASHPs) and two Sanyo mini-split units. Primary heating is supplied by hot water radiant heaters, and the supplemental heat from the ASHPs and mini-split systems.

The Police Department office area is separated into three primary zones for cooling and one zone for heating. Each ASHP is controlled using a single, programmable thermostat per zone, with one thermostat located in each of the following spaces: Lieutenant's Office, Upper Level Stairwell, and the Clerk's Office. Each of these thermostats heating setpoint was 67°F during the site walkthrough. Radiant heating is controlled by a central thermostat outside of the Police Chief's Office. Based on onsite observations, the radiant heating setpoint in winter is 70°F.

The Police Department Garage is provided heat by a unit heater and is controlled by its own local thermostat set to 67°F. Supplementary heating and cooling provided by the mini-split systems located in the lunch room adjacent to the garage and is controlled by a local thermostat and is adjusted manually when the space is occupied.

The basement of the Police Department is heated and cooled by a mini-split system in the exercise room. The exercise room mini-split is controlled by its own local thermostat and is adjusted manually when the space is occupied.

The Fire Department 2nd floor is conditioned using the three International Comfort Product roof top units (RTUs), each serving one of three zones. Digital, programable thermostats controlling the units are located in: 1) the main conference room; 2) the office; 3) the main living space. During the sit walkthrough, all three thermostats were set to the "Off" position with actual space temperatures in the 63 - 67°F range.

The Fire Department Apparatus Bays are heated by three Reznor natural gas-fired unit heaters. Each unit heater in the Apparatus Bays is controlled by its own local thermostat. Based on on-site observations, the unit heater winter setpoint is 65°F.

The energy consumption of the HVAC system is estimated using equipment nameplate data, estimated annual run-hours, and estimated operational load factors. The estimated electric energy consumption is 68,444 kWh/year at a cost of $6,159/year. The total estimated natural gas consumption is 220 MMBtu/year at a cost of $2,521/year. Baseline energy calculations are found in Appendix B, Table 5-1.

AB

The AB's HVAC system is largely decentralized, with 10 separate pieces of forced-air equipment providing cooling and heating to the building. Table in Appendix B provides a detailed list of equipment, and below is a summary list of units by space.

Main Administration Building – Occupied Portion

- (3) Carrier A59CP5A040 split system: DX-cooling (2 Tons, 12 SEER each); NG-heating (24 kBtuh each)
- (1) Arcoaire split system: DX-cooling (5 Tons, 12 SEER); NG-heating (60 kBtuh)
- (3) Forced-air natural gas furnaces (24 kBtuh each)
- (1) Mueller Climatrol 105-150 forced-air natural gas furnace (120 kBtuh)

Main Administration Building – Unoccupied Portion

- (1) Well-McLain LGB-15 105-150 natural gas water-tube boiler (1.28 MMBtuh)

The front portion of the Administration Building is provided cooling using three Carrier split system units and one Arcoaire split unit. One of the Carrier units serves the Public Works Office, one serves the Tax Office, and one serves the Mayor's Office. Similarly, there is one furnace per office. Each office has their own non-programable thermostat controlling both the furnace and the cooling unit for each respective office. The Arcoaire unit provides cooling to the Council Chambers and the common area hallways in the front of the building. Heating to these areas is provided using one Mueller Climatrol natural gas-fired furnace, both of which are controlled by a non-programmable thermostat. Heating setpoints for the front of the building range from 67-70°F, and cooling setpoints range from 68-72°F.

The rear, northern end of the Administration Building is heating only. Heating is controlled manually by each room's thermostat, with no unoccupied temperature setbacks currently in place. Based on onsite observations, the heating setpoint for of the rear of the building is 60°F when unoccupied, which is 99% of the time.

Approximately half of the Administration Building, the gymnasium side, is unoccupied and not accessible to building occupants due to sever roof leaks and related mold concerns. Within this unoccupied portion of the building, heating is kept to a minimum to prevent pipes from freezing. Radiant heating is provided by the Weil-McLain boiler and distributed by two small hot water pumps. The supply fan of a single air handling unit (AHU) also runs year-round.

Adjacent to the Administration Building is the Public Works Garage. This building is conditioned only during winter months with two Reznor natural gas-fired unit heaters. There is no cooling system serving this space.

The energy consumption of the HVAC system is estimated using equipment nameplate data, assumed annual run-hours, and assumed operational load factors. The estimated electric energy consumption is 57,656 kWh/year at a cost of $5,189/year. The estimated natural gas consumption is 855 MMBtu/year at a cost of $7,447/year. Baseline energy calculations are found in Appendix B, Table 5-2.

3.3.2- Lighting

PSB

The interior lighting system consists of mainly 2'x4' recessed troffer fixtures. While some interior downlighting and strip lights have been updated to LEDs, the majority of fixtures utilize 32W linear fluorescent lamps, screw-in CFLs, and incandescent bulbs. The exterior lighting consists of four wall sconces utilizing incandescent and CFL lamps.

The energy consumption of the lighting system is estimated using fixture/lamps counts and estimated annual run-hours. The estimated electric energy consumption is 37,041 kWh/year at a cost of $2,963/year for interior lighting and 344 kWh/year at a cost of $27.52/year for exterior lighting. Baseline energy calculations are found in Appendix B, Table 5-3.

AB

The interior lighting system consist of mainly 2'x4' recessed troffer fixtures using 4', 32W T-8 lamps. A few other fixtures are present utilizing screw-in CFLs and incandescent bulbs. Exterior lighting includes 5 single-head LED pole lights and a variety of HID wallpacks, some of which are controlled by photocells. Exterior lighting fixtures were assumed to be on 9 hours a day.

The energy consumption of the lighting system is estimated using fixture/lamps counts and assumed annual run-hours. The estimated electric energy consumption is 27,057 kWh/year at a cost of $2,164/year for interior lighting and 8,026 kWh/year at a cost of $642/year for exterior lighting. Baseline energy calculations are found in Appendix B, Table 5-4.

3.4- Potential Opportunities

The following energy conservation opportunities (ECOs) are identified in the energy conservation plan for the site. These are based on the key areas indicated by the energy flow map and input from the City of North College Hill personnel.

In addressing energy conservation opportunities, the prioritization is based on the following:

1. Current energy usage, ensuring that the end use requirements are properly understood and met using best available current technologies at the appropriate level and quality.
2. Current situation in terms of business needs, equipment condition, and capital projects under consideration.

3.4.2- HVAC System Energy Conservation Opportunities

ECO 1a – Turn Off HVAC Equipment in Unoccupied Portion of AB

Currently half of AB is unoccupied, the gymnasium side, due to severe roof leak issues and resulting mold concerns. The heating and air handling equipment for this half of the building is still running at minimum possible state during colder months for freeze protection purposes. During all other seasons the equipment runs for maintenance and reliability purposes, because if they were shut-off in warmer months there will likely be major issues preventing the systems from restarting in colder months. The equipment running includes: the boiler, (2) boiler pumps, and the AHU's supply fan. None of this equipment serves the needs of the occupied portion of the building, and thus could be shut down with no negative impact to the occupied portion.

It is recommended to drain the domestic water pipes, heating hot water pipes, and turn off the boiler, boiler pumps, and AHU within the unoccupied portion of the AB. This will save both electricity and natural gas, though will likely result in the loss of certificate of occupancy for the building, thus adding more challenges and cost to repairing and re-occupying the building in the future if the space is needed. The resulting electric energy savings is estimated to be 50,469 kWh/year with a cost savings of $4,477 and a natural gas savings of 528 MMBtu/year with a cost savings of $4,605. Savings calculations are found in Appendix C, Table 6-1.

ECO 1b – Thermostat Optimization at PSB (Police)

Currently, the radiant heating system in the Police Department is controlled by mechanical thermostat located in the hallway near the Office area. Older style, mechanical thermostats do not have any scheduling ability. All set points changes are made manually resulting in lost energy savings from set-point set-backs during unoccupied hours. Three to seven percent reduction in heating and cooling energy is possible by utilizing programable thermostats. It is recommended to replace the mechanical thermostat with a digital, programmable thermostat and implement daily temperature setpoint schedules based on typical occupancy patterns.

Additionally, three digital and programable thermostats control the three ASHPs but do not have any occupied or unoccupied set points programmed. This includes the thermostat in the Lieutenant's Office/Server Room, the thermostat at the top of the stairwell on the second floor, and the thermostat in the Central Office. It is recommended to program occupied sets point of 72°F for cooling and 68°F for heating, and unoccupied set points of 78°F for cooling and 65°F. The thermostat in the Central Office controls areas that are occupied 24/7, and therefore, may not be able to implement unoccupied set points.

Significant HVAC cooling and heating energy savings can be achieved by installing a programmable thermostat to control the radiant heating, standardizing the ASHPs' thermostat schedules, and also by decreasing any space heater usage. The resulting electric energy savings is estimated to be 4,717 kWh/year with a cost savings of $428 and a natural gas savings of 28 MMBtu/year with a cost savings of $317. Savings calculations are found in Appendix C, Table 6-2.

ECO 1c – Thermostat Optimization at AB

Standard heating setpoints in the Administration Building for occupied spaces range from 67-70°F, and 68-72°F for cooling setpoints. None of the existing thermostats are programable. All set points changes are made manually resulting in lost energy savings from set-point set-backs during unoccupied hours. A three to seven percent reduction in heating and cooling energy is possible by utilizing programable thermostats.

It is recommended to replace the existing thermostats with a digital, programmable thermostat and implement daily temperature setpoint schedules based on typical occupancy patterns. The resulting electric energy savings is estimated to be 1,443 kWh/year with a cost savings of $128 and a natural gas savings of 3 MMBtu/year with a cost savings of $27. Savings calculations are found in Appendix C, Table 6-3.

ECO 1d – Replacement Strategy for ASHPs at PSB (Police)

The three existing ASHPs at the Police Department are approximately nine years old and have a Seasonal Energy Efficiency Rating (SEER) of 15.0. According to American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) the useful life of ASHPs is 10-12 years. Similarly, the US EPA currently requires a minimum SEER of 15.0 for a new ASHP to be Energy

Star certified. However, the Energy Start standards are now five years old and many units available today have a SEER in the 16.0 – 20.0 range, or approximately 20% more efficient. Additionally, the existing ASHPs have a Heating Seasonal Performance Factor (HSPF) of 8.0, while new units have a HSPF ranging from 8.5 – 10.5.

