TOWN OF CARRBORO

Town Hall Building; Century Center Building; Public Works Complex

Net Zero Energy Study

May 6, 2021

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Introduction

Sud Associates has been engaged by Jim Spencer Architects and the Town of Carrboro (TOC) to provide energy analysis and net zero consulting services for three TOC facilities: Town Hall, the Century Center, and the Public Works complex. These services are part of a larger initiative by the TOC to develop a renovation strategy which incorporates the goals of the Town's Strategic Energy and Climate Action plan and addresses the more immediate needs of the Town and the specific buildings.

The Strategic Energy and Climate Action plan calls for Town facilities to work toward net zero energy use. Two initial steps toward that end are to define net zero explicitly and to perform energy analyses on the buildings in question. These were the focus of Sud Associates' efforts.

Energy Analysis

The purpose of the energy analysis is to inform decisions in the renovation planning and design process. Energy and water consumption models were created to help understand how energy is consumed in each building, and where the most substantial opportunities for potential savings lie. They also provide valuable information in assessing the feasibility of modifying the buildings to achieve net zero carbon emissions. Further, the models create a benchmark for each building, establishing existing consumption characteristics and allowing a metric for assessing improvements.

The energy analysis for each building was carried out using the following basic process:

- Study Facility Documents
- Analyze Utility Data
- Perform Site Visits
- Research Building Use and Schedules
- Research Building Equipment
- Create Energy Simulations
- Create Water Usage Spreadsheet Models
- Calibrate Energy Simulations and Water Models

Net Zero Consulting

Sud Associates provided consulting on the net zero process by first providing a framework and information needed to create a specific definition of the metric and boundary to be used in evaluating "net zero". Implications of the various options for defining net zero were discussed, and the Town Council settled on an official Town definition which uses greenhouse gasses (GHG) as the net zero metric and which allows off-site renewable energy to be used in offsetting a building's GHG emissions.

General strategic concepts for how to achieve net zero were also presented. Sud Associates is combining the information learned from the energy analyses with the net zero definitions chosen by the Town to provide basic recommendations for general strategic approaches to moving each building toward net zero. Approaches to renovating the HVAC systems in each building are included in these recommendations.

Contents

This document is a compilation of the various deliverables generated during this effort. These include:

Town of Carrboro
Town Hall Building; Century Center Building; Public Works Complex
Energy Modeling for Net Zero Energy Study

November 23, 2020

Background

The Town of Carrboro is considering options for renovating the Town Hall, Century Center, and the Public Works complex. The Town is seeking to develop a long-term renovation strategy while at the same time addressing immediate needs which have been identified by Town Staff. As part of the renovation effort, the Town would like to work towards the energy sustainability goals set forth in the Town's adopted Strategic Energy and Climate Action plan, which includes working toward net zero energy use.

Energy and water consumption models have been created for each of these facilities to inform decisions in the renovation planning and design process. These models are used to help understand how energy is consumed in each building, and where the most substantial opportunities for potential savings lie. They also provide valuable information in assessing the feasibility of modifying the buildings to achieve net zero carbon emissions. Further, the models create a benchmark for each building, establishing existing consumption characteristics and allowing a metric for assessing improvements.

Existing Systems

Town Hall

The Town Hall is a three-story building which houses office areas, a chamber room, a town server room, and a connected facilities maintenance shop. The exterior walls are uninsulated brick having mostly clear, double pane, operable windows. Most of the roof area is flat with recently installed rigid foam insulation above the deck.

The building is heated and cooled by 9 independent heat pump systems of varying ages. These systems are zoned to serve the basement offices, the server room, the chamber room, the north offices on the1st floor, the south offices on the 1st floor, the 2nd floor offices, the 1st floor of the west wing, the 2nd floor of the west wing, and the shop. None of these systems supply outdoor air for ventilation.

The lighting in the building is a mix of new LED fixtures, T-8 fluorescent fixtures, and T-12 fluorescent fixtures. The plug loads are mostly typical for office areas other than the facilities shop which sees typical shop usage. Hot water is provided by a tank-type electric water heater.

Century Center

Carrboro's Century Center is a two-story historic structure which houses office areas, community activity areas, a public computer resource area, a kitchen, and a large event hall. Part of the building serves the police department, which operates 24/7. Built in 1924, the Century Center has 18" thick uninsulated masonry walls with clear, double pane, operable windows. The roof is insulated at the attic floor by 9" of blown-in fiberglass insulation.

The building is conditioned by 3 variable air volume AHUs. Two of the AHUs utilize VAV boxes with hot water reheat, while the third AHU is a single-zone VAV unit serving the large event hall. Heating is provided by a 750 MBH natural gas-fired hot water boiler, and cooling is provided by a 70 ton air-cooled packaged chiller. The AHUs and chiller are controlled by a central control system, while the boiler operates on stand-alone controls.

The majority of the lighting throughout the building is T8 tube linear tube fluorescent fixtures. Most of the plug-in equipment is typical for an office building, though the computer resource area has a higher density of computers, and the all-electric kitchen contains heavy duty commercial cooking, refrigerating, and ice making equipment. Domestic hot water is provided by two tank-type natural gas-fired hot water heaters (75 gallon and 100 gallon).

Public Works

The public works complex is collection of buildings including office areas, an auto shop, sign shop, vehicle, equipment, and materials storage areas, a fuel station, and a carwash station. The primary energy consuming building is a 6,100 square foot pre-engineered metal building with an additional 2,400 square feet of unconditioned loft storage and mechanical space. This building houses public works administration offices, a small server room, and the fleet maintenance shop.

The office areas are divided into 3 separate HVAC zones, each of which is conditioned by a natural gas furnace with split system A/C. The shop area is conditioned by a 156 MBH natural gas unit heater. The sign shop utilizes a small heat pump window unit.

Lighting is provided by a mix of LED and fluorescent fixtures. The miscellaneous electrical loads in the complex are significant and highly variable in usage. Other than standard office equipment, these include air compressors, auto lifts, car vacuums, fuel pumps, garage doors, and various shop equipment. Domestic hot water is provided by natural gas-fired instantaneous water heaters.

Historical Utility Consumption

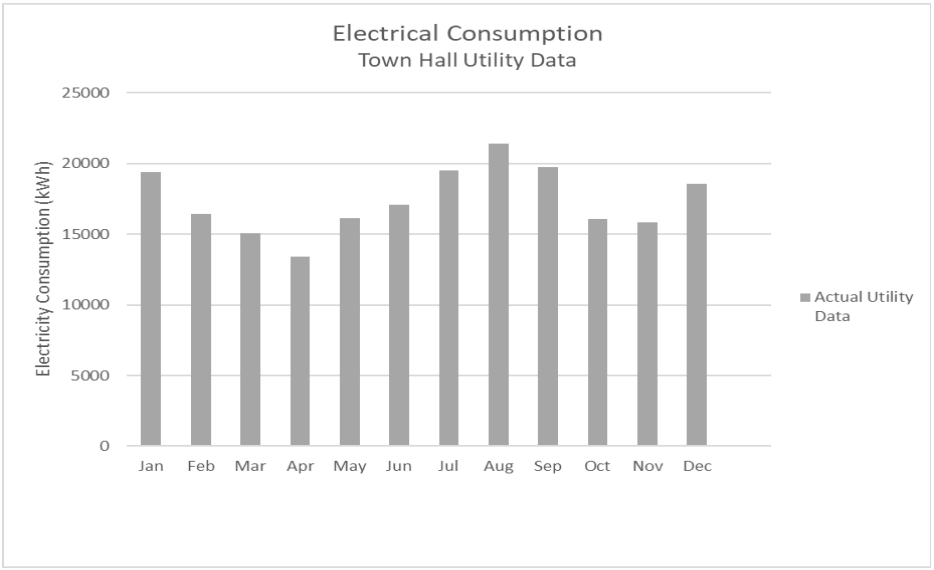
An analysis of the historical utility data was performed as a first step in creating energy and water consumption models of the facilities. 12 months for electricity, natural gas, and water utility data were obtained for the analyses. The data used were from the 2019 calendar year to eliminate any effect from the 2020 COVID-19 pandemic shutdowns. Usage by each facility was analyzed separately.

Town Hall

The town hall does not use natural gas, as all heating, water heating, and cooking use electricity.

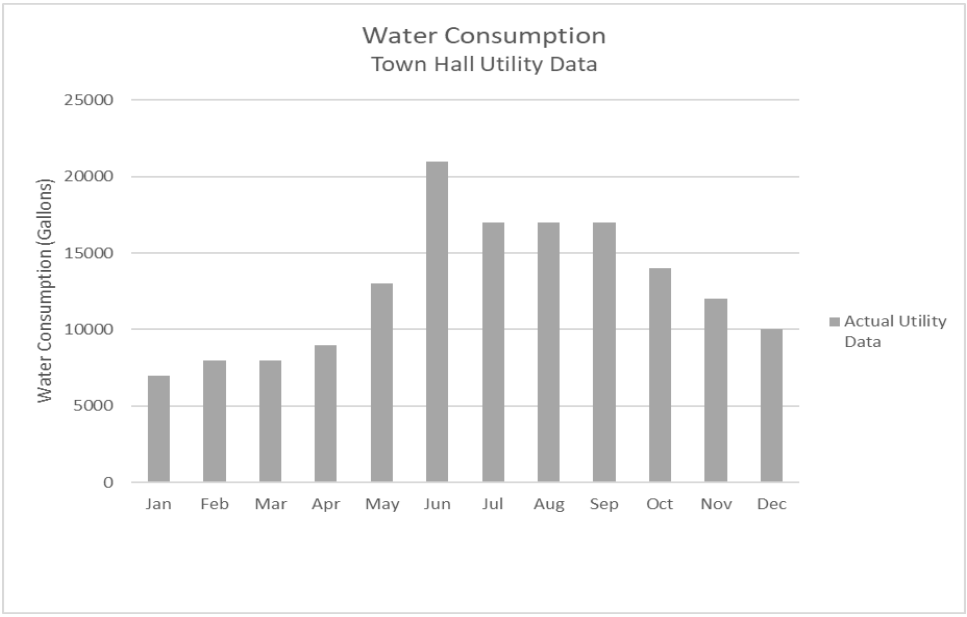
Electricity

The building is served by three separate electric meters. One meter serves the majority of the building, one meter serves the shop, and the server room is served from the meter serving Fire Station 1. Onsite power readings, in conjunction with Fire Station 1 utility data, allowed the annual energy consumption of the server room (servers plus HVAC) to be estimated and extracted from the Fire Station data. This estimate was added to the data from the main building meter and the shop meter to obtain a monthly set of consumption data for the entire building. This combined usage is presented below.



Water

A single water meter serves the building. Data from this meter are presented below.

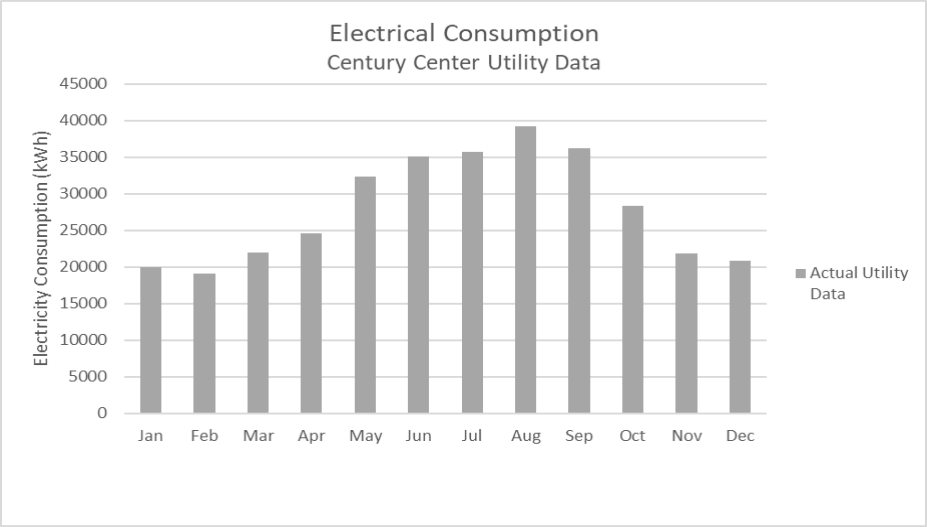


Century Center

The Century Center uses electricity, natural gas, and water.

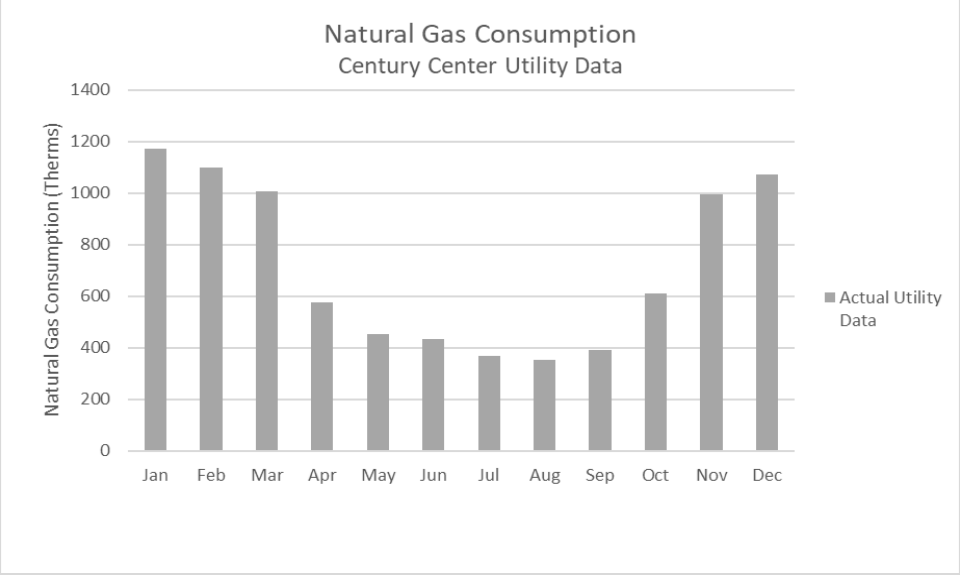
Electricity

A single electric service entrance serves the entire building. Data from this meter are presented below.



