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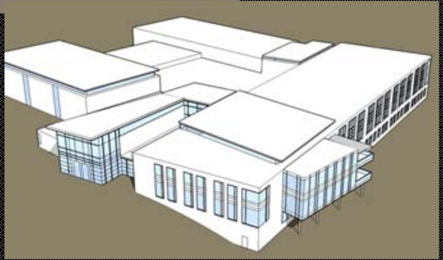
Thesis Final Presentation



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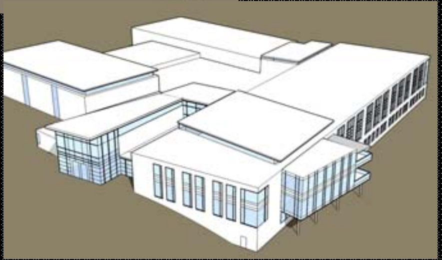
Facility Information

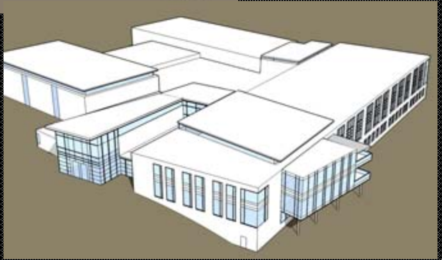
Size:	186,000 SF
Location:	Fort George G. Meade, MD
Owner:	Army Corps of Engineers
Architect:	HOK
Engineers:	AECOM |HSMM
Occupancy:	24/7 Operation, Television Studios, Data Center
Completion Date:	September 2011



Presentation Outline

Mechanical Information

Air Delivery System:	Variable Air Volume
Chilled Water System:	(3) 500 Ton Water Cooled Chillers
Distribution System:	Primary/Secondary Flow
Hot Water System:	(3) 3000 MBH Condensing Boilers
Control System:	Direct Digital Control using BACnet
Waterside Economizers:	Used for Data Center
Airside Economizers:	Used in AHU’s



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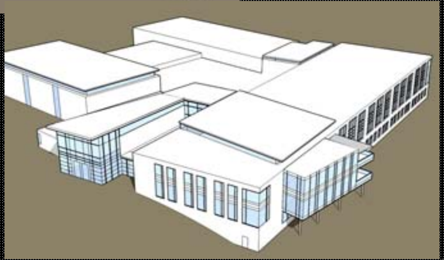
Goal:

Minimize Costs Spent on Energy Consumption, Making the Building Less Expensive and More Efficient to Operate



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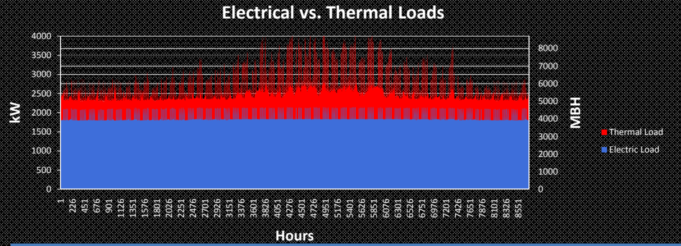
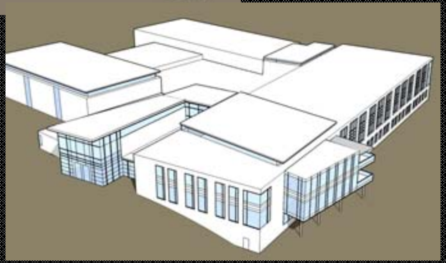
Combined Heat & Power



<u>Electric</u>
- 1.8 MW Base Load
- 2.2 MW Peak Load

<u>Thermal (*Heating & Cooling*)</u>
- 4,900 MBH Base Load
- 9,200 MBH Peak Load



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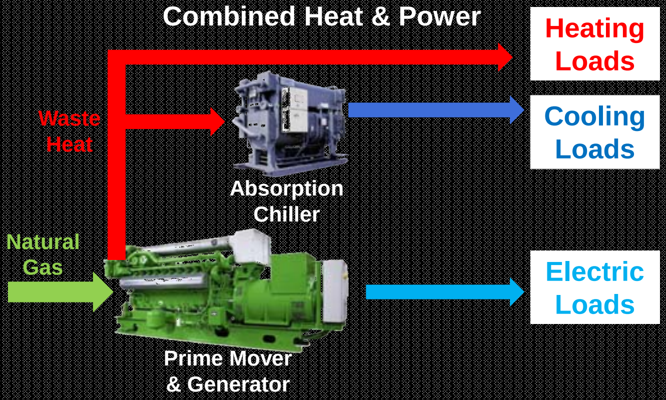

