CLEAN ENERGY MASTER PLAN SUNY ESF

JANUARY 11, 2021

RAMBOLL

CLEAN ENERGY MASTER PLAN
SUNY ESF

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EXECUTIVE SUMMARY

Since its founding in 1911, the SUNY College of Environmental Science and Forestry (ESF) has been committed to teaching, developing, researching, and implementing sustainable practices across a range of fields. For over a decade, this commitment has included making improvements to ESF's Syracuse campus and regional properties to reduce energy use, transition to renewable energy sources, and lower greenhouse gas (GHG) emissions. Energy conservation and efficiency, on-campus energy systems, green building standards, and facilities stewardship programs have been successfully implemented and have reduced energy use, utility costs, fossil fuel dependence, and GHG emissions. ESF has demonstrated the College's commitment to clean energy practices through the formation of the Office of Sustainability, building and commissioning the Gateway Center combined heat & power (CHP) plant, hiring the College's first Energy Manager, creating an Energy Conservation, Development and Controls Team, and successfully integrating campus clean energy projects with curriculum and student and faculty research. These efforts have been fostered by strong support from ESF leadership and many collaborations across campus, and opportunities exist for further advancements.

In 2017, ESF was awarded a grant from the NYSERDA Reforming the Energy Vision (REV) Campus Challenge to create a Clean Energy Master Plan (CEMP) in partnership with Ramboll. Building on ESF's 2009 Climate Action Plan, the CEMP for ESF provides a snapshot of historical energy and GHG emission trends, and a roadmap for further reductions in energy use, fossil fuel dependence, utility costs, and GHG emissions. A team of ESF staff, faculty and students worked closely with a team of engineers from Ramboll to create the CEMP and engage ESF leadership, the campus community, SUNY Construction Fund and other key stakeholders in the process. The CEMP takes a comprehensive approach to energy management with strategic focus areas in energy efficiency, resiliency, renewables, stewardship, and engagement.

Energy utility data, audit results, feasibility studies, and plans for current and future energy and construction projects provided the basis for the CEMP analysis. ESF's clean energy efforts to date have reduced GHG emissions by 25% since increasing campus sustainability efforts and committing to dramatically reduce our GHG emissions. Total campus energy use and energy use per square foot have also decreased over that time. The primary driver of GHG reductions has been reduced dependence on purchased steam and electricity from the grid, offset by the more efficient onsite Gateway Center CHP plant. Still, heating remains the largest source of energy use, fossil fuel dependence, and GHG emissions, representing about two thirds of ESF's fossil fuel consumption and GHG emissions. ESF is currently dependent on natural gas-fired steam for heating. This includes steam purchased from an external source, and steam produced at the Gateway Center CHP, which primarily uses natural gas. The Gateway CHP is fueled by a mix of natural gas and biomass, and has the potential to use a greater percentage of biomass. ESF's biggest opportunity for deep decarbonization over the long term is finding alternatives to natural gas and purchased steam to heat the Syracuse campus buildings during cold winters and shoulder months.

Energy modeling and scenario planning conducted by Ramboll identified one potential approach to address this issue and dramatically reduce GHG emissions over the mid- to long-term through phased implementation of a low-temperature hot water distribution system. This could be expanded over time and work as an integrated system with a diverse mix of clean energy technologies such as geothermal, biomass, and biofuels to offset purchased steam and natural gas. This hot water loop and required building retrofits could be implemented in a phased approach in sync with the ESF Facilities Master Plan (FMP) and periodic investments to retrofit existing buildings including SUNY-driven Deep Energy Retrofits. In addition to natural gas and purchased steam for heat, grid-purchased electricity is the next largest opportunity for reductions, accounting for approximately 28% of ESF’s energy/fossil fuel use and GHG emissions. ESF’s participation in the Large-Scale Renewable Energy (LSRE) consortium of SUNY and other NYS colleges, which would secure 100% of purchased electricity from renewable sources, is a critical component of the CEMP and ESF’s leadership towards SUNY and NYS energy and carbon goals.

The CEMP for ESF is living document that provides a vision and pathway for transitioning to a low-carbon campus that showcases and benefits from a mix of proven clean energy technologies and operational strategies that increase energy independence and resilience. With a continued comprehensive approach to energy management, ESF has the potential to reduce energy use, transition to a blend of renewable sources, and cut GHG emissions by 40% in the near term, and 80% or more over the long term. At the same time, these practices will continue to reduce utility costs and fossil fuel dependence, making the College more financially and operationally sustainable. The CEMP supports ESF’s expanding potential to serve as a clean energy leader for SUNY, NYS, and beyond, while creating new opportunities for student and faculty engagement and collaboration. The CEMP strengthens the foundation for a growing suite of clean energy tools and initiatives at ESF, leading the way toward the sustainable, zero-carbon institution of the future.

TECHNICAL SUMMARY

Purpose
SUNY College of Environmental Science and Forestry (ESF) is a Reforming the Energy Vision (REV) Campus Challenge Partner under the New York State Energy Research and Development Authority (NYSERDA) REV Campus Challenge Technical Assistance for Roadmaps program. NYSERDA co-funded the development of this Clean Energy Master Plan (CEMP), which creates a vision for low carbon and renewable technologies and operational strategies to reduce fossil fuel use/dependency, increase electrification of utility operations, and maintain resiliency and reliability.

Energy and Climate Drivers
ESF is subject to New York State Mandates and SUNY System Administration and State University Construction Fund (SUCF) Directives associated with energy and carbon (*i.e.*, greenhouse gases (GHG)) reduction targets that include the following:

New York State Mandate	Goals
Executive Order 166 (EO 166)	Reduce GHG emissions (from 1990 levels): • 40% by 2030 • 80% by 2050
New Efficiency New York	• 2025 statewide energy efficiency target of 185 trillion British thermal units (TBtu) of site energy savings
The Climate Leadership and Community Protection Act (CLCPA)	• Carbon free electricity system by 2040 • Reduce GHG 85% below 1990 levels by 2050 on a path toward carbon neutrality

SUNY and SUCF Directives/Drivers	Goals
SUCF Directive 1B-2	• Commitment to clean energy • Deep energy retrofits on existing buildings • Net zero carbon new buildings
SUNY Clean Energy Roadmap	• Guidelines to help accelerate progress towards NYS's goal to reduce GHG 40% by 2030

Greenhouse Gas Emissions Trend
Greenhouse gas emissions from ESF are derived from a variety of energy fuel types. As shown in Figure 1, 86% of the energy use is from Syracuse University (SU) steam, natural gas, and purchased electricity. Nearly 60% of the total is from SU steam and natural gas, which provides the basis for heating campus buildings. These are the primary fuel sources for heating and are the opportunity areas for broader energy efficiency and decarbonization considerations through fossil fuel reduction.

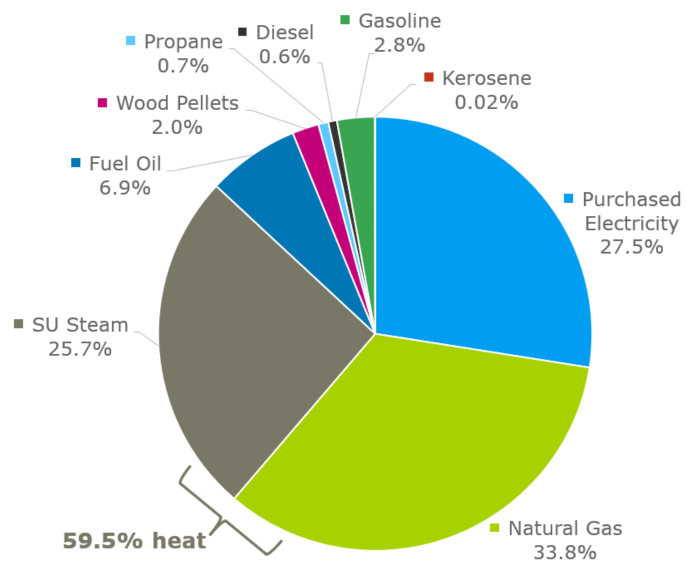

Figure 1. ESF Energy Use by Fuel Type (FY 2018-19)

Figure 2 summarizes the GHG emissions (Scope 1 and Scope 2 sources) trend from fiscal year (FY) 2006-2007 (FY06-07) through FY18-19. The values represent ESF facilities and properties including the main campus, satellite campuses and research stations, and forest properties.

GHG emissions have reduced 25% over the 13-year period even with the opening of the Gateway Center (2013/2014) and a 16% increase in student enrollment. A significant impact to energy reduction is observed from FY15-16 to FY18-19, which is attributed to a combination of hiring the campus' first Energy Manager, implementing energy efficiency projects, and broader utilization of the combined heat & power (CHP) plant located in the Gateway Center starting in FY16-17 (resulting in the associated increase in Scope 1 emissions and decrease in Scope 2 emissions).

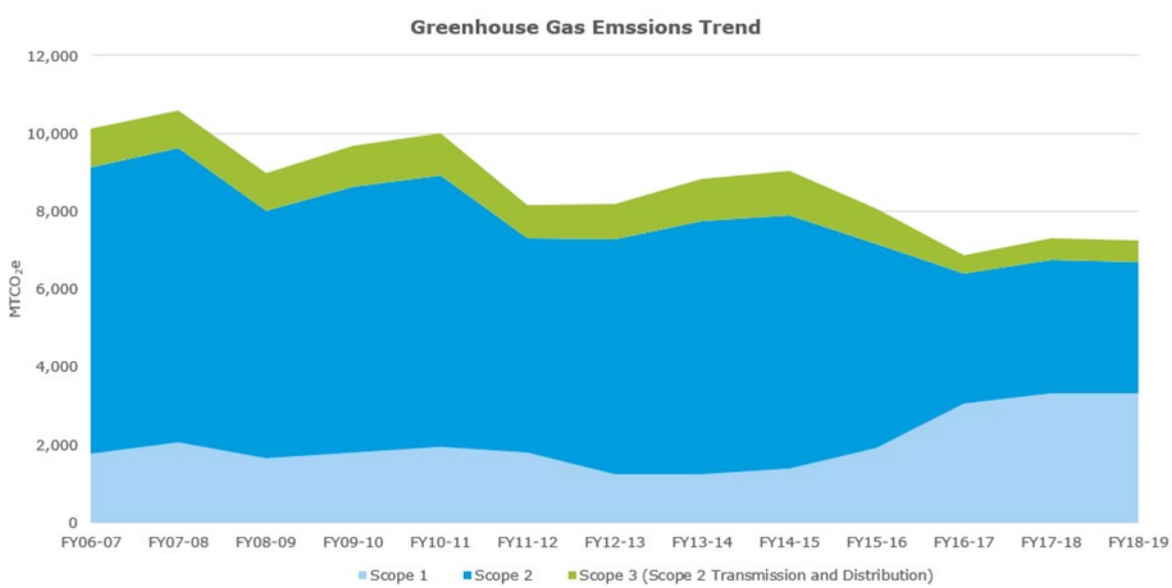

Figure 2. ESF GHG Emissions Trend Since Fiscal Year 06-07

Clean Energy Master Plan

The CEMP process allowed for critical discussion to align campus priorities with key mandates and drivers, coupled with strategic thinking of clean energy options to create a vision of the most economically viable low carbon and renewable technologies and operational strategies to reduce fossil fuel use/dependency, increase electrification, and maintain resiliency and reliability. Table 1 provides a high-level summary of the planned actions within five strategic focus areas of ***Energy Efficiency, Resiliency, Renewable Energy, Stewardship, and Engagement.***

Table 1. Energy Roadmap | Strategic Focus Areas

ENERGY EFFICIENCY	RESILIENCY	RENEWABLE ENERGY	STEWARDSHIP	ENGAGEMENT
Low Cost/No Cost Measures	Steam to Low Temperature Hot Water	Large Scale Solar Power Purchase Agreement	Campus Energy Manager	Energy Conservation Awareness and Behavioral Change
Energy Conservation Measures	Low Carbon Energy Supply • Geothermal Heat Pumps • Thermal Energy Storage • Backup and Peak Generation	Biomass	Retro-commissioning	Integration with Curriculum, Research, and Workforce Development
Building Renovations	Gateway CHP	EV Fleet Transition	Preventative Maintenance Focus	
Deep Energy Retrofits	Integration with Facilities Master Plan (FMP)		Advanced Metering and Data Analysis	
Net Zero Carbon New Buildings			Workforce Development	
% Contribution to GHG Reduction				
26%	**41%**	**25%**	**6%**	**2%**
% Contribution to Total Source kBtu/GSF Reduction				
40%	**47%**	**0%**	**9.5%**	**3.5%**

The fundamental basis for establishing a low carbon campus is transitioning the district heating network from steam to hot water and moving to 100% renewable sources for electricity, while a shift to all renewable electricity and energy efficiency measures are essential to reaching the campus' targets. Stewardship is a central part of all aspects of ESF's teaching research and service, and the engagement from students, faculty and staff around energy and environmental issues are part of the campus culture. Figure 3 summarizes the current situation of a steam-based campus (Main Campus) district energy network and the vision of a future low carbon energy supply.

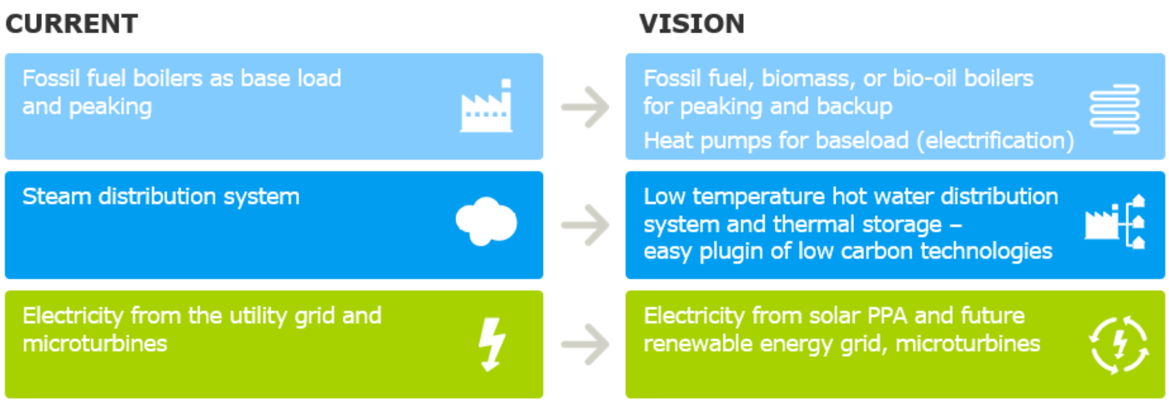

Figure 3. ESF District Energy Network – Current Versus Vision of Low-Carbon Technologies

To help establish the vision of a future low carbon energy supply, energy modeling and scenario planning was completed to provide quantitative information and path forward considerations. Figure 4 represents the five scenarios (2b, 3a, 3b, 5a, and 5b) that aligned ESF's priorities with NYS mandates and SUNY's goals/directives. Further detail is provided in Sections 4.2 and 4.3.

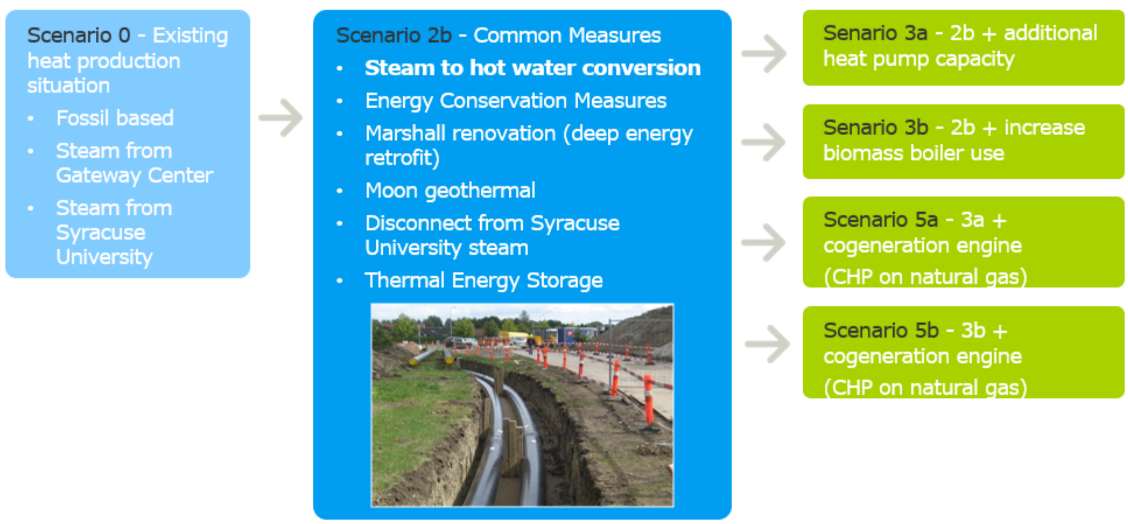

Figure 4. Main Campus – Existing Stream Distribution and Potential Hot Water Distribution

Figure 5 provides a comparison of project costs (in net present value (NPV)) and associated GHG emissions from the five scenarios. The yellow diamonds show the present value for each of the scenarios in million US Dollars. All costs (capital expenditures, operating and maintenance expenditures) are accounted for in each year over a 20-year period.

The blue bars are the CO_2e emissions and are read on the right axis. The percentage noted at the bottom of each blue bar is the GHG portion remaining after reductions for that scenario as compared to the year 1 existing condition baseline (represented by the green bar).

