ECN2015

ESF Carbon Neutral by 2015

Climate Action Plan for SUNY ESF

State University of New York
College of Environmental Science and Forestry
Syracuse, NY

Department of Renewable Energy Systems
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Abstract

SUNY ESF is committed to expanding sustainability efforts on campus, in the local community, and beyond. Two fundamental prerequisites of a sustainable and prosperous human society are a healthy environment and a stable climate. Greenhouse Gas (GHG) air pollution and the climatic disruption it contributes to are a threat to sustainable human prosperity and all life on earth. In 2007 ESF became a charter signatory of the **American College and University Presidents Climate Commitment**, *"a high-visibility effort to address global warming by garnering institutional commitments to neutralize greenhouse gas emissions"* (ACU-PCC, 2009). ESF President Dr. Cornelius B. Murphy has set a target date of June 30th, 2015 for achieving institution-wide carbon neutrality. ESF students, faculty, staff, and administration have united to craft a unique and creative plan for reducing campus GHG emissions & energy use. The findings of this analysis indicate that ESF is on-track to meet its carbon neutral commitment and is well positioned to emerge a leader in campus sustainability & climate action.

> *"Building on the growing momentum for leadership and action on climate change, the Presidents Climate Commitment provides a framework and support for America's colleges and universities to go climate neutral. The Commitment recognizes the unique responsibility that institutions of higher education have as role models for their communities and in training the people who will develop the social, economic and technological solutions to reverse global warming."*
>
> *- (ACU-PCC, 2009)*

❖Introduction

Founded in Syracuse in 1911, The State University of New York - College of Environmental Science and Forestry (SUNY ESF) is one of the nation's oldest and most respected colleges of forestry and the environment. True to its history, ESF is committed to improving our world by addressing and mitigating the broad spectrum of environmental and human challenges of the 21st century. **ECN2015** is a comprehensive assessment of climate & sustainability projects, energy use, and GHG emissions at ESF. It is also a quantitative analysis of ESF's path to carbon neutrality and reduced fossil fuel dependence. The following pages are a brief summary of the primary methods & tools used in this analysis.

*'For the purposes of the ACU-PCC, **climate neutrality** is defined "as having **no net greenhouse gas emissions**, to be achieved by minimizing GHG emissions as much as possible, and using carbon offsets or other measures to mitigate the remaining emissions.'*

-(ACU-PCC, 2007)

Bray Hall - SUNY ESF

Analysis Boundaries

- **Organizational Boundaries**

  All facilities and properties owned and operated by SUNY ESF

  - Main Campus
  - Satellite Campuses & Research Stations
  - Forest Properties

- **Operational Boundaries**

  All significant & ACU-PCC required* sources of campus GHG Emissions & Energy Inputs

  - Direct combustion of fossil fuels (Scope 1)
  - Purchased electricity and steam (Scope 2)
  - Commuting , Air travel, and Transmission & Distribution (T&D) Losses (Scope 3)

  ** Fugitive CFC and HCFC emissions are considered "de minimis" as defined by ACU-PCC Guidelines (2007).*

- **Temporal Boundaries**

  2003 - 2015
  - Phase One: 2003-2006
  - Phase Two: 2007-2009
  - Phase Three: 2010-2015

Clean Air-Cool Planet - Campus Carbon Calculator

- **ECN2015** uses CA-CP to calculate the following:

    - Campus carbon footprint and energy input data to *"standards of the GHG Protocol of the World Business Council for Sustainable Development (WBCSD) and the World Resources Institute (WRI)… the most widely-used international accounting tool for quantifying GHG emissions"* (ACU-PCC, 2007)

    - Emission of "*all six greenhouse gases specified by the Kyoto Protocol (CO2, CH4, N2O, HFC and PFC, and SF6*)" (CA-CP, 2008).

    - Global Warming Potentials, Emission Factors, and Energy Use Factors

- **CA-CP** and **ECN2015** use one standardized unit for all emissions.

    - **MTCO2e** (metric tons carbon dioxide equivalent) is used to measure and express all institutional GHG emissions and GWPs as listed above.

- The initial GHG audit conducted by students at ESF in 2008 using CA-CP v5.0 has been updated and revised for **ECN2015**. Key amendments include:

    - Updated CA-CP to latest available version (v6.3)
    - Reformulated "custom fuel mix" for purchased electricity and purchased steam
    - Inclusion of commuter data estimates in ESF's Carbon Footprint (CFP)
    - Inclusion of T&D losses in CFP
    - Corrected input errors
    - Inputs registered only for years with complete and verifiably accurate data

GHG Emission Scopes

"The GHG Protocol presents a useful accounting concept, called scopes, that can help entities understand and structure decisions about operational boundaries, and can simultaneously help address the potential for "double counting". This approach defines ***three levels of responsibility for emissions****, and basically posits that an entity's responsibility for emissions is directly related to its control over, or ownership of, the sources of those emissions."*

-(CA-CP, 2008)

- **Scope 1:** Direct emissions from sources owned and controlled by ESF.
    - Example: Combustion of fossil fuels to power university buildings or vehicle fleet.

- **Scope 2:** Indirect emissions from sources that are not owned nor operated by ESF but whose products are directly linked to on-campus energy inputs.
    - Example: Purchased steam, purchased electricity.

- **Scope 3:** Emission sources not owned or operated by ESF but either directly financed or encouraged by ESF.
    - Example: Institution funded air travel, commuting of students and faculty.

❖Meeting the Challenge

ESF is prepared to meet the challenge, the commitment, and the responsibility of successfully implementing **ECN2015**. ESF is dedicated to steadily increasing its portfolio of sustainability & climate action projects. **ECN2015** establishes a comprehensive **five-fold path** to carbon neutrality, reduced energy use, and reduced fossil fuel dependence. In aggregate the projects examined in this document represent an **over 100% reduction** in MTCO2e emissions from 2007 levels. ESF is further committed and prepared to remain carbon neutral indefinitely, despite increases in enrollment, building space, unforeseen GHG increases, etc. Since joining with the now over 600 signatories of the ACU-PCC, and with the advent of **ECN2015**, ESF has actively upheld its commitment to full compliance with ACU-PCC guidelines by...

- ✓ "Establishing an institutional structure to oversee the development and implementation of the school's program".
  - *(Department of Renewable Energy Systems, Climate Change Committee)*
- ✓ "Completing an emissions inventory within a year and annually thereafter".
  - *(Completed 2008, revised 2009)*
- ✓ "Establishing a climate neutrality action plan".
  - (Formalized with **ECN2015**)
- ✓ "Taking some immediate steps to reduce greenhouse gas emissions".
  - (See "Completed Initiatives: 2007-2009" p. 20)
- ✓ Continually "integrating sustainability into the curriculum".
  - (See "Education" p. 52)
- ✓ "Making their climate action plan, inventory and progress reports publicly available".
  - (**ECN2015**, web presence, local television news spots, other media)

-(ACU-PCC, 2007)

❖Planting the Seeds *2003-2006*

Since 2003 ESF has been laying the ground work for a sustainability-focused overhaul to the entire campus. A diligent period of assessment, planning, preparations, and formal commitments has refined existing ideas and produced a new vision for ESF that is both progressive and in line with institutional history and educational programs. ESF has also taken some very tangible steps toward these ends. The following projects represent the beginning of a new era in campus sustainability & climate action at ESF.

- **Green Roof -** (Walters Hall) Improved building heating and cooling efficiencies, improved storm water management, vegetative carbon sequestration, natural habitat for local biodiversity, increased longevity of roof, aesthetic value.

Green Roof - SUNY ESF

- **Recycling -** Batteries, cardboard, cans, glass, plastic, print cartridges, computer equipment, electronic equipment, light bulbs, paper, and scrap metal.
- **Composting -** Dining hall scraps, student bins around campus.
- **Green Campus Initiative -** (student group) Energy conservation & awareness campaigns, campus waste audits & reduction efforts, recycled cereal-box notebooks, documentary club, etc.
- **Water Conservation -** Water-saving plumbing fixtures including infrared sensor faucets and flush valves, low volume toilets and urinals, spring-operated lavatory faucets, etc.

- **Hybrid & Alternative Fuel Vehicles:** - Thirty-four (34) vehicles, 17% of university fleet. Hybrids, plug-in hybrids, Biofuels, propane/natural gas, etc.

ESF President Neil Murphy driving a plug-in hybrid van

- **Alternative Fuel Vehicle Fueling Station -** Dual 3,000 gallon tanks and pumps provide on-campus fueling station for University Vehicle Fleet. One tank stores an E85 gasoline & ethanol blend while the other holds a mix of diesel & biodiesel.

- **SUNY Center for Sustainable and Renewable Energy -** Sixty-four (64) campus cooperative, headquarters located at ESF & coordinated by ESF faculty and administrators.

- **Baker Laboratory Renovations -** $37 Million LEED Silver building overhaul. Electronic lighting controls, occupancy sensors, digital air handling units & exhaust system, recycled building materials, natural lighting maximization, storm water recovery for gray water uses.

- **"Sustaining the Green" -** Official campus sustainability trademark and oversight committee.

- **Green Cleaning Products -** comprehensive line.

- **Sustainability Planning -** Vision 2020, Sustainability Plan, Campus Master Plan.

- **Climate Change Committee -** Meets regularly to discuss campus climate action status and progress.

- **"Flexipave" Walkways -** Part of a $1.9 million renovation to the campus grounds, walkways are made from 50% recycled materials, and are semi-permeable for improved drainage and storm water management.

- **Bio-retention Basin -** (rain-garden) Green infrastructure, ecological engineering, improved storm water management, restores natural water cycle & purification, aesthetic value.

Rain Garden - SUNY ESF

- **Auto Refurbishment Program -** Conserves energy, emissions, and financial capital by refurbishing used vehicles (including heavy machinery) instead of purchasing new ones.

- **Commuter Friendly Campus -** Expanded bike parking, 80% of students walk or bike.

- **"STARS" -** Participant in AASHE "STARS" (Sustainability Tracking Assessment and Rating System) Pilot Program.

- **Eco-House -** Off campus student housing cooperative dedicated to green living.

- **Energy Star Purchasing Policy -** 100% of appliances.

- **Guest Speakers -** High profile sustainability and climate experts.

- **Education - "**ESF is unique among colleges and universities in that all of its educational and research programs are oriented toward natural resources, and toward the natural and designed environments. All that ESF is and does serves the mission of achieving a sustainable world." (ESF, 2009) (see p. 49)

- **Research:** extensive research by students and faculty in many areas of sustainability. (see p. 54)

- **Outreach:** Numerous sustainability and climate related conferences and workshops throughout the year aimed at professionals in all fields, teachers, students, K-12, and the general public (see p. 55).

- **Earth Week Celebrations:** Week long program of sustainability, climate, and environmental awareness & action events.

❖Baseline: 2007

ECN2015 uses fiscal year 2007 as the baseline for campus energy use, GHG emissions, and other key metrics. This establishes an accurate and consistent starting point for quantifying reduction strategies and making future plans and projections.

ESF 2007

Institutional Data

- Operating Budget: $35,650,000
- Research Budget: $15,799,000
- Energy Budget: $2,212,900.00
- Fulltime Students: 1655
- Part-time Students: 600
- Faculty and Staff: 540
- Building Space: 714,548 sq ft
- Forest Land: 25,000 acres +

ESF Carbon Footprint* - 2007

12,145 MTCO2e

*reflects GWPs and emission factors

Scope 1		Scope 2		Scope 3		
Stationary Combustion	Vehicle Fleet	Purchased Electricity	Purchased Steam	Commuting	Air Travel	Scope 2 T&D Losses
1,535	226	4,040	3,979	593	830	942

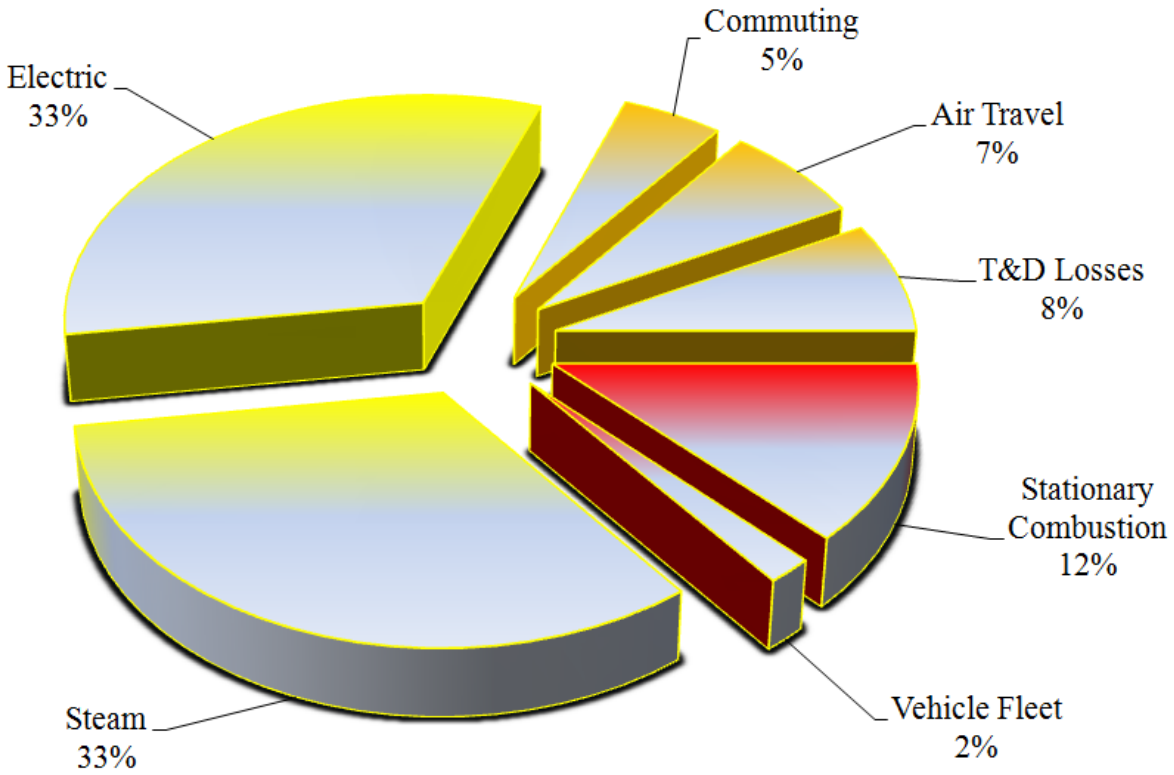


Figure 1 - ESF Carbon Footprint 2007

Scope 1 Emissions:
1,761 MTCO2e

Scope 2 Emissions
8,018 MTCO2e

Scope 3 Emissions:
2,365 MTCO2e

ESF Energy Inputs* - 2007

184,394 MMBtu

*reflect energy use factors

Scope 1					Scope 2		Scope 3		
Distillate Oil	Natural Gas	Propane	Gasoline	Diesel	Electric	Steam	Commute	Air Travel	Scope 2 T&D
7,342	18,047	718	2,608	533	52,075	75,199	8,242	4,213	15,405

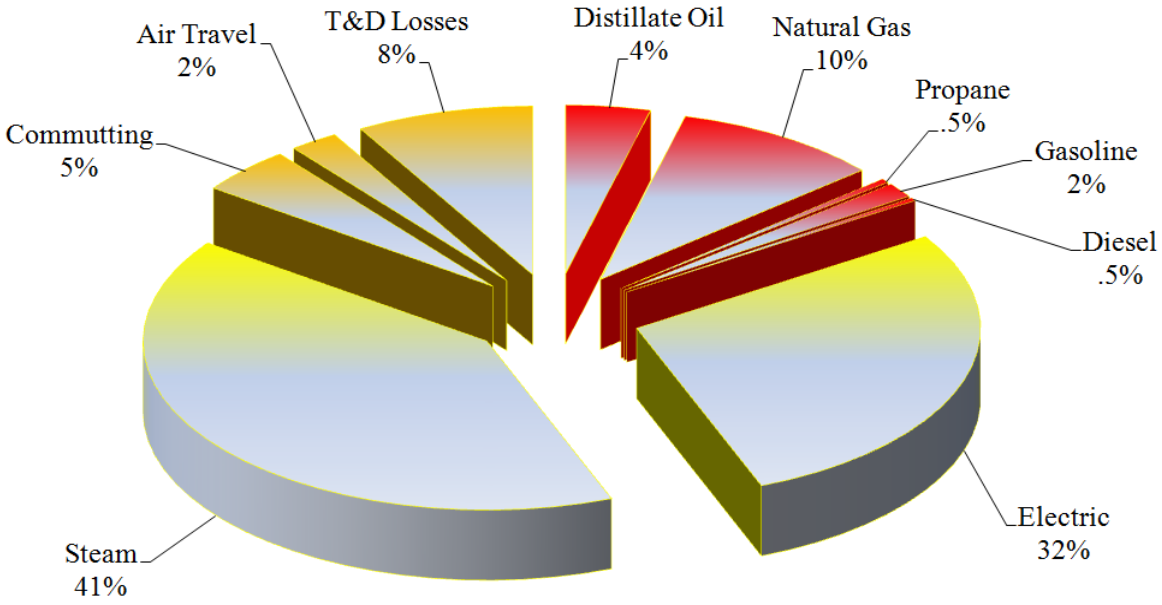


Figure 2 - ESF Energy Inputs 2007

Scope 1 Energy Inputs:
29,247 MMBtu

Scope 2 Energy Inputs:
127,275 MMBtu

Scope 3 Energy Inputs:
27,859 MMBtu

The Five-Fold Path

ECN2015 organizes all sustainability projects 2007-2015 into five major categories as follows...

