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- **Proposed Redesigns**
  - **Load Reduction**
  - **DOAS & Chilled Beam Analysis**
  - **Floor-to-Floor Height Reduction – Breadth Topic**
  - **Chiller Plant Analysis**
- **Conclusion**

Duval County Unified Courthouse Facility

Jacksonville, FL

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Duval County Unified Courthouse Facility

Jacksonville, FL

Proposed Depth & Breadth Topics:

- Building Envelope Load Reduction
- Dedicated Outdoor Air Systems with Active Chilled Beams
- Chiller Plant Implementation (MAE Course Work)
- Electrical Breadth – Solar Photovoltaic Analysis
- Construction Management – Floor-to-Floor Height Reduction

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Use: Office/Courthouse
Cost: $224 Million

Delivery: Design-Build
Construction Start: May 2009
Construction End: May 2012

Location: Downtown Jacksonville, Florida
Size: 798,000 s.f. with 7 Levels above grade

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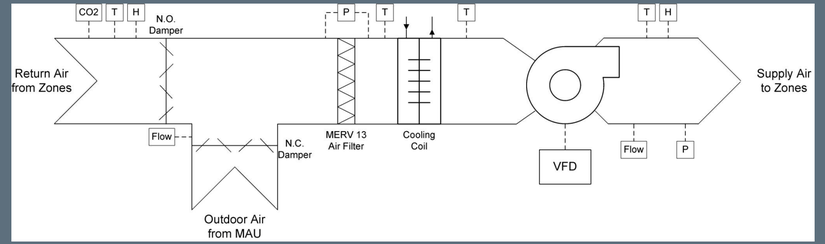
Airside Systems:

- 25 Variable Air Volume Air Handling Units (3,300 to 50,000 CFM)
  - 14 AHUs for 51 Courtrooms
  - 11 AHUs for remaining spaces
- 3 Make-Up Air Units (40,000 CFM each)
  - 2 MAUs use sensible energy wheels



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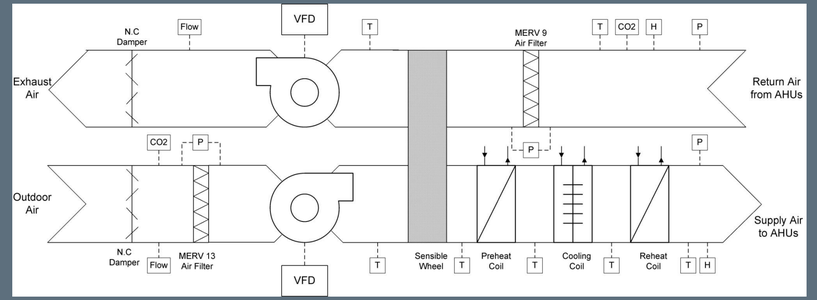

