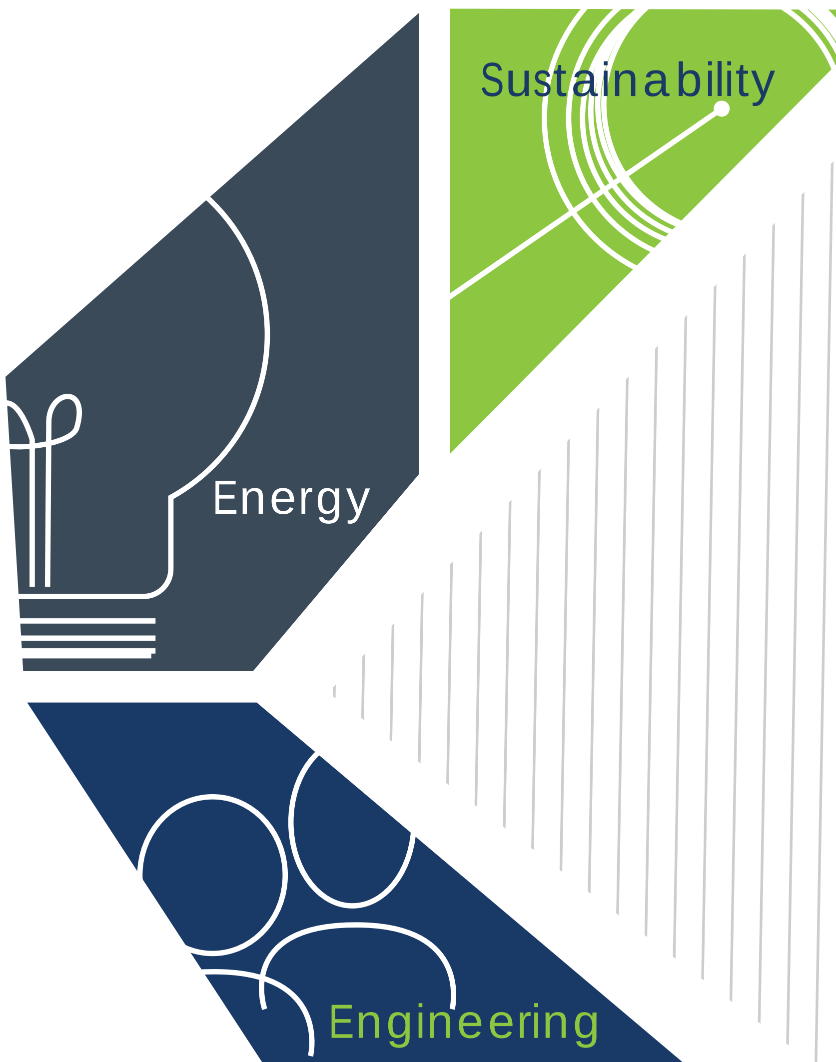
St. Lawrence University

Energy Master Plan

June 2018



wendel

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introduction

St Lawrence University (SLU) has made energy planning and investment a priority and is challenged with meeting the current energy needs of the campus while also reducing energy and greenhouse gas (GHG) emissions for the long term sustainability of the University. The University has a goal of net zero emissions by the year 2040, but faces unique challenges specific to the existing buildings and infrastructure that require careful considerations and planning. This master plan establishes a road map for the strategic development of St Lawrence University's central plant and utility assets.

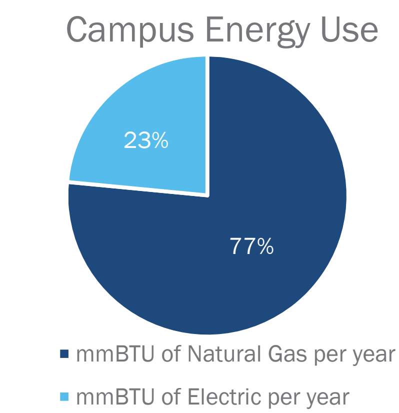
This plan takes into consideration the current energy infrastructure, energy consumption and projected growth model in order to set goals and initiatives for the University to achieve. The University has already taken some action towards reducing and tracking their energy consumption through the replacement of buried tunnel steam lines and installation of electric sub meters. The University is also investing in renewable energy production and has recently entered into an agreement to purchase hydroelectric power through a Purchase Power Agreement (PPA) from Kings Falls Hydro Facility in Lewis County, NY along with a solar project that is due to come online in late 2018. The development of this master plan is only the first step in the planning process. In order to achieve the goals and initiatives outlined in this report, the University must continually complete ongoing condition assessments, engage with stakeholders, reflect on strategic planning documents and report on the measurable impacts of the plan.

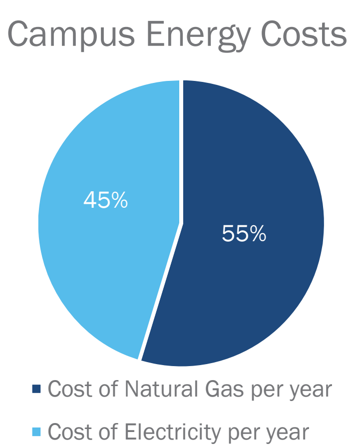
Wendel has developed this Energy Master Plan in conjunction with various stakeholders at the University. The first step in this process was an analysis of the energy used by the buildings on campus over the past 5 years. This facilitated in establishing a baseline of current usage and projecting usage out to the year 2040. Wendel then met with various sustainability and financial planning groups at the University to provide feedback and prioritize the competing goals and objectives outlined in the original RFP. Based on this input, the following goals and initiatives were identified:

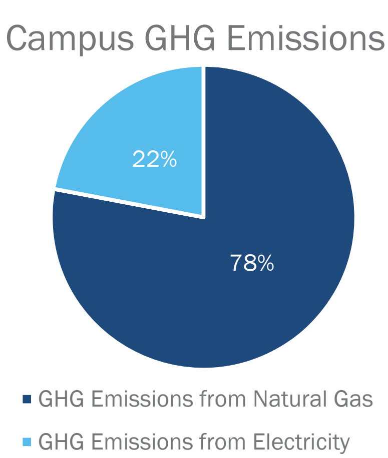
1. Provide Central Heating Plant Redundancy
2. Increase in Energy Efficiency
3. Reduce Green House Gas (GHG) Emissions
4. Manage Cost/Benefit
5. Account for Future Capital Costs
6. Account for Growth Plans

Long Term Goal – Carbon Neutrality by 2040

Campus and Energy Overview







St Lawrence University consists of a wide variety of buildings of different vintages, sizes and use types serving over 2,500 students. This includes buildings used for academic, administration, residential, athletic and other purposes. For energy planning purposes, this report considers 69 buildings totaling 1,824,226 square feet. A summary of the buildings and associated energy account type is included and appended to the end of this report. The buildings consume a cumulative annual average of approximately 15,729,914 kWh per year of electricity and 173,524 mmBTU per year of natural gas for a total equivalent use of 227,195 mmBTU per year. These amounts are based on the non-normalized utility information provided by St Lawrence University averaged over 5 years. This amount of energy usage equates to GHG emissions of 11,665 MT CO_2e per year.

The adjacent charts depict St Lawrence University's energy consumption by fuel source type and costs. It is important to note that while electricity accounts for just under one quarter of the energy used, it is closer to half of the energy costs for the University. Vice versa, the natural gas usage for the campus is approximately three quarters of the energy usage, but accounts for just over half of the energy costs.

GHG emissions for natural gas and electricity are roughly proportional to their usage, as shown below. It should be noted that New York State has a relatively low GHG emissions electricity production grid at 295.9 lbs CO_2e / MWh compared to the USA national average of 1130.2 lbs CO_2e / MWh (based on eGRID 2016).

business as usual

Background

Five years of fuel and electrical utility data has been received from St Lawrence University for analysis along with existing building square footage and the Facilities Master Plan (FMP) dated August 2015. Using the historical energy use data, an energy consumption trend was established to predict the future baseline building energy usage through to the year 2040. New building construction and renovations were then extracted from the FMP and applied to the baseline projection in order to establish a "Business As Usual" energy projection case.

Five Year Trend

Fuel and electrical utility data from August 2012 to July 2017 was analyzed in order to project baseline energy usage through to the year 2040. Since Kirk Douglas Hall was added to the building portfolio in 2014/2015, an estimated annual electrical and fuel usage was subtracted from this baseline in order to provide an accurate trend for the projection. All buildings located on campus, approximately 1.8M square feet of area, have been taken into consideration for the purpose of this analysis.