1. **Energy Conservation Measures:** energy audits, energy saving renovations, technology & facilities upgrades.
   - 15 Initiatives
   - 1,100+ MTCO2e/yr Offset
   - Target 10% Reduction in Carbon Footprint

2. **Alternative Energy Projects:** on-site green and renewable energy projects to power existing buildings.
   - 14 Initiatives
   - 1,600+ MTCO2e/yr Offset
   - Target 15% Reduction in Carbon Footprint

3. **Green-Building Energy Systems:** systems design of new construction to include advanced Biomass Fired Combined Heat and Power (CHP) energy systems. Ultra efficient building envelopes allow excess energy and emission-offsets from the system to flow to surrounding buildings.
   - 1 Initiative (5 components)
   - 2,700+ MTCO2e/yr Offset
   - Target 22% Reduction in Carbon Footprint

4. **Campus Action Campaigns:** campaigns among students, staff, and faculty for reduced energy use and emissions, policy changes, awareness, reduced waste, etc.
   - 4 Initiatives
   - 400+ MTCO2e/yr Offset
   - Target 5% Reduction in Carbon Footprint

5. **Forest Carbon Sequestration:** official analysis, designation, and management of select ESF Forest Properties to meet carbon sequestration & storage goals.
   - 2 Initiatives
   - 7,000+ MTCO2e/yr Offset
   - Target 55% Reduction in Carbon Footprint

Total - all sustainability & climate action projects at ESF, 2007-2015.

- 40 Initiatives
- 13,000+ MTCO2e/yr Offset
- Target 110% + Reduction in Carbon Footprint

Target Reductions

Table 1 represents the target reductions by category and in aggregate for all climate & sustainability initiatives at ESF 2007 - 2015.

	Carbon Footprint	Purchased Electricity	Purchased Fossil Fuel Energy*
Total	**110%**	**70%**	**65%**
Energy Conservation Measures	10%	5%	15%
Alternative Energy Projects	15%	40%	15%
Green-Building Energy Systems	25%	20%	30%
Campus Action Campaigns	5%	5%	5%
Forest Carbon Sequestration	55%	-	-

Table 1 - Target Reductions

*Purchased Fossil Fuel Energy includes purchased steam and all direct (scope 1) combustion

❖Completed Initiatives: *2007-2009*

The second phase of **ECN2015** builds on ESF's previous sustainability efforts and takes the next step in climate neutrality and reduced fossil fuel dependence with the installation of several new Alternative Energy Projects. (For complete environmental, energy, and economic data on all projects 2007-2015 please refer to tables 2-9 on p. 22-25 & 34-37) For detailed descriptions & ratings of all projects 2007-2015 please refer to Appendix A)

- 250 kW Molten Carbonate Fuel Cell (Main Campus)
- 25 kW Photovoltaic Array (Baker Laboratory)
- 15 kW Photovoltaic Array (Walters Hall)
- 5 kW Wind Turbine (Heiberg Memorial Forest & Tully Field Station)
- Biodiesel from Fryer oil (Main Campus)
- High Efficiency Chillers (Illick Hall and Walters Hall)

250-kW Molten Carbonate Fuel Cell - SUNY ESF

25-kW Solar PV Array, Baker Lab - SUNY ESF

❖ Planned Initiatives: *2010-2015*

The third phase of **ECN2015** significantly increases the number and intensity of sustainability & climate action projects at ESF. A recent energy audit revealed numerous opportunities for Energy Conservation Measures. The Department of Renewable Energy Systems and the ESF community have also identified several opportunities for substantial reductions in GHG emissions and energy use.

Energy Conservation Measures

- Glycol Heat Recovery Loop (Jahn Laboratory)
- Variable Frequency Drives on Chill Water Pumps (Jahn Laboratory)
- Metal Halide Re-lamping (Jahn Laboratory, Mechanical Room)
- Vending Machine Sensors (Main Campus)
- High Efficiency Motors (Main Campus)
- T-12 Re-lamping (Newcomb Campus)
- Radiator Steam Trap Replacement (Marshal Hall)
- Variable Frequency Drives on Air Handling Units (Moon & Illick)
- Occupancy Sensors (Bray Hall)
- Occupancy Sensors (Main Campus)
- Hallway De-lamping (Illick Hall)
- Maintained Grounds Improvements (Main Campus)
- Building Retrofits (Illick Hall)
- Rooftop Greenhouse Replacement (Illick Hall)

Energy Conservation Measures at SUNY ESF

		Annual							Lifecycle						Economic			
Energy Consevation Measures	ECM #	MTCO2e Offset	% CFP*	Electric Savings *MWh*	% PE*	Energy Savings *MMBtu*	% PFF*	Fuel Type Offset	Life Span *years*	MTCOC2e Offset	Marginal capital cost per MTCO2e offset	Fossil Fuel Input *MMBtu*	Fossil Fuel Offset *MMBtu*	Net Energy Ratio *(x/1)*	Cost	Annual Savings	NYSERDA Incetntive	Simple Payback *years*
ECM Totals	15	1480	12.2	815	7.5	15,973	15.3	Electric, Steam	28	52,677	$93	50,866	997,074	20	$4,878,784	$531,731	$293,914	8.6
Heat Recovery Loop (Jahn Lab)	1	341	2.8	-550	-5.1	7,743	7.41	Steam	50	17,058	$67	11,905	293,375	25	$1,141,868	$142,370	$0	8.0
VFD Chilled Water Pumps (Jahn Lab)	2	11	0.1	29	0.27	0	0.00	Electric	25	269	$65	183	7,381	40	$17,508	$2,244	$2,596	6.6
Metal Halide Replacement (Jahn Lab)	3	32	0.3	85	0.78	0	0.00	Electric	15	474	$76	377	12,997	35	$36,114	$7,674	$9,233	3.5
Vendor Misers	4	8	0.1	23	0.21	0	0.00	Electric	15	127	$28	37	3,497	93	$3,588	$1,772	$2,050	0.9
High Efficiency Motors	5	10	0.1	28	0.26	0	0.00	Electric	25	261	$166	451	7,153	16	$43,224	$3,116	$4,145	12.5
Lighting Upgrades (Newcomb)	6	16	0.1	43	0.39	0	0.00	Electric	18	286	$83	248	7,851	32	$23,805	$2,598	$17,843	2.3
Replace Steam Traps (Marshall Hall)	7	294	2.4	0	0.00	4,174	4.00	Steam	25	7,361	$8	608	104,350	172	$58,320	$108,698	$0	0.5

Table 2 - Energy Conservation Measures 1

*CFP = Baseline Carbon Footprint, *PE = Baseline Purchased Electricity, *PFF = Baseline Purchased Fossil Fuel Inputs

Energy Conservation Measures at SUNY ESF (continued)

		Annual							Lifecycle						Economic			
Energy Consevation Measures	ECM #	MTCO2e Offset	% CFP*	Electric Savings *MWh*	% PE*	Energy Savings *MMbtu*	% PFF*	Fuel Type Offset	Life Span *years*	MTCOC2e Offset	Marginal capital cost per MTCO2e offset	Fossil Fuel Input *MMBtu*	Fossil Fuel Offset *MMBtu*	Net Energy Ratio *(x/1)*	Cost	Annual Savings	NYSERDA Incetntive	Simple Payback *years*
VFDs on AHUs (Moon and Illick)	8	107	0.9	106	0.97	955	0.91	Electric, Steam	25	2,668	$37	1,098	50,873	46	$105,275	$33,227	$5,363	3.0
Occupancy Sensors (Bray Hall)	9	9	0.1	23	0.22	0	0.00	Electric	25	219	$97	243	6,011	25	$23,328	$1,827	$2,114	11.6
Occupancy Sensors (Main Campus)	10	44	0.4	117	1.08	0	0.00	Electric	25	1,095	$97	1,216	30,054	25	$116,640	$9,135	$10,570	11.6
High Efficiency Chillers (Illick and Walters)	11	224	1.8	600	5.54	0	0.00	Electric	40	8,954	$107	12,511	245,664	20	$1,200,000	$72,000	$240,000	13.3
Hallway Delamping (Illick Hall)	12	26	0.2	70	0.65	0	0.00	Electric	25	654	$0	1	17,933	17201	$100	$8,410	$0	0.0
Grounds Improvements (Main Campus)	13	50	0.4	0	0.00	20	0.02	Gasoline	20	1,000	$10	104	400	4	$10,000	$500	$0	20.0
Green House Replacement (Illick Hall)	14	151	1.2	0	0.00	2,143	2.05	Steam	50	7,559	$145	11,458	107,150	9	$1,099,014	$56,651	$0	19.4
Building Retrofits (Illick Hall)	15	156	1.3	242	2.23	938	0.90	Electric, Steam	30	4,691	$213	10,426	102,384	10	$1,000,000	$81,509	$0	12.3

Table 3 - Energy Conservation Measures 2

Alternative Energy Projects

- 25 kW Photovoltaic Array (Moon Library)
- 15 kW Photovoltaic Array (Newcomb Dining Hall)
- 15 kW Photovoltaic Array (Newcomb Administration Building)
- Wood Pellet Boilers (Newcomb Campus)
- Radiant Floor Heating (Newcomb Campus)
- Wood Pellet Boilers (Tully Field Station)
- Vertical Axis Wind Turbines (Illick Hall)
- CHP Downdraft Biomass Gasifier

Alternative Energy Projects at SUNY ESF

		Annual							*Lifecycle*						*Economic*			
Alternative Energy Projects	**AEP #**	**MTCO2e Offset**	**% CFP***	**Electric Savings** *MWh*	**% PE***	**Energy Savings** *MMBtu*	**% PFF***	**Fuel Type Offset**	**Life Span** *years*	**MTCOC2e Offset**	**Marginal capital cost per MTCO2e offset**	**Fossil Fuel Input** *MMBtu*	**Fossil Fuel Offset** *MMBtu*	**Net Energy Ratio** *(x/1)*	**Cost**	**Annual Savings**	**NYSERDA Incetntive**	**Simple Payback** *years*
AEP Totals	14	1746	14.4	3,946	38.4	15,516	14.9	Electric, Steam, Fuel Oil, Diesel	38	81,131	$19	42,614	1,899,918	45	$3,719,092	$473,484	$2,188,000	3.2
250 kW Molten Carbonate Fuel Cell (Main Campus)	1	233	1.9	1,700	15.7	3,000	2.9	Electric, Steam	30	7,004	$4	17,914	306,018	17	$1,350,000	$241,750	$1,325,000	0.1
15 kW PV Array (Walters Hall)	3	6	0.1	17	0.16	0	0.0	Electric	30	190	$237	1,251	5,220	4	$120,000	$1,560	$75,000	28.8
25 kW PV Array (Baker Lab)	4	9	0.1	24	0.22	0	0.0	Electric	30	269	$279	2,085	7,370	4	$200,000	$2,600	$125,000	28.8
25 kW PV Array (Moon Library)	5	9	0.1	24	0.22		0.0	Electric	30	269	$279	2,085	7,370	4	$200,000	$2,600	$125,000	28.8
15 kW Photovoltaic (Newcomb Dining)	6	6	0.1	17	0.16	0	0.0	Electric	30	190	$237	1,251	5,220	4	$120,000	$1,560	$75,000	28.8
15 kW Photovoltaic (Newcomb Admin.)	7	6	0.1	17	0.16	0	0.0	Electric	30	190	$237	1,251	5,220	4	$120,000	$1,560	$75,000	28.8
6 kW Photovoltaic (Tully)	8	3	0.0	7	0.06	0	0.0	Electric	30	78	$230	500	2,150	4	$48,000	$625	$30,000	28.8

Table 4 - Alternative Energy Projects 1

Alternative Energy Projects at SUNY ESF (continued)

		Annual							Lifecycle						Economic			
Alternative Energy Projects	AEG #	MTCO2e Offset	% CFP*	Electric Savings *MWh*	% PE*	Energy Savings *MMBtu*	% PFF*	Fuel Type Offset	Life Span *years*	MTCOC2e Offset	Marginal capital cost per MTCO2e offset	Fossil Fuel Input *MMBtu*	Fossil Fuel Offset *MMBtu*	Net Energy Ratio *(x/1)*	Cost	Annual Savings	NYSERDA Incetntive	Simple Payback *years*
Pellet Boilers (Newcomb)	9	178	1.5	281	2.59	1,000	1.0	Electric, Fuel Oil	50	8,889	$29	2,689	193,723	72	$257,921	$33,698	$0	7.7
Radiant Floor Heating (Hungtington)	10	21	0.2	57	0.52	0	0.0	Electric	50	1,058	$12	138	29,025	211	$13,196	$6,805	$0	1.9
Pellet Boilers (Tully)	11	21	0.2	56	0.52	0	0.0	Electric	50	1,048	$19	209	28,743	138	$20,000	$6,739	$0	3.0
50 kW Vertical Axis Wind Turbines (Illick Hall)	2	17	0.1	45	0.42	0	0.0	Electric	50	839	$250	2,189	23,031	11	$209,975	$5,400	$0	38.9
CHP Downdraft Biomass Gasifier (Main Campus)	12	1199	9.9	1,700	15.7	8,000	7.7	Steam, Electric	50	59,930	$11	10,426	1,270,060	122	$1,000,000	$154,590	$333,000	4.3
5 kW Windturbine (Tully)	13	3	0.0	8	0.08	0	0.0	electric	40	125	$160	469	3439.3	7	$45,000	$1,008	$25,000	19.8
Onsite Biofuel Production (Main Campus)	14	35	0.3	-7	-0.06	516	0.5	diesel	30	1,052	$14	156	13,328	85	$15,000	$12,989	$0	1.2

Table 5 - Alternative Energy Projects 2

Green-Building Energy Systems

In addition to retrofitting existing buildings to LEED Gold & Platinum standards, ESF is committed to applying eco-design and green-building techniques to all new construction. ESF's commitment to these principles will be exemplified in the Gateway Building, scheduled for competition in late 2011. Drawing on in-house expertise in sustainable construction and renewable energy systems, ESF has teamed up with Architerra Inc., and VanZelm Engineers to create a unique and progressive facility. The building will serve the campus community in a variety of ways and provide a demonstration platform for Biomass-Fired Combined Heat & Power Energy Systems.

