Senior Thesis Final Presentation

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Mechanical Option	Gambier, Ohio
Advisor: Professor Treado	4/11/11

Introduction

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Gambier, Ohio
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Kenyon College
- The Village of Gambier
- Peirce Hall history

Intention of Studies
- LEED certification

Benefits
- Reduced energy use
- Qualify for incentives
- Grants

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Kenyon College

Size: 66,640 SF

Occupancy types: A-2 (restaurant) and A-3 (assembly)

Dates of Construction: Spring 2006 - Spring 2008

Total Cost: $18 Million

Project Team:
Owner - Kenyon College
Architect - Gund Partnership
Structural Engineer - LeMessurier Consultants, Inc.
Construction Management - The Albert M. Higley Co.
MEP and FP Engineers - Syska Hennessy Group, Inc.

Project Delivery: Design-Bid-Build

Rear View from North East

Rear View from South East

Servery Link Construction

New Servery Link

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Heating

-Kenyon College natural gas fueled campus steam distribution
-Steam system (26 PSI)
-Hot water system (190°F)

Power

-Purchased from American Electric Power Company

LEED Credit Assessment	
Section	Points Acquired
Sustainable Sites	9/29
Water Efficiency	4/10
Energy and Atmosphere	5/35
Materials and Resources	2/14
Indoor Environmental Quality	6/15
Innovation Design	1/6
Regional Priority	0/4
Total	**27/80**

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Basic CHP Concept

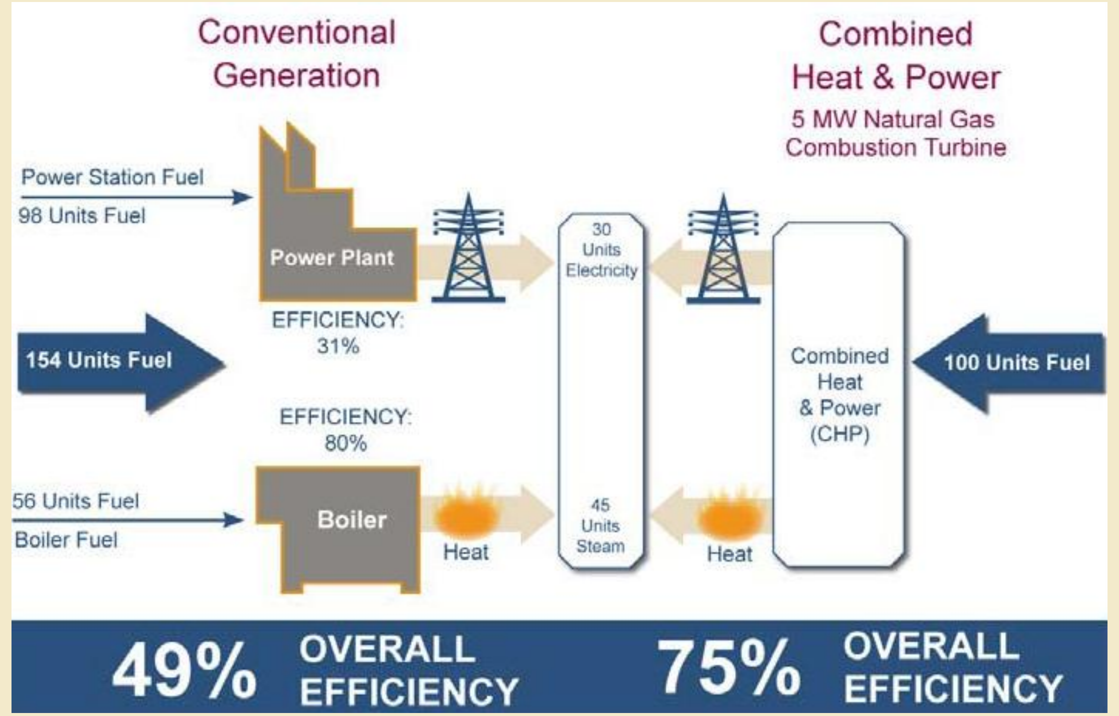
-Burn fuel to generate electricity. Recover and distribute a fraction of the exhausted heat from heat engine.

Benefits

-Highly efficient process → lower utility cost
-Distributed generation
-Multiple uses for recovered heat
-Decreased exhaust emissions

Disadvantages

-Complex operation and maintenance
-Careful application design considerations



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Basic CHP Concept

-Burn fuel to generate electricity. Recover and distribute a fraction of the exhausted heat from heat engine.