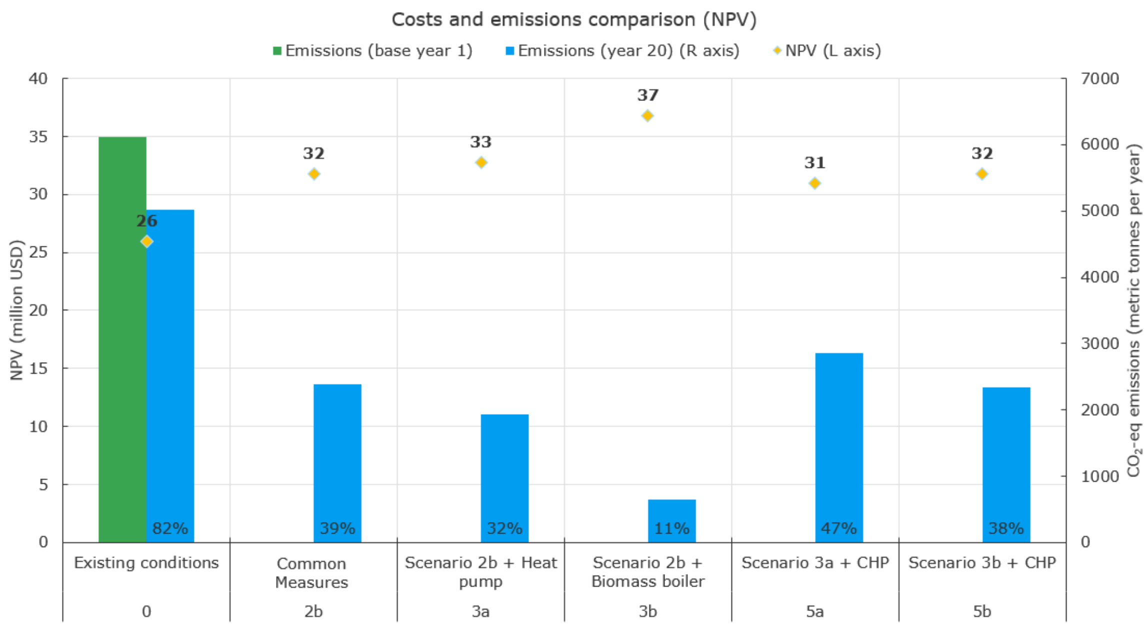

Figure 5. Low Carbon Energy Scenarios Comparison

Greenhouse Gas Emissions and Energy Use Intensity Reduction Impact

Figure 6 summarizes potential GHG emission reductions from the scenario modeling. Results assume a renewable electricity grid, which aligns with the CLCPA commitment to a carbon free electric grid by 2040, as well as ESF's planned participation in the New York Higher Education Large Scale Renewable Energy (NY HE LSRE) consortium or another potential power purchase agreement (PPA) option. Wood pellets and bio-oil are assumed to have limited GHG emissions given their consideration as renewable energy sources. While not part of the selected scenarios that were modeled, Ramboll also estimated (for additional comparative GHG emissions assessment) the potential impact of 70% electrification of the total heat demand. That is, 70% production from heat pump base load operations and 30% production from either natural gas or bio-oil).

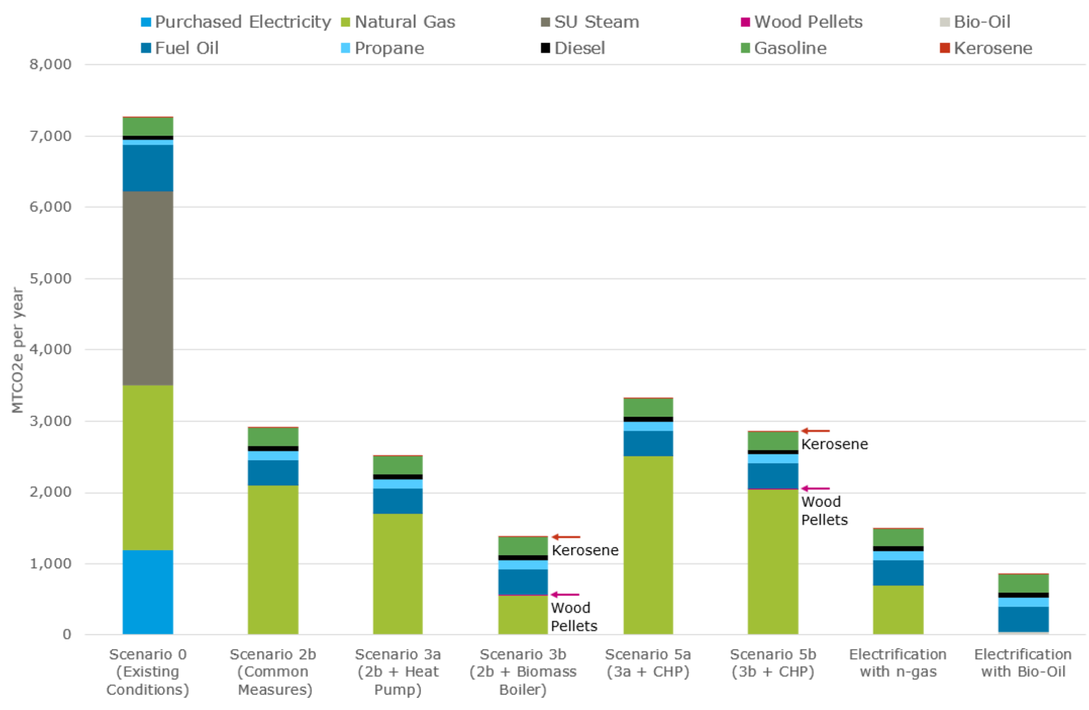

Figure 6. All ESF Properties – GHG Emissions with Renewable Electricity

Figure 7 represents a GHG emissions trajectory from 2020 through 2040. The figure accounts for short-term and long-term energy reductions that ESF is anticipated to implement; subject to change based on annual campus priorities and plans, available budgets and funding options, and FMP considerations.

Short term energy reductions are represented by the blue dashed portion of the trajectory and are anticipated to occur by 2025. The primary influence is from ESF's planned participation in NY HE LSRE consortium or other PPA, which offsets nearly 1,200 $MTCO_2e$ and would allow ESF to meet its 40% reduction goal (baseline year 2007).

Long-term energy reductions are represented by the yellow dashed portion of the trajectory. ESF's actual progress during the time period of 2025-2035 will be achieved predominately by building renovations tied to the Facilities Master Plan (FMP), as well as ultimate low carbon campus strategy adopted by ESF as a roadmap. It is noted that ESF also has 25,000 acres of forest property that can be utilized for carbon sequestration management in offsetting a portion of ESF's GHG emissions towards NYS mandates and campus neutrality goals.

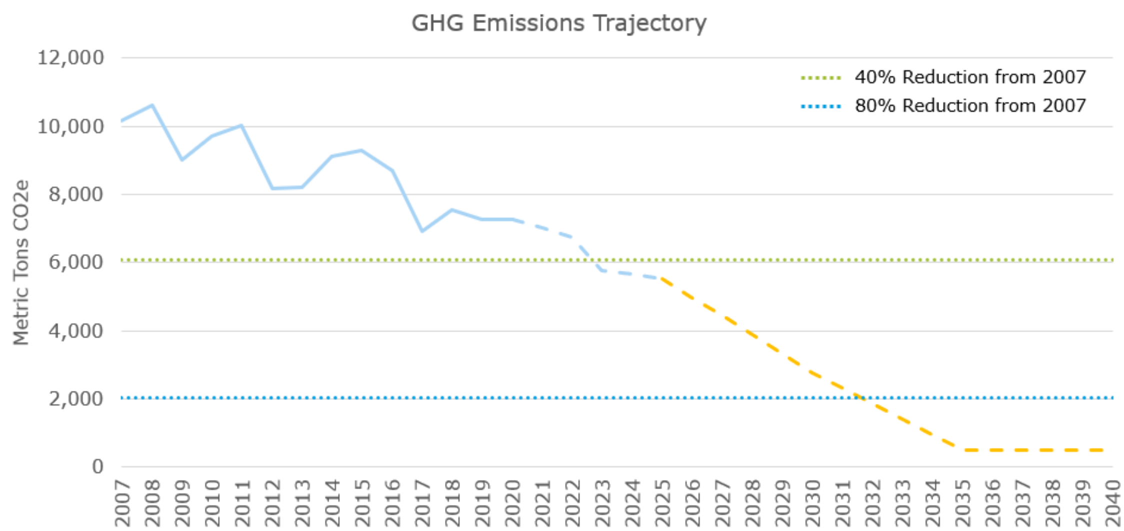

Figure 7. GHG Emissions Trajectory

Figure 8 illustrates the estimated site EUI reduction impact of short-term and long-term energy projects. The reduction impact is largely from steam and natural gas reductions through the implementation of clean energy technologies.

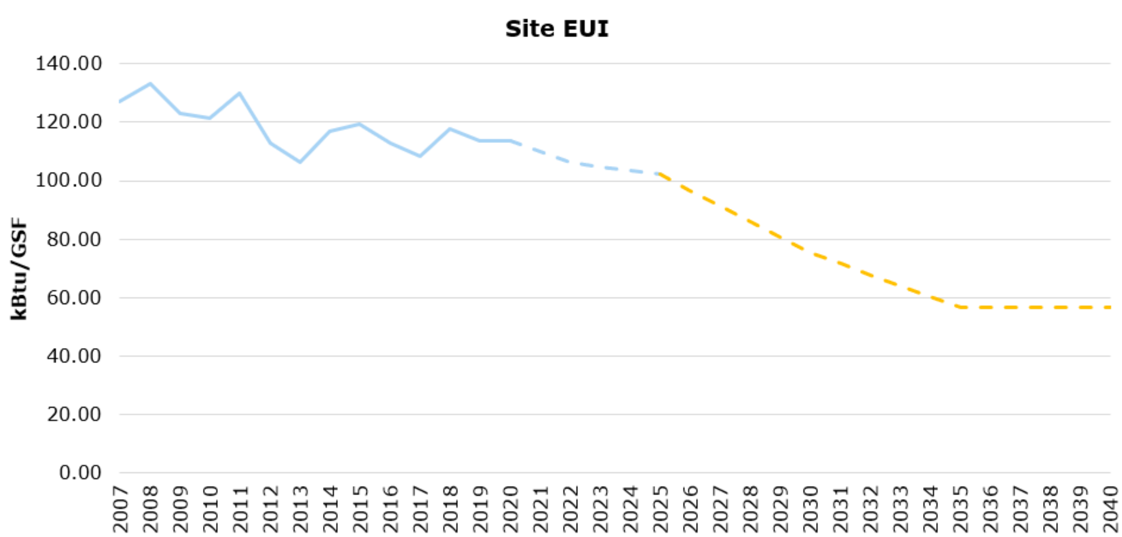

Figure 8. Site Energy Use Intensity Trajectory

A Bold Vision

The CEMP will guide actions over a 20-year horizon and establishes ESF's desire and vision to be "bold" in its commitment to being a leader of energy and sustainability within SUNY. Energy reductions are achieved through ***decreasing fossil fuel use, establishing a platform for electrification and clean energy supply technologies, using renewable energy, completing building upgrades, stewardship of physical assets, and engaging campus stakeholders.***

1. PURPOSE, DRIVERS AND APPROACH

1.1 Purpose

The New York State Energy Research and Development Authority (NYSERDA) Reforming the Energy Vision (REV) Campus Challenge Technical Assistance for Roadmaps (REV Campus Challenge) supports REV Campus Challenge members by providing the means for campuses to evaluate existing energy-related conditions on campus and establish an Energy Roadmap for managing changing campus energy needs. As a State University of New York (SUNY) institution and REV Campus Challenge member, SUNY College of Environmental Science and Forestry (ESF) is committed to the goals of the REV Campus Challenge through the development of this NYSERDA co-funded Clean Energy Master Plan (CEMP), along with assisting other colleges and universities in this process through collaboration and sharing best practices and lessons learned.

1.2 Energy and Climate Drivers

While ESF is a REV Campus Challenge member, ESF is also subject to New York State Mandates and SUNY System Administration and State University Construction Fund (SUCF) Directives associated with energy and carbon reduction targets, which include the following:

New York State Mandates

- **Executive Order 166 (EO 166)** was issued by Governor Andrew Cuomo on June 2, 2017. The goals are to reduce statewide greenhouse gas (GHG) emissions 40% by 2030 and 80% by 2050, from 1990 levels (or "40x30" and "80x50").
- **New Efficiency New York**, established in April 2018 by New York State Energy Research and Development Authority (NYSERDA), set a 2025 statewide energy efficiency target of 185 trillion British thermal units (TBtu) of cumulative site energy savings relative to forecasted energy consumption in 2025.
- **The Climate Leadership and Community Protection Act (CLCPA)**, which was signed into law by Governor Cuomo in July 2019. The CLCPA requires NYS to achieve a carbon free electricity system by 2040 and reduce GHG 85% below 1990 levels by 2050, setting a new standard for states and the nation to expedite the transition to a clean energy economy. To support the implementation of the CLCPA, the New York Power Authority (NYPA) will be issuing BuildSmart 2025 guidance and will work with state and local governments to complete energy efficiency projects and move New York closer to a clean energy economy.

SUNY and SUCF Directives/Drivers

- **SUCF Directive 1B-2** – SUNY has a commitment to clean energy and has defined goals such as performing deep energy retrofits on existing buildings to bring them to net zero. In support of the goals, State University Construction Fund (SUCF) issued Directive 1B-2 (Net Zero Carbon New Buildings and Deep Energy Retrofits of Existing Buildings). At the time of this writing, Directive 1B-2 is undergoing revisions.
- **SUNY Clean Energy Roadmap** - In April 2019 SUNY Chancellor, Dr. Kristina Johnson announced SUNY joining forces with NYS's energy agencies to launch the SUNY Clean Energy Roadmap, which will accelerate progress toward NYS's goal to reduce greenhouse gas emissions 40 percent by 2030.

1.3 Approach and Guiding Principles

The CEMP development approach was a deliberate and collaborative process of stakeholder engagement that allowed for critical discussion of key institutional goals and targets, strategic thinking of clean energy options and best practices, and establishing strategies to implement the CEMP. Engagement and thought leadership from the CEMP Implementation Team, ESF Administration, Physical Plant & Facilities, and Energy Management were critical to aligning campus priorities with SUNY's Clean Energy Roadmap ambitious goals. Key stakeholder engagement meetings conducted during the development of the CEMP are summarized below in Table 1. Guiding principles that have influenced ESF's campus priorities in strategic focus areas of Energy Efficiency, Resiliency, Renewable Energy, Stewardship, and Engagement include:

1. Create a CEMP that provides a roadmap for near-term actions and a decision-making framework for the long-term vision to meet or exceed NYS energy efficiency and GHG reduction mandates, and set a path for carbon neutrality.
2. Identify the most economically viable clean energy (low carbon and renewable) technologies and operational strategies to reduce fossil fuel use/dependency, increase electrification, and maintain resiliency and reliability.
3. Align the CEMP and Facilities Master Plan (FMP) (JMZ Architects and Planners, P.C., (JMZ) 2020) to compliment capital planning and modernization of campus buildings including critical maintenance and SUCF Directive 1B-2.
4. Integrate campus operations with curriculum, research, and workforce development.

Table 2. Key Stakeholder Engagement Meetings

Date	Audience	Purpose
Project Duration	CEMP Team	Discuss scope tasks and results; Facilitate and formulate CEMP strategy, direction, and content development during draft and final stages
November 2018	Administrative Leadership	Share overview of the CEMP process; Seek input on energy and GHG reduction goals; Confirm commitment in being a leader of energy and sustainability within SUNY
September 2019	Facilities Master Plan Architect	Share summary scope efforts to understand each party's charge and where efforts might compliment or conflict
February 2020	Administrative Leadership	Share approach and results towards a low carbon campus and seek input and guidance
April 2020	ESF Town Hall	Share overview of the CEMP process and the vision of a low carbon campus to help meet energy and GHG goals
September 2020	ESF Board Meeting	Share overview of the CEMP process and the vision of a low carbon campus to help meet energy and GHG goals

2. ASSESS – EXISTING CONDITIONS AND OPPORTUNITIES

The CEMP process initiated with a November 2018 stakeholder engagement meeting with the CEMP Implementation Team and ESF Administration to discuss existing conditions and opportunities and the broad picture of "where are we now" relative to the ESF energy program. Further, the meeting confirmed ESF's desire to be "bold" in terms of its commitment to being a leader of energy and sustainability within SUNY. ESF's strong history of energy and sustainability are presented in Figure 1.

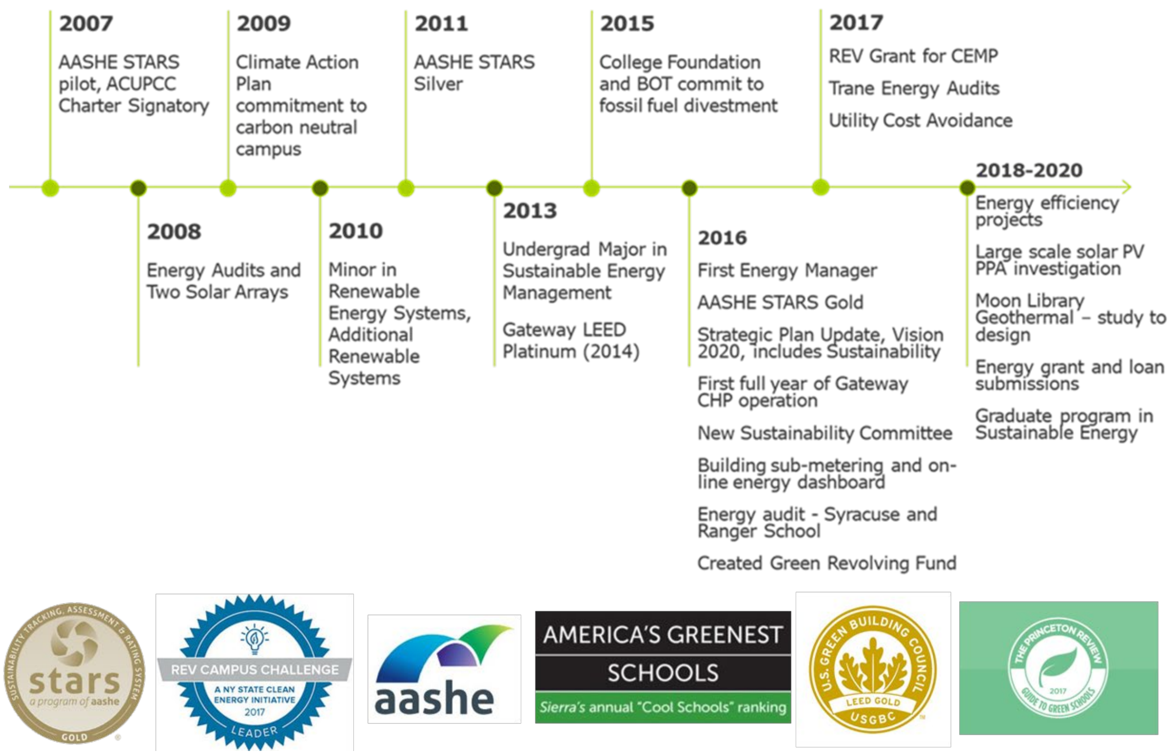

Figure 9. Recent History of Energy and Sustainability Actions at ESF

2.1 Greenhouse Gas Emissions and Energy Use Intensity

Greenhouse gas emissions from ESF are derived from a variety of energy fuel types. This information is recorded and maintained in EnergyCAP, an energy management and utility bill accounting software. From Figure 2 below, 86% of the energy use is from Syracuse University (SU) steam, natural gas, and purchased. Nearly 60% of the total is from SU steam and natural gas, which provides the basis for heating campus buildings. Wood pellets (used for peak load heating at the Main Campus) and No. 2 fuel oil (used for heating at some satellite campuses) make up about 9% of the total energy use. These are the primary fuel sources for heating and are the opportunity areas for broader energy efficiency and decarbonization considerations through fossil fuel reduction.