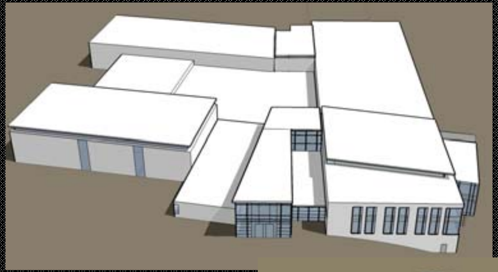

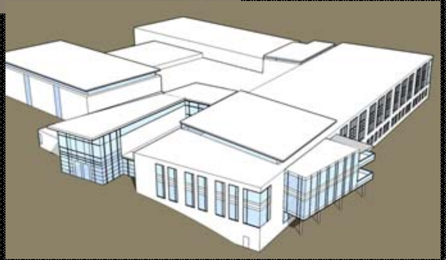

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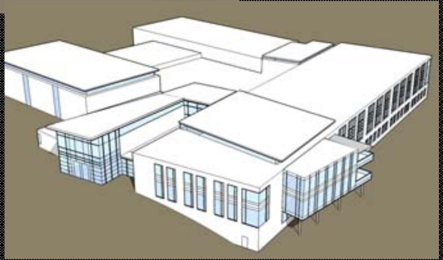
CHP Options

System	Engine Type	Options	Electric Production	Load	Cooling	Heat Source
A	Internal Combustion	-	2390 kW	100%	800 Ton Absorption Chiller	Waste Heat + Boiler
B		-	2390 kW	100%	(2) 500 Ton Electric Chillers	Waste Heat Only
C		-	2390 kW	100%	700 Ton Absorption Chiller and a 300 ton Electric Chiller	Waste Heat Only
D		-	2390 kW	Load-Following	800 Ton Absorption Chiller	Waste Heat + Boiler
E		-	2390 kW	Load-Following	700 Ton Absorption Chiller and a 300 ton Electric Chiller	Waste Heat Only
F		-	1801 kW	100%	800 Ton Absorption Chiller	Waste Heat +Boiler
G	Turbine	-	1200 kW	100%	800 Ton Absorption Chiller	Waste Heat Only
H		Back-Pressure Steam Turbine	1904 kW	100%	800 Ton Absorption Chiller	Waste Heat +Boiler
I		Back-Pressure Steam Turbine	1904kW	100%	400 Ton Absorption Chiller and a 500 ton Electric Chiller	Waste Heat +Boiler



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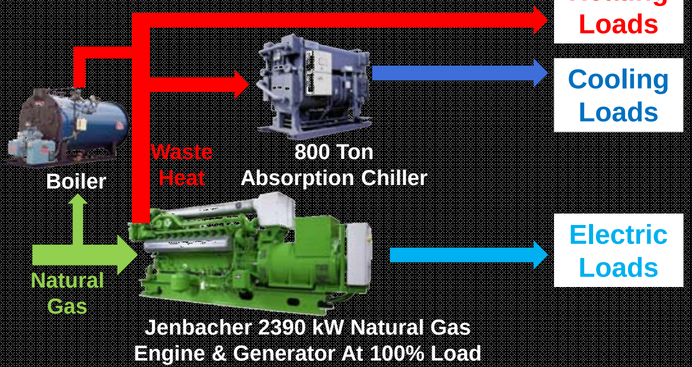
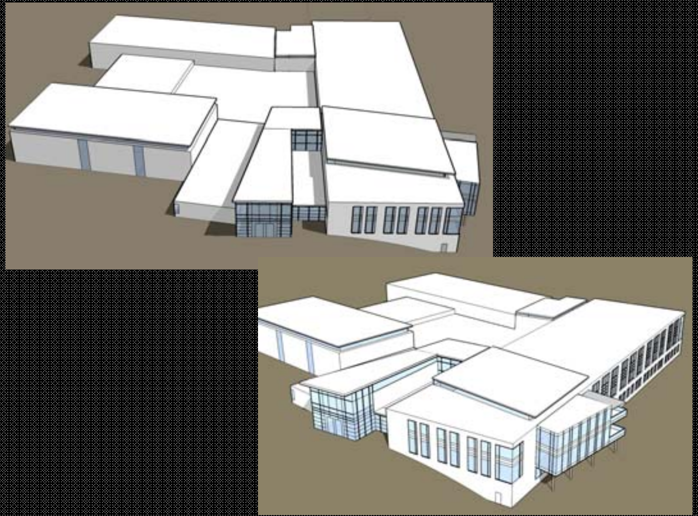
System A