Spark Gap Calculation		
Cost per Million Btu		Spark Gap
Power	Fuel	
$36	$10	$26

Benefits

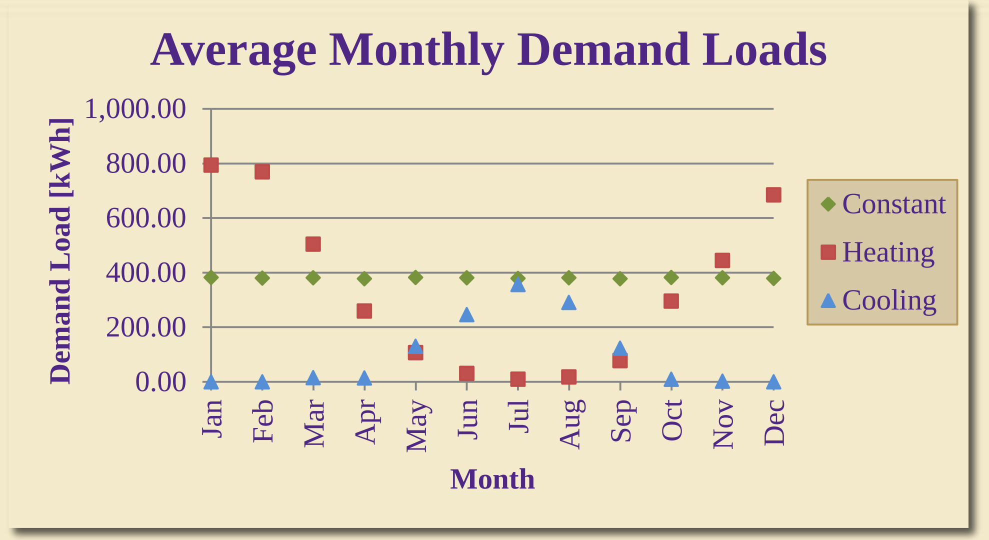
-Highly efficient process → lower utility cost
-Distributed generation
-Multiple uses for recovered heat
-Decreased exhaust emissions