Energy savings from ASHP replacement is estimated using name plate data, estimated operational hours per year, and estimated operational load factors. Replacement equipment performance was selected based on typical performance of new units being sold today, most of which exceed Energy Star standards. The estimated electrical energy savings is 7,688 kWh/year with a cost savings of $697/year. Savings calculations are found in Appendix C, Table 6-4.

ECO 1e – Replacement Strategy for RTUs at PSB (Fire Department)

The three existing RTUs at the Fire Department are approximately three years old and have an Energy Efficiency Rating (EER) of 11.5 to 12.0. According to American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) the useful life of RTUs is 15-20 years. Similarly, the US EPA currently requires a minimum EER of 12.0 for a new RTU to be Energy Star certified. However, the Energy Start standards are now five years old and many units available today have an EER in the 15.0 – 16.0 range, or approximately 25% more efficient. Additionally, the RTUs have a heating efficiency ranging from 80-82%. New replacement units have an efficiency of at least 95%. Even though the existing units are relatively new and reasonably energy-efficient, it is recommended to develop a replacement strategy to maximize operational savings in the case of premature unit failure.

Energy savings from RTU replacement is estimated using name plate data, estimated operational hours per year, and assumed operational load factors. Replacement equipment performance was selected based on typical performance of new units being sold today, most of which exceed Energy Star standards. The estimated electrical energy savings is 2,560 kWh/year with a cost savings of $232/year and a natural gas savings of 43 MMBtu/year with a cost savings of $497/year. Savings calculations are found in Appendix C, Table 6-5.

ECO 1f – HVAC Replacement Strategy at AB

The four existing packaged air conditioning units at the Administrative Building are approximately six years old and are assumed to have an Energy Efficiency Rating (EER) of 12.0. The useful life of central air conditioners is typically between 12-15 years. The US EPA currently requires a minimum EER of 12.0 for new central air conditioners to be Energy Star certified. However, the Energy Star standards are now five years old and many units available today have an EER in the 15.0 – 16.0 range, or approximately 25% more efficient. Additionally, the AHUs/furnaces in each of the AB's front offices is assumed to have a heating efficiency ranging from 80-84%. New replacement units have an efficiency of at least 95%. Even though the existing units are relatively new and reasonably energy-efficient, it is recommended to develop a replacement strategy to maximize operational savings in the case of premature unit failure. It is also recommended to replace the existing Mueller Climatrol furnace in the AB's mechanical room. This furnace is estimated to have a derated efficiency of 64%. This is 34% less efficient than newer models.

Energy savings from the replacement of central air conditioners and furnaces is estimated using name plate data, assumed operational hours per year, and assumed operational load factors. Replacement equipment performance was selected based on typical performance of new units being sold today, most of which exceed Energy Star standards. The estimated electrical energy savings is 4,222 kWh/year with a cost savings of $447/year and a natural gas savings of 115 MMBtu/year with a cost savings of $3,167/year. Savings calculations are found in Appendix C, Table 6-6.

ECO 1g – Replace Breakroom Spot Cooler and Space Heater with Window Unit (AB)

A breakroom utilized by the city employees working in the Public Works Garage is located in the rear of AB. Since the rest of the rear portion of the building is usually unoccupied and the heating and cooling systems turned off, the break room utilizes a portable, electric space heater for providing heat and a portable spot cooler for cooling. The break room is a reasonably small, enclosed room.

Portable spot coolers are designed to be used in larger, open areas such as unconditioned manufacturing areas and only for cooling what is located directly Infront of where they discharge cold air. For example, a manufacturing worker who never moves more than a few feet from a specify location. Spot coolers are not intended to cool an entire space. In using a spot cooler for cooling the small enclosed breakroom, the spot cooler actually adds cooling load to the space (its waste heat is expelled into the space we want to cool) making it an inefficient solution for cooling in this case. Utilizing a mini-split system or even a window unit air conditioner is a much more efficient approach, as these systems are space coolers since they expel their waste heat to a different space than that to be kept cool.

Additionally, by installing a min-split system or window unit heat pump heating efficiency is improved also. Heat pumps are two to three times more efficient for providing heat vs an electric resistance space heater. By appropriately installing an ASHP window unit in the break room such that its condenser is located outside of the breakroom itself, electricity savings will be realized and climate comfort in the break room improved. The resulting electric energy savings is estimated to be 1,783 kWh/year with a cost savings of $158/year. Savings calculations are found in Appendix C, Table 6-7.

3.4.3- Lighting System Energy Conservation Opportunities

ECO 2a – Retrofit Interior Fluorescent Lighting to LED at PSB

During the PSB site walkthrough, it was observed that the building uses interior fluorescent lighting. Significant energy savings can be realized by replacing the fluorescent lamps with LEDs. The next sections will detail different replacement strategies available at the PSB building. If ballast replacement is likely to be required soon, Type B fixture replacement is recommended.

ECO 2a-i – Retrofit Interior Fluorescent Lighting to Type A LED at PSB

Type A tubes are referred to as 'plug-n-play' because the lamps are designed to simply plug into the current fixture and utilize the current fluorescent ballast installed. This allows for the lowest upfront project costs due to not having to replace the current fixture or ballast, or purchase a lamp with an internal driver. On the other hand, Type A tubes sacrifice efficiency due to the additional power loss from the existing ballast and offer limited dimming and controls. Since the lifetime of these tubes depend directly on the lifetime of the existing ballasts, using Type A tubes could lead to additional maintenance costs within the lifetime of the product.

The estimated cost to implement Type A lamp replacement at the PSB building, including Duke Energy rebates and labor costs, is $5,693, with total energy savings estimated as 18,880 kWh/year ($1,510). Cost estimates come from the Grainger's database. Savings calculations are found in Appendix C, Table 6-8.

ECO 2a-ii – Retrofit Interior Fluorescent Lighting to Type B LED at PSB

Type B tubes are a ballast bypass model where the internal driver is powered directly from the main voltage supplied to the existing fixture, thereby requiring several structural and wiring modifications. This often leads to higher initial cost when compared to Type A replacement, but lower maintenance costs due to the absence of ballasts. Type B tubes are characteristically more efficient than Type A, with no power loss from the removal of the existing LFL ballast, but Type B tubes are similarly limited in dimming and control capabilities. Since direct wiring can cause sparking and lamp failure, strict adherence to installation instructions is mandatory.

The estimated cost to implement Type B lamp replacement at the PSB building, including Duke Energy rebates and labor costs, is $7,686 with total energy savings estimated as 19,989 kWh/year ($1,599). Cost estimates come from the Grainger's database. Savings calculations are found in Appendix C, Table 6-8.

ECO 2a-iii – Retrofit Interior Fluorescent Lighting to LED Fixtures at PSB

LED Fixture replacement offers high system efficiency, system compatibility, and overall performance. Type C fixture replacement requires the replacement of the entire fixture but eliminates the need for an external driver. Note that this analysis considers the replacement of all 4-foot 2, 4, and 6 lamp fixtures for LED fixture replacement.

The estimated cost to implement LED fixture replacement at the PSB building, including Duke Energy rebates and labor costs, is $11,845 with total energy savings estimated as 22,054 kWh/year ($1,764). Cost estimates come from 1,000Bulbs and BeesLighting.com. Savings calculations are found in Appendix C, Table 6-8.

ECO 2d – Retrofit Exterior Lighting to LED at PSB

A small amount of energy savings can be realized by replacing incandescent and CFL bulbs in exterior wall sconces with LED screw in bulbs at the PSB.

The cost to implement these changes are expected to be less than $20 with total energy savings estimated as 167 kWh/year ($13). Savings calculations are found in Appendix C, Table 6-9.

ECO 2b – Retrofit Interior Fluorescent Lighting to LED at AB

During the site walkthrough at the Administrative Building, it was observed that interior fluorescent lighting is used throughout the site. Significant energy savings can be realized by replacing the fluorescent lamps with LEDs. Energy cost savings in the rear of the building will be limited due to infrequent occupancy, but a quicker payback will be recognized in the front offices with consistent occupancy. The next sections will detail different replacement strategies available. If ballast replacement is likely to be required soon, Type B fixture replacement is recommended.

ECO 2b-i – Retrofit Interior Fluorescent Lighting to Type A LED at AB

Type A tubes are referred to as 'plug-n-play' because the lamps are designed to simply plug into the current fixture and utilize the current fluorescent ballast installed. This allows for the lowest upfront project costs due to not having to replace the current fixture or ballast, or purchase a lamp with an internal driver. But Type A tubes sacrifice efficiency due to the additional power loss from the existing ballast and is limited in dimming and controllability. Since the lifetime of these tubes depend directly on the lifetime of the ballasts, using Type A tubes could lead to additional maintenance costs within the lifetime of the product.

The estimated cost to implement Type A lamp replacement at the AB, including Duke Energy rebates and labor costs, is $7,693 with total energy savings estimated as 10,281 kWh/year ($822). Cost estimates come from Grainger's database. Savings calculations are found in Appendix C, Table 6-10.

ECO 2b-ii – Retrofit Interior Fluorescent Lighting to Type B LED at AB

Type B tubes are a ballast bypass model where the internal driver is powered directly from the line voltage supplied to the existing fixture, thereby requiring several structural and wiring modifications. This often leads to higher initial cost when compared to Type A replacement, but lower maintenance costs due to the absence of ballasts. Type B tubes are characteristically more efficient than Type A, with no power loss from the existing ballast, but Type B tubes are also limited in dimming and control capabilities. Since direct wiring can cause sparking and lamp failure, strict adherence to installation instructions is mandatory.

The estimated cost to implement Type B lamp replacement at AB, including Duke Energy rebates and labor costs, is $10,386 with total energy savings estimated as 10,886 kWh/year ($870). Cost estimates come from Grainger's database. Savings calculations are found in Appendix C, Table 6-10.