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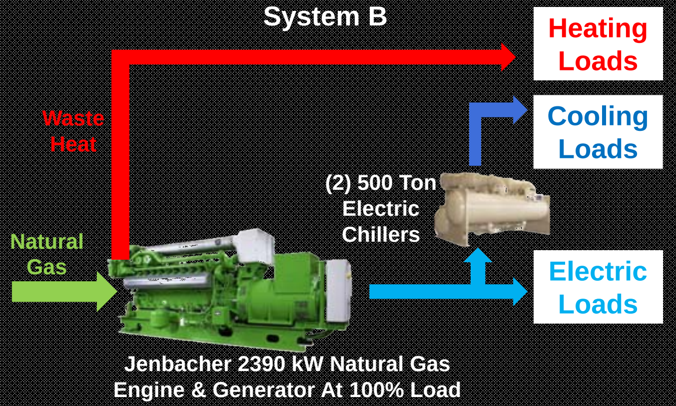
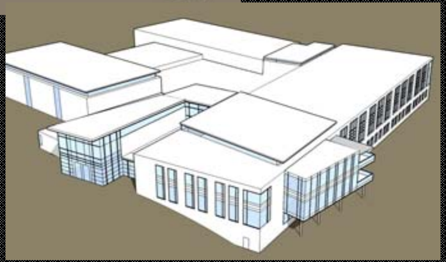
System B





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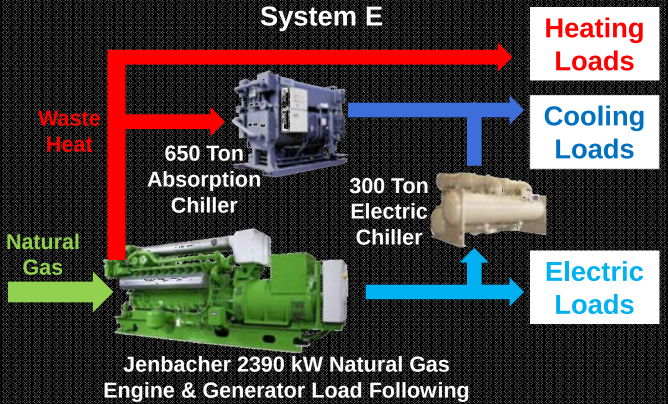
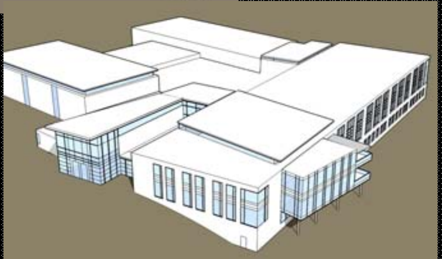
System E





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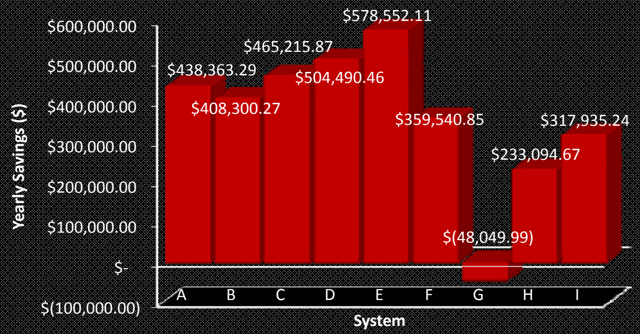
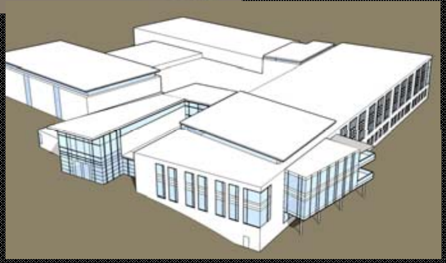
Yearly Energy Cost Savings by System