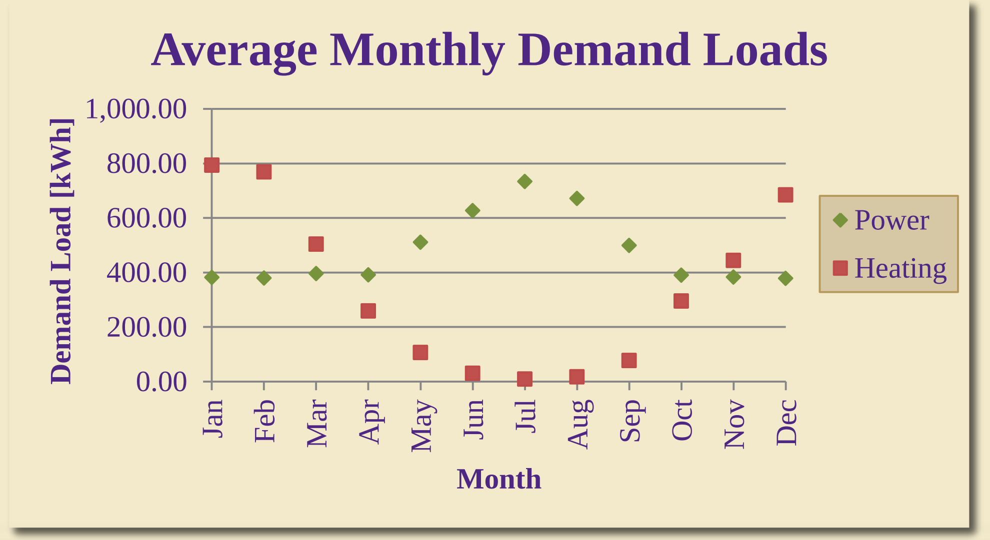
Disadvantages

-Complex operation and maintenance
-Careful application design considerations

Components

-Heat engine (prime mover)
-Generator
-Heat exchanger
-System interconnections





Siemens' W501FD Test Facility in Berlin, Germany

Capstone C30 Microturbine

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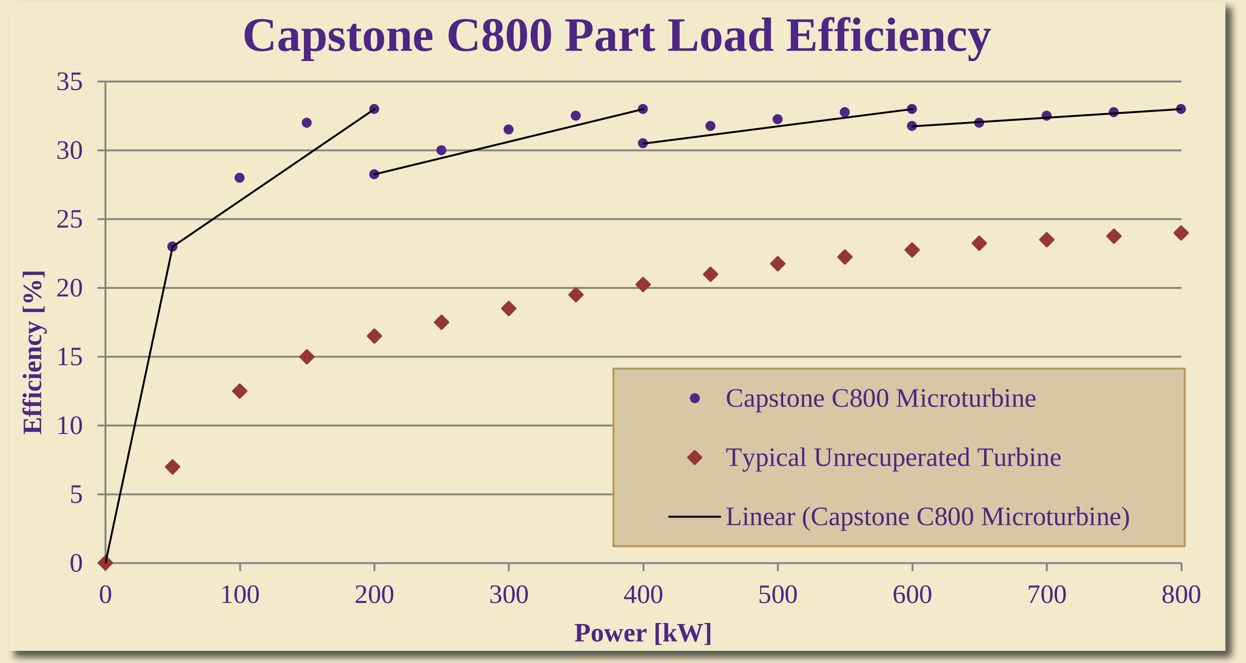
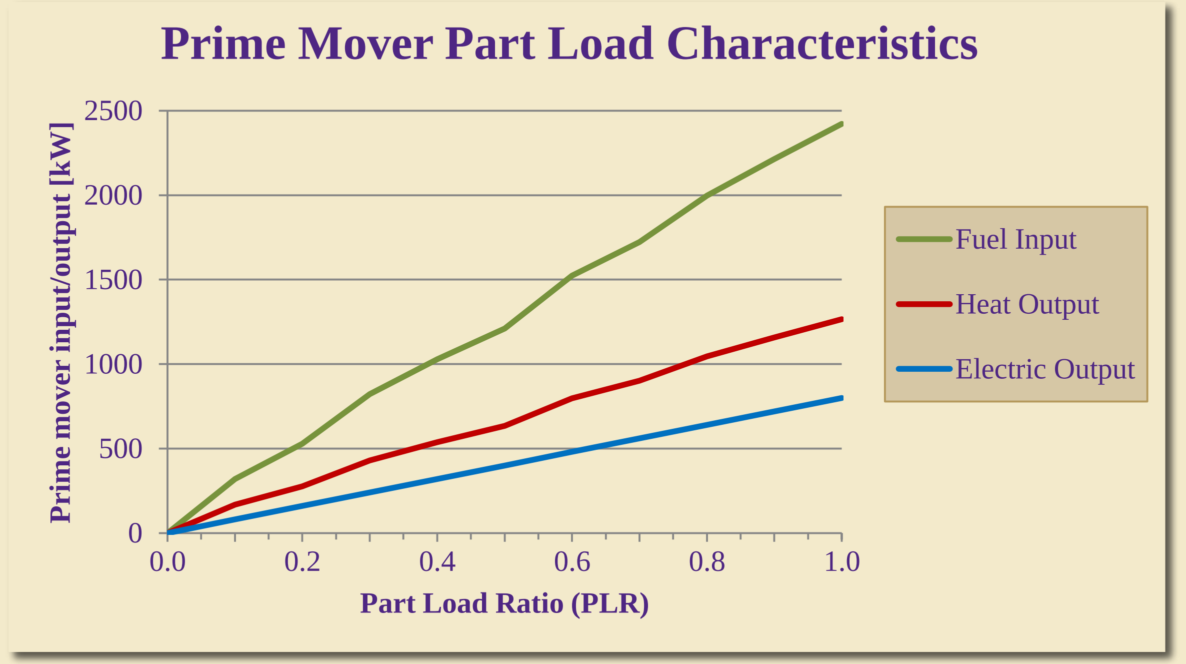
Microturbine