ECO 2b-iii – Retrofit Interior Fluorescent Lighting to LED Fixtures at AB

LED Fixture replacement offers high system efficiency, system compatibility, and overall performance. Type C fixture replacement requires the replacement of the entire fixture but eliminates the need for an external driver. The fixture replacement has lower upfront costs but ultimately has lower energy savings. Note that this analysis considers the replacement of all 4-foot 2, 4, and 6 lamp fixtures for LED fixture replacement.

The estimated cost to implement Type C fixture replacement at the AB, including Duke Energy rebates and labor costs, is $9,975 with total energy savings estimated as 13,441 kWh/year ($1,075). Cost estimates come from 1,000Bulbs and BeesLighting.com. Savings calculations are found in Appendix C, Table 6-10.

ECO 2e – Retrofit Exterior Lighting to LED at AB

Significant energy savings can be realized by replacing exterior wallpacks and metal halide lamps with LEDs at the Administration Building. It is recommended that the existing wallpacks and metal halide lamps be replaced with screw-in "corn bulb" and "paddle bulb" LED lamps. These screw-in bulbs have internal drivers, and require the removal of existing fixture ballasts before operation.

The cost to implement exterior lamp replacement at the AB is $1,058 with total energy savings estimated as 4,102 kWh/year ($328). Refer to Appendix C: Table 6-11 for details on the savings calculations. Note that Duke Energy offers up to $15 per HID fixture between 100-500W.

ECO 2c – Retrofit Interior Fluorescent Lighting to LED at Public Works Garage

During the site walkthrough at the Public Works Garage, it was observed that the building uses high bay fluorescent lighting. Significant energy savings can be realized by replacing the fluorescent lamps with LEDs. The next sections will detail different replacement strategies available. If ballast replacement is likely to be required soon for either site, Type B replacement is recommended.

ECO 2c-i – Retrofit Interior Fluorescent Lighting to Type A LED at Public Works Garage

Type A tubes are referred to as 'plug-n-play' because the lamps are designed to simply plug into the current fixture and utilize the current fluorescent ballast installed. This allows for the lowest upfront project costs due to not having to replace the current fixture or ballast, or purchase a lamp with an internal driver. But Type A tubes sacrifice efficiency due to the additional power loss from the existing ballast and is limited in dimming and controllability. Since the lifetime of these tubes depend directly on the lifetime of the ballasts, using Type A tubes could lead to additional maintenance costs within the lifetime of the product.

The estimated cost to implement Type A lamp replacement at the Public Works Garage, including Duke Energy rebates and labor costs, is $1,440 with total energy savings estimated as 3,819 kWh/year ($305). Cost estimates come from Grainger's database. Savings calculations are found in Appendix C, Table 6-12.

ECO 2c-ii – Retrofit Interior Fluorescent Lighting to Type B LED at Public Works Garage

Type B tubes are a ballast bypass model where the internal driver is powered directly from the line voltage supplied to the existing fixture, thereby requiring several structural and wiring modifications. This often leads to higher initial cost when compared to Type A replacement, but lower maintenance costs due to the absence of ballasts. Type B tubes are characteristically more efficient than Type A, with no power loss from the existing ballast, but Type B tubes are also limited in dimming and control capabilities. Since direct wiring can cause sparking and lamp failure, strict adherence to installation instructions is mandatory.

The estimated cost to implement Type B lamp replacement at the Public Works Garage, including Duke Energy rebates and labor costs, is $1,944 with total energy savings estimated as 4,044 kWh/year ($323). Cost estimates come from Grainger's database. Savings calculations are found in Appendix C, Table 6-12.

ECO 2c-iii – Retrofit Interior Fluorescent Lighting to LED Fixtures at Public Works Garage

LED Fixture replacement offers high system efficiency, system compatibility, and overall performance. Type C fixture replacement requires the replacement of the entire fixture but eliminates the need for an external driver. The fixture replacement has lower upfront costs but ultimately has lower energy savings. Note that this analysis considers the replacement of all 4-foot 2, 4, and 6 lamp fixtures for LED fixture replacement.

The estimated cost to implement Type C fixture replacement at the Public Works Garage, including Duke Energy rebates and labor costs, is $3,402 with total energy savings estimated as 3,819 kWh/year ($305). Cost estimates come from BeesLighting.com. Savings calculations are found in Appendix C, Table 6-12.