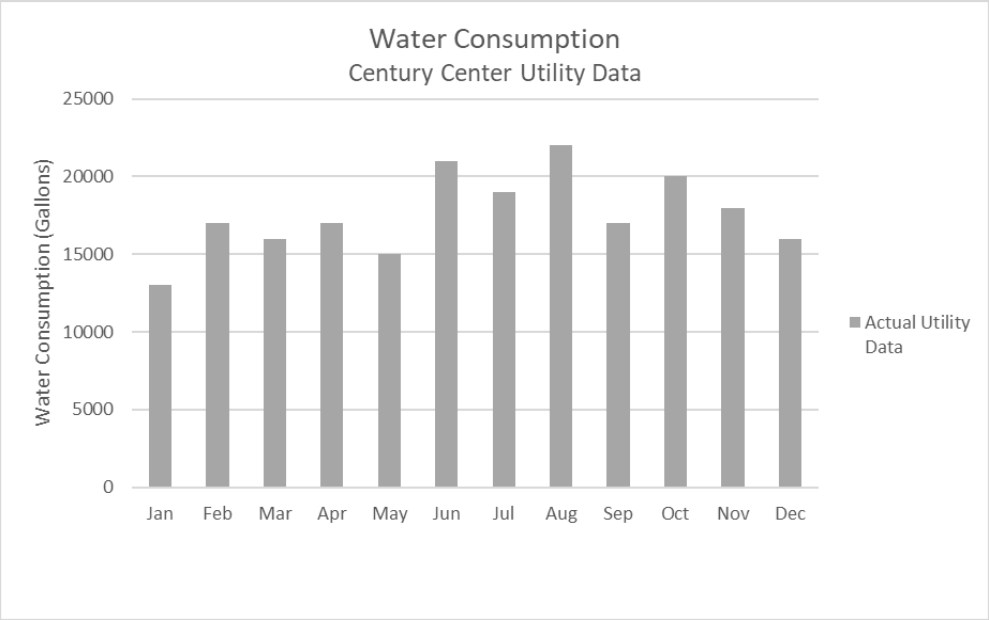
Natural Gas

A single natural gas service entrance serves the entire building. Data from this meter are presented below.



Water

A single water service entrance serves the entire building. Data from this meter are presented below.

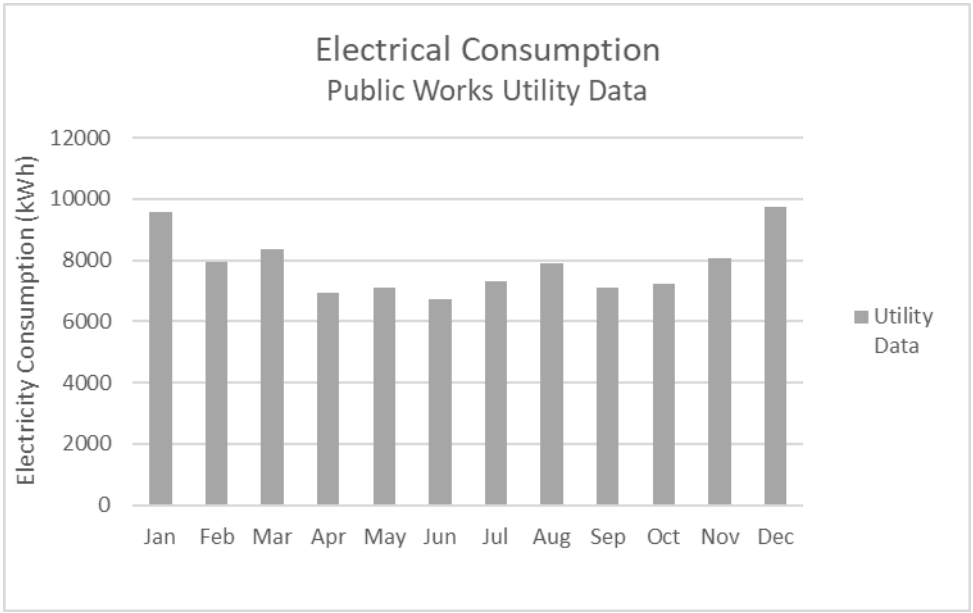


Public Works

The Public Works complex utilizes electricity, natural gas, and water.

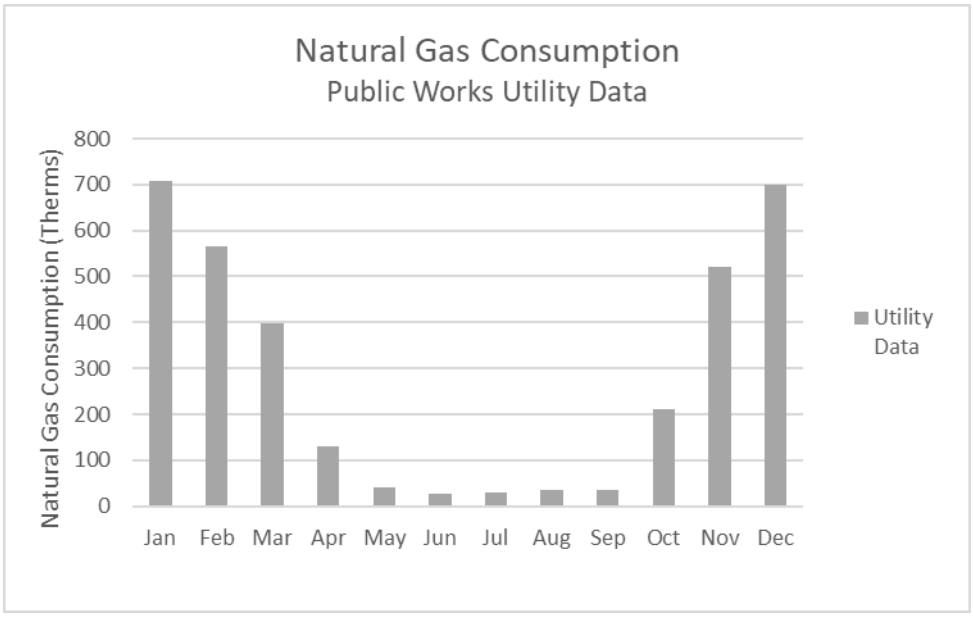
Electricity

Public Works is served by three electric service entrances. One meter currently has no load connected to it, one meter serves the server room and its A/C unit, and one meter serves the rest of the complex. The data presented below show the combined metered usage for the complex.



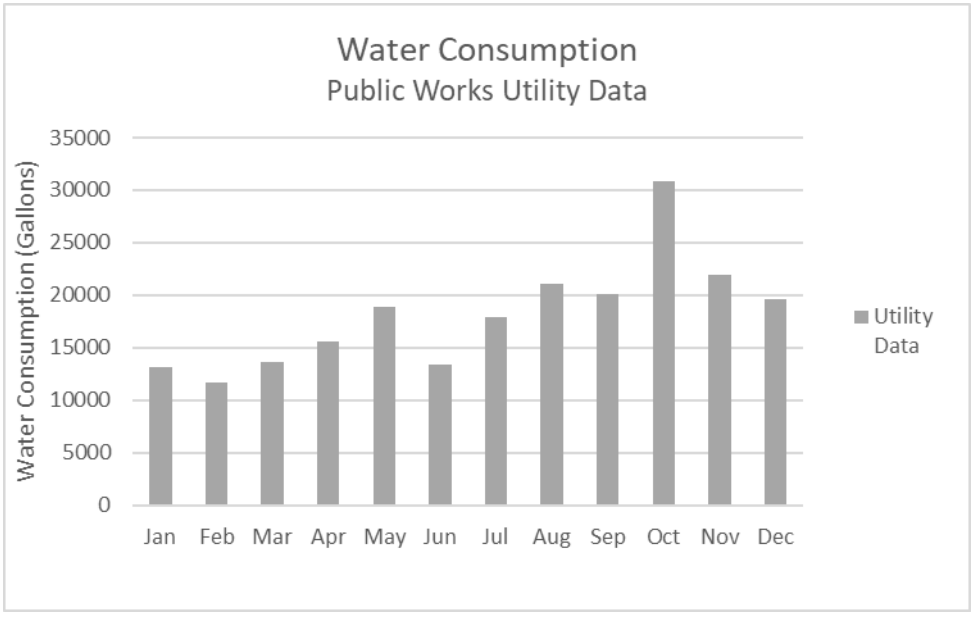
Natural Gas

Two natural gas meters serve the facility. One meter serves the generator and the instantaneous hot water heaters, and one meter serves the rest of the facility. The combined usage is shown below.



Water

A single water service serves the entire complex. Data from this meter are presented below.



Simulation Methodology

Energy and water consumption simulations were created for each building. The energy models for the Century Center and the Town Hall were generated using the Trane TRACE software. TRACE uses a comprehensive set of environmental and building characteristics to simulate the energy consumption

for the entire building each hour of a full typical year. TRACE excels at simulating the complex interactions among various end uses, schedules, and control strategies as are found at the Century Center and Town Hall.

Due to the nature of the Public Works complex, in-house spreadsheet tools were used in lieu of TRACE to simulate annual energy usage. The usage of this facility is highly dependent on inconsistent variables such as the amount of time garage doors are open, frequency of shop equipment use, frequency and duration of car washes, etc. This type of facility is best modeled using versatile, transparent, independent calculations in conjunction with known historical utility data. Through this approach a more reliable and understandable breakdown of how the facility uses energy can be obtained.

Hourly energy simulations require detailed weather data for the specific location of the buildings. TMY3 (Typical Meteorological Year) weather files for the Durham area were utilized for the Carrboro models. Building inputs include the constructions of the walls, windows, roofs, and floor systems, HVAC equipment and control strategies, room-by-room lighting systems, plug-in equipment, and occupancy, domestic hot water systems, and schedules of usage for occupants and each energy end use. The values utilized in the Carrboro models were obtained via building drawings, site visits, measurements, and conversations with Carrboro staff.

Water models are generally much less complex than energy simulations. These are usually analyzed on an annual basis, as hourly calculations would provide little additional value to understanding the facility. In-house spreadsheet tools were used for these models. The primary inputs for these models are occupancy types, general occupancy schedules, and the various water-using fixture data.

Energy and Water Model Results and Calibration

Each energy and water model was calibrated to match the historical utility consumption to within an acceptable error tolerance based on industry standard practice. The Carrboro energy models were calibrated such that the modeled electricity and natural gas consumption is within 10% of the actual consumption for each month of the year, and within 5% of the total annual consumption. The water models were calibrated to within 5% of the annual consumption.

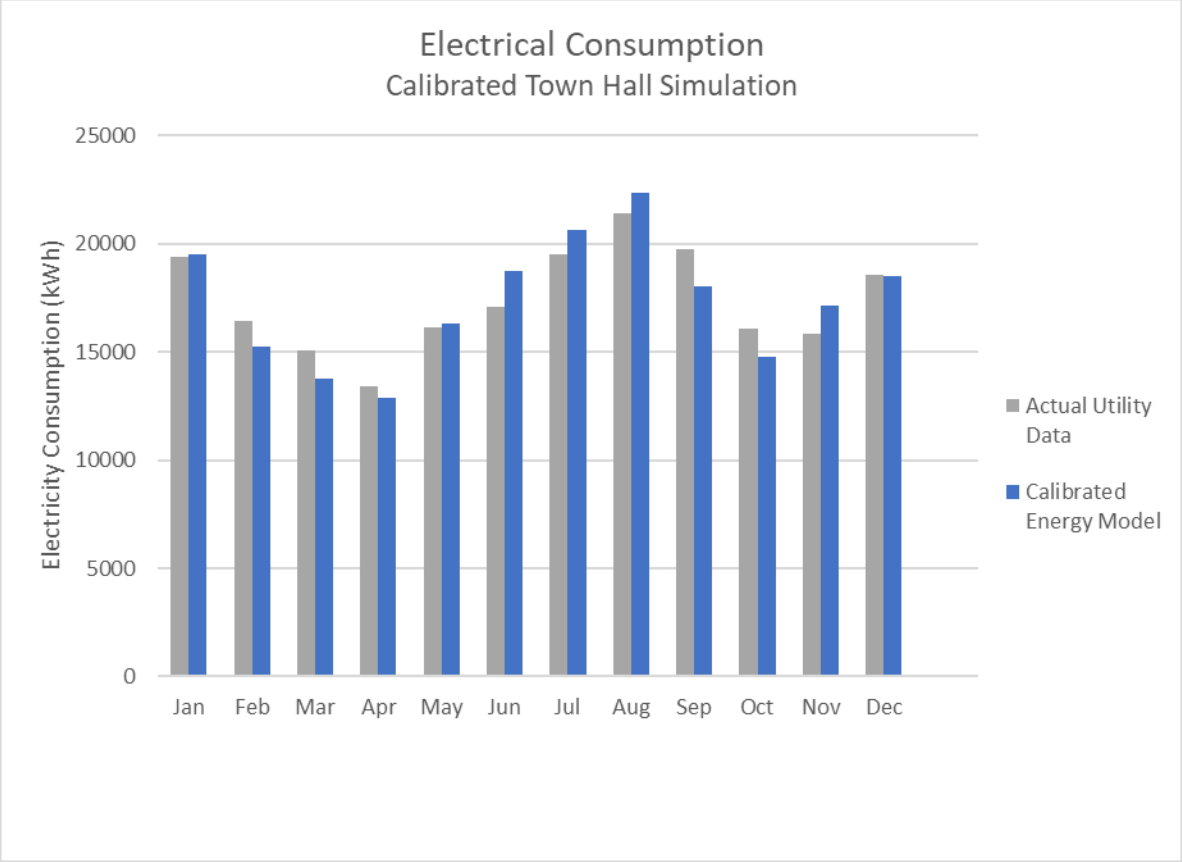
Town Hall

The energy consumption results for the Town Hall are presented below, along with its energy use intensity.