Capstone C800 High-Pressure Natural Gas 800 kW Power Package

Benefits:
- -Efficiency
- -Emissions
- -Capacity

Prime Mover Statistics:
- -800 kW power output
- -5,400 Btu/h heat output per kW generated





Selected Prime Mover

Control Scenarios

Results & Analysis

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CHP Model

-Calculate demand load
-Apply desired control scenario
-Calculate prime mover output
-Analyze amount of demand met and amount of additional energy needed or wasted

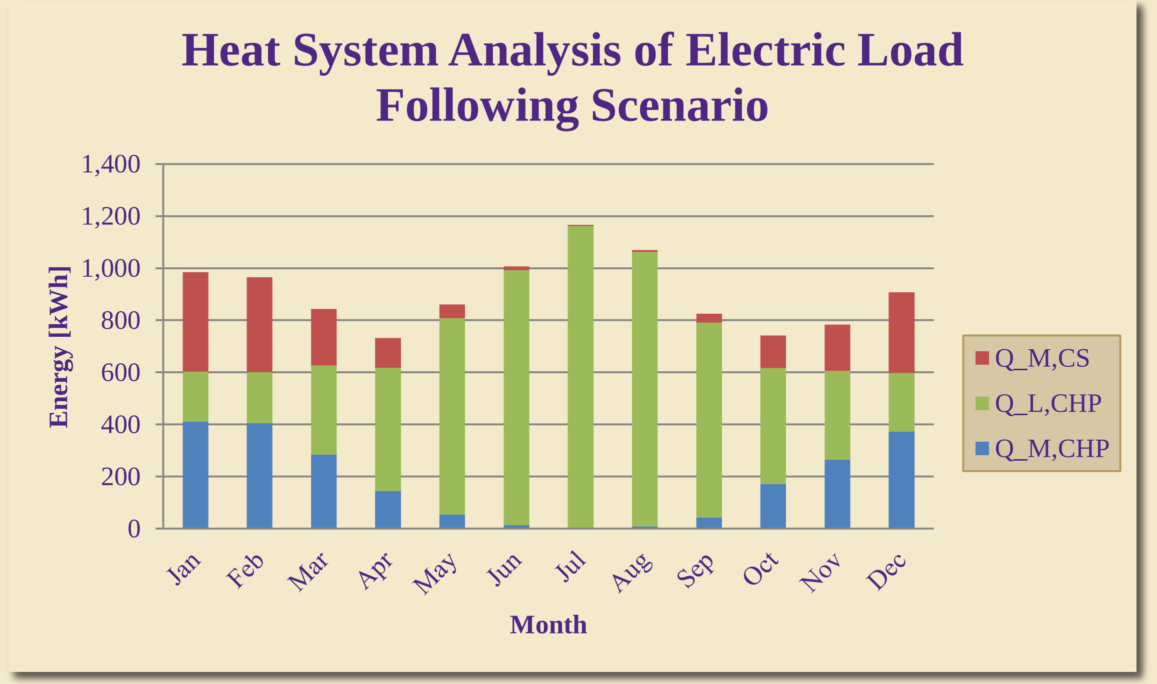
Legend for the Following Tables:

Q_M,CS: Heating Demand Load Met By Campus Steam System
Q_L,CHP: Unused Heat Generated by CHP Prime Mover
Q_M,CHP: Heating Demand Load Met By CHP System