The new Gateway to the ESF Community

(Images courtesy of Architerra Inc.)

Gateway Building

Primary Objectives

- Reduce ESF fossil fuel dependence by outputting more renewable energy than the building consumes
- Reduce ESF carbon footprint by offsetting more emissions than the building generates
- Provide a showcase, demonstration, and testing grounds for renewable energy systems and green-building techniques
- Effectively & efficiently use sustainable, local sources of biomass to meet campus energy needs
- Reduce and stabilize campus energy costs
- A building that teaches, inspires, and improves campus life
- Serve as the physical representation of ESF's academic programs and institutional commitments to sustainability
- Serve as the Gateway to the entire ESF Community and a second century of leadership in environmental education

Inside the Gateway Building - SUNY ESF

Gateway Building

Additional Goals & Design Features

- ~45,000 sq ft building
- LEED Platinum+
- Target energy intensity 36 kBtu/sq ft/year or less
- Progressive eco-design principles
- Emphasis on sustainably harvested, local hardwoods for interior
- Provide over 11,000 sq. ft. of green space to the campus community
- Strengthen campus identity and mission statement
- Maximize use of natural ventilation and minimize use of air-conditioning
- House multiple departments & multiple functions: special events, admissions, outreach, bookstore, food service, common area, green space, campus & student hub, offices, gateway energy system
- Interactive exhibits & highlights of sustainability research at ESF
- Gateway to ESF Satellite Campuses (webcams, information, exhibits)
- Comfortable, day-lit, healthy environment
- Support and showcase regional economy

Gateway Building - SUNY ESF

Gateway Building

Focus on Combined Heat and Power (Cogeneration)

The main focus of Green-Building Energy Systems projects at ESF is advanced CHP units fired by local sources of biomass.

- CHP is up to twice as efficient as traditional generation systems (35-45% becomes 70-80%)
- Heating systems capture waste energy and convert to electricity.
- Electricity generating systems capture waste energy and use for space heating
- Fired by clean burning & renewable fuel sources

Gateway Building - SUNY ESF

Gateway Building

Focus on Biomass

- Biomass is a renewable local resource.
- Biomass has favorable environmental, energetic, and economic returns on investment competitive with fossil fuels.
- ESF is a school of forestry and is already heavily invested in biomass education, research, & development projects.
- ESF will initially purchase pellets made from a local industrial residue sources with the intent of establishing a vertically integrated pellet production, processing, transportation, and end use system in the near future.
- Biomass is considered a carbon neutral fuel source.
    - In a case study for the National Renewable Energy Laboratories (NREL), Spath & Mann (2004) analyzed and compared the energetic, environmental, and economic outputs of several forms of direct burn biomass.
    - Systems analysis of several forms of biomass incineration revealed closed CO2e loops for systems similar to the Gateway Biomass Energy System at ESF
    - For systems burning industrial or agricultural residues, Spath & Mann (2004) calculated a lifecycle assessment of over 100% CO2e closure.
        - System Boundaries
            - Avoided Emissions from landfill/mulching
            - Transportation and processing of fuel
            - Construction and operation of conversion technology
    - For systems burning dedicated feedstock, Spath & Mann (2004) again calculated a lifecycle assessment of over 100% CO2e closure.
        - System Boundaries
            - Vegetative CO2e Sequestration
            - Transportation and Processing of fuel
            - Construction and operation of conversion technology

Gateway Building Energy System

The keystone of **ECN2015** is the **Gateway Building Energy System**. Biomass, Combined Heat & Power, and Systems Design are the three trademarks and guiding principles of this system. An interconnected mix of energy conversion technologies is housed and fully integrated within the Gateway Building and linked to existing campus energy distribution grids and infrastructure. The system is intentionally designed to output significantly more energy than the Gateway Building will consume, allowing excess heat and electricity to flow to other buildings. Because the system is powered by clean burning & renewable fuel sources, the energy distributed to other buildings will significantly reduce ESF's carbon footprint and fossil fuel dependence. The system is anchored by a large wood pellet steam boiler. The boiler is connected to a backpressure turbine that captures excess heat and converts it to electricity while reducing steam pressure. Three additional micro-turbines (two natural gas fired, one biofuel) provide additional electricity generation and are also tied into the system's heat recovery loop. A large roof mounted photovoltaic array rounds out the system. Solar thermal applications and vertical axis wind turbines may also be retrofitted to the system if appropriate technologies can be matched to site conditions. The entire system will serve as a working demonstration for green & renewable energy systems.

System Components

6,000 MBtu Wood Pellet Steam Boiler

200 kW Back Pressure Steam Turbine

30 kW Biodiesel Fired CHP Micro-Turbine

Two (2) 65 kW Natural Gas CHP Micro-Turbines

50 kW Photovoltaic Array

Gateway Building Energy System

System Output

Thermal Output = 65% Campus Heating Needs -
(35,000+MMBtu/yr)

Electrical Output = 20% of Campus Electrical Needs -
(2,000+ MWh/yr)

Environmental Impact = 22% Reduction in Carbon Footprint -
(2,700+ MTCO2e/yr)

Economics

System Cost: $ 3.2 Million

Annual Savings: $ 336,000

Grants & Incentives: $ 1,485,000

15 Year Net Present Value: $ 1.5 Million

Gateway Building Energy System

Additional Notes

- 25% Improvement to overall campus efficiency
- Annual fossil fuel offset equivalent to…
  - 9,000+ barrels of oil or 2,500+ short tons coal
- Green Energy Return on Fossil Investment in less than 1 year

Annual Operation and Energy Flows

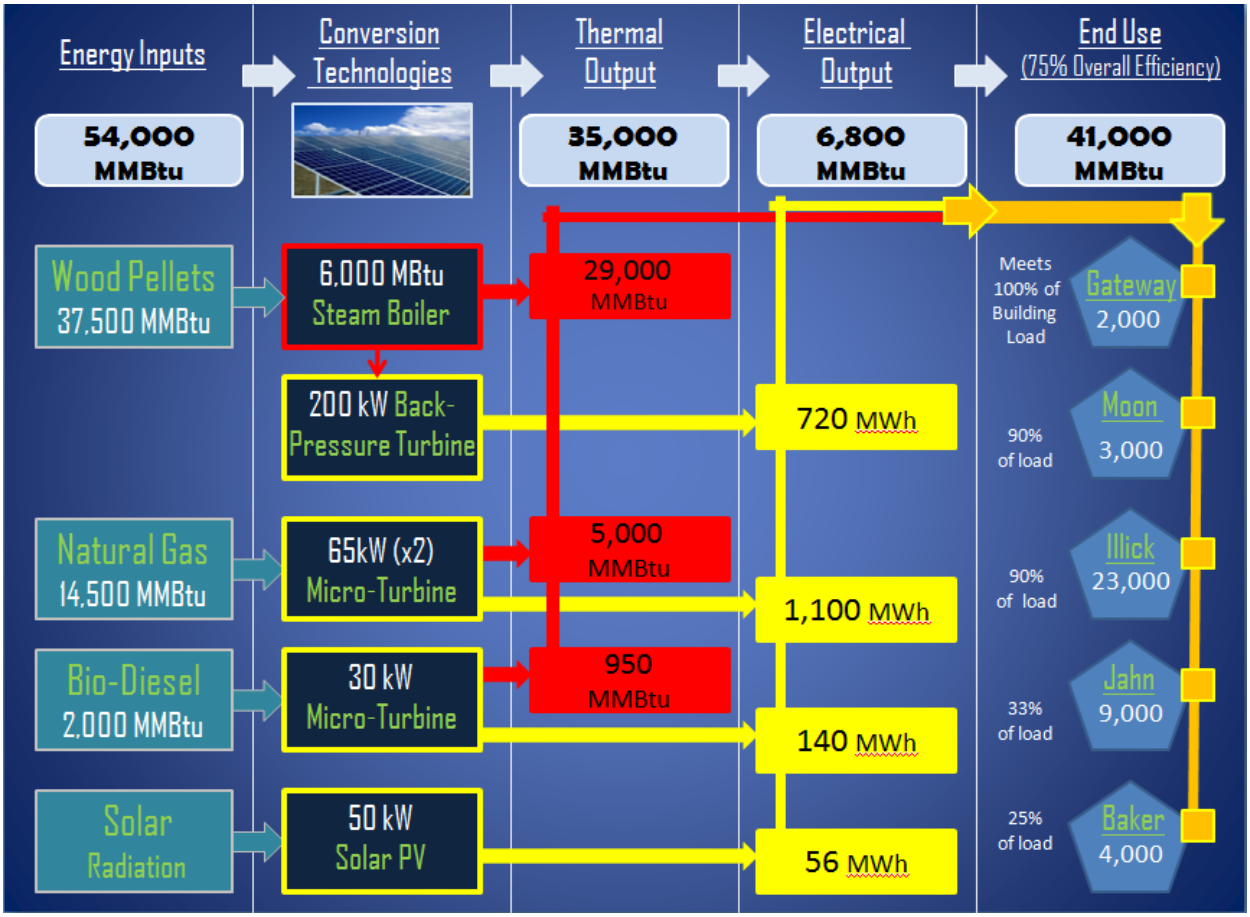


Figure 3 - Gateway Energy Flow

Campus Action Campaigns

Campus Action Campaigns at ESF are projects aimed at achieving significant emission reductions through voluntary behavioral adjustments, policy changes, and smart use of energy. Projects in this category are considered to have minimal or no capital investment or recurring costs, relying primarily on information, awareness, and activism.

- Travel Reduction and Efficiency (Main Campus)
- Temperature Settings (Main Campus)
- Campus Awareness Initiatives (Main Campus)
- Campus-wide De-lamping

Campus Action Campaigns at SUNY ESF

		Annual							*Lifecycle*						*Economic*			
Campus Action Campaigns	**CAC #**	**MTCO2e Offset**	**% CFP***	**Electric Savings** *MWh*	**% PE***	**Energy Savings** *MMBtu*	**% PFF***	**Fuel Type Offset**	**Life Span** *years*	**MTCOC2e Offset**	**Marginal capital cost per MTCO2e offset**	**Fossil Fuel Input** *MMBtu*	**Fossil Fuel Offset** *MMBtu*	**Net Energy Ratio** *(x/1)*	**Cost**	**Annual Savings**	**NYSERDA Incetntive**	**Simple Payback** *years*
CAC Totals	4	778	6.4	647	6.3	4,746	4.5	Electric, Steam, Travel Fuels	30	23,348	$0.09	21	341,186	>100	$2,000	$200,640	$0	<1
Travel Reduction & Efficiency	1	246	2.0	0	0.0	628	0.60	Travel Fuels	30	7,388	$0.00	5	18,845	>100	$500	$15,729	$0	<1
Temperature Settings (Main Campus)	2	351	2.9	200	1.85	3,920	3.75	Electric, Steam	30	10,535	$0.00	5	179,016	>100	$500	$126,077	$0	<1
Campus Awareness (Main Campus)	3	50	0.4	97	0.90	197	0.19	Electric, Steam	30	1,508	$0.00	5	35,847	>100	$500	$16,834	$0	<1
Comprehensive Campus De-lamping	4	131	1.1	350	3.23	0	0.00	Electric	30	3,917	$0.00	5	107,478	>100	$500	$42,000	$0	<1

Table 6 - Campus Action Campaigns

Forest Carbon Sequestration

The final step in **ECN2015** for achieving net-zero GHG emissions is forest carbon sequestration & storage. ESF began in 1911 as a school of sustainable forestry practices and remains so to this day. ESF properties now include close to 25,000 acres of forest land in eight locations. To meet the Carbon Sequestration goals set forth in **ECN2015** (7,000 MTCO2e/yr), ESF Forestry experts analyzed *"continuous forest inventory data from over 1,000 permanent re-measurement plots"* to determine the annual above ground forest carbon sequestration & storage (Davis, 2009). For the purposes of **ECN2015**, two properties have been selected for official designation as sequestration initiatives. Management of these areas is in-line with Chicago Climate Exchange (CCE, 2009) and GHG Protocol Standards as described in "*Land Use, Land-Use Change, and Forestry" (LULCF, 2006)*. Sites are sustainably managed so that growth in carbon stocks exceeds harvest.

Forest Name	Forest Location	Net Designated Acerage	MTCO2e/ac/yr Sequestered	Total MTCO2e/yr Sequestered
Pack Demonstration Forest	Warrensburg, NY	2,181	3.031	6,612
Heiberg Memorial Forest	Tully, NY	1,486	2.454	3,647
Total: 10,258* MTCO2e/yr sequesterd & stored				

Table 7 - Forest Carbon Sequestration

*Additional 3,258 MTCO2e/yr beyond **ECN2015** sequestration targets is not officially claimed as offsets in this report. In aggregate ESF sequesters far more MTCO2e/yr than it emits. ESF is committed to taking every feasible action to reduce institutional GHG emissions as much as possible, and officially claiming only the minimum amount of sequestration offsets. Officially claiming currently undesignated forest sequestration capabilities will remain an option for ESF in the future as necessary.

Summary All Projects 2007-2015

Table 8 summarizes all climate & sustainability projects quantified by **ECN2015**. GHG emissions, purchased electricity, and purchased fossil fuel reductions are listed along with their respective percentages of baseline offsets. A more detailed summary can be found in table 9 on the following page.

	Number of Innitiatives	Annual Reduction MTCO2e	% Carbon Footprint Mitigated	Annual Offset MWh	% Purchased Electricity	Annual Offset MMBtu	% Purchased Fossil Fuel Energy*
Total	40	13,730	113.0	7,443	72.5	70,066	67.1
Conservation	15	1,480	12	815	8	15,973	15
Alternative Energy Projects	14	1,746	14	3,946	38	15,516	15
Green-Building Energy Systems	5	2,725	22	2,034	17	33,831	32
Campus Action	4	778	6	647	6	4,746	5
Sequestration	2	7,000	58	-	-	-	-

*Purchased Fossil Fuel Energy includes purchased steam and all direct (scope 1) combustion

Table 8 - Summary

Detailed Summary all Projects 2007-2015

Project	Annual							Lifecycle						Economic			
Planned & Completed Initiatives 2007-2015	MTCO2e offset	% CFP*	Electric Savings *MWh*	% PE*	Energy Savings *MMBtu*	% PFF*	Fuel Type Offset	Average Life Span *(years)*	MTCO2e Offset	Marginal capital cost per MTCO2e offset	Fossil Fuel Input *MMBtu*	Fossil Fuel Offset *MMBtu*	Net Energy Ratio *(x/1)*	Cost	Annual Savings	NYSERDA Incetntive	Simple Payback *years*
Total	13,730	113	7,443	72	70,066	67	All Fossil Inputs	30	476,171	$16	126,864	4,868,996	38	$11,799,876	$1,541,745	$3,966,914	5
Energy Conservation Measures	1,480	12	815	8	15,973	15	Electric, Steam	28	52677	$93	50,866	997,074	20	$4,878,784	$531,731	$293,914	9
Alternative Energy Projects	1,746	14	3,946	38	15,516	15	Electric, Steam, Fuel Oil, Diesel	38	81131	$19	42,614	1,899,918	45	$3,719,092	$473,484	$2,188,000	3
Green- Building Energy Systems	2,725	22	2,034	17	33,831	32	Electric, Steam	40	109015	$16	33,363	1,630,818	49	$3,200,000	$335,889	$1,485,000	5
Campus Action Campaigns	778	6	647	6	4,746	5	Electric, Steam, Travel Fuels	30	23348	0.09	21	341,186	>100	$2,000	$200,640	$0	<1
Forest Carbon Sequestration	7,000	58	-	-	-	-	-	30	210000	-	-	-	-	-	-	-	-

Table 9 - Detailed Summary

Five-Year Fuel Mix Trend

Figure 4 represents the total Scope 1 & 2 energy inputs (direct combustion of fossil fuels, & purchased steam/electricity) for ESF from 2010 to 2014. ESF is poised to transition from approximately a 99:1 ratio in favor of fossil fuels to a 70:30 mix in favor of renewables in just the next five years. Major projects in their first full year of operation are listed at the bottom.