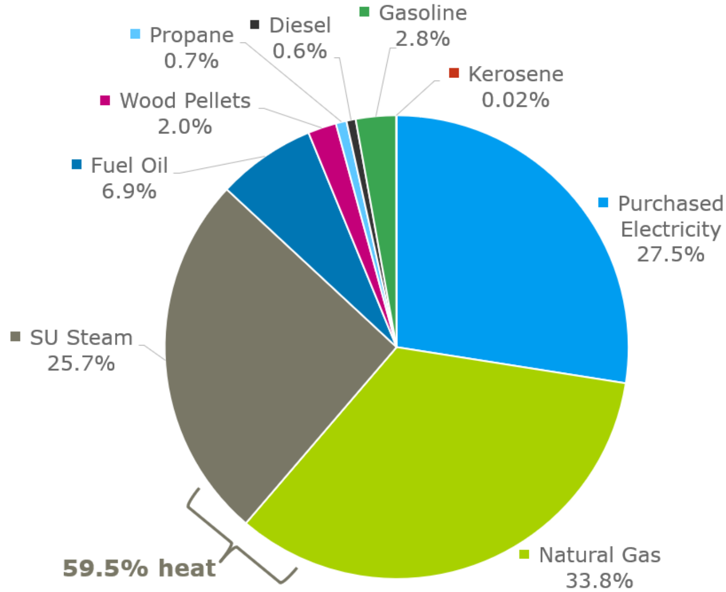

Figure 10. ESF Energy Use by Fuel Type (FY 2018-19)

Figure 3 below summarizes the GHG emissions (Scope 1 and Scope 2 sources) trend from fiscal year (FY) 2006-2007 (FY06-07) through FY18-19, where FY06-07 is being considered the baseline year for this CEMP. The values represent ESF facilities and properties including the main campus, satellite campuses and research stations, and forest properties.

GHG emissions were calculated utilizing emission factors within or referenced in the United States Environmental Protection Agency (USEPA) Simplified GHG Emission Calculator (SGEC)(sgec_tool_v5_1.xlsm). A summary of greenhouse gas emissions, including emission factors and source of fuel type and quantities, is provided in Appendix A. While opinions and stances vary, the UESPA is treating biogenic CO_2 emissions resulting from the combustion of biomass from managed forests at stationary sources for energy production as carbon neutral[1]. For purposes of developing this CEMP, CO_2 emissions from burning wood pellets have been assumed to be zero, while the associated carbon dioxide equivalent (CO_2e) constituents of methane (CH_4) and nitrous oxide (N_2O) have been included for estimating GHG emissions.

Scope 1 emissions are direct emissions from sources owned and controlled by ESF (*e.g.*, steam boilers, No. 2 fuel oil boilers, vehicle fleet) and Scope 2 emissions are indirect emissions from sources that are owned or operated by ESF, but whose products are directly linked to on-campus energy inputs (*e.g.*, purchased SU steam and purchased electricity). GHG emissions associated with Scope 2 transmission and distribution losses of the purchased SU steam are also noted, and are technically categorized as Scope 3 emissions; emission sources not owned or operated by ESF, but are related to ESF activities.

GHG emissions have reduced 25% over the 13-year period depicted in Figure 3, which included the opening of the Gateway Center (2013/2014) and a 16% increase in student enrollment. A

[1] https://www.epa.gov/air-and-radiation/epas-treatment-biogenic-carbon-dioxide-emissions-stationary-sources-use-forest#:~:text=On%20April%2023%2C%202018%2C%20EPA,energy%20production%20at%20stationary%20sources.

significant impact to energy reduction is observed from FY15-16 to FY18-19, which is attributed to a combination of hiring the campus' first Energy Manager, implementing energy efficiency projects, and broader utilization of the combined heat & power (CHP) plant located in the Gateway Center starting in FY16-17 (resulting in the associated increase in Scope 1 emissions and decrease in Scope 2 emissions).

Figure 4 provides a graphical representation of energy use intensity (EUI). EUI is estimated based on site energy data recorded in EnergyCAP and total ESF building property gross square footage. The overall trend (which is not weather normalized) has varied, but EUI has decreased approximately 10% since FY06-07.

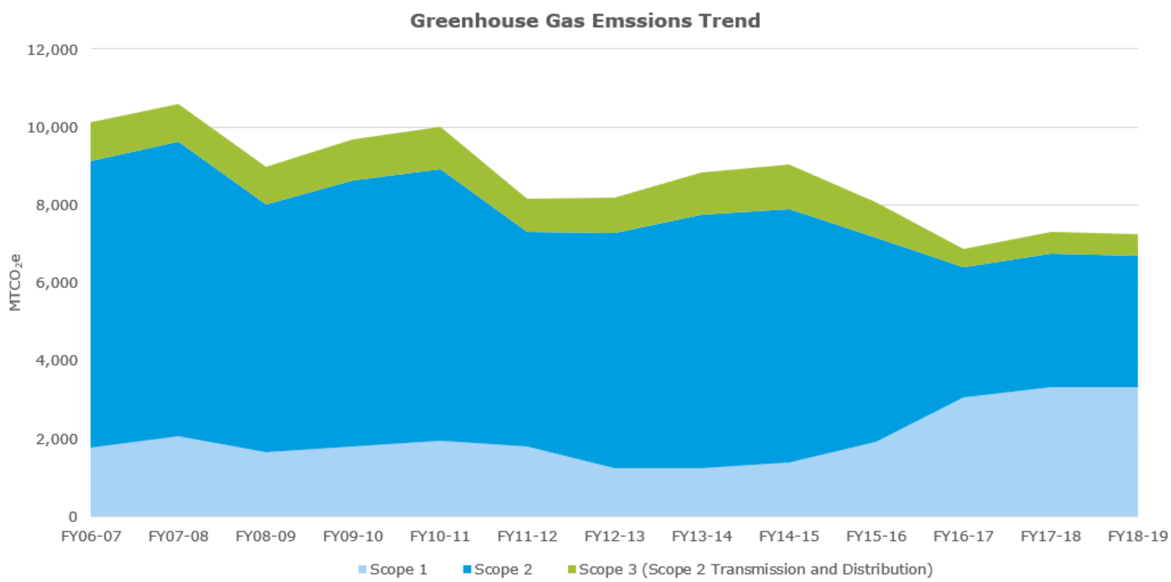

Figure 11. ESF GHG Emissions Trend Since Fiscal Year 06-07

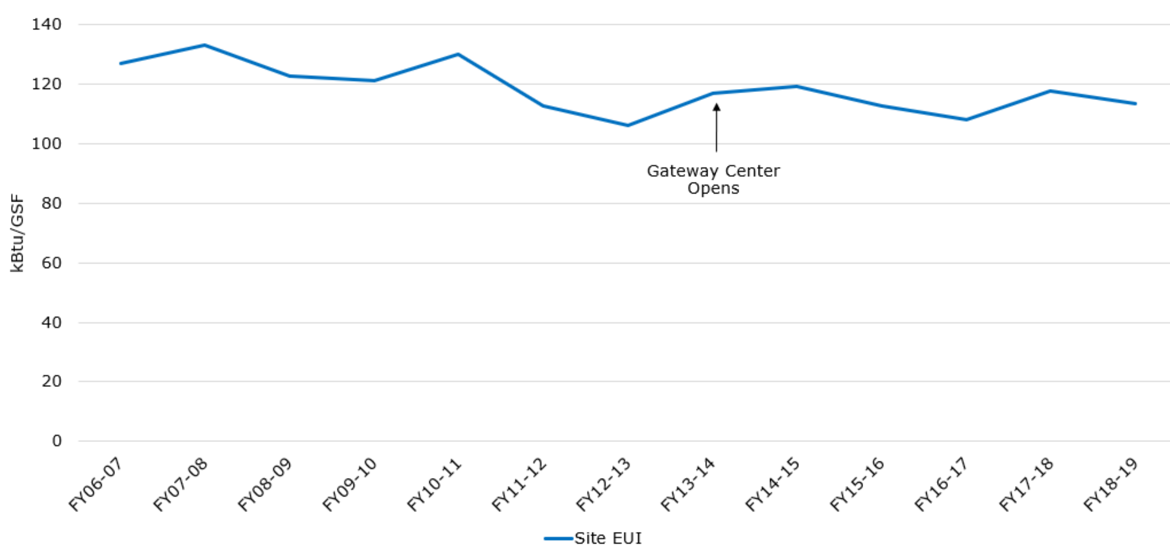

Figure 12. ESF Energy Use Intensity Trend Since Fiscal Year 06-07

2.2 Existing Conditions and Opportunities

Developing the CEMP included assessing energy sources, energy use, clean energy options, and institutional factors through a process of facilitated stakeholder engagement. Through aligning campus priorities with vision and goals of EO166, SUNY's Clean Energy Master Plan, the CLCPA, and SUCF directive 1B-2, the actions to reduce energy usage, increase energy efficiency, and decrease operating costs include five strategic focus areas – ***Energy Efficiency, Resiliency, Renewable Energy, Stewardship, and Engagement***. Table 2 through Table 6 summarizes the primary observations and opportunities in those five strategic focus areas.

Marshall Hall – Full renovation planned through 2022; discontinued steam use and designed to achieve SUNY goals for Deep Energy Retrofits (DER)

Table 3. Existing Conditions and Opportunities – Energy Efficiency

ASSESS: Existing Conditions and Opportunities		
	Existing Conditions	**Opportunities**
ENERGY EFFICIENCY Energy efficiency and conservation measures often involve capital expenditures that have short to moderate payback periods and are focused on driving near term reductions in GHG emissions and EUI, sometimes referred to as "low hanging fruit". Energy efficiency can also consider infrastructure renewal under major building major renovations or gut rehabilitations that will follow the performance goals of SUCF Directive 1B-2.		
Main Campus	• 2016: First full year of Gateway Center CHP operation	• ECMs being considered/planned: ○ Building automation system (BAS) control enhancements

ASSESS: Existing Conditions and Opportunities		
	Existing Conditions	**Opportunities**

	• 2017 Trane energy audit[2] (reference report for specific details)
	• Example ECMs implemented since 2017:
	  ○ Air handling unit rehabilitation and retro-commissioning
	  ○ Boiler #2 non-condensing stack economizer (Gateway)
	  ○ Compressed air replacement
	  ○ Controls systems optimization
	  ○ Electric motor replacements
	  ○ Installation of variable frequency drive (VFD) drives on feed pumps (Gateway)
	  ○ LED lighting retrofits
	  ○ Microturbine optimization (Gateway)
	  ○ Steam trap survey and replacements
		○ Building envelope (targeted air sealing, thermal bridging)
		○ Chiller optimization (Baker, Illick, and Jahn)
		○ Demand controlled ventilation (Illick)
		○ LED lighting upgrades (interior and exterior across campus)
		○ Retro-commissioning of air systems (Illick)
		○ Pipe insulation (piping valves and fitting assemblies)
		• Marshall Hall renovation

Ranger School	• 2017 ASHRAE Level 2 energy audit by Trane (reference report for specific details)
	• June 2019: Preliminary Feasibility Report[3] for biomass energy system
	• 2016-2017: Building envelope improvements, 50% complete.
	• October 2018: LED lighting retrofit, approximately 25% complete
		• Option 2 from the June 2019 Feasibility Report: Expanded Use of Existing Pellet Boiler, with the addition of thermal storage
		• ECMs considered/planned
		  ○ Further LED lighting upgrades (interior and exterior)
		  ○ BAS controls enhancements to improve occupant thermal comfort and reduce energy
		  ○ Variable speed drives on hot water and chilled water pumps
		  ○ Building envelope upgrades to the 1928 Main Building – wall insulation, replacing doors, sealing existing windows
		  ○ On-demand domestic hot water heaters

[2] Trane, *SUNY ESF FlexTech Energy Study*, April 2017

[3] US Department of Agriculture Forest Service, USFS Wood Education and Resource Center, Wilson Engineering Services, *Preliminary Feasibility Report, SUNY ESF Ranger School, Biomass Energy System*, June 2019

ASSESS: Existing Conditions and Opportunities		
	Existing Conditions	**Opportunities**
Other Satellite Campuses	• Cranberry Lake Biological Station: Full LED retrofit for all cabins and classrooms • Heiberg Forest facility: ○ Installed new right sized on-demand point of use electric water heater ○ Installed programmable line voltage thermostat for electric baseboard heat in maintenance supervisor's office	Cranberry Lake • Building envelope improvements • LED lighting upgrades and lighting controls
Building Level Sub-metering	• 2016: Installed building submetering and on-line energy dashboard (Lucid OS Platform). The eleven campus buildings are metered for electricity, steam, natural gas, and water.	• For Jahn Labs, NYPA has provided a New York Energy Manager (NYEM) budgetary proposal for up to 600 data points (45 meters) for system level submetering, and connection/integration with the NYEM' cloud-based analytics platform • Further deep submetering within other individual buildings at a system level • Potential to leverage NYSERDA's Real-Time Energy Manager (RTEM) Program

ESF Quad – Potential geothermal field location for ground source heat pump system designed for heating and cooling of Moon Library

Table 4. Existing Conditions and Opportunities - Resiliency

<table>
<tr><th colspan="3">ASSESS: Existing Conditions and Opportunities</th></tr>
<tr><th></th><th>Existing Conditions</th><th>Opportunities</th></tr>
<tr><td colspan="3">RESILIENCY
Defining resiliency is unique to each campus. Resiliency for ESF is the desire to decarbonize through reducing fossil fuels and increasing renewables and electrification. This includes both short-term and long-term transition aspects; completing building renovations to utilize low carbon energy supplies, establishing energy storage, maximizing the use of the Gateway Center CHP assets, and maintaining backup and peaking capabilities to cover heating/cooling needs.</td></tr>
<tr><td>District Energy Network</td><td>• ESF operates a steam distribution network. Approximately 40% of steam used is purchased from Syracuse University (SU) and the remaining 60% is produced by the Gateway Center CHP plant
• SU steam serves
  ○ Baker Hall (kilns and autoclaves)
  ○ Bray Hall
  ○ Illick Hall (50%)</td><td>• Transition from steam to a low temperature hot water distribution network that would:
  ○ Enable a platform with flexible compatibility for low carbon/renewable energy supplies such as geothermal, thermal energy storage, heat pumps, and biomass, along with providing provisions for future developments of heating and cooling technology developments</td></tr>
</table>

ASSESS: Existing Conditions and Opportunities		
	Existing Conditions	**Opportunities**
District Energy Network	○ Jahn Laboratory (autoclaves) ○ Marshall Hall (planned gut renovation/deep energy retrofit during 2020-2022 in accordance with SUCF Directive 1B-2, and will be decentralized) ○ Old Greenhouse (will be decentralized when Marshall Hall is renovated) ○ Physical Plant ○ Walters Hall • The Gateway Center CHP plant serves itself, Baker Laboratory, Jahn Laboratory, Illick Hall, and Moon Library. Before the Gateway Center, 100% of the campus steam was purchased from Syracuse University. The CHP plant provides 60% of the thermal energy and 12% of the electrical energy to the campus, and includes the following technologies: ○ Biomass (wood pellet) boiler that produces high-pressure steam that feeds a steam turbine to produce electricity ○ Two natural gas-fired steam boilers ○ Three 65 kW CHP natural gas microturbines • Heat recovery steam generator	• Align with SUCF Directive 1B-2 for deep energy retrofits and energy efficiency • Become more energy independent and better manage utility costs, and • Help meet or exceed GHG mandates • ESF desires to decarbonize by reducing fossil fuel use and increase renewables (see below) and electrification. This would be a long-term horizon transition and would be coupled with necessary building renovations to utilize low carbon energy supplies. As an interim transition step, steam (currently supplied from SU) would be needed for Bray Hall, Walters Hall and Old O&M until the buildings are renovated. The steam network should be evaluated to identify potential options of supplying steam to these buildings from Gateway Center, which could help maximize the life of the assets.