4.0- APPENDIX A: ENERGY FLOW MAPS

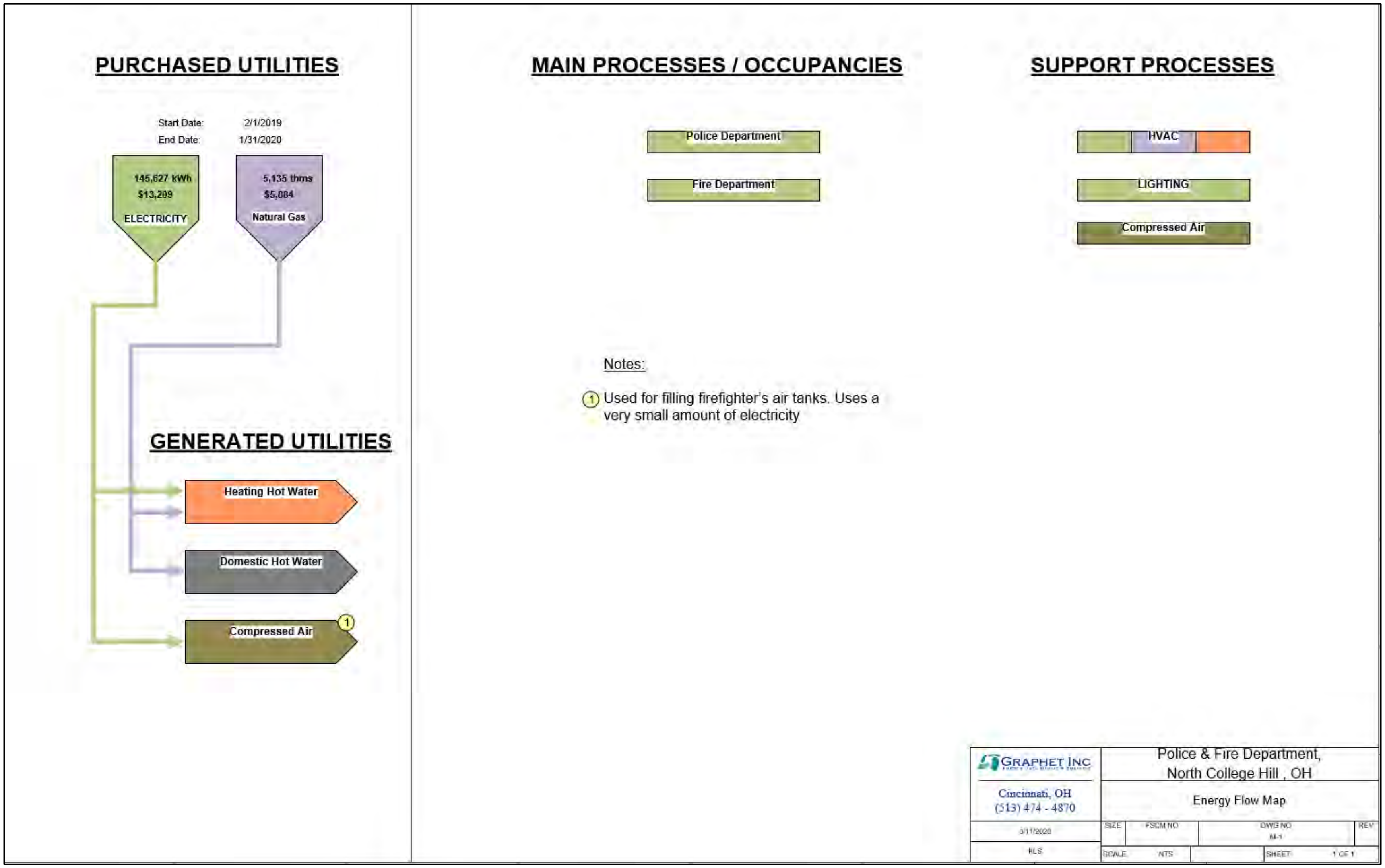


Figure 4-1: PSB Energy Flow Map

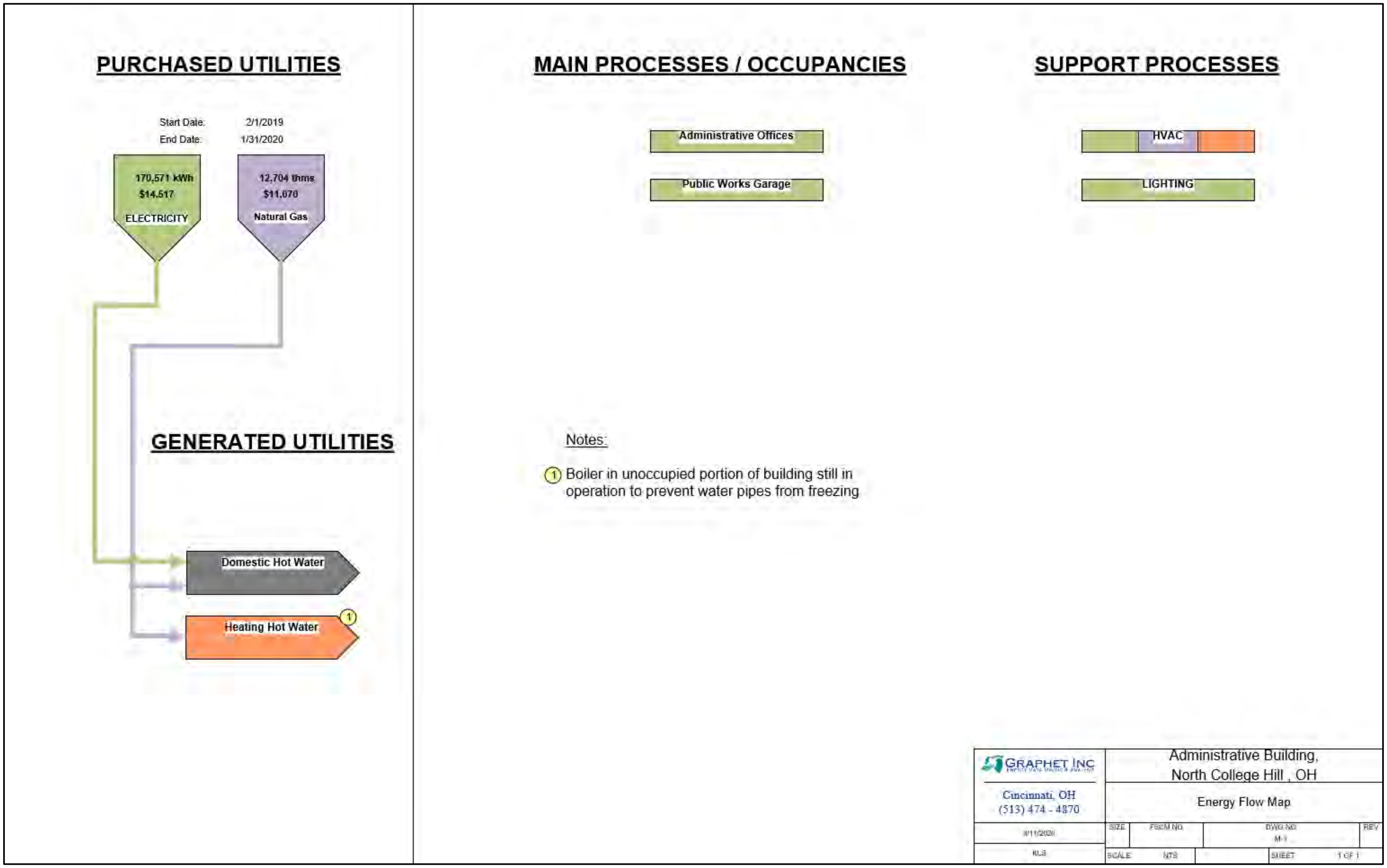


Figure 4-2: AB Energy Flow Map

5.0- APPENDIX B: BASELINE ENERGY CONSUMPTION CALCULATIONS

Note: Items in red are assumptions.

Table 5-1: PSB HVAC Equipment List

			Cooling			Heating	Fan				
Manuf	Model #	Serves	Cooling (tons)	Colling (Btuh)	SEER/EER	Heating (Btuh)	Fan (HP)	Fan (kW)	Airflow (CFM)	Age	Notes
ICP	PGD436060K000E1	Fire Department	3	36,000	/12	49,000	0.75	0.56	1200	3	RTU 1 - Dx clg, NG htg
ICP	RGX036HECA0AAAA	Fire Department	3	36,000	14/15	93,000	0.75	0.56	1200	1	RTU 2 - Dx clg, NG htg
ICP	RGV060HEFAOAAAA	Fire Department	5	60,000	14/15	88,000	0.75	0.56	2000	1	RTU 3 - Dx clg, NG htg
Reznor	UDAP100	Fire Department	-	-	-	87,150	0.25	0.19	-	Unknown	Unit Heater, NG htg
Reznor	UDAP150	Fire Department	-	-	-	124,500	0.25	0.19	-	Unknown	Unit Heater, NG htg
Reznor	UDAP150	Fire Department	-	-	-	124,500	0.25	0.19	-	Unknown	Unit Heater, NG htg
Carrier	FX4DNF043	Police Department	3	36,000	12.5/	36,000	0.5	0.37	1400	Unknown	ASHP 1 -Dx clg, Dx htg
Carrier	Unknown	Police Department	3.5	42,000	12.5/	42,000	0.5	0.37	1400	Unknown	ASHP 2 -Dx clg, Dx htg
Carrier	Unknown	Police Department	4	48,000	12.5/	48,000	0.75	0.56	1750	Unknown	ASHP 3 -Dx clg, Dx htg
Lochinvaar	KBN286	Police Department	-	-	-	259,000	-	-	-	Unknown	Condensing Boiler, NG htg
Reznor	UDAP60	Police Department	-	-	-	49,800	0.06	0.04	-	Unknown	Unit Heater, NG htg

Table 5-2: AB HVAC Equipment List

			Cooling			Heating	Fan				
Manuf	Model #	Serves	Cooling (tons)	Colling (Btuh)	SEER/EER	Heating (Btuh)	Fan (HP)	Fan (kW)	Airflow (CFM)	Age	Notes
Carrier	59CP5A040E141110	New Admin Building	2	24,000		24,000	0.5	0.37	800	6	Split System w/AHU DX clg, NG htg
Carrier	59CP5A040E141110	New Admin Building	2	24,000		24,000	0.5	0.37	800	6	Split System w/AHU DX clg, NG htg
Carrier	595P5A040	New Admin Building	2	24,000		24,000	0.5	0.37	800	6	Split System w/AHU DX clg, NG htg
Arcoaire	59CP5A040E141110	New Admin Building	5	60,000		60,000	0.75	0.56	1600	6	Split System w/AHU DX clg, NG htg
Unknown	Unknown	Historical Society	-	-	-	24,000	0.5	0.37	800	Unknown	Dedicated Furnace, NG htg
Unknown	Unknown	Women's Legion/Storage	-	-	-	24,000	0.5	0.37	800	Unknown	Dedicated Furnace, NG htg
Unknown	Unknown	DAV	-	-	-	24,000	0.5	0.37	800	Unknown	Dedicated Furnace, NG htg
Mueller Climatrol	105-150	Meeting Rooms, Halls	-	-	-	120,000	1.5	1.12	2000	Unknown	Dedicated Furnace, NG htg
Unknown	Unknown	Old Admin Building	-	-	-	-	5	3.73	-	Uknown	AHU, Fan runs 24-7
Weil-McLain	LGB-15	Old Admin Building	-	-	-	1,282,000	-	-	-	Unknown	Boiler, set to minimum to prevent pipes from freezing

Table 5-3: PSB Baseline Lighting Fixture List and Calculations

Interior Fixtures

Not Replaced

Public Safety Building Interior

Space	Fixture Description	Fixture Count	Lamps/Fixture	Lamp Count	Hours Operation (Hrs/Wk)	Hours Operation (Hrs/Yr)	Wattage/Lamp or Fixture	Baseline	
							Baseline	kWh/yr	$/yr
Arsenal	1 ft T12 Work Light	1	2	2	84	4368	15	131.0	$ 10.48
FD Meeting Room	2x2 U-Tube fluorescent	1	2	2	84	4368	20	174.7	$ 13.98
Lieutenant's Office	2x4 32-watt T8 fluorescent	4	4	16	40	2080	32	1065.0	$ 85.20
Court Room	2x4 32-watt T8 fluorescent	4	4	16	5	260	32	133.1	$ 10.65
Police Chief Office	2x4 32-watt T8 fluorescent	2	4	8	40	2080	32	532.5	$ 42.60
Men's RR	2x4 32-watt T8 fluorescent	1	4	4	10.5	546	32	69.9	$ 5.59
Hall	2x4 32-watt T8 fluorescent	1	4	4	40	2080.000	32	266.2	$ 21.30
Entrance Hall	2x4 32-watt T8 fluorescent	1	4	4	40	2080	32	266.2	$ 21.30
Men's Locker Room	2x4 32-watt T8 fluorescent	2	2	4	7	364	32	46.6	$ 3.73
Processing Office	2x4 32-watt T8 fluorescent	1	4	4	40	2080	32	266.2	$ 21.30
Evidence Office	2x4 32-watt T8 fluorescent	1	4	4	40	2080	32	266.2	$ 21.30
Small Clerk Office	2x4 32-watt T8 fluorescent	1	4	4	168	8736	32	1118.2	$ 89.46
Clerk Office 2	2x4 32-watt T8 fluorescent	4	4	16	168	8736	32	4472.8	$ 357.83
Interview Room	2x4 32-watt T8 fluorescent	1	4	4	40	2080	32	266.2	$ 21.30
Side Office	2x4 32-watt T8 fluorescent	2	4	8	168	8736	32	2236.4	$ 178.91
West Entrance	2x4 32-watt T8 fluorescent	1	4	4	168	8736	32	1118.2	$ 89.46
Clerk of Court Office	2x4 32-watt T8 fluorescent	1	4	4	168	8736	32	1118.2	$ 89.46
Weight Room	2x4 32-watt T8 fluorescent	7	4	28	10	520	32	465.9	$ 37.27
FD Middle South Bay	2x4 32-watt T8 fluorescent	6	4	24	21	1092	32	838.7	$ 67.09
FD Far South Bay	2x4 32-watt T8 fluorescent	6	4	24	21	1092	32	838.7	$ 67.09
FD Middle North Bay	2x4 32-watt T8 fluorescent	7	4	28	21	1092	32	978.4	$ 78.27
FD Meeting Room	2x4 32-watt T8 fluorescent	6	4	24	21	1092	32	838.7	$ 67.09
FD Storage Room	2x4 32-watt T8 fluorescent	2	4	8	1	52	32	13.3	$ 1.06
FD Kitchen	2x4 32-watt T8 fluorescent	2	4	8	168	8736	32	2236.4	$ 178.91
FD Offices	2x4 32-watt T8 fluorescent	8	4	32	84	4368	32	4472.8	$ 357.83
FD Barracks	2x4 32-watt T8 fluorescent	4	4	16	28	1456	32	745.5	$ 59.64
FD Hall	2x4 32-watt T8 fluorescent	1	4	4	184	9568	32	1224.7	$ 97.98
FD Locker Room	2x4 32-watt T8 fluorescent	3	4	12	20	1040	32	399.4	$ 31.95
FD Break Room	2x4 32-watt T8 fluorescent	2	4	8	42	2184	32	559.1	$ 44.73
FD Bathroom 1	2x4 32-watt T8 fluorescent	1	4	4	10	520	32	66.6	$ 5.32
Storage - Old Holding Cell	4 ft 32-watt T8 fluorescent	2	2	4	1	52	32	6.7	$ 0.53
Squad Room	4 ft 32-watt T8 fluorescent	6	2	12	168	8736	32	3354.6	$ 268.37
Garage	4 ft 32-watt T8 fluorescent	8	2	16	84	4368	32	2236.4	$ 178.91
Arsenal	4 ft 32-watt T8 fluorescent	4	2	8	84	4368	32	1118.2	$ 89.46
Basement Stairwell	4 ft 32-watt T8 fluorescent	2	2	4	10	520	32	66.6	$ 5.32
Side Office (Vacant)	4 ft 32-watt T8 fluorescent	1	2	2	0	0	32	0.0	$ -
Basement RR	4 ft 32-watt T8 fluorescent	1	2	2	2	104	32	6.7	$ 0.53
Drawing Storage	4 ft 32-watt T8 fluorescent	2	2	4	0.02	1	32	0.1	$ 0.01
FD Middle South Bay	4 ft 32-watt T8 fluorescent	7	2	14	21	1092	32	489.2	$ 39.14
FD Far South Bay	4 ft 32-watt T8 fluorescent	1	1	1	21	1092	32	34.9	$ 2.80
FD Far North Bay	4 ft 32-watt T8 fluorescent	16	2	32	21	1092	32	1118.2	$ 89.46
FD Restroom	4 ft 32-watt T8 fluorescent	1	2	2	2	104	32	6.7	$ 0.53
FD Storage	4 ft 32-watt T8 fluorescent	1	2	2	0.1	4	32	0.3	$ 0.02
Women's Locker Room	4 Ft LED Strip Lights	2	1	2	7	364	40	29.1	$ 2.33
Evidence Office	4 Ft LED Strip Lights	2	1	2	20	1040	40	83.2	$ 6.66
Arsenal	4 ft T12 Work Light	1	2	2	84	4368	40	349.4	$ 27.96
Stairs	4 Ft Strip Light T8	1	2	2	40	2080	38	158.1	$ 12.65
Lieutenant's Office Closet	Incandescent Bulb	1	1	1	0.1	5.2	60	0.3	$ 0.02
Court Room	LED Can Lights	18	1	18	5	260	10	46.8	$ 3.74
FD Meeting Room	LED Can Lights	9	1	9	40	2080	10	187.2	$ 14.98
FD Break Room	LED Can Lights	6	1	6	84	4368	10	262.1	$ 20.97
FD Bathroom 1	LED Can Lights	1	1	1	7	364	10	3.6	$ 0.29
FD Bathroom 2	LED Can Lights	2	1	2	7	364	10	7.3	$ 0.58
West Entrance	LED recessed ceiling PAR	1	1	1	168	8736	10	87.4	$ 6.99
Breakroom	Recessed Screw-in LEDs	6	1	6	42	2184	10	131.0	$ 10.48
Entrance Hall	Round Light Fixture - Screw in CFL	1	1	1	4	208.000	15	3.1	$ 0.25
Women's RR	Round Light Fixture - Screw in CFL	1	1	1	7	364	15	5.5	$ 0.44
Men's RR Storage	Screw-in CFL	1	1	1	0.083	4.333	15	0.1	$ 0.01
Women's RR	Screw-in CFL	3	1	3	7	364	15	16.4	$ 1.31
Men's Locker Room	Screw-in CFL	1	1	1	7	364	15	5.5	$ 0.44
Mechanical Room	Screw-in CFL	1	1	1	0.12	6	15	0.1	$ 0.01
								37,041	$ 2,963.25

