PORT ROYAL CONDOMINIUMS

ENERGY AUDIT REPORT
(ASHRAE LEVEL 2)

Prepared for:
The City of Alexandria, T&ES Office of Environmental Quality. Prepared with funding from DOE's Energy Efficiency & Conservation Block Grant.

Prepared by:
2rw Consultants Inc.
100 Tenth Street, NE
Charlottesville, VA

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Acronyms Defined

ACGIH - American Conference of Industrial Hygenists
AHU - Air Handler Unit
ASA - Alexandria Sanitation Authority
ASHRAE - American Society of Heating, Refrigerating and Air-Conditioning Engineers
CBECS - Department of Energy's Commercial Building Energy Consumption Survey
CDD - Cooling Degree Days
cf - cubic feet CFM - Cubic Feet per Minute
CFL - Compact Fluorescent
CMU - Concrete Masonry Unit
CO - Carbon Monoxide
CO-2-eq - Carbon Dioxide Equivalent
DHW - Domestic Hot Water
ECM - Energy Conservation Measure
EPA - U.S. Environmental Protection Agency
EPR - Energy Performance Rating
FCU - Fan Coil Unit
gpf - Gallons per Flush
gpm - Gallon per minute
gpw - Gallons per wash
HDD - Heating Degree Days
HHW - Heating Hot Water
HUD - Department of Housing and Urban Development
HVAC - Heating Ventilation and Air Conditioning
HVU - Heating Ventilation Unit
kWh - Kilowatt-hour
MBH - Thousand BTU's per hour
NFPA - National Fire Protection Agency
ppm - Parts per million
TMY - Typical Meteorological Year

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1. Executive Summary

Rising energy costs have caused the energy budgets of facilities across the country to increase dramatically in the past years. Electric utility companies are continuing to increase electric rates to cover their increased generating costs, while natural gas and oil prices remain volatile due to political unrest in the Middle East, impacts on supplies of the commodities, and natural disasters. In response to these rising costs, the City of Alexandria commissioned 2rw Consultants to perform an energy audit at Port Royal Condominiums in Alexandria, VA.

An Energy Star Target Finder ™ analysis of the utility consumption for the building revealed an Energy Performance Rating of 70 out of 100 which indicates that the facility shows opportunity for energy conservation. The EnergyStar Target Finder ™ also suggests potential for a 28% reduction in CO_2-eq emissions from the current 1,261 metric tons/year. Table 1 presents the conservation measures identified and analyzed. These options are to provide the management of the building the opportunity to select the most appropriate measures to meet its goals.

Table 1: Utility Conservation Measure Rankings

	Project Description	Annual Energy Savings				Total Project Cost	Simple Payback (Yrs)
		Electrical (kWh)	Natural Gas (MMBtu)	Water (kgal)	Total Savings ($)		
1	ECM 1 - Lighting Upgrade T5	2,271	-	-	$ 173	$ 9,073	53
2	ECM 2 - HHW Boiler Replacement	-	479	-	$ 4,842	$ 133,826	28
3	ECM 3 - DHW Boiler Replacement	-	367	-	$ 3,710	$ 74,550	20
4	ECM 4 - Added Piping Insulation	-	92	-	$ 924	$ 1,900	2
5	ECM 5 - Garage CO Controls	22,860	892	-	$ 7,243	$ 24,393	3
6	ECM 6 - Water Conserving Fixtures	-	1,376	2,170	$ 13,899	$ 96,974	7
7	ECM 7 - Added Wall Insulation	9,857	1,079	-	$ 11,643	$ 266,684	23

Detailed information about the energy audit is provided throughout the report. The body of this report is organized into six major sections: Existing Conditions, Utility Analysis, Metering, Energy Conservation Measures for Condo Association, Energy Conservation Suggestions for Condo Owners and Recommendations. Appendices provide some additional detail about the calculations conducted during the energy audit.

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2. Existing Conditions

Port Royal is a seventeen-story building with gross floor area of approximately 217,000 square feet. The building houses condominiums with zero (studio), one, and two bedrooms; common space; and commercial office space.

Figure 1: Street view of Port Royal Condo building.

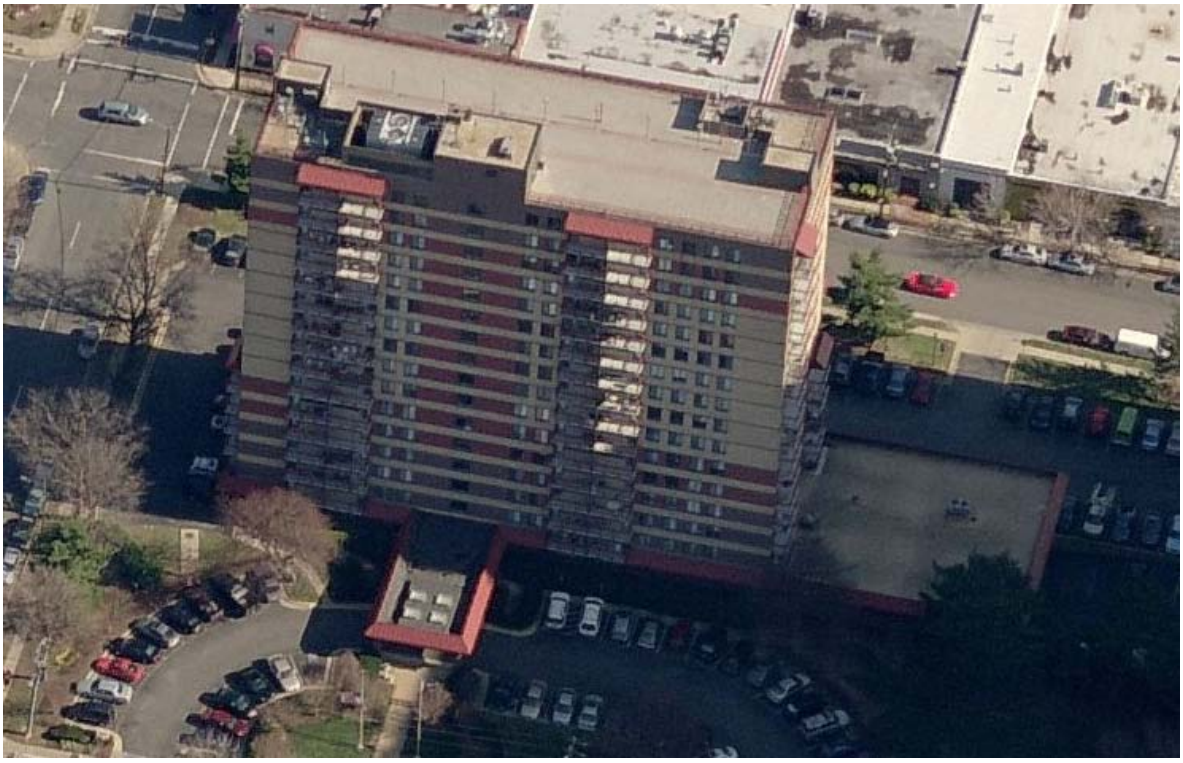

Figure 2: Aerial view of Port Royal Condo building from Microsoft Bing Maps.

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Building Envelope

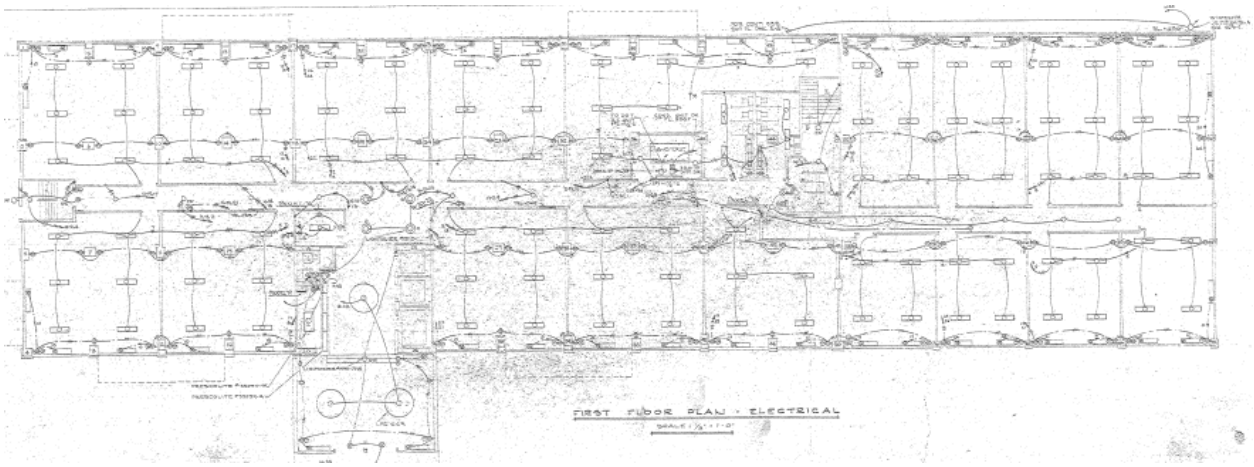
Neither wall section drawings nor information showing the building's envelope materials were provided to 2rw. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 90.1 and prior building construction experience held by 2rw Consultants were used as a basis for analysis. The building construction materials were estimated from outside-in to be 4 in brick, 2 in air gap, 8 in Concrete Masonry Unit (CMU), 18 gauge steel stud framing and 5/8 in gypsum. It was mentioned during the site assessment that there was no cavity insulation between the common wall steel frame studs. An analysis of building envelope heat loss and heat gain of various wall envelope construction types and materials was carried out in order to estimate potential energy savings from added envelope insulation.

Building Occupancy and Usage

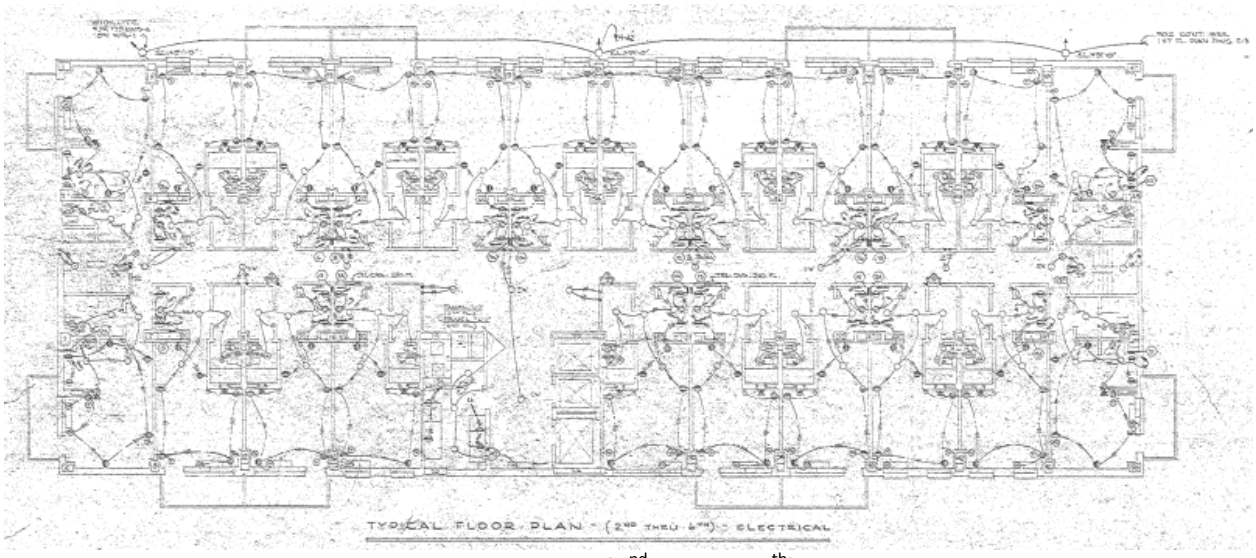
The building is a typical condominium housing 110 studio apartments, 78 one-bedroom condos, and 22 two-bedroom condos. Occupancy was estimated at one person per efficiency and 1.2 people per bedroom within one and two bedroom units. These values were determined through experience in conducting energy audits for multi-family residential buildings. The building also houses commercial businesses and common areas on the Lobby level.