Fuel usage has been normalized based on Heating Degree Day (HDD) data in order to correlate the energy usage with local weather patterns. Prior to this normalization, it appeared that the fuel usage was on a decline, however, it can be seen that the decrease in usage in the two most recent years were due to the substantially lower HDDs as shown below. After normalizing the fuel usage for the campus, it is evident that there is a slight annual increase trend in fuel consumption (see Figure 1). The electrical usage trend also shows an increase in annual electricity consumption (See Figure 2).

Year	Electrical Usage (kWh)	Fuel Usage (mmBtu)	HDD	Normalized Fuel Usage (mmBtu)
2012 - 2013	15,298,298	168,595	7638	178,550
2013 - 2014	14,933,751	188,754	8649	176,532
2014 - 2015	15,350,124	181,063	8427	173,801
2015 - 2016	16,149,735	164,991	7192	185,569
2016 - 2017	15,670,254	157,059	7142	177,884

Note: Heating Degree Days shown for Massena, NY. Normal HDD is 8089 per year.

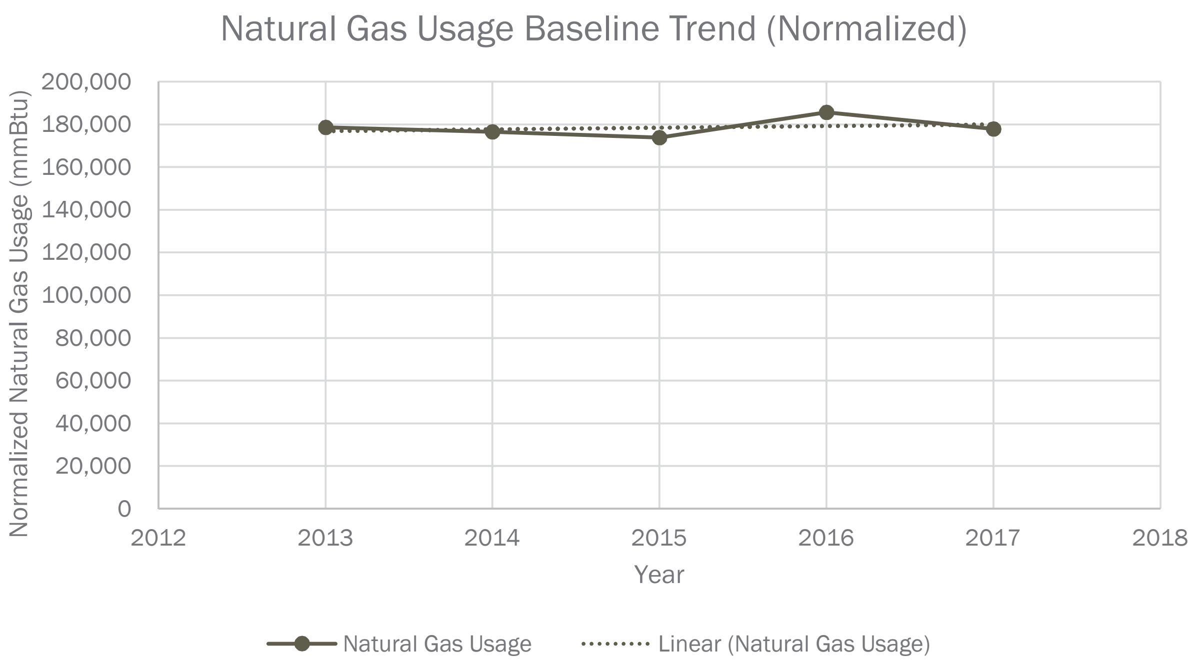


Figure 1 – Natural Gas Usage Trend from past 5 years

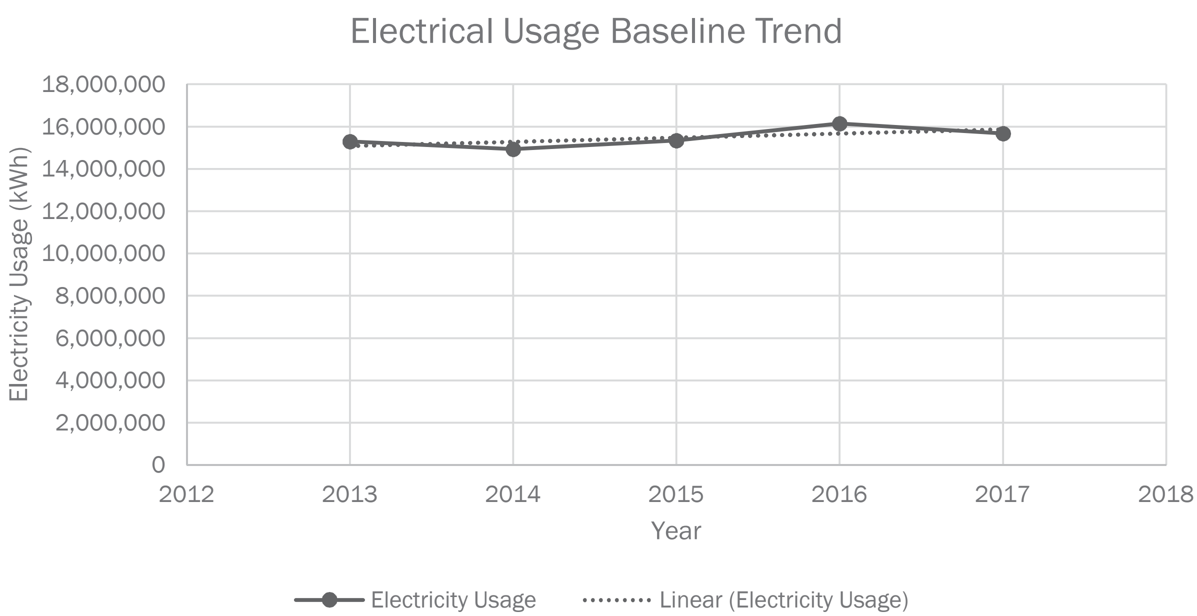


Figure 2 – Electricity Trend from past 5 years

2040 Energy Projection (Business as Usual)

Renovations and building additions extracted from the FMP have been used for projecting energy usage to the year 2040. Low intensity renovations, as defined in the master plan, have not been included in this analysis as these are deemed to be cosmetic changes that would have minimal or no effect on energy usage. The following is a summary of the renovations and building additions from the FMP.

Short Term (2018-2022)

1. 2018 - Renovation of ODY Library – Moderate Intensity –7,500 sq ft
2. 2019 - Renovation of Madill – Moderate Intensity – 6,620 sq ft
3. 2019 - Demolition of Whitman Annex – DEMO – 8,000 sq ft
4. 2019 - Renovation of Bewkes Science Hall – High Intensity – 60,324 sq ft
5. 2020 - Renovation of Brown Hall – Moderate Intensity – 28,997 sq ft
6. 2021 - Renovation of Valentine Hall – High Intensity – 23,600 sq ft
7. 2021 - Renovation of Flint Hall – Moderate Intensity – 10,004 sq ft
8. 2022 - Renovation of Appleton Arena – Other – 78,179 sq ft
9. 2022 - Addition to Appleton Arena – NEW – 50,000 sq ft

Mid-Term (2023-2027)

1. 2023 - New Academic Building – NEW – 53,000 sq ft
2. 2024 - Renovation of Hepburn Hall – High Intensity – 23,604 sq ft
3. 2025 - Renovation of Piskor Hall – High Intensity – 25,466 sq ft
4. 2026 - Renovation of Dean Eaton Hall – Moderate Intensity – 94,850 sq ft
5. 2027 - Renovation of Augsbury Newell – Moderate Intensity – 91,357 sq ft
6. 2028 - Renovation of ODY Library – Moderate Intensity – 86,421 sq ft