Town Hall Energy Consumption Profile		
End Use	**Energy Consumption (kBTU/yr)**	**Percent of Total**
Heating	83,044	11.7%
Cooling	169,247	23.9%
Fans/Pumps	99,651	14.1%
Lighting	119,697	16.9%
DHW	9,687	1.4%
Plug Loads / Other	228,125	32.2%
Total	709,451	100%
Conditioned Area (sf)	12,235	
Energy Use Intensity (kBTU/sf/yr	57.99	

The calibrated results for the Town Hall building are presented below. A breakdown of the energy model results is provided in Appendix I.

Electricity (Town Hall)



Town Hall Electricity Consumption (kWh)			
Month	**Actual Utility Data**	**Calibrated Model**	**% Error**
Jan	19376	19511	1%
Feb	16401	15249	-7%
Mar	15073	13769	-9%
Apr	13404	12849	-4%
May	16112	16328	1%
Jun	17091	18748	10%
Jul	19536	20641	6%
Aug	21386	22342	4%
Sep	19764	18056	-9%
Oct	16086	14755	-8%
Nov	15835	17120	8%
Dec	18583	18499	0%
Total	**208646**	**207867**	0%

Water (Town Hall)

Town Hall Water Consumption (gal)			
Period	**Actual Utility Data**	**Calibrated Model**	**% Error**
Annual	155734	155731	0%

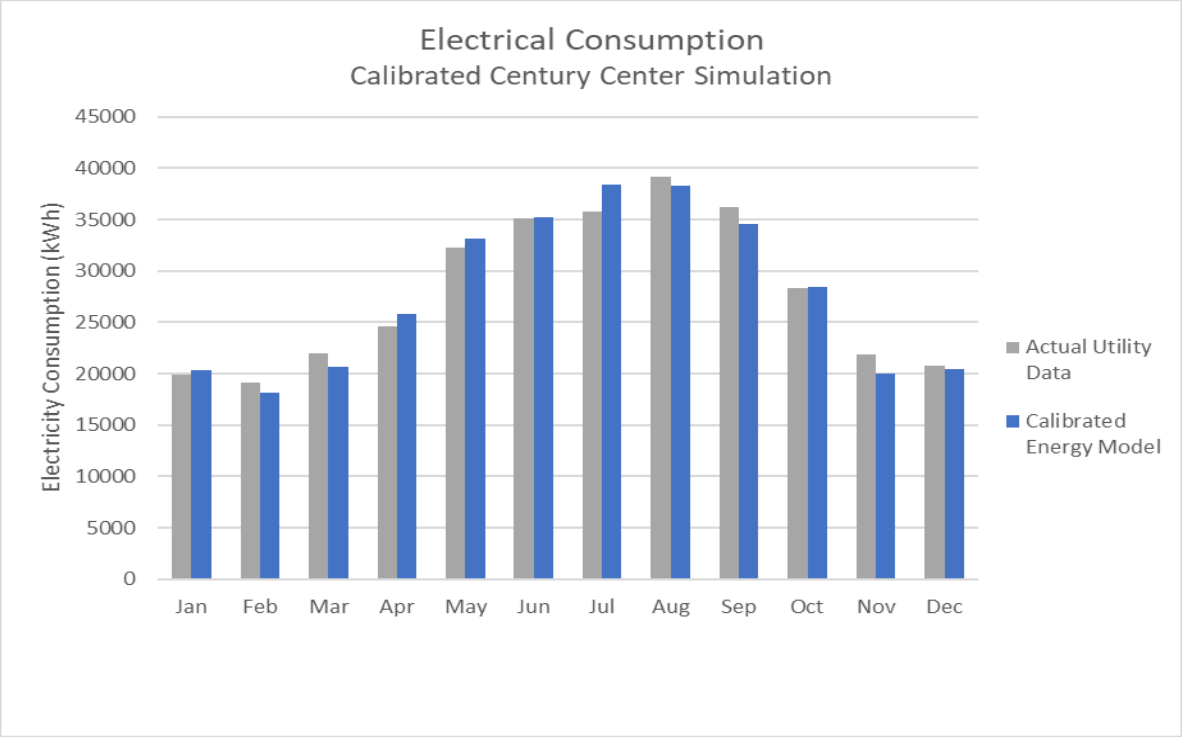
Century Center

The energy consumption results for the Century Center are presented below, along with its energy use intensity.

Century Center Energy Consumption Profile		
End Use	**Energy Consumption (kBTU/yr)**	**Percent of Total**
Heating	848,026	42.7%
Cooling	224,216	11.3%
Fans/Pumps	548,968	27.6%
Lighting	203,910	10.3%
DHW	13,420	0.7%
Plug Loads / Other	147,747	7.4%
Total	1,986,287	100%
Conditioned Area (sf)	19,912	
Energy Use Intensity (kBTU/sf/yr	99.75	

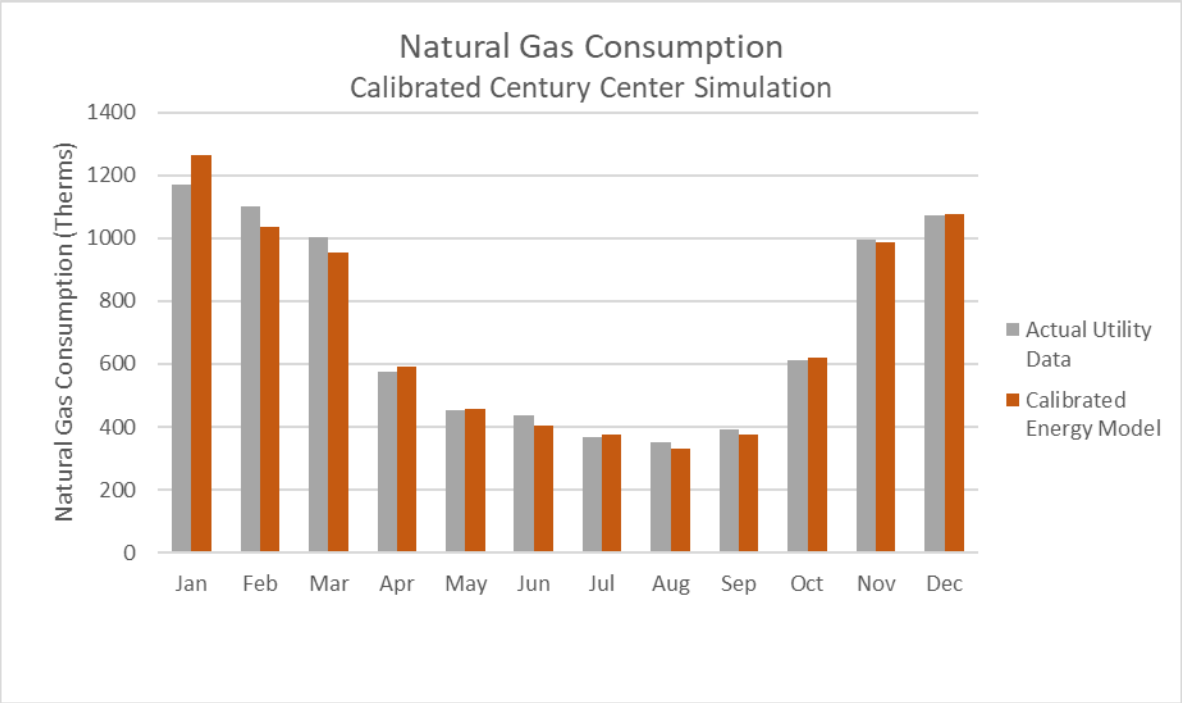
The calibrated results for the Century Center are presented below. A breakdown of the energy model results is provided in Appendix II

Electricity (Century Center)



Century Center Electricity Consumption (kWh)			
Month	**Actual Utility Data**	**Calibrated Model**	**% Error**
Jan	19932	20377	2%
Feb	19082	18203	-5%
Mar	21936	20665	-6%
Apr	24586	25760	5%
May	32315	33172	3%
Jun	35082	35268	1%
Jul	35727	38364	7%
Aug	39209	38241	-2%
Sep	36198	34531	-5%
Oct	28286	28423	0%
Nov	21833	19996	-8%
Dec	20796	20465	-2%
Total	**334982**	**333463**	**0%**

Natural Gas (Century Center)



Century Center Natural Gas Consumption (therms)			
Month	**Actual Utility Data**	**Calibrated Model**	**% Error**
Jan	1170	1263	8%
Feb	1100	1035	-6%
Mar	1005	955	-5%
Apr	574	592	3%
May	451	458	2%
Jun	435	406	-7%
Jul	366	377	3%
Aug	351	331	-6%
Sep	390	377	-3%
Oct	611	622	2%
Nov	995	987	-1%
Dec	1073	1078	0%
Total	**8522**	**8482**	**0%**

Water (Century Center)

Century Center Water Consumption (gal)			
Period	**Actual Utility Data**	**Calibrated Model**	**% Error**
Annual	219416	219264	0%

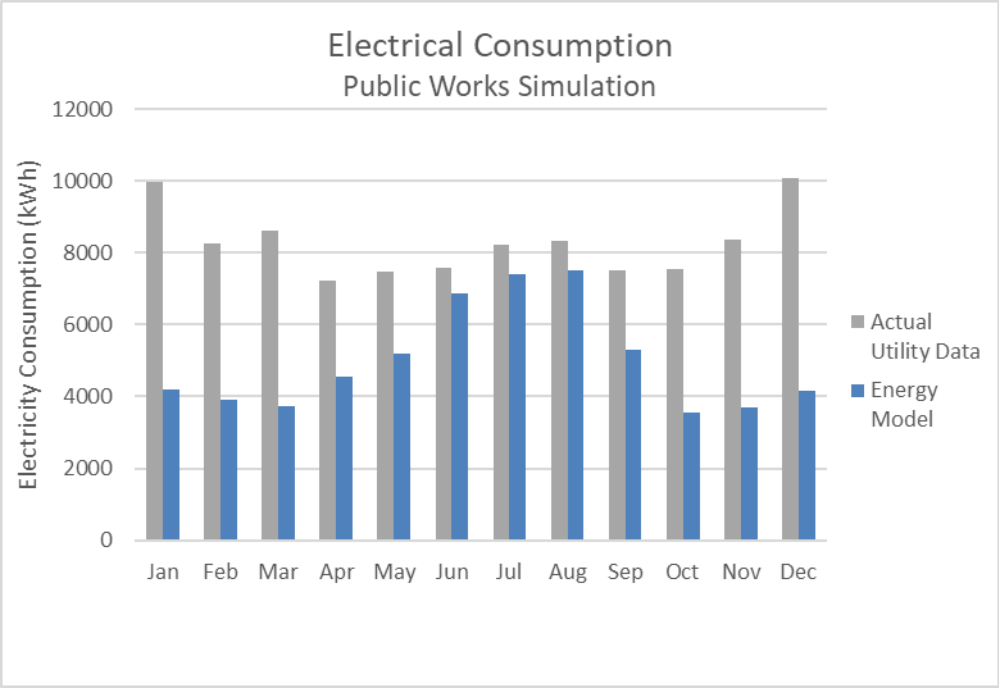
Public Works

The energy consumption results for the Town Hall are presented below, along with its energy use intensity.