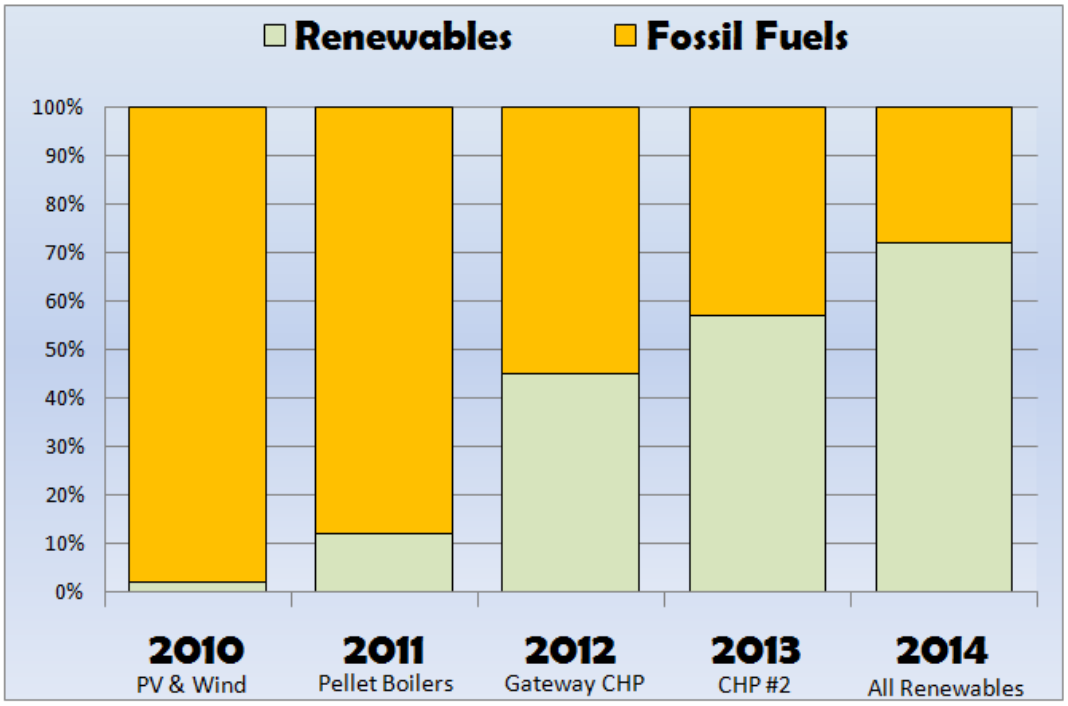


Figure 4 - Fuel Mix Trend

Key-Reductions

Figure 5 is a visualization of the three primary reductions achieved by the sustainability projects quantified in **ECN2015**. 2007 levels are set against 2015 levels, illustrating the substantial reduction in these key areas.

	2007	2015
GHG Emissions (MTCO2e)	12,145	-1,585
Purchased Electricity (MWh)	10,828	3,385
Purchased Fossil Fuels (MMBtu ÷ 10)	10,445	3,438

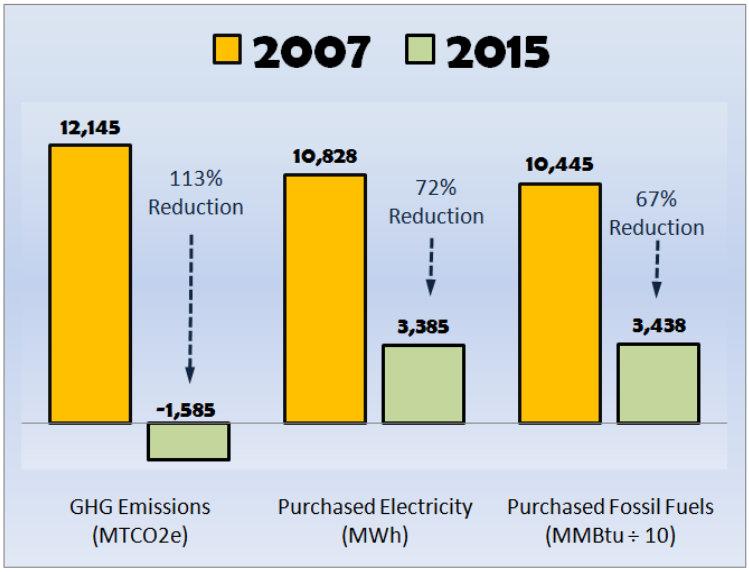


Figure 5 - Key Reductions

Environmental Analysis

ESF has a long standing commitment to the preservation of the natural world and the conservation of natural resources. The sustainability & climate action projects in this report represent a significant contribution to the global effort to mitigate the effects of human influenced climate change and a successful model of neutrality for other institutions to follow. ESF is prepared to stay significantly below the carbon neutral threshold, indefinitely remaining a net-zero emitter. Figure 6 depicts the five categories of sustainability efforts at ESF and their impact on total emissions from 2007-2015.

Emission Wedges Timeline

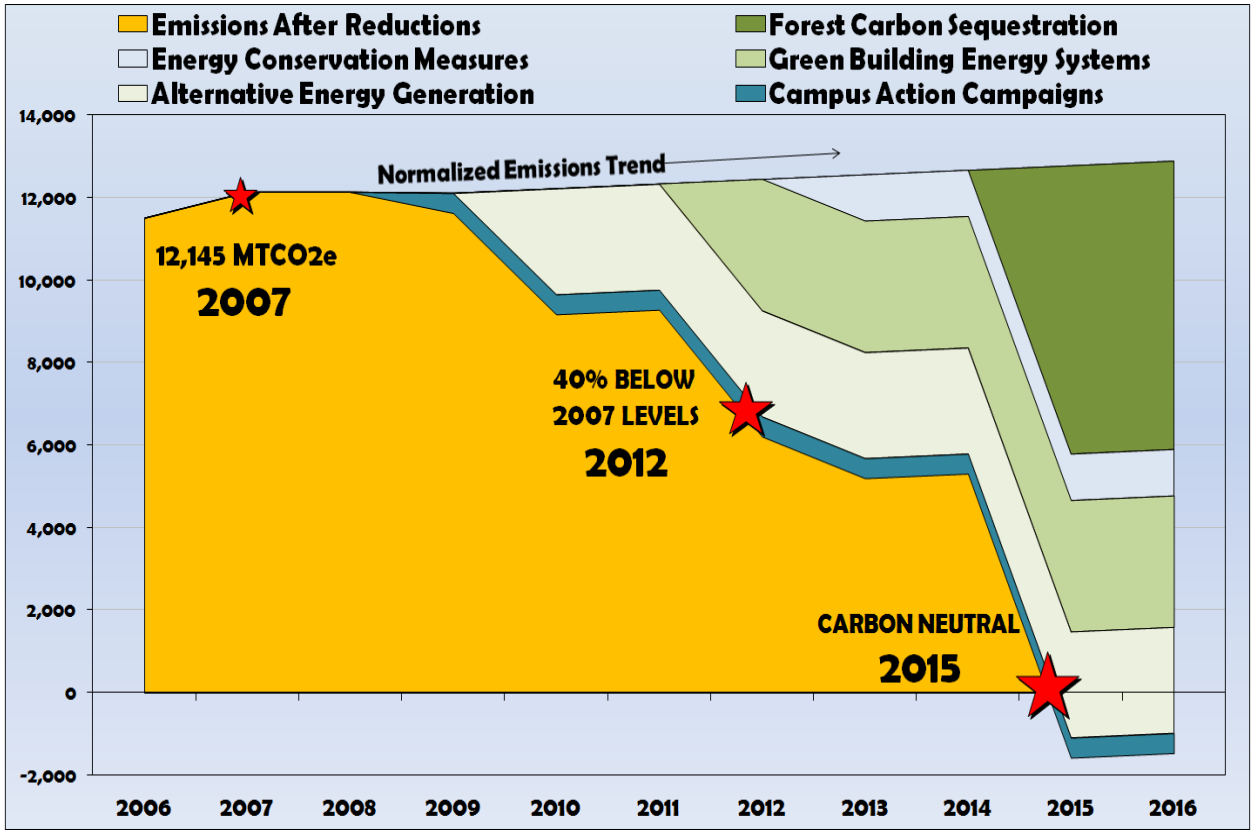


Figure 6 - Emission Wedges

Lifecycle Environmental Analysis of all projects by category

Table 10 shows the lifecycle fossil fuel offsets, crude oil equivalents, and GHG emissions mitigated by category and in aggregate for all projects enacted 2007-2015.

	Fossil Fuel Offset (MMBtu)	**Crude Oil Equivalent** (Barrels)	**Emissions Offset** (MTCO2e)
Energy Conservation Measures	**997,074**	**171,909**	**52,677**
Alternative Energy Projects	**1,899,918**	**327,572**	**81,131**
Green-Building Energy Systems	**1,630,818**	**281,176**	**109,015**
Campus Action Campaigns	**341,186**	**58,825**	**23,348***
Forest Carbon Sequestration	**-**	**-**	**210,000***
Total	**4,868,996**	**839,482**	**476,171**