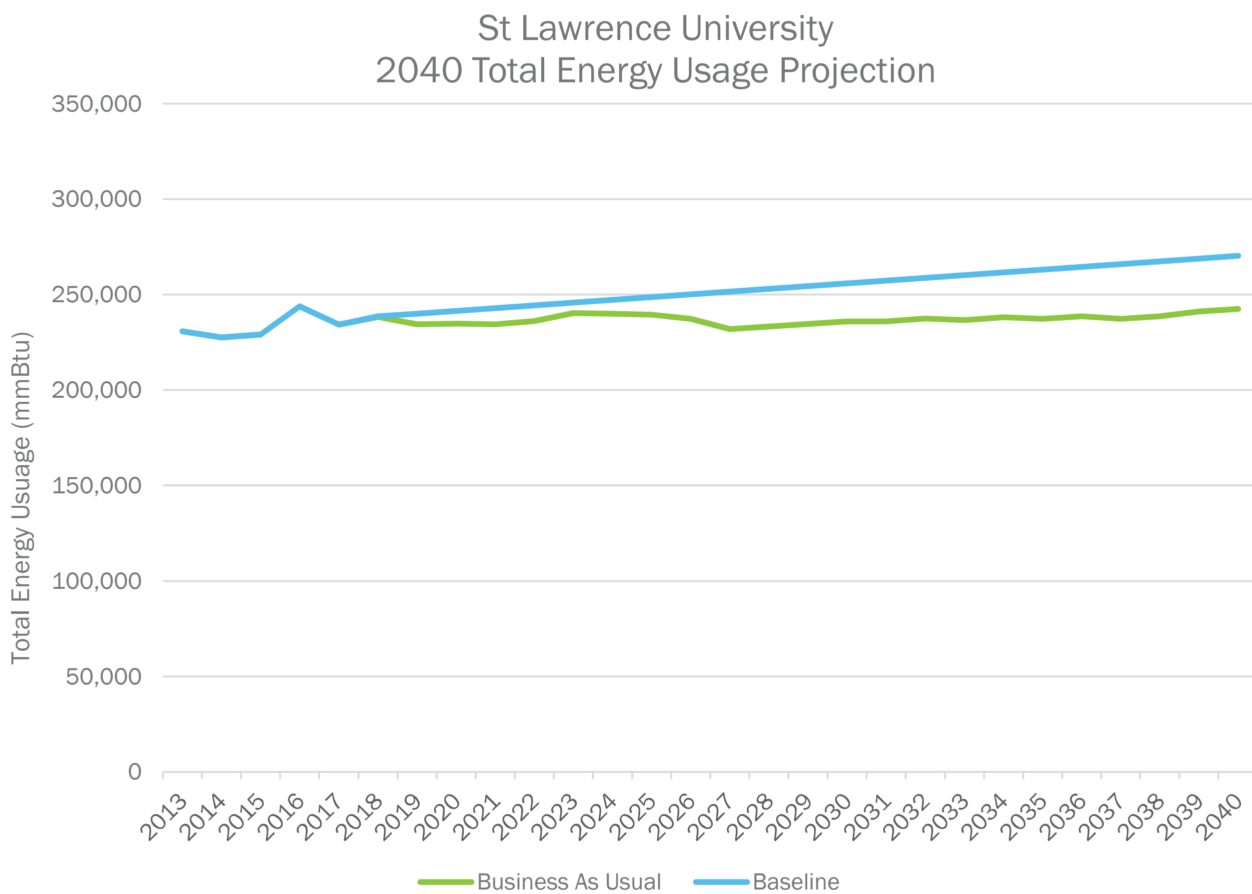
Long-Term (2028+)

1. 2029 - Renovation of Memorial Hall – Moderate Intensity – 5,100 sq ft
2. 2031 - Renovation of Vilas Hall – Moderate Intensity – 38,003 sq ft
3. 2033 - Renovation of Whitman Hall– Moderate Intensity – 57,570 sq ft
4. 2035 - Renovation of Rebert Hall – Moderate Intensity – 58,240 sq ft
5. 2037 - Renovation of Lee Hall – Moderate Intensity – 74,490 sq ft

A high intensity renovation is assumed to be a Level 3 Alteration, as defined by the New York State Building Code, and would require the building area to be brought up to current energy code standards for new buildings. The EUI reduction would bring the building in line with new construction.

A moderate intensity renovation is assumed to be a Level 2 Alteration, and would require only affected systems to be brought up to current energy code standards. As such, a moderate intensity renovation is assumed to have approximately half the EUI reduction of a high intensity renovation.

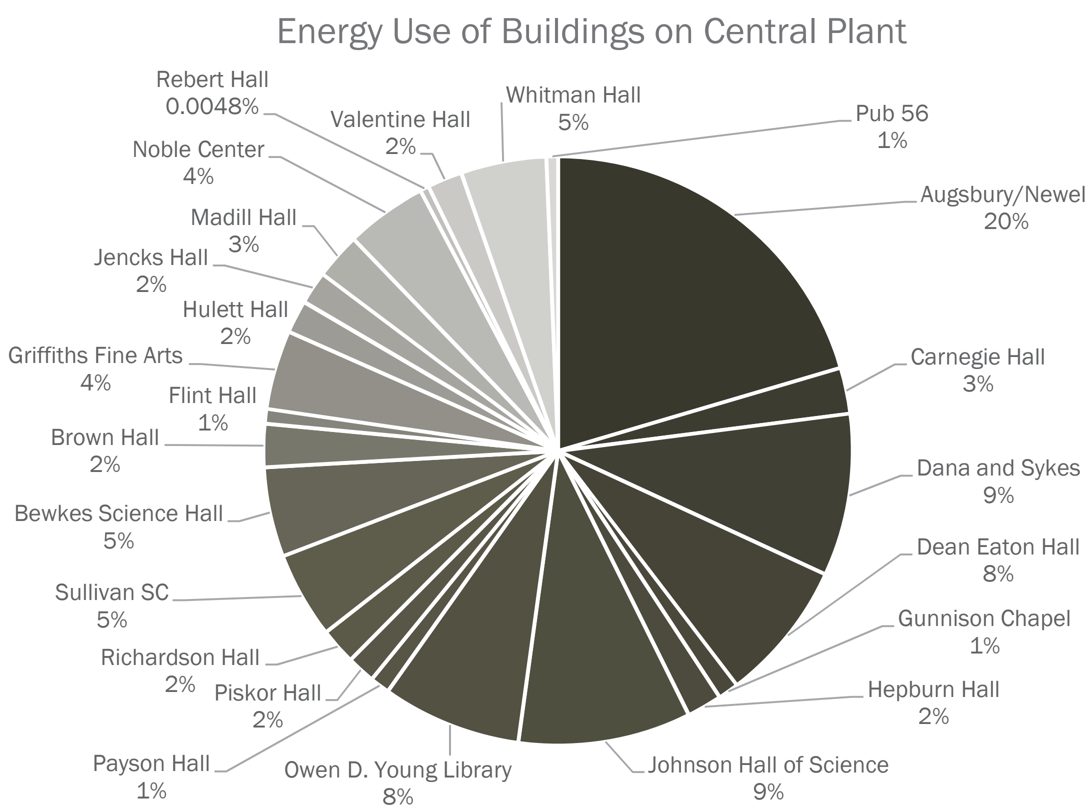
Due to the unique nature of Appleton Arena, the EUI reduction (other) has been calculated using energy conservation measures identified in a previous study performed by Wendel. This assumes that ice rink equipment will be upgraded along with lighting, building envelope improvements (including roof insulation), and water conservation measures. This was calculated to be similar to a low to moderate intensity renovation.


St Lawrence University
2040 Total Energy Usage Projection
Total Energy Usage (mmBtu)
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040
Business As Usual
Baseline

Central Heating Plant

The central heating plant currently provides heating during the winter months to 24 buildings totaling 1,224,527 square feet, 70% of the total campus square footage. The buildings use a 5 year un-normalized average of 131,611 mmBtu of natural gas from the central heating plant. Several smaller buildings including Vilas Hall, Atwood Hall, Herring Cole Hall and Lee Hall have recently been provided with their own decentralized boiler in order to reduce the load on the central heating plant. Generally, other smaller buildings throughout the campus have their own individual natural gas supply accounts to provide decentralized heating. Though the decentralization of several buildings has resulted in a lower load on the heating plant, there is still a short term redundancy issue that must be resolved to ensure adequate operation of university buildings in the event of a boiler failure.

The following is a visual representation of the estimated load of each building connected to the central plant based on the square footage of the relevant building. Without sub-meters in place, the allocation of energy usage to each building is based on area and building type.



Existing System

The CHP consists of three (3) Cleaver Brooks water-tube steam boilers. One (1) 1,200hp boiler (40,000 lbs per hr. steam) installed circa 1970 and two (2) 600hp boilers (each 20,000 lbs per hr. steam) installed circa 1975. All boilers are dual fuel capable and are able to fire either natural gas or no. 6 fuel oil for combustion. This dual fuel capability allows for the fuel gas service to be classified under the interruptible service tariff structure. Interruptible service allows the utility, during high demand periods, to direct SLU to switch the natural gas supply to use the stored No. 6 oil with little or no advanced warning. The benefit of this is SLU to consume natural gas at a lower cost than a typical firm rate service customer.

Boiler combustion control for the burners is provided by a series of mechanical linkages, which provides a marginal level of control.

Operating on No. 6 oil is typically less desirable than using Natural Gas. Its use necessitates on-site storage and additional systems for heating (to allow for pumping) and handling. Additionally, emissions of No. 6 oil are higher in CO2, NOx (nitrogen oxides) and SOx (sulfur dioxides) content than natural gas and are subject to strict emissions requirements.