Public Works Energy Consumption Profile		
End Use	**Energy Consumption (kBTU/yr)**	**Percent of Total**
Heating	306,672	44.3%
Cooling	62,858	9.1%
Fans	36,683	5.3%
Lighting	54,922	7.9%
DHW/Carwash/Generator	30,900	4.5%
Office Equipment	15,861	2.3%
Server	15,040	2.2%
Air Compressor	24,088	3.5%
Shop/Site Equipment	11,495	1.7%
Currently Unaccounted	133,601	19.3%
Total	692,120	100%
Conditioned Area (sf)	6,300	
Energy Use Intensity (kBTU/sf/yr	109.9	

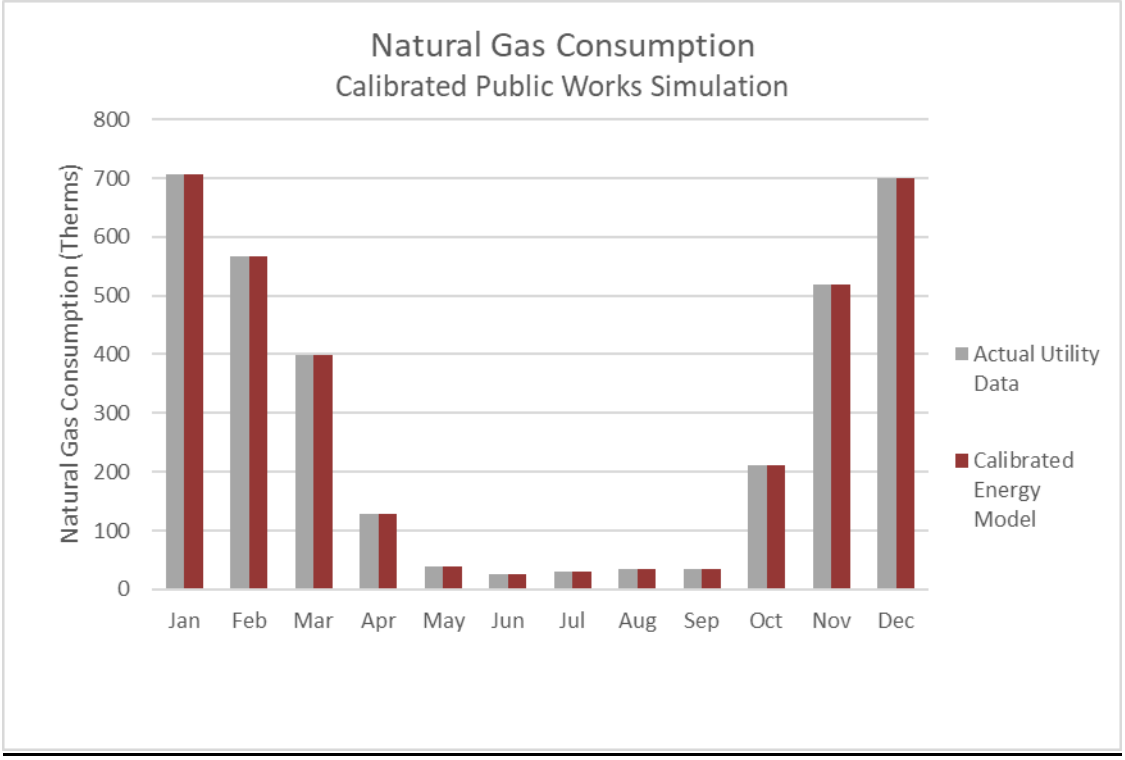
Note that the model is unable to account for a large percentage of the electrical consumption in the facility. This is shown in the table above as “Currently Unaccounted”, and in the electricity chart and table below as the percent error between the model and the utility data. The tables below show the energy model results as compared to the utility data. See Appendix III for a breakdown of modeled end uses.

Electricity (Public Works Complex)



Public Works Electricity Consumption (kWh)			
Month	**Actual Utility Data**	**Calibrated Model**	**% Error**
Jan	9965	4193	58%
Feb	8277	3919	53%
Mar	8606	3726	57%
Apr	7229	4549	37%
May	7472	5190	31%
Jun	7600	6868	10%
Jul	8231	7419	10%
Aug	8330	7522	10%
Sep	7511	5288	30%
Oct	7553	3535	53%
Nov	8355	3710	56%
Dec	10079	4143	59%
Total	**99208**	**60063**	**39%**

Natural Gas (Public Works Complex)



Public Works Natural Gas Consumption (therms)			
Month	**Actual Utility Data**	**Calibrated Model**	**% Error**
Jan	707	707	0%
Feb	566	566	0%
Mar	399	399	0%
Apr	129	129	0%
May	40	40	0%
Jun	26	26	0%
Jul	31	31	0%
Aug	35	35	0%
Sep	35	35	0%
Oct	210	210	0%
Nov	520	520	0%
Dec	699	699	0%
Total	**3397**	**3397**	**0%**

Water (Public Works Complex)

Public Works Water Consumption (Gallons)			
Period	Actual Utility Data	Calibrated Model	% Error
Annual	217948	216000	1%

Conclusions

The creation of energy models allows a better understanding of how resources are used within a facility, and can offer insight as to what opportunities there may be to save energy and water. These results will be used to guide design decisions moving forward in the process of upgrading these three facilities. The energy and water simulations for the Century Center and the Town Hall reconcile cleanly with the utility data. The natural gas and water models for the Public Works facility also match the utility data. Currently, however, there are unknown factors resulting in discrepancies between simulations and utility data for the electricity consumption at Public Works. This should be further investigated, as the large discrepancy could point to energy saving opportunities.

Appendix I

TRACE Energy Consumption Summary (Town Hall)

ENERGY CONSUMPTION SUMMARY

By Sud Associates, P.A.

	Elect Cons. (kWh)	% of Total Building Energy	Total Building Energy (kBtu/yr)	Total Source Energy* (kBtu/yr)
Alternative 1				
Primary heating				
Primary heating	24,332	11.7 %	83,044	249,156
Other Htg Accessories		0.0 %	0	0
Heating Subtotal	**24,332**	**11.7** %	**83,044**	**249,156**
Primary cooling				
Cooling Compressor	39,897	19.2 %	136,167	408,541
Tower/Cond Fans	4,758	2.3 %	16,239	48,721
Condenser Pump		0.0 %	0	0
Other Clg Accessories	4,935	2.4 %	16,842	50,530
Cooling Subtotal....	**49,589**	**23.9** %	**169,247**	**507,792**
Auxiliary				
Supply Fans	29,198	14.1 %	99,651	298,984
Pumps		0.0 %	0	0
Stand-alone Base Utilities	2,838	1.4 %	9,687	29,064
Aux Subtotal....	32,036	15.4 %	109,338	328,048
Lighting				
Lighting	35,071	16.9 %	119,697	359,128
Receptacle				
Receptacles	66,840	32.2 %	228,125	684,443
Cogeneration				
Cogeneration		0.0 %	0	0
Totals				
Totals**	**207,867**	**100.0** %	**709,451**	**2,128,567**

* Note: Resource Utilization factors are included in the Total Source Energy value .

** Note: This report can display a maximum of 7 utilities. If additional utilities are used, they will be included in the total.

Appendix II

TRACE Energy Consumption Summary (Century Center)

ENERGY CONSUMPTION SUMMARY

By Sud Associates, P.A.

	Elect Cons. (kWh)	Gas Cons. (kBtu)	Water Cons. (1000 gals)	% of Total Building Energy	Total Building Energy (kBtu/yr)	Total Source Energy* (kBtu/yr)
Alternative 1						
Primary heating						
Primary heating		833,181		42.0 %	833,181	877,032
Other Htg Accessories	4,350		27	0.8 %	14,845	44,539
Heating Subtotal	**4,350**	**833,181**	**27**	**42.7** %	**848,026**	**921,571**
Primary cooling						
Cooling Compressor	58,800			10.1 %	200,685	602,115
Tower/Cond Fans	6,315			1.1 %	21,553	64,667
Condenser Pump				0.0 %	0	0
Other Clg Accessories	580			0.1 %	1,978	5,934
Cooling Subtotal....	**65,695**			**11.3** %	**224,216**	**672,716**
Auxiliary						
Supply Fans	72,367			12.4 %	246,990	741,045
Pumps	73,385			12.6 %	250,463	751,463
Stand-alone Base Utilities	14,632	14,997		3.3 %	64,935	165,615
Aux Subtotal....	160,384	14,997		28.3 %	562,388	1,658,123
Lighting						
Lighting	59,745			10.3 %	203,910	611,791
Receptacle						
Receptacles	43,290			7.4 %	147,747	443,287
Cogeneration						
Cogeneration				0.0 %	0	0
Totals						
Totals**	**333,463**	**848,178**	**27**	**100.0** %	**1,986,287**	**4,307,489**

* Note: Resource Utilization factors are included in the Total Source Energy value .

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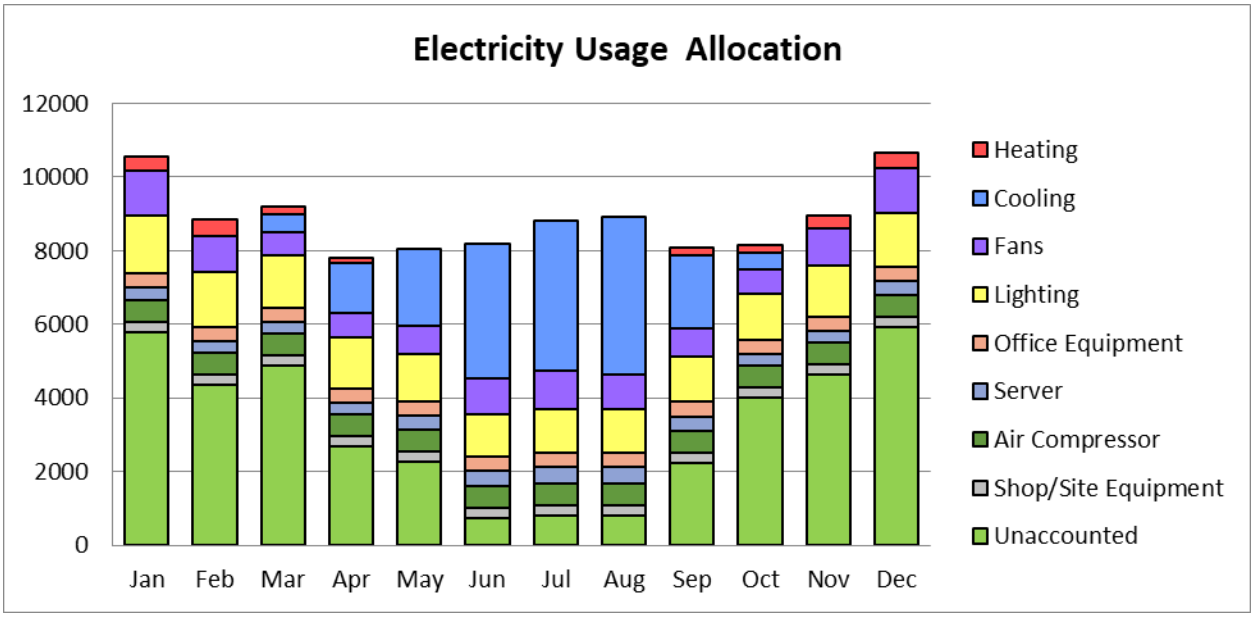
Appendix III

Energy Consumption Summary Charts (Public Works)



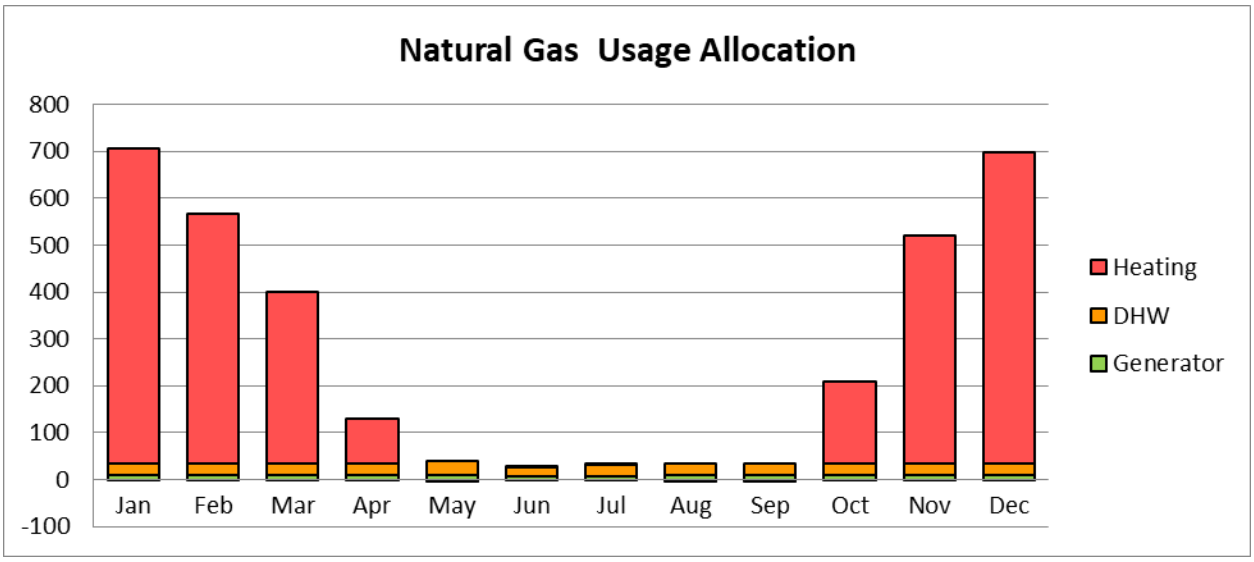


EXHIBIT E-2

Town of Carrboro
Town Hall Building; Century Center Building; Public Works Complex
Defining Net Zero Metrics and Boundaries

November 13, 2020

DRAFT REPORT

Background

The Town of Carrboro is considering options for renovating the Town Hall, Century Center, and the Public Works complex. The Town is seeking to develop a long-term renovation strategy while at the same time addressing immediate needs which have been identified by Town Staff. As part of the renovation effort, the Town would like to work towards the energy sustainability goals set forth in the Town's adopted Strategic Energy and Climate Action plan, which includes working toward net zero energy use.