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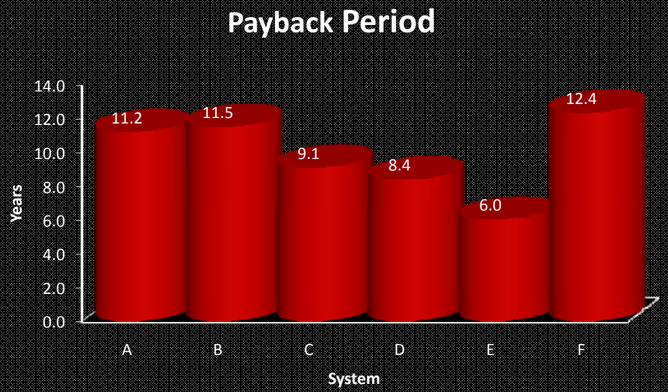

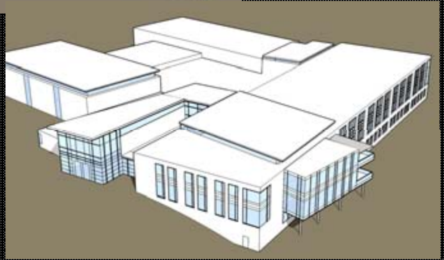

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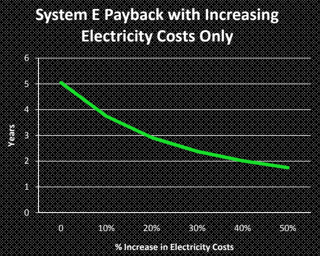
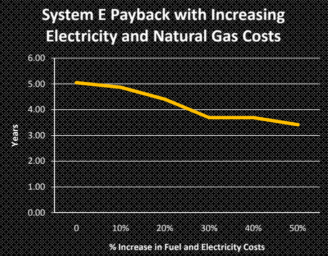
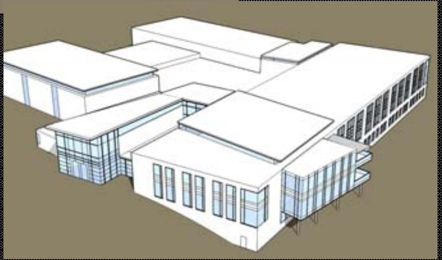
Sensitivity Analysis







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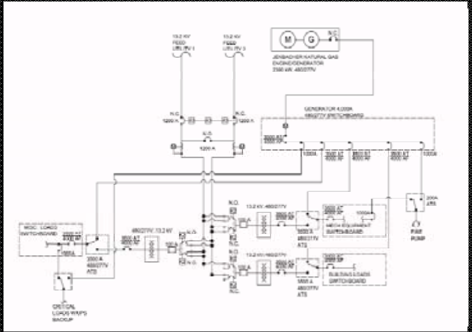
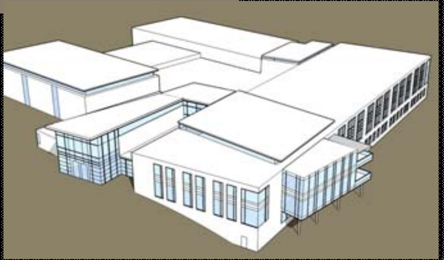
Electrical Interface for CHP

•The generator switchboard and the breakers were sized based on current electrical design

•Redundant Automatic Transfer Switches were added to critical equipment
- •Data Center
- •Fire Pump





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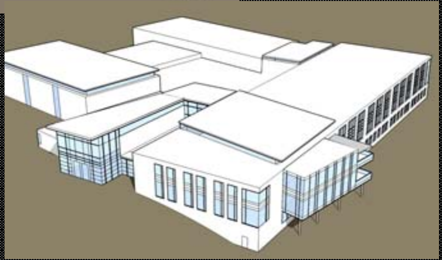
Acoustical Analysis