W_L,CHP: Unused Electricity Generated by CHP Prime Mover
W_M,GRID: Electrical Demand met by Grid
W_M,CHP: Electrical Demand Load Met By CHP System

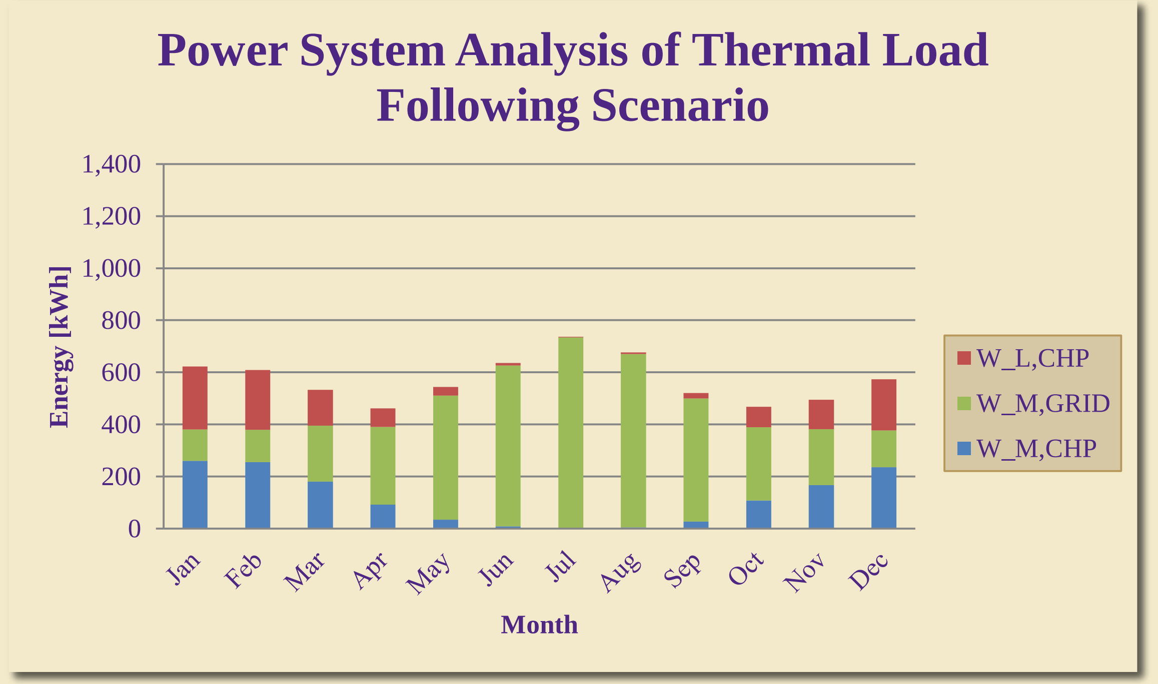
Electric Load Following

-100% of power demand met by CHP system
-Large amount of heat wasted during summer months



Thermal Load Following

-100% heating demand met by CHP system
-System becomes inactive in summer months
-Large amount of power required from grid



Results & Analysis

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Summary of Results

- Electric load following design is most effective:
  - Independence from grid provider
  - Efficiency equal to grid provider
  - Wasted energy can potentially be utilized