The boilers produce steam at approximately 100 psig which is reduced in pressure to 25 to 40 psig through a CHP PRV (pressure reducing valve). Steam distribution pressure reduction is also accomplished through the use of the exhaust steam generated from the installed micro-turbine located in the CHP. The steam driven micro-turbine is capable of generating approximately 800,000 to 1,000,000 kWh per year of electricity and is currently in operation.

Condition and Projected Useful Life

Though these boilers are between 42 to 47 years of age, the maintenance being provided appears to be very good. The current staff is very knowledgeable on the operation of this type of equipment. These boilers may be able to provide reliable service for the near future, however, maintenance costs are likely to continue to rise to such a point where replacement of the equipment will be more economical than repair or rebuild.

In late 2004 and 2005 SLU hired an outside consultant to perform Condition Assessments for Boiler No. 4 and Boilers No. 2 & 3 respectively. The Conditions Assessments involved a thorough inspection of the units. The inspections included examining general, external and internal components including fireside and waterside components. Overall the boilers were considered to be generally in good condition. At that time, some predictions of the estimated useful life of key components were made and are given below:

REMAINING PREDICTED YEARS OF SERVICE - 2005 *(2018)*

	STEAM DRUM	MUD DRUM	TUBES	MAN/HAND-HOLDS	STACK
BLR NO. 2	30 (18)	30 (18)	11+ (-1+)	20 (8)	N/A
BLR NO. 3	30 (18)	30 (18)	11+ (-1+)	20 (8)	N/A
BLR NO. 4	15-20 *(3-8)*	15-20 *(3-8)*	15-20 *(3-8)*	15-20 *(3-8)*	15-20 *(3-8)*

The Remaining Predicted Years of Service are given as indicated in the 2005 reports and updated for the current year (2018). The most notable concern at this point is the prediction of imminent tube failure for boilers No. 2 & 3. The original analysis was based on measurement and comparison to the standard expected loss of material at key areas of the tubes that typically have the greatest corrosion and erosion due to high temperature, low flow, and tube bend configuration. While there has not been any evidence reported that a significant number of tubes are currently failing, it may be prudent to perform testing again to reevaluate the likelihood of their failure in the near future in order to gage the immediacy of the decision making process for addressing CHP viability.

In order to more accurately update the remaining useful life, another detailed Conditions Assessment, including ultrasonic tube testing, would need to be performed.

In the past 5 years, approximately $75,000 of outside maintenance has been performed on the CHP. Some major repairs were performed in from 2012 to 2015 which resulted in lower repair costs in 2016, though it appears those costs may be rising again.

Other Items of note:

The SLU CHP Deaerator is also an area of concern. While the functionality of the current system is operable, its configuration is not up to current standards for a modern Boiler Plant. The internal components lack spray nozzles and trays to effectively remove dissolved O2 (oxygen) and CO2 (carbon dioxide) from the feed water system. This deficiency results in the requirement to use more chemicals than usual (and extra costs) to mitigate pitting and corrosion from this source.

Fuel Sources:

The primary fuel source is natural gas with number 6 fuel oil as back-up. Going forward number 6 fuel oil will be phased out of operation and number 2 fuel oil will need to be utilized. This will require a complete replacement of the tanks and fuel lines. An alternative option would be to switch to a non-interruptible service class of natural gas. This would result in a higher utility rate but would avoid costly upgrades to the existing plant. These may be seen as a short term solution while the University is considering a biomass boiler plant.

Sub metering:

As previously noted, the district energy system is not currently fully sub-metered. This limited the available data per building needed to understand building performance, identify leaks and track building level energy usage. This is a common issue at many campus style facilities. The appendix provided includes a standard for installing sub-meters going forward. In addition studies have shown that real time management of energy usage typically results in an annual savings of roughly 3%. This is attributed to operators being able to better manage and operate the system by utilizing the feedback from the management system.

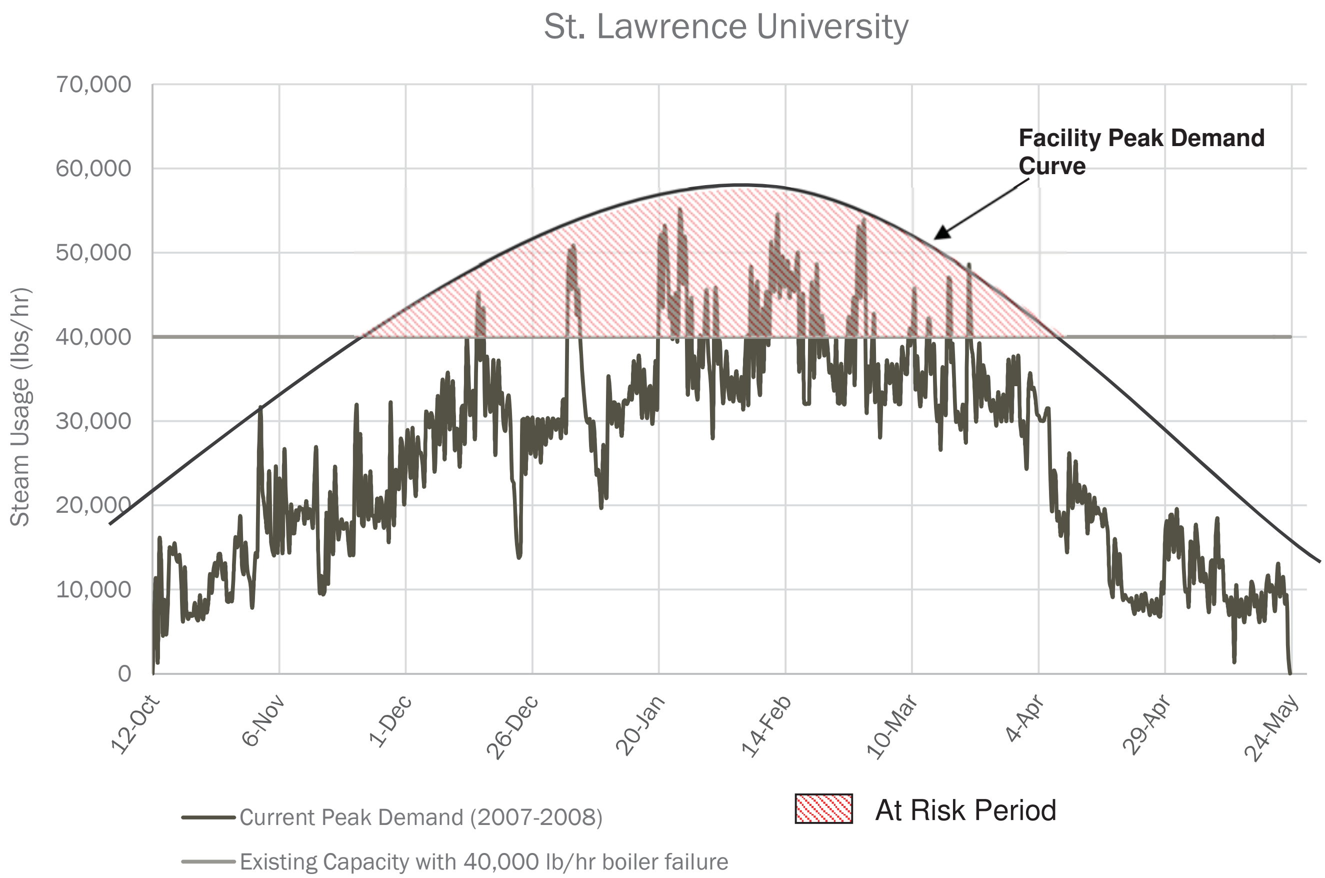
New York State Facilities include college campuses, correctional facilities, mental health facilities and other large campus style energy systems. As part of the Governors energy initiative referred to as EO88, state entities are **required to sub meter** all buildings over a preselected area. This project is intended to manage data to facility better operation and the development of future improvements.

Required Capacity

A preliminary analysis of historical steam production at SLU has been made. Review of CHP logs provided to Wendel indicate that the maximum daily steam developed over the course of the previous three years was 1,043,000 lbs per day. The data given was for a 24 hour period of time in February 2016. This translates to an average of 43,458 lbs. per hour Assuming that an instantaneous steam demand during that time could have swung to a 25% increase over the average, a peak demand is estimated at 54,323 lbs. per hour.

Typically an N+1 redundancy would be a minimum standard for a plant such as this. N+1 redundancy means that the available operating capacity of the plant would meet the demand at all times on the loss of one (1) of the largest boilers. For the current installed capacity of 80,000 lbs per hour (two at 20,000 lbs per hour and one at 40,000 lbs. per hour), a loss of availability of the largest boiler leaves the facility short on capacity for this identified peak by over 14,000 lbs. per hour (420 HP).