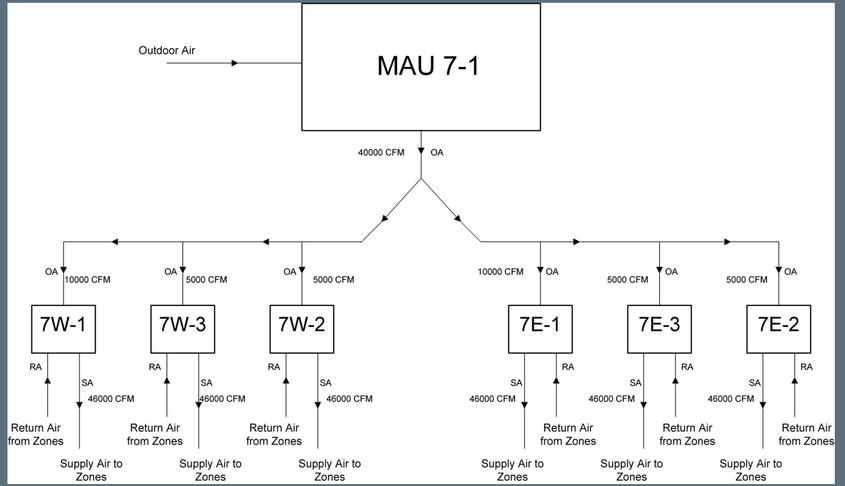

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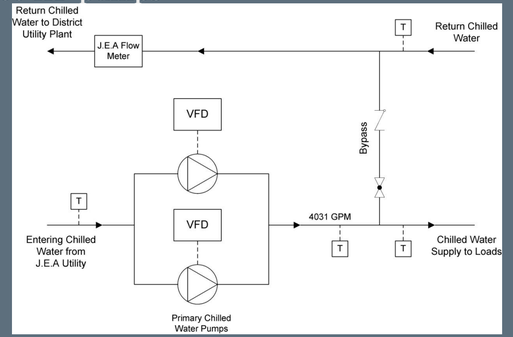
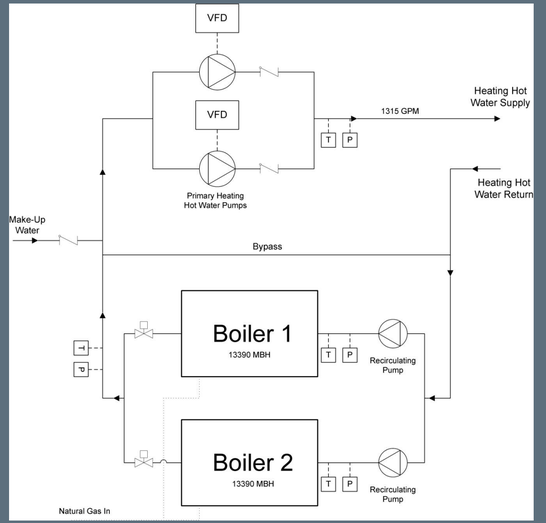
Waterside Systems:

- 2 Natural Gas Boiler (13,390 MBH each)
- Chilled water supplied by J.E.A. Public Utility Company
  - Pumped from central pumping room to coils with two 2,200 GPM 200 HP pumps





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Zone Conditioning:

- Areas served by VAV AHUs
- Terminal VAV boxes with reheat in zones
- 872 VAV boxes (200 to 6,300 CFM)

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Energy Sources:

Utility Rates

Utility	Unit Cost
Electricity	$0.0292/MBTU
Chilled Water	$0.0132MBTU
Natural Gas	$0.0083/MBTU

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Energy Sources:

Utility Rates

Utility	Unit Cost
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Chilled Water	$0.0132MBTU
Natural Gas	$0.0083/MBTU

Energy Use:

Energy Use Summary

Electric		Natural Gas		Chilled Water		Total
Consumption (kWh)	Peak Demand (kW)	Consumption (MCF)	Peak Demand (MCF/hr)	Consumption (kGal)	Peak Demand (Gal/hr)	Consumption (MMBTU)
5,176,611	1,880	783	5.8	341	227.7	55,081

Energy Cost:

Energy Cost Summary

Electric			Natural Gas	Chilled Water	Total
Consumption	Demand	Total	Consumption	Consumption	Consumption
$517,661.10	205,690.00	$723,351.10	$6,696.44	$483,274.44	$1,213,321.98

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Goals and Objectives:

- Reduce Cooling Loads on building
  - Climatic loads such as solar and dehumidification
- Reduce Energy Consumption
- Reduce Utility Costs

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Bases for Comparison:

- Initial Cost
- Life Cycle Cost
- Energy Use & Cost
- Simple Payback
- Environmental Impact
- LEED Applicability

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      - New Loads
      - Economics
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➢Large amount of glazing contributes greatly to building cooling loads

➢Solar gain through windows is large and has a significant impact on the building loads

Building Loads				
Total Cooling Load	Glazing Solar Load	Glazing Conduction Load	Total Glazing Load	Glazing Load Percentage of Total
(Tons)	(Tons)	(Tons)	(Tons)	
2030	164	110	274	13.5%

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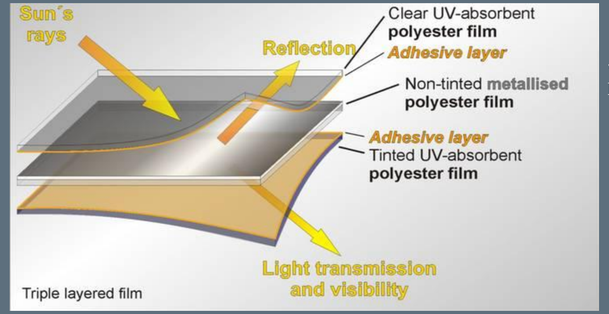

*Images Courtesy of Multifilm® website

➢Normal blinds trap direct solar radiation between glazing and blind's surface

➢Multifilm ® blinds use multiple films, with a thin layer of reflective aluminum

➢Allows solar radiation to be reflected back out glazing before it turns into heat in the trapped space
➢Allows enough visible light in and out to allow for glare-free natural lighting and views out

➢Improves SHGC and U-Value of glazing system
➢For ease of modeling the solar radiation reduction benefits, the glazing system's SHGC was modified instead of utilizing an internal shading model

➢The Multifilm® *Film-Façade-Systems* product has been chosen for the DCUCF due to the large glazing areas
➢This system allows for an electrically motorized operation system to adjust the vertical length of the blind

➢The control of these internal shades will use photosensors on each main façade of the building to control the motors