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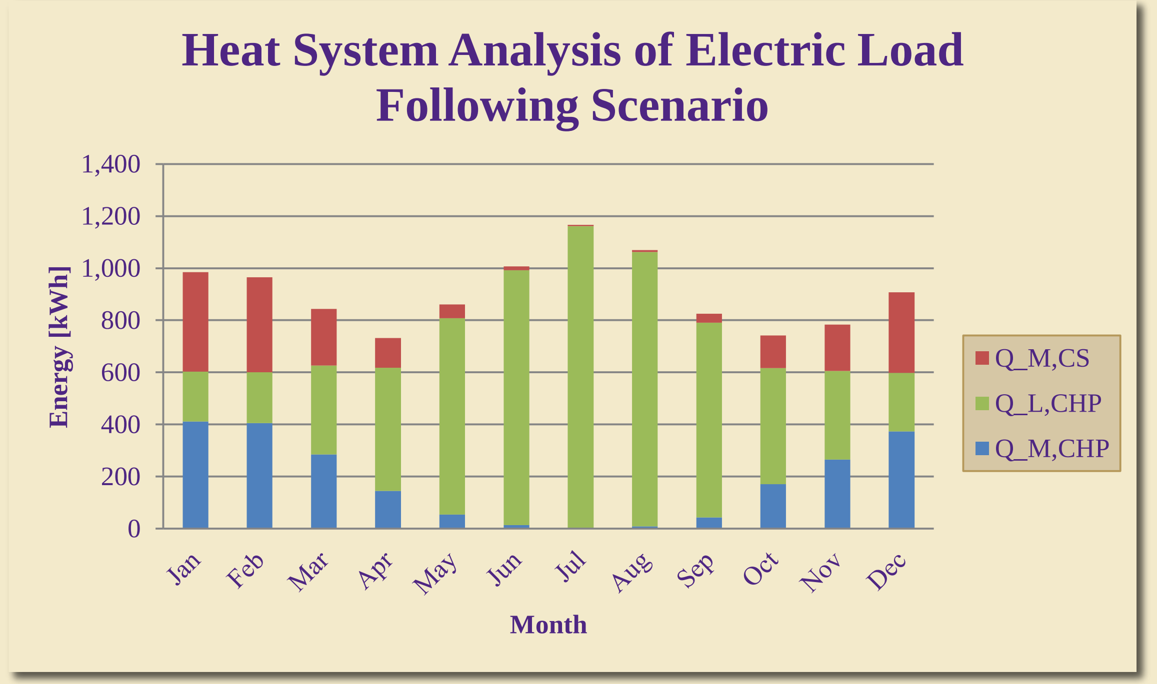
Room for Improvement

- Absorption cooling
- Expanded system



Annual Cost Comparison by Operation Scenario						
System	Fuel	Δ from SHP	Power	Δ from SHP	Total	Δ from SHP
SHP	$99,000		$416,000		$515,000	
CHP (Electric)	$468,000	373%	$0	-100%	$468,000	-9%
CHP (Thermal)	$190,000	92%	$378,000	-9%	$568,000	10%

EPA Annual Emissions Analysis (SHP Comparison)	CHP System	Displaced Electricity Production	Displaced Thermal Production	Emissions/Fuel Reduction	Percent Reduction
NOx (tons/year)	0.77	9.34	1.29	9.86	93%
SO2 (tons/year)	0.01	28.15	0.01	28.14	100%
CO2 (tons/year)	2,530	3,942	1,500	2,913	54%
Carbon (metric tons/year)	625	975	371	720	54%
Fuel Consumption (MBtu/year)	43,352	38,426	25,714	20,788	32%
Number of Cars Removed				481	