Building Floor Plan

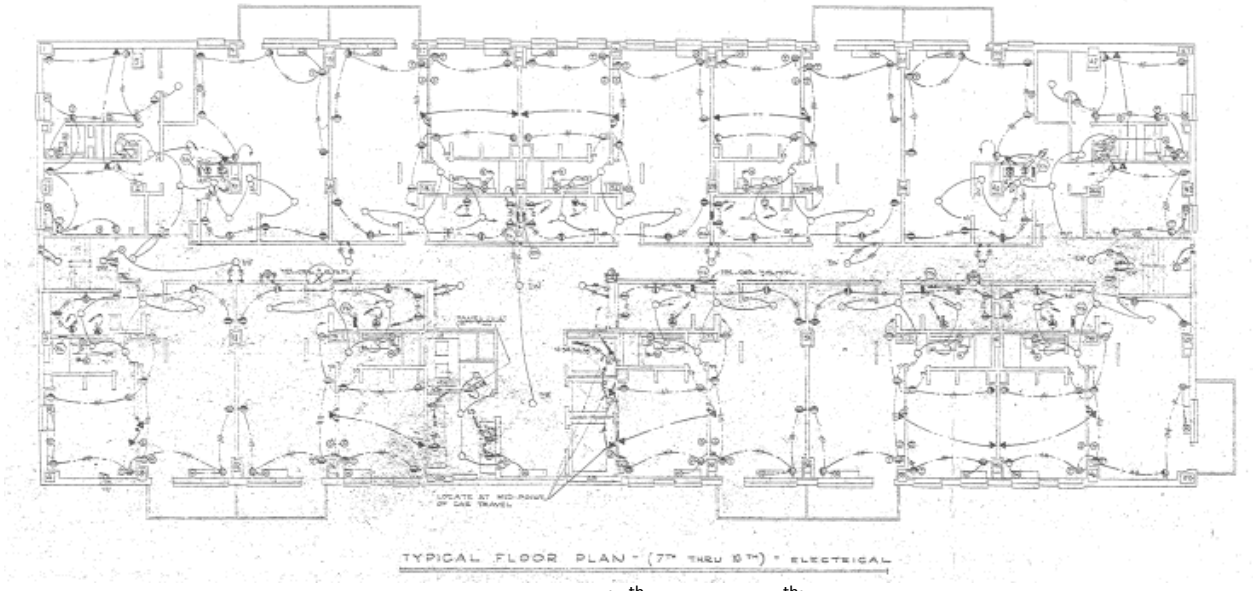
Port Royal is a 17 story building with two ground levels that house the mechanical equipment and also serve as parking decks. The lobby is located on the first floor and also contains commercial offices. The 23 studio apartments are located on floors 2-6. Floors 7-17 each house 8 one-bedroom condos and 2 two-bedroom condos.



First Floor Plan



Typical Floor Plan (2nd through 6th)



Typical Floor Plan (7th through 17th)

Heating Ventilation and Air Conditioning (HVAC)

The heating and cooling system consists of one Trane M-Series Climate Changer air handler unit (AHU) that serves the lobby level (first floor) offices and fan coil units (FCU) to provide heating and cooling in each of the dwelling units and lobbies. The AHU has three-way control valves for heating hot water and chilled water. Three-way valves incorporate a bypass leg to allow a constant volume of water to either enter the coil or bypass the coil. The FCUs have a constant volume of water always circulating through them as there are no control valves. Temperature is controlled by modulating the fans via a wall-mounted thermostat.

Port Royal generates chilled water with two water cooled Evergreen™ chillers manufactured by the Carrier Corporation. The two 161 ton chillers have a rated full-load efficiency of 0.714 (kW/Ton) utilizing

twin screw compressors. The chilled water is circulated throughout the building by constant volume pumps. The chillers reject heat to two Baltimore Aircoil Company modular cooling towers located on the roof. Water is circulated between the chiller's condenser and cooling tower by two constant volume pumps located in the mechanical room.

Heating hot water is generated by two natural gas/oil fired boilers manufactured by DDR Americas. The boilers have an AHRI rated thermal efficiency of 85.2%. The heated hot water is circulated through the building by constant volume pumps to each heating/cooling fan coil units.

Lighting & Electricity

The two parking levels are lit primarily by one-foot by four-foot strip light fixtures containing one T8 fluorescent lamp powered by electronic ballasts. The boiler room and first floor air handler room primarily consists of 22 four-foot T12 fixtures with magnetic ballasts. The hallway lighting consists primarily of plug-in compact fluorescent (CFL) fixtures. The units within Port Royal are offered CFL lamps if they wish for a more efficient lighting option, else they are required to provide their own incandescent fixtures. Lighting and electricity use savings are a difficult assessment when evaluating condominiums which only have a single meter for the entire building. Condo owners who pay a flat rate for electricity see little incentive to reduce consumption and can only be encouraged to implement energy conserving habits.

Other Energy Users

The first floor of the Port Royal Condominium building consists primarily of office space and includes standard office equipment such as computers, printers, copiers etc. The lobby and front desk area also contains similar equipment to be used by Port Royal management staff.

Water

Domestic hot water is supplied by two A.O. Smith boilers that are capable of burning both natural gas and fuel oil. These boilers and associated heat exchanges and storage tanks are housed in the central mechanical room. A pump circulates domestic hot water through the building so that domestic hot water is always available. Typical plumbing fixtures include a mixture of 3.5 and 1.6 gallon-per-flush (GPF) toilets, 2.5 gallon-per-minute (GPM) shower heads, and 2.2 GPM sink aerators.

3. Utility Analysis

Existing Facility Energy and Water Consumption

The following figure represents the baseline energy usage profiles for the building. The baseline energy use profiles were derived from utility data and data acquired during the site observation. Many of the distinctions between energy profiles utilizing the same site energy source were made possible through seasonal data variations. For example, the cooling and receptacle profiles are both derived from electricity use, yet, cooling electrical use occurs during warm seasons and receptacle energy use remains constant. Other energy profile distinctions were developed from data acquired from the on-site audit. *Receptacles* are defined as any plug allowing for current to be used to run a variety of electrical devices (computers, printer/fax units, clocks, etc). The total estimated energy and water consumption for the building is **13,563 MMBtu/year** and **6,345 kgal/year**, respectively.

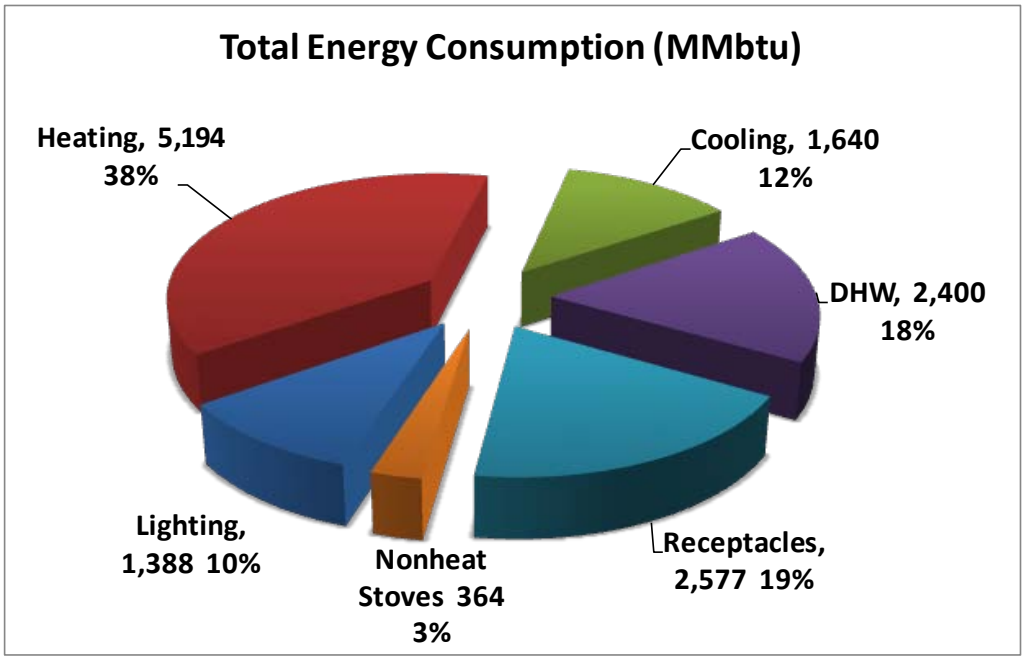


Figure 3: Estimated energy consumption for Port Royal Condominiums.

Savings estimates from any conservation measures implemented will depend on the costs of utility resources. This section contains an assessment of the resource utilization, and an analysis of historical cost and consumption trends for electricity, natural gas, water, and sewer utilities.

Energy Utilization Assessment

An assessment of energy efficiency has been determined based on the U.S. Environmental Protection Agency's (EPA) Energy Star Target Finder™ computer software. Target Finder™ uses information about a facility and its annual energy consumption to determine an Energy Performance Rating. The Energy Performance Rating (EPR) uses a scale from 1-100, with 100 being the most energy efficient. A building can receive an Energy Star ranking with an EPR of 75 or above. Target Finder™ is based on the US Department of Energy's Commercial Building Energy Consumption Survey (CBECS) data.

The EPA has defined three categories of EPR scores. The EPA recommends a different course of action for each category. The definitions of the three categories are quoted below from the EPA's website.

> **Low ratings (1-49) - Greatest opportunities for investments**
> Buildings in this category have the most attractive returns for capital investments. Look for opportunities to upgrade lighting and other significant energy using systems, including system coordination. Renewing the commitment of senior executives to energy management will be an important component to your strategy.
> **Middle ratings (50-74) - Fine tune O&M**
> Buildings with mid-range benchmarks should consider low- or no-cost activities such as re-commissioning campus buildings, developing and implementing preventative maintenance plans, increasing employee training, or re-assessing incentive, recognition, and reward systems to ensure that they drive energy performance. Often, these relatively low-cost efforts can turn these facilities into "top performers".
> **High ratings (75-100) - Reward and Learn**
> Buildings within this range are among the highest energy performers compared to U.S. hospitals. Facility managers may consider sharing their energy management plans and operational strategies with other hospitals in their system. And they can continue to improve performance."
> **SOURCE: EPA**

Target Finder™ has calculated an EPR of **70** for the building. This indicates that the building is performing well, however there are some opportunities for optimizing the buildings energy use. The table below provides the estimated Target Energy performance results for Port Royal and a representative average building. A target rating of 75 is shown because this is the EPR required for Energy Star building certification.

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Table 2: Target Energy Performance Results (estimated).

Target Energy Performance Results (estimated)			
Energy	**Design**	**Target**	**Average Building**
Energy Performance Rating (1-100)	70	75	50
Energy Reduction (%)	23	28	0
Source Energy Use Intensity (kBtu/Sq.	134	125	174
Site Energy Use Intensity (kBtu/Sq.	67	63	87
Total Annual Source Energy (kBtu)	27,051,227	25,181,689	34,949,494
Total Annual Site Energy (kBtu)	13,562,551	12,625,230	17,522,469
Total Annual Energy Cost ($)	$ 196,672	$ 183,080	$ 254,095
Pollution Emissions			
CO2-eq Emissions (metric tons/year)	1,261	1,174	1,630
CO2-eq Emissions Reduction (%)	23%	28%	0%

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Electricity

Electricity to the building is provided by one electric service from Dominion Virginia Power.

Rate Schedule

Electricity is provided to the building by Dominion Virginia Power and is billed under the Non-Residential Service under the GS-2T rate schedule. The bills are calculated based on a number of factors including a monthly service fee, the electrical energy used, and the electrical demand required. The average electricity cost of $0.07 per kilowatt-hour for 2010 was used as a basis for all energy savings calculations. The components of the GS-2T billing rate schedule as well as the rider surcharges are shown in the section below.

II. 30-DAY RATE

A. Distribution Service Charges

1. Basic Customer Charge
   Basic Customer Charge $26.17 per billing month.

2. Plus Distribution Demand Charge
   All kW of Distribution Demand @ $ 3.387 per kW

3. Plus each Distribution kilowatthour used is subject to all applicable riders, included in the Exhibit of Applicable Riders.

B. Electricity Supply (ES) Service Charges

1. Generation Demand Charge

   a. For the Billing Months of June - September
      All On-peak ES kW of Demand @ $5.524 per kW

   b. For the Billing Months of October - May
      All On-peak ES kW of Demand @ $4.115 per kW

2. Plus Generation Adjustment Demand Charge
   All kW of Demand @ ($0.740) per kW

3. Plus Generation kWh Charge
   All On-peak ES kWh @ 3.155¢ per kWh
   All Off-peak ES kWh @ 0.524¢ per kWh

4. Each Electricity Supply kilowatthour used is subject to all applicable riders, included in the Exhibit of Applicable Riders.

5. Each kW of On-Peak Electricity Supply Demand billed pursuant to Paragraph II.B.1 above, is subject to all applicable riders, included in the Exhibit of Applicable Riders.

C. The minimum charge shall be as may be contracted for.

Figure 4: Rate Schedule for Electricity, GS-2T Dominion Power.

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Table 3: Applicable Riders for Electricity, GS-2T Dominion Power.

Rider	Description	Effective Date
A	Fuel Charger Rider A	For Usage On and After 07-01-10
R	Bear Garden Generating Station	For Usage On and After 04-01-11
S	Virginia City Hybrid Energy Center	For Usage On and After 04-01-11
T	Transmission	For Usage On and After 01-01-11
C1	Peak-Shaving	For Usage On and After 04-01-11
C2	Energy Efficiency	For Usage On and After 04-01-11
D	Tax Effect Recovery Factor	9/1/2009
EDR	Economic Development	8/11/1998
F	Receivers or Trustees	3/1/1954
G	Renewable Energy Program	On and After 01-01-09
J	Interruptible Electric Water Heating Service- Residential Customers	On and After 09-30-97
Credit Rider BRC	Base Rate Credit	Effective For Usage On and After 01-01-11 Through and Including 12-31-12

Trends in Electricity Use

The figure below illustrates electricity use over the period March 2008 through December 2010. The line labeled CDD illustrates the monthly cooling degree-days, indicating the magnitude of the weather-dependent space cooling load. The data was "day normalized" to adjust any irregular billing periods to reflect an actual month.