A first step in the process of achieving a net zero energy building is to define the term "net zero" and to establish the criteria for a net zero energy building. This is more than an exercise in semantics, as the definition and criteria chosen can have significant effects on design decisions and project costs.

Defining "Net Zero"

The basic idea of a net zero energy building is that, over the course of a year, it has completely offset its energy usage by renewable energy production. Beyond this general concept, there is no single, universally accepted definition for a net zero energy building. The exact definition used for any given project is a choice made by the building owners and project team based on motivations, priorities, budget, building and site characteristics, and other constraints. The US DOE and the National Renewable Energy Laboratory (NREL) have developed a clear framework and guidance to aid owners and designers in choosing the defining criteria for their specific project.

In short, there are two decisions to be made: what metric will be used to evaluate the building's performance (i.e. net zero what?), and what is the boundary within which renewable energy may be generated? Each of these questions is addressed below.

Defining the Metric

NREL has presented 4 options for defining the metric by which a net zero building can be evaluated: Site energy consumption, source energy consumption, greenhouse gas (GHG) emissions, and energy cost.

Option 1: Net Zero Site Energy: A net zero site energy building will offset the energy it uses on site with renewable energy. The energy consumed is seen directly on the building's utility bills. Some owners see net zero site energy as an attractive metric primarily because it is easy to understand and its calculation does not depend on complex factors outside the boundary of the building. This metric steers designers away from natural gas as a heat or domestic hot water fuel in favor of heat pumps or even electric resistance heating. Solar hot water is often a more attractive renewable energy source than photovoltaics under this metric.

Option 2: Net Zero Source Energy: The source energy metric considers the source of the energy used in the building. For instance, the source energy metric would account not for the electricity used in the building, but for the coal used at the power plant to produce the electricity used in the building. This metric is favored by owners whose primary motivation is to conserve the Earth's fossil-based energy sources and to reduce the environmental damage associated with the extraction of these fuels. Using this approach largely levels the field when comparing natural gas heating versus electric heat pumps.

Option 3: Net Zero GHG Emissions: This metric is based on the GHG emissions associated with the energy used in the building rather than the energy itself. For instance, the GHG emissions metric would account not for the electricity used in the building, but rather for the airborne pollution generated by the power plant as it produces the electricity used in the building. A net zero GHG building might also be called a "carbon neutral" building. Net zero GHG emissions is chosen by owners whose primary motivation is to mitigate climate change. This metric favors the use of natural gas over electricity use, and places high value on producing renewable electricity (e.g. photovoltaic panels).

Option 4: Net Zero Energy Cost: A net zero energy cost building will offset the building's energy cost over the course of a year with renewable energy sold to the grid or other users. This metric is perhaps the simplest to understand, but it may not fit with the Town's Climate Action Plan. The most attractive systems and fuel types under this metric are variable, depending on the comparative market rates of the different fuels.

Defining the Boundary

Any net zero building will require renewable energy either to power the building directly or (more likely) to offset the building's consumption of non-renewable energy. Where this renewable energy can be generated in order to count towards this offset is determined by the building owners and project team. NREL has presented 4 options, in order of decreasing constraint: building footprint generation, building site generation, imported renewables, and purchased generation.

Option A: Building Footprint Generation: This option applies the constraint that all renewable energy must be generated within the footprint of the building itself. A common example of this would be PV panels installed on the building's roof.

Option B: Building Site Generation: Renewable energy may be generated anywhere within the property lines of the net zero building. Under this option, for example, a building may have PV panels on its roof as well as on the ground or on an on-site parking canopy.

Option C: Imported Renewables: Under this option, renewable energy may be imported from off-site and used on-site. A typical example would be biomass or biofuels used for heating. This option simply expands options for renewable generation, it does not exclude the possibility that some energy may still be generated on the building or the building site.

Option D: Purchased Generation: This option allows renewable energy to be generated by others and purchased by the building. This is often done in the form of Renewable Energy Credits (RECs). In this case the renewable energy itself is not necessarily used in the building, but the offsets created by the renewable energy are purchased and claimed by the building owners. Under this option, each of the previous three options may be included in the total mix of generation possibilities.

EXHIBIT E-3

BUILDING ENERGY ANALYSIS
TOWN OF CARRBORO

Town Hall
Century Center
Public Works

Presented to Town Council, 12/1/2020

JSA ARCHITECTS

SUD ASSOCIATES, P.A.
CONSULTING ENGINEERS

PROCESS

- Study Facility Documents
- Analyze Utility Data
- Perform Site Visits
- Research Building Use and Schedules
- Research Building Equipment
- Create Energy Simulations
- Create Water Usage Spreadsheet Models
- Calibrate Energy Simulations and Water Models

JSA ARCHITECTS

SUD ASSOCIATES, P.A.
CONSULTING ENGINEERS

TOWN HALL

JSA ARCHITECTS

SUD ASSOCIATES, P.A.
CONSULTING ENGINEERS

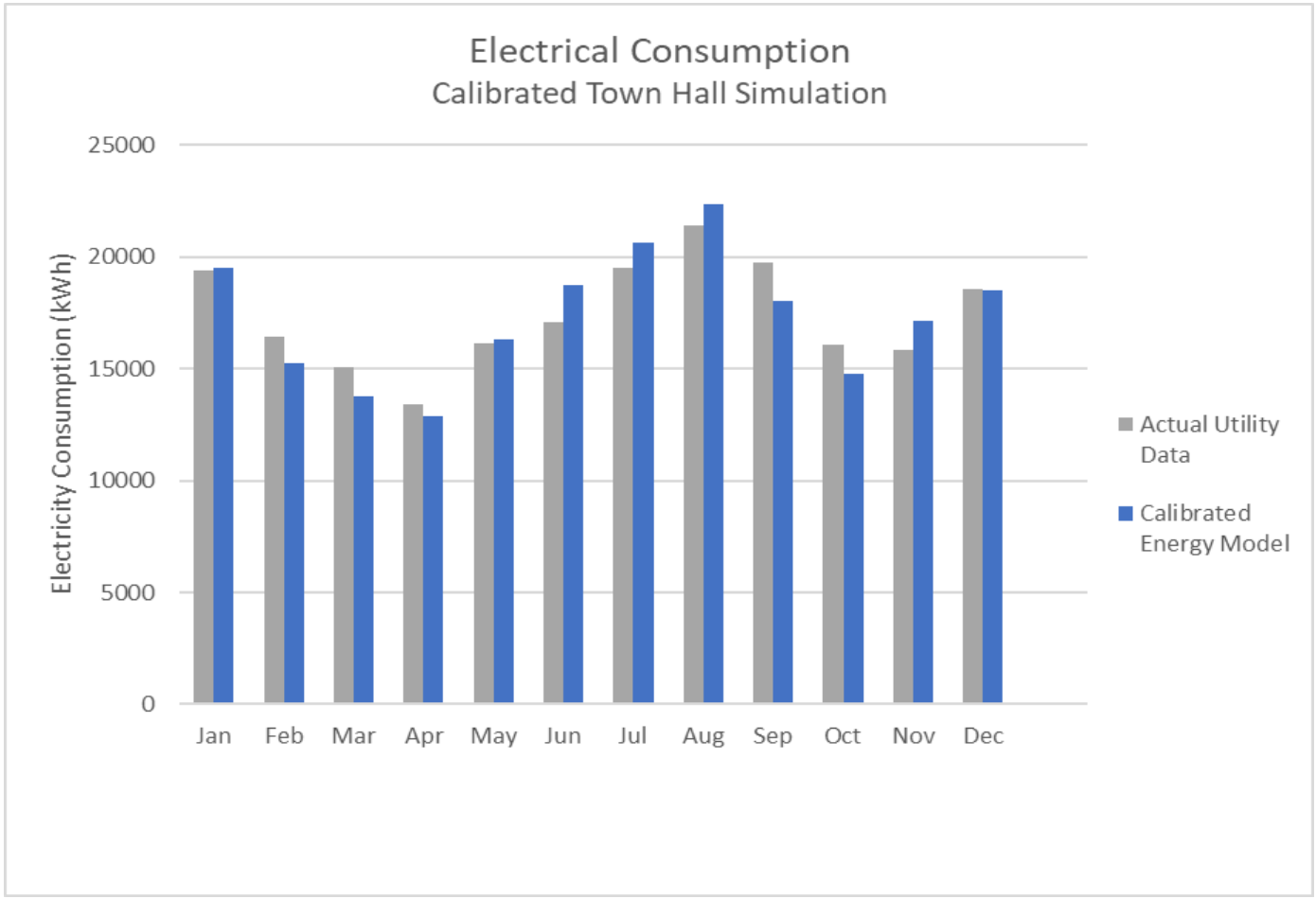
SIMULATED ENERGY SUMMARY

Town Hall Energy Consumption Profile		
End Use	Energy Consumption (kBTU/yr)	Percent of Total
Heating	83,044	11.7%
Cooling	169,247	23.9%
Fans/Pumps	99,651	14.1%
Lighting	119,697	16.9%
DHW	9,687	1.4%
Plug Loads / Other	228,125	32.2%
Total	709,451	100%
Conditioned Area (sf)	12,235	
Energy Use Intensity (kBTU/sf/yr	57.99	

JSA ARCHITECTS

SUD ASSOCIATES, P.A.
CONSULTING ENGINEERS

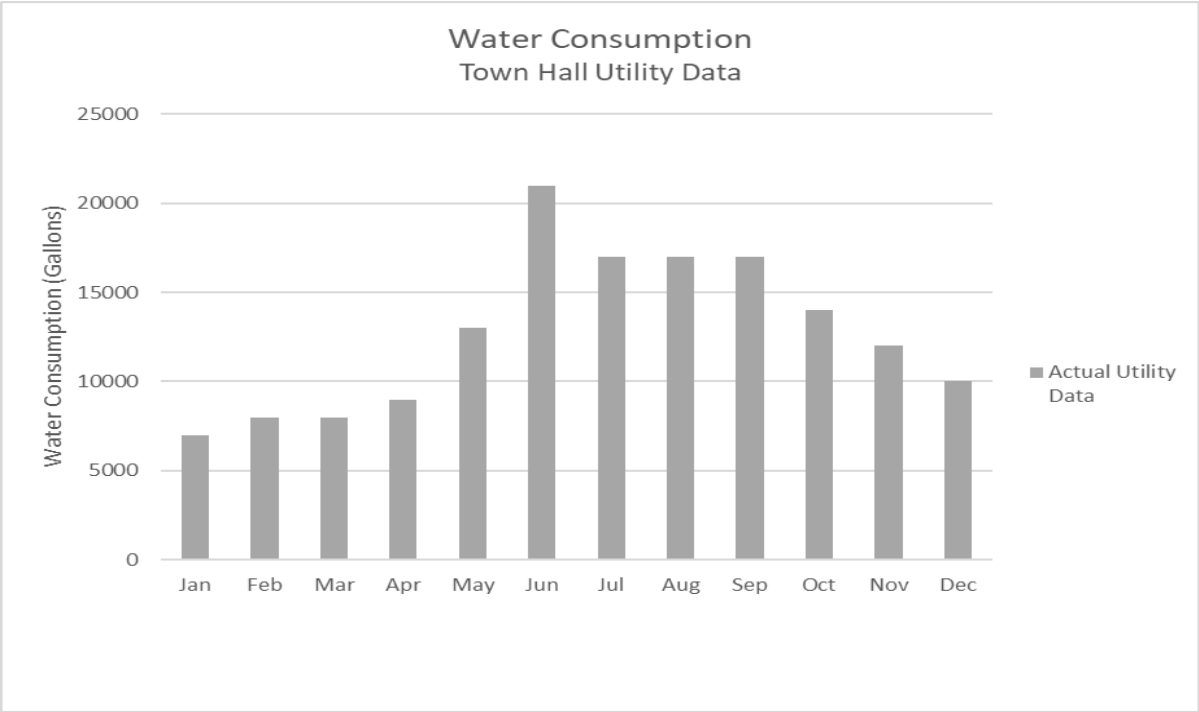
ELECTRICITY



JSA ARCHITECTS

SUD ASSOCIATES, P.A.
CONSULTING ENGINEERS

WATER



Town Hall Water Consumption (gal)			
	Actual Utility Data	Calibrated Model	% Error
Annual	155734	155731	0%

JSA ARCHITECTS

SUD ASSOCIATES, P.A.
CONSULTING ENGINEERS

CENTURY CENTER

JSA ARCHITECTS

SUD ASSOCIATES, P.A.
CONSULTING ENGINEERS

SIMULATED ENERGY SUMMARY

Century Center Energy Consumption Profile		
End Use	Energy Consumption (kBTU/yr)	Percent of Total
Heating	848,026	42.7%
Cooling	224,216	11.3%
Fans/Pumps	548,968	27.6%
Lighting	203,910	10.3%
DHW	13,420	0.7%
Plug Loads / Other	147,747	7.4%
Total	1,986,287	100%
Conditioned Area (sf)	19,912	
Energy Use Intensity (kBTU/sf/yr	99.75	