The referenced Conditions Assessments indicated that boilers No. 2 & 3 would be capable of receiving burner upgrades. The burner capacities would be increased to produce an additional 5,600 lbs. per hour of steam. The 11,200 lbs. per hour increase would marginally correct the redundancy of the CHP, but would not allow for any future increase in demand without installation of additional steam generation equipment or source.


St. Lawrence University
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
Steam Usage (lbs/hr)
12-Oct
6-Nov
1-Dec
26-Dec
20-Jan
14-Feb
10-Mar
4-Apr
29-Apr
24-May
Facility Peak Demand Curve
Current Peak Demand (2007-2008)
Existing Capacity with 40,000 lb/hr boiler failure
At Risk Period

the plan

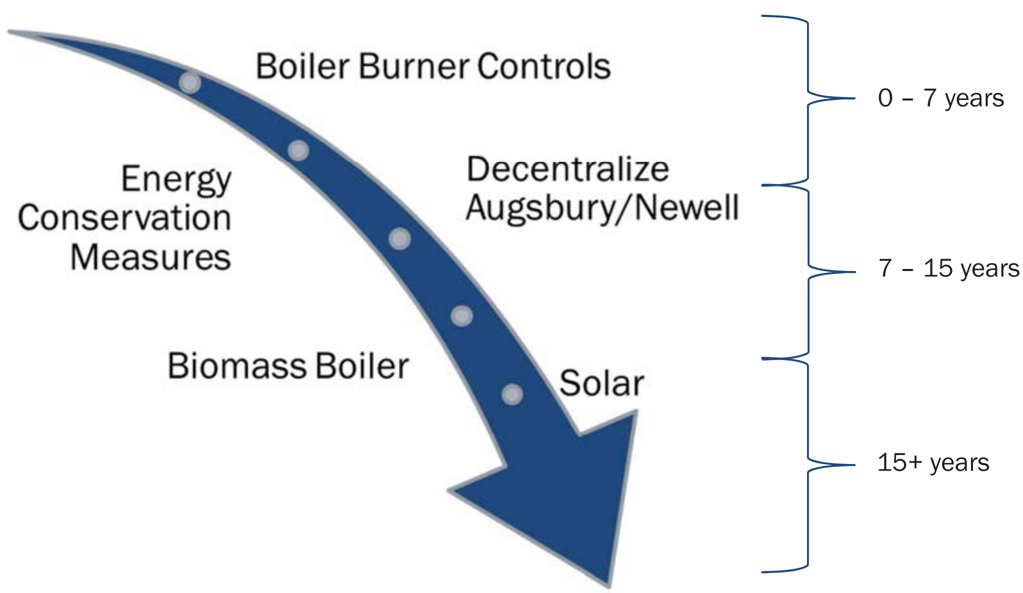
This long term master plan looked to balance SLU's long term goals, near term needs, and produce a business plan that would facilitate a path to achieving these goals. To do this we looked at three horizons; near-term, mid-term and long-term.

In the near-term horizon (0-7 years), we looked to address current changes with an eye to the future. This time period takes into account the typical process for developing a comprehensive plan, developing the design, permitting and construction.

In the mid-term horizon (7-15 years), we looked at taking progressive steps that will transform the way the University uses and distributes energy. This time period takes into account staggering and prioritizing the near-term projects financial commitments so that the energy cost savings can create positive revenue to offset future projects. The time period here also accounts for the typical process for developing a comprehensive plan, developing the design, permitting and construction.

In the long-term horizon (15+ years), we looked at identifying gaps in what is achievable through conservation and central plant improvements and addressing them with renewable generation options.

Within each horizon we identified **initiatives** that are recommended to help the University go down the path to achieving their goals. Since this plan is a **living document**, we have presented **alternative** options so if conditions should change at the University (i.e. a new building is built that has a large cooling load), the path that is taken to achieving the long term plan may change seamlessly. For these **alternatives** we have identified **catalysts**. **Catalysts** are changes from the business as usual case that may cause the University to seek out an alternative path.



near-term

The near-term horizon (0-7 years) looks to address current changes with an eye to the future.

Initiative 1 | Increase Efficiency of Existing Boilers

As detailed in the utility plant review section of this report, the existing boiler combustion control is provided by a series of mechanical linkages providing a marginal level of combustion control for the system. Burner upgrades should be implemented to provide more efficient combustion, which would also lead to an increase in peak capacity for the boiler system. This would result in an increase of approximately 11,200 lbs per hour in overall capacity (5,600 lbs per hour for each boiler), resulting in increased redundancy for the central plant.

SAVINGS POTENTIAL

Additional Capacity:	11,200 lbs / hr peak steam redundancy (PARTIAL REDUNDANCY)
Energy Savings:	11,516 mmBTU / yr
Energy Savings:	$84,409 / yr
MT CO2e reduction:	611

Initiative 2 | Reduce Energy Consumption through Building Efficiency

Energy efficiency upgrades to existing building systems would be an effective approach to reduce energy consumption and GHG emissions. Energy Conservation Measures (ECMs) would be identified after detailed energy audits were performed investigating the lighting, HVAC, HVAC Controls and building envelope systems.

Lighting improvements typically consist of replacing existing fluorescent style lamps with LED lamps. A lighting system typical makes up about 15% to 40% of a buildings electrical load and LED upgrades would reduce energy usage by 50% of the associated load.

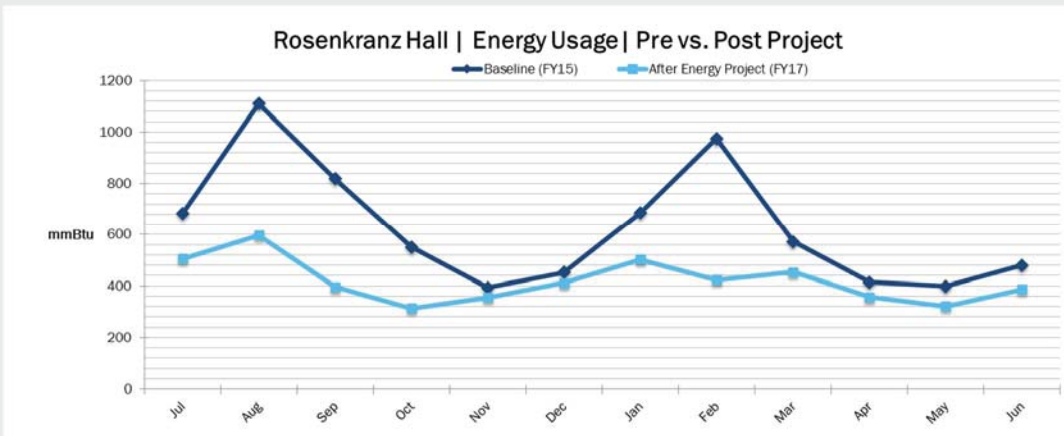
CASE STUDY | **LED Lighting & Advanced Lighting Controls**

The DesignLights Consortium (DLC) and the U.S. Department of Energy recently conducted a demonstration project at Yale University to understand the impact of LED lighting and advanced lighting controls. The resulting project showed that these systems in an office building setting can reduce energy usage up to 70%. The full case study is provided in the appendix.

HVAC Controls improvements will focus on the operation of existing controls systems. These systems typical make up 50% to 70% of a buildings total energy load (electric and natural gas). These improvements will optimize system performance by adjusting temperature set point, ventilation rates and system schedules. These improvements can reduce energy usage by 15% to 70% of the associated load and 5% to 40% of the total building energy usage.

CASE STUDY | **HVAC Controls Improvements**

Rosenkranz Hall at Yale University is a 70,710 sqft facility that achieved LEED Silver status when it was completed in the fall 2009. The building is home to the Political Science Department and Jackson Institute for Global Affairs. As part of a recent energy conservation project, improvements were made to optimize building ventilation and temperature controls. Following these upgrades, the facility realized over 33% energy savings.



Examples of preliminary ECMs are shown in the NYPA Recharge Audit portion of this report which can be found in the appendix. ECMs would be selected to be implemented based on a detailed financial analysis to project a Return on Investment (ROI) considering not only energy savings, but also Operation and Maintenance (O&M) costs and Avoided Recapitalization Costs.

The target for this initiative is to reduce energy consumption across campus buildings by 30%. In order to achieve this goal, it is currently estimated that an investment of $200 per mmBtu of energy saved would be required. This estimated value is based on budgets that major universities have established from similar projects. These include Yale University and The Ohio State University. This investment would result in a significant amount of reduction in both natural gas and electricity usage as shown below. It is assumed that energy savings initiatives would be implemented over 10 years.