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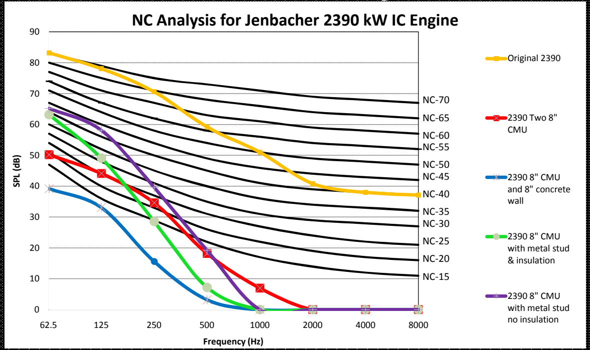
Acoustical Analysis



- Double 8” Concrete filled CMU wall
- 8” CMU wall, and 8” Concrete wall
- 8” CMU wall and a Metal Stud wall with insulation

8” CMU wall and a Metal Stud, with no insulation

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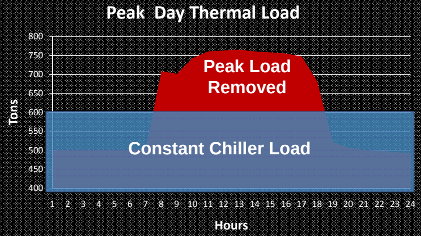
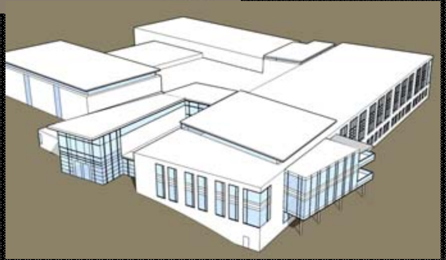
Thermal Storage

- Peak Shaving Strategy for:
  - Ice Storage Chilled
  - Water Storage



Ice storage produced negative savings from this analysis due to inefficiency of making ice and low electric rates.



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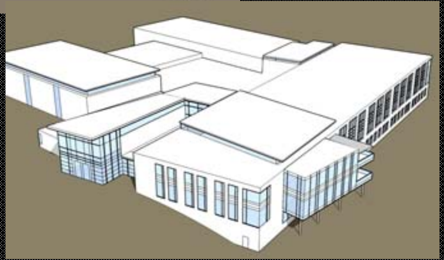


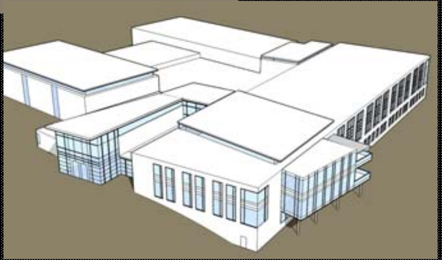
Thermal Storage

- Peak demand was determined on a monthly basis.
- On-Peak to Off-Peak shift was determined on a daily basis.

Chilled Water Storage Savings

Demand Savings:	$3,617.22
On-Peak Savings:	$7,025.21
Total Yearly Savings:	**$10,643.43**

Presentation Outline



Simple Payback Period

• Initial Investment was determined based on a 3,500 Ton-hr, 400,000 Gallon Tank and required accessories such as pumps, piping, etc.
• Due to N+1 Redundancy requirements, one chiller/cooling tower could be removed and the remaining chillers/cooling towers have to be upsized to 600 tons.
• Savings from one less chiller can be used to pay for the chilled water storage tank

Initial Investment:	$173,666
Simple Payback Period:	16.32 Years

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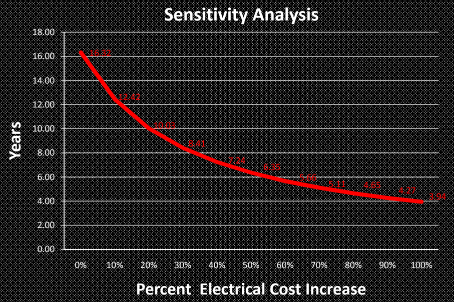
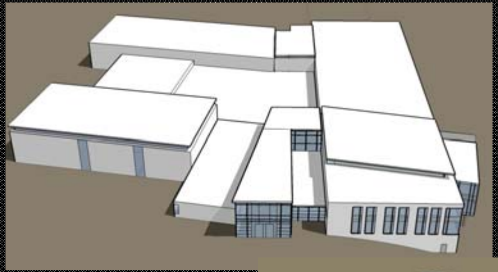
Thermal Storage