ASSESS: Existing Conditions and Opportunities		
	Existing Conditions	**Opportunities**
Geothermal	• Moon Library: Participation in the Geothermal Clean Energy Challenge through NYPA and NYSERDA. November 2019: Advanced to Stage 3 of study, which includes test bore hole, energy audit/feasibility study, and 30% design submission. • In February 2020, ESF competed for a NYSERDA Energy to Lead grant to fund Moon Library Ground Source Heat Pump (GSHP) Project, however, project was not selected	• A well field located in the Quad would serve Moon Library, but could also potentially serve a campus district hot water loop, and thereby achieve a higher utilization of full load hours • Other potential locations for wells exist and should be assessed further for feasibility and heat/cooling capacity
Facilities Master Plan	• A Facilities Master Plan (FMP) was developed concurrently with the CEMP. This afforded the opportunity for a collaboration meeting with JMZ in September 2019 to discuss the scope, status, and anticipated outcomes of each project, and attempt to understand any diverging paths, conflicts, or synergies between the two planning efforts. • JMZ presented Master Plan Concepts in February 2020; Concept 1 (no build) and Concept 2 (new build).	• Once a concept is selected by ESF, further integration of the FMP and CEMP would be needed to align the vision, projects, and implementation phasing of both documents

Baker Laboratory 25 kW solar photovoltaic array that also provides window shading for the building's south side

Table 5. Existing Conditions and Opportunities – Renewable Energy

ASSESS: Existing Conditions and Opportunities		
	Existing Conditions	**Opportunities**
RENEWABLE ENERGY Renewable energy centers on ESF's desire to achieve GHG reductions by decreasing fossil fuel use and increasing electrification of campus operations that would utilize renewable electricity, along with continued use of biomass where economically feasible.		
Large Scale Solar PV	• Participating in New York Higher Education Large Scale Renewable Energy (NY HE LSRE), a large-scale solar consortium of New York State public and private campuses. Price estimates and detailed analysis are expected in summer 2020	• Decide whether to participate and at what level

ASSESS: Existing Conditions and Opportunities		
	Existing Conditions	**Opportunities**
Campus Solar PV	• ESF has three roof-mounted PV arrays on the main campus. A 25-kilowatt (kW) array on Walters Hall, a 25-kW array on Baker Laboratory, and a 50-kW on Moon. • A small ground-mounted array at the ESF Tully research station, but these projects provide less than 1% of ESF's total electricity demand and are only operating at about 80% of the anticipated production	• Participation in NY HE LSRE consortium (noted above) could make a substantial near-term impact towards the campus' electricity being renewable energy • Further, through the Climate Leadership & Community Protection Act (CLCPA), NYS is committed to reducing GHG gas emissions 85% by 2050 (from 1990 levels) and having a carbon free electric grid by 2040. In this case, the electricity grid is expected to be incrementally cleaner each year towards those goals, thus impacting ESFs annual GHG emissions.
EV Fleet Transition	• Participated in Energy to Lead Competition 2017 (NYSERDA RFP 3675) under an application titled: ***Driving on Sunshine****, Solar Power, Electric Vehicles and Charging Stations.* The aim of the project was to demonstrate the potential for campuses, communities, organizations and individuals to transition to renewable solar photovoltaic (PV) and electric vehicles (EVs). However, the project was not selected.	• While the project was not selected, the goals are in line with ESF's vision and mission, and the principles and targets of REV, with the intent to assist SUNY, the REV Campus Challenge network, NYSERDA, and NYS in meeting common goals for renewables and climate action • ESF is currently in process to install EV charging stations for public use. ESF will look to SUNY System Administration for guidance on electrification/phase out of the college vehicle fleet.
Biomass	• Gateway Center: Today, operation of the existing wood pellet boiler is limited to peak load situations due to the high operational cost of wood pellets relative to natural gas. ESF committed to 200 tons for the 2019-2020 heating season. • Ranger School: June 2019: Preliminary Feasibility Report for biomass energy system	• Gateway Center: Future consideration for a biomass boiler would be more economical to operate if based on wood chips or similar low-cost biomass fuel in bulk form • Ranger School: The installation of a biomass heating system presents the opportunity to reduce energy costs, reduce fossil fuel use, net GHG emissions, and utilize wood resources produced from the school's managed forest lands.

Heiberg Forest energy audit to identify energy conservation measures

Table 6. Existing Conditions and Opportunities – Stewardship

ASSESS: Existing Conditions and Opportunities		
	Existing Conditions	**Opportunities**
STEWARDSHIP Stewardship focuses on the human capital and physical capital needs of managing energy systems to achieve and maintain peak performance.		
Campus Energy Management	• Campus Energy Manager established in 2016 • Director or Energy Management & Utilities established in 2018 • Energy Conservation Development & Controls (ECDC) Team	• Implementation of short-term and long-term actions within the CEMP
Workforce Training	• Participating in NYSERDA PON 3715 Workforce Training: Building Operations & Maintenance. Working with Urban Green Council (UGC) to enhance skills of operations and maintenance staff in the use of tools to monitor, analyze and conserve energy	• Leverage NYSERDA PON 3715 – Workforce Training: Building Operations & Maintenance for energy management and human capital development through On-the-Job-Training (OTJT) • Continued development of tools and skill sets that are required to make the program sustainable, including GPRO

ASSESS: Existing Conditions and Opportunities		
	Existing Conditions	**Opportunities**
	• Established workforce and potential for institutional knowledge loss in the next 5 to 10 years from the trade crafts and supervisors due to retirement and/or career transition	O&M and NYEM (potentially), along with integrating new training initiatives within standard business procedures and merge training into the campus culture to support operations and maintenance • Establishment of an ongoing training program for documentation and recordkeeping of institutional knowledge
Preventive Maintenance Focus	• Preventive Maintenance Software – Equipment inventory, preventative maintenance (PM), and work order management are currently through FY20-21	• Continuous development of preventative and predictive maintenance program • Plans for use of AssetWorks AiM platform for Computerized Maintenance Management System (CMMS)
Advanced Metering and Data Analysis	• Current use of Lucid OS Platform (with an annual subscription fee)	• Potential for system level submetering, and connection/integration cloud-based analytics platforms like NYEM and RTEM
Retro-commissioning (RCx)	• Focus area since 2016 when ESF filled the Energy Manager position, now Director or Energy Management & Utilities	• Make RCx and ongoing commissioning (Cx) an integral part of the College's O&M program
Sustainability Standards	• Planned establishment of Sustainability Standards	• ESF has a target of achieving an AASHE STARS Platinum rating for sustainability and a Zero Waste Campus defined by a 90% diversion rate
Energy Policies and Guidelines	• Campus Space Temperature Guidelines • Guidelines for space heater drafted for approval	• Enforcement of guidelines • Complete and/or develop program and policy changes that support reduced emission behaviors • Establish vehicle purchase and operation standards to reduce fuel consumption, while working with SUNY System Administration on plans for EV Fleet transition • Expand data inventory of energy using systems through AssetWorks

ASSESS: Existing Conditions and Opportunities		
	Existing Conditions	**Opportunities**
Forest Management and Sequestration	• Climate and Applied Forest Research Institute (CAFRI) based at ESF. A multi-disciplinary team of forest, energy and climate experts. CAFRI is developing a four-part protocol for forest carbon accounting that includes high-resolution forest mapping, historical change detection, landscape monitoring and hierarchical forecasting. This work is being carried out in close partnership with the Office of Climate Change and the Division of Lands & Forests at the NYS Department of Environmental Conservation, and is supported by the NYS Environmental Protection Fund.	• ESF has 25,000 acres of forest property that can be utilized for carbon sequestration management in offsetting a portion of ESF's GHG emissions towards NYS mandates and campus neutrality goals.
Planning Documents	• Facilities Master Plan (FMP) (2020) • Strategic Plan Update (2016) • Vision 2020	• Integration of the CEMP and FMP • SUCF and capital fund critical maintenance plans and projects

Students and physical plant staff paired up to install nearly 300 tubes for the Main Campus LED Lighting Blitz

Table 7. Existing Conditions and Opportunities – Engagement

ASSESS: Existing Conditions and Opportunities		
	Existing Conditions	**Opportunities**
ENGAGEMENT Engagement focuses on how ESF integrates energy and sustainability into the cultural fabric of the College, as well as through building and connecting through community engagement.		
ESF-Wide Overview	• NYSERDA REV Campus Challenge Leader • Achieved AASHE STARS Gold in 2016 • Second Nature, Sierra Cool Schools, and Princeton Green Review participation and reporting	• Committed to attaining AASHE STARS Platinum • Continued focus on promoting energy conversation awareness to impact behavioral change
Curriculum and Student Engagement	• 2009 Climate Action Plan (CAP) and AASHE STARS reports • Energy and sustainability projects for pay or course credits • Senior capstone projects to analyze energy efficiency and renewable energy on campus	• Student educational and engagement potential for the Moon Library GSHP project, as well as a future low temperature hot water distribution network.

ASSESS: Existing Conditions and Opportunities		
	Existing Conditions	**Opportunities**
	• Sustainable construction management program – analysis and modeling of campus buildings and energy use	
Outreach and Community Engagement	• Sharing lessons learned and best practices through existing and new channels • Over ten years of hosting the Sustainable Use of Renewable Energy (SURE) conference • For seven years, the Outreach Office provided a solar PV installation training outreach program • Engagement with New York Coalition of Sustainability in Higher Education (NYCSHE) • Participation in NYSERDA REV Workshops • Founder and 18-year sponsor of the New York Green Building Conference • Hosting and sponsoring of the 2020 Mass Timber Symposium	• Continued leadership in building dialogue and making connections to advance energy and sustainability market initiatives

3. ACT – CLEAN ENERGY MASTER PLAN

The CEMP process allowed for critical discussion of key mandates and drivers, coupled with strategic thinking of clean energy options to create a vision of the most economically viable low carbon and renewable technologies and operational strategies to reduce fossil fuel use/dependency, increase electrification, and maintain resiliency and reliability. Table 7 below provides a high-level summary of the planned actions within the five strategic focus areas of ***Energy Efficiency, Resiliency, Renewable Energy, Stewardship, and Engagement***, followed by support actions, and the expected reduction of GHG emissions and site EUI.

Table 8. Energy Roadmap | Strategic Focus Areas

ENERGY EFFICIENCY	RESILIENCY	RENEWABLE ENERGY	STEWARDSHIP	ENGAGEMENT
Low Cost/No Cost Measures	Steam to Low Temperature Hot Water	Large Scale Solar Power Purchase Agreement	Campus Energy Manager	Energy Conservation Awareness and Behavioral Change
Energy Conservation Measures	Low Carbon Energy Supply • Geothermal Heat Pumps • Thermal Energy Storage • Backup and Peak Generation	Biomass	Retro-commissioning	Integration with Curriculum, Research, and Workforce Development
Building Renovations	Gateway CHP	EV Fleet Transition	Preventative Maintenance Focus	
Deep Energy Retrofits	Integration with Facilities Master Plan (FMP)		Advanced Metering and Data Analysis	
Net Zero Carbon New Buildings			Workforce Development	
% Contribution to GHG Reduction				
26%	**41%**	**25%**	**6%**	**2%**
% Contribution to Total Source kBtu/GSF Reduction				
40%	**47%**	**0%**	**9.5%**	**3.5%**

3.1 Basis for a Low Carbon Transition

The fundamental basis for establishing a low carbon campus is transitioning the district heating network from steam to hot water and moving to 100% renewable sources for electricity. Figure 5 below summarizes the current situation of a steam-based campus (Main Campus) district energy network and the vision of a future low carbon energy supply. This conversion has the following attributes:

- Enables a platform with flexible compatibility for low carbon technologies to be incorporated over time – a plug and play approach, while providing provisions for future developments of heating and cooling technology developments
- Allows the use of existing assets to extent practical during the transition period
- Integrates with building improvements tied to the FMP.

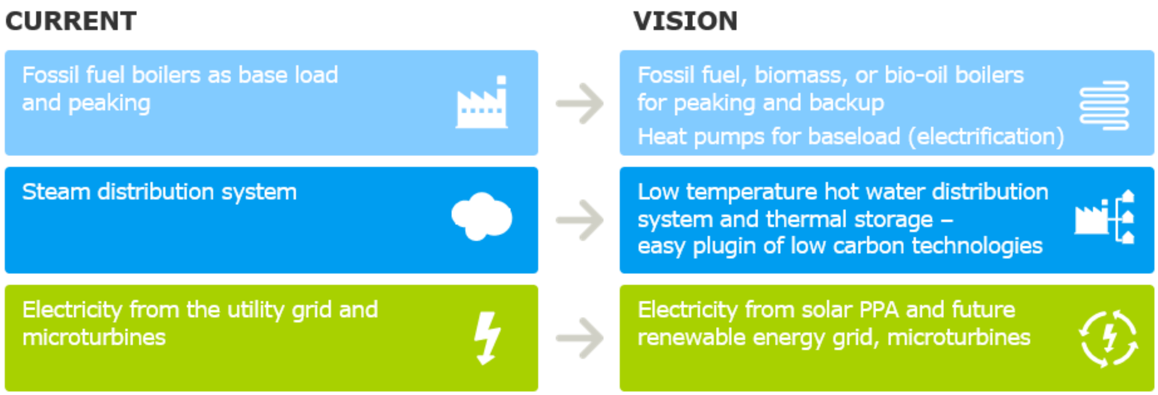

Figure 13. ESF District Energy Network – Current Versus Vision of Low-Carbon Technologies

Figure 6 details the existing steam distribution network and a potential hot water distribution network. The black line indicates the steam distribution network from Syracuse University; the red line indicates steam that is produced and distributed by the Gateway Center; and the blue line indicates a potential hot water distribution network. The location and layout of the hot water network is dependent and conditional on the direction ESF chooses for the FMP.

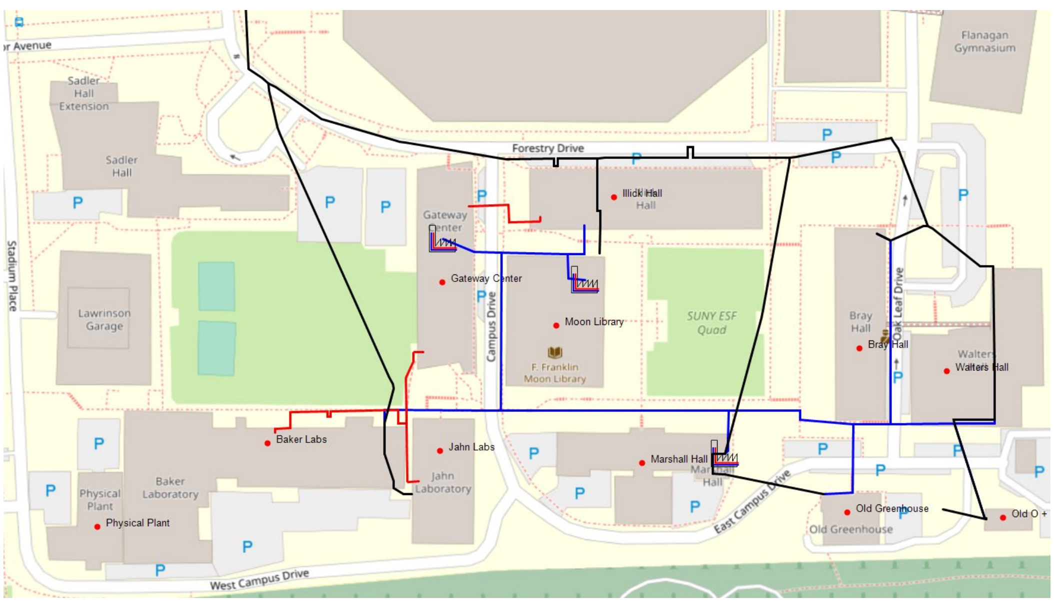

Figure 14. Main Campus – Existing Steam Distribution and Potential Hot Water

Existing Steam Distribution Network – From Syracuse University

Existing Steam Distribution Network – SUNY ESF

Proposed Hot Water Distribution Network

3.2 Energy Modeling and Scenario Planning

To help establish the vision of a future low carbon energy supply, a feasibility study of energy scenarios was completed to provide quantitative information and path forward considerations. The current situation (*i.e.*, Scenario 0) was compared to seventeen scenarios that included integrated combinations of measures and technologies such as energy conversation measures, steam to low temperature hot water (hot water) conversion, building renovations, geothermal, thermal energy storage, biomass, heat pumps, and co-generation. The results are summarized in an Energy Scenario Planning Report (April 2020) that can be referenced for specific details.

A stakeholder engagement meeting was held on February 6, 2020 with the ESF CEMP committee and ESF Administration to share the energy modeling and scenario planning results, and discuss current and future district energy aspects at ESF. Figure 7 presents the five scenarios (2b, 3a, 3b, 5a, and 5b) that aligned ESF's priorities with NYS mandates and SUNYs goals/directives.

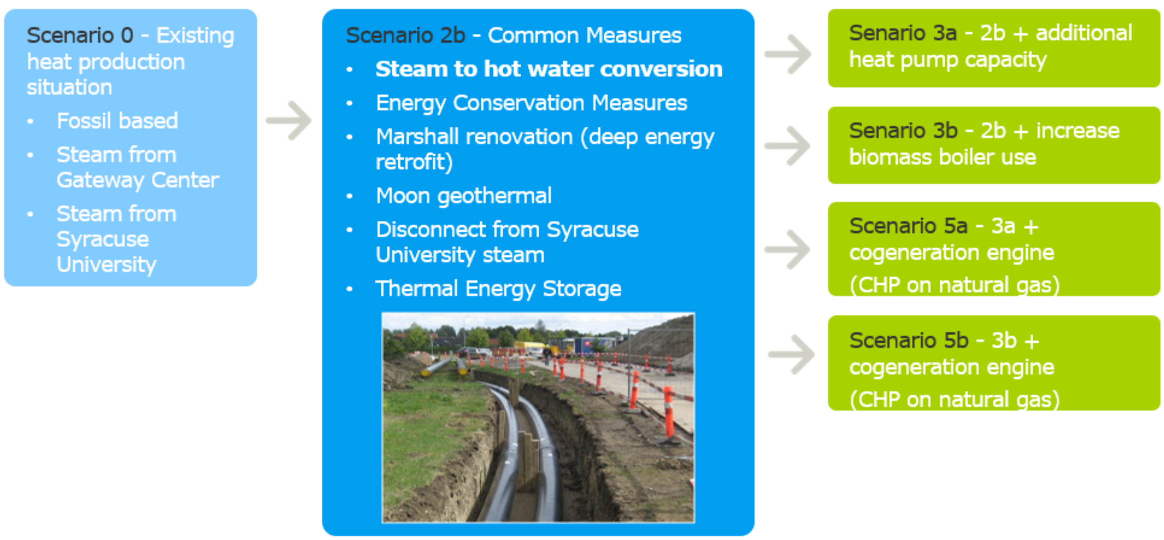

Figure 15. Main Campus – Clean Energy Scenarios

Scenario 2b are common measures, in addition to steam to hot water conversion, that ESF would include in the basis for the transitioning to low campus solutions at the Main Campus. Of those common measures, energy conservation measures (ECMs) have been and will continue to be implemented, Marshall Hall renovations are scheduled to occur through October 2022, Moon Library ground source heat pump (GSHP) 30% design is underway in 2020, and a hot water network is envisioned that would include thermal energy storage.

Scenario 3a includes an additional GSHP system with the same capacity as the Moon Library GSHP. A final location of the wells is not agreed upon at this time, but the parking lot at Walters Hall (P1) is a possibility, along with the assessing the potential of well development in parking lots to the west of campus including the Stadium Place parking lot (P22) or other areas.