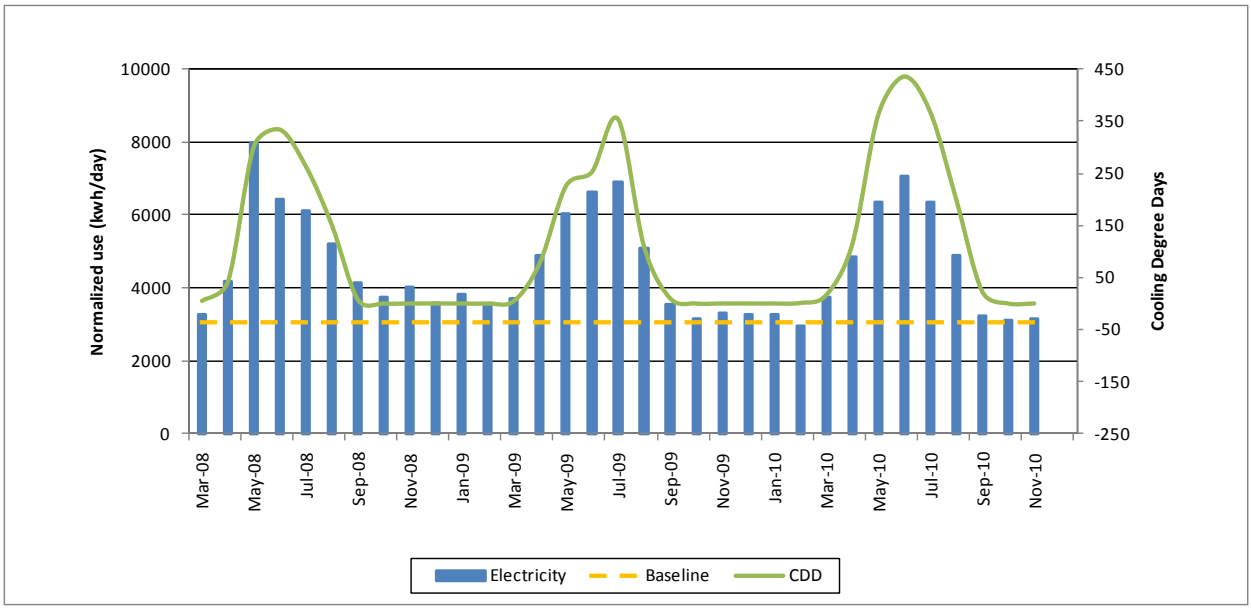

Figure 5: Electrical energy use, March 2008 – March 2010.

A review of the electricity consumption indicates:

- Space cooling is a significant proportion of the total electricity use. The strong correlation between CDD and the cooling energy profile (the blue line above the baseline) indicates the building has a considerable envelope load.
- The largest proportion of electricity consumption is the base load - lighting, ventilation fans, computers, and other plug loads. For this facility, about 3,069 kWh per day is used for these purposes.

The figure below displays electrical demand history for the building for March 2009 to December 2010.

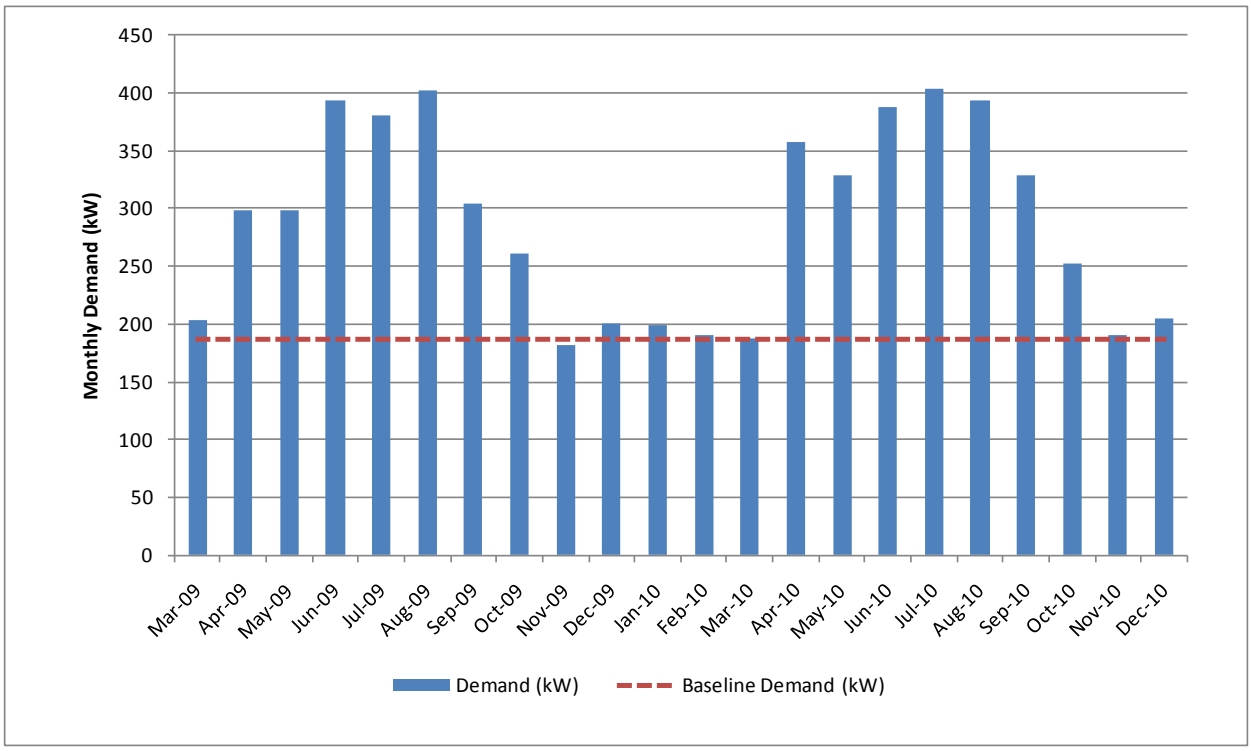

Figure 6: Electrical demand history, March 2009 – December 2010.

A review of the electrical demand indicates several things regarding Port Royal:

- Significant summer demand peaks indicate that space cooling constitutes a sizeable proportion of the total electrical demand.
- The base load (lighting, ventilation fans, computers, and other plug loads) represents about half of the total demand during the cooling season.

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The figure below illustrates the history of the building's electrical load factor over the two-year period.

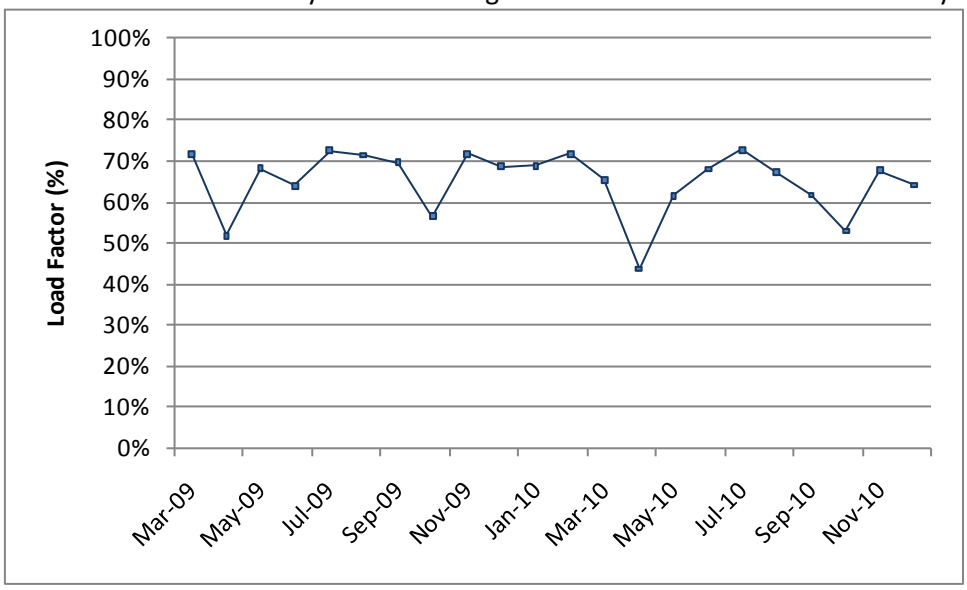

Figure 7: History of electrical load factor, March 2009 – Dec 2010.

The *load factor* is defined as the ratio of average electrical power usage within a system to its maximum or "peak power" usage. Plotting the load factor on a monthly basis creates a graphical representation of the electrical power usage in comparison to the peak electrical demand which can serve to help identify current usage profiles and building schedule.

A review of load factor indicates several things regarding the Port Royal building:

- The load factor has become more variable, but shows no apparent increase over the past two years.
- Because the building is residential with a nearly continuous operating schedule, a high load factor is typical.

Natural Gas

Heating and conventional stove top cooking natural gas is purchased as a commodity from the Hess Corporation and is delivered to the building by Washington Gas . Over the past year, the average price of natural gas for the building was about $1.00 per therm (1 therm = 100,000 Btu).

Rate Schedules

Average annual heating natural gas consumption exceeds 60,000 therms and as a result is billed under the Washington Gas Rate Schedule 7. Schedule 7 is an interuptable delivery rate. "Interuptable" means that during times of high gas usage, the gas company can notify Port Royal that their natural gas service will cease for a defined duration and the boilers will be required to switch to buring fuel oil. A delivery schedule is used in situations where a building owner negotiates a separate contract to purchase the natural gas commodity and the local gas company is only responsible for distributing the gas to the building. Port Royal Condominium Association has elected to contract with the Hess Corporation to provide the commodity. The components of the Washington Gas Rate Schedule 7 are shown below.

RATE FOR MONTHLY DELIVERIES	
System Charge (Per customer)	
All Billing Months	$100.00
Distribution Charge (Per therm)	
All gas delivered during the billing month:	
First 75,000 therms	9.01¢
Over 75,000 therms	5.22¢

Figure 8: Rate schedule for heating natural gas, Schedule 7 Washington Gas.

Port Royal has a separate account for natural gas used for the gas stove in the condos. This account is billed from a non-interuptable distribution rate schedule, Schedule 3A. The components of this rate schedule are shown below.

RATE FOR MONTHLY DELIVERIES	
System Charge (Per customer)	Washington Gas
Heating and/or Cooling	
All Billing Months	$44.60
Non-Heating and Non-Cooling	
All Billing Months	$14.80
Distribution Charge (Per therm)	
All therms delivered during the billing month:	
First 125 therms	29.79¢
Next 875 therms	23.86¢
Over 1,000 therms	18.62¢

Figure 9: Rate schedule for cooking natural gas, Schedule 3A Washington Gas.

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Trends in Gas Use

The figure below illustrates heating hot water and domestic hot water natural gas use for the building over the past three years. The line labeled HDD illustrates the monthly heating degree-days, indicating the magnitude of the weather-dependent space heating load. The data was "day normalized" to adjust any irregular billing periods to reflect an actual month.

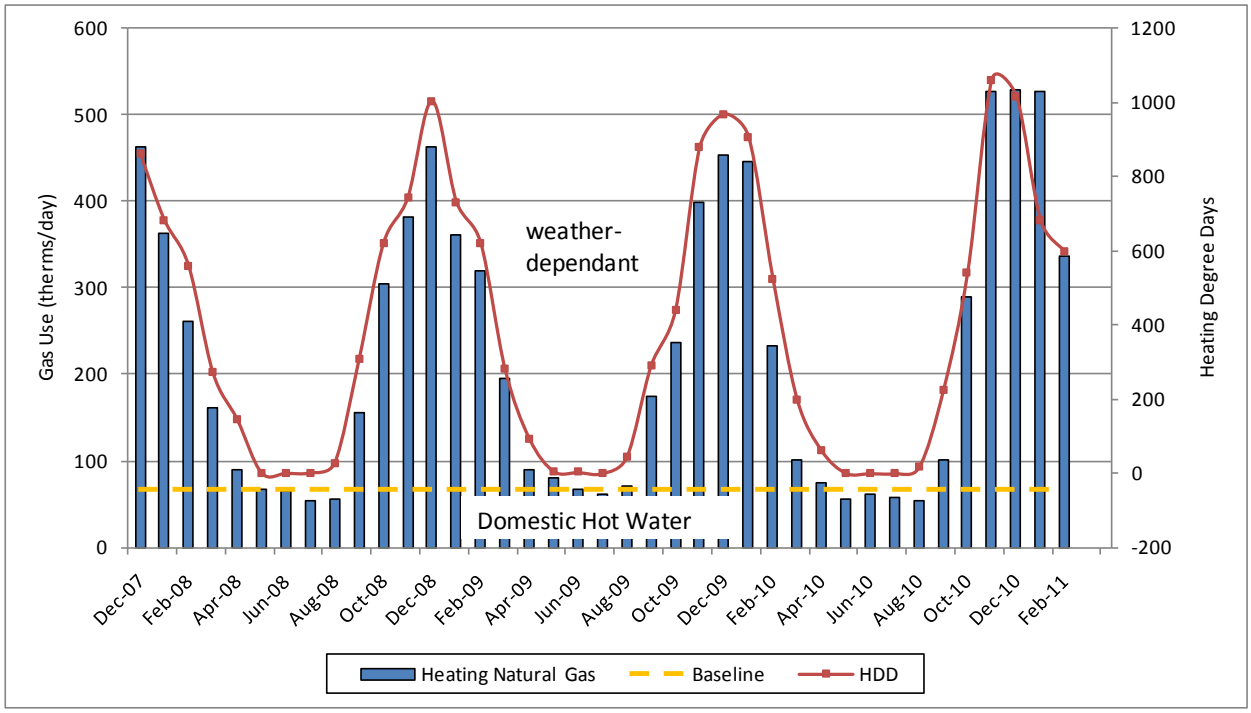

Figure 10: Natural gas use history, December 2007 – February 2011.