Results & Analysis

Acoustic Considerations

Acoustic Treatment

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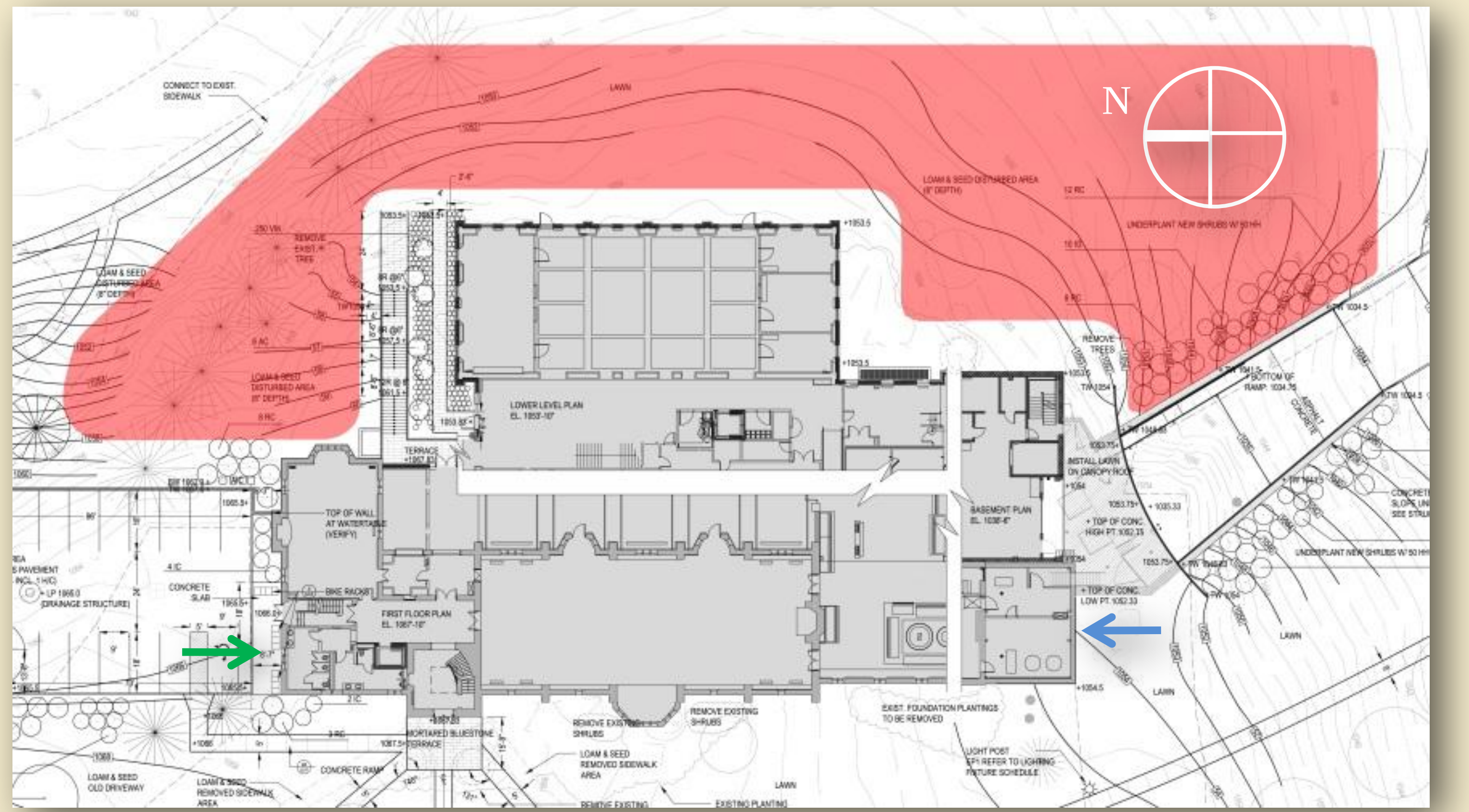
Location Considerations

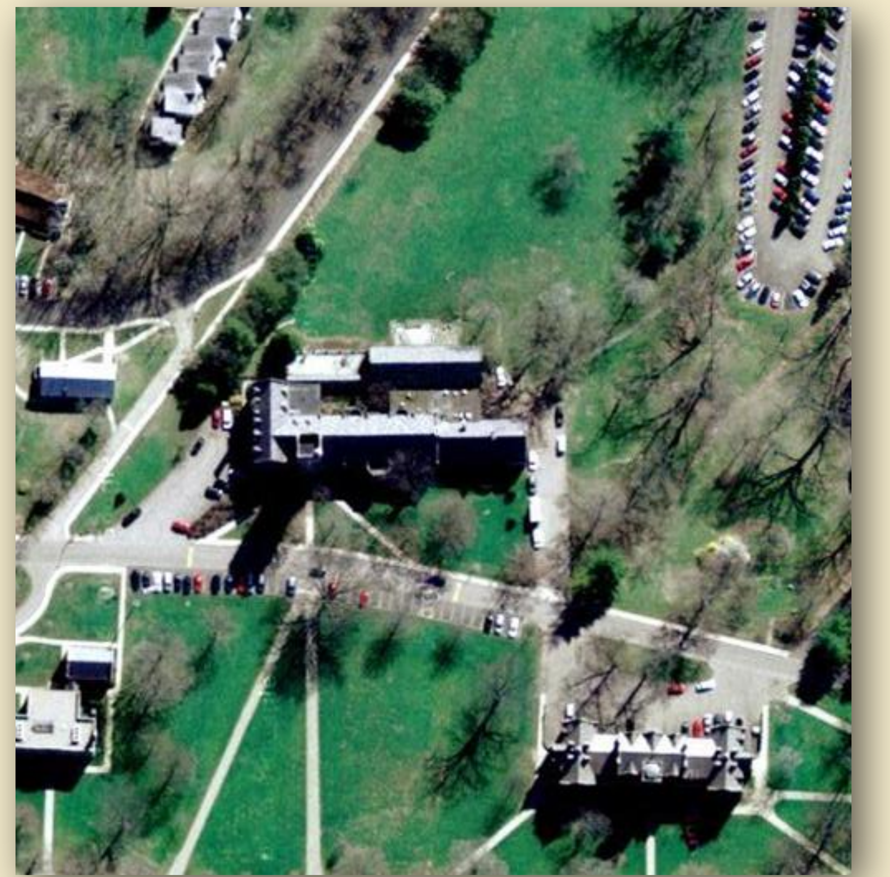
-Size
-Proximity to steam and power building entrances
-Sightlines to inner campus and surrounding areas