Exterior Fixtures

PSB Exterior Lighting

Space	Lamp Description	Fixture Count	Hours Operation (Hrs/Yr)	Wattage/Fixture		Baseline	
				Baseline	Replacement	kWh/yr	$/yr
Exterior	Screw in CFL	3	3276	15	15	147	$ 11.79
Exterior	Screw in Incandescent	1	3276	60	9	197	$ 15.72
					Total	344	$ 27.52

Table 5-4: AB Baseline Lighting Fixture List and Calculations

Interior Fixtures

Not Replaced

Administrative Building Interior

Space	Fixture Description	Fixture Count	Lamps/Fixture	Lamp Count	Hours Operation (Hrs/Wk)	Hours Operation (Hrs/Yr)	Wattage/Lamp or Fixture	Baseline	
							Baseline	kWh/yr	$/yr
Town Hall Conference Room	2x4 32-watt T8 fluorescent	14	4	56	5	260	32	465.9	$ 37.27
Entrance Hall and Side Hall	2x4 32-watt T8 fluorescent	6	4	24	40	2080	32	1597.4	$ 127.80
Kitchen Back Room	2x4 32-watt T8 fluorescent	2	4	8	10	520	32	133.1	$ 10.65
Facility Management Office	2x4 32-watt T8 fluorescent	12	4	48	20	1040	32	1597.4	$ 127.80
Tax Office	2x4 32-watt T8 fluorescent	12	4	48	40	2080	32	3194.9	$ 255.59
Mayor's Office	2x4 32-watt T8 fluorescent	12	4	48	40	2080	32	3194.9	$ 255.59
Safety Lights (2 in each office)	2x4 32-watt T8 fluorescent	6	4	24	168	8736	32	6709.2	$ 536.74
Caucus Room	2x4 32-watt T8 fluorescent	2	4	8	2	104	32	26.6	$ 2.13
Historical Room	2x4 32-watt T8 fluorescent	12	4	48	2.5	130	32	199.7	$ 15.97
Rear Entry	2x4 32-watt T8 fluorescent	8	4	32	2	104	32	106.5	$ 8.52
DAV	2x4 32-watt T8 fluorescent	14	4	56	20	1040	32	1863.7	$ 149.09
Storage	2x4 32-watt T8 fluorescent	12	4	48	0.12	6	32	9.6	$ 0.77
Breakroom	2x4 32-watt T8 fluorescent	4	4	16	5	260	32	133.1	$ 10.65
Women's Legion	2x4 32-watt T8 fluorescent	14	4	56	1	52	32	93.2	$ 7.45
CYO Storage Room	2x4 32-watt T8 fluorescent	14	4	56	0.12	6	32	11.2	$ 0.89
Mechanical Room	300 W Screw-in Incandescent bulbs	3	1	3	0.12	6	300	5.6	$ 0.45
Kitchen	4 ft T12 Strip Light	1	1	1	10	520	40	20.8	$ 1.66
Kitchen	4 ft T8 Strip Light	1	1	1	10	520	32	16.6	$ 1.33
Tax Office Storage	Screw-in CFL	1	1	1	0.1	6	15	0.1	$ 0.01
								19,380	$ 1,550.37

Public Works Garage

Space	Fixture Description	Fixture Count	Lamps/Fixture	Lamp Count	Hours Operation (Hrs/Wk)	Hours Operation (Hrs/Yr)	Wattage/Lamp or Fixture	Baseline	
							Baseline	kWh/yr	$/yr
Public Works Garage	4 ft T8 Strip Light	18	6	108	40	2080	32	7188.5	$ 575.08
Public Works Garage	8 ft F96T8	1	2	2	40	2080	86	357.8	$ 28.62
Public Works Garage	LED Wall Pack	1	1	1	63	3276	40	131.0	$ 10.48
								7,677	$ 614.18

Exterior Fixtures

Administrative Building Exterior Lighting

Space	Lamp Description	Fixture Count	Hours Operation (Hrs/Yr)	Wattage/Fixture		Baseline	
				Baseline	Replacement	kWh/yr	$/yr
Exterior	Parking Single-Head LED Pole Lights	5	3276	150	150	2,457	196.56
Exterior	Wall Pack HPS	6	3276	100	30	1,966	157.25
Exterior	HID	7	3276	100	24	2,293	183.46
Exterior	HID	1	3276	400	100	1,310	104.83
					Total	8,026	$ 642.10

6.0- APPENDIX C: ENERGY SAVINGS CALCULATIONS

Table 6-1: ECO 1a: Decommission Unoccupied Portion of AB

	Electric (kWh/year)	Natural Gas (MMBtu/year)
AHU Supply Fan (5HP)	37,364	
Boiler (0.91kBtuh, 0.1HP blower)	35	528
Boiler Pumps (2 @ 1HP ea)	13,070	
Energy Consumption @ 8760 hours/year	**50,469**	**528**

	Electric (kWh/year)	Natural Gas (MMBtu/year)
AHU Supply Fan (5HP)	18,682	
Boiler (0.91kBtuh, 0.1HP blower)	18	264
Boiler Pumps (2 @ 1HP ea)	6,535	
Energy Consumption @ 4380 hours/year	**25,235**	**264**

Table 6-2: ECO 1b: Thermostat Optimization at PSB (Police Department)

Police Department HVAC Baseline				
Electric Useage			Natural Gas Useage	
51,068	kWh/year		4,542	therms/year
Estimated Savings - Thermostats*				
Electric			Natural Gas	
7.7%	Savings Opp		6.1%	Savings Opp
3,937	kWh/year		277	therms/year
$ 357			$ 317	
Estimated Savings - Turning Off Space Heaters				
Electric			Natural Gas	
780	kWh/year		-	
$ 71			-	
Total Savings				
Electric			Natural Gas	
4,717	kWh/year		277	therms/year
$ 428			**$ 317**	

Table 6-3: ECO 1c: Thermostat Optimization at AB

AB HVAC Baseline (*Minus Unoccupied portion*)			
Electric Useage		Natural Gas Useage	
18,714	kWh/year	496	therms/year
Estimated Savings			
Electric		Natural Gas	
7.7%	Savings Opp	6.1%	Savings Opp
1,443	kWh/year	30	therms/year
$ 128		**$ 26**	

Table 6-4: ECO 1d: Replacement Strategy for Air Source Heat Pumps at PSB (Police Department)

			Baseline	Proposed		Baseline	Proposed	Savings	
Equip	Manuf	M#	SEER	SEER	% Savings	kWh/yr	kWh/yr	kWh/yr	$
ASHP1	Carrier	FX4DNF043	15	18	17%	7,424	6,187	1,237	$ 112
ASHP2	Carrier	Unknown	15	18	17%	7,424	6,187	1,237	$ 112
ASHP3	Carrier	Unknown	15	18	17%	7,424	6,187	1,237	$ 112
						22,272	**18,560**	**3,712**	**$ 337**