A review of natural gas use reveals the following trends:

- Natural gas use is highly dependent upon weather, peaking during the winter months when space heating requirements are greatest.
- HVAC represents a significant portion of the natural gas use.

The figure below illustrates cooking natural gas use for the building over the past three years.

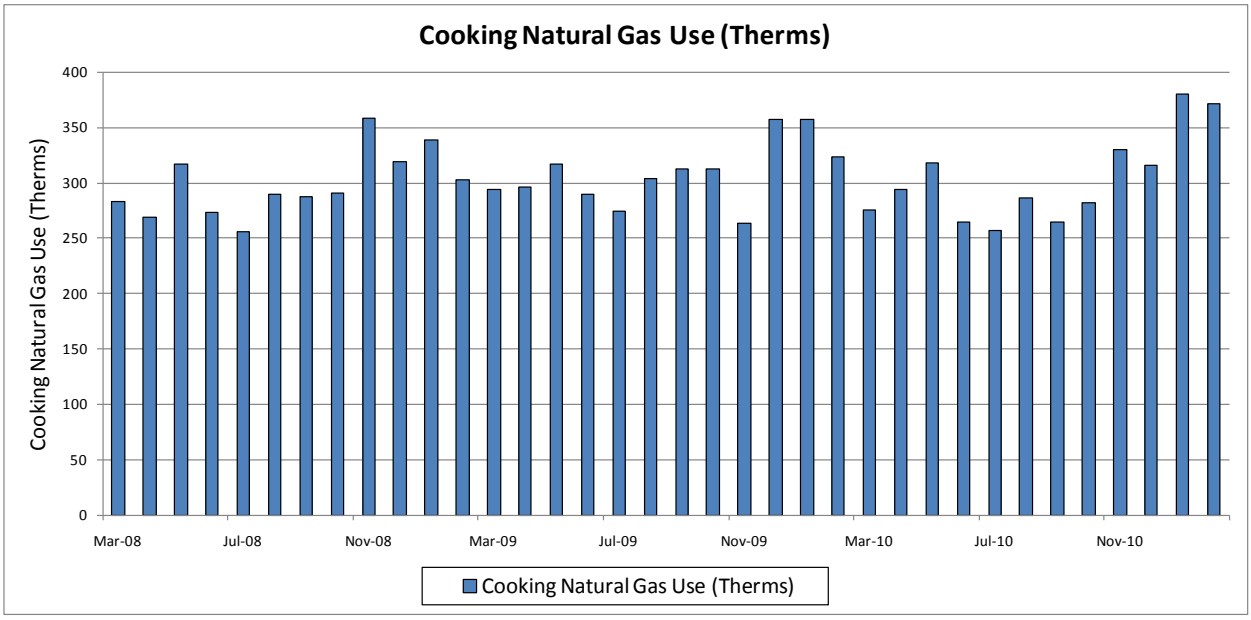

Figure 11: Natural gas cooking use for March 2008 to March 2011.

A review of cooking natural gas use reveals the following trends:

- Cooking Natural gas use is fairly consistent and is not dependent on weather or peaking during the winter months when space heating requirements are greatest.

The figure below shows the average annual cooking, heating and domestic hot water natural gas given the last three years of utility data.

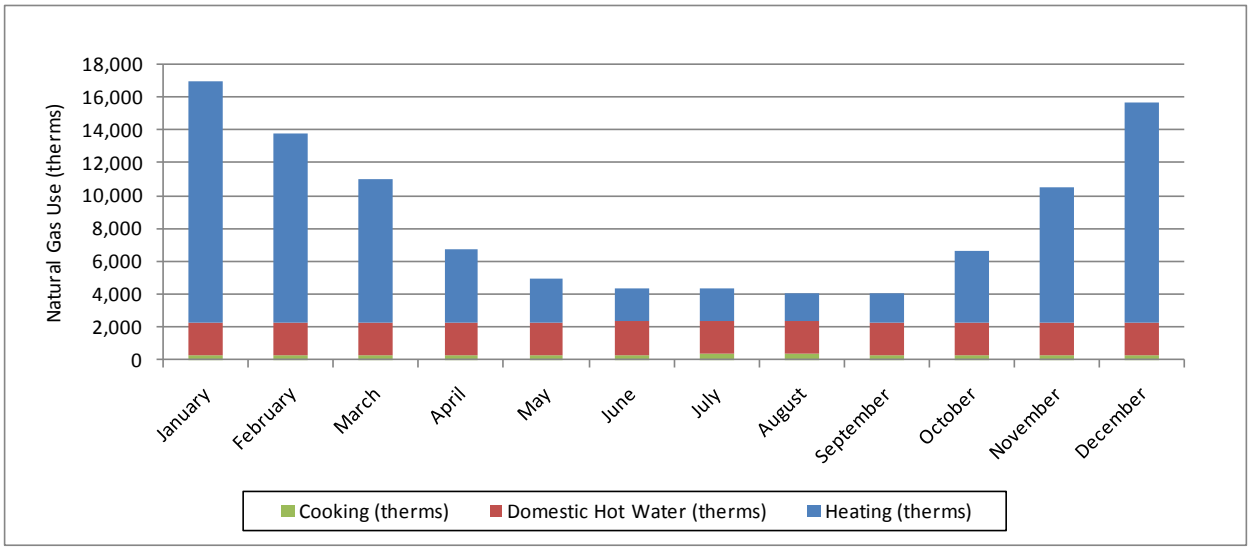

Figure 12: Average annual cooking, heating and domestic hot water monthly natural gas use.

Water & Sewer

Rate Schedule

Water is provided to the Port Royal Condominium Association by the Virginia American Water Company and the sewer utility is the Alexandria Sanitation Authority (ASA). The average cost of water and sewer utilities combined has been about $5.00 per thousand gallons given the utility information provided. The ASA bill is calculated based on the total gallons purchased for consumption from VA American Water.The rate schedule for potable water provided bt Virginia American Water Company is shown below.

RATE:

	Gallons Per Month	Gallons Per Quarter	Rate Per 1,000 Gallons
For the first	2,000	6,000	(minimum charge)
For all over	2,000	6,000	$3.8593

MINIMUM CHARGE:

No bill will be rendered for less than the minimum charges set forth below:

Size of meter		Minimum Charge Per Month	Minimum Charge Per Quarter
5/8	inch	$9.05	$27.15
3/4	inch	13.57	40.71
1	inch	22.62	67.86
1 1/2	inch	45.23	135.69
2	inch	72.38	217.14
3	inch	135.69	407.07
4	inch	226.17	678.51
6	inch	452.32	1,356.96
8	inch	723.72	2,171.16

ACTIVATION CHARGE:

When a customer applies to initiate water service, a charge of twenty-five dollars ($25.00) will be assessed to cover the cost of activating the service.

SERVICE CONNECTION CHARGE:

3/4 inch Service Connection	$675.00
Service Connections over 3/4 inch	Actual cost to Company including overhead

All service connection charges will be gross-up for federal income tax if any should occur.
The customer shall pay to the Company the service connection charge prior to installation.

Turn-on and shut-off charges during normal scheduled working hours associated with new accounts, seasonal customers, as well as non-payment and rules violation situations, will be $25.00. An additional charge of $25.00 will be made for all returned checks tendered.

Figure 13: Virginia American Water Company Rate Schedule.

Riders included with utility billing consist of the following; Rider A – Purchased Water Surcharge Rate and Rider B Sales and Use Tax Surcharge Rate. Methodology for computing Rider A and Rider B are shown below.

RIDER A
ALEXANDRIA DISTRICT
Computation of the Purchased Water Adjustment Rate
In Accordance with Rider A Original Sheet No. 18 S.C.C. VA. No. 11.

A = Amount charged or (credited) to Company by Fairfax County Water Authority to adjust estimated expense to actual.

B = Amount (over) or under collected in the previous year's Purchased Water Adjustment factor, excluding gross receipts taxes (True-up Mechanism - ACA).

C = Estimated sales from June 1 through December 31 (1,000 gallons).

T = Sum of state and local gross receipts tax rates.

$$\frac{(A + B)}{C} \times \frac{1}{(1 - T)}$$

Figure 14: Virginia American Water Company Rider A.

RIDER B
ALEXANDRIA DISTRICT
Computation of the Sales & Use Tax Surcharge Rate
In Accordance with Va Code & 58.1-603 and 58.1-604

A = Amount charged to Company by Vendors for sales tax to tangible personal property

B = Amount (over) or under collected in the previous year's sales tax.

C = Estimated sales from September 1 through August 31 (1,000 gallons).

T = Sum of state and local gross receipts tax rates.

$$\frac{(A + B)}{C} \times \frac{1}{(1 - T)}$$

Figure 15: Virginia American Water Company Rider B.

Trends in Water Use

Historical water use at the building over the past three years is shown in the following figure.

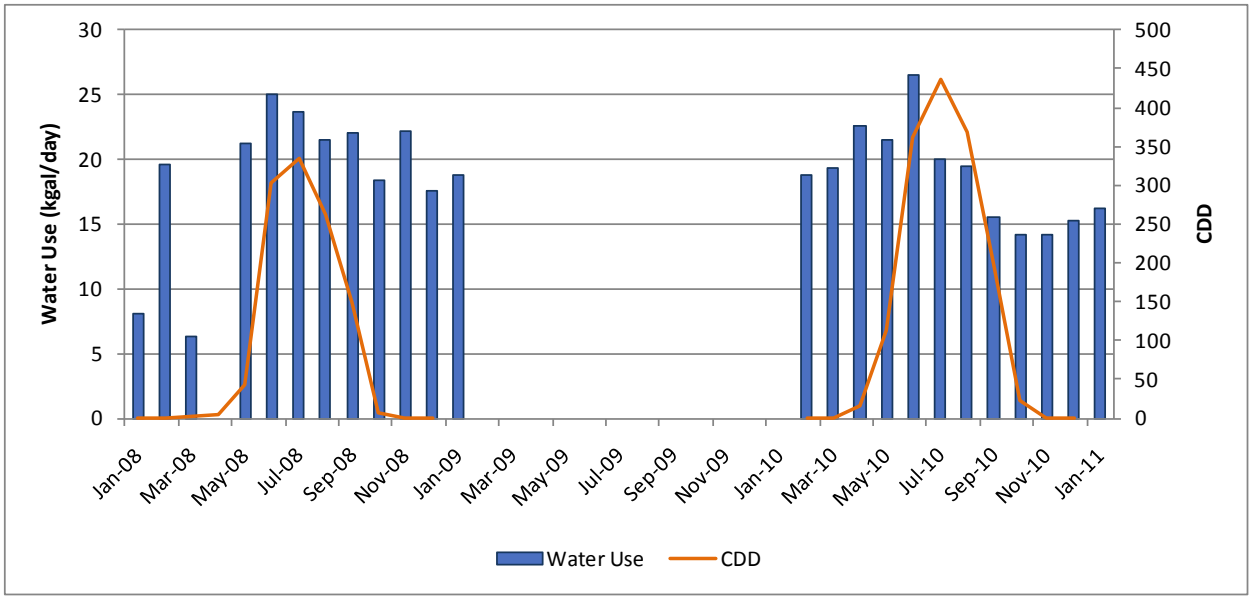

Figure 16: History of water use, March 2004 – February 2007.

The history of water use reveals the following trends:

- The consumption chart indicates no clear seasonal dependence in water use. Water used by the cooling tower is masked by the building's other consumption.
- Average water use is over 19,000 gallons per day.

4. Metering

Currently, the Port Royal condominium building is master metered and the condo association is responsible for paying all of the utility bills. Each condo owner is assessed a monthly association fee of which part is used to pay for the utilities. Because there is essentially a fixed utility cost for each of the condo owners with no means for each owner to know how their behavior impacts the utility cost, utility bills will tend to be higher than individually metered condos where each tenant receives a bill and is provided a level of accountability for the manner in which they operate their condo. According to the Department of Housing and Urban Development (HUD), the accountability associated with the installation of individual utility meters can result in reduced energy consumption between 10 and 25 percent.[1]

To determine the potential magnitude of energy savings that could result from the installation of a utility sub-metering system, an engineered estimate of how much energy conserving households would consume given the construction of this building and the typical types of equipment observed during the site visit was developed. To conduct this analysis, 2rw used a variety engineering tools and its experience from working with multi-family housing complexes.