Acoustic Characteristics

-Single unit sound pressure level (SPL) is 65 dBA at 10 m
-Known part load high pitch noise
-Reduced SPL at Pierce Hall exterior wall below 50 dBA



Peirce Hall Site with Possible Prime Mover Location



Google Map of Peirce Hall Site

Acoustic Treatment

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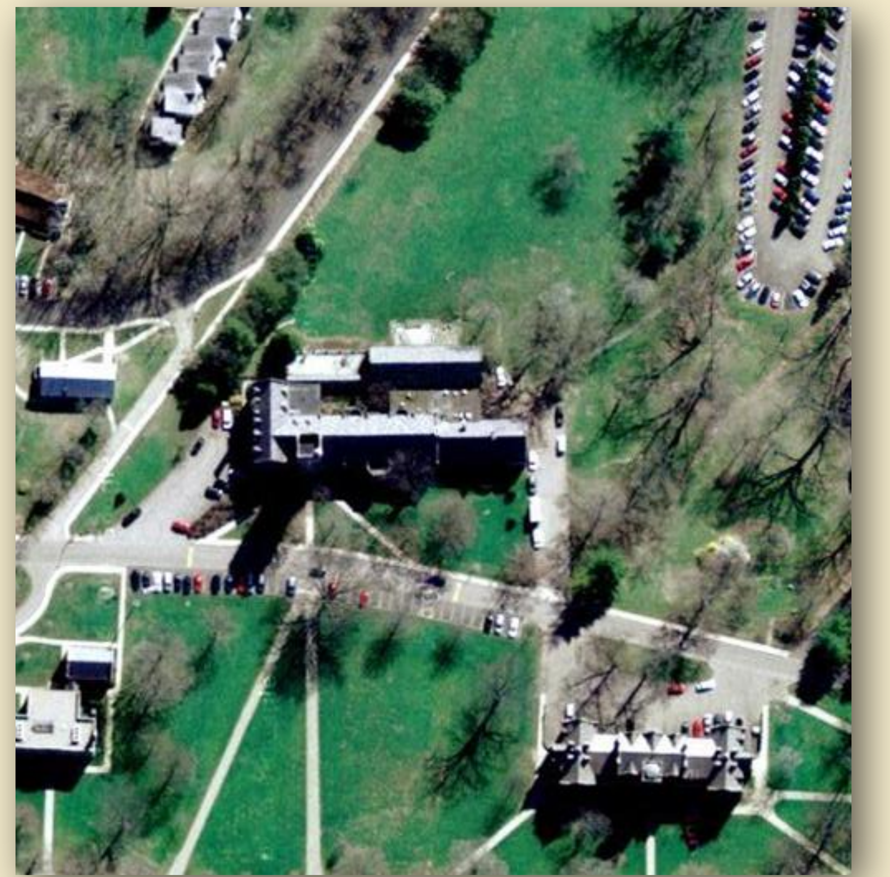
Acoustic Characteristics

- Construct a "sealed" housing structure for the prime movers
- Three CMU wall constructions explored:
  1) Standard 8" x 8" x 16" CMU [STC – 45]
  2) (1) with center grout and steel reinforcement [STC – 48]
  3) (2) with 2 coats oil based paint on each side [STC – 55]

Sound Pressure Level at Peirce Hall from 20 ft

Type	STC	SPL (dBA)
1	45	33
2	48	30
3	55	23

Peirce Hall Site with Prime Mover Location



Google Map of Peirce Hall Site

Meeting Intentions of Studies

-Recognizably efficient building systems
-Fuel savings provide improvement needed
-LEED prerequisites

LEED Credit Assessment	
Section	Points Acquired
Sustainable Sites	9/29
Water Efficiency	4/10
Energy and Atmosphere	5(+13)/35
Materials and Resources	2/14
Indoor Environmental Quality	6/15
Innovation Design	1/6
Regional Priority	0/4
Total	**40/80**

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Sponsors:
Kenyon College
Syska Hennessy Group, Inc.

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Questions?