JSA ARCHITECTS

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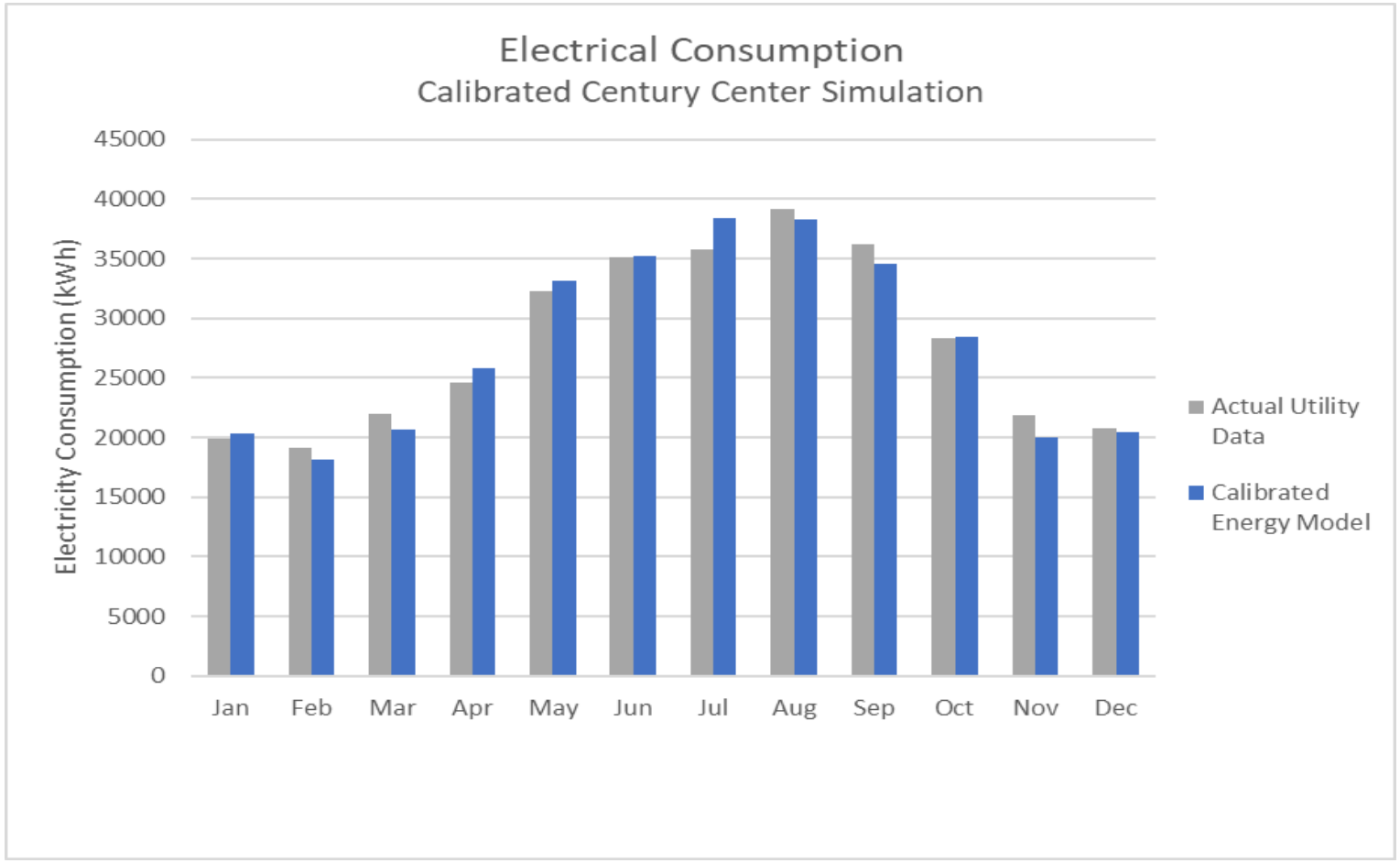
CONSULTING ENGINEERS

ELECTRICITY



JSA ARCHITECTS

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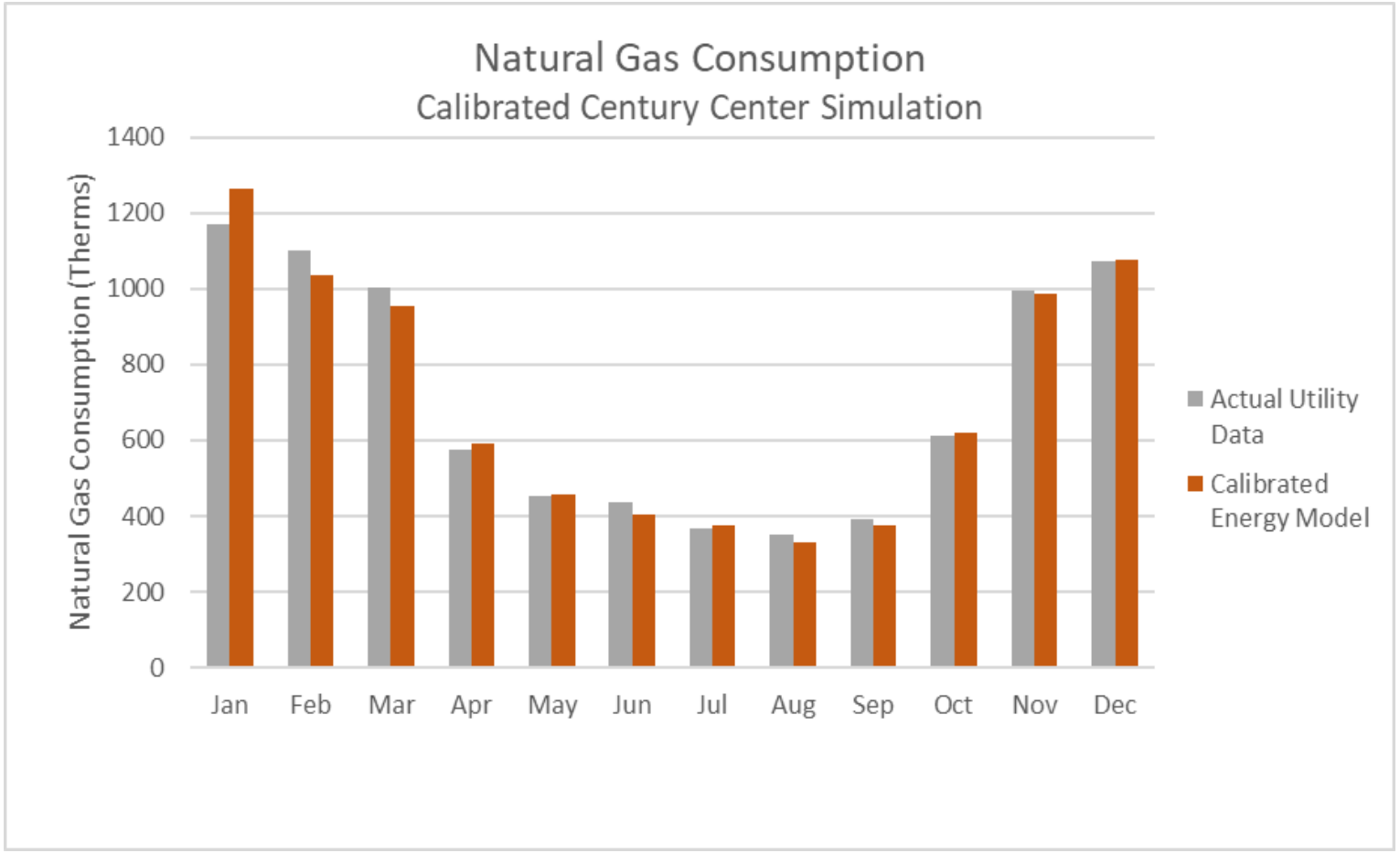
CONSULTING ENGINEERS

NATURAL GAS



JSA ARCHITECTS

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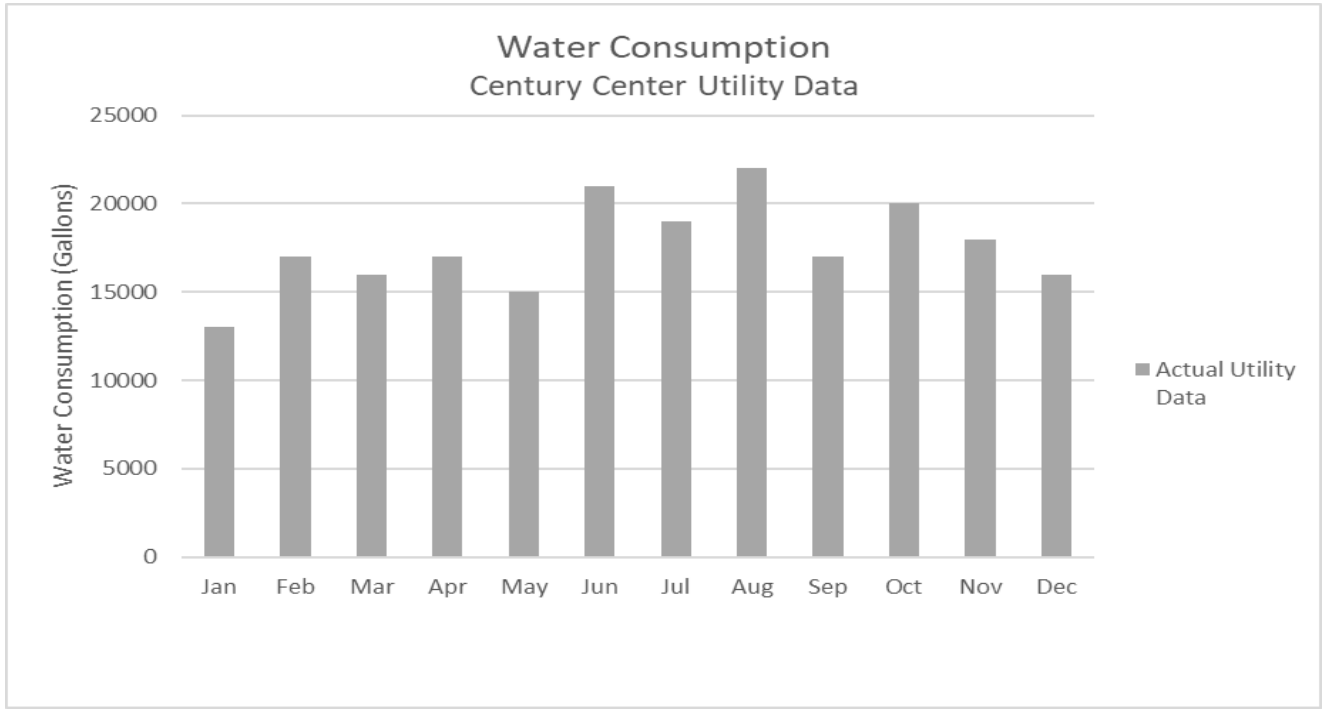
CONSULTING ENGINEERS

WATER



Century Center Water Consumption (gal)			
	Actual Utility Data	Calibrated Model	% Error
Annual	219416	219264	0%

SUD ASSOCIATES, P.A.
CONSULTING ENGINEERS

PUBLIC WORKS

JSA ARCHITECTS

SUD ASSOCIATES, P.A.
CONSULTING ENGINEERS

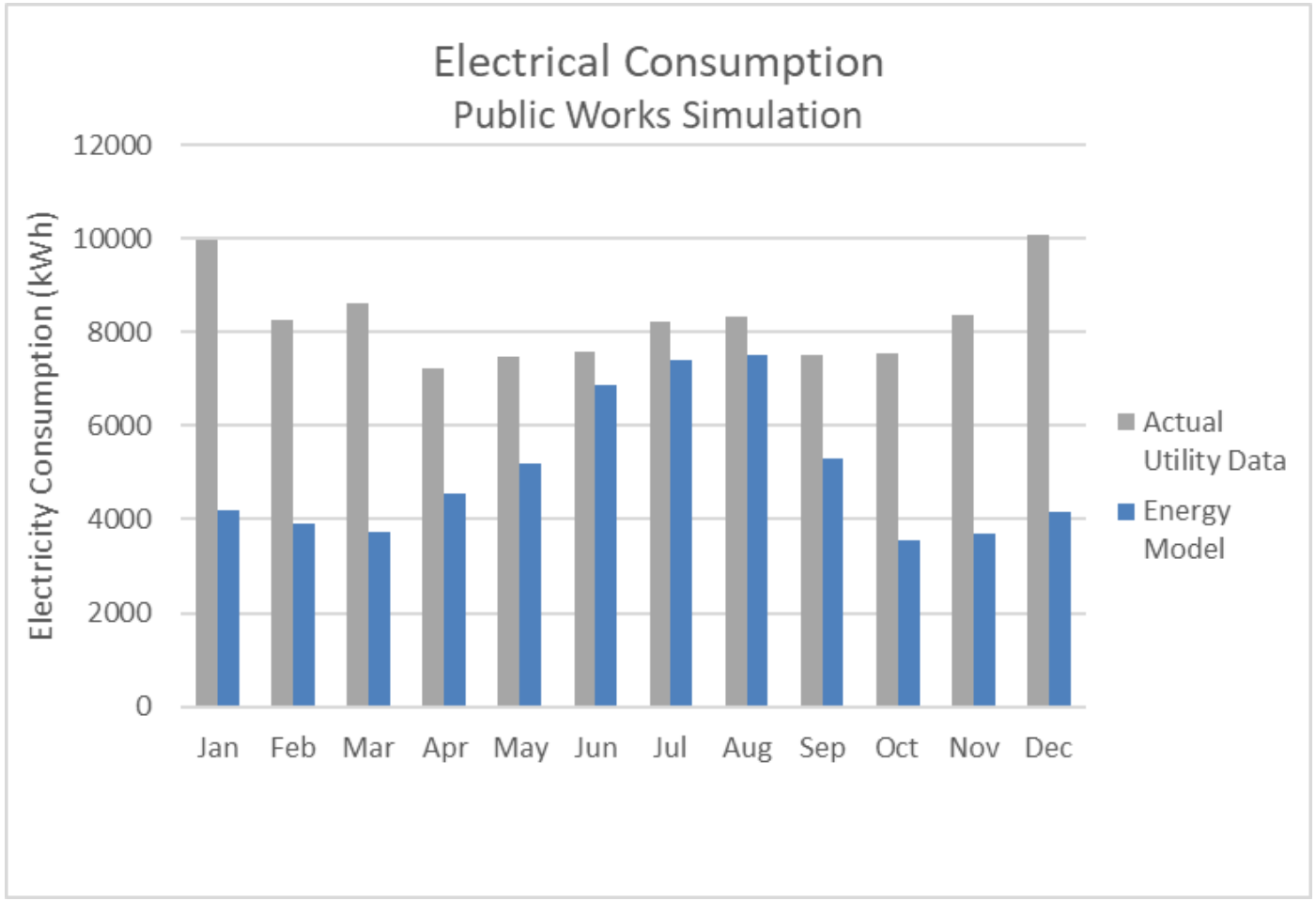
SIMULATED ENERGY SUMMARY

Public Works Energy Consumption Profile		
End Use	Energy Consumption (kBTU/yr)	Percent of Total
Heating	306,672	44.3%
Cooling	62,858	9.1%
Fans	36,683	5.3%
Lighting	54,922	7.9%
DHW/Carwash/Generator	30,900	4.5%
Office Equipment	15,861	2.3%
Server	15,040	2.2%
Air Compressor	24,088	3.5%
Shop/Site Equipment	11,495	1.7%
Currently Unaccounted	133,601	19.3%
Total	692,120	100%
Conditioned Area (sf)	6,300	
Energy Use Intensity (kBTU/sf/yr	109.9	