The building energy simulation tool, ESim, was used to derive estimations of the heating and cooling energy requirements for each of eight typical condo styles if an energy conserving individual were living in the unit. Next, typical lighting and receptacle loads (refrigerator, microwave, computer, television, chargers, etc.) were estimated with typical usage patterns for a conserving household as defined by the Lawrence Berkeley National Laboratory. Finally, domestic water consumption was estimated for each of the typical condominium types to determine the energy required to heat the water.

These natural gas and electricity energy consumption estimates were then used to provide a basis of comparison between current energy consumption and potential energy consumption at Port Royal if a metering system were installed to encourage energy conservation and awareness of potentially wasteful behaviors.

[1] Energy Conservation for Housing – A Workbook: Prepared by Abt Associates Inc. for U.S. Department of Housing and Urban Development, January 1998.

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Basis for Analysis

Using standard engineering basis for calculations, typical energy consumptions were calculated for electricity and natural gas. All calculations were based on an average occupancy of 1.2 persons per bedroom; a value determined from an analysis of numerous multifamily utility allowance studies performed by 2rw. Electricity estimates were based on the wattage of light fixtures and hours of use for room types in addition to energy allotments for appliances. DHW heating energy allowances are based on typical hot water consumption and the water heater efficiency. Heating and cooling calculations were based upon actual dwelling unit configurations, existing boiler and chiller efficiencies, and estimated wall and roof assembly constructions. The following section outlines the basis of the analysis conducted to estimate the potential savings associated with the installation of a metering system.

Cooling electricity accounts for nearly 12% of the total current energy use by Port Royal. Tables 3 and 4 in Appendix A show the potential cooling electricity use of each unit type assuming energy conservative practices and behaviors. The set point temperature for an occupied cooling space was programmed at 74°F and an unoccupied set point of 78°F. The cooling months were derived from the utility data and programmed as April to October. Monthly cooling loads were derived using ESim™ utilizing this entered set point information, building and unit type information as well as uploaded city TMY2 weather data. The ESim™ modeling software suggests that there is a potential 4,000 kWh per year savings of electricity if each unit type followed the prior mentioned set points.

Heating natural gas accounts for 38% of the total current energy use by Port Royal. Table 1 in appendix A shows the potential natural gas use of each unit type assuming model energy practices and behaviors. The set point temperature for occupied heating space was programmed at 70°F and an unoccupied set point of 68°F. The heating months were derived from the utility data and programmed as November to May. Monthly heating loads were derived using ESim™ utilizing this entered set point information, building and unit type information as well as uploaded city TMY2 weather data. The ESim modeling software suggests that there is a potential 10,200 therms per year savings of natural gas if each unit type followed the prior mentioned set points.

Floor Plan Zoning

Each of the condominiums were first categorized as one of 8 unique types, based on the following; exterior wall area, total floor area, and presence of a roof. For the purposes of this model, balcony floor area was not included within the analysis. Unit types TOP A-C include the roof load. The following floor plans highlight the unique unit types.

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Figure 17: Established unit types for ESim™ modeling. Floors 2-6.

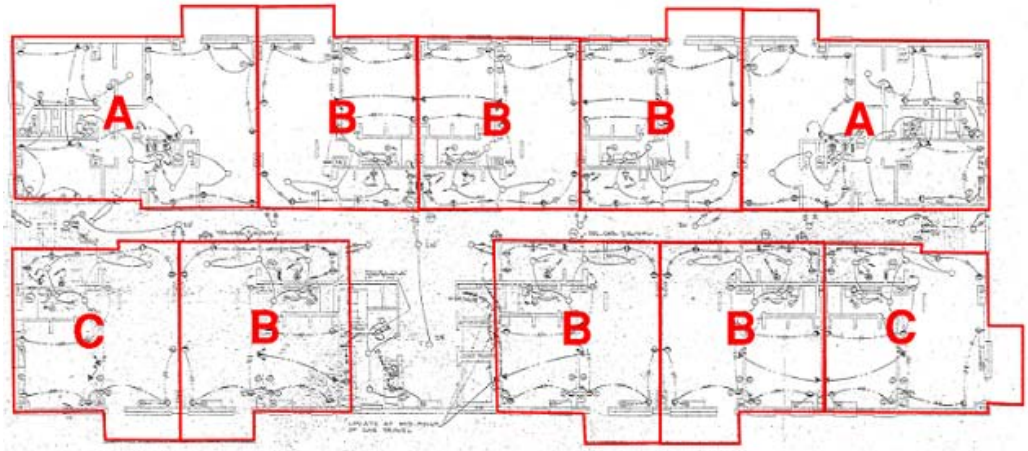

Figure 18: Established unit types for ESim™ modeling. Floors 7-16.

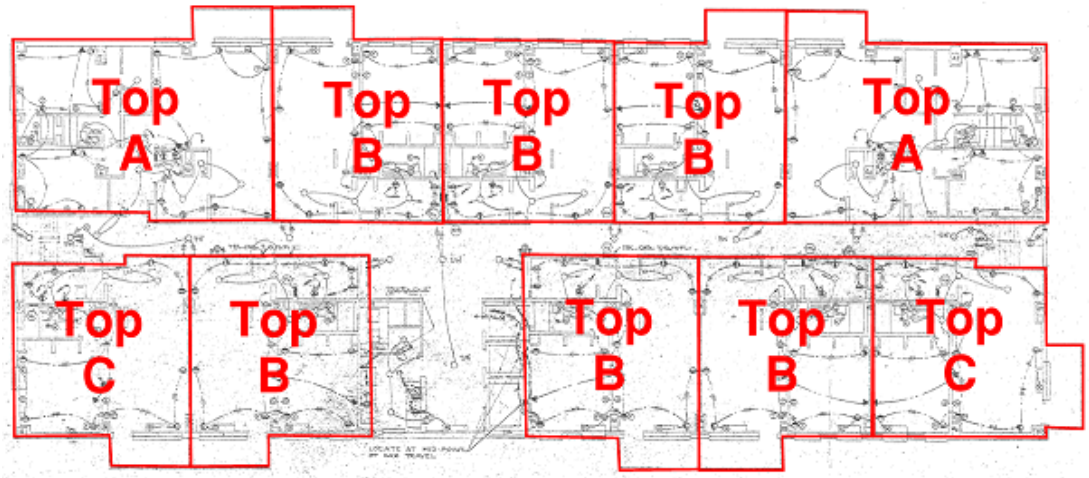

Figure 19: Established unit types for ESim™ modeling. Floor 17.

Heating and Air Conditioning Estimates

Heating and air-conditioning energy estimates were based on the number of residents, dwelling unit square footage, windows (number and type), walls (type and area), roof (type and area), air infiltration,

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set-point temperatures, and type of equipment. The set-point temperatures used for the calculations were 70° F for heating and 74° F for cooling. The building envelope and the efficiency and capacity of the boilers and chillers as defined by available construction documents, estimates made by 2rw engineers, or manufacturer specifications (described in the Existing Conditions section of this report) were used in the calculations.

Lighting and Appliance Estimates

Since a conserving household would use energy efficient compact fluorescent lighting fixtures and bulbs, this became the basis for estimating the consumption required for lighting the dwelling units. Lighting allowances are based on a wattage per typical lighting fixture in each unit and the average annual hourly usage of each fixture per a study conducted by Lawrence Berkley Laboratory. [2] The following table summarizes lighting fixture usage allotments for each type of room.

Table 4: Lighting Fixture Usage.

Location	Hrs/Day	Hrs/Year
Bathroom	2	730
Bedroom (s)	3	1095
Hallway	1	365
Kitchen	4	1460
Living Room	3	1095
Dining Room	2	730
Closet	0.25	91.25

The electricity needed for ranges, and other receptacle loads, were based on typical appliance energy consumption adapted from the HUD Utility Allowance Guidebook. The electricity needed to operate refrigerators was estimated to be 410-kWh/year, based on a standard 17.9 cf Energy Star™ model. For all applicable appliances estimates were based on Energy Star™ rated equipment. An itemized list of consumption by appliance and number of bedrooms can be found in the table below.

[2] Koomey, J.G., C. Dunham, and J.D. Lutz, 1994. The effect of efficiency standards on water use and water heating energy use in the U.S.: A detailed end-use treatment. Lawrence-Berkeley Laboratory publication LBL-34575, pp. 4-5.

Table 5: Receptacle Equipment Usage.

Appliance	Wattage	Quantity			kWh/year		
		0BR	1BR	2BR	0BR	1BR	2BR
Laundry							
Clothes Dryer	770	1	1	1.2	770	770	924
Washing machine	145	1	1	1.2	145	145	174
					100,650	**73,200**	**21,960**
Food Prep							
Blender	2.5	1	1	1.2	2.5	2.5	3
Dishwasher	170	1	1	1.2	170	170	204
Coffee maker	80	1	1	1.2	80	80	96
Microwave	120	1	1	1.2	120	120	144
Refrig/Freezer(20cu ft)	800	1	1	1.2	800	800	960
Mixer	3	1	1	1.2	3	3	3.6
Toaster	35	1	1	1.2	35	35	42
					133,155	**96,840**	**29,052**
Health & Beauty							
Hair dryer	45	1	1	1.2	45	45	54
Tooth brush	1	1	1	1.2	1	1	1.2
Shaver	1	1	1	1.2	1	1	1.2
Hair curler	2	1	1	1.2	2	2	2.4
Hair straightener	2.4	1	1	1.2	2.4	2.4	2.9
					5,654	**4,112**	**1,234**
Home Entertainment							
TV >49" pre 2008	750	0	2	2	0	750	900
TV >39" pre 2008	350	1	0	0	350	0	0
Radio	70	1	1	1.2	70	70	84
DVD player	40	1	2	2	40	40	48
Cellphone charger	18	1	1	1.2	18	18	21.6
Computer (laptop)	77	1	1	1.2	77	77	92.4
					65,450	139,611	35,563
					304,909	**313,763**	**87,808**

Domestic Hot Water Estimates

DHW heating energy consumption was estimated based upon a 60°F rise in water temperature and the hot water system efficiency. The DHW heating energy portion of the estimates were calculated based on hot water consumption per person, as defined in the table below.

Table 6: Domestic Hot Water Energy Consumption Per Person.

Use	Capacity	Uses / day	Total (gal/pers/day)	DHW (gal/pers/day)
Showers (gpm)	1.5	12.55	18.8	10.7
baths (gallons)	25	0.3	7.5	3.8
bathroom faucets (gpm)	2	3.5	7.0	3.5
Kitchen faucets (gpm)	2	1.5	3.0	1.5
Dishwasher (gpm)	5	0.33	1.7	1.7
Toilet (gpf)	1.6	5	8.0	0
Subtotals			46.0	**21.2**
Washing Machine (gpw)	35	0.25	8.8	4.4
Totals			54.7	**26**

Results

The following table presents the potential energy and water savings that could occur if each individual condo were metered and the condo owners were aware and cautious of their energy consumption.

Table 7. Potential energy savings from implementing a sub-metering system.

Load	**Current Consumption**	**Estimated Consumption**	**Theoretical Savings**
Heating	52,961 Therms	42,739 Therms	10,222 Therms; 19%
Cooling	480,711 kWh	367,927 kWh	112,784 kWh; 23%
Base Load	1,161,889 kWh	993,294 kWh	125,774 kWh; 14%
Receptacle Loads	755,228 kWh	646,999 kWh	204,661 kWh; 14%
Lighting	406,661 kWh	346,295 kWh	81,245 kWh; 15%
Domestic Hot Water	24,000 Therms	10,239 Therms	13,761 Therms; 57%

5. Energy Conservation Measures for Condo Association

The following table outlines the ECMs pursued for this building, including the estimated annual energy savings, energy cost savings, implementation costs and simple payback period of each measure. Following the table is a brief description and data for each ECM.

Table 8: Summary of Energy Conservation Measures Analyzed for the Building.

	Project Description	Annual Energy Savings				Total Project Cost	Simple Payback (Yrs)
		Electrical (kWh)	Natural Gas (MMBtu)	Water (kgal)	Total Savings ($)		
1	ECM 1 - Lighting Upgrade T5	2,271	-	-	$ 173	$ 9,073	53
2	ECM 2 - HHW Boiler Replacement	-	479	-	$ 4,842	$ 133,826	28
3	ECM 3 - DHW Boiler Replacement	-	367	-	$ 3,710	$ 74,550	20
4	ECM 4 - Added Piping Insulation	-	92	-	$ 924	$ 1,900	2
5	ECM 5 - Garage CO Controls	22,860	892	-	$ 7,243	$ 24,393	3

ECM 1: Lighting System Upgrade

The Port Royal parking decks are lit primarily by one-foot by four-foot strip light fixtures containing one T8 fluorescent lamp powered by electronic ballasts. These luminaires, compared to other common luminaires used within similar commercial settings, are relatively energy efficient. However, due to the continuous (24 hour per day) parking level garage lighting schedule, there is significant potential for energy savings through the replacement of all T8 lamps with T5 lamps.

