
CampusEnergy2021
BRIDGE TO THE FUTURE
Feb. 16-18 | CONNECTING VIRTUALLY
WORKSHOPS | Thermal Distribution: March 2 | Microgrid: March 16

Smith College's Life with Our Combined Heat and Power Plant

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Epsilon ASSOCIATES INC.

Smith College

INTERNATIONAL DISTRICT ENERGY ASSOCIATION

Q&A Will Not Be Answered Live

Please submit questions in the Q&A box.
The presenters will respond to questions off-line.

Smith College's Energy Needs

- Smith College
  - Private Liberal Arts college located in Northampton MA
  - Total enrollment of 2,400 women
  - Aging Physical Plant that provided steam, hot water and cooling (via steam)
    - Three smaller boilers that were 1950s vintage
    - Two larger boilers that were installed in early 1970s

Smith College's Energy Needs

- Smith Physical Plant
  - Boilers 1-3: 50.4 MMBtu/hr firing No. 6 oil only
    - ~15,000 lb/hr of steam at 125 psi
    - NOx 0.37 lb/MMBtu PM 0.13 lb/MMBtu
    - SO2 0.5-2.2%S VOC 0.02 lb/MMBtu
  - Boiler 4-5: 68.1 MMBtu/hr firing natural gas and No. 6 as backup (when natural gas interrupted – allowed for interruptible contract)
    - 20,000 lb/hr of steam at 125 psi

Fuel	Gas	Oil
NOx	0.1 lb/MMBtu	0.37 lb/MMBtu
SO2	0.0006 lb/MMBtu	0.5-2.2%S when on oil
PM	0.014 lb/MMBtu	0.13 lb/MMBtu
VOC	0.003 lb/MMBtu	0.02 lb/MMBtu

  - Cooling provided by separate facility using steam-driven and electrical chillers providing 2,500 tons of chilling
  - Multiple water heaters scattered around campus providing hot water during summer and shoulder seasons
  - Dozens of emergency generators located around campus

Smith College's Permitting Status

- Permitting Situation
  - Both Restricted Emissions Status Approval and an Operating Permit
  - RES for NOx
  - major for SO2 since it was firing 2.2%S fuel oil as one of the fuels

- Permitting Situation
  - Both Restricted Emissions Status Approval (RES) and an Operating Permit
  - RES for NOx to avoid Reasonably Available Control Technology
  - Major for SO2 since it was firing 0.5-2.2%S fuel oil as their backup fuel
  - Fuel sulfur content had been reduced in order to comply with PM limits

Smith College's Emissions and Fuel Inputs/Outputs

- Typical Emissions
  - NOx 40 tpy
  - SO2 160 tpy
  - PM 14 tpy
  - VOC 0.3 tpy
  - CO2 21,000 tpy
- Typical Inputs/Output
  - No. 6 oil averaged 83% of fuel input, ranging from 60-98%
  - Needed to balance natural gas and No. 6 oil to maintain NOx emission limits
  - 65,000 lb/hr of steam output to the campus demand

Smith College's Energy Needs

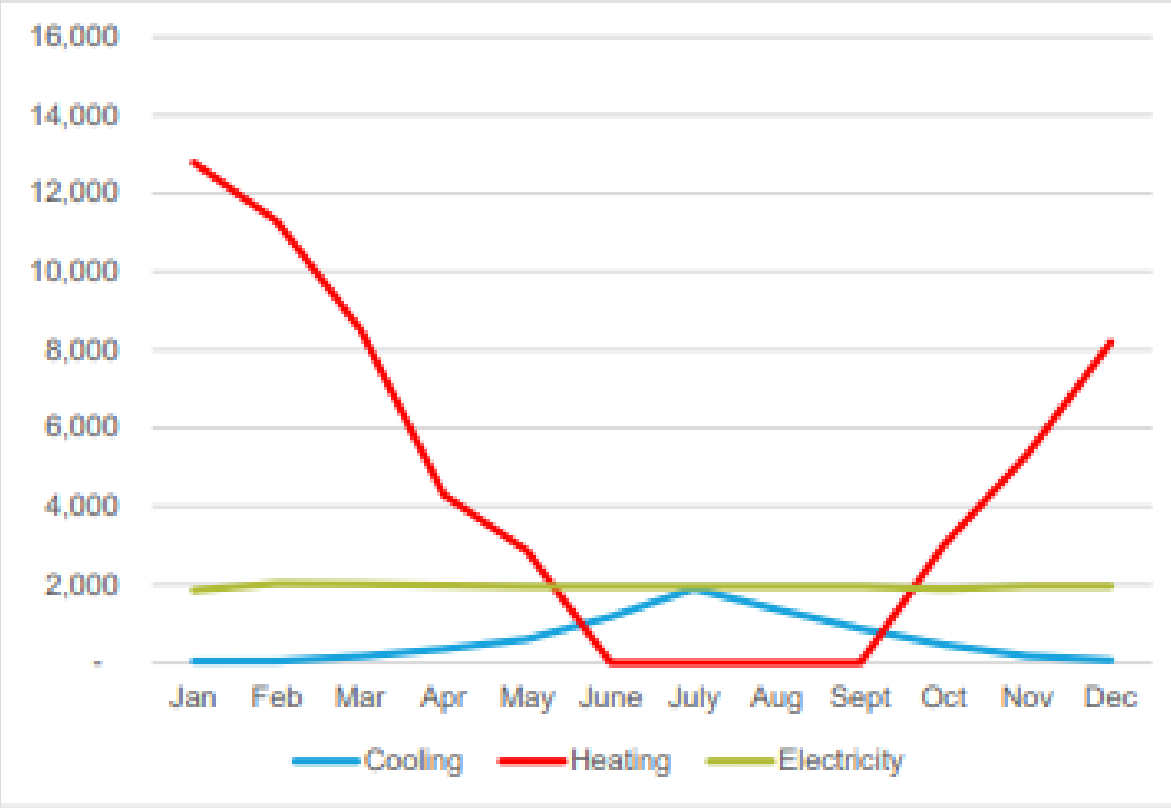
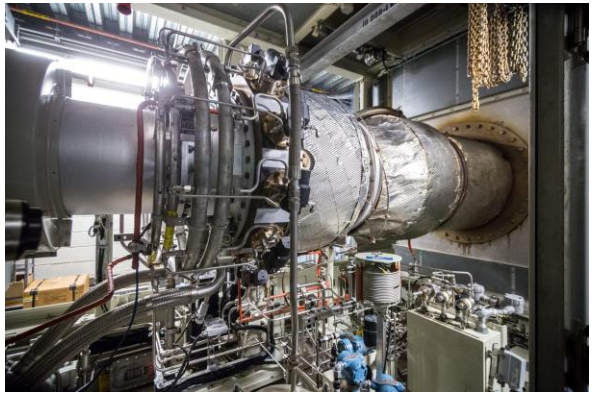