Scenario 3b considers increased use of the existing biomass boiler. Today, operation of the existing wood pellet boiler is limited to peak load situations due to the relatively high operational costs; primarily the high price of wood pellets. Instead of installing a new wood pellet boiler, the existing wood pellet boiler is used as intermediate load. In this scenario, the biomass boiler is operated more than the gas boilers to achieve carbon reductions even though the marginal cost of gas boilers is lower. Scenarios 5a and 5b include CHP with Scenarios 3a and 3b, respectively.

3.3 Scenario Planning – Economic Results and Discussion

Figure 8 provides a comparison of project costs (in net present value (NPV)) and associated GHG emissions from the five scenarios. By developing a hot water loop for district heating it will be possible to lower emissions considerably. The total costs over the 20-year evaluation period are higher than in the business as usual situation (existing conditions) when moving toward low emission technologies. This is primarily due to low natural gas prices. Note that the existing conditions year 20 emissions are lower than the year 1 emissions due to the expected reduction in grid electricity emissions through the CLCPA.

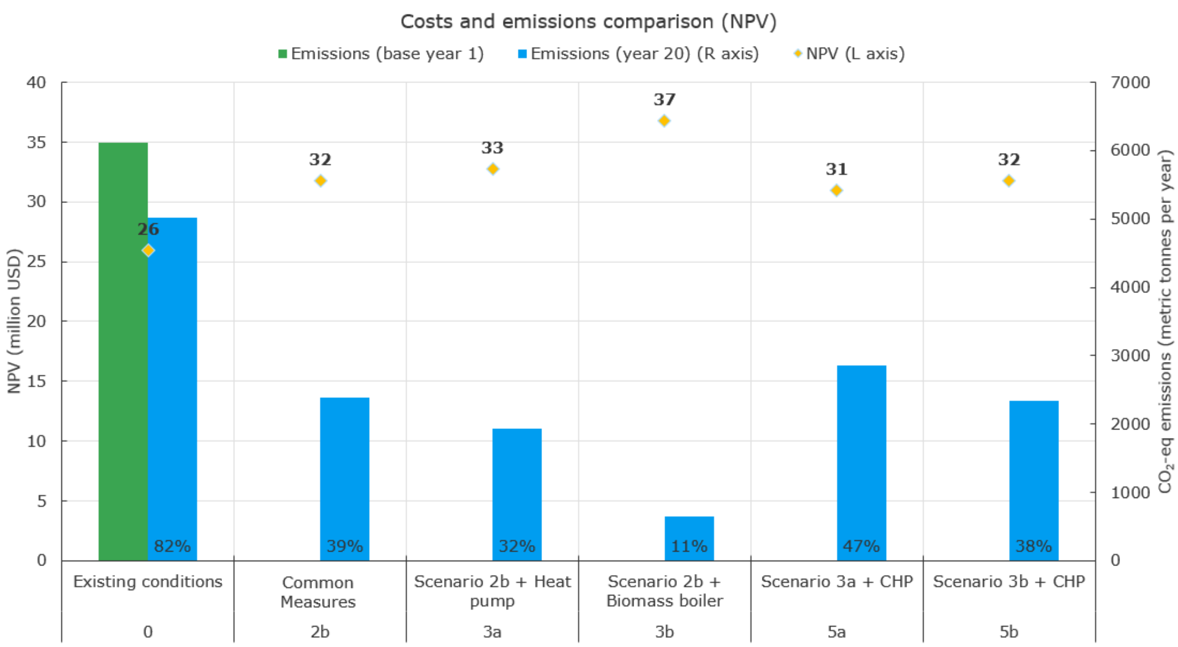

Figure 16. Low Carbon Energy Scenarios Comparison

The yellow diamonds show the present value for each of the scenarios in million US Dollars. All costs (capital expenditures, operating and maintenance expenditures) are accounted for in each year in a 20-year period. The residual value of assets that have a technical lifetime beyond the 20-year period is also accounted for. The net present value is the lifetime costs assuming a 4.5% discount rate. The present values of the costs (called NPV in Figure 8) are read on the left axis but are also identified for each scenario.

The blue bars are the CO_2e emissions and are read on the right axis. The percentage noted at the bottom of each blue bar is the GHG portion remaining after reductions for that scenario as compared to the year 1 existing condition baseline (represented by the green bar).

NPV costs increase from the existing conditions. The reason is that costs for energy efficiency measures and conversion of steam buildings to hydronic have been incorporated into the modeling with an estimated total capital expenditure of $12 million. The $12 million cost estimate considers only energy measures associated with heat demand reduction.

Scenarios **3a and 3b** show significant NPV cost increases due to the high price of wood pellets. The operational costs increase if more capacity is added or if the existing wood pellet boiler is used to serve base or intermediate loads rather than only peak loads.

With a projected increase share of wind and solar PV electricity to the grid as a result of the CLCPA, the lowest hourly electricity prices might gradually decrease. This will increase operational costs (and reduce or eliminate savings) to operate a CHP compared to other technologies (lower prices for electricity).

Since electricity from the grid is expected to be carbon neutral by 2040, heat pumps (as in Scenarios 3a and 3b) will be a good low carbon option. A consideration is whether biomass should be combined with heat pumps production; this will depend on the biomass price as well as the perception of biomass as a low carbon fuel.

Based on these additional considerations, combined with uncertainty about consideration of bio-oil as a low carbon technology, a new CHP as part of the future generation asset mix should be further evaluated. It is noted, that if additional heat pump installations will require electrical feeder upgrades, then additional CHP capacity could be an alternative to the feeder upgrade. CHP could also be considered for resiliency reasons in the event of power grid outages.

The main difference between Scenarios 5a and 5b is that the existing biomass boiler in 5b is assumed to be producing the intermediate load, whereas the intermediate load and peak load are produced from gas boilers in Scenario 5a. Since wood pellets were considered a low carbon fuel in the assessment, the emissions in Scenario 5b will be lower. Similar emission reductions could be achieved in Scenario 5a with a conversion to bio-oil on the existing boilers. Additional heat pump capacity is an alternative to installation of new CHP capacity (as in Scenarios 5a and 5b). If the heat pumps are heat recovery chillers, then it will be possible to co-produce heating and cooling.

3.4 Potential Low Carbon Heating Strategy

A potential low carbon heating strategy for ESF to follow could be to increase the GSHP capacity beyond what is planned for Moon Library. Due to high investment costs, the heat pumps should be sized to a design capacity corresponding to maximum 50% to 60% of the network peak heat demand and should be base loaded in operation. The production to the low temperature network from heat pumps could look as in Figure 9.

Figure 9 is a load duration curve showing the hourly estimated heating load for the main campus central heating system after ECM's are applied to the buildings. The shaded areas under the curve represent the amount of heat provided by each supply asset.

Heat pumps combined with thermal storage enable a connection between the electric grid and the heat demand, but the heat pumps should only be used in combination with a heat storage tank to be able to support the electric grid and should primarily produce in off-peak hours. In peak hours, other technologies should produce heating in the event thermal storage capacities are insufficient. A heat pump system could be combined with other supply technologies, which might be bio-oil boilers. Bio-oil boilers can be used to operate for only short periods of time during peak heating loads when sufficient heat pump capacity has been installed.

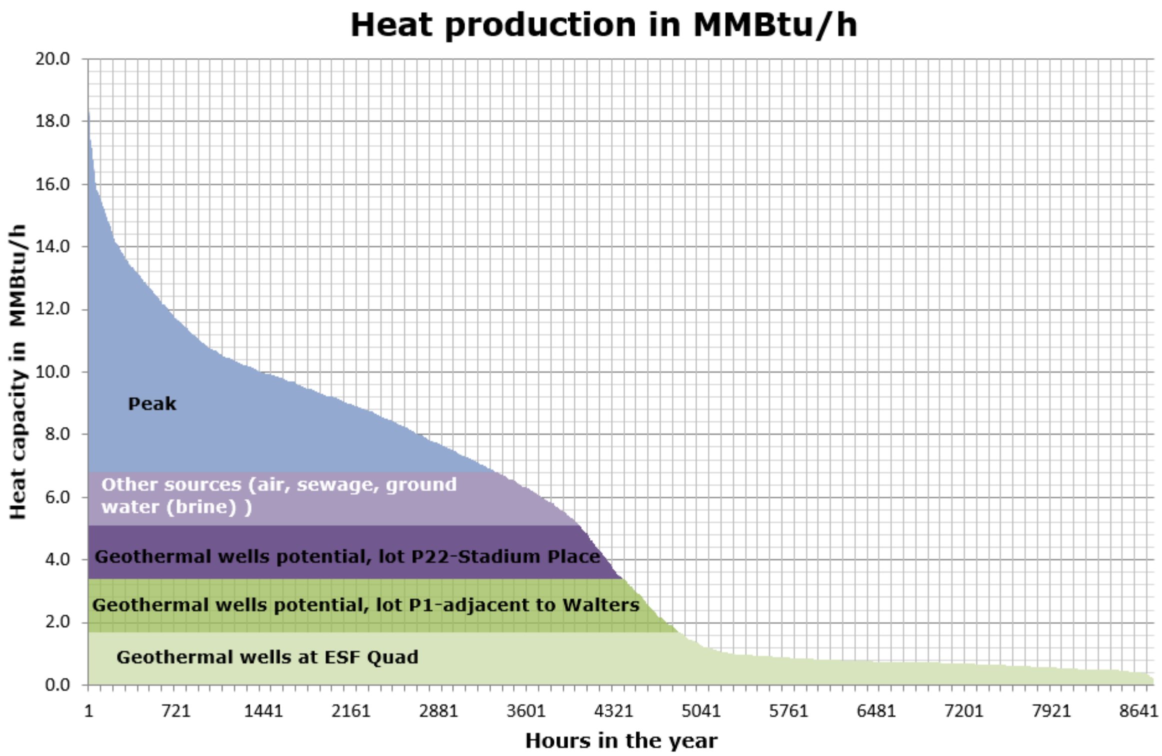

Figure 17. Heat Production with Different Locations for Heat Sources

For base load purposes, "Wells at ESF Quad" are the Moon Library heat pumps. Instead of serving only Moon Library, this system could be connected to the central heating loop. Figure 9 also suggests other sources for GSHP heat pumps (*e.g.*, other parking lots, sewage, ground water). These sources would need further feasibility investigation, but the total production from heat pumps is illustrated at approximately 65-70% of the total annual heating load, which is anticipated to also cover the full demand for cooling assuming establishment of a central heating and cooling loop.

3.5 Proposed Steam to Hot Water Phasing Plan

Establishing the hot water network will have challenges and will require careful consideration to maintain building heating throughout the project period. It will be necessary in early project phases to have both the new low temperature hot water network in operation together with the existing steam system to serve the non-hydronic buildings. Figure 10 provides a proposed steam to low temperature hot water phasing plan that aims for a pragmatic transition timeframe, while incorporating the continued use of Gateway Center as a bridging facility for the east side of campus.

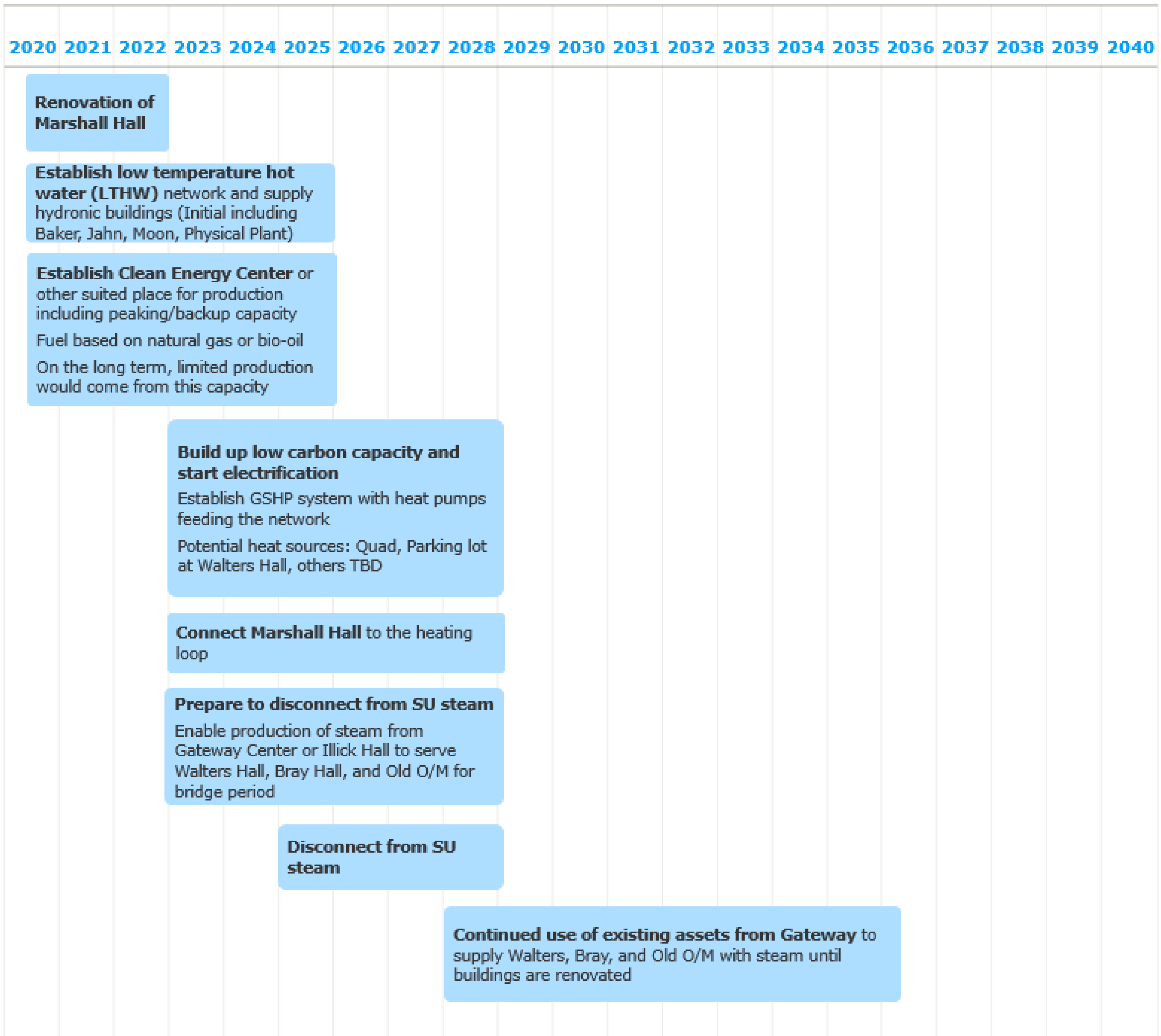

Figure 18. Proposed Steam to Low Temperature Hot Water Phasing Plan

3.6 Summary of Energy Projects

ESF has implemented and continues to implement ECMs. Major renovations to some buildings are also planned and will include deep energy retrofits (*e.g.*, Marshall Hall). The total efficiency of the energy system can be significantly improved by reducing the required heating supply temperature and increasing the required cooling supply temperature for chilled water to the buildings. This will help allow for strategic use of low carbon technologies.

Table 4 in Appendix B identifies ECMs that have not been completed, but are still being considered (most from consulting reports) for implementation or are planned for implementation as a result of this CEMP development process. Major gut renovations that are planned (Marshall Hall) or being considered (Illick Hall) are also noted. The measures reflect the campus' priorities in physical asset renewal, cost savings, EUI reduction, capital outlay, and GHG reductions. Subtotals for each of the five strategic focus areas were multiplied by an assumed 0.7 interactive factor to account for potential interaction between measures.

Energy savings were derived from the following utility rates:

- Electricity 0.069 $/kWh
- Natural gas 0.443 $/therm
- Steam 22.86 $/klbs
- Fuel oil 1.25 $/gal
- Propane 0.95 $/gal

Energy conservation measures generally involve capital expenditures that have short to moderate payback periods and are focused on driving near term reductions in GHG emissions and EUI, sometimes referred to as "low hanging fruit". Even with a portfolio of completed energy projects and actions, it has become increasingly difficult to achieve additional deep energy savings without making significant capital investments. Careful consideration is required before investing in ECMs that affect systems and controls that are at or near the end of their effective useful life. The short-term savings need to be weighed against the long-term cost effectiveness if the buildings they serve are destined for overall renovation in the foreseeable future.

Long Term Infrastructure Renewal – Energy improvements to systems and equipment that have reached the end of their effective life need to address system/equipment replacement to maintain the comfort, health, and safety of building occupants. This requires major renovation and significant capital investment resulting in longer term payback periods than ECM projects. However, in addition to the energy savings, these projects provide the benefits associated with newer systems and infrastructure. Major building major renovations or gut rehabilitations will follow the performance goals of SUCF Directive 1B-2.

3.7 Greenhouse Gas Emissions and Energy Use Intensity Reduction Impact

The figures below summarize potential GHG emission reductions estimated from the modeling scenarios that were short listed. Figure 11 and Figure 12 show the impact to the Main Campus emissions under two considerations; GHG emissions without a renewable electricity grid (year 1) and GHG emissions with a renewable electricity grid (year 20). Figure 13 and Figure 14 show the impact to All ESF Properties emissions under the same two considerations.

In all four figure illustrations, Scenario 0 represents grid GHG emissions in year 1. Figures 12 and 14 represent grid GHG emission in year 20. The assumption of a renewable electricity grid aligns with the CLCPA commitment to a carbon free electric grid by 2040, as well as ESF's planned participation in the NY HE LSRE consortium or another potential power purchase agreement (PPA) option. Further, wood pellets and bio-oil are assumed to have limited GHG emissions given their consideration as renewable energy sources. Refer to Appendix A for additional information about GHG emissions.

For illustration and comparative purposes, electrification (with natural gas and with bio-oil) is also shown to represent the potential impact of non-fossil fuel base load operations. In these illustrations, it is assumed that 70% of heat production would be from heat pumps, and 30% would be from either natural gas or bio-oil. However, it is noted that electrification of base load operations was not modeled as part of the scenario planning analysis; that would require subsequent investigation to assess feasibility and project economics.

In Figure 11 and Figure 12, Scenario 0 shows 6,532 metric tons carbon dioxide equivalent ($MTCO_2e$) from the existing conditions at the Main Campus (steam-based). As noted in Section 3.2, Scenario 2b incorporates common measures that ESF would include in the basis for the transitioning to low carbon campus solutions. In Figure 11, Scenario 2b represents a 47% reduction of $MTCO_2e$ as compared to Scenario 0. Scenarios 3a through 5b have reductions that range from 47% to 74%. Electrification, with natural gas and with bio-oil, represents approximately 67% and 79% reductions in GHG emissions, respectively.