			Baseline	Proposed		Baseline	Proposed	Savings	
Equip	Manuf	M#	HSPF	HSPF	% Savings	kWh/yr	kWh/yr	kWh/yr	$
ASHP1	Carrier	FX4DNF043	8	10.5	24%	5,567	4,242	1,325	$ 120
ASHP2	Carrier	Unknown	8	10.5	24%	5,567	4,242	1,325	$ 120
ASHP3	Carrier	Unknown	8	10.5	24%	5,567	4,242	1,325	$ 120
						16,701	**12,725**	**3,976**	**$ 361**

Table 6-5: ECO 1e: Replacement Strategy for RTUs at PSB (Fire Department)

			Baseline	Proposed		Baseline	Proposed	Savings	
Equip	Manuf	M#	SEER	SEER	% Savings	kWh/yr	kWh/yr	kWh/yr	$
RTU1	ICP	PGD436060K000E1	11.5	13	12%	3,831	3,389	442	$ 40
RTU2	ICP	RGX036HECA0AAAA	14	18	22%	3,738	2,907	831	$ 75
RTU3	ICP	RGV060HEFAOAAAA	14	18	22%	5793.6042	4,506	1,287	$ 117
						13,363	**10,803**	**2,560**	**$ 232**

			Baseline	Proposed		Baseline	Proposed	Savings	
Equip	Manuf	M#	AFUE	AFUE	% Savings	MMBtu/yr	MMBtu/yr	MMBtu/yr	$
RTU1	ICP	PGD436060K000E1	82	95	16%	84	70	13	$ 152
RTU2	ICP	RGX036HECA0AAAA	81	95	17%	84	69	14	$ 166
RTU3	ICP	RGV060HEFAOAAAA	80	95	19%	84	68	16	$ 180
						251	**208**	**43**	**$ 497**

Table 6-6: ECO 1f: Replacement Strategy for HVAC at AB

Equip	Manuf	M#	SN	Baseline SEER	Proposed SEER	% Savings
SS1 clg	Carrier	59CP5A04E141110	Unknown	12	19	37%
SS2 clg	Carrier	59CP5A04E141110	Unknown	12	19	37%
SS3 clg	Carrier	59CP5A04E141110	Unknown	12	19	37%
SS4 clg	Arcoaire	NACO48AKA4	Unknown	12	19	37%

Baseline kWh/yr	Proposed kWh/yr	Savings kWh/yr	Savings $
4,276	2,701	1,576	$ 140
4,276	2,701	1,576	$ 140
4,276	2,701	1,576	$ 140
799	504	294	$ 26
13,628	8,607	5,021	$ 447

Equip	Manuf	M#	SN	Baseline AFUE	Proposed AFUE	% Savings
SS1 htg	Unknown	Unknown	Unknown	83.6	96.7	14%
SS2 htg	Unknown	Unknown	Unknown	83.6	96.7	14%
SS3 htg	Unknown	Unknown	Unknown	83.6	96.7	14%
SS4 htg	Mueller Climatrol	105-150	Unknown	64	96.7	34%

Baseline mmBtu/yr	Proposed mmBtu/yr	Savings mmBtu/yr	Savings $
48	41.19561531	6	$ 178
48	41.19561531	6	$ 178
48	41.19561531	6	$ 178
282	186.7979317	95	$2,633
425	310	115	$3,167

Table 6-7: ECO 1g: Replace Breakroom Spot Cooler and Space Heater with Window Unit (AB)

Spot Cooler

Size (Btu)	10,500
EER	10
COP	2.930832356
Annual Run Hours	702
Energy Consumption (kWh)	***917***
Operational Cost	***$ 81.62***

Savings Opportunity

% Reduction	34%
Energy Savings (kWh)	***313***
Energy Savings ($)	***$ 27.85***

Space Heater

Size (kW)	1.5
Operational Load Factor	0.4
Annual Run Hours	4496
Energy Consumption (kWh)	***2698***
Operational Cost	***$ 240.06***

Savings Opportunity

Heat Pump Window Unit HSPF	7.5
Heat Pump Window Unit Energy Consumption (kWh)	1,227
Energy Savings (kWh)	***1470***
Energy Savings ($)	***$ 130.85***