CASE STUDY | **Energy Programs**

The Ohio State University recently entered into a unique business arrangement with ENGIE Services with the goal of improving energy efficiency on its Campus. The overall deal included a concessionaire agreement where ENGIE purchased the central plant assets and will sell the utilities to OSU over the next 50 years. As part of this agreement, ENGIE will also reduce energy usage by 25% through energy conservation with a total budget of $250M. This equates to a cost per savings ration between $170 and $200 / mmBtu.saved.

SAVINGS POTENTIAL	
Energy Savings:	54,009 mmBTU/yr and 4,718,974 kWh per year
Energy Savings:	$736,454.80 /yr
MT CO2e reduction:	3,653

Alternative | Decentralization of Augsbury/Newell Building

Catalyst | if SLU decides a biomass boiler plant is not a path that they want to pursue

The Augsbury/Newell Building is a great candidate to be removed from the central plant in order to increase redundancy for the central plant system. Augsbury/Newell is a 250,357 square foot facility which is estimated to account for 20% of the load on the central steam plant. The building is located at the terminal end of a steam line that runs underneath Park St.

In order to decentralize this building, two new steam boilers would be installed in the existing basement mechanical room. Decentralization would result in the avoidance of the future costs associated with replacing the steam line under Park Street as well as providing a more energy efficient system. New steam boilers will have a higher efficiency than the existing CHP, which consists of older technology. Additionally, the existing energy losses associated with the current distribution system would be negated. As the pressure of the steam changes, the energy content is reduced. A decentralized boiler would produce steam directly at the pressure required for building usage and result in a higher overall system efficiency.

Although removing Augsbury/Newell from the central plant would help with the redundancy issue at SLU, **it would be heated by natural gas**, which has a GHG emission associated with the fuel. Switching the central plant to an alternate fuel source to reduce GHG emissions would not have any effect on Augsbury/Newell should it be decentralized. Thus, decentralization would not significantly help to meet the 2040 goal of carbon neutrality.

SAVINGS POTENTIAL		
Additional Capacity:	7,292 lbs/hr – peak	(PARTIAL REDUNDANCY)
	26,908 mmBTU/yr total central plant load reduction	
Energy Savings:	6,600 mmBTU/yr	
Energy Savings:	$21,668 /yr	

mid-term

The mid-term horizon (7-15 years) looks at taking progressive steps that will transform the way the University uses and distributes energy.

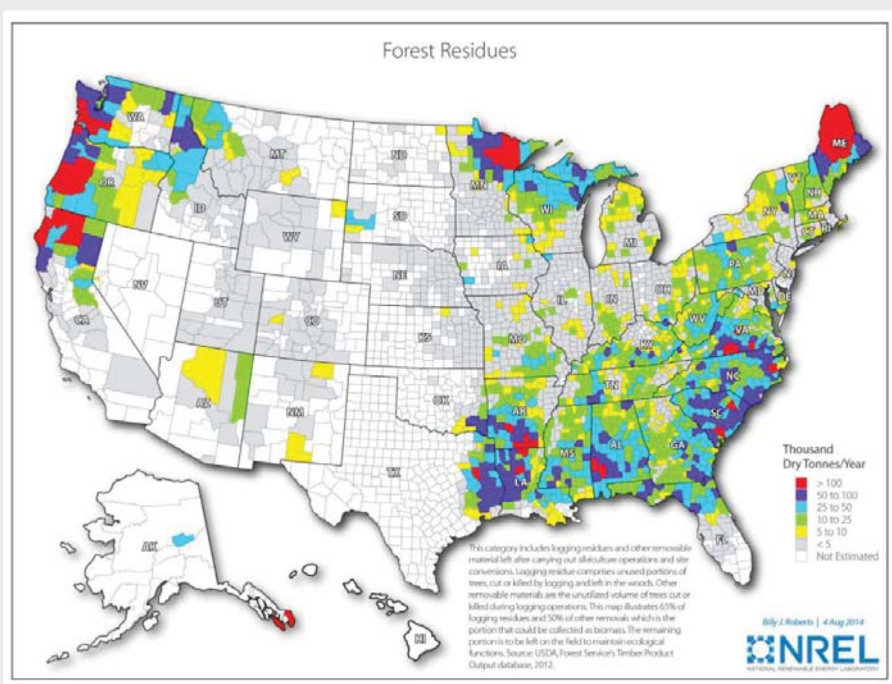
Initiative 3 | Biomass Boilers

Biomass boilers utilize organic based fuel, typically wood chips or pellets, for combustion. St Lawrence University is uniquely located to allow for the local sourcing of biomass. A 600hp biomass boiler with a capacity of 20,700 lbs per hour of steam could be installed, resolving SLUs redundancy issue on its own along with providing substantial GHG reductions.

The biomass boiler would be located remotely from the existing central plant, but would be connected to the central plant on the high pressure side of the micro-turbine. Steam lines would be required to run from the proposed new boiler location to the existing central plant location. The biomass boiler would be the primary boiler in order to provide carbon neutral energy whenever possible. During peak loading, the existing natural gas boilers may be used in order to meet demand. However, depending on other energy conservation efforts and decentralization of Augsbury/Newell, the natural gas boilers would seldom be required. It should be noted that under these scenarios, it is not anticipated that energy conservation improvements will change boiler size requirements.

There are a variety of biomass fuel types that could be considered as the biomass facility is designed. It is likely that the biomass fuel source found most suitable for this project would be commercial products such as wood chips or wood pellets. Moisture content and density vary by fuel type which impact the onsite emissions and frequency of deliveries. For instance, wood pellets have an energy content of 7.44btu/lbs with a density of 40lbs/ft^3. Wood chips have an energy content of 5.42btu/lbs with a density of 15lbs/ft^3. Depending on the time of year and onsite storage, wood pellet deliveries could vary from once a day to once a week. Refer to the Appendix for a Cost and Referenced Biomass study.

CASE STUDY | **NREL Forest Residues**



SAVINGS POTENTIAL

Additional Capacity:	20,000 lbs/hr (SOLVES CENTRAL PLANT REDUNDANCY)
Energy Savings:	120,107 mmBTU/yr (of natural gas)
Energy Savings:	$24,579 $/yr (including O&M)
MT CO2e reduction:	6,374 MT CO2e

Initiative 4 | Solar

Rooftop or ground mounted solar panels are an option for producing on-site renewable energy and reducing greenhouse gas emissions. Solar is easily scalable and can be implemented over a number of years and distributed throughout different areas around the university campus. It is recommended that any time a new building is constructed or a roof is due for replacement, that an analysis of installing rooftop solar panels is considered for implementation. Ground mounted solar could also be considered where feasible and have the added incentive of aiding in establishing an environmentally conscious image for the university campus.

Solar is limited by the peak electricity demand during the summer period. System volatility can be experienced if the instantaneous amount of electricity being produced by the solar panels exceeds the demand. This would be effectively feeding electricity back in to the distribution grid. The infrastructure required in order to handle excess electricity generation is costly and causes issues for utility providers. Technological advances in electricity storage could mitigate this risk, however, current storage solutions are not cost effective.

For the purposes of this report, it is assumed that approximately 4490 kW of solar energy could potentially be installed throughout the campus, though this would be phased over a period of 10 years.

CASE STUDY New York State (NYS) Reforming the Energy Vision (REV)

Reforming the Energy Vision (REV) is Governor Andrew M. Cuomo's comprehensive energy strategy for New York. REV helps consumers make more informed energy choices, develop new energy products and services, and protect the environment while creating new jobs and economic opportunity throughout the state. As part of this program, New York's Clean Energy Standard ensures 50% of New York's electricity will come from renewable sources by 2030. We are also putting customers first and have energy efficiency, increased use of renewables, and more resilient distributed energy resources at the core of our energy system.

NEW YORK STATE OF OPPORTUNITY | Reforming the Energy Vision

SAVINGS POTENTIAL

Energy Savings:	5,388,000 kWh
Energy Savings:	$375,370 $/yr
MT CO2e reduction:	898 MT CO2e

Alternative 3 | Geothermal

Catalyst | new building or major renovation including HVAC system

Geothermal is effective in reducing the natural gas load required for a building. However, electricity needs for the building(s) connected to the geothermal system increases significantly due to compressor and pumping loads. This trade-off is important since the proportional cost savings associated with a geothermal project will not be as great as the proportional energy savings. This is due to the relatively high cost for electricity production versus natural gas supply.