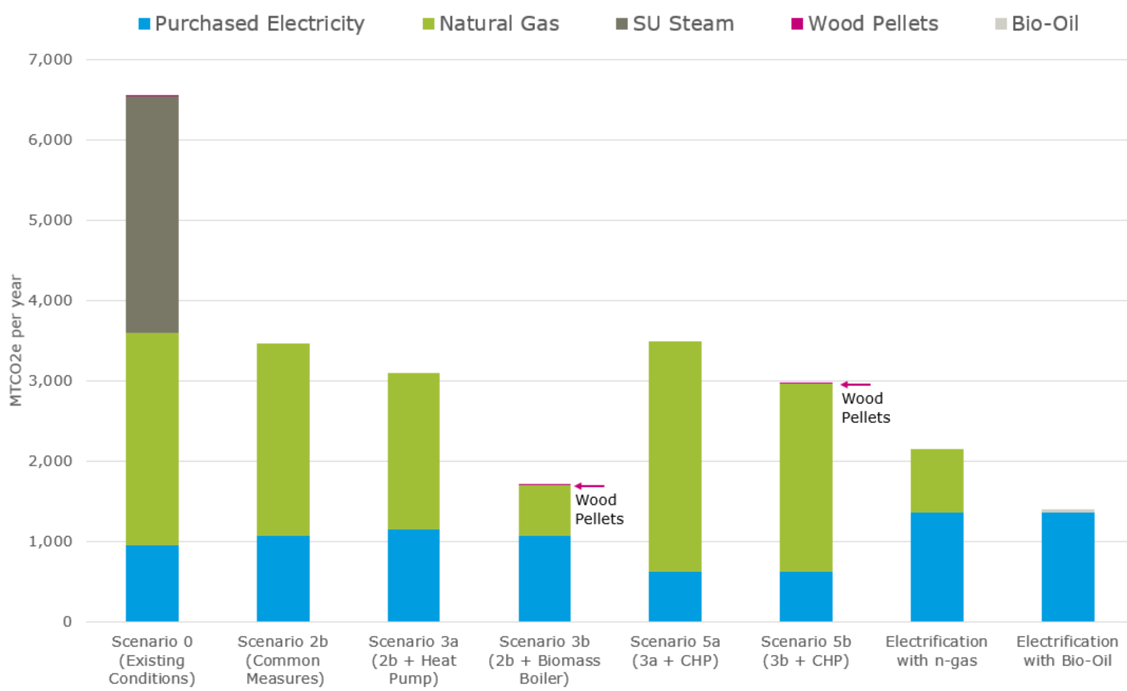

Figure 19. ESF Main Campus – GHG Emissions without Renewable Electricity

In Figure 12, the same scenarios are compared against the assumption of the electricity grid is expected to be carbon free by 2040. In this case, Scenario 2b represents a 63% reduction of $MTCO_2e$ as compared to Scenario 0. Scenarios 3a through 5b have reductions that range from 64% to 90%. Electrification, with natural gas and with bio-oil, represent approximately 88% and 99% reductions in GHG emissions, respectively. Electrification represents approximately 88% to 99% reduction in GHG emissions.

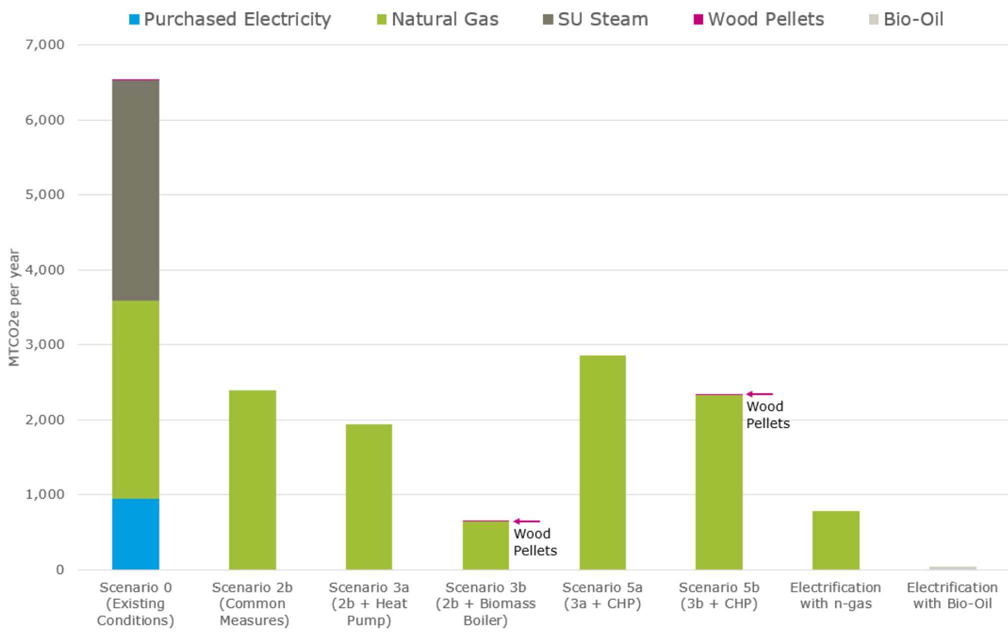

Figure 20. ESF Main Campus – GHG Emissions with Renewable Electricity

In Figure 13 and Figure 14, Scenario 0 shows 7,275 $MTCO_2e$ from energy used at All ESF Properties. Scenario 2b common measures remain as the basis for the transitioning to low campus solutions. In Figure 13, the estimated $MTCO_2e$ reduction of comparing Scenario 0 to Scenario 2b is approximately 42%. Scenarios 3a through 5b have reductions that range from 43% to 63%. Electrification (with natural gas and with bio-oil) represents approximately 57% to 66% reduction in GHG emissions.

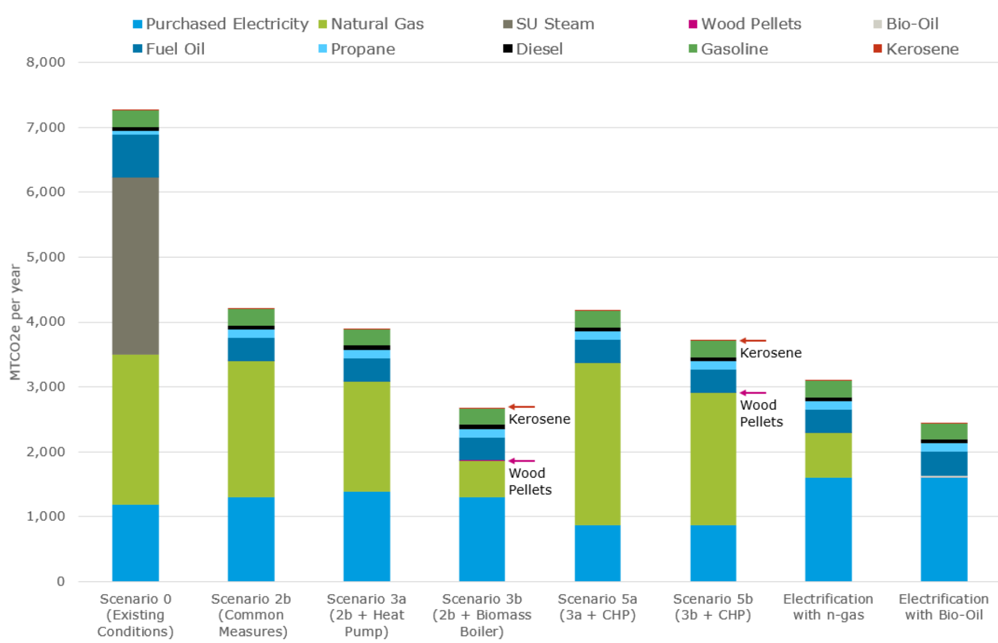

Figure 21. All ESF Properties – GHG Emissions without Renewable Electricity

In Figure 14, the same scenarios are compared against the assumption of the electricity grid is expected to be carbon free by 2040. The estimated $MTCO_2e$ reduction of comparing Scenario 0 to Scenario 2b is approximately 63%. Scenarios 3a through 5b have reductions that range from 54% to 81%, and electrification represents approximately 79% to 99% reduction in GHG emissions.

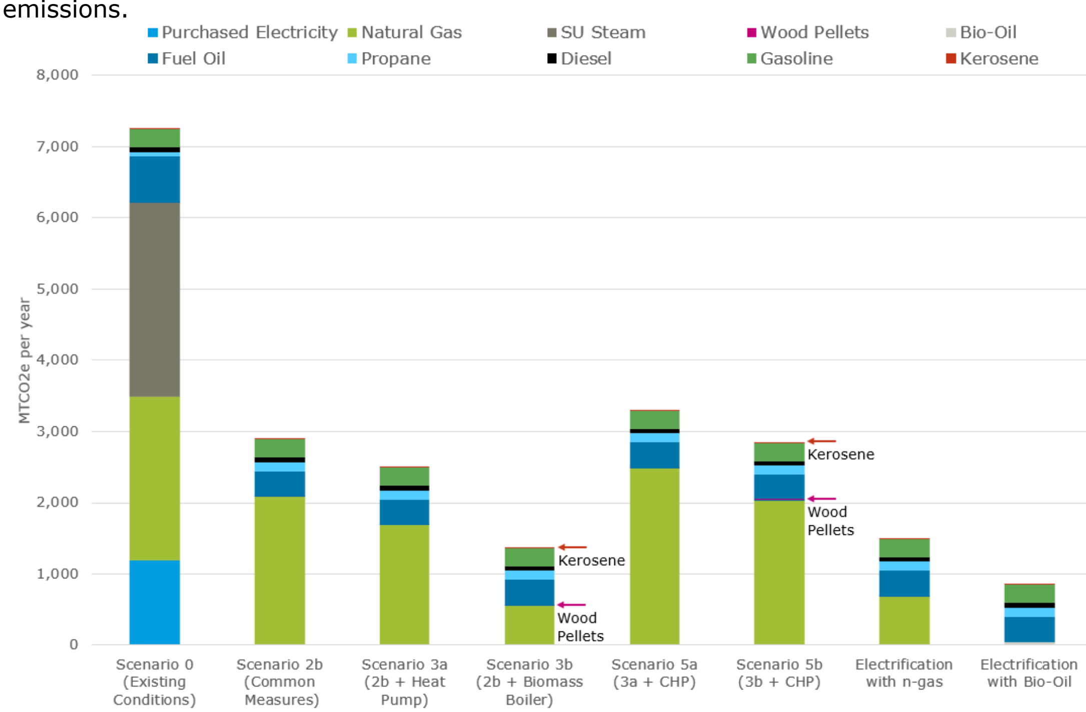

Figure 22. All ESF Properties – GHG Emissions with Renewable Electricity

Figure 15 and Figure 16 represent GHG emissions and EUI trajectories, respectively. Since a final concept selection from the FMP is not determined at the time of this writing, for illustration purposes, the business-as-usual GSF is held constant and planned. Short and long-term energy reductions are included. These assumptions are subject to change based on annual campus priorities and plans, available budgets and funding options, and FMP considerations. Short and long-term energy reductions are from estimated implementation timeframes summarized in Table 4 (Appendix B). These include energy projects associated with energy efficiency, renewable electricity plans, clean energy technologies, stewardship, and engagement.

Short term energy reductions are represented by the blue dashed portion of the trajectory and are anticipated to occur by 2025. As seen in Figure 15, GHG emissions reduce by approximately 1,500 $MTCO_2e$ during the 2020-2025 period. The primary influence is from ESF's planned participation in NY HE LSRE consortium or other PPA, which offsets nearly 1,200 $MTCO_2e$ and would allow ESF to meet its 40% reduction goal (baseline year 2007).

Long-term energy reductions are represented by the yellow dashed portion of the trajectory. ESF's actual progress during the time period of 2025-2035 will be primarily through building renovations tied to the FMP, as well as the ultimate low carbon campus strategy adopted by ESF as a roadmap. It is noted that ESF also has 25,000 acres of forest property that can be utilized for carbon sequestration management in offsetting a portion of ESF's GHG emissions towards NYS mandates and campus neutrality goals.

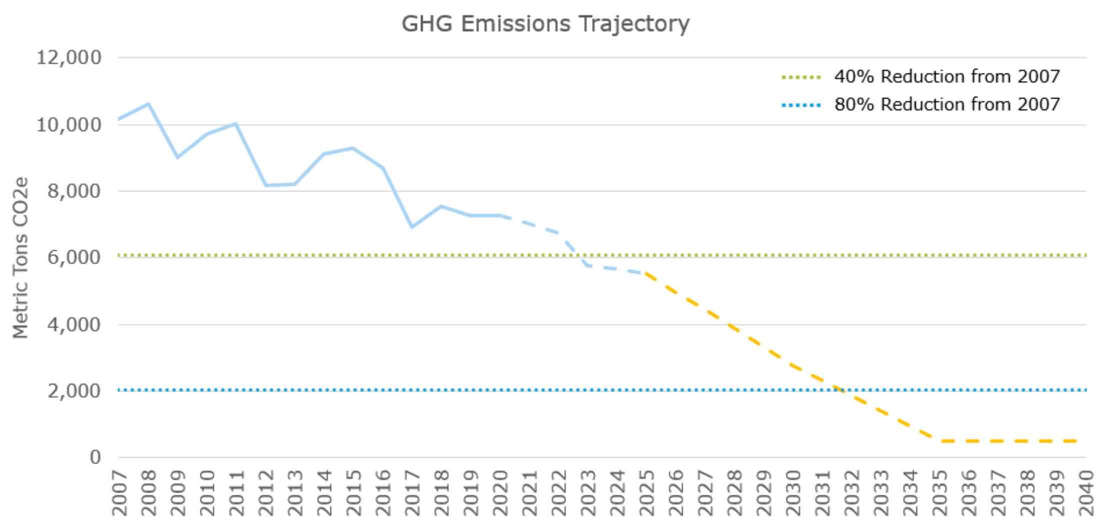

Figure 23. GHG Emissions Trajectory

Figure 16 illustrates the estimated site EUI reduction impact of short-term and long-term energy projects. Short-term energy projects are estimated to reduce site EUI from 109 to 102 kilo British thermal units per gross square feet (kBtu/GSF). Long-term energy projects are estimated to reduce site EUI from 102 to 57 kBtu/GSF; impacted largely by steam and natural gas reductions from the implementation of clean energy technologies.

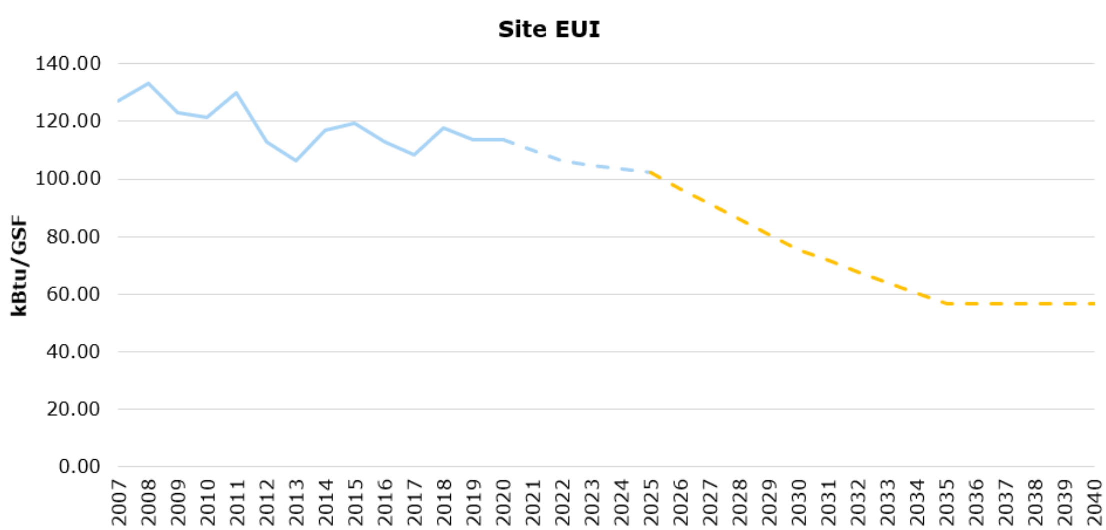

Figure 24. Site Energy Use Intensity Trajectory

3.8 Factors Impacting a Low Carbon Campus Transition

The following factors could influence and impact campus operations, future energy use, and selected energy supply technologies.

- Once an FMP concept is selected by ESF, further integration of the FMP and CEMP will be needed to align the vision, projects, and implementation phasing of both documents.
- Current low natural gas cost utility costs and the impact on capital project economics and operations and maintenance (O&M) costs.

- Market availability and pricing of biomass or bio-oil as fuel options.
- ESF stakeholder perception of the carbon neutral aspects of biomass or bio-oil.
- Availability of grants or incentives to offset first capital costs. For example, NYSERDA's Ground Source Heat Pump Rebate program.
- Uncertainty of a potential future market tax on carbon or fossil fuels.
- Enrollment changes and associated revenue fluctuations.
- Demand for cooling in buildings that do not have it.

3.9 Summary Considerations and Approach to a Low Carbon Transition for Main Campus

The following key components and considerations shape the roadmap of a low-carbon future at ESF.