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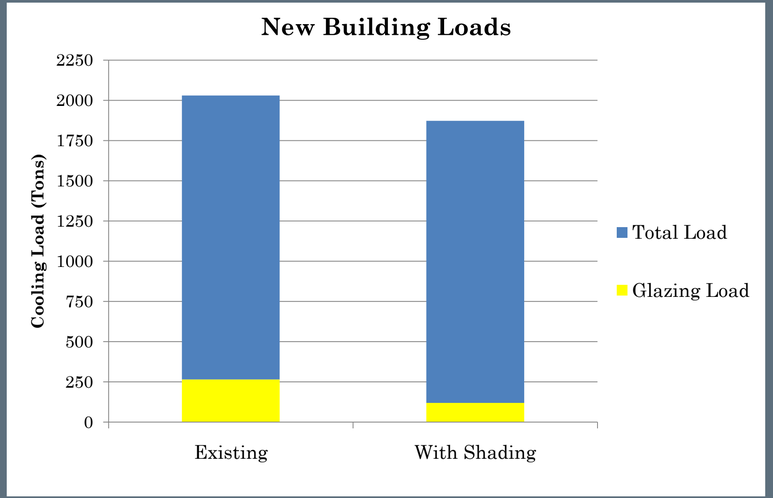
New Building Loads

Total Cooling Load	Glazing Solar Load	Glazing Conduction Load	Total Glazing Load	Glazing Load Percentage of Total
(Tons)	(Tons)	(Tons)	(Tons)	
1873	49	70	119	6%



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➢Total energy use reduced by 2,529 MMBTU

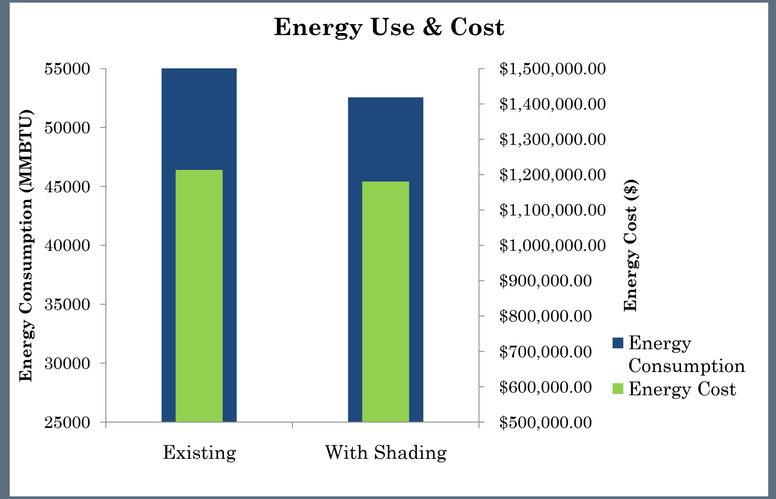
Energy Use Summary

Electric		Natural Gas		Chilled Water		Total
Consumption (kWh)	Peak Demand (kW)	Consumption (MCF)	Peak Demand (MCF/hr)	Consumption (kGal)	Peak Demand (Gal/hr)	Consumption (MMBTU)
5,219,790	1,852	609	4.0	317	210	52,552

➢Total energy cost reduced by $32,940

Energy Cost Summary

Electric			Natural Gas	Chilled Water	Total
Consumption	Demand	Total	Consumption	Consumption	Consumption
$521,979.00	202,880.00	$724,859.00	$5,214.89	$450,307.44	$1,180,381.33



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Initial Cost: $1,154,400
Annual Savings: $32,940
Simple Payback: 35 Years
20 Year LCC: $21,244,274

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    - System Description
    - Resulting Cooling Loads
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- Current facility requires a total cooling airflow of 486,632 CFM with 137,099 CFM of ventilation air
- Ventilation Load of 504 tons
- DOAS/ACB take care of ventilation and zone cooling separately
- Allows for minimum airflow to be sent to space
  - Reduces ductwork
  - Handles only latent loads
- Active Chilled Beams are more efficient at cooling space

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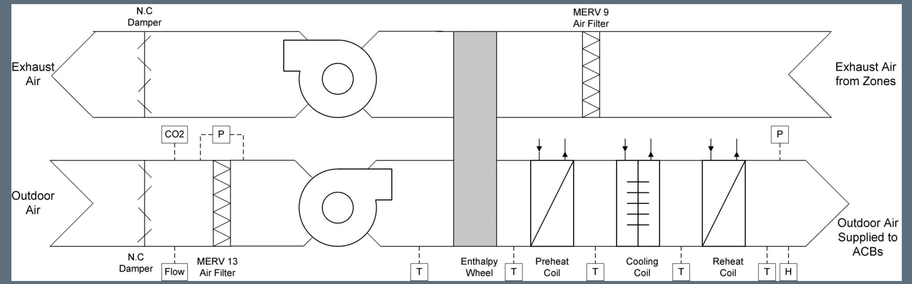
➢ **Remove 25 VAV AHUs and replace with 12 DOAS units and 7 new VAV units**
- **12 DOAS units for office, courtroom, hearing spaces, etc.**
- **7 VAV units for storage, restrooms, corridors, etc.**