Due to both this trade-off as well as the large initial investment to retro-fit a building to be a geothermal building, the utilization of geothermal at St Lawrence University should typically only be considered for new construction and in conjunction with a renewable source of electricity production (ie. Solar power) to maximize GHG reductions and minimize energy costs. We estimated the cost to do a full retrofit of the following buildings. A key metric is the cost per mmBtu saved. Please note that an energy conservation project has a metric of around $200/mmBtu saved.

Location	Cost (including fees)	Electrical savings (kWh)	Demand Savings (kW)	Fuel Savings (mmBtu)	Cost/ mmBtu Saved	Total Savings ($)
Science Complex	$8,997,450	-45,640	0	11,089	$811	$105,721
Vilas Hall	$3,466,082	-64,010	-60.1	4,718	$735	$32,884
Noble Center	$2,388,701	-107,010	-20.5	3,189	$749	$21,661
Whitman	$5,328,650	-210,950	-38.2	5,894	$904	$39,169

Alternative 4 | Combined Heat and Power

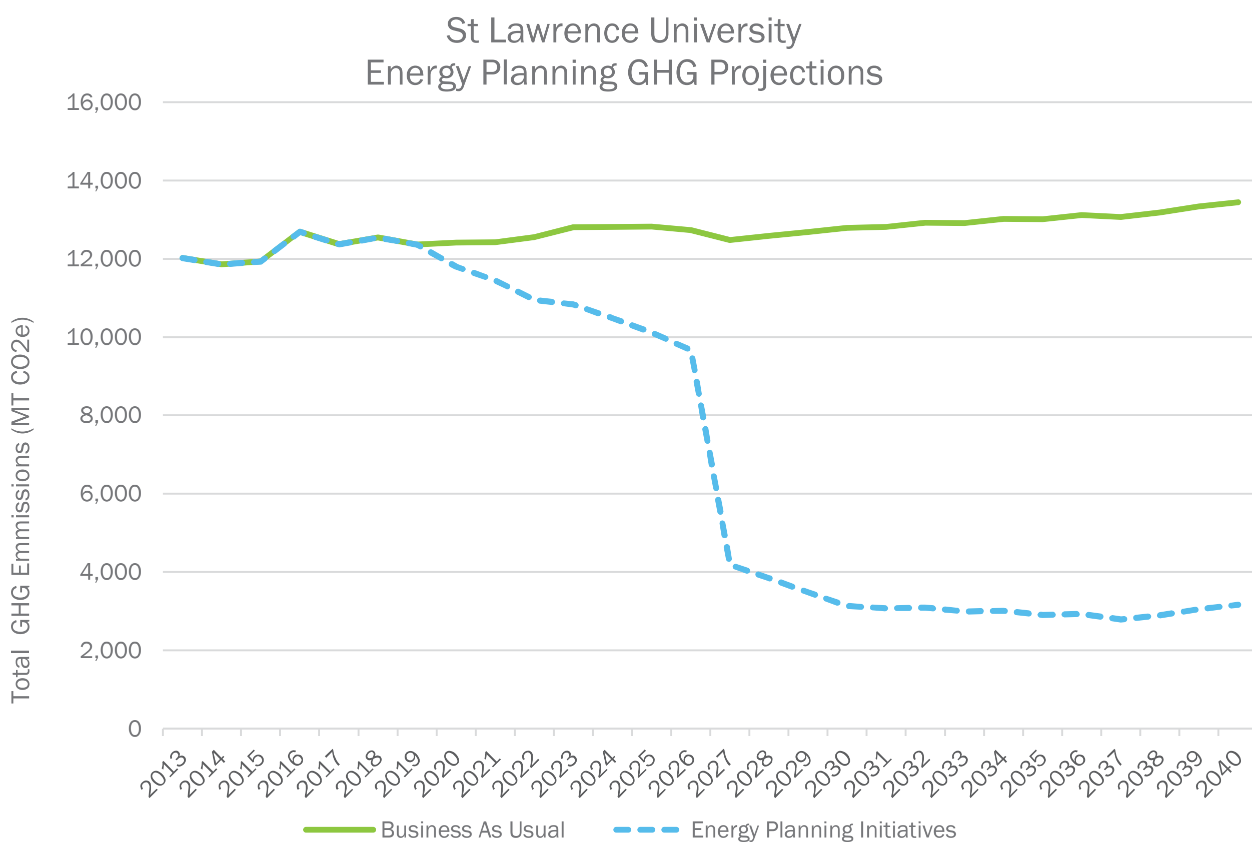
Catalyst | new building or major renovation that has a large summer heating load

Combined heat and power (CHP), otherwise referred to as cogeneration, produces both electricity and process heat simultaneously. CHP systems act to capture the waste heat from electricity generation in order to provide either heating or hot water for building use. This makes the overall efficiency of a CHP system very high. Wendel performed a cursory review of whether CHP is a feasible option for SLU. Peak electricity loads generally exist during the summer months. St Lawrence University does not have high enough summer thermal loads for this type of system to be financially viable.

It should be noted that SLU actually already implements a quasi-cogeneration configuration with the central plant. The central plant has a steam to electricity generator that doubles as a pressure reduction station. This generator produces up to 1,000,000 kWh per year.

long-term

The long-term horizon (15+ years) looks at identifying gaps in what is achievable through conservation and central plant improvements and addressing them with renewable generation options.



This chart shows where the initiatives outlined above will take us. The final gap can be addressed in a couple of ways.

1. The application of new technology or solutions developed over the next 10 years.
2. Implementation of a "Utility Scale" solar project.
3. Purchase of Renewable Energy Credits (RECs)

Utility Scale Solar Project

A Utility Scale solar project is when a system is designed to produce significantly more electrical energy than the campus can consume, effectively making the project area a net exporter of electrical energy. This would offset the emissions associated with the natural gas consumption necessary to heat smaller buildings. Due to the size of these systems, often times infrastructure upgrades need to be completed by the utility to accept the excess power onto the grid. These costs would be passed onto the university.

Renewable Energy Credits

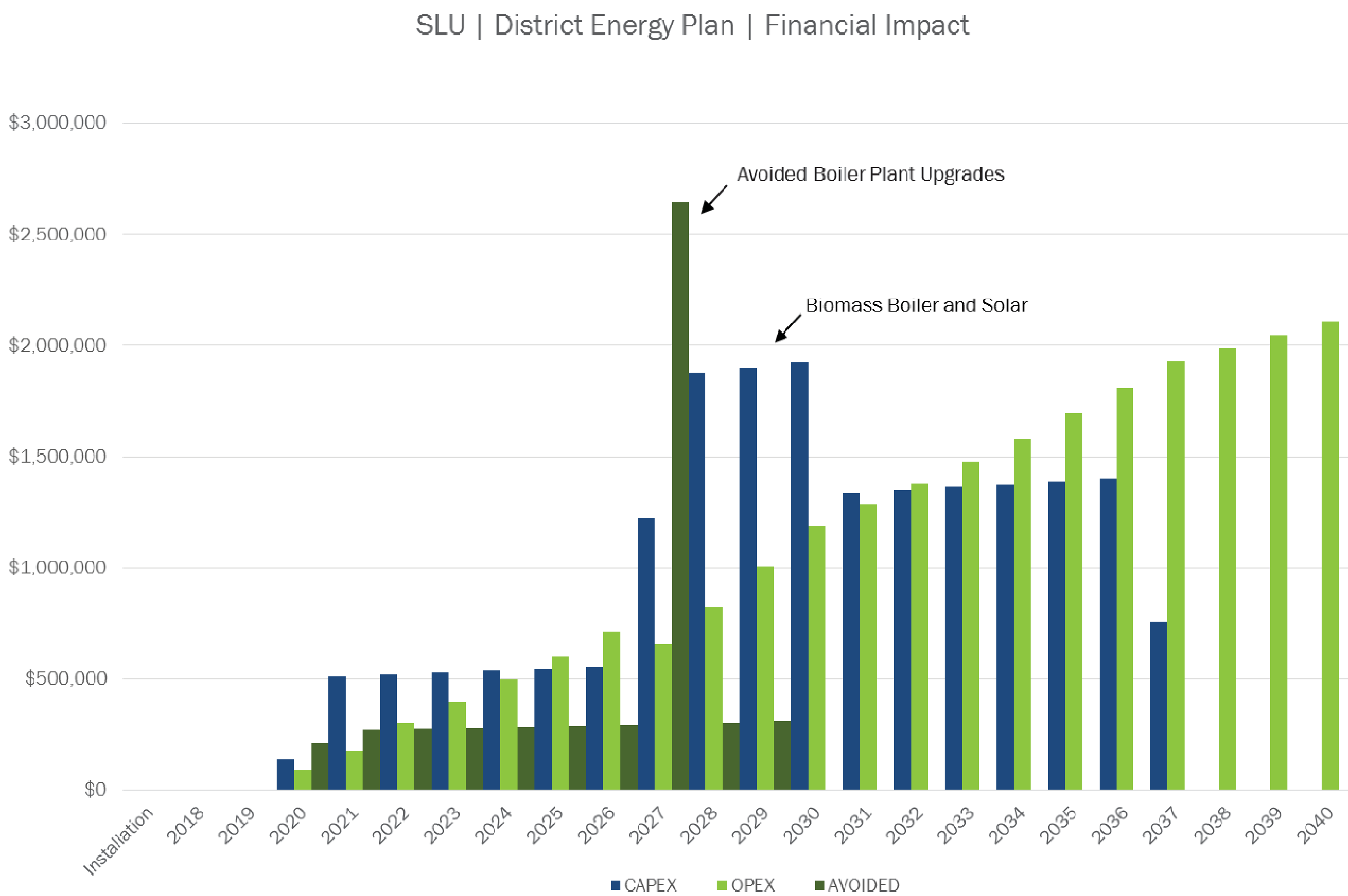
Though the above measures are steps towards reaching Net Zero emissions, there are some challenges that must be addressed. Though the majority of the larger buildings are connected to the central heating plant, there are many smaller buildings that use natural gas for heating, hot water, or other uses. The central heating plant accounts for approximately 76% of the annual natural gas consumption for the campus. This means that there are emissions associated with the remaining 24% of the natural gas use, some of which can be reduced by Energy Conservation Measures, but a base load will still exist. Consideration could be given to converting these buildings to be fully electric and offsetting the electricity usage with renewable energy sources, but this would be costly from both a capital investment and operating cost perspective. The only feasible way to eliminate the emissions associated with the natural gas accounts is through purchasing Renewable Energy Credits (RECs).