Figure 2: Existing Campus Thermal Energy & Electricity Demand (MWh)

Smith College's New Cogen System



- In 2008, Smith modified its Physical Plant as follows:
  - Gas turbine capable of producing 3.5 MW of electricity and 20,000 lbs/hr of steam
    - 46.9 MMBtu/hr heat input
    - Capable of firing natural gas and No. 2 fuel oil (not installed yet)
    - Operates using Selective Catalytic Reduction (SCR) and an Oxidation Catalyst to reduce emissions
  - New Boiler 3 added, designed to produce 65,000 lb/hr of steam
    - 79 MMBtu/hr heat input
    - Equipped with dry low NOx burners reducing overall emissions
    - Capable of operating on natural gas, No. 6 fuel oil and "yellow grease"
    - Only achieved 50,000 lb/hr in actual operation
  - Old Boilers 1-3 removed
  - Overall cost of the project was $11.5 million

Permitting the New Cogen System

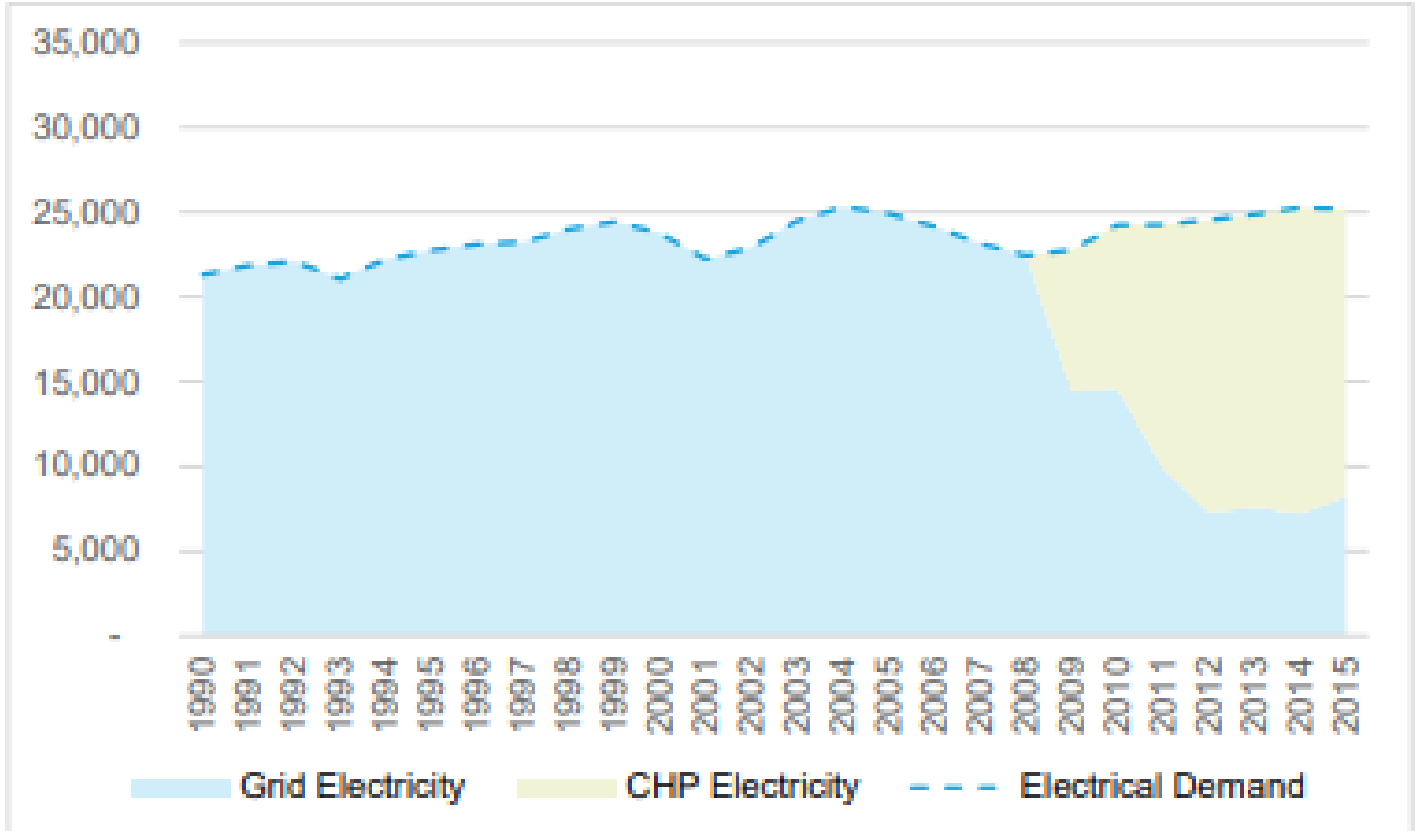
- Gas turbine approved using MassDEP's Environmental Results Program
  - Applicable for Non-Emergency Turbines greater than 50 kW
  - No air permit needed provided it meets all design criteria
  - Need to meet specific emission limits
    - Fuel Gas ULSD
    - NOx 0.14 0.34 lb/MW-hr
    - CO 0.09 0.18 lb/MW-hr
    - CO2 1,650 1,650 lb/MW-hr
    - NH3 2 ppm @ 15% O2
  - Detailed stack and sound level requirements
  - Air quality modeling analysis