Total Savings

Consumption (kWh)	**1783**
($)	**158.70**

Table 6-8: ECOs 2a-i thru 2a-iii: PSB Interior Lighting Calculations

Not Replaced

Public Safety Building Interior

Space	Fixture Description	Fixture Count	Lamps/Fixture	Lamp Count	Hours Operation (Hrs/Wk)	Hours Operation (Hrs/Yr)	Wattage/Lamp or Fixture					Baseline		Type A		Type B		Type C		Fixture	
							Baseline	Type A	Type B	Type C	Fixture	kWh/yr	$/yr	kWh/yr	$/yr	kWh/yr	$/yr	kWh/yr	$/yr	kWh/yr	$/yr
Arsenal	1 ft T12 Work Light	1	2	2	84	4368	15	15	15	15	15	131.0	$ 10.48	131.0	$ 10.48	131.0	$ 10.48	131.0	$ 10.48	131.0	$ 10.48
FD Meeting Room	2x2 U-Tube fluorescent	1	2	2	84	4368	20	20	20	20	20	174.7	$ 13.98	174.7	$ 13.98	174.7	$ 13.98	174.7	$ 13.98	174.7	$ 13.98
Lieutenant's Office	2x4 32-watt T8 fluorescent	4	4	16	40	2080	32	15	14	12	39	1065.0	$ 85.20	499.2	$ 39.94	465.9	$ 37.27	399.4	$ 31.95	324.5	$ 25.96
Court Room	2x4 32-watt T8 fluorescent	4	4	16	5	260	32	15	14	12	39	133.1	$ 10.65	62.4	$ 4.99	58.2	$ 4.66	49.9	$ 3.99	40.6	$ 3.24
Police Chief Office	2x4 32-watt T8 fluorescent	2	4	8	40	2080	32	15	14	12	39	532.5	$ 42.60	249.6	$ 19.97	233.0	$ 18.64	199.7	$ 15.97	162.2	$ 12.98
Men's RR	2x4 32-watt T8 fluorescent	1	4	4	10.5	546	32	15	14	12	39	69.9	$ 5.59	32.8	$ 2.62	30.6	$ 2.45	26.2	$ 2.10	21.3	$ 1.70
Hall	2x4 32-watt T8 fluorescent	1	4	4	40	2080.000	32	15	14	12	39	266.2	$ 21.30	124.8	$ 9.98	116.5	$ 9.32	99.8	$ 7.99	81.1	$ 6.49
Entrance Hall	2x4 32-watt T8 fluorescent	1	4	4	40	2080	32	15	14	12	39	266.2	$ 21.30	124.8	$ 9.98	116.5	$ 9.32	99.8	$ 7.99	81.1	$ 6.49
Men's Locker Room	2x4 32-watt T8 fluorescent	2	2	4	7	364	32	15	14	12	39	46.6	$ 3.73	21.8	$ 1.75	20.4	$ 1.63	17.5	$ 1.40	28.4	$ 2.27
Processing Office	2x4 32-watt T8 fluorescent	1	4	4	40	2080	32	15	14	12	39	266.2	$ 21.30	124.8	$ 9.98	116.5	$ 9.32	99.8	$ 7.99	81.1	$ 6.49
Evidence Office	2x4 32-watt T8 fluorescent	1	4	4	40	2080	32	15	14	12	39	266.2	$ 21.30	124.8	$ 9.98	116.5	$ 9.32	99.8	$ 7.99	81.1	$ 6.49
Small Clerk Office	2x4 32-watt T8 fluorescent	1	4	4	168	8736	32	15	14	12	39	1118.2	$ 89.46	524.2	$ 41.93	489.2	$ 39.14	419.3	$ 33.55	340.7	$ 27.26
Clerk Office 2	2x4 32-watt T8 fluorescent	4	4	16	168	8736	32	15	14	12	39	4472.8	$ 357.83	2096.6	$ 167.73	1956.9	$ 156.55	1677.3	$ 134.18	1362.8	$ 109.03
Interview Room	2x4 32-watt T8 fluorescent	1	4	4	40	2080	32	15	14	12	39	266.2	$ 21.30	124.8	$ 9.98	116.5	$ 9.32	99.8	$ 7.99	81.1	$ 6.49
Side Office	2x4 32-watt T8 fluorescent	2	4	8	168	8736	32	15	14	12	39	2236.4	$ 178.91	1048.3	$ 83.87	978.4	$ 78.27	838.7	$ 67.09	681.4	$ 54.51
West Entrance	2x4 32-watt T8 fluorescent	1	4	4	168	8736	32	15	14	12	39	1118.2	$ 89.46	524.2	$ 41.93	489.2	$ 39.14	419.3	$ 33.55	340.7	$ 27.26
Clerk of Court Office	2x4 32-watt T8 fluorescent	1	4	4	168	8736	32	15	14	12	39	1118.2	$ 89.46	524.2	$ 41.93	489.2	$ 39.14	419.3	$ 33.55	340.7	$ 27.26
Weight Room	2x4 32-watt T8 fluorescent	7	4	28	10	520	32	15	14	12	39	465.9	$ 37.27	218.4	$ 17.47	203.8	$ 16.31	174.7	$ 13.98	142.0	$ 11.36
FD Middle South Bay	2x4 32-watt T8 fluorescent	6	4	24	21	1092	32	15	14	12	39	838.7	$ 67.09	393.1	$ 31.45	366.9	$ 29.35	314.5	$ 25.16	255.5	$ 20.44
FD Far South Bay	2x4 32-watt T8 fluorescent	6	4	24	21	1092	32	15	14	12	39	838.7	$ 67.09	393.1	$ 31.45	366.9	$ 29.35	314.5	$ 25.16	255.5	$ 20.44
FD Middle North Bay	2x4 32-watt T8 fluorescent	7	4	28	21	1092	32	15	14	12	39	978.4	$ 78.27	458.6	$ 36.69	428.1	$ 34.25	366.9	$ 29.35	298.1	$ 23.85
FD Meeting Room	2x4 32-watt T8 fluorescent	6	4	24	21	1092	32	15	14	12	39	838.7	$ 67.09	393.1	$ 31.45	366.9	$ 29.35	314.5	$ 25.16	255.5	$ 20.44
FD Storage Room	2x4 32-watt T8 fluorescent	2	4	8	1	52	32	15	14	12	39	13.3	$ 1.06	6.2	$ 0.50	5.8	$ 0.47	5.0	$ 0.40	4.1	$ 0.32
FD Kitchen	2x4 32-watt T8 fluorescent	2	4	8	168	8736	32	15	14	12	39	2236.4	$ 178.91	1048.3	$ 83.87	978.4	$ 78.27	838.7	$ 67.09	681.4	$ 54.51
FD Offices	2x4 32-watt T8 fluorescent	8	4	32	84	4368	32	15	14	12	39	4472.8	$ 357.83	2096.6	$ 167.73	1956.9	$ 156.55	1677.3	$ 134.18	1362.8	$ 109.03
FD Barracks	2x4 32-watt T8 fluorescent	4	4	16	28	1456	32	15	14	12	39	745.5	$ 59.64	349.4	$ 27.96	326.1	$ 26.09	279.6	$ 22.36	227.1	$ 18.17
FD Hall	2x4 32-watt T8 fluorescent	1	4	4	184	9568	32	15	14	12	39	1224.7	$ 97.98	574.1	$ 45.93	535.8	$ 42.86	459.3	$ 36.74	373.2	$ 29.85
FD Locker Room	2x4 32-watt T8 fluorescent	3	4	12	20	1040	32	15	14	12	39	399.4	$ 31.95	187.2	$ 14.98	174.7	$ 13.98	149.8	$ 11.98	121.7	$ 9.73
FD Break Room	2x4 32-watt T8 fluorescent	2	4	8	42	2184	32	15	14	12	39	559.1	$ 44.73	262.1	$ 20.97	244.6	$ 19.57	209.7	$ 16.77	170.4	$ 13.63
FD Bathroom 1	2x4 32-watt T8 fluorescent	1	4	4	10	520	32	15	14	12	39	66.6	$ 5.32	31.2	$ 2.50	29.1	$ 2.33	25.0	$ 2.00	20.3	$ 1.62
Storage - Old Holding Cell	4 ft 32-watt T8 fluorescent	2	2	4	1	52	32	15	14	12	39	6.7	$ 0.53	3.1	$ 0.25	2.9	$ 0.23	2.5	$ 0.20	4.1	$ 0.32
Squad Room	4 ft 32-watt T8 fluorescent	6	2	12	168	8736	32	15	14	12	39	3354.6	$ 268.37	1572.5	$ 125.80	1467.6	$ 117.41	1258.0	$ 100.64	2044.2	$ 163.54
Garage	4 ft 32-watt T8 fluorescent	8	2	16	84	4368	32	15	14	12	39	2236.4	$ 178.91	1048.3	$ 83.87	978.4	$ 78.27	838.7	$ 67.09	1362.8	$ 109.03
Arsenal	4 ft 32-watt T8 fluorescent	4	2	8	84	4368	32	15	14	12	39	1118.2	$ 89.46	524.2	$ 41.93	489.2	$ 39.14	419.3	$ 33.55	681.4	$ 54.51
Basement Stairwell	4 ft 32-watt T8 fluorescent	2	2	4	10	520	32	15	14	12	39	66.6	$ 5.32	31.2	$ 2.50	29.1	$ 2.33	25.0	$ 2.00	40.6	$ 3.24
Side Office (Vacant)	4 ft 32-watt T8 fluorescent	1	2	2	0	0	32	15	14	12	39	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -
Basement RR	4 ft 32-watt T8 fluorescent	1	2	2	2	104	32	15	14	12	39	6.7	$ 0.53	3.1	$ 0.25	2.9	$ 0.23	2.5	$ 0.20	4.1	$ 0.32
Drawing Storage	4 ft 32-watt T8 fluorescent	2	2	4	0.02	1	32	15	14	12	39	0.1	$ 0.01	0.1	$ 0.00	0.1	$ 0.00	0.0	$ 0.00	0.1	$ 0.01
FD Middle South Bay	4 ft 32-watt T8 fluorescent	7	2	14	21	1092	32	15	14	12	39	489.2	$ 39.14	229.3	$ 18.35	214.0	$ 17.12	183.5	$ 14.68	298.1	$ 23.85
FD Far South Bay	4 ft 32-watt T8 fluorescent	1	1	1	21	1092	32	15	14	12	39	34.9	$ 2.80	16.4	$ 1.31	15.3	$ 1.22	13.1	$ 1.05	42.6	$ 3.41
FD Far North Bay	4 ft 32-watt T8 fluorescent	16	2	32	21	1092	32	15	14	12	39	1118.2	$ 89.46	524.2	$ 41.93	489.2	$ 39.14	419.3	$ 33.55	681.4	$ 54.51
FD Restroom	4 ft 32-watt T8 fluorescent	1	2	2	2	104	32	15	14	12	39	6.7	$ 0.53	3.1	$ 0.25	2.9	$ 0.23	2.5	$ 0.20	4.1	$ 0.32
FD Storage	4 ft 32-watt T8 fluorescent	1	2	2	0.1	4	32	15	14	12	39	0.3	$ 0.02	0.1	$ 0.01	0.1	$ 0.01	0.1	$ 0.01	0.2	$ 0.01
Women's Locker Room	4 Ft LED Strip Lights	2	1	2	7	364	40	40	40	40	40	29.1	$ 2.33	29.1	$ 2.33	29.1	$ 2.33	29.1	$ 2.33	29.1	$ 2.33
Evidence Office	4 Ft LED Strip Lights	2	1	2	20	1040	40	40	40	40	40	83.2	$ 6.66	83.2	$ 6.66	83.2	$ 6.66	83.2	$ 6.66	83.2	$ 6.66
Arsenal	4 ft T12 Work Light	1	2	2	84	4368	40	40	40	40	40	349.4	$ 27.96	349.4	$ 27.96	349.4	$ 27.96	349.4	$ 27.96	349.4	$ 27.96
Stairs	4 Ft Strip Light T8	1	2	2	40	2080	38	15	14	12	40	158.1	$ 12.65	62.4	$ 4.99	58.2	$ 4.66	49.9	$ 3.99	83.2	$ 6.66
Lieutenant's Office Closet	Incandescent Bulb	1	1	1	0.1	5.2	60	9	9	9	9	0.3	$ 0.02	0.0	$ 0.00	0.0	$ 0.00	0.0	$ 0.00	0.0	$ 0.00
Court Room	LED Can Lights	18	1	18	5	260	10	10	10	10	10	46.8	$ 3.74	46.8	$ 3.74	46.8	$ 3.74	46.8	$ 3.74	46.8	$ 3.74
FD Meeting Room	LED Can Lights	9	1	9	40	2080	10	10	10	10	10	187.2	$ 14.98	187.2	$ 14.98	187.2	$ 14.98	187.2	$ 14.98	187.2	$ 14.98
FD Break Room	LED Can Lights	6	1	6	84	4368	10	10	10	10	10	262.1	$ 20.97	262.1	$ 20.97	262.1	$ 20.97	262.1	$ 20.97	262.1	$ 20.97
FD Bathroom 1	LED Can Lights	1	1	1	7	364	10	10	10	10	10	3.6	$ 0.29	3.6	$ 0.29	3.6	$ 0.29	3.6	$ 0.29	3.6	$ 0.29
FD Bathroom 2	LED Can Lights	2	1	2	7	364	10	10	10	10	10	7.3	$ 0.58	7.3	$ 0.58	7.3	$ 0.58	7.3	$ 0.58	7.3	$ 0.58
West Entrance	LED recessed ceiling PAR	1	1	1	168	8736	10	10	10	10	10	87.4	$ 6.99	87.4	$ 6.99	87.4	$ 6.99	87.4	$ 6.99	87.4	$ 6.99
Breakroom	Recessed Screw-in LEDs	6	1	6	42	2184	10	10	10	10	10	131.0	$ 10.48	131.0	$ 10.48	131.0	$ 10.48	131.0	$ 10.48	131.0	$ 10.48
Entrance Hall	Round Light Fixture - Screw in CFL	1	1	1	4	208.000	15	15	15	15	15	3.1	$ 0.25	3.1	$ 0.25	3.1	$ 0.25	3.1	$ 0.25	3.1	$ 0.25
Women's RR	Round Light Fixture - Screw in CFL	1	1	1	7	364	15	15	15	15	15	5.5	$ 0.44	5.5	$ 0.44	5.5	$ 0.44	5.5	$ 0.44	5.5	$ 0.44
Men's RR Storage	Screw-in CFL	1	1	1	0.083	4.333	15	15	15	15	15	0.1	$ 0.01	0.1	$ 0.01	0.1	$ 0.01	0.1	$ 0.01	0.1	$ 0.01
Women's RR	Screw-in CFL	3	1	3	7	364	15	15	15	15	15	16.4	$ 1.31	16.4	$ 1.31	16.4	$ 1.31	16.4	$ 1.31	16.4	$ 1.31
Men's Locker Room	Screw-in CFL	1	1	1	7	364	15	15	15	15	15	5.5	$ 0.44	5.5	$ 0.44	5.5	$ 0.44	5.5	$ 0.44	5.5	$ 0.44
Mechanical Room	Screw-in CFL	1	1	1	0.12	6	15	15	15	15	15	0.1	$ 0.01	0.1	$ 0.01	0.1	$ 0.01	0.1	$ 0.01	0.1	$ 0.01
									Total			37,041	$ 2,963.25	18,160	$ 1,452.83	17,051	$ 1,364.10	14,833	$ 1,186.64	14,987	$ 1,198.94
											Savings/yr			18,880	$ 1,510.42	19,989	$ 1,599.15	22,208	$ 1,776.61	22,054	$ 1,764.31
											Annual % Reduction			51%		54%		60%		60%	
											Estimated Material Costs (With Rebates)			$ 2,135.00		$ 2,348.50		$ 8,392.50		$ 7,603.48	
											Estimated Labor Costs (With Rebates)			$ 3,558.33		$ 5,337.50		$ 8,040.00		$ 4,242.00	
											Simple Payback (yrs)			3.8		4.8		9.2		6.7	