The largest advantage to T5 lamps is that they have the ability to create the same amount of light in lumens as a T8 lamp, but with less wattage. Installing these higher efficiency lamps can maintain current lighting levels while decreasing energy consumption and cost.

Scope of Work - Lighting Upgrade (T5)

The Port Royal garage levels were the only sites identified for lighting upgrades due to the number of fixtures and the appropriate authority to renovate. Removing the T8 fixtures and replacing them with T5 fixtures and F28T5 lamps was identified as a possible energy conservation measure. The following generally outlines how each of these upgrades would be completed, along with the calculated savings.

A. Install Electronic Ballast T5 Fixtures and Lamps
   - Remove existing T8 fixtures as required to facilitate installation of T5 fixtures.
   - Provide replacement T5 GE LIGHTING fixtures for all T8 parabolic fixtures.
     - Number of Fixtures- **65**
   - Provide F28T5 lamps for upgraded fixtures.
     - Number of lamps- **65**

Table 9: Estimated energy consumption post ECM 1 implementation of a F28T5 lamps.

Baseline		Post ECM 1 Implementation		ECM 1 Implementation Cost	Savings		Simple Payback
Electricity Use (kWh/yr)	Electricity Use ($/yr)	Electricity Use (kWh/yr)	Electricity Cost ($/yr)	F28 T5 Equipment and Installation [$]	Electricity Use (kWh/yr)	Electricity Cost ($/yr)	Initial Cost/ Energy Savings [yrs]
18,171	$ 1,381	15,900	$ 1,208	$ 9,073	2,271	$173	53

High Efficiency Heating Hot Water Boiler Upgrade

The existing heating hot water boilers can be replaced with high efficiency condensing boilers. Condensing boilers use a secondary heat exchanger to recover energy normally exhausted through the flue in a conventional (non-condensing) boiler. As heat is transferred from the flue gas to the returning hot water, through a secondary heat exchanger, the water vapor in the flue gas condenses. Because the flue gas from a condensing boiler is at a lower temperature than the flue gas from a conventional boiler, stainless steel flues must be used to prevent corrosion from occurring. A powered fan is required to ensure the gas is exhausted. The figure below displays the concept schematically.

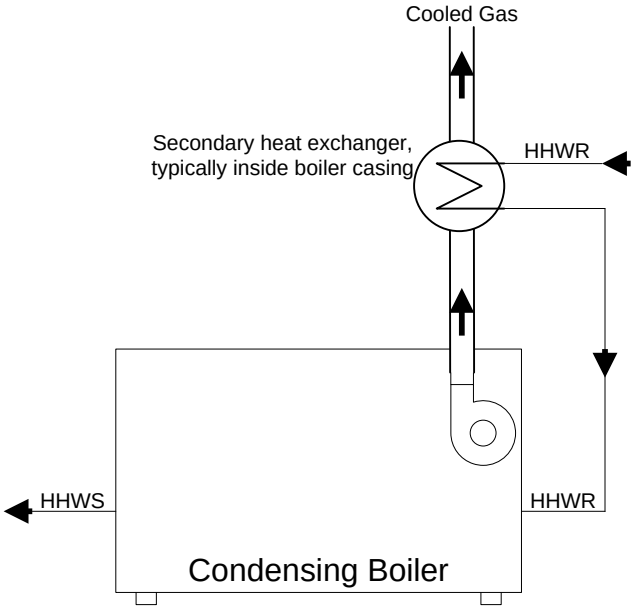

Figure 20: Schematic of a high efficiency condensing boiler.

Like the existing boilers, condensing boilers can be installed in a modular arrangement to optimize run-time and efficiency. The proposed boilers will be fired by natural gas, which is piped to the boiler rooms for the existing boilers. Condensing boilers operate at higher efficiencies at lower return water temperatures, thus the return water temperature should be optimized.

Scope of Work - Install High Efficiency HVAC Equipment

- Install higher efficiency heating hot water condensing boilers
    - Remove existing heating hot water boilers located in the boiler room and remove piping as necessary to facilitate installation of new equipment. Recycle all equipment in accordance with all federal, state, and local laws.
    - Provide two new Aerco BMK 3.0 Low NOx (model # BMK 3.0 LN) high efficiency condensing boilers at 2,610 – 2,883 MBH output.
    - Provide piping and other appurtenances as required to reconnect existing piping to new unit.
    - Provide control wiring as necessary to connect the boiler to the building automation system.

Table 10: Estimated energy consumption post ECM 2 implementation of a higher efficiency HHW boiler.

Baseline		Post ECM 2 Implementation		ECM 2 Implementation Cost	Savings		Simple Payback
Natural Gas Use [MMbtu/yr]	Natural Gas Use [$/yr]	Natural Gas Use [MMBtu/yr]	Natural Gas Use [$/yr]	Aerco BMK Boilers Equipment and Installation [$]	Natural Gas Use [MMBtu/yr]	Natural Gas Use [$/yr]	Initial Cost/ Energy Savings [yrs]
5,194	$ 52,459	4,715	$47,617	$ 133,826	479	$4,842	28

ECM 3: Install Higher Efficiency Domestic Hot Water Boiler

High Efficiency Domestic Hot Water Boiler Upgrade

The existing domestic hot water boilers can also be replaced with high efficiency condensing boilers. For more information regarding high efficiency condensing boilers, reference ECM 9 – under the section titled “High Efficiency Heating Hot Water Boiler Upgrade.”

Scope of Work - Install Higher Efficiency HVAC Equipment

- Install higher efficiency heating hot water condensing boilers
    - Remove existing heating hot water boilers located in the boiler room and remove piping as necessary to facilitate installation of new equipment. Recycle all equipment in accordance with all federal, state, and local laws.
    - Provide two new Raypack, Inc HI Delta Series (Model# H4902B-CHX) high efficiency condensing boilers at 882 MBH output.
    - Provide piping and other appurtenances as required to reconnect existing piping to new unit.

Table 11. Estimated energy consumption post ECM 3 implementation.

Baseline		Post ECM 3 Implementation		ECM 3 Implementation Cost	Savings		Simple Payback
Natural Gas Use [MMbtu/yr]	Natural Gas Use [$/yr]	Natural Gas Use [MMBtu/yr]	Natural Gas Use [$/yr]	Raypak, INC HI Delta Series Boilers Equipment and Installation [$]	Natural Gas Use [MMBtu/yr]	Natural Gas Use [$/yr]	Initial Cost/ Energy Savings [yrs]
2,400	$ 24,240	2,033	$ 20,529	$ 74,550	367	$3,711	20

ECM 4: Install Hot Water Piping Insulation

Added Piping Insulation

Lack of insulation results in increased heat loss to the surroundings (for steam and hot water pipes) or heat gain from the surroundings (for chilled water pipes), effectively increasing system loads on central equipment (boilers and chillers). In addition to energy loss, un-insulated pipes can also cause several other problems. Water can condense on chilled water pipes and drip, causing damage to floors and walls. Standing water from dripping can also lead to the growth of mold and mildew, or slippery conditions to passersby. Also, if the condensation persists for long periods of time, corrosion can shorten the useful life of the pipe. In addition, heat losses from un-insulated steam or hot water pipes can result in excessive heat build-up in conditioned spaces. By insulating piping each of these problems is prevented, and utility costs will decrease as a result.

During the site assessment, a total of 60 feet of un-insulated heated hot water piping was found. The un-insulated piping is located in the garage as well as the boiler room. Within the garage, approximately 40 feet of heating hot water piping being delivered to the heating fan coil units was un-insulated. Within the boiler room, approximately 20 feet of the piping from the domestic hot water heat exchanger to the hot water tank was un-insulated.

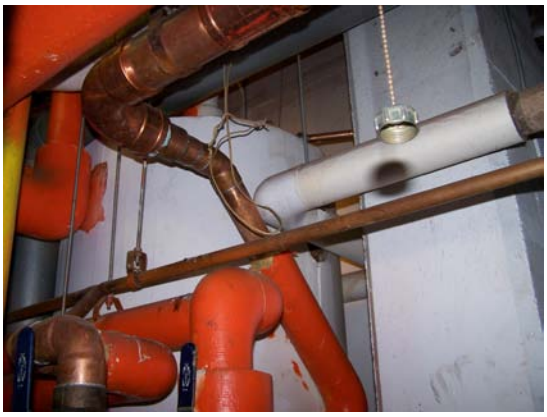

Figure 21a: Boiler room un-insulated piping.

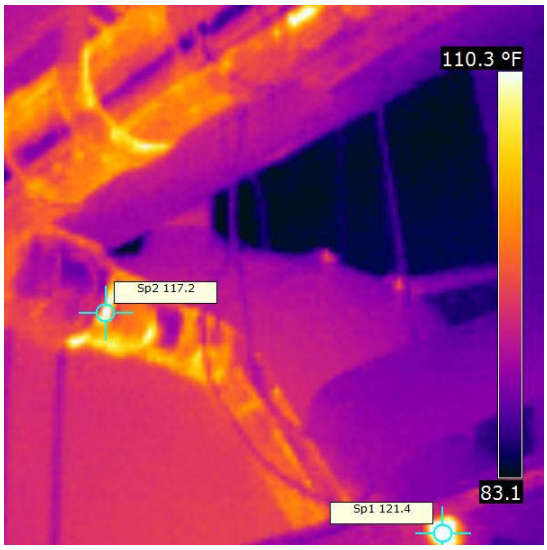

Figure 21b: Thermal Image of un-insulated piping

Figure 22: Un-insulated HHW Pipe entering parking level FCU.

Scope of Work – Added Piping Insulation

- Locate and identify un-insulated piping
  - Prepare exposed piping by cleaning any debris that has developed over time.
  - Trim old insulation flush to run perpendicular with piping.
  - Install 2" wall insulation to the exposed piping.
  - Seal/repair any gaps, holes and rips.
  - Discard any excess insulation or cuttings properly.

Table 12: Estimated energy consumption post ECM 4 implementation added piping insulation.

Baseline		Post ECM 4 Implementation		ECM 4 Implementation Cost	Savings		Simple Payback
Natural Gas Use [MMbtu/yr]	Natural Gas Use [$/yr]	Natural Gas Use [MMBtu/yr]	Natural Gas Use [$/yr]	Added 2" Wall Insulation Equipment and Installation [$]	Natural Gas Use [MMBtu/yr]	Natural Gas Use [$/yr]	Initial Cost/ Energy Savings [yrs]
75,457	$ 76,211	74,533	$ 75,278	$ 1,900	924	$933	2

ECM 5: CO Controls for Garage Exhaust

Underground parking garages are ventilated by dedicated exhaust fans with either heating ventilation (HVs) units or outside air louvers supplying make-up air. The temperature is maintained to a temperature between 45°F and 50°F by hot water unit heaters. The Port Royal building has parking garages underground and ventilation is required to remove harmful emissions created by operating automobiles in an enclosed space. The most serious emission is Carbon Monoxide (CO). The amount of ventilation required to dilute CO to acceptable levels is satisfactory to control the level of other contaminants as well as defined in ASHRAE Applications 2003, Section 13.9. The code requirement for ventilation had long been 1.5 cfm/ft^2, but the standard has been changed to 1.0 cfm/ft^2 per NFPA 88A.

ASHRAE recommends adjusting the exhaust and supply air flows as a function of CO level. However, the existing exhaust fans are set to run continuously. This provides excess ventilation and requires unnecessary conditioning to the garage at times when there is no vehicular activity. CO sensors

integrated with variable flow controls will reduce the garage heating load energy use as well as fan energy use. Sensors would be installed throughout the garages to ensure that complete coverage is achieved. These sensors would be connected and relayed back to the variable flow fan controls. The CO limit threshold recommended by ACGIH (1998) is 25 parts per million (ppm) for an eight hour exposure. With the installation of CO sensors, an automatic control is proposed to regulate fan operation. Automatic controls will be added to the exhaust fans and interlock the makeup air units. These units will be automatic which will eliminate the need for manual control.

Savings Analysis

A vehicular traffic profile was created for a typical day for the parking garages. The hours in which automobiles were not active were classified as unoccupied. Energy savings were calculated from the ventilation airflow specified on received floor plan drawings, supply fans, and pre-heat coils. The table below shows the basis for analysis used to calculate the period in which the garage is inactive.

Calculation Methodology for Time Garage Inactive

The following hour blocks were used for when vehicles will be entering/exiting the garage:
5:30am - 9:30am
11:30am - 1:30pm
3:30pm - 6:30pm

The equation below was used to calculate time garage inactive

$Time_{inactive}$=[11:30am - (9:30am + x)] + [3:30pm - (1:30pm + x)] + [5:30am - (6:30pm + x)]

where x is equal to the amount of time it takes for all the air in the garage to be exhausted out (in hours)

Figure 23: Calculation Methodology for Time Garage Inactive.

The fan savings are calculated by taking the difference between the existing energy use and the proposed energy use. The proposed energy use assumes that the fan motors are not in use while the garage is unoccupied with running vehicles. The thermal savings are calculated an hourly basis, using TMY2 data. The heated hot water energy used to heat the outside air to a set point of 45 °F (for freeze protection) is calculated using the total exhausted CFM and difference between the outside temperature and 45°F setpoint. The following heating load and relative savings are shown in the table below.