1. Establish a low temperature hot water network (maximum design temperature of approximately 180°F) with a goal to transition off steam. This would create a platform for utilization of low temperature heat sources with lower GHG emissions.
2. Include provisions for adequate peaking and backup capacity. As additional electrified heating supply assets (heat pumps) are added, they should be base loaded, and the fuel-fired generating assets will remain to provide peaking and backup capacity with limited operating hours. This safeguards that low carbon technologies supply most of the load but there is always backup as needed. Fuel-fired generating assets should have low capital cost. Boilers are recommended as the peaking and backup technology; either operating on natural gas, biomass, or bio-oil.
3. Produce heating (and chilled water) centrally and avoid installing satellite boilers. Central production of heating and cooling enables waste heat recovery (*e.g.*, from cooling heat rejection) and thermal storage. Installation costs can also be reduced due to economies of scale and better planning for diversity and redundancy. If heat pumps (additional GSHP or possibly air source heat pumps) are introduced as part of the low carbon technologies, they will also be able to produce cooling. The capacity of heat pumps will depend on the availability of a heat source for the heat pumps.
4. Extend capacity of the GSHP system by identifying other suited places for wells (*e.g.*, parking lot near Walters Hall).
5. Convert remaining non-hydronic buildings to hydronic heating during planned building renovations to enable buildings to utilize low temperature hot water and enable energy efficient, low carbon energy supplies. Marshall Hall is an example where this will occur.
6. Consider local electric steam generators to serve the remaining process steam loads that cannot be converted to hot water supply (*e.g.*, laboratory autoclaves).
7. Deliberate additional wood pellet capacity while assessing if other lower cost wood pellet supplies are an option.
8. Further evaluate whether to establish additional cogeneration. The expected increasing share of renewable energy in the NYS electrical grid is likely to reduce prices for electricity in the longer-term making operation of cogeneration potentially uneconomical.
9. Consider the potential location for central production of heating and cooling. This might be a new "Clean Energy Center" with adequate space for heat pumps, boilers, chillers, cogeneration, as applicable. Include tank thermal energy storage for heating. A major benefit would be centrally located production of heating and chilled water for the entire campus. By establishing a Clean Energy Center, this could potentially free up basement space in the existing buildings currently used or planned for heating and cooling equipment. Operation

and maintenance costs would be reduced since fewer supply assets would be required in a centralized system. Colocation of heating and cooling assets in a centralized production facility also opens opportunities for heat recovery chillers that increase the overall energy efficiency.

Note that the capital expenditure for a new building is not included in the economic estimates. A suggested location for the Clean Energy Center has been shown on Figure 17. Assuming a well-insulated/cladded metal building was to be constructed and fitted out, an order of magnitude estimate may be $200 to $300/GSF (approximately $1.3 to $2.0 million). The potential pros and cons of a Clean Energy Center must be discussed in detail in subsequent planning phases.

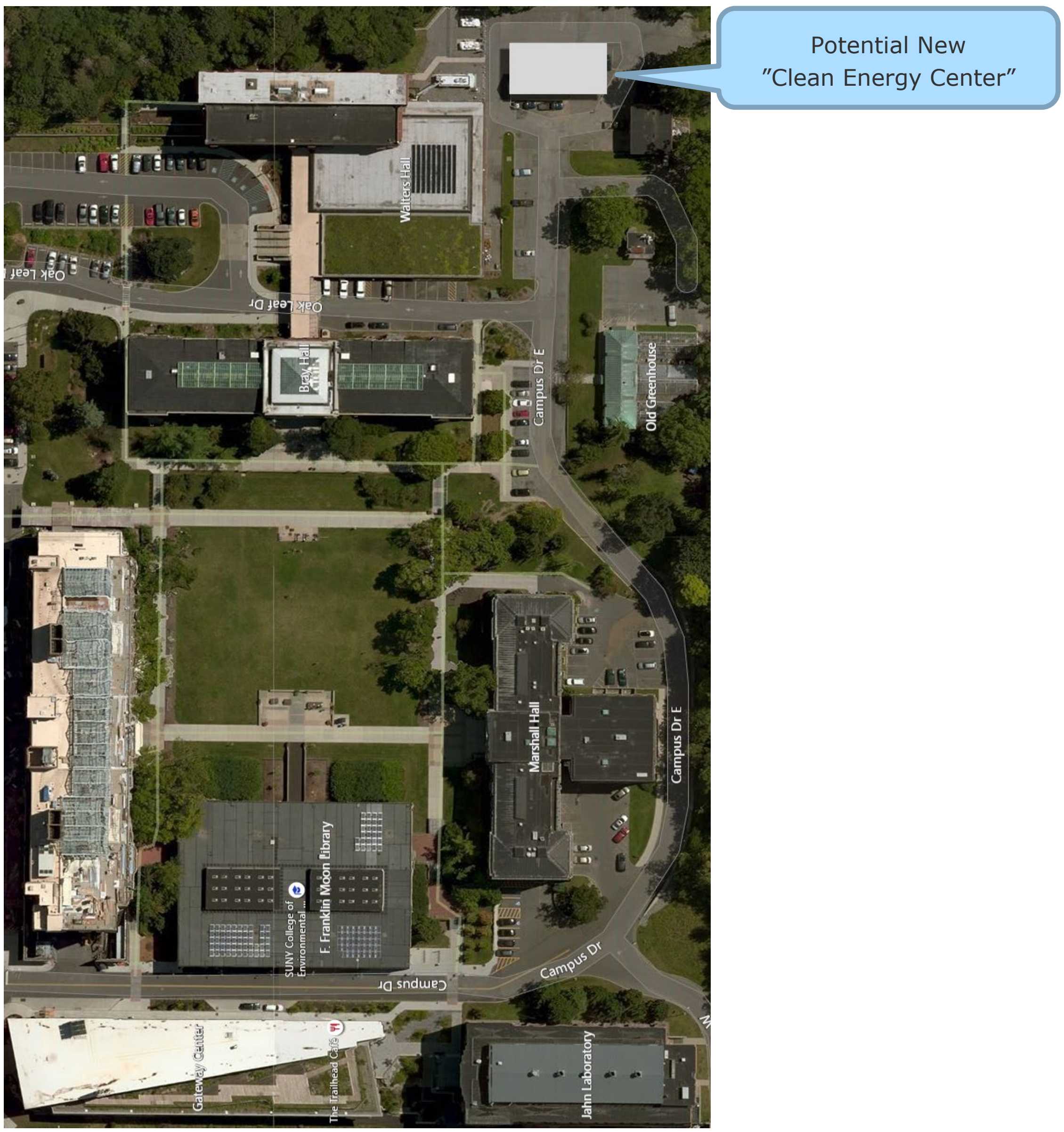

Figure 25. Potential Location of New Campus Energy Center

4. ACHIEVE – IMPLEMENTATION PLAN

ESF's engagement and thought leadership were essential to developing a CEMP that captures the campus vision while aligning with goals of SUNY's Clean Energy Master Plan, the CLCPA, and SUCF directive 1B-2. Table 4 provides a summary of the three key components that will help ESF implement the CEMP and realize the goals of reducing energy usage, increasing energy efficiency, and decreasing operating costs. A broader discussion of these areas immediately follows.

Table 9. Roadmap Implementation Plan Summary

ACHIEVE: Implementation Plan		
Funding	**Implementation Team and Partners**	**Policies and Procedures**
• Alumni • Capital budget • DASNY bonds • Grants/incentives/rebates • Matching funds • NYPA (Performance contract, financing) • Operating budget • SUNY Green Revolving Loan Fund	ESF Team • Administration • CEMP Committee • Energy management • Physical plant and facilities • Others? Partners • Consultants and contractors • DASNY • National Grid • NYSERDA • NYPA • SUCF	• AssetWorks – to support preventative and predictive maintenance program • Carbon sequestration management • Energy and environmental conversation policies • Education/engagement to promote behavioral change • Facilities Master Plan integration • Key Performance Indicator tracking and performance assessment • SUCF Direction 1B-2 • Workforce Development Program for Building Operations and Maintenance

4.1 Funding

ESF, like many other SUNY campuses, has capital improvement needs outside of energy efficiency, and projects compete for limited available capital funding. ESF will assess capital budgets from the NYS Governor's Office annually, in addition to the annual SUCF allocation, for potential contribution to the CEMP goals. Many of the ECMs will go through the SUCF funding process. To ensure a consistent funding stream to implement the CEMP, ESF anticipates engaging the New York Power Authority (NYPA) to provide low-interest financing for some of the CEMP projects. NYPA financed projects will be paid back from ESF's utility budget. Smaller projects that are not financed by NYPA will be implemented using campus cash and operating monies. Grants and incentives from utility providers and others (*e.g.*, National Grid), New York State Energy Research and Development Authority (NYSERDA), and Federal agencies will be monitored for potential funding offsets. SUNY's Green Revolving Loan Fund was paused at the time of this writing, but could be a potential resource in the future. Of particular note is that ESF's Director of

Energy Management & Utilities has been approached by the Alumni Foundation with specific interest to financially support energy projects.

4.2 Implementation Team

ESF has several contracting mechanisms to implement energy efficiency projects, but the primary mechanism will be through SUCF, NYPA and/or DASNY, who can provide several implementation services options for energy projects. SUCF, NYPA, and DASNY also have term consultants under contract who can be utilized for design and construction management. Administration of the CEMP will be performed by the Director of Energy Management and Utilities and the Energy Conservation Development and Controls Division (ECDC) in Partnership with the Sustainability Division, Facilities Planning Design and Construction, and ESF Administration.

4.3 Policies and Procedures

The continued demand for more services, including extended building schedules and environmental controls, necessitates the need for careful planning to address the increased demands in a thoughtful and sustainable manner.

SUCF Directive 1B-2 is the policy mechanism for new construction, deep energy retrofits, and buildings renovations or system replacement projects to incorporate the highest levels of energy efficiency and sustainability to significantly impact the overall campus EUI and GHG reductions. At the time of this writing, it is undergoing revisions.

Education, engagement and outreach can play an increasingly important role to curb occupant-controlled energy use in buildings, which has seen an increase with the proliferation of connected devices on college campuses. Senior leadership support and carefully thought-out policies and procedures are crucial to ensuring that campus constituents' requests are weighed alongside the needs of the campus and its energy and GHG reduction goals.

4.4 Keys to Success

Keys to successfully implement the Roadmap include:

- Integration with the FMP
- Continued support from senior administration on energy efficiency and sustainability goals
- Availability of SUCF and DASNY funding, as well as NYPA financing at a reasonable interest rate to fund the projects
- Adequate administrative and technical resource allocation to manage the design and implementation of the projects
- Investment in campus O&M staff to maintain the energy performance of buildings and systems.

4.5 Key Performance Indicators

Key Performance Indicators that can be used to measure progress and impact can include:

- Annual Greenhouse Gas (GHG) emissions monitored in carbon dioxide equivalent (CO_2e) using a single agreed upon methodology
- Annual Site EUI
- Financial impact (*e.g.*, project costs, energy and cost savings, return on investment, annual net cash flow, \$/MTCO_2e reduced)
- Dollars invested in infrastructure renewal

- Operations & maintenance savings
- Integration in curriculum, research, and work force development programs
- Student/staff/faculty perception/feedback
- Non-energy benefits including improvements in occupant comfort, reliability, and resiliency
- Advancement and achievement of sustainability goals.

The CEMP will guide actions over a 20-year horizon that will help position ESF to achieve short-term and long-term energy goals. Energy reductions are achieved through energy efficiency, infrastructure renewal, incorporating clean energy supply technologies, renewable energy, building upgrades, stewardship of physical assets, and engaging campus stakeholders.

APPENDIX A
GREENHOUSE GAS EMISSIONS SUMMARY

Greenhouse Gas Emisisons Summary

SUNY ESF

Syracuse, New York

GHG Emission Source	FY06-07	FY07-08	FY08-09	FY09-10	FY10-11	FY11-12	FY12-13	FY13-14	FY14-15	FY15-16	FY16-17	FY17-18	FY18-19
Scope 1 ($MTCO_2e$)													
Natural Gas	958	1,115	743	726	858	919	438	145	352	1,075	2,272	2,342	2,297
Fuel Oil #2	551	532	549	570	591	424	435	677	634	504	461	575	654
Wood Pellets	0	0	0	0	0	0	0	0	0	0	0	1	0
Propane	47	72	46	53	49	49	60	54	62	63	39	64	59
Diesel	41	62	52	37	41	40	29	31	51	45	53	68	61
Gasoline	184	270	249	416	416	364	279	338	272	234	236	272	254
Kerosene	0	0	0	0	0	0	8	7	2	0	1	0	2
Total Scope 1	1,781	2,051	1,639	1,801	1,953	1,796	1,249	1,253	1,372	1,922	3,062	3,321	3,327
Scope 2 (MTCO2e)													
Purchased Electricity	3,383	3,617	2,495	2,616	2,701	2,080	2,304	2,051	1,967	1,518	1,471	1,210	1,189
Purchased Steam	3,973	3,941	3,886	4,215	4,276	3,426	3,716	4,430	4,555	3,708	1,872	2,220	2,181
Total Scope 2	7,356	7,558	6,381	6,831	6,977	5,506	6,020	6,481	6,522	5,226	3,343	3,429	3,370
Scope 3 (MTCO2e)													
Total Commuting	0	0	0	0	0	0	0	0	0	0	0	0	0
Faculty/staff commuting	0	0	0	0	0	0	0	0	0	0	0	0	0
Student commuting	0	0	0	0	0	0	0	0	0	0	0	0	0
Solid Waste	0	0	0	0	0	0	0	0	0	0	0	0	0
Scope 3 (Scope 2 Transmission and Distribution)	993	985	971	1,054	1,069	857	929	1,107	1,139	927	468	555	545
Electric T&D													
Steam T&D	993	985	971	1,054	1,069	857	929	1,107	1,139	927	468	555	545
Total Scope 3	993	985	971	1,054	1,069	857	929	1,107	1,139	927	468	555	545
Total (Scope 1 and 2)	*9,137*												
Total (Scope 1, Scope 2, and Scope 2 T&D)	*10,130*	*10,594*	*8,992*	*9,686*	*10,000*	*8,158*	*8,198*	*8,841*	*9,034*	*8,075*	*6,874*	*7,305*	*7,243*

Notes:
(a) GHG emissions were calculated utilizing emission factors within or referenced in the United States Environmental Protection Agency (USEPA) Simplified GHG Emission Calculator (SGEC)(sgec_tool_v5_1.xlsm).

	FY06-07	FY07-08	FY08-09	FY09-10	FY10-11	FY11-12	FY12-13	FY13-14	FY14-15	FY15-16	FY16-17	FY17-18	FY18-19
Fuel input for steam	4966												
Emissions from UNH Carbon Calc Electric (MTCO2e/kWh)	0.0003124	0.0003124	0.0002283	0.000250053	0.000250053	0.0001879	0.0001879	0.0001668	0.0001668	0.0001342	0.0001342	0.0001152	0.0001152
	eGRID 2010 Year 2007 NYUP	eGRID 2010 Year 2007 NYUP	eGRID 2012 Year 2009 NYUP	eGRID 9th Ed. Year 2010 NYUP	eGRID 9th Ed. Year 2010 NYUP	eGRID 2012 NYUP	eGRID 2012 NYUP	eGRID 2014 NYUP	eGRID 2014 NYUP	eGRID 2016 NYUP	eGRID 2016 NYUP	eGRID 2018 NYUP	eGRID 2018 NYUP
Steam Scope 2 (MTCO2e/MMBtu)	0.0590	0.0590	0.0590	0.0664	0.0664	0.0664	0.0664	0.0664	0.0664	0.0664	0.0664	0.0664	0.0664

APPENDIX B
ENERGY PROJECTS SUMMARY

State University of New York College of Environmental Science and Forestry
REV Campus Challenge - Clean Energy Master Plan