JSA ARCHITECTS

SUD ASSOCIATES, P.A.
CONSULTING ENGINEERS

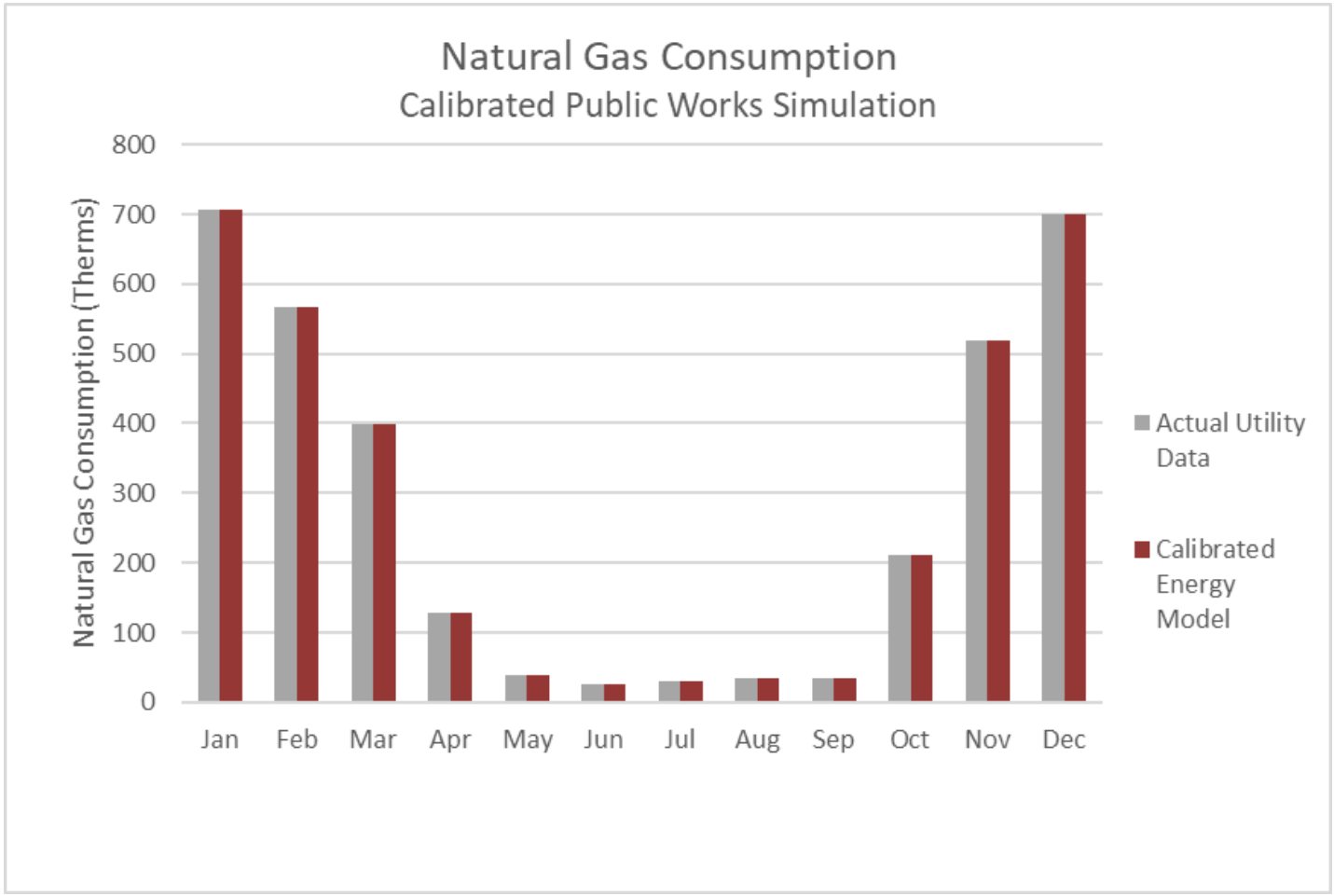
ELECTRICITY



JSA ARCHITECTS

SUD ASSOCIATES, P.A.
CONSULTING ENGINEERS

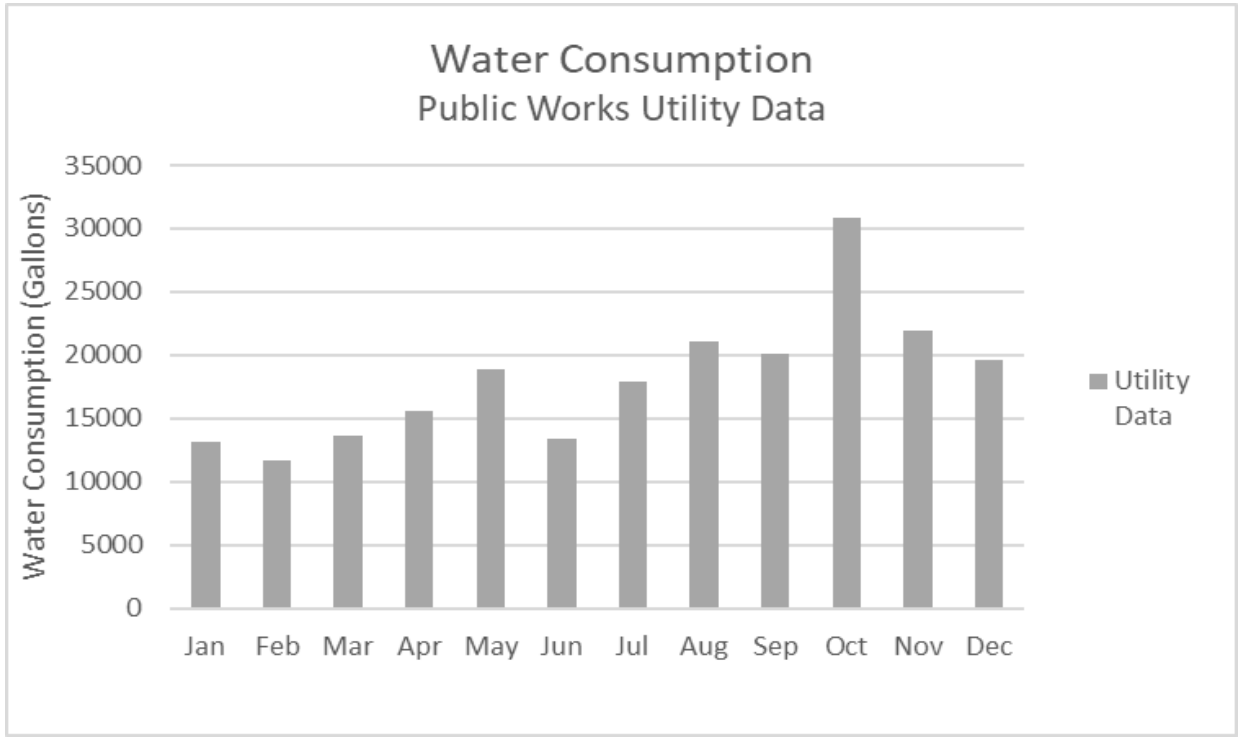
NATURAL GAS



JSA ARCHITECTS

SUD ASSOCIATES, P.A.
CONSULTING ENGINEERS

WATER



Public Works Water Consumption (Gallons)			
Period	Actual Utility Data	Calibrated Model	% Error
Annual	217948	216000	1%

JSA ARCHITECTS

SUD ASSOCIATES, P.A.
CONSULTING ENGINEERS

DEFINING NET ZERO
TOWN OF CARRBORO

Town Hall

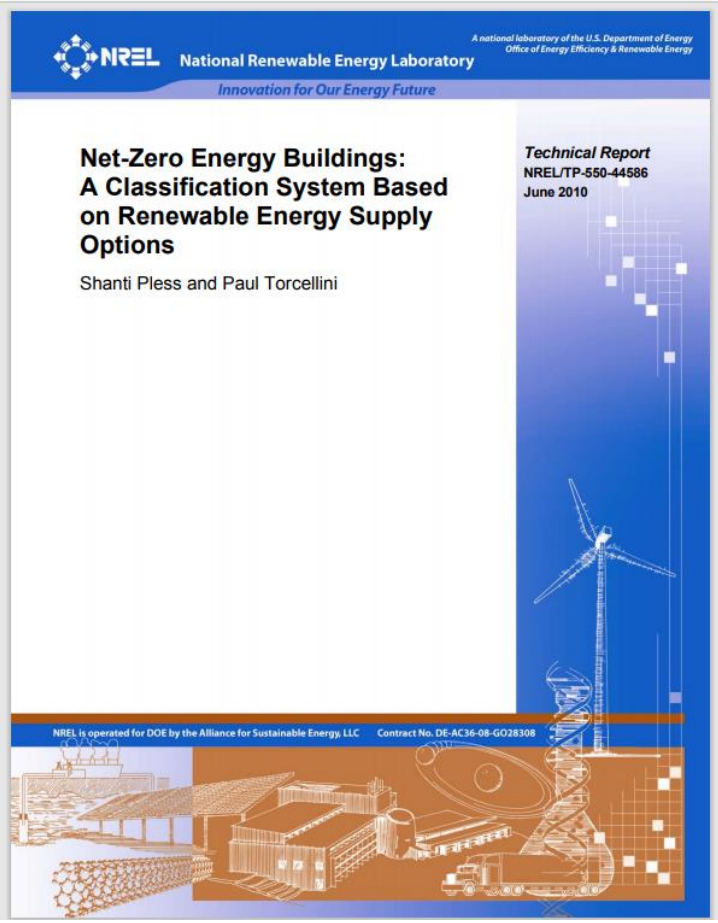
Century Center

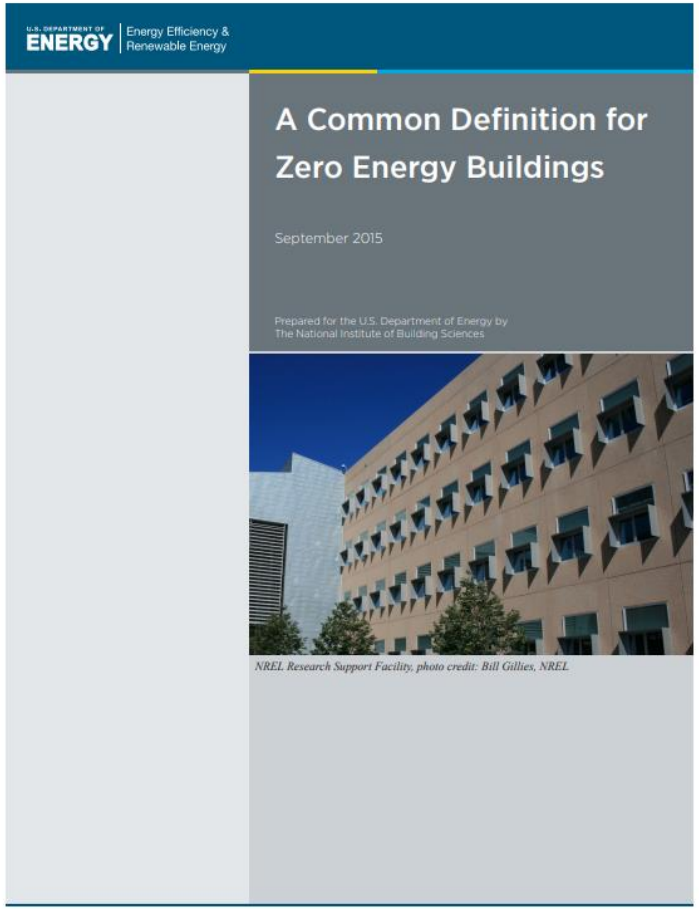
Public Works

JSA ARCHITECTS

SUD ASSOCIATES, P.A.
CONSULTING ENGINEERS

DEFINING “NET-ZERO”