Table 10 - Environmental Analysis

*Emissions offset every 30 years

Lifecycle Carbon Cost Efficiency

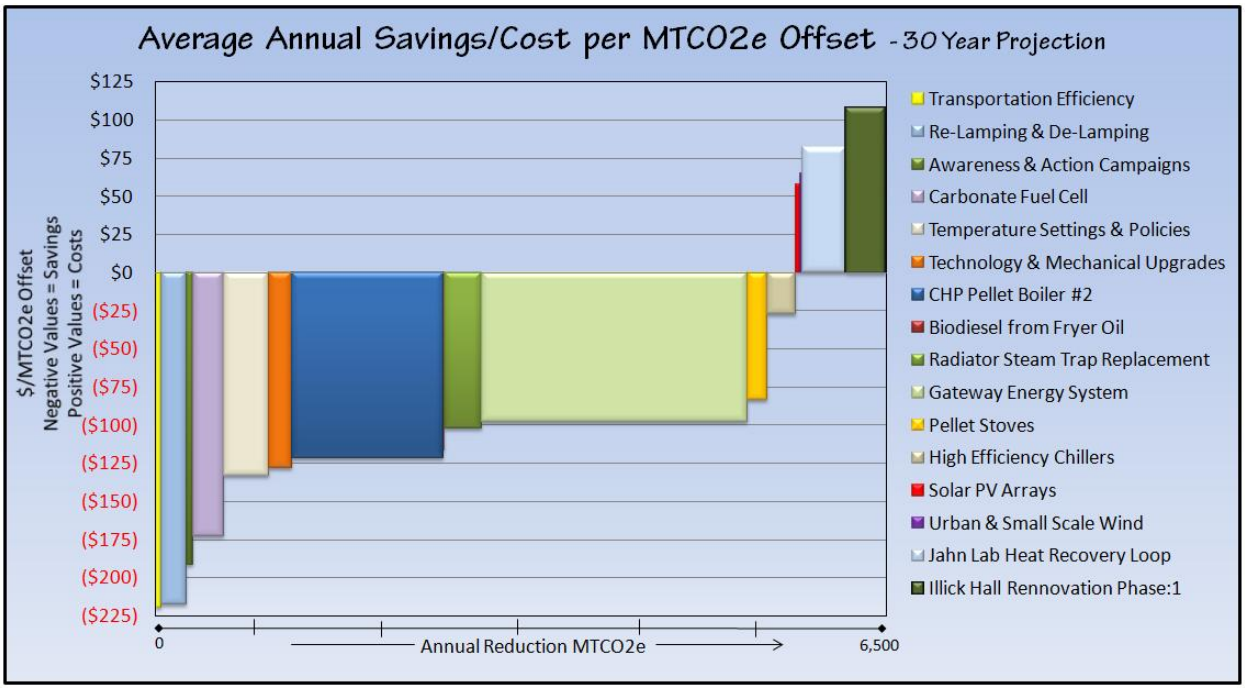


Figure 7 - Carbon Cost Efficiency

Emission Trajectory

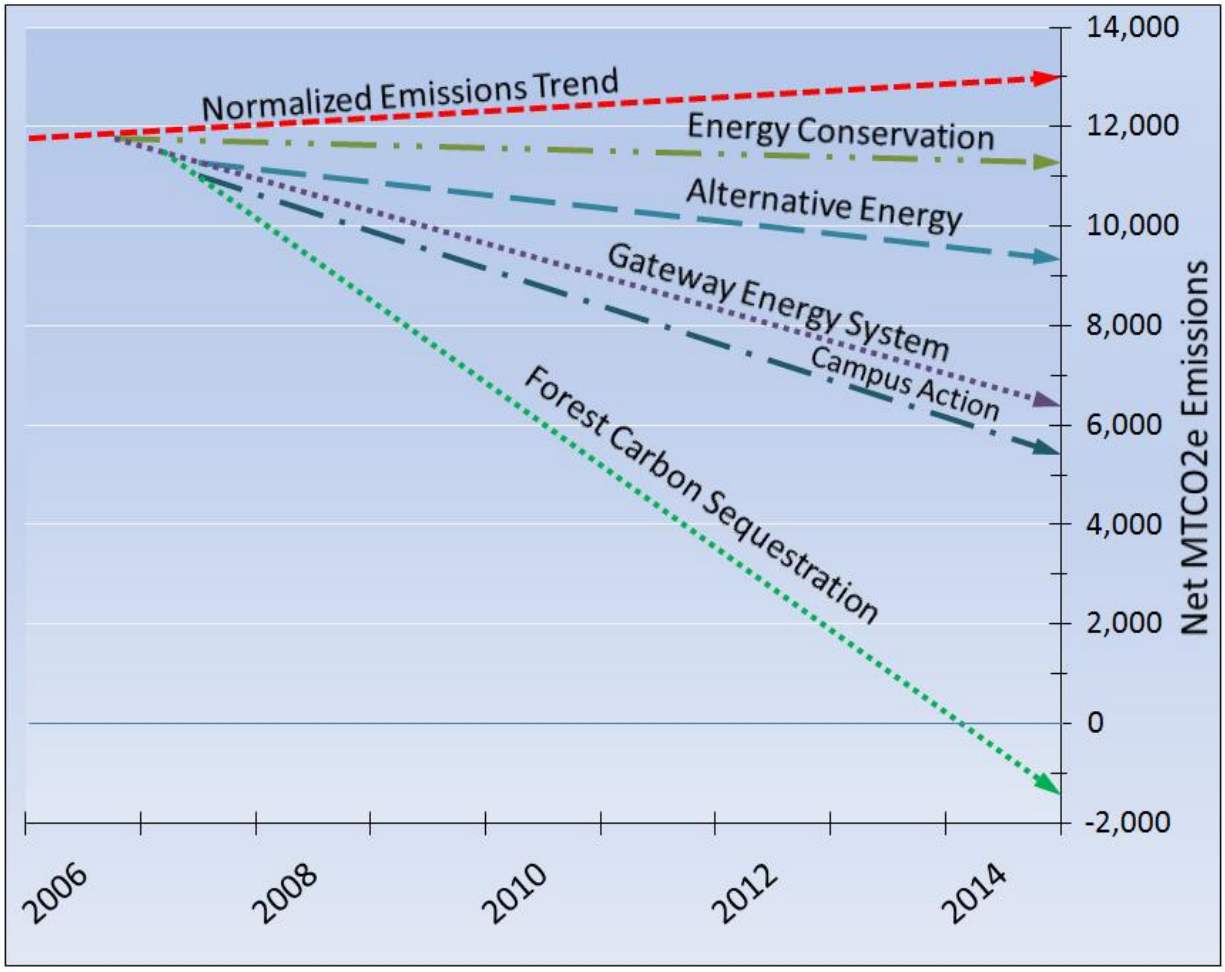


Figure 8 - Emissions Trajectory

Energy Analysis

One of the exciting and important areas of study and research at ESF is the field of net energy analysis, also known as EROI (Energy Return on energy Investment). EROI and the maximum power principle (see Hall, 1995) are influential factors of self organizing ecological systems. These ideas began with Alfred Lotka (see Lotka, 1922), and were refined and expanded substantially by ecologist Howard Odum in many works throughout his career (see Odum 1971, 1988). Dr. Charles A. S. Hall, a former PhD. student of Odum's, brought the concept of EROI with him to ESF over fifteen years ago. Today the concepts and importance of EROI are emphasized in numerous classes at ESF. Like sustainability, EROI analysis can be applied to a wide range of academic disciplines. The basic premise of EROI is that all living organisms must maintain a positive net energy balance in order to survive and overcome the ubiquitous forces of entropy. Energy must be continually obtained for growth, reproduction, homeostasis, and all the basic life functions to continue. Humans are part of the natural world and this concept can also be applied to human dominated ecosystems and actions. In order to survive and prosper in a sustainable manner, humans must also abide by the laws of EROI and maintain a positive net energy balance. Dr. Hall and his students have preformed thorough EROI analyses of natural resource extraction and energy production. This has proven to be an effective tool for analyzing and comparing the costs, benefits, and trends of the different ways in which humans harvest, convert, and use energy.

ECN2015 acknowledges EROI as a beneficial analysis tool for sustainability efforts. A form of EROI analysis has been used to evaluate all climate and sustainability initiatives at ESF from 2007-2015. Climate change and the inevitable peak in global production of all fossil fuels have created the need for unique and progressive mitigation strategies to these two interrelated challenges. One such strategy is the maximization of fossil energy savings or green energy output per unit of fossil fuel input. An EROI estimate for all initiatives 2007-2015 has been derived to provide the reader with a feel for green return on fossil investment. Fossil energy input is estimated by multiplying the project cost by 11MJ/$. This conversion ratio represents a weighted average of:

1) The estimated embodied energy of all economic activity (8.7 MJ/$) (Hall, et. al., 2009)

2) The estimated embodied energy of economic activity involving heavy construction (14 MJ/$) (Hall, et. al., 2009)

Campus Action Campaigns display the highest EROI ratios of any project category due to minimal input costs and the reliance on behavioral and policy changes as opposed to capital (and energy) intensive investments in conversion technologies or facilities upgrades. Projects in this category all have EROI ratios well over 100, the rate of return for US oil extraction in the 1930's (Hall, 2009) and the informal standard for exceptional energetic returns. Some **Energy Conservation Measures** also register EROIs above 100:1, but the majority of ECMs register in the 25-50 range, still a highly favorable return on investment. **Alternative Energy Projects** exhibit a range of EROIs from as low as 5:1 for highly incentivized technologies like Solar PV, and as high as 50:1 and up for technologies with little or no incentives such as common wood burning stoves. **Green-Building Energy Systems** also have highly favorable Green Output to Fossil input EROIs around 50:1.

Lifecycle EROI Analysis for energy intensive sustainability efforts

	Fossil Fuel Input* (MMBtu)	**Fossil Fuel Offset**** (MMBtu)	**Net Energy Ratio*****
Energy Conservation Measures	**50,866**	**997,074**	**20:1**
Alternative Energy Projects	**42,614**	**1,899,918**	**38:1**
Green-Building Energy Systems	**33,363**	**1,630,818**	**48:1**
Total	**126,864**	**4,868,996**	**36:1**

Table 11 - Energy Analysis

*Fossil Fuel Input = Project cost x 11MJ/$
**Fossil Fuel Offset = Lifecycle renewable energy output or fossil energy savings
*** Net Energy Ratio = Units of Green Energy Output for every One Unit of Fossil Fuel Input

Economic Analysis

In addition to the favorable environmental and energetic returns on investment, the majority of sustainability projects at ESF also have favorable economic returns and relatively short payback periods when capital costs minus incentives are divided by annual savings. While **ECN2015** calculates only simple payback periods, more advanced forms of Net Present Value analysis (accounting for interest & discount rates, rising fuel costs, tax incentives, inflation, etc) confirm the cost effectiveness of the projects listed in this report. Funding sources for the majority of projects listed in **ECN2015** have been earmarked or appropriated in ESF's annual budgets, endowment, grants, loans, state and federal funding.

Economic Analysis for all capital intensive sustainability efforts

	Initial Cost	Grants & Incentives	Annual Savings	Simple Payback Period
Energy Conservation Measures	$4,878,784	$293,914	$531,731	9 years
Alternative Energy Projects	$3,719,092	$2,188,000	$473,484	3 years
Green-Building Energy Systems	$3,200,000	$1,485,000	$335,889	5 years
Total	$11,797,876	$3,966,914	$1,341,104	5 years

Table 12 - Economic Analysis

❖Sustainable Futures: *2015 and Beyond*

The passionate and inspired community at ESF is constantly striving to make the campus greener and more sustainable. The following are some of the new proposals recently developed in conjunction with **ECN2015** and the campus community. Some of these proposals are likely to be enacted and operational by or before 2015.

- Annual campus sustainability conference and awards ceremony
- Annual on- & off-campus sustainability action challenges
- Re-lamping of exit signs with LEDs or photo-luminescent technology
- Student operated bicycle shop
- Expanded bicycle parking facilities on campus
- Better bicycle lanes and road signs in campus neighborhood
- "Push to View" controls for informational flat-screen televisions around campus
- Campus-wide smart grid, energy monitoring and control system
- Green computing solutions
- Campus vegetable garden
- Outdoor lighting system upgrades
- Increased recycling and solid waste reduction efforts

Other Initiatives on the Horizon

ESF is committed to training the future leaders in sustainability and spearheading initiatives that will have a lasting positive effect on the natural world, human culture, and the relationship between the two. The following are some of the major undertakings ESF plans to explore in the near future or is already preparing for.

- **Pilot Biomass Pellet Plants**
  - ESF is researching the viability of constructing a series of biomass pellet projects in Upstate New York.
  - Objectives include:
    - Research, demonstration, and testing grounds for pellets made from various sources of biomass that can be locally produced (willow shrubs, switch grass, agricultural residue, industrial residue, woody biomass)
    - Successful community-scale biomass production & end-use.
    - Local, campus owned source of pellets to fuel ESF biomass CHP units.

Short-Rotation Biomass Energy Crop Production Cycle

(Planting>Growth>Harvest>Processing)

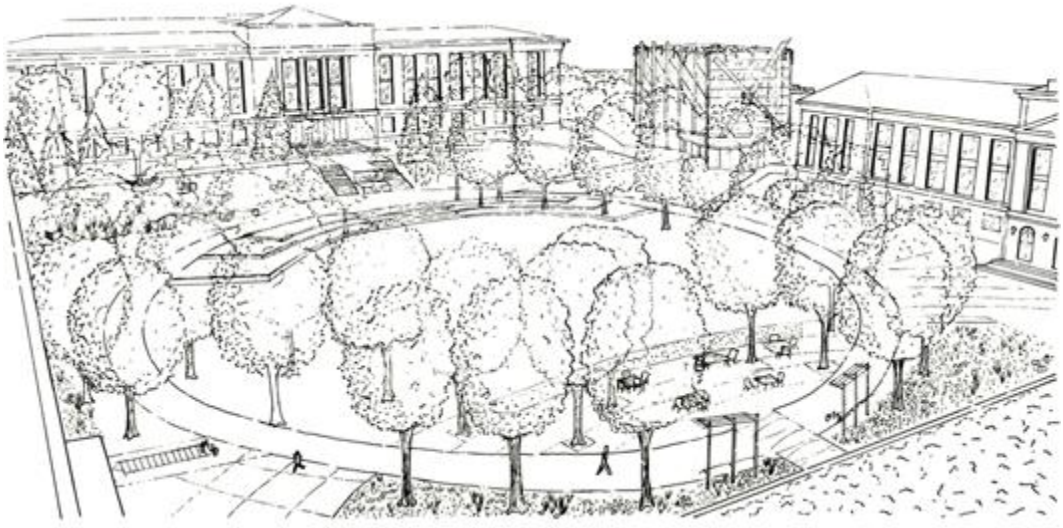
- **Ongoing Energy Efficiency and GHG Audits.**
    - ESF is committed to continually reassessing and reducing its energy use and GHG emissions beyond carbon neutrality. A second round of energy audits is planned for the remaining buildings on the main campus. Renovations of these buildings based on target improvements are also tentatively scheduled.
    - ESF plans to more fully account for its GHG emissions in future audits by including more scope 3 emissions as appropriate.

- **Green Energy Cooperative**
    - ESF has received a funding and is exploring the options for a green energy cooperative in partnership with Syracuse University's Whitman School of Management. The cooperative would sell biodiesel produced onsite from waste vegetable oil to local businesses as an exercise in Green Entrepreneurship.

- **Future Green-Building Projects**
    - Academic Research Building
    - Student Housing Project
    - Student Center

- **Periodic remodeling/retrofitting of all buildings to maximize energy efficiency, update, and modernize**
    - Illick Hall, Phase 2: 2016-2018
    - Moon Library: 2018-2020
    - Old Greenhouses: 2019
    - Marshall Hall: 2020-2021
    - Bray Hall: 2021-2022
    - Walters Hall:2022-2024

- **Grounds Improvements**
  - The Department of Landscape Architecture at ESF has crafted an appealing and desirable vision for the campus grounds. Major themes of this vision include:
    - open space maximization
    - reduced turf grass
    - a consistent and "leafy" green campus identity
    - Zen-like aesthetics
    - green communal spaces
    - water features and living storm water management
    - a landscape that teaches
    - union of form and function.



Green Quad Concept Design

Courtesy Department of Landscape Architecture, SUNY ESF

- **Education**
  - In addition to the hundreds of “sustainability focused” and “sustainability related” classes offered every year, ESF is continually striving to update its curriculum and degree programs to the highest industry and academic standards (see below for additional information)

- **Campus Action & Awareness**
  - ESF realizes that campus action can be highly effective, efficient, and enjoyable form of energy conservation and sustainable practices. Fostering general awareness and specific initiatives will remain paramount to the success of current and future Campus Action Campaigns.

❖The Broader Commitment

At ESF, the commitment to sustainability extends far beyond changes to the campus grounds and operations. Sustainability is ultimately an interpersonal and intergenerational effort that is reliant as much on social capital as it is on financial, built, or environmental capital. In this vein, ESF is committed to fostering the human relationships, technical skills & knowledge, and deeper wisdom that are essential to forging a prosperous and sustainable human society in harmony with the natural world. As with the five-fold path to climate neutrality, ESF is pursuing a similar five-fold path to the more subtle, but equally important side of sustainability.

Fostering Social Capital

- *Education*
- *Research*
- *Outreach*
- *Partnerships*
- *Community Service*

➢ *Education*

The ACU-PCC Commitment, AASHE Membership, and ESF's institutional foundation recognize that being a leader in sustainability *today*, means educating and enabling the leaders of *tomorrow*. In many ways ESF is ahead of the curve in this arena because fostering a mutually beneficial relationship between humans and the natural world has been ESF's educational mission for nearly a century. AASHE's *"Climate Action Planning Wiki"* points to *"The Essex Report"* as a good example of core values that would be paramount to a sound sustainability education (AASHE, 2009).

- How the natural world works
- The interdependence of humans and the environment
- How to assess the effects on humans and on the biosphere of human population dynamics; energy extraction, production and use; and other human activities such as agriculture, manufacturing, transportation, building and recreation
- The relationship of population, consumption, culture, social equity and the environment
- How to apply principles of sustainable development in the context of their professional activities
- Technical, design, scientific and institutional strategies and techniques that foster sustainable development, promote energy and natural resource efficiency and conservation, prevent and control the generation of pollution and waste, remediate environmental problems, and preserve biological diversity
- Social, cultural, legal and governmental frameworks for guiding environmental management and sustainable development
- Strategies to motivate environmentally just and sustainable behavior by individuals and institutions.

(Second Nature, 1995)

These sentiments accurately articulate and crystallize the educational goals of countless classes, departments, degree programs, and much of the overall educational experience at ESF. Furthermore, because sustainability is a rapidly advancing, trans-disciplinary field, ESF is committed to constantly reassessing its curriculum and remaining a world leader in sustainability education. The following pages contain a list of all undergraduate and graduate degree programs offered at ESF as of 2008/2009.