Table 13: Estimated heating natural gas savings post ECM 5 implementation.

Baseline		Post ECM 5 Implementation		ECM 5 Implementation Cost	Savings		Simple Payback
Garage Heating Load Natural Gas Use (Therms/yr)	Garage Heating Load Natural Gas Use ($/yr)	Garage Heating Load Natural Gas Use (Therms/yr)	Garage Heating Load Natural Gas Use ($/yr)	8 CO Sensors + Fan Controls Equipment and Installation [$]	Garage Heating Load Natural Gas Use (Therms/yr)	Garage Heating Load Natural Gas Use ($/yr)	Initial Cost/ Energy Savings [yrs]
8,354	$ 8,438	2,785	$ 2,813	$ 24,393	5,569	$ 5,625	3

Table 14: Estimated heating electricity savings post ECM 5 implementation.

Baseline		Post ECM 5 Implementation		ECM 5 Implementation Cost	Savings		Simple Payback
Garage Heating Load Electric Fan Use (kWh/yr)	Garage Heating Load Electric Fan Use ($/yr)	Garage Heating Load Electric Fan Use (kWh/yr)	Garage Heating Load Electric Fan Use ($/yr)	8 CO Sensors + Fan Controls Equipment and Installation [$]	Garage Heating Load Electric Fan Use (kWh/yr)	Garage Heating Load Electric Fan Use ($/yr)	Initial Cost/ Energy Savings [yrs]
34,290	$ 2,427	11,430	$ 809	$ 24,393	22,860	$ 1,618	3

6. Energy Conservation Suggestions for Condo Owners

The following table outlines the ECMs pursued for this building for condo owners, including the estimated annual energy savings, energy cost savings, implementation costs and simple payback period of each measure. Following the table is a brief description and data for each ECM.

Table 15: Summary of Energy Conservation Measures Analyzed for Condo Owners.

	Project Description	Annual Energy Savings				Total Project Cost	Simple Payback (Yrs)
		Electrical (kWh)	Natural Gas (MMBtu)	Water (kgal)	Total Savings ($)		
6	ECM 6 - Water Conserving Fixtures	-	1,376	-	$ 13,899	$ 96,974	7
7	ECM 7 - Added Wall Insulation	9,857	1,079	-	$ 11,643	$ 266,684	23

ECM 6: Water Conservation Measures

Provide Low Flow Toilets (including dual-flush toilets)

Many older toilets consume 3.5 gallons per flush (GPF) or more. Currently manufactured toilets use between 0.8 and 1.6 GPF, many with similar or superior flushing capabilities as compared to the older, higher volume models. Significant water and sewer savings will be achieved by installing new low-flow toilets throughout all facilities.

Dual flush toilets have flush valves capable of either a low- or high-volume flush. This allows users to flush the toilet with the appropriate amount of water in order to achieve successful flushing. For many models, the high volume flush is 1.6 GPF, while the low volume flush is 0.8 to 1.1 GPF.

Provide Low Flow Aerators and Shower Heads

Aerators and shower heads are installed to restrict water flow and form a particular spray pattern. In response to government mandated minimum flow rates as well as market desire for more efficient use of potable water, manufactures have developed new products that provide a similar user experience while consuming less water. Aerators for public lavatories are now available, and recommended, with flow rates of 0.5 gallons per minute. For break room and kitchen sinks, flow rates are recommended to be 1.0 to 1.5 gallons per minute. Shower heads are now available in models with flow rates of 1.5 gallons per minute that have little to no impact on user satisfaction.

Provide Low Flow Urinals

Manufacturers have been working to produce fixtures and flush valves that reliable flush with as little water as one pint. A majority of urinals installed in the past ten years consume between 1.5 and 1.0 gallons per flush. Significant water savings are achievable by replacing the flush valves with low flow models.

Scope of Work - Install Water Conserving Fixtures

- Low Flow Toilets
  - Remove all existing toilet fixtures.
  - Provide a new china water closet, AquaSource White High Efficiency Round 1.28 gallon-per-flush Toilets.
  - Provide wax rings and necessary appurtenances to complete installation.
  - Reconnect sanitary and domestic cold water piping as required.
- Low-flow urinals
  - Remove existing urinal fixtures.
  - Provide 2 new china urinals with 0.5 gallon-per-flush flush valves in the first floor bathroom.
  - Provide any necessary appurtenances to complete installation.
  - Reconnect sanitary and domestic cold water piping as required.
- Install Water Flow Restrictors On Shower Heads And Faucets
  - Install 0.5 gpm low-flow aerators on faucets in restrooms.
  - Install 1.5 gpm low-flow aerators on faucets in kitchen sinks
  - Install 1.5 gpm low-flow shower heads in restrooms.

Table 16a. Estimated savings for Efficiency and One Bedroom units post ECM 6 implementation.

Baseline		Post ECM 6		Savings		
Water Use [kgal/yr]	DHW Energy Use [therms/yr]	Water Use [kgal/yr]	DHW Energy Use [therms/yr]	Water Use [kgal/yr]	DHW Energy Use [therms/yr]	Water and NG Savings [$/yr]
16	115	7	49	10	66	$ 67

Table 16b. Estimated savings for Two Bedroom units post ECM 6 implementation.

Baseline		Post ECM 6		Savings		
Water Use [kgal/yr]	DHW Energy Use [therms/yr]	Water Use [kgal/yr]	DHW Energy Use [therms/yr]	Water Use [kgal/yr]	DHW Energy Use [therms/yr]	Water and NG Savings [$/yr]
27	190	12	96	15	94	$ 95

ECM 7: Added Wall Cavity Insulation

It was mentioned during the site assessment that there was no cavity insulation between the common wall steel frame studs. Building envelope heat loss and heat gain analysis of various wall envelope construction types and materials was carried out in order to estimate potential energy savings from added envelope insulation. The table below shows two walls with no continuous rigid insulation and differing wall cavity insulations (Wall 1 and Wall 2). The table also shows two wall types with added continuous rigid insulation and differing wall cavity insulation (Wall 3 and Wall 4). Because as-built wall section drawings were not provided, this analysis was conducted using two “baseline” existing wall constructions. Wall 1 and Wall 3 serve as two different “baseline” existing walls to show potential energy savings through the addition of cavity insulation.

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Table 17: Two different "baseline" wall types and resulting R-Value from added cavity insulation

Wall Types	Wall 1 : No Cavity Insulation	Wall 2 : Added Cavity Insulation	Wall 3 : No Cavity and Added Continous	Wall 4: Added Cavity and Continous
Materials	**Baseline A**	**Added Insulation**	**Baseline B**	**Added Insulation**
	Exterior Air Film	Exterior Air Film	Exterior Air Film	Exterior Air Film
	4" brick	4" brick	4" brick	4" brick
	2" Air gap	2" Air gap	Continuous Insulation	Continuous Insulation
	8" CMU	8" CMU	8" CMU	8" CMU
	18 Gauge Steel Stud Framing	18 Gauge Steel Stud Framing with Cavity Insulation R-13	18 Gauge Steel Stud Framing	18 Gauge Steel Stud Framing with Cavity Insulation R-13
	5/8" Gypsum	5/8" Gypsum	5/8" Gypsum	5/8" Gypsum
	Interior Air Film	Interior Air Film	Interior Air Film	Interior Air Film
Total R-Value	5.06	10.12	9.15	14.21

Properly insulated exterior walls allow for heat produced during the colder winter months to be retained within the building envelope for longer periods. Properly insulated exterior walls also help to prevent heat transfer from outside to inside during the summer cooling months. There are many different types of insulation one can utilize when designing a home, unfortunately, the majority of insulating occurs during the initial construction of the building making it difficult to renovate exterior wall insulations.

When adding insulation to an existing wall it is important to determine the wall type as well as any other present insulation. Knowing these materials can help qualified energy auditors determine how much insulation is necessary to create the optimal cost/savings ratio. By adding insulating, the overall *R-value* of the wall is increased. The total R-value of a wall indicates the wall's resistance to heat flow; the higher the R-value, the greater the insulating effectiveness.

The two most common ways of adding insulation to an existing wall are primarily *loose-fill* and *spray foam* insulation. There are three different types of Loose-fill insulation; Cellulose, Fiberglass and Rockwool. There are also four main types of liquid spray foam insulation; Cementitious, Phenolic, Polyisocyanurate and Polyurethane. Loose-fill insulations are fill spaces with small particles whereas spray foam is a liquid that fills through expansion. The most cost effective measure for adding insulation to Port Royal Condominium's existing walls was determined to be Cellulose.

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Table 18: Estimates heating energy cost and potential savings

Baseline			Post ECM 7a Implementation		Savings	
Wall Type Comparison	Natural Gas Use [MMbtu/yr]	Natural Gas Use [$/yr]	Natural Gas Use [MMBtu/yr]	Natural Gas Use [$/yr]	Natural Gas Use [MMBtu/yr]	Natural Gas Use [$/yr]
1 - 2	2,157	$ 21,787	1,079	$ 10,894	1,079	$10,894
3 - 4	1,193	$ 12,049	768	$ 7,758	425	$4,290

Table 19: Estimates cooling energy cost and potential savings

Baseline			Post ECM 7b Implementation		Savings	
Wall Type Comparison	Electricity Use [kWh/yr]	Electricity Use [$/yr]	Electricity Use [kWh/yr]	Electricity Use [$/yr]	Electricity Use [kWh/yr]	Electricity Use [$/yr]
1 - 2	19,715	$ 1,498	9,858	$ 749	9,857	$749
3 - 4	10,903	$ 829	7,020	$ 534	3,882	$295

Unfortunately, mandating all exterior wall insulation throughout the building may be a difficult endeavor and would have to be initiated by willing condominium owners. A conservative cost/savings estimate for this project by unit type is provided in the table below. More information regarding the cost/savings analysis can be found in Appendix B.

Table 20: Provides estimated costs and savings of adding wall insulation per unit type.

Unit Type*	Exterior Walls Cost Savings Percentage	Cost Per Unit [$]	Annual Savings Range Per Unit Type [$]		Unit Type Simple Payback Range [yrs]	
			Low Estimate	High Estimate	Low Estimate	High Estimate
A	19%	$ 2,303	$ 39	$ 99	59	23
B	22%	$ 889	$ 15	$ 38	59	23
C	15%	$ 1,818	$ 31	$ 78	59	23
D	14%	$ 1,867	$ 32	$ 80	59	23
E	30%	$ 889	$ 15	$ 38	59	23

*See "Floor Plan Zoning" section of 4. Metered Utility Suggestions

The “Low Estimate” and “High Estimate” columns describe the range of potential savings and payback based on the current “baseline” wall construction. The “Low Estimate,” or more conservative estimate, assumes savings are calculated per unit using Wall 3 (existing wall has two inches of rigid insulation in place) as a baseline for comparison. The “High Estimate” assumes savings are calculated per unit using Wall 1 (existing wall has no insulation in place) as a baseline for comparison.

Replace Pilot Light Stoves with Electric Ignition Stoves

A pilot light is a small flame kept constantly burning to serve as an ignition source for a gas burner. When operating a natural gas appliance, a valve is used to increase gas flow to be burned thus increasing heat production. Occasionally, pilot lights may be accidentally extinguished posing a potential fire hazard/safety concern due to the continuous flow of potent natural gas. Modern pilot lights should be equipped with safety sensors to restrict gas flow when no pilot light flame is detected. In recent years, pilot lights have been identified as potential medium for energy reduction and utility savings. Pilot

lights are not needed for the majority of the time they are lit and, as a result, waste natural gas or at a constant rate. Pacific Gas and Electric has estimated that pilot lights use up to 0.09 therms per hour and according to Cornell Environmental Health and Safety account for 20% of United States' natural gas use.

The estimated annual pilot light natural gas use for Port Royal is 1,578 therms per year. By replacing each pilot light stove with electric ignition stoves each unit may be able to save 76 therms per year of cooking natural gas. This savings is equivalent to $76 per year. This energy conservation measure is not included in the overall energy conservation table due to the high simple payback period.

7. Recommendations

The estimated annual electricity, natural gas, and water usage for this facility is 1,642,600-kWh, 75,940-therms, and 6,345-kgal respectively. If the recommended energy conservation projects were to be implemented at this facility, an estimated energy savings of **22,860-kWh** of electricity, **2,360-therms** of natural gas, and water savings of **2,053 kgal** could be achieved. This results in a **1.4%** reduction in electricity, **3.1%** reduction natural gas, and **34.8%** reduction in potable water. Given the current utility rates, the estimated cost savings is **$22,065** excluding rate escalation.

The proposed construction cost for this packaged project is $123,267 with a combined simple payback of 6 years, exclusive of capital cost savings from existing equipment replacement. For more detailed engineering and economic analysis of these energy conservation measures refer to the body of the report and corresponding ECM appendices.