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CONSULTING ENGINEERS

DEFINING THE METRIC

- Net-Zero…

- Option 1: Site Energy
  - Energy usage as seen on utility bills offset by renewables
- Option 2: Source Energy
  - Considers inefficiencies introduced by power plants and transmission
- Option 3: Greenhouse Gas Emissions
  - Focuses on atmospheric pollutants rather than fossil fuels themselves
- Option 4: Energy Cost
  - Based on utility costs. May not apply to the Climate Action Plan

JSA ARCHITECTS

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CONSULTING ENGINEERS

DEFINING THE BOUNDARY

- Renewable Energy is Generated…

- Option A: Within the Building Footprint
  - e.g. solar panels on the building's roof
- Option B: Within the Property Boundary
  - e.g. panels on the building's roof and on a separate parking canopy
- Option C: Off Site
  - Imported to site, e.g. wood chips shipped to the site for building heat
  - Generated off site, e.g. PV panels on Town-owned Property
- Option D: By Others (RECs)
  - Carbon offsets can be purchased to supplement other strategies

JSA ARCHITECTS

SUD ASSOCIATES, P.A.
CONSULTING ENGINEERS

IMPLICATIONS

- Option 1: Net-Zero Site Energy
  - Favors using electricity over natural gas
- Option 2: Net-Zero Source Energy
  - Natural gas vs electricity comparison requires analysis
- Option 3: Net-Zero GHG Emissions
  - Favors using natural gas over electricity
- Option 4: Net-Zero Energy Cost
  - Natural gas vs electricity comparison requires analysis

JSA ARCHITECTS

SUD ASSOCIATES, P.A.
CONSULTING ENGINEERS

NEXT STEPS

- Settle on Net Zero Definition
- Design Building Improvements
  - Must first meet basic safety, health, and comfort needs
  - Incorporate changes in space usage
  - Preserve historic quality
  - Pursue efficiency upgrades toward the Net Zero goal
    - Minimize energy consumption
    - Provide the balance with renewable generation

QUESTIONS?

EXHIBIT E-4

Attachment A

A RESOLUTION FOR ADOPTING A NET ZERO DEFINITION FOR THE TOWN OF CARRBORO BUILDINGS

WHEREAS, the Town Council received a Net Zero Buildings report and presentation at the December 1, 2020 Town Council Meeting by the Town's consultant, Sud Associates, P.A., and subsequently discussed the Net Zero Buildings metric and boundary options presented; and

WHEREAS, the Environmental Advisory Board (EAB) received the same presentation on January 11, 2021 and have submitted the attached hereto comments; and

WHEREAS, the Town Council and the EAB are in agreement with which Net Zero Buildings definition to adopt for the Town of Carrboro; and

WHEREAS, the Town Council and the EAB agree that the approach to any Net Zero Buildings project will be to first conserve as much as possible through energy efficiency measures, then to make up the balance through renewable energy generation; and

NOW, THEREFORE, BE IT RESOLVED by the Carrboro Town Council that the following Net Zero Buildings definition be adopted for the Town of Carrboro:

Net Zero Buildings shall be evaluated using greenhouse gas emissions (GHG) as the accounting metric. Renewable energy can be generated off-site to offset GHG emissions from non-renewable energy consumption.

This definition conforms to Option 3C of the attached report.

This the 19th day of February in 2021.

TOWN OF CARRBORO

Environmental Advisory Board

301 West Main Street, Carrboro, North Carolina 27510

RECOMMENDATION

January 11, 2020

Net Zero Discussion

Motion was made by Echart and seconded by Brandon that the EAB recommends:

Defining Net Zero

- Option 3: Greenhouse Gas Emissions
- The Town will need timely and defensible data to back up greenhouse gas emissions calculations
    - Search for more granular data (Duke Energy vs. NREL)
    - Published emissions data can be out-of-date so the Town will need to make some assumptions
        - Need to capture life cycle emissions from the production and transportation of the energy, especially natural gas

Defining the Boundary

- Option C: Off Site
- Develop solar energy anywhere on the grid, provided that it is owned by the Town
- Does not need to be Town property or within Town boundaries
- Look into Town parks, covered parking lots
- At some point the Town may need to examine creative yet feasible opportunities
    - Community solar
    - Buy a stake in a larger operation in another location; invest in solar farms
- The entire Carrboro community is a system, the location of the renewables is not as important
- However, on-site solar will minimize distribution losses

<u>Additional Comments</u>

Energy Sources

- The EAB recommends not locking the Town into natural gas usage
    - If the Town relies on electrification, it has more control and flexibility
- The makeup of the Town's energy sources is a moving target
    - The Town will need to take future trends into account

RECs

- Some EAB members are skeptical of RECs due to the fact that some renewable projects may already be in place and would not represent new emissions reductions

Overall

- The Town needs to work towards a goal of reducing fossil fuel use
- The Town should first pursue maximizing the energy efficiency of its buildings
- Next, the energy usage of the buildings must be offset completely by renewables in order for the Town to reach its goals of 80% reduction of 2010 greenhouse gas emissions levels by 2030
- The building analysis is a great first step towards evaluating all municipal energy usage and ultimately, the community's energy usage

VOTE:

AYES: (5) Kaufman, Turner, Brandon, Schalkoff, Echart

ABSENT/EXCUSED: (1) Blanco

NOES: (0)

ABSTENTIONS: (0)

Laura Janoway 1-11-21

For Tim Turner, Chair (Date)

Town of Carrboro
Town Hall Building; Century Center Building; Public Works Complex
Defining Net Zero Metrics and Boundaries

November 23, 2020

Background

The Town of Carrboro is considering options for renovating the Town Hall, Century Center, and the Public Works complex. The Town is seeking to develop a long-term renovation strategy while at the same time addressing immediate needs which have been identified by Town Staff. As part of the renovation effort, the Town would like to work towards the energy sustainability goals set forth in the Town's adopted Strategic Energy and Climate Action plan, which includes working toward net zero energy use.

A first step in the process of achieving a net zero energy building is to define the term "net zero" and to establish the criteria for a net zero energy building. This is more than an exercise in semantics, as the definition and criteria chosen can have significant effects on design decisions and project costs. Regardless of the definition chosen, the general approach to achieving net zero is to first conserve as much energy as is feasible, then use renewable energy to offset the remaining usage.

Defining "Net Zero"

The basic idea of a net zero energy building is that, over the course of a year, it has completely offset its energy usage by renewable energy production. Beyond this general concept, there is no single, universally accepted definition for a net zero energy building. The exact definition used for any given project is a choice made by the building owners and project team based on motivations, priorities, budget, building and site characteristics, and other constraints. The US DOE and the National Renewable Energy Laboratory (NREL) have developed a clear framework and guidance to aid owners and designers in choosing the defining criteria for their specific project.

In short, there are two decisions to be made: what metric will be used to evaluate the building's performance (i.e. net zero what?), and what is the boundary within which renewable energy may be generated? Each of these questions is addressed below.

Defining the Metric

NREL has presented 4 options for defining the metric by which a net zero building can be evaluated: Site energy consumption, source energy consumption, greenhouse gas (GHG) emissions, and energy cost.

Option 1: Net Zero Site Energy: A net zero site energy building will offset the energy it uses on site with renewable energy. The energy consumed is seen directly on the building's utility bills. Some owners see net zero site energy as an attractive metric primarily because it is easy to understand and its calculation does not depend on complex factors outside the boundary of the building. This metric steers designers away from natural gas as a heat or domestic hot water fuel in favor of heat pumps or even electric resistance heating.

Solar hot water is often a more attractive renewable energy source than photovoltaics under this metric.

Option 2: Net Zero Source Energy: The source energy metric considers the source of the energy used in the building. For instance, the source energy metric would account not for the electricity used in the building, but for the coal used at the power plant to produce the electricity used in the building. This metric is favored by owners whose primary motivation is to conserve the Earth's fossil-based energy sources and to reduce the environmental damage associated with the extraction of these fuels. Using this approach largely levels the field when comparing natural gas heating versus electric heat pumps.

Option 3: Net Zero GHG Emissions: This metric is based on the GHG emissions associated with the energy used in the building rather than the energy itself. For instance, the GHG emissions metric would account not for the electricity used in the building, but rather for the airborne pollution generated by the power plant as it produces the electricity used in the building. A net zero GHG building might also be called a "carbon neutral" building. Net zero GHG emissions is chosen by owners whose primary motivation is to mitigate climate change. This metric favors the use of natural gas over electricity use, and places high value on producing renewable electricity (e.g. photovoltaic panels).

Option 4: Net Zero Energy Cost: A net zero energy cost building will offset the building's energy cost over the course of a year with renewable energy sold to the grid or other users. This metric is perhaps the simplest to understand, but it may not fit with the Town's Climate Action Plan. The most attractive systems and fuel types under this metric are variable, depending on the comparative market rates of the different fuels.

Defining the Boundary

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Option A: Building Footprint Generation: This option applies the constraint that all renewable energy must be generated within the footprint of the building itself. A common example of this would be PV panels installed on the building's roof.

Option B: Building Site Generation: Renewable energy may be generated anywhere within the property lines of the net zero building. Under this option, for example, a building may have PV panels on its roof as well as on the ground or on an on-site parking canopy.

Option C: Off Site Renewables: Under this option, renewable energy may be imported from off-site and used on-site. A typical example would be biomass or biofuels used for heating. While not explicitly stated by NREL, it is our opinion that renewable energy generated by a system owned by the building owner and located on land which is owned by the building owner (though not on the building site) would qualify under Option C. An example would be PV panels located on a Town-owned park. This option simply expands options for renewable generation, it does not exclude the possibility that some energy may still be generated on the building or the building site.

Option D: Purchased Generation: This option allows renewable energy to be generated by others and

purchased by the building. This is often done in the form of Renewable Energy Credits (RECs). In this case the renewable energy itself is not necessarily used in the building, but the offsets created by the renewable energy are purchased and claimed by the building owners. Under this option, each of the previous three options may be included in the total mix of generation possibilities.

EXHIBIT E-5

HVAC UPGRADE CONCEPTS AND RECOMMENDATIONS
TOWN OF CARRBORO

Town Hall

Century Center

Public Works

JSA ARCHITECTS

SUD ASSOCIATES, P.A.
CONSULTING ENGINEERS

STUDY PROCESS

- Energy Analysis
  - Study Facility Documents
  - Analyze Utility Data
  - Perform Site Visits
  - Research Building Use and Schedules
  - Research Building Equipment
  - Create Energy Simulations
  - Create Water Usage Spreadsheet Models
  - Calibrate Energy Simulations and Water Models
- Net Zero Consulting
  - Produce guidance material for Net Zero strategies and definitions
  - Provide general recommendations for moving toward Net Zero at each facility

JSA ARCHITECTS

SUD ASSOCIATES, P.A.
CONSULTING ENGINEERS

PRESENTATIONS

- 10-21-2020 – TOC Facilities Committee
  - Presented on the energy modeling process and results
- 12-1-2020 – TOC Town Council
  - Presented on the energy modeling process and results
  - Presented on Net Zero definitions to aid council in choosing a Net Zero metric and boundary
- 1-11-2021 – TOC Environmental Advisory Board
  - Presented on Net Zero definitions to allow EAB to advice Town Council

JSA ARCHITECTS

SUD ASSOCIATES, P.A.
CONSULTING ENGINEERS

CENTURY CENTER

- Keep existing system types (HW, CHW)
  - Allows reuse of existing piping and ducting
  - Boiler is new, highly efficient
  - HW and CHW enables flexibility, effectiveness, and efficiency
  - Use of natural gas boiler does not aid goal of electrification
- Improve Operation
  - Apply strategies to save natural gas and electricity
  - Address extended hours areas separately
- Equipment upgrades
  - As chiller is slated for replacement, consider heat recovery chiller as an option
    - Aids goal of electrification by displacing some gas heat with electrical “waste heat”

JSA ARCHITECTS

SUD ASSOCIATES, P.A.
CONSULTING ENGINEERS

TOWN HALL

- Complete redesign of systems
  - Electricity based systems
  - Consider new occupancy types and schedules
  - State of the art efficiency in equipment and strategies
  - VRF AHUs w/ VAV boxes one possible option

JSA ARCHITECTS

SUD ASSOCIATES, P.A.
CONSULTING ENGINEERS

PUBLIC WORKS

- Focus first on system operation
  - Make the most of existing systems
- Upgrade equipment as appropriate
  - Select system types tailored to space needs
  - Continue goal of electrification
  - State of the art efficiency in equipment for new spaces

JSA ARCHITECTS

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CONSULTING ENGINEERS

MOVING TOWARD NET ZERO

- Conserve first
  - Efficiency upgrades and no-cost/low-cost solutions
- Renewable energy
  - Solar PV the most probable primary solution
  - Some or most generation will likely need to be off-site
    - Century Center has almost no space other than the roof
    - Town Hall has several on-site options, but will likely need to supplement
- Economy of scale
  - Larger, simpler systems more cost effective than small scattered systems
  - Consider TOC as a single entity as opposed to individual buildings

JSA ARCHITECTS

SUD ASSOCIATES, P.A.
CONSULTING ENGINEERS