Table 6-9: ECO 2d: PSB Exterior Lighting Calculations

PFD Exterior Lighting

Space	Lamp Description	Fixture Count	Hours Operation (Hrs/Yr)	Wattage/Fixture		Baseline		Replacment	
				Baseline	Replacement	kWh/yr	$/yr	kWh/yr	$/yr
Exterior	Screw in CFL	3	3276	15	15	147	$ 11.79	147	$ 11.79
Exterior	Screw in Incandescent	1	3276	60	9	197	$ 15.72	29	$ 2.36
					Total	344	$ 27.52	177	$ 14.15
							Savings/yr	167	$ 13.37
							Annual % Reduction	49%	
							Estimated Material Costs (With Rebates)	$ 15.00	
							Estimated Labor Costs	$ -	
							Simple Payback (yrs)	1.1	

Table 6-10: ECOs 2b-i thru 2b-iii: AB Interior Lighting Calculations

Administrative Building Interior

Space	Fixture Description	Fixture Count	Lamps/Fixture	Lamp Count	Hours Operation (Hrs/Wk)	Hours Operation (Hrs/Yr)	Wattage/Lamp or Fixture				
							Baseline	Type A	Type B	Type C	Fixture
Town Hall Conference Room	2x4 32-watt T8 fluorescent	14	4	56	5	260	32	15	14	12	39
Entrance Hall and Side Hall	2x4 32-watt T8 fluorescent	6	4	24	40	2080	32	15	14	12	39
Kitchen Back Room	2x4 32-watt T8 fluorescent	2	4	8	10	520	32	15	14	12	39
Facility Management Office	2x4 32-watt T8 fluorescent	12	4	48	20	1040	32	15	14	12	39
Tax Office	2x4 32-watt T8 fluorescent	12	4	48	40	2080	32	15	14	12	39
Mayor's Office	2x4 32-watt T8 fluorescent	12	4	48	40	2080	32	15	14	12	39
Safety Lights (2 in each office)	2x4 32-watt T8 fluorescent	6	4	24	168	8736	32	15	14	12	39
Caucus Room	2x4 32-watt T8 fluorescent	2	4	8	2	104	32	15	14	12	39
Historical Room	2x4 32-watt T8 fluorescent	12	4	48	2.5	130	32	15	14	12	39
Rear Entry	2x4 32-watt T8 fluorescent	8	4	32	2	104	32	15	14	12	39
DAV	2x4 32-watt T8 fluorescent	14	4	56	20	1040	32	15	14	12	39
Storage	2x4 32-watt T8 fluorescent	12	4	48	0.12	6	32	15	14	12	39
Breakroom	2x4 32-watt T8 fluorescent	4	4	16	5	260	32	15	14	12	39
Women's Legion	2x4 32-watt T8 fluorescent	14	4	56	1	52	32	15	14	12	39
CYO Storage Room	2x4 32-watt T8 fluorescent	14	4	56	0.12	6	32	15	14	12	39
Mechanical Room	300 W Screw-in Incandescent bulbs	3	1	3	0.12	6	300	300	300	300	300
Kitchen	4 ft T12 Strip Light	1	1	1	10	520	40	40	40	40	40
Kitchen	4 ft T8 Strip Light	1	1	1	10	520	32	15	14	12	40
Tax Office Storage	Screw-in CFL	1	1	1	0.1	6	15	15	15	15	15

Not Replaced

Space	Baseline		Type A		Type B		Type C Lamp		Fixture	
	kWh/yr	$/yr	kWh/yr	$/yr	kWh/yr	$/yr	kWh/yr	$/yr	kWh/yr	$/yr
Town Hall Conference Room	465.9	$ 37.27	218.4	$ 17.47	203.8	$ 16.31	174.7	$ 13.98	142.0	$ 11.36
Entrance Hall and Side Hall	1597.4	$ 127.80	748.8	$ 59.90	698.9	$ 55.91	599.0	$ 47.92	486.7	$ 38.94
Kitchen Back Room	133.1	$ 10.65	62.4	$ 4.99	58.2	$ 4.66	49.9	$ 3.99	40.6	$ 3.24
Facility Management Office	1597.4	$ 127.80	748.8	$ 59.90	698.9	$ 55.91	599.0	$ 47.92	486.7	$ 38.94
Tax Office	3194.9	$ 255.59	1497.6	$ 119.81	1397.8	$ 111.82	1198.1	$ 95.85	973.4	$ 77.88
Mayor's Office	3194.9	$ 255.59	1497.6	$ 119.81	1397.8	$ 111.82	1198.1	$ 95.85	973.4	$ 77.88
Safety Lights (2 in each office)	6709.2	$ 536.74	3145.0	$ 251.60	2935.3	$ 234.82	2516.0	$ 201.28	2044.2	$ 163.54
Caucus Room	26.6	$ 2.13	12.5	$ 1.00	11.6	$ 0.93	10.0	$ 0.80	8.1	$ 0.65
Historical Room	199.7	$ 15.97	93.6	$ 7.49	87.4	$ 6.99	74.9	$ 5.99	60.8	$ 4.87
Rear Entry	106.5	$ 8.52	49.9	$ 3.99	46.6	$ 3.73	39.9	$ 3.19	32.4	$ 2.60
DAV	1863.7	$ 149.09	873.6	$ 69.89	815.4	$ 65.23	698.9	$ 55.91	567.8	$ 45.43
Storage	9.6	$ 0.77	4.5	$ 0.36	4.2	$ 0.34	3.6	$ 0.29	2.9	$ 0.23
Breakroom	133.1	$ 10.65	62.4	$ 4.99	58.2	$ 4.66	49.9	$ 3.99	40.6	$ 3.24
Women's Legion	93.2	$ 7.45	43.7	$ 3.49	40.8	$ 3.26	34.9	$ 2.80	28.4	$ 2.27
CYO Storage Room	11.2	$ 0.89	5.2	$ 0.42	4.9	$ 0.39	4.2	$ 0.34	3.4	$ 0.27
Mechanical Room	5.6	$ 0.45	5.6	$ 0.45	5.6	$ 0.45	5.6	$ 0.45	5.6	$ 0.45
Kitchen	20.8	$ 1.66	20.8	$ 1.66	20.8	$ 1.66	20.8	$ 1.66	20.8	$ 1.66
Kitchen	16.6	$ 1.33	7.8	$ 0.62	7.3	$ 0.58	6.2	$ 0.50	20.8	$ 1.66
Tax Office Storage	0.1	$ 0.01	0.1	$ 0.01	0.1	$ 0.01	0.1	$ 0.01	0.1	$ 0.01
Total	19,380	$ 1,550.37	9,098	$ 727.86	8,493	$ 679.48	7,284	$ 582.71	5,939	$ 475.11
Savings/yr			10,281	$ 822.51	10,886	$ 870.89	12,096	$ 967.66	13,441	$ 1,075.26
Annual % Reduction			53%		56%		62%		69%	
Estimated Material Costs (With Rebates)			$ 2,885.00		$ 3,173.50		$ 10,818.75		$ 9,830.99	
Estimated Labor Costs			$ 4,808.33		$ 7,212.50		$ 8,700.00		$ 8,640.00	
Simple Payback (yrs)			9.4		11.9		20.2		17.2	

Table 6-11: ECO 2e: AB Exterior Lighting Calculations

Administrative Building Exterior Lighting

Space	Lamp Description	Fixture Count	Hours Operation (Hrs/Yr)	Wattage/Fixture		Baseline		Replacment	
				Baseline	Replacement	kWh/yr	$/yr	kWh/yr	$/yr
Exterior	Parking Single-Head LED Pole Lights	5	3276	150	150	2,457	196.56	2,457	196.56
Exterior	Wall Pack HPS	6	3276	100	30	1,966	157.25	590	47.17
Exterior	HID	7	3276	100	27	2,293	183.46	619	49.53
Exterior	HID	1	3276	400	100	1,310	104.83	328	26.21
					Total	8,026	$ 642.10	3,993	$ 319.48
							Savings/yr	4,033	$ 322.62
							Annual % Reduction	50%	
							Estimated Material Costs (With Rebates)	$ 540.94	
							Estimated Labor Costs	$ 560.00	
							Simple Payback (yrs)	3.4	

Table 6-12: ECOs 2c-i thru 2c-iii: Public Works Garage Interior Lighting Calculations

Public Works Garage

Space	Fixture Description	Fixture Count	Lamps/Fixture	Lamp Count	Hours Operation (Hrs/Wk)	Hours Operation (Hrs/Yr)	Wattage/Lamp or Fixture					Baseline		Type A		Type B		Type C Lamp		Fixture	
							Baseline	Type A	Type B	Type C	Fixture	kWh/yr	$/yr	kWh/yr	$/yr	kWh/yr	$/yr	kWh/yr	$/yr	kWh/yr	$/yr
Public Works Garage	4 ft T8 Strip Light	18	6	108	40	2080	32	15	14	12	90	7188.5	$ 575.08	3369.6	$ 269.57	3145.0	$ 251.60	2695.7	$ 215.65	3369.6	$ 269.57
Public Works Garage	8 ft F96T8	1	2	2	40	2080	86	86	86	86	86	357.8	$ 28.62	357.8	$ 28.62	357.8	$ 28.62	357.8	$ 28.62	357.8	$ 28.62
Public Works Garage	LED Wall Pack	1	1	1	63	3276	40	40	40	40	40	131.0	$ 10.48	131.0	$ 10.48	131.0	$ 10.48	131.0	$ 10.48	131.0	$ 10.48
									Total			7,677	$ 614.18	3,858	$ 308.67	3,634	$ 290.70	3,184	$ 254.76	3,858	$ 308.67
													Savings/yr	3,819	$ 305.51	4,044	$ 323.48	4,493	$ 359.42	3,819	$ 305.51
													Annual % Reduction	50%		53%		23%		50%	
													Estimated Material Costs (With Rebates)	$ 540.00		$ 594.00		$ 1,980.00		$ 1,962.00	
													Estimated Labor Costs	$ 900.00		$ 1,350.00		$ 1,080.00		$ 1,440.00	
													Simple Payback (yrs)	4.7		6.0		8.5		11.1	