The replacement of the current domestic hot water boilers with high efficiency condensing boilers is recommended only after a non-interrupt natural gas service is established. The high efficiency Raypack, Inc HI Delta Series (Model# H4902B-CHX) condensing boilers condensing boilers do not have dual fuel capabilities and a non interrupt service would be necessary for continuous operation.

The following table outlines the recommended ECMs for Port Royal Condominiums, the resulting energy savings, estimated cost, and simple payback.

Table 21: Summary of Recommended Energy Conservation Measures.

	Project Description	Annual Energy Savings				Total Project Cost	Simple Payback (Yrs)
		Electrical (kWh)	Natural Gas (MMBtu)	Water (kgal)	Total Savings ($)		
1	ECM 4 - Added Piping Insulation	-	92	-	$ 924	$ 1,900	2
2	ECM 5 - Garage CO Controls	22,860	892	-	$ 7,243	$ 24,393	3
3	ECM 6 - Water Conserving Fixtures*	-	1,376	2,170	$ 13,899	$ 96,974	7

*Water fixture savings shown for entire building.

Appendix A –Metered Heating

Table A1: Esim simulated heating natural gas use per unit type using TMY2 data.

Floor Plan Type	Natural Gas Use (therms/yr)	Average Heating Natural Gas Cost ($/yr)
A	277	$ 280
B	129	$ 130
C	105	$ 106
D	97	$ 97
E	56	$ 57
Top - A	373	$ 377
Top - B	213	$ 215
Top - C	169	$ 171

Table A2: Esim simulated total building heating natural gas use per unit type using TMY2 data.

Floor Plan Type	Number of Units per Floor	Number of Floors Unit Type Serves	Total Unit Type NG Consumption* (therms)
A	2	10	7,242
B	6	10	10,094
C	2	10	2,741
D	4	5	2,523
E	18	5	6,642
Top - A	2	1	975
Top - B	6	1	1,668
Top - C	2	1	442
First Floor	-	-	3,781.10
Parking Decks	-	-	6,631.56
Total Building :			**42,739**
*Consumption Assuming Boiler Efficiency of 0.85			
Current Heating Load Estimated From Utility Data (therms)			**52,961**
Current Cooling Load Estimated from Utility Data (kWh)			
Potential NG Savings			**10,222**

Table A3: Esim simulated cooling electriciy use per unit type.

Floor Plan Type	Electric Air Conditioner/heatpump (kWh/yr)	Electric Air Conditioner/heatpump ($/kWh)
A	2,398	$ 170
B	1,762	$ 125
C	2,388	$ 169
D	1,333	$ 94
E	1,969	$ 139
Top - A	3,292	$ 233
Top - B	1,628	$ 115
Top - C	2,968	$ 210

Table A4: Esim simulated total building cooling electricity use per unit type.

Floor Plan Type	Number of Units per Floor	Number of Floors Unit Type Serves	Total Unit Type Cooling Load Electric Consumption (kWh)
A	2	10	40,774
B	6	10	89,859
C	2	10	40,595
D	4	5	22,659
E	18	5	150,662
Top - A	2	1	5,596
Top - B	6	1	8,304
Top - C	2	1	5,046
First Floor	-	-	3,357
Parking Decks	-	-	1,074
Total Building :			**367,927**
Current Cooling Load Estimated from Utility Data (kWh)			**363,400**

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Appendix B - Added Wall Insulation

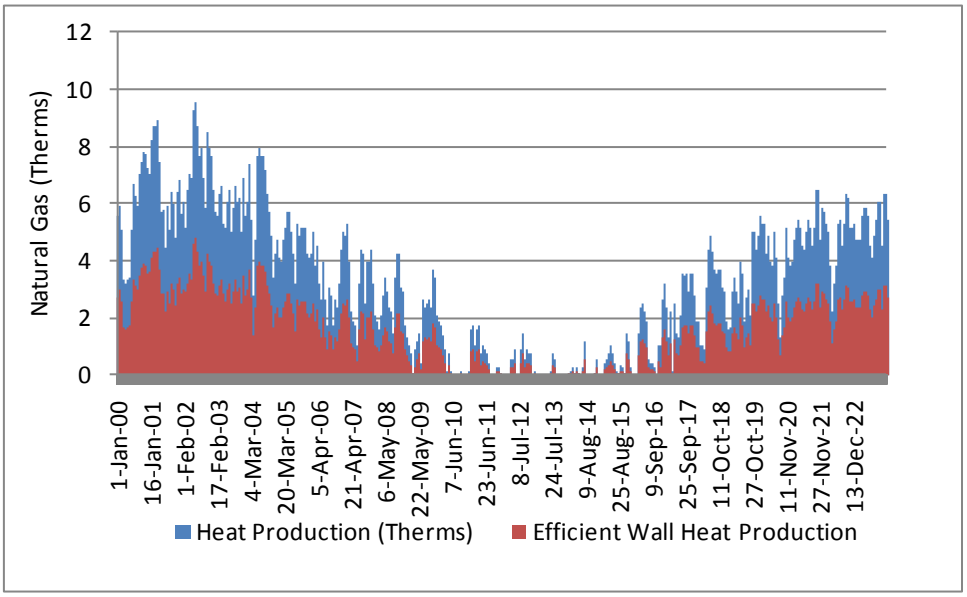

Figure B1: Heating Savings Comparing "baseline" Wall 1 with Wall 2 (added cavity insulation).

Table B1: Shows the proposed annual natural gas savings by comparing Wall 1 and Wall 2.

Evaluation Criteria	Old Wall	New Wall
Annual Heating Natural Gas Consumption (therms)	21,571.68	10,785.84
Annual Natural Gas Cost	21,571.68	10,785.84
Annual Savings	10,786	
Percent Reduction in Natural Gas Use and Heat Loss	**50%**	

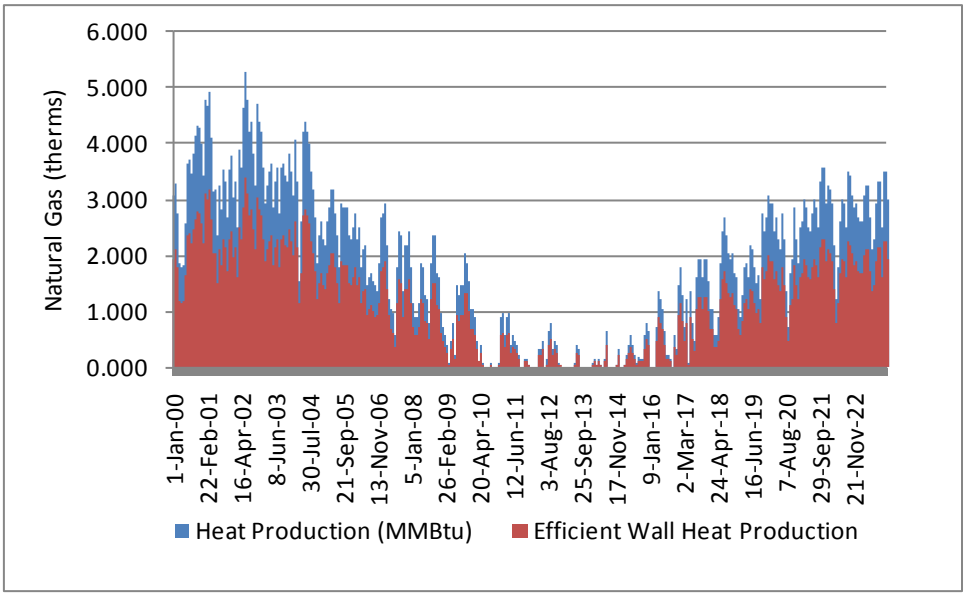

Figure B2: Heating Savings Comparing "baseline" Wall 3 with Wall 4 (added cavity insulation).

Table B2: Shows the proposed annual natural gas savings by comparing Wall 3 and Wall 4.

Evaluation Criteria	Old Wall	New Wall
Annual Heating Natural Gas Consumption (therm)	11,929.26	7,681.40
Annual Natural Gas Cost	11,929.26	7,681.40
Annual Savings	4,248	
Percent Reduction in Heat Loss and Gas Use	**36%**	

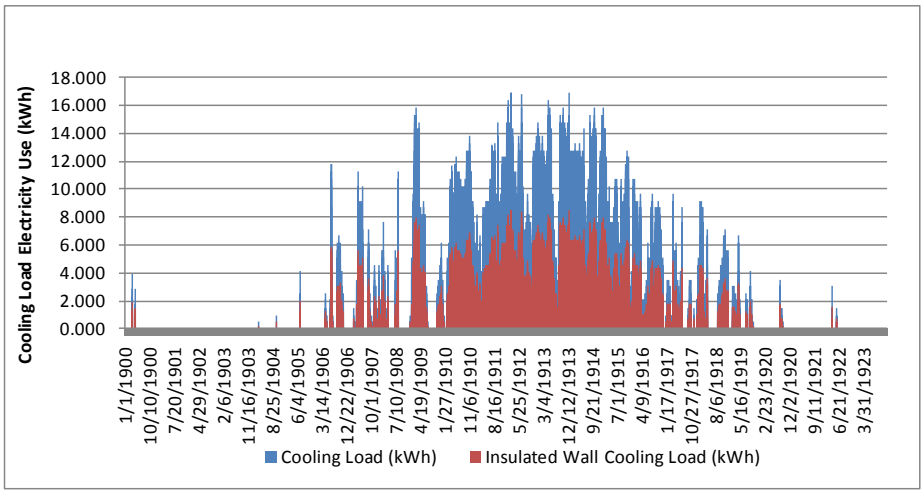

Figure 3: Cooling Savings comparing "baseline" Wall 1 and Wall 2 (added cavity insulation).

TableB 3: Shows the proposed annual electric savings by comparing "baseline" Wall 1 with Wall 2 (added cavity insulation).

Evaluation Criteria	Old Wall	New Wall
Annual Cooling (kWh)	19,715.33	9,857.66
Annual Electric Cost	1,380.07	690.04
Annual Savings	690	
Percent Reduction in Heat Gain	**50%**	

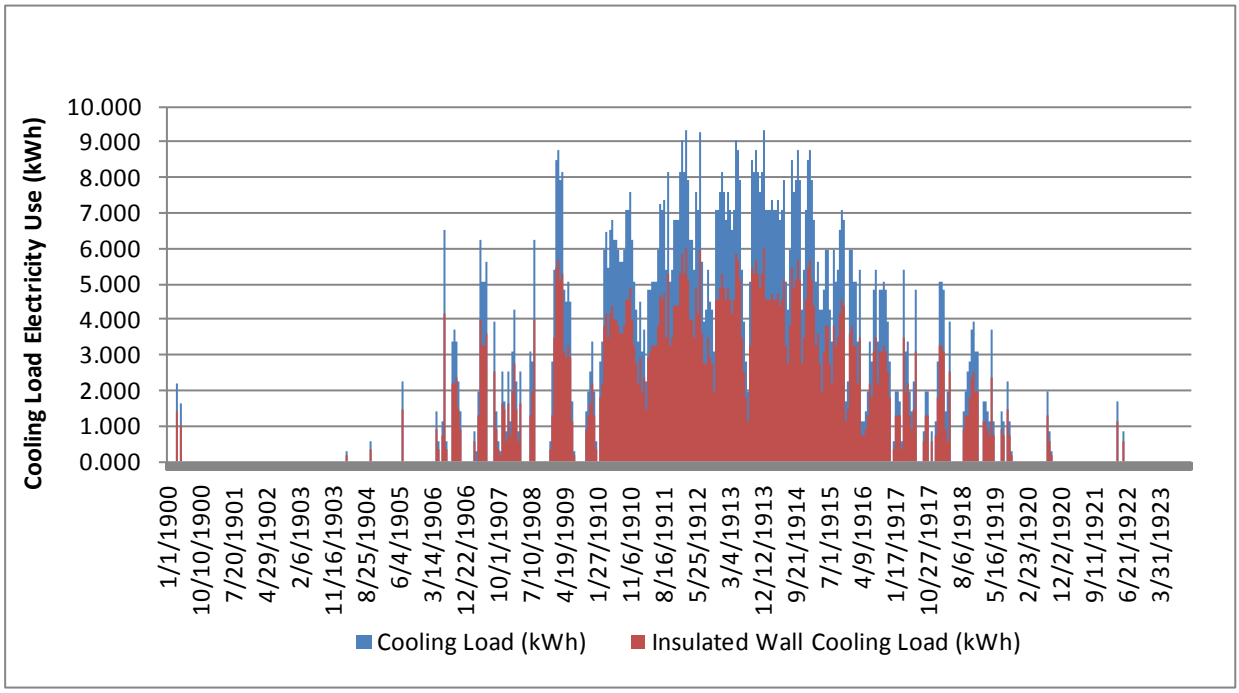

Figure 4: Cooling Savings comparing Wall 3 and Wall 4.

Table B4: Shows the proposed annual electric savings by comparing "baseline" Wall 3 with Wall 4 (added cavity insulation).

	Old Wall	New Wall
Annual Cooling (kWh)	10,902.68	7,020.38
Annual Electric Cost	763.19	491.43
Annual Savings	272	
Percent Reduction in Heat Gain	**36%**	