Undergraduate Degree Programs at ESF

Aquatic and Fisheries Science
Bachelor of Science
* biology and diversity of aquatic animals and plants
* application of ecological principles to understand and manage aquatic resources
* hands-on ecosystem studies in Adirondacks, Finger Lakes, Thousand Islands region, and Atlantic coast

Bioprocess Engineering - Bachelor of Science
* biologically based engineering program focused on renewable resources and sustainable practices
* flexibility to focus on the engineering, biology, and chemistry of ecologically sound industrial technologies and processes
* career possibilities in bioengineering, resource engineering, pharmaceuticals, renewable energy, and environmental engineering

Biotechnology - Bachelor of Science
* plant biotechnology
* phytoremediation and bioremediation
* alternative energy and materials
* conservation of endangered plant species

Chemistry -Bachelor of Science
* biochemistry and organic chemistry of natural products
* environmental chemistry
* natural and synthetic polymer chemistry
* secondary science teacher certification (joint program with Syracuse University)

Conservation Biology - Bachelor of Science
* application of science to conserve the earth's imperiled species and ecosystems
* focus on biological diversity and value of nature
* integration of biological perspectives with social, economic and legislative ones

Construction Management - Bachelor of Science
* management of sustainable construction processes
* analysis and design of structural components and systems
* emphasis on environmental and engineering issues
* 30 hour OSHA Certification and Level 1 Certified Professional Constructor exam

Environmental Biology - Bachelor of Science
* flexible, broad-based degree program in biological sciences
* orientation to natural resources and environmental concerns
* secondary science teacher certification (joint program with Syracuse University)

Environmental Resources and Forest Engineering - Bachelor of Science
* forest engineering
* environmental and natural resources engineering
* mapping science
* geographic information systems
* water resources engineering

Environmental Science - Bachelor of Science
* environmental information and mapping
* watershed science
* health and the environment
* earth and atmospheric systems science
* environmental analysis
* environmental engineering science
* renewable energy

Environmental Studies - Bachelor of Science
* environmental policy
* environmental communication and culture
* biological science applications

Forest Ecosystem Science - Bachelor of Science
* combining forestry and environmental biology

Forest Health - Bachelor of Science
* multidisciplinary studies leading to the understanding and protection of the world's forest resources
* identification and impact of biological agents of disease
* preparation for state and federal positions and for additional graduate work

Forest Resources Management - Bachelor of Science
* forest management
* forest ecology and biology
* forest measurements
* forest policy and administration

Landscape Architecture - Bachelor of Landscape Architecture
* site design
* urban and regional planning
* historic preservation
* community and environmental design
* computer applications
* off-campus study program

Natural History and Interpretation - Bachelor of Science
* patterns and relationships in the natural world
* identification, life history, distribution, and abundance of organisms
* interpretation and communication of knowledge to diverse audiences using modern methods

Natural Resources Management - Bachelor of Science
* environmental and natural resources management
* recreation resources management
* water resources management

Paper Engineering - Bachelor of Science
* chemical engineering-based education applied to the pulp, paper, and related chemical industries
* courses focus on both product and process design
* internships and co-ops provide practical, hands-on experience in the field

Paper Science -Bachelor of Science
* balanced program of science, engineering and technology applied to the pulp and paper industry
* flexibility to focus on a variety of areas including management and computer systems
* careers in technical service, product development, process and environmental improvement, management

Wildlife Science -Bachelor of Science
* emphasis on vertebrate, invertebrate, and plant ecology and taxonomy
* balance the needs of people and the needs of wildlife
* emphasis on endangered species as well as over-abundant species

Wood Products Engineering - Bachelor of Science
* sustainable construction and renewable materials
* marketing and production
* wood science

ESF College-wide Minors
* Bioprocess Science
* Computer and Information Technology
* Construction Management
* Paper Science
* Recreation Resource and Protected Area Management
* Renewable Energy
* Sustainable Construction Management
* Urban Environmental Science
* Marketing (joint program with Syracuse University)
* Management Studies (joint program with Syracuse University)
* Entrepreneurship (joint program with Syracuse University)

Associate Degree Programs at The Ranger School
Forest Technology
Associate in Applied Science
Land Surveying Technology
Associate in Applied Science

Graduate Degree Programs at ESF

Environmental and Forest Biology Master of Professional Studies with areas of study in:
o Applied Ecology
o Chemical Ecology
o Conservation Biology
o Ecology
o Entomology
o Environmental Interpretation
o Environmental Physiology
o Fish and Wildlife Biology and Management
o Forest Pathology and Mycology
o Plant Biotechnology
o Plant Science and Biotechnology
* Master of Science and Doctor of Philosophy with areas of study in:
o Chemical Ecology
o Conservation Biology
o Ecology
o Entomology
o Environmental Interpretation
o Environmental Physiology
o Fish and Wildlife Biology and Management
o Forest Pathology and Mycology
o Plant Science and Biotechnology

Environmental and Forest Chemistry
* Master of Science, Master of Professional Studies and Doctor of Philosophy with areas of study in:
o Biochemistry
o Environmental Chemistry
o Organic Chemistry of Natural Products
o Polymer Chemistry

Environmental and Resource Engineering
* Environmental Resources and Forest Engineering
* Master of Professional Studies with areas of study:
o Environmental Management
o Mapping Sciences
* Master of Science and Doctor of Philosophy with areas of study in:
o Ecological Engineering
o Forest Engineering
o Geo-spatial Information Science and Engineering
o Water Resources Engineering
* Paper and Bioprocess and Engineering Option

* Master of Professional Studies with areas of study:
o Process and Environmental Systems Engineering
o Pulp and Paper Technology
* Master of Science and Doctor of Philosophy with areas of study in:
o Chemistry of Pulping and Bleaching
o Colloid Chemistry and Fiber Flocculation
o Fiber and Paper Mechanics
o Process and Environmental Systems Engineering
o Pulp and Paper Technology
o Renewable Energy and Bioprocess Engineering
* Construction Management and Wood Products Engineering Option
* Master of Professional Studies with areas of study:
o Construction and Construction Management
o Wood Science and Technology
* Master of Science and Doctor of Philosophy with areas of study in:
o Construction and Construction Management
o Engineered Wood Products and Structures: Timber Structures Design
o Tropical Timbers
o Wood Anatomy and Ultrastructure
o Wood Science and Technology
o Wood Treatments

Environmental Science
* Master of Professional Studies and Master of Science with areas of study in:
o Environmental and Community Land Planning
o Environmental Communication and Participatory Processes
o Environmental Policy and Democratic Processes
o Environmental Systems and Risk Management
o Water and Wetland Resource Studies
* Doctor of Philosophy with areas of study in:
o Environmental Communication and Participatory Processes
o Environmental and Community Land Planning
o Environmental and Natural Resources Study
o Environmental Policy and Democratic Processes
o Environmental Systems and Risk Management
o Water and Wetland Resource Studies

Environmental Studies
* Master of Professional Studies and Master of Science

Landscape Architecture
* Master of Landscape Architecture and Master of Science with areas of study in:
o Community Design and Planning
o Cultural Landscape Studies and Conservation
o Landscape and Urban Ecology

ESF Students absorbing knowledge, sunshine, and fresh air.

➢ *Research*

"Research at the College of Environmental Science and Forestry is remarkably diverse, current and challenging. Contributions are being made in fields that include aquatic ecosystems, bioenergy, biotechnology, biodiversity, ecology, genetic engineering, nanotechnology, remote sensing, wildlife disease prevention, and many others. ESF is a leader in integrating the energy and excitement of research with the formal requirements of degree and certificate programs. A high percentage of undergraduates and virtually all graduate students participate in research activity as part of their educational experience."

(SUNY ESF, 2009)

Sample of Sustainability Focused Research at ESF

- Research centers and projects at the local, state, national, & international levels
- Adirondack Ecological Center
- Center for Brownfield Studies
- Center for Community Design Research
- Biomass for Bio-Energy, Biofuels, & Bio-products
- Green-Building
- Renewable Energy Systems
- EROI Net Energy Analysis
- Great Lakes Research Consortium
- Cellulose Research Institute
- SUNY Center for Sustainable and Renewable Energy
- Center for Urban Environment
- Woody Biomass Program
- Projects in North & South America, Russia, Europe, New Zealand, Antarctica, etc
- Biodegradable Plastics from Renewable Sources
- Ecological Engineering
- Sustainability Emergy Analysis
- Natural wastewater treatment systems
- Living Machines

➢ *Outreach*

Hosting "a variety local, state, regional, national and international programs related to ESF's professional and research programs. Practitioners, scholars, educators, government officials and others comprise the many advisory councils that inform program strategy and approaches. CEUs, PDHs, and other professional certification may be earned through many programs."

-(SUNY ESF, 2009)

Highlights of Sustainability Focused Outreach Programs at ESF

- Sustainable Use of Renewable Energy (SPARE)
- Sustainable Innovations in the Built Environment
- Academy for Sustainable and Green Entrepreneurship
- Advanced Training Workshops in Alternative Energy
- Advanced PV Installer Course
- International Conference on Biorefinery (ICB)
- Sustainably Energizing New York's Creative Core
- Annual Green Building Conference
- Over a dozen ongoing K-12 environmental and sustainability outreach programs
- Guest Speakers

Climate and Sustainability Outreach Programs at ESF

➢ *Community Service*

ESF Named to Community Service Honor Roll for second straight year...

"ESF was recognized for its exemplary student community service and service-learning programs by being named to the President's Higher Education Community Service Honor Roll for 2007. The Honor Roll is a program of the Corporation for National and Community Service and is sponsored by the President's Council on Service and Civic Participation, the USA Freedom Corps, and the U.S. departments of Education and Housing and Urban Development... ESF's Service Learning Initiative (is committed to) improving the student experience and contributing to local communities. The College continues to expand the scope of its service learning initiative with increased, community involvement. Faculty use service learning to give students hands-on experience and community service helps students focus their career goals by affirming their chosen path or introducing them to new possibilities. Students contributed more than **62,000 hours** through the service learning initiative and community service in 2007-2008."

-(SUNY ESF, 2009)

ESF Students improving the local community

➢ *Partnerships*

Paramount to the success of **ECN2015** and the majority of campus sustainability efforts at ESF are the collaborative partnerships that ESF has established with several key organizations.

- **AASHE -** Association for the Advancement of Sustainability in Higher Education
  - *"Providing resources, professional development, and a network of support to enable institutions of higher education to model and advance sustainability in everything they do, from governance and operations to education and research" (AASHE, 2009).*

http://www.aashe.org/

- **NYPA** - New York Power Authority
  - *Providing ESF with energy auditing services, planning assistance, and funding for energy conservation measures and renewable energy Initiatives.*

http://www.nypa.gov/

- **CA-CP** - Clean Air Cool Planet Campus Carbon Calculator
  - *CA-CP has been an invaluable resource for us for which we are very grateful to the entire CA-CP team. ESF would highly recommend this tool to any campus.*

http://www.cleanair-coolplanet.org/

- **NYSERDA** - New York State Energy Resource and Development Authority
  - *Helping ESF "formulate and fund a practical and effective plan that fits its philosophy and its budget" (NYSERDA, 2009).*
  - *Providing funding for renewable energy generation; efficiency improvements; new construction; renovations; and equipment upgrades.*

http://www.nyserda.org/default.asp

- **ACUPCC -** American Colleges and Universities Presidents Climate Commitment
  - *Providing "a framework and support for America's colleges and universities to go climate neutral" (ACUPCC, 2009).*

http://www.presidentsclimatecommitment.org/

- **Syracuse COE** - Syracuse Center of Excellence in Environmental and Energy Systems
  - *Teaming up with ESF to "create jobs and wealth in New York State through collaborations in research, development, and education" (SCOE, 2009).*

http://www.syracusecoe.org/index.aspx

- **Syracuse University**
  - *Partners and collaborators with ESF for nearly a century*

❖Conclusion

Three main conclusions can be drawn from the analysis undertaken in the drafting of **ECN2015**:

1) ESF has created a comprehensive climate & sustainability action plan that will effectively:
    a. neutralize all campus GHG emissions by 2015 and beyond
    b. reduce campus energy use
    c. significantly reduce fossil fuel use and dependence
    d. make the entire campus greener and more sustainable

2) ESF is currently on-track to meet or exceed all of its climate & sustainability goals and commitments, but there is always room for improvement.

3) All climate & sustainability action projects examined in **ECN2015**, both individually and in aggregate, have favorable returns of investment from an environmental, energetic, and economic perspective.

Objectives Moving Forward

The findings of **ECN2015** indicate several important areas of focus for ESF moving forward:

- Continue and increase efforts to foster *awareness & involvement* with sustainability & climate action projects among the campus community.
- *Publicize & expand* sustainability efforts to the local community and beyond.
- Closely *monitor & adjust* plans, progress, & goals as necessary.
- Continue growing ESF's *portfolio* of sustainability efforts.
- Keeping raising the bar!

Closing Remarks

- ESF is *unique* among colleges and universities and already has a leg up in many areas of sustainability.

- ESF has been fostering a mutually beneficial and sustainable relationship between humans and the natural world for nearly *100 years* and will continue to do so.

- At ESF sustainability is a *passion and a way of life*, not just a buzzword.

- ESF is well positioned and prepared to serve as a *leader* in sustainability & climate action...
    - within the campus grounds
    - in the local community and beyond

- Sustainability efforts at ESF are a golden opportunity to...
    - *practice* what we teach & learn
    - improve campus *unity & identity*
    - make a *positive impact on society*
    - ... and *have some fun* doing it!

Appendix A

All campus climate & sustainability initiatives for ESF from 2007-2015 are cataloged in the following pages and rated from an Environmental, Energetic, and Economic perspective. The ratings system used here is based on the data ranges calculated during the drafting of **ECN2015.** These are unofficial ratings intended to provide the reader with a sense of the relative return on investment for each initiative from an Environmental, Energetic, and Economic perspective.

Environmental Analysis: Carbon Cost Efficiency

- *Marginal Capital cost per MTCO2e Offset lifecycle*

Performance Rating	Range ($)
Excellent	<75
Good	75-150
Average	150-225
Fair	>225

Energy Analysis: Energy Return on Investment

- *Green energy return, on fossil energy input (lifecycle)*

Performance Rating	Range (x to 1)
Excellent	>50
Good	25-50
Average	5-24
Fair	<5

Economic Analysis: Simple Payback Period

- *Final Cost over annual savings*

Performance Rating	Range (years)
Excellent	<5
Good	5-10
Average	11-15
Fair	>15

Initiative					
Name	AEP #1 – CHP Molten Carbonate Fuel Cell				
Location	Main Campus				
Cost	$1,350,000 ($1 million paid by NYSERDA, $250K by DOE, $75K EPRI)				
Completed	2007				
Annual					
GHG Offset	233 MTCO2e (1.9% of Carbon Footprint)				
Energy Output	1,700 MWh 3000 MMBtu (steam) -11,500 MMBtu (natural gas)				
Cost Savings	$179,010				
Lifecycle					
Environmental Rating	Fair	Average	Good	Excellent	
Energy Rating	Fair	Average	Good	Excellent	
Economic Rating	Fair	Average	Good	Excellent	

Description

Molten carbonate fuel cell uses hydrogen produced from natural gas, carbon dioxide, and oxygen to generate electricity. These elements combine in a series of chemical reactions in which negatively charged electrons move through an external circuit toward a cathode, creating electrical current. Waste heat generated from this reaction is also captured and used to heat Walters Hall in the winter by means of a heat exchanger. This process uses roughly 50 percent less and cleaner burning fuel per kWh than traditional electricity generation (SUNY ESF, 2009). In its first full year of operation the fuel cell generated over fifteen percent of ESF's electricity demand in an efficient and more environmentally sound manner. ESF is exploring the possibility of substituting biogas for natural gas, further reducing emissions.

Initiative	
Name	AEP #3 – 15 kW Photovoltaic Array
Location	Walters Hall
Cost	$120,000 ($75,000 paid by NYSERDA incentive)
Completed	2007
Annual	
GHG Offset	6 MTCO2e (.1% of Carbon Footprint)
Energy Output	17,000 kWh
Cost Savings	$1,560
Lifecycle	
Environmental Rating	Fair Average Good Excellent
Energy Rating	Fair Average Good Excellent
Economic Rating	Fair Average Good Excellent
Description	The first photovoltaic panels and the first modern renewable energy technology on the ESF campus were installed on roof of Walters Hall and dedicated by President Murphy who acknowledged that the panels represented a major stepping stone for ESF on the path to carbon neutrality and increased sustainability

Initiative	
Name	REG #4 – 25 kW Photovoltaic Array
Location	Baker Laboratory
Cost	$200,000 ($125,000 paid by NYSERDA incentive)
Completed	2007
Annual	
GHG Offset	9 MTCO2e (.1% of Carbon Footprint)
Energy Output	24,000 kWh
Cost Savings	$2,600
Lifecycle	
Environmental Rating	Fair Average Good Excellent
Energy Rating	Fair Average Good Excellent
Economic Rating	Fair Average Good Excellent
Description	The second installation of solar photovoltaic panels on the ESF campus was dedicated in December 2007 by ESF President Neil Murphy. The second photovoltaic array was installed on the south side of the newly refurbished baker lab and was the capstone of the $29 million renovation of that building. In addition to generating electricity, the panels, positioned on the south face of building around the windows, also provide shade keeping the building cooler and further reducing energy consumption in the summer.