- Exponential Decline in the payback period
- As Electricity Rates increase, the payback period decreases

16.3 years to 12.4 years at a 10% increase





Presentation Outline

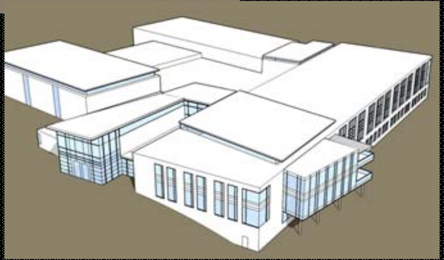
CHP Integrated with Thermal Storage

• CHP System A was used for this System Optimization Analysis

  ❑ This system had the largest amount of wasted heat, which makes it a good candidate for integration with thermal storage.

• Integrating thermal storage into a CHP system produced slightly better results than thermal storage on its own.

Yearly Energy Cost Savings: $11,644



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  - DOAS
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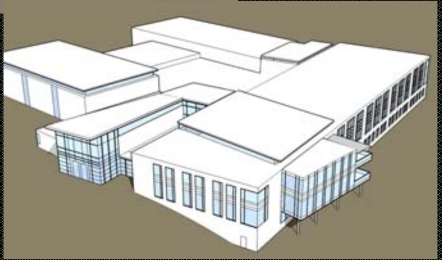
- Due to a smaller tank, and slightly larger yearly savings, the simple payback period for thermal storage was around

10.6 Years

Initial Investment for Thermal Storage with CHP	
350,000 Gallon Tank	$ 354,200.00
300 Feet of 5" Pipe	$ 10,500.00
300 Feet of 2" Insulation for 5" Pipe	$ 5,874.00
(2) 15 HP Pumps	$ 10,220.00
One Less (500 Ton) Chiller	$ (293,062.50)
One Less (500 Ton) Cooling Tower	$ (50,472.80)
Increasing Size of Original Chiller (500 to 650 tons)	$ 71,200.00
Increasing Size of Original Towers (500 to 650 tons)	$ 14,950.00
Total	**$ 123,408.70**



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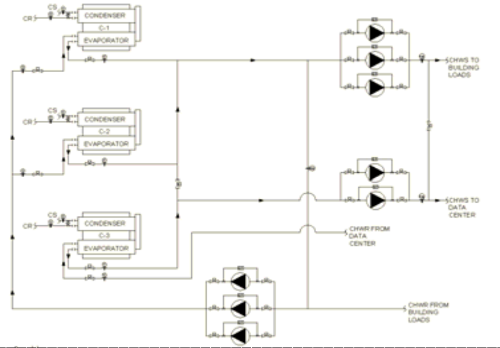
Dedicating a Chiller to the Data Center



Presentation Outline

Even with higher pumping costs, the total energy savings from running a chiller at higher temps was substantial

Cooling Cost of the Data Center

Temperature	MMBTU/year	Savings $/yr
44˚ F	15137.0	-
55˚ F	14065.4	$28,155.00
60˚ F	13046.8	$54,946.00

• Initial Investment for dedicating a chiller only involved adding in a few valves, (2) pumps, and some piping.

•The simple payback period calculated for running a chiller at 55˚ F was less than a year.

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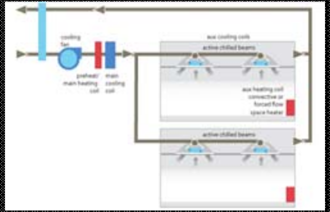
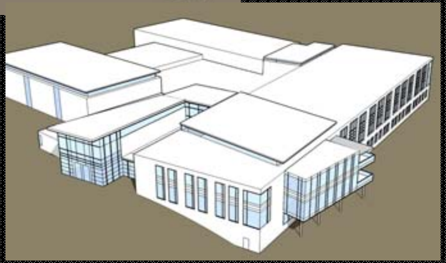
DOAS

- DOAS paralleled with Chilled Beams was modeled in TRACE 700 for annual energy and cost savings
- Only lower energy density areas were modeled as DOAS with Chilled Beams