Energy Projects Summary

ECM No.	Potential ECM	Buildings Affected	Annual Electrical Savings (kWh/yr)	Electrical Peak Demand Savings (kW)	Annual Natural Gas Savings (therms/yr)	Annual Steam Savings (klbs/yr)	Annual Fuel Oil Savings (gal/yr)	Annual Propane Savings (gal/yr)	Annual Wood Pellet Savings (ton/yr)	Annual Energy Cost Savings ($/yr)	Estimated Capital Cost	Simple Payback Period (years)	Annual GHG Reduction (MTCO2e)	Cost per MTCO2e Reduction	Campus Site EUI Reduction (kBtu/GSF/yr)	Percent EUI Reduction from FY18-19	Estimated Implementation Timeframe from Year 0 (years)	Notes	Include Measure in CEMP?
	Energy Efficiency																		
ECM-1	**Chiller Optimization**	Baker Labs	5,960	0.0	0	0	0	0	0	$411	$200,910	488.5	1	$292,698	0.0	0.0%	0-5	1, 2	Y
ECM-2	**Lighting Upgrades**	Baker Labs	234,313	796.0	0	0	0	0	0	$16,168	$647,889	40.1	27	$24,009	0.7	0.4%	0-5	1	Y
ECM-3	**Pipe Insulation**	Baker Labs	0	0.0	2,838	0	0	0	3	$1,874	$23,644	12.6	15	$1,568	0.3	0.2%	0-5	1	Y
ECM-4	**Building Envelope**	Baker Labs	0	0.0	1,679	0	0	0	2	$1,109	$15,971	14.4	9	$1,791	0.2	0.1%	0-5	1	Y
ECM-5	**Steam Radiator Control System**	Bray Hall	0	0.0	0	244	0	0	0	$5,578	$327,347	58.7	20	$16,170	0.2	0.1%	5-10	1	Y
ECM-6	**BAS Control Enhancements**	Bray Hall	0	0.0	0	0	0	0	0	$0	$49,623	N/A	0	N/A	0.0	0.0%	5-10	1	Y
ECM-7	**Replace Admin Area Multizone AHU with VAV**	Bray Hall	4,897	-15.0	0	4	0	0	0	$429	$81,533	189.9	1	$91,011	0.0	0.0%	5-10	1	Y
ECM-8	**Lighting Upgrades**	Bray Hall	134,735	424.0	0	0	0	0	0	$9,297	$328,469	35.3	16	$21,168	0.4	0.2%	0-5	1	Y
ECM-9	**Pipe Insulation**	Bray Hall	0	0.0	0	38	0	0	0	$869	$11,062	12.7	3	$3,509	0.0	0.0%	0-5	1	Y
ECM-10	**Building Envelope**	Bray Hall	0	0.0	0	46	0	0	0	$1,052	$8,301	7.9	4	$2,175	0.0	0.0%	0-5	1	Y
ECM-11	**Capstone Efficiency Improvement - identify savings using CHW coil to precool air**	Gateway Center	42,253	84.0	4,745	0	0	0	4	$6,049	$79,591	13.2	30	$2,647	0.6	0.3%	0	1, 3	Y
ECM-12	**Lighting Upgrades**	Gateway Center	54,231	174.0	0	0	0	0	0	$3,742	$162,365	43.4	6	$25,996	0.2	0.1%	0-5	1	Y
ECM-13	**Pipe Insulation**	Gateway Center	0	0.0	4,582	0	0	0	4	$3,026	$29,827	9.9	24	$1,225	0.5	0.2%	0-5	1	Y
ECM-14	**Lighting Upgrades**	Old Greenhouse	62,742	165.0	0	0	0	0	0	$4,329	$67,116	15.5	7	$9,288	0.2	0.1%	0-5	1	Y
ECM-15	**Pipe Insulation**	Old Greenhouse, Chem Storage, Old O + M	0	0.0	0	144	0	0	0	$3,292	$88,011	26.7	12	$7,367	0.1	0.1%	0-5	1	Y
ECM-16	**Building Envelope**	Old Greenhouse	0	0.0	0	68	0	0	0	$1,554	$39,773	25.6	6	$7,050	0.1	0.0%	0-5	1	Y
ECM-17	**Chiller Optimization**	Illick Hall	11,652	0.0	0	0	0	0	0	$804	$168,759	209.9	1	$125,756	0.0	0.0%	Not Recommended	1, 4, 5	N
ECM-18	**Abandoned Coil**	Illick Hall	1,216	0.0	0	0	0	0	0	$84	$17,880	213.1	0	$127,675	0.0	0.0%	Not Recommended	1, 4, 5	N
ECM-19	**DCV on AHUs**	Illick Hall	240,599	0.0	14,868	2,229	0	0	13	$77,363	$327,653	4.2	292	$1,124	4.2	2.2%	Already Implemented	1, 6	N
ECM-20	**Glycol Heat Recovery System on S-10, EF-4, EF-10, EF-13**	Illick Hall	-207,562	-27.0	19,947	2,990	0	0	18	$67,194	$1,394,120	20.7	330	$4,223	4.1	2.1%	2-7	1, 4	N
ECM-21	**Replace Window AC with Central Cooling**	Illick Hall	-180,194	-382.0	0	0	0	0	0	-$12,433	$25,351	N/A	-21	N/A	-0.5	-0.3%	Not Recommended	1, 4, 5	N
ECM-22	**Fume Hood Control**	Illick Hall	67,280	8.0	1,288	193	0	0	1	$9,907	$1,450,004	146.4	31	$47,369	0.5	0.3%	Not Recommended	1, 4, 5	N
ECM-23	**Retrofit DD Boxes to VAV Boxes**	Illick Hall	85,277	0.0	4,112	616	0	0	4	$22,690	$433,984	19.1	83	$5,241	1.2	0.6%	0-5	1, 4	N
ECM-24	**Lighting Upgrades**	Illick Hall	351,565	1,360.0	0	0	0	0	0	$24,258	$373,752	15.4	40	$9,231	1.1	0.6%	0-5	1, 4	N
ECM-25	**Pipe Insulation**	Illick Hall	0	0.0	2,052	308	0	0	2	$8,386	$47,815	5.7	36	$1,313	0.5	0.3%	0-5	1, 4	N
ECM-26	**Building Envelope**	Illick Hall	0	0.0	467	70	0	0	0	$1,907	$10,571	5.5	8	$1,277	0.1	0.1%	0-5	1, 4	N
ECM-27	**Fume Hoods and Fan Upgrades**	Jahn Labs	1,949	3.0	2,611	0	0	0	2	$1,858	$483,335	260.1	14	$34,299	0.3	0.1%	Not Recommended	1, 5	N
ECM-28	**Chiller Replacement (2-300 Ton)**	Jahn Labs	257,267	89.0	0	0	0	0	0	$17,751	$1,046,351	58.9	30	$35,315	0.8	0.4%	0-5	1, 2	Y
ECM-29	**Chiller Optimization**	Jahn Labs	33,912	32.0	0	0	0	0	0	$2,340	$177,749	76.0	4	$45,511	0.1	0.1%	0-5	1, 2	Y
ECM-30	**VSD on Cooling Towers**	Jahn Labs	16,196	0.0	0	0	0	0	0	$1,118	$32,800	29.4	2	$17,584	0.0	0.0%	0-5	1, 2	Y
ECM-31	**Lighting Upgrades**	Jahn Labs	191,467	706.0	0	0	0	0	0	$13,211	$218,237	16.5	22	$9,897	0.6	0.3%	0-5	1	Y
ECM-32	**Pipe Insulation**	Jahn Labs	0	0.0	1,506	0	0	0	1	$994	$46,888	47.2	8	$5,862	0.2	0.1%	0-5	1	Y
ECM-33	**Building Envelope**	Jahn Labs	0	0.0	260	0	0	0	0	$172	$5,131	29.9	1	$3,715	0.0	0.0%	0-5	1	Y
ECM-34	**Radiator Controls**	Marshall Hall	0	0.0	0	255	0	0	0	$5,829	$483,470	82.9	21	$22,852	0.2	0.1%	Not Recommended	1, 7	N
ECM-35	**DCV on HV Unit in Auditorium**	Marshall Hall	1,318	0.0	0	546	0	0	0	$12,573	$31,387	2.5	45	$691	0.5	0.3%	Not Recommended	1, 7	N
ECM-36	**Restore Cooling to Ten Fan Coil Units**	Marshall Hall	-21,925	0.0	0	0	0	0	0	-$1,513	$431,932	N/A	-3	N/A	-0.1	0.0%	Not Recommended	1, 7	N
ECM-37	**Lighting Upgrades**	Marshall Hall	156,229	568.0	0	0	0	0	0	$10,780	$222,337	20.6	18	$12,357	0.5	0.2%	Not Recommended	1, 7	N

State University of New York College of Environmental Science and Forestry
REV Campus Challenge - Clean Energy Master Plan

Energy Projects Summary

ECM No.	Potential ECM	Buildings Affected	Annual Electrical Savings (kWh/yr)	Electrical Peak Demand Savings (kW)	Annual Natural Gas Savings (therms/yr)	Annual Steam Savings (klbs/yr)	Annual Fuel Oil Savings (gal/yr)	Annual Propane Savings (gal/yr)	Annual Wood Pellet Savings (ton/yr)	Annual Energy Cost Savings ($/yr)	Estimated Capital Cost	Simple Payback Period (years)	Annual GHG Reduction (MTCO2e)	Cost per MTCO2e Reduction	Campus Site EUI Reduction (kBtu/GSF/yr)	Percent EUI Reduction from FY18-19	Estimated Implementation Timeframe from Year 0 (years)	Notes	Include Measure in CEMP?
ECM-38	**Pipe Insulation**	Marshall Hall	0	0.0	0	89	0	0	0	$2,035	$64,772	31.8	7	$8,772	0.1	0.0%	Not Recommended	1, 7	N
ECM-39	**Building Envelope**	Marshall Hall	0	0.0	0	112	0	0	0	$2,560	$11,851	4.6	9	$1,275	0.1	0.1%	Not Recommended	1, 7	N
ECM-40	**DCV in Moon Library**	Moon Library	3,752	0.0	4,214	0	0	0	4	$3,042	$92,953	30.6	23	$4,074	0.4	0.2%	0-5	1, 8	N
ECM-41	**Convert Air Handling System to VAV**	Moon Library	129,224	0.0	2,654	0	0	0	2	$10,669	$132,661	12.4	29	$4,578	0.7	0.3%	0-5	1, 8	N
ECM-42	**Runaround Heat Recovery System**	Moon Library	-36,379	-8.0	3,553	0	0	0	3	-$164	$238,772	N/A	15	$16,261	0.3	0.1%	0-5	1, 8	N
ECM-43	**Duct Sealing**	Moon Library	190	0.0	141	0	0	0	0	$106	$15,269	143.9	1	$19,831	0.0	0.0%	0-5	1, 8	N
ECM-44	**Pipe Insulation**	Moon Library	0	0.0	2,459	0	0	0	2	$1,624	$14,948	9.2	13	$1,144	0.3	0.1%	0-5	1	Y
ECM-45	**Building Envelope**	Moon Library	0	0.0	574	0	0	0	1	$379	$7,753	20.5	3	$2,542	0.1	0.0%	0-5	1	Y
ECM-46	**Lighting Upgrades**	Physical Plant	27,437	94.0	0	0	0	0	0	$1,893	$68,589	36.2	3	$21,706	0.1	0.0%	0-5	1	Y
ECM-47	**Building Envelope**	Physical Plant	0	0.0	0	199	0	0	0	$4,549	$11,164	2.5	17	$676	0.2	0.1%	0-5	1	Y
ECM-48	**Lighting Upgrades (Main)**	Ranger School	51,718	201.0	0	0	-64	0	0	$3,489	$155,458	44.6	5	$29,313	0.1	0.1%	0-5	1, 9	Y
ECM-49	**Lighting Upgrades (Misc)**	Ranger School	36,269	162.0	0	0	0	0	0	$2,503	$53,963	21.6	4	$12,919	0.1	0.1%	0-5	1, 9	Y
ECM-50	**BAS Controls**	Ranger School	4,649	-3.0	0	0	678	0	0	$1,168	$143,263	122.6	7	$19,156	0.1	0.1%	Not Recommended	1, 5	N
ECM-51	**DHW**	Ranger School	12,286	37.0	0	0	12,628	-12,474	0	$4,782	$52,992	11.1	60	$878	0.6	0.3%	0-5	1	Y
ECM-52	**Envelope Upgrade**	Ranger School	72	1.0	0	0	698	0	0	$877	$170,540	194.5	7	$23,847	0.1	0.0%	0-5	1, 10	Y
ECM-53	**Variable Speed Drives**	Ranger School	4,326	21.0	0	0	0	0	0	$298	$37,142	124.4	0	$74,550	0.0	0.0%	Not Recommended	1, 5	N
ECM-54	**Trane BAS with Fume Hoods and Fan Upgrades**	Walters Hall	22,591	0.0	0	566	0	0	0	$14,498	$966,669	66.7	50	$19,504	0.6	0.3%	10-15	1	Y
ECM-55	**Central AC in Building**	Walters Hall	-10,093	-46.0	0	0	0	0	0	-$696	$2,046,450	N/A	-1	N/A	0.0	0.0%	10-15	1	Y
ECM-56	**Duct Sealing**	Walters Hall	91	0.0	0	18	0	0	0	$418	$15,269	36.5	2	$10,153	0.0	0.0%	0-5	1	Y
ECM-57	**Lighting Upgrades**	Walters Hall	165,479	586.0	0	0	0	0	0	$11,418	$586,751	51.4	19	$30,788	0.5	0.3%	0-5	1	Y
ECM-58	**Building Envelope**	Walters Hall	0	0.0	0	236	0	0	0	$5,395	$79,229	14.7	20	$4,046	0.2	0.1%	0-5	1	Y
ECM-59	**Demand Controlled Ventiation (Aircuity)**	Illick Hall	1,454,944	441.0	52,840	7,920	0	0	48	$316,332	$2,500,000	7.9	1,105	$2,262	16.8	8.8%	5-10	4, 11	N
ECM-60	**Marshall Hall Building Renovations**	Marshall Hall	-64,137	-199.0	-23,254	5,209	0	0	0	$104,351	$14,551,665	139.4	301	$48,293	2.4	1.2%	0-5	12, 13	Y
ECM-61	**Illick Hall Building Renovations**	Illick Hall	1,248,104	422.8	29,142	4,368	0	0	26	$205,212	$34,451,476	N/A	661	$52,125	10.6	5.5%	5-10	4, 14	Y
	SUBTOTAL		**1,769,453**	**2,599.7**	**17,172**	**7,798**	**9,283**	**-8,732**	**30**	**$318,538**	**$39,845,054**	**125.1**	**988**	**$40,337**	**14.7**	**7.6%**			
	Resiliency																		
ECM-62	**Groundsource Heat Pump (GSHP) System**	Moon Library	-104,682	0.0	22,959	0	0	0	0	$2,948	$708,706	240.4	110	$6,451	1.7	0.9%	2-10	8, 15	Y
ECM-63	**Low Carbon Energy Supply Scenario (TBD, but assumed as Scenario 3a)**	Campus Wide	-1,687,302	0.0	99,581	21,888	0	0	0	$428,051	$3,849,600	9.0	2,150	$1,790	23.2	12.1%	5-15	16	Y
	SUBTOTAL		**-1,254,389**	**0.0**	**85,778**	**15,322**	**0**	**0**	**0**	**$301,699**	**$3,190,814**	**10.6**	**1,582**	**$2,017**	**17.4**	**9.1%**			
	Renewable Energy																		
ECM-64	**Increase Biomass use at Gateway**	Gateway, Jahn, Baker, Moon, Illick	0	0.0	6,288	0	0	0	-37	-$6,094	$0	N/A	33	$0	0.01	0.0%	0-5	17	Y
ECM-65	**Increase Biomass use at Ranger School**	Ranger School	0	0.0	0	0	14,602	0	-123	-$2,068	$263,900	N/A	149	$1,767	-0.02	0.0%	0-5	18	Y
ECM-66	**Offsite Large Scale Purchased Renewable Energy**	Campus Wide	0	0.0	0	0	0	0	0	-$71,218	$0	N/A	1,189	$0	0.00	0.0%	2-3	19	Y
	SUBTOTAL		**0**	**0.0**	**4,402**	**0**	**10,221**	**0**	**-112**	**-$55,567**	**$184,730**	**N/A**	**960**	**$192**	**-0.01**	**0.0%**			
	Stewardship																		
ECM-67	**Energy Conservation Awareness and Behavioral Change**	Campus Wide	516,076	0.0	21,629	1,643	0	0	8	$84,591	$0	0.0	311	$0	5.1	2.6%	0-2	20	Y
	SUBTOTAL		**361,253**	**0.0**	**15,141**	**1,150**	**0**	**0**	**5**	**$59,214**	**$0**	**0.0**	**217**	**$0**	**3.5**	**1.8%**			

Energy Projects Summary

ECM No.	Potential ECM	Buildings Affected	Annual Electrical Savings (kWh/yr)	Electrical Peak Demand Savings (kW)	Annual Natural Gas Savings (therms/yr)	Annual Steam Savings (klbs/yr)	Annual Fuel Oil Savings (gal/yr)	Annual Propane Savings (gal/yr)	Annual Wood Pellet Savings (ton/yr)	Annual Energy Cost Savings ($/yr)	Estimated Capital Cost	Simple Payback Period (years)	Annual GHG Reduction (MTCO2e)	Cost per MTCO2e Reduction	Campus Site EUI Reduction (kBtu/GSF/yr)	Percent EUI Reduction from FY18-19	Estimated Implementation Timeframe from Year 0 (years)	Notes	Include Measure in CEMP?
	Engagement																		
ECM-69	**Workforce Training**	Walters Hall	102,200	0.0	12,500	526	0	0	0	$24,614	$4,600	0.2	122	$38	1.9	1.0%	0-2	21	Y
	SUBTOTAL		**71,540**	**0.0**	**8,750**	**368**	**0**	**0**	**0**	**$17,230**	**$3,220**	**0.2**	**85**	**$38**	**1.3**	**0.7%**			
	GRAND TOTAL		**947,857**	**2,599.7**	**131,242**	**24,638**	**19,505**	**-8,732**	**-76**	**$641,114**	**$43,223,819**	**67.4**	**3,833**	**$11,278**	**37.0**	**19.2%**			

Notes	
1	Savings and project cost estimate from Trane Audit report dated August 2017. Project costs for this study were escalated by 2% per year to 2020.
2	Measure to be included as part of interconnection of Baker and Jahn chilled water loops for redundancy and resiliency.
3	Measure implemented in October 2019, savings accounted for since it was completed after the most recent fiscal year (FY18-19) included in the project analyses.
4	Illick Hall individual ECMs are mutually exclusive with Illick Hall Renovation (ECM-61). The individual ECM savings are not included in the subtotals, and are included in the building renovation savings. The building renovation savings in ECM-61 assume the renovations comply with SUCF Directive 1B-2. ECM-61 Project cost taken from the JMZ Illick Hall Program Study, dated February 27, 2020.
5	Measure not recommended based on high simple payback, capital cost, and discussions with ESF.
6	Measure already implemented, savings are not included in the roadmap.
7	Marshall Hall individual ECMs are mutually exclusive with Marshall Hall Renovation (ECM-60). The individual ECM savings are not included in the subtotals, and are included in the building renovation savings.
8	Moon Library individual ECMs are mutually exclusive with the Moon geothermal project (ECM-61). The individual ECM savings are not included in the subtotals.
9	Measure 25% implemented. Savings and project cost were reduced by 25% from the reported total measure savings.
10	Measure 50% implemented. Savings and project cost were reduced by 50% from the reported total measure savings.
11	Savings and project cost estimate from Aircuity report dated April 2019. Heating savings in Aircuity report represented in therms assuming a 75% boiler efficiency. Savings converted to steam savings at the building.
12	Savings estimate from SUNY ESF Marshall Hall Rehabilitation modeling report prepared by Pathfinder. Savings calculated as the difference between the existing building compared to the proposed design. The estimated capital cost for ECM-60 is from the Tropy Point Pre-Bide Estimate dated January 31, 2020.
13	Estimated capital cost taken from the Tropy Point Pre Bid Estimate, Revised 1/31/2020. Estimate only includes the renovation costs for THERMAL & MOISTURE PROTECTION, OPENINGS, HVAC, and ELECTRICAL divisions.
14	Estimated capital cost taken from the Tropy Point Program Study Estimate, dated 2/21/2020. Estimate only includes the renovation costs for THERMAL & MOISTURE PROTECTION, OPENINGS, HVAC, and ELECTRICAL divisions.
15	Savings and project cost estimate from Geothermal Clean Energy Challenge Advanced Report - Stage 2 prepared by ICF.
16	Savings and project cost estimate represents Scenario 3a from the Ramboll Scenario Planning Feasibility Study Report.
17	Increase in wood pellet consumption from 163 tons/year to 200 tons/year. Natural gas savings calculated asssuming a biomass boiler efficiency of 82% and a natural gas boiler efficiency of 80%. Since the biomass boiler is a peaking boiler, the operating efficiencies are assumed to be near rated efficiencies.
18	Savings and project cost estimate represents Option 2 from the SUNY ESF Ranger School Biomass Energy System Preliminary Feasibility Study, dated June 13, 2019.
19	Measure assumes 100% of electricity will be purchased through offsite renewable energy, with a 10% increase in purchased electricity costs.
20	Measure assumes a 5% reduction in electricity and natural gas consumption can be achieved through energy conservation awareness and behavioral changes
21	Savings and project cost estimate from SUNY ESF Energy Management Project Report, dated July 1, 2019.
22	Subtotals are multiplied by a 0.7 interactive factor to account for interaction between measures.