Initiative

Name	AEP # 13 - 5kW Wind Turbine
Location	Heiberg Memorial Forest and Tully Field Station
Cost	$45,000 ($25,000 paid by NYSERDA incentive)
Completed	2009

Annual

GHG Offset	3 MTCO2e (.1 % of Carbon Footprint)
Energy Output	8,400 kWh
Cost Savings	$1,008

Lifecycle

Environmental Rating	Fair	Average	Good	Excellent
Energy Rating	Fair	Average	Good	Excellent
Economic Rating	Fair	Average	Good	Excellent

Description

Construction on ESF's first operational wind turbine was completed in July of 2009 at the Tully Field Station. Average wind speeds at site of about 12.5 mph are adequate to power the 5 kW turbine and produce roughly 650 kWh per month which is enough to meet the majority of electricity needs of the two remote classrooms at the site.

Crew raising ESF's first operational wind turbine, SUNY ESF

Initiative

Name	ECM # 11 - High Efficiency Chillers
Location	Illick and Walters Hall
Cost	$1,200,000 ($240,000 paid by NYSERDA incentive)
Completed	2007

Annual

GHG Offset	224 MTCO2e (1.8 % of Carbon Footprint)
Energy Offset	600,000 kWh
Cost Savings	$72,000

Lifecycle

Environmental Rating	Fair	Average	Good	Excellent
Energy Rating	Fair	Average	Good	Excellent
Economic Rating	Fair	Average	Good	Excellent

Description

NYPA assisted installation of two high efficiency chillers replacing obsolete units in Illick and Walters hall.

High Efficiency Chillers, SUNY ESF

Initiative

Name	REG #14 – Biodiesel from fryer oil
Location	Main Campus
Cost	$15,000
Completed	2007

Annual

GHG Offset	35 MTCO2e (.3 % of Carbon Footprint)
Energy Output	-7,000 kWh 517 MMBtu (Diesel)
Cost Savings	$12,989

Lifecycle

Environmental Rating	Fair	Average	Good	Excellent
Energy Rating	Fair	Average	Good	Excellent
Economic Rating	Fair	Average	Good	Excellent

Description

With the help and initiative of ESF students, ESF has been successfully producing its own biodiesel onsite since 2006. Used fryer oil from the nearby Sadler Dining Hall is converted into biodiesel which now powers 20% of ESF's diesel vehicle fleet. Initial investment for the processing equipment was relatively small, the majority of raw materials are free, and the labor is done by work-study students, making Biodiesel an excellent economic, energetic, and environmental return on investment for ESF. ESF is also in the process of expanding production and developing a glycerol recovery operation that would allow byproducts of the biofuel production process to be recycled and composted.

Initiative					
Name	ECM #1 - Heat Recovery Loop				
Location	Jahn Laboratory				
Cost	$1,141,868				
Completed	2010				
Annual					
GHG Offset	341 MTCO2e (2.8 % of Carbon Footprint)				
Energy Offset	-549,675 kWh 7,743 MMBtu (steam)				
Cost Savings	$142,370				
Lifecycle					
Environmental Rating	Fair	Average	Good	Excellent	
Energy Rating	Fair	Average	Good	Excellent	
Economic Rating	Fair	Average	Good	Excellent	
Description	NYPA energy audit identified the opportunity for the installation of a glycol heat recovery loop in Jahn laboratory. Lab areas are supplied with 100% outdoor air via three AHU's in the basement. Three exhaust fans operate continuously in the building penthouse. The proposed heat recovery loop will link exhaust fans in lab areas with air intake units in the basement (NYPA, 2009). Heat is captured from exhaust system instead of being released into the outdoor air and recycled back into the building saving energy and significantly reducing purchased steam requirements. Large capital investment and increased electricity demand are balanced by the largest reduction of purchased steam needs and carbon footprint by any single ECM.				

Initiative				
Name	ECM #2 - Variable Frequency Drives on Chilled Water Pumps			
Location	Jahn Laboratory			
Cost	$17,508 (Possible $2,596 NYSERDA incentive)			
Completed	2010			
Annual				
GHG Offset	11 MTCO2e (.1% of Carbon Footprint)			
Energy Offset	28,842 kWh			
Cost Savings	$2,224			
Lifecycle				
Environmental Rating	Fair	Average	Good	Excellent
Energy Rating	Fair	Average	Good	Excellent
Economic Rating	Fair	Average	Good	Excellent
Description	NYPA energy audit has identified the opportunity for the installation of VFDs and flow measuring equipment on the two 20-hp pumps which currently circulate more chilled water than is necessary to satisfy peak demand and minimum flow (NYPA, 2009). Installation will allow pumps to more accurately meet peak and minimum loads, reducing the total horsepower used and purchased electricity use.			

Initiative				
Name	ECM #3: Metal Halide Re-lamping			
Location	Jahn Laboratory, Mechanical Room			
Cost	$36,114 (Possible $9,233 NYSERDA incentive)			
Completed	2010			
Annual				
GHG Offset	32 MTCO2e (.3% of Carbon Footprint)			
Energy Offset	84,646 kWh			
Cost Savings	$7,674			
Lifecycle				
Environmental Rating	Fair	Average	Good	Excellent
Energy Rating	Fair	Average	Good	Excellent
Economic Rating	Fair	Average	Good	Excellent

Description

NYPA energy audit has identified the opportunity for the replacement of 22 metal halide lighting fixtures (15-250 Watt & 7-400 Watt) used to illuminate the penthouse and basement mechanical spaces of Jahn laboratory. The metal halide fixtures will be replaced with energy efficient T5 high output florescent fixtures (NYPA, 2009).

In addition to equivalent or better lumen output and energy savings from higher efficiency ratings, the new lighting fixtures will allow lights to be shut off when not needed as opposed to the current fixtures which remain on constantly due to an inconvenient 15 minute “warm up period” to full lumen output of metal halide. The result is increased reduction in purchased electricity needs (NYPA, 2009)

Initiative	
Name	ECM #4 - Vending Machine Sensors
Location	Main Campus
Cost	$ 3,588 (Possible $2,050 NYSERDA incentive)
Completed	2010
Annual	
GHG Offset	8 MTCO2e (.1 % of Carbon Footprint)
Energy Offset	22,776 kWh
Cost Savings	$1,772
Lifecycle	
Environmental Rating	Fair Average Good Excellent
Energy Rating	Fair Average Good Excellent
Economic Rating	Fair Average Good Excellent
Description	NYPA Energy audit and student research has identified the opportunity for the installation of "Vending Machine Misers" technology on vending machines at the main campus. 13 vending machines across campus use energy for cooling and lighting on a continuous basis. Misers can be programmed and use timers and occupancy sensors to allow machines to automatically power down when school is unoccupied, saving energy and reducing purchased electricity needs.

Initiative	
Name	ECM # 5 - High Efficiency Motors
Location	Main Campus
Cost	$43,224 (Possible $4,145 NYSERDA incentive)
Completed	2010
Annual	
GHG Offset	10 MTCO2e (.1 % of Carbon Footprint)
Energy Offset	27,951 kWh
Cost Savings	$3,116
Lifecycle	
Environmental Rating	Fair Average Good Excellent
Energy Rating	Fair Average Good Excellent
Economic Rating	Fair Average Good Excellent
Description	NYPA energy audit has identified the opportunity for the replacement of 20 motors across campus with more efficient models. Motor loss is reduced and energy savings is achieved by replacing standard efficiency models with premium efficiency models, reducing purchased electricity needs.

Initiative	
Name	ECM # 6 - T-12 Re-lamping
Location	Newcomb Campus
Cost	$ 23,805 (Possible $17,843 NYSERDA incentive)
Completed	2010
Annual	
GHG Offset	11 MTCO2e (.1 % of Carbon Footprint)
Energy Offset	42,613 kWh
Cost Savings	$2,598
Lifecycle	
Environmental Rating	Fair Average Good Excellent
Energy Rating	Fair Average Good Excellent
Economic Rating	Fair Average Good Excellent
Description	NYPA energy audit has identified the opportunity for the replacement of inefficient T-12 florescent lighting fixtures with new Super T-8 fixtures, reducing purchased electricity needs. (NYPA, 2009) T-8 fixtures will improve lighting quality in addition to energy savings. Maximum NYSERDA inventive covers 75% of installation cost proving a very favorable environmental and economic return on investment.

Initiative	
Name	ECM #7 – Radiator Steam trap replacements
Location	Marshall Hall
Cost	$ 58,320
Completed	2010
Annual	
GHG Offset	294 MTCO2e (2.4 % of Carbon Footprint)
Energy Offset	4,174 MMBtu (Steam)
Cost Savings	$108,698
Lifecycle	
Environmental Rating	Fair Average Good Excellent
Energy Rating	Fair Average Good Excellent
Economic Rating	Fair Average Good Excellent
Description	NYPA energy audit has identified the opportunity for the replacement of 216 radiator steam traps in Marshall Hall. Existing traps are in poor condition resulting in significant amounts of wasted energy. All old and malfunctioning traps on main ends and wall radiators will be replaced for significant reduction of wasted heat purchased steam needs (NYPA, 2009).The high cost of steam, excessive waste caused by old traps, and low cost of replacements makes this project one of the most favorable economic, environmental, and energetic returns on investment

Initiative	
Name	ECM #8 - Variable Frequency Drives installed on Air Handling Units
Location	Moon Library and Illick Hall
Cost	$ 105,275 (Possible $5,363 NYSERDA incentive)
Completed	2010
Annual	
GHG Offset	107 MTCO2e (.9% of Carbon Footprint)
Energy Offset	105, 504 kWh 954 MMBtu (Steam)
Cost Savings	$33,227
Lifecycle	
Environmental Rating	Fair Average Good Excellent
Energy Rating	Fair Average Good Excellent
Economic Rating	Fair Average Good Excellent
Description	Moon Library - NYPA energy audit has indentified the opportunity for the installation of VFDs on two AHUs and one exhaust fan. Fan speeds will be automatically adjusted by VFD between 75% and 95% during occupied periods. The Demand Control Ventilation strategy already implemented will continue to provide the required quantity of air for ventilation needs. VFD's will regulate the flow of air without sacrificing air quality and providing additional energy savings on top of the DCV system, reducing purchased electricity needs. (NYPA, 2009) Illick Hall - NYPA energy audit has identified the opportunity for the installation of VFDs on fume hood exhaust fans. During un-occupied hours (9pm - 5 am Mon-Fri), VFDs will allow two 7.5 HP exhaust fans to drop from normal operating speeds of 95% to 50% maximum speed, reducing purchased electricity needs. The associated air intake fans will be off when the exhaust fans drop to 50%, resulting in an infiltration reduction of roughly 50%, adequate levels of exhaust, and a reduction in purchased steam needs. (NYPA, 2009)

Initiative	
Name	ECM #9 - Occupancy Sensors
Location	Bray Hall
Cost	$23,328 (Possible $2,114 NYSERDA incentive)
Completed	2010
Annual	
GHG Offset	9 MTCO2e (.1 % of Carbon Footprint)
Energy Offset	23,489 kWh
Cost Savings	$1,827
Lifecycle	
Environmental Rating	Fair Average Good Excellent
Energy Rating	Fair Average Good Excellent
Economic Rating	Fair Average Good Excellent
Description	NYPA energy audit has identified the opportunity for the installation of occupancy sensors on the five floors of Bray Hall. Administrative and academic areas often remain powered when space is unoccupied. Sensors installed in 100+ will rooms allow lights to power down when unoccupied, reducing purchased electricity needs.

Initiative	
Name	ECM #10 - Occupancy Sensors
Location	Main Campus
Cost	$116,640 (Possible $10,570 NYSERDA incentive)
Completed	2010
Annual	
GHG Offset	44 MTCO2e (.4 % of Carbon Footprint)
Energy Offset	117,445 kWh 0 MMBtu
Cost Savings	$9,135
Lifecycle	
Environmental Rating	Fair Average Good Excellent
Energy Rating	Fair Average Good Excellent
Economic Rating	Fair Average Good Excellent
Description	Student research at ESF has identified additional opportunities for energy savings using occupancy sensor technology. After hours energy audit walkthroughs have noted similar conditions to those listed in the NYPA energy audit for the buildings of Walters, Marshall, Jahn, and Baker. Occupancy sensors in classrooms and offices allow lights to power down automatically when appropriate and represent an excellent opportunity for energy savings and reduction of purchased electricity needs.

Initiative	
Name	ECM #12 – Hallway Delamping
Location	Illick Hall
Cost	$0
Completed	2011
Annual	
GHG Offset	26 MTCO2e (.2% of Carbon Footprint)
Energy Offset	70,080 kWh
Cost Savings	$8,410
Lifecycle	
Environmental Rating	Fair Average Good Excellent
Energy Rating	Fair Average Good Excellent
Economic Rating	Fair Average Good Excellent
Description	Faculty, staff, and student research has identified the opportunity for lighting reductions in the hallways of Illick Hall. Significant energy and cost savings can be achieved with little or no cost to the school simply by reducing the lighting in excessively illuminated areas. Hallways on floors 1 through 4 are over-lit and eligible for de-lamping. Each floor has roughly 30-40 double ballasts, each with a four, 32 watt bulb capacity. While one bulb in each double ballast would provide adequate lighting up to building code standards, most ballasts have 3-4 bulbs operating on a continuous basis. Removing excess bulbs could save upwards of 70,000 kWh/year and still provide sufficient illumination. Reducing bulbs to a bare minimum may create a need for increased maintenance of the hallways, as one bulb burning out could result in dark spots. Even a moderate reduction in bulbs would be a good choice for ESF as it would still achieve energy and cost savings, provide adequate lighting and dark spot coverage, all without purchasing expensive digital ballasts and occupancy sensors.

Initiative	
Name	ECM #13 – Maintained Grounds Improvements
Location	Main Campus
Cost	n/a
Completed	Target 2010
Annual	
GHG Offset	50 MTCO2e (.4% of Carbon Footprint)
Energy Offset	kWh MMBtu
Cost Savings	n/a
Lifecycle	
Environmental Rating	Fair Average* Good Excellent
Energy Rating	Fair Average* Good Excellent
Economic Rating	Fair Average* Good Excellent
Description	The Department of Landscape Architecture at ESF has identified the opportunity for improving the maintained grounds at ESF in a green and sustainable fashion. The proposed improvements would have multiple benefits. Replacing steeply sloped lawns with native plant species would provide more vegetative carbon sequestration per square foot. It would also reduce the amount of mowing and maintenance needed in these areas, saving fuel and reducing emissions. Certain plants species and grounds improvements such as water gardens could also provide living learning opportunities and better storm water management. Aesthetics and campus identity also improved.
	*assumed returns on investment (full data not yet available)

Initiative					
Name	ECM#14 – Building Retrofits				
Location	Illick Hall				
Cost	n/a				
Completed	2014				
Annual					
GHG Offset	156 MTCO2e (1. 3% of Carbon Footprint)				
Energy Offset	242,000 kWh 938 MMBtu				
Cost Savings	$81,509				
Lifecycle					
Environmental Rating	Fair	Average	Good*	Excellent	
Energy Rating	Fair	Average	Good*	Excellent	
Economic Rating	Fair	Average	Good*	Excellent	
Description	Having completed renovations on Baker Laboratory, similar renovations and energy saving retrofits are planned for the remaining buildings on the main campus. The first of these Initiatives will be a two phase renovation of Illick Hall, the first half of which is scheduled for completion in late 2015. Similar economics, environmental, and energetic returns on invest are expected to previous ECM and renovation projects				
	*assumed returns on investment (full data not yet available)				

Initiative					
Name	ECM #15 – Rooftop Greenhouse Replacement				
Location	Illick Hall				
Cost	$1,099,014				
Completed	Target 2014				
Annual					
GHG Offset	156 MTCO2e (1.2 % of Carbon Footprint)				
Energy Offset	0 kWh 2,143 MMBtu				
Cost Savings	$56,651				
Lifecycle					
Environmental Rating	Fair	Average	Good	Excellent	
Energy Rating	Fair	Average	Good	Excellent	
Economic Rating	Fair	Average	Good	Excellent	
Description	ESF faculty and NYPA energy audit has identified the opportunity for energy savings and improved working conditions through the replacement of the Illick Hall rooftop green houses. The six existing greenhouses are over 40 years old and made of single glazing panels. Many of the greenhouses vents and louvers are inoperable (NYPA, 2009). Replacement greenhouses should have dual temperature zones, open roof technology, double pane polycarbonate glazing, retractable thermal curtains, insulated knee walls, automatic fans and louvers, and other energy saving features (NYPA, 2009).				