- Annual Energy Savings: 1,913 x 10^6 [BTU/yr]
- Annual Cost Savings: $46,949



Presentation Outline

Conclusion

CHP System E Yearly Savings:	$578,552
Dedicated Chiller to Data Center @ 55˚ F:	$28,155
Chilled Water Storage W/CHP System A Savings:	$11,644
Chilled Water Storage Yearly Savings:	$10,643
DOAS (Office) Yearly Savings:	$46,949

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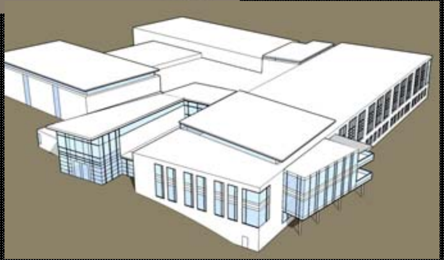
Acknowledgements:

Special Thanks To:
All the AE Faculty
&
Family and Friends



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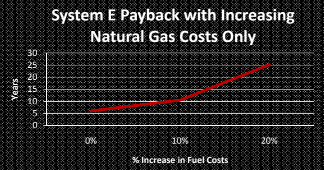
Mechanical Option

Initial Investment by CHP System	
System	Cost
A	$ 2,754,407.05
B	$ 2,483,717.55
C	$ 2,478,387.55
D	$ 2,800,156.55
E	$ 2,439,842.55
F	$ 2,381,676.53

Wall Type	Total Cost
Total: Additional 8" Concrete	~~$14,991.14~~
Total: Additional metal stud wall with insulation	$28,731.25
Total: Additional metal stud wall, no insulation	$14,498.80
Total: Additional block wall	$28,085.95

Initial Investment for Thermal Storage	
400,000 Gallon Tank	$ 382,800.00
300 Feet of 5" pipe	$ 10,500.00
300 Feet of 2" Insulation for 5" Pipe	$ 5,874.00
(2) 15 HP pumps	$ 10,220.00
One Less Chiller	$ (293,062.50)
One Less Cooling Tower	$ (50,472.80)
Increasing size of original Chillers	$ 94,648.00
Increasing size of original Towers	$ 13,160.00
Total	$ 173,666.70



Initial Investment for Thermal Storage with CHP	
400,000 Gallon Tank	$ 354,200.00
300 Feet of 5" Pipe	$ 10,500.00
300 Feet of 2" Insulation for 5" Pipe	$ 5,874.00
(2) 15 HP Pumps	$ 10,220.00
One Less Chiller	$ (293,062.50)
One Less Cooling Tower	$ (50,472.80)
Increasing Size of Original Chiller	$ 71,200.00
Increasing Size of Original Towers	$ 14,950.00
Total	$ 123,408.70

Presentation Outline

- Introduction
- CHP Analysis
- Electrical Analysis
- Acoustical Analysis
- Thermal Storage Analysis
- System Optimization Analysis
- Conclusion
- Acknowledgements
- Questions

DMA Building

Fort George G. Meade, MD

Pavel Likhonin

Mechanical Option

CO2e Savings when compared to Grid

		A	B	C	D	E	F
IC Engine	kWh	20,936,400.00	20,982,933.93	20,936,400.00	16,673,858.17	17,305,591.92	15,776,760.00
	BTU	74,893,389,355.47	71,635,736,437.02	71,476,869,600.00	70,082,301,286.29	59,081,290,819.32	53,861,858,640.00
	CO2e (lb)	10,260,394.34	9,814,095.89	9,792,331.14	9,601,275.28	8,094,136.84	9,011,793.30
Grid	kWh	18,602,443	18,602,443	18,602,443	18,602,443	18,602,443	18,602,443
	CO2e (lb)	33,856,445.42	33,856,445.42	33,856,445.42	33,856,445.42	33,856,445.42	33,856,445.42
	Savings (lb)	**23,596,051.08**	**24,042,349.53**	**24,064,114.29**	**24,255,170.15**	**25,762,308.58**	**24,844,652.12**

- Equivalent of removing 1,916 cars!
- Spark Gap: $18.99
- O&M costs from EPA.gov: $0.005/kWh
- Assumed 40% Elect. Efficiency at 75% load. From manufacturer, full load electrical efficiency is 42.6%
- System E never drops below 75% of the load, making load following very efficient
- Thermal to Electric Ratio of 0.85 to 1.25 during the peak summer months