- Also required a 750-kW emergency generator for black start capability
  - Approved using the ERP certification process for emergency engines
  - Tier 2 Non-Road engine certification
  - Stack design and operational limitations

Permitting the New Boiler

- Boiler approved using MassDEP's Air Plan Approval Application
  - For boilers greater than 40 MMBtu/hr
  - Requires top-down Best Available Control Technology (BACT) Analysis determining whether more stringent emission limits were cost-effective
  - SCR, ultra-low NOx burners (with enhanced flue gas recirculation (FGR)) and an oxidation catalyst were evaluated and determined to be not cost effective
  - The Project substantially reduced SO2 emissions capacity

Smith College's Electrical Consumption



Smith College's Energy Needs

- Turbine has had a high availability since installed
- Although Campus electrical demand did not increase significantly, the Cogen substantially displaced the quantity of electricity purchased from the grid
- Furthermore, in 2014, Smith began to sell some of its generated power to the grid
  - Smith receives the standard LMP pricing, which can add up to $25,000 each month
- Smith's cost to generate power is $0.04/kW-hr while its average cost to buy power from the grid is $0.14/kW-hr
- The daily average amount of power generated throughout 2020 was 2 MW from Oct-Apr, 1.1 MW year-round.

Smith College's Emissions Reductions

- Overall emissions reductions for the Physical Plant are as follows:

Year	NOx	SO2	PM	VOC	CO2
2001	40.00	160	14	0.3	21,000
2019	5.27	0.08	2.81	0.9	18,929
Reduction	34.73	159.92	11.19	-0.6	2,071
%	87%	99.9%	80%	-200%	10%

- Reductions are substantial are from switching to natural gas, pollutions controls, and unit efficiencies
- NOx and SO2 had the largest reductions
- Campus became a minor source, reducing overall emissions fees and compliance requirements

Smith College's Economic Benefits

- Receives Alternative Energy Credit since Massachusetts was encouraging CHP facilities
  - Up until last year, these payments were averaging $100,000 per quarter
  - Does not operate in the summer due to lack of electrical demand
  - Last year, due to large expansion of renewables, export payments have been reduced by 20-25%

Smith College's O&M Costs

- Smith is in a Full-Service Contract with Solar
  - Based on the turbine output
  - Currently at $225,000 per year providing:
    - 100% parts coverage
    - 100% labor coverage
    - Diagnostics with unlimited services calls
    - Provides a new engine every 50,000 hours
  - In last 10 years, Smith has not paid a dime outside of its contract

Conclusions

- This project has been great for Smith
- The CHP has provided a huge amount economic benefit by:
  - Switching fuel costs
  - Self-generating electricity at a fraction of the cost
  - Selling power to the grid
  - Provided Alternative Energy Credits
- The CHP has reduced emissions dramatically
- The Project replaced the oldest campus boilers, providing alternative fuel options
  - Natural gas in lieu of No. 6 oil
  - Option of yellow grease