the business case

The initiatives outlined in this plan all require a capital investment (CAPEX). The return on that investment comes in several forms:

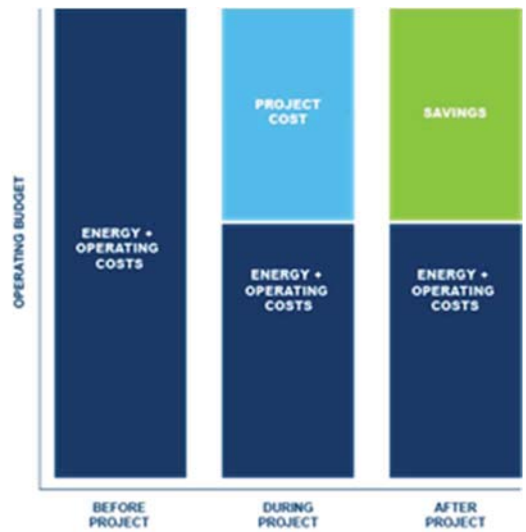
1. Direct reduction in operating expenses (OPEX)
2. Avoidance of future capital expenses that would otherwise occur (AVOIDED)
3. Increase in revenue (not included as a tangible value)

There are several unique project delivery and financial models that can be leveraged to implement these projects and finance the costs.



1 - Large capital investments are assumed to be financed for 10 years at 3.5% interest rate
2 - OPEX and AVOIDED are savings
3 - O&M costs / savings assumed to be neutral
4 - Energy escalation rate at 3%
5 - Inflation rate assumed at 1.8%

Energy Savings Performance Contracting



Energy Savings Performance Contracting (ESPC) was developed to streamline the process for public and private entities to improve energy efficiency. The ESPC process is structured to simplify the typical multi-step, time-consuming procurement process required for traditional capital projects. It allows an entity to select an Energy Services Company (ESCO) to act as a general contractor, thus eliminating the need to bid each aspect of the project. Thousands of Towns, Villages, Cities, Universities, School Districts and Counties have implemented energy saving performance contracts following the simple concept that facility improvements are funded by guaranteed energy savings.

As part of the ESPC process, the ESCO will identify and evaluate facility energy efficiency and operational cost reduction opportunities, and develop a project showing how savings from these opportunities will pay for the cost of the improvements. In other words, current budget funds are "repurposed" into needed capital improvements. ESPCs are structured such that projects will have no budgetary impact or they will actually generate surplus savings. A key element of an Energy Performance Project is that the savings are guaranteed by the ESCO. Any shortfall in savings is made up by the ESCO.

When considering this delivery approach, SLU should be mindful of requiring ESCOs that:

- Provide transparent mark-ups and low overhead costs
- Have no conflicts of interest
- Competitively select subcontractors in an open bid style process with the University
- Fully disclosed construction costs allow for fully cost transparent and comprehensive project

Power Purchase Agreements

Power Purchase Agreements (PPAs) were developed to streamline the process for public and non-profit entities to implement renewable energy projects and take advantage of the federal investment tax credits. The PPA process is structured where the PPA provider owns and operates the system and the University pays them for the power generated. This eliminates the upfront capital costs on the University and incorporates them into an incremental increase in energy costs.

When considering this delivery approach, SLU should be mindful of the following key PPA provisions:

- "Take or pay" agreements which may require SLU to pay for the power generated by the system even if they don't use it
- Balloon payments at the end of the PPA to acquire the assets
- Escalation rates on PPA rates

Demand Response

Demand response programs are available through the energy utility (National Grid) or through a 3rd party Curtailment Service Provider (CPower, NRG Energy, etc…). Demand response programs reward customers by agreeing to shed a pre-determined amount of load on short notice during peak grid energy usage times, which are typically during the summer months. When an event is called, the customer is required to shed electricity loads by turning down or shutting down certain building services or equipment. Alternatively, buildings could be shifted on to an emergency generator, though this would be subject to EPA emission regulations.

The utility and/or Curtailment Service Provider pays the customer a monthly amount for enrolling and committing to a specified demand reduction in additional to a payout if a Demand Response Event is called. Typical incentives for enrollment in a Demand Response program range from $1.65 to $2.75 per kW per month for the 5 or 6 summer months. Assuming St. Lawrence could reduce their peak summer load by 100 kW this would translate to roughly $1,000 to $1,500 per year. If a Demand Response event is called, there are additional savings of 18 to 50 cents per kWh. Assuming an event lasts for 5 hours, this could result in an additional $250 in revenue. The amount of Demand Response events can vary from year to year, and occasionally there will not even be an event.

Though Demand Response could be implemented at SLU, in order to be cost effective, it is recommended that new buildings, or intensive level renovations, consider designing the capability to shed load into the building automation system. This allows for future flexibility of participating in Demand Response programs.

future consideration

NOT FOR INCLUSION AT THIS TIME

Renewable Fuel Oils

Catalyst | if SLU decides a biomass boiler plant is not a path that they want to pursue

Renewable Fuel Oils (RFOs) are a low carbon heating oil manufactured from renewable resources. RFO's could be used in lieu of fuel oil #6 in the central plant boilers in order to provide a reduced carbon heating source. Though these fuels have been used by industrial users in the past, they have typically only been used in limited applications. Adoption by institutional users has only recently begun and they have been limited instances.

There are several challenges and considerations involved with the implementation of RFOs at St Lawrence University:

- Regulatory Approval:
  Currently, there are no installations of RFOs in New York State and the Department of Environmental Conservation (DEC) has not approved this product for use.
- Fuel Capacity:
  The energy capacity of RFOs is approximately 75,000 BTU/gal compared to 153,000 BTU/gal for No. 6 fuel oil. Since the energy capacity of RFOs is approximately one half that of No. 6 fuel oil, larger storage tanks or more frequent deliveries would be required.
- Equipment Changes:
  The current central plant at SLU has No. 6 fuel oil located in storage tanks adjacent the boiler house. The existing tanks and feed lines to the boilers are not compatible with RFOs and would need to be replaced as part of a conversion project. In addition, an increase in fuel storage capacity would be required as discussed above. Installation of new tanks would be a significant capital expenditure and would be the most costly component of switching to RFOs.
- Limited Current Installations:
  At the time of this report, limited institutional facilities have switched, or partially switched, to RFOs. Since this is a relatively new source of fuel for institutions such as SLU, there is an inherent risk associated with early adoption.
- Limited Supply:
  At the time of this report, current production of RFOs at existing facilities is limited. Though construction of new production facilities is planned by suppliers, the long term availability of this fuel is unknown along with long term pricing.

RFOs are a relatively attractive option for SLU to reduce its carbon footprint from the perspective that the central plant produces a large percentage of the campus heating demand. This centralized heating system at SLU lends itself towards switching to a less GHG intensive fuel such as RFOs, Biomass or a combination of the two. However, consideration should be given to the above items and the capital investment required to replace the underground tanks in order to accommodate RFOs or other biofuels.