Initiative	
Name	AEP #5 – 25 kW Photovoltaic Array
Location	Moon Library
Cost	$200,000 (Possible $125,000 NYSERDA incentive)
Completed	2010
Annual	
GHG Offset	9 MTCO2e (.1 % of Carbon Footprint)
Energy Output	24,000 kWh
Cost Savings	$2,600
Lifecycle	
Environmental Rating	Fair Average Good Excellent
Energy Rating	Fair Average Good Excellent
Economic Rating	Fair Average Good Excellent
Description	The department of Renewable Energy at ESF, student research, and NYPA energy audit has identified the opportunity for the installation of a 25 kW solar photovoltaic array on the roof of moon library. The roof is an ideal space for PV panel installation with roughly 17,000 square feet of flat surface free of any major physical or solar obstructions (NYPA, 2009).

Initiative	
Name	AEP #6 – 15 kW Photovoltaic Array
Location	Newcomb Dining Hall
Cost	$120,000 (Possible $75,000 NYSERDA incentive)
Completed	2011
Annual	
GHG Offset	7 MTCO2e (.1% of Carbon Footprint)
Energy Output	17,000 kWh
Cost Savings	$1,560
Lifecycle	
Environmental Rating	Fair Average Good Excellent
Energy Rating	Fair Average Good Excellent
Economic Rating	Fair Average Good Excellent
Description	NYPA energy audit has identified the opportunity for the installation of a 15kW PV array on the dining hall roof of the Newcomb campus.

Initiative	
Name	AEP #7 – 15 kW Photovoltaic array
Location	Newcomb Administration Building
Cost	$120,000 (Possible $75,000 NYSERDA incentive)
Completed	2010
Annual	
GHG Offset	6 MTCO2e (.1 % of Carbon Footprint)
Energy Output	17,000 kWh
Cost Savings	$1,560
Lifecycle	
Environmental Rating	Fair Average Good Excellent
Energy Rating	Fair Average Good Excellent
Economic Rating	Fair Average Good Excellent
Description	NYPA energy audit has identified the opportunity for the installation of a 15 kW of solar PV panels on the southern exposure of the administration building. No solar obstructions and a large, flat, open space make this area an excellent candidate for ground mounted PV panels. Panels will be on a adjustable tilt mount to maximize the amount of incoming solar radiation absorbed by the panels year round and avoid snow build up in the winter (NYPA, 2009)

Initiative	
Name	AEP # 8 - 6 kW Photovoltaic Array
Location	Tully Field Station
Cost	$48,000 (Possible $30,000 NYSERDA incentive)
Completed	2010
Annual	
GHG Offset	3 MTCO2e (.1% of Carbon Footprint)
Energy Output	7,000 kWh
Cost Savings	$625
Lifecycle	
Environmental Rating	Fair Average Good Excellent
Energy Rating	Fair Average Good Excellent
Economic Rating	Fair Average Good Excellent
Description	NYPA energy audit has identified the opportunity for the installation of a 6kW solar photovoltaic array at the Tully Field Station.

Initiative	
Name	AEP # 9 - Wood Pellet Boilers
Location	Newcomb Campus
Cost	$257,921
Completed	2010
Annual	
GHG Output	178 MTCO2e (1.3 % of Carbon Footprint)
Energy Offset	140,409 kWh 400 MMBtu (Fuel Oil)
Cost Savings	$23,518
Lifecycle	
Environmental Rating	Fair Average Good Excellent
Energy Rating	Fair Average Good Excellent
Economic Rating	Fair Average Good Excellent
Description	The department of Renewable Energy at ESF, student research, and NYPA energy audit have identified the opportunity for the installation of 2 wood pellet boilers at the Newcomb campus. The installation will replace the existing oil fired boiler and electric resistance heating in the Administrative Building and Dining Hall. It will also replace residential size oil boilers used to heat smaller buildings on the campus (NYPA, 2009).

Initiative	
Name	AEP #10 - Radiant Floor Heating
Location	Newcomb Campus
Cost	$6,598
Completed	2010
Annual	
GHG Offset	21 MTCO2e (.2% of Carbon Footprint)
Energy Offset	56,356 kWh
Cost Savings	$1,269

Lifecycle				
Environmental Rating	Fair	Average	Good	Excellent
Energy Rating	Fair	Average	Good	Excellent
Economic Rating	Fair	Average	Good	Excellent

Description

NYPA energy audit has identified the opportunity for the installation of radiant floor heating in the Huntington Great Room. The heated water will be supplied by the new wood pellet boiler and circulated through tubing installed between floor joists (NYPA, 2009). This will replace the current inefficient electric baseboard heating system, reducing purchased electricity and meeting heating needs with a carbon neutral fuel source. The low cost and long life of this ECM provide an excellent environmental, energy, and economic return on investment.

Initiative	
Name	AEP #11 - Pellet Boilers
Location	Tully Field Station
Cost	$20,000
Completed	2011
Annual	
GHG Offset	21 MTCO2e (.2 % of Carbon Footprint)
Energy Output	56,000 kWh
Cost Savings	$2,408

Lifecycle				
Environmental Rating	Fair	Average	Good	Excellent
Energy Rating	Fair	Average	Good	Excellent
Economic Rating	Fair	Average	Good	Excellent

Description

The department of Renewable Energy Systems at ESF, student research, and NYPA energy audit has identified the opportunity for the installation of a wood pellet boiler at the Tully Field Station. The system will offset the use of inefficient electric space heating.

Initiative

Name	AEP #11 - 10 Vertical Axis Wind Turbines
Location	Illick Hall
Cost	$209,975
Completed	2014

Annual

GHG Offset	17 MTCO2e (.2 % of Carbon Footprint)
Energy Output	45,000 kWh 0 MMBtu
Cost Savings	$3,542

Lifecycle

Environmental Rating	Fair	Average	Good	Excellent
Energy Rating	Fair	Average	Good	Excellent
Economic Rating	Fair	Average	Good	Excellent

Description

Student research has identified the opportunity for the installation of up to ten (10), 5 kW vertical axis wind turbines on the roof of Illick Hall. Small scale urban VAWTs are an emerging technology that does not provide substantial energy or economic returns on investment in its current state of development. It is also questionable whether the wind speeds atop Illick hall will be consistently strong enough to make this initiative a favorable investment for ESF. Currently NYSERDA incentives for wind power include only horizontal axis wind turbines. A change in NYSERDA policy or special request to NYSERDA allowing a portion of the cost to be incentivized would make VAWTs more viable.

Vertical Axis Wind Turbine

Initiative	
Name	AEP #12 - Downdraft Biomass Gasifier CHP
Location	Main Campus (east end)
Cost	n/a
Completed	2014
Annual	
GHG Offset	1,158 MTCO2e (9.5 % of Carbon Footprint)
Energy Output	170,000 kWh 8,000 MMBtu
Cost Savings	n/a
Lifecycle	
Environmental Rating	Fair Average Good* Excellent
Energy Rating	Fair Average Good* Excellent
Economic Rating	Fair Average Good* Excellent
Description	The Department of Renewable Energy Systems at ESF has identified the opportunity for the installation of a second Biomass CHP system to be located on the east end of the main campus. The system would offset a substantial percentage of purchased electricity needs as well as the majority of purchased steam needs not already offset by the Gateway Energy System. The system would use the emerging biomass gasification technology, after allowing several more years for the technology to develop.
	*assumed returns on investment (full data not yet available)

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Initiative	
Name	GES #1 - 6,000 MBtu Wood Pellet Steam Boiler
Location	Gateway Building
Cost	Total Gateway Energy System Cost = $3.2 Million Total Gateway Energy System Incentive = 1.48 Million
Completed	2011
Annual	
GHG Offset	2066 MTCO2e (17.0 % of Carbon Footprint)
Energy Output	29,284 MMBtu
Cost Savings	Total Gateway Energy System Cost Savings
Lifecycle	
Environmental Rating	Fair Average Good Excellent
Energy Rating	Fair Average Good Excellent
Economic Rating	Fair Average Good Excellent
Description	The centerpiece of the Gateway Energy System is the 6,000 MBtu Wood Pellet Boiler. This boiler will generate enough steam to meet 100% of the heating needs of the Gateway Building, roughly 80% of the heating needs of Moon Library and Illick Hall, and roughly 25% of the heating needs of Baker Laboratory and Jahn Laboratory. Overall 65% of campus heating needs will be met by this boiler and waste heat captured from three micro-turbines.

Initiative	
Name	GES #2 - 200 kW CHP Back Pressure Turbine
Location	Gateway Building
Cost	(Included in total system cost)
Completed	2011
Annual	
GHG Offset	265 MTCO2e (2.2% of Carbon Footprint)
Energy Offset	711 MWh
Cost Savings	(Included in total system savings)
Lifecycle	
Environmental Rating	Fair Average Good Excellent
Energy Rating	Fair Average Good Excellent
Economic Rating	Fair Average Good Excellent
Description	Back pressure turbine connected to pellet boiler reduces steam pressure from 125 psi to 10 psi, converting waste heat to electricity.

Initiative

Name	GES # 3 - 30 kW Biodiesel Micro-turbine
Location	Gateway Building
Cost	(Included in total system cost)
Completed	2011

Annual

GHG Offset	100 MTCO2e (1% of Carbon Footprint)
Energy Offset	142 MWh 670 MMBtu (steam)
Cost Savings	(Included in total system savings)

Lifecycle

Environmental Rating	Fair	Average	Good	Excellent
Energy Rating	Fair	Average	Good	Excellent
Economic Rating	Fair	Average	Good	Excellent

Description

30kW CHP Micro-Turbine capable of burning biodiesel produced onsite at ESF.

Biodiesel Micro-turbine

Initiative					
Name	GES # 4 65kW Natural Gas Micro-turbine (x2)				
Location	Gateway Building				
Cost	(Included in total system cost)				
Completed	2011				
Annual					
GHG Offset	~200 MTCO2e (1% of Carbon Footprint)				
Energy Output	1,096 MWh 5,187MMBtu (steam)				
Cost Savings	(Included in total system savings)				
Lifecycle					
Environmental Rating	Fair	Average	Good	Excellent	
Energy Rating	Fair	Average	Good	Excellent	
Economic Rating	Fair	Average	Good	Excellent	
Description	Two 65kW CHP Micro-Turbines powered by natural gas meet electrical and heating loads more efficiently and with fewer emissions than purchased electricity and steam.				

Initiative					
Name	GES #5 - 50 kW Solar PV arrary				
Location	Gateway Building				
Cost	(Included in total system cost)				
Completed	2011				
Annual					
GHG Offset	28 MTCO2e(.2% of Carbon Footprint)				
Energy Output	75,000 kWh				
Cost Savings	(Included in total system savings)				
Lifecycle					
Environmental Rating	Fair	Average	Good	Excellent	
Energy Rating	Fair	Average	Good	Excellent	
Economic Rating	Fair	Average	Good	Excellent	
Description	Minimum 50 kW Solar PV array on large open space roof will provide between 50 and 100 kWh annually. ESF is currently exploring funding opportunities and different models of PV panels in order to find the most beneficial array type for the projected site conditions.				

Initiative	
Name	CAC # 1 - Travel Reduction and Efficiency
Location	Main Campus
Cost	Minimal
Completed	2010
Annual	
GHG Offset	246 MTCO2e (2% of Carbon Footprint)
Energy Offset	628 MMBtu (Transportation Fuels)
Cost Savings	$15,729
Lifecycle	
Environmental Rating	Fair Average Good Excellent
Energy Rating	Fair Average Good Excellent
Economic Rating	Fair Average Good Excellent
Description	ESF has planned and begun implementing a number of initiatives aimed at achieving a 10% reduction in travel associated emissions. These strategies include but are not limited to: Transportation Demand Strategies, Purchase of fuel efficient and hybrid vehicles, parking arrangements, maximization fleet passenger miles to vehicle miles, bike and car sharing programs, increased bike parking, commuter action challenges.

Initiative	
Name	CAC #2 – Temperature Settings
Location	Main Campus
Cost	Minimal
Completed	2010
Annual	
GHG Offset	241 MTCO2e (2 % of Carbon Footprint)
Energy Offset	200,000 kWh 3,553 MMBtu (Steam)
Cost Savings	$126,077
Lifecycle	
Environmental Rating	Fair Average Good Excellent
Energy Rating	Fair Average Good Excellent
Economic Rating	Fair Average Good Excellent
Description	The Department of Renewable Energy System has set an initial target of 5% reduction in purchased steam and electricity through adjusted thermostat settings, and a revised personal air conditioning & space heating unit policy. The effectiveness of these measures was demonstrated through the first half of 2009 and will be reevaluated in early 2010

Initiative

Name	CAC #3– Campus Awareness Initiatives
Location	Main Campus
Cost	Minimal
Completed	2010

Annual

GHG Offset	49 MTCO2e (2 % of Carbon Footprint)
Energy Offset	97,00 kWh 197 MMBtu (Steam)
Cost Savings	$16,834

Lifecycle

Environmental Rating	Fair	Average	Good	Excellent
Energy Rating	Fair	Average	Good	Excellent
Economic Rating	Fair	Average	Good	Excellent

Description

The Department of Renewable Energy Systems at ESF, student research, and the student organization "Green Campus Initiative" have identified and begun taking action on opportunities for energy conservation through voluntary behavioral adjustments. Methods for these reductions include; energy awareness campaigns, stickers and signs near all light switches reminding people to turn them off when not in use, an increased web presence encouraging voluntary conservation, and a word of mouth buzz around campus uniting the community under the common goal of reducing wasted energy as much as possible. These savings add up quickly when everyone is onboard and ESF will continue to promote this highly effective conservation strategy and culture at ESF.

Initiative					
Name	CAC # 4 - Campus-wide De-lamping				
Location	All campus facilities				
Cost	Minimal				
Completed	2012				
Annual					
GHG Offset	131 MTCO2e (1.1% of Carbon Footprint)				
Energy Offset	350+ kWh				
Cost Savings	$42,000				
Lifecycle					
Environmental Rating	Fair	Average	Good	Excellent	
Energy Rating	Fair	Average	Good	Excellent	
Economic Rating	Fair	Average	Good	Excellent	
Description	Research by the Department of Renewable Energy Systems at ESF indicates significant opportunities comprehensive de-lamping of the entire campus and satellite locations. De-lamping (removing excessive and unnecessary lighting) is one of the most cost effective and environmentally friendly undertakings that ESF can engage in. Electricity consumption, GHG emissions, and operating costs can be significantly reduced with little or no capital expenses, recurring costs, energy inputs, or upstream emissions.				

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