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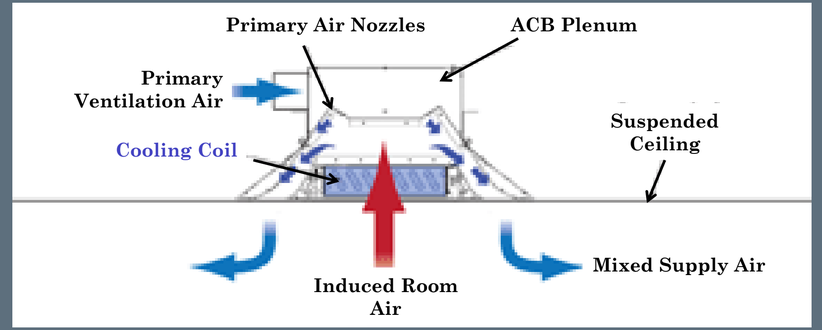
➢Zones served by DOAS units are equipped with Active Chilled Beams
➢Minimal Ceiling Space Requirements



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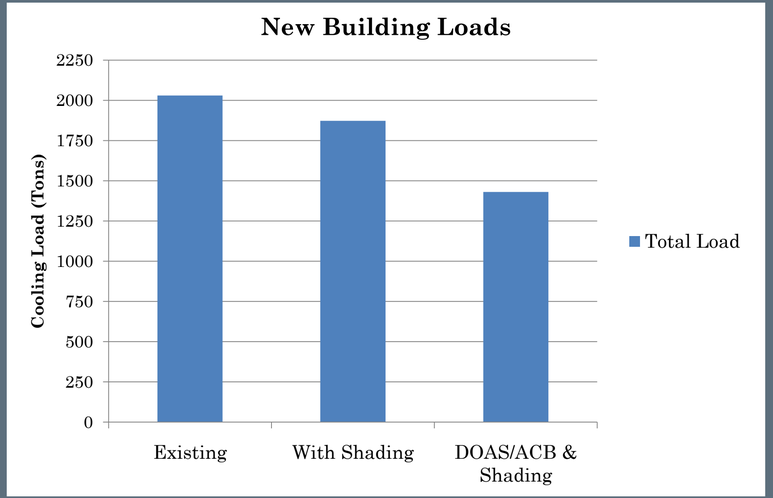
New Building Loads

Total Cooling Load	Ventilation Load	Total Cooling Supply Air	Ventilation Supply Air
(Tons)	(Tons)	(CFM)	(CFM)
1,431	322	208,986	127,526



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➢**Total energy use reduced by 17,054 MMBTU**

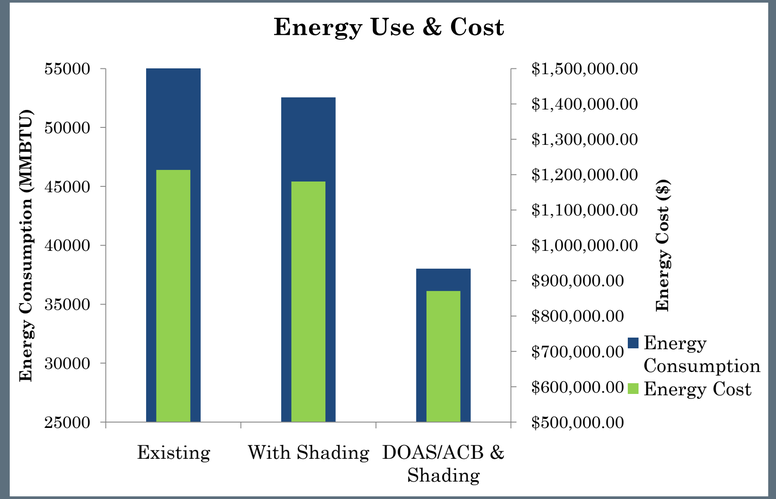
Energy Use Summary

Electric		Natural Gas		Chilled Water		Total
Consumption (kWh)	Peak Demand (kW)	Consumption (MCF)	Peak Demand (MCF/hr)	Consumption (kGal)	Peak Demand (Gal/hr)	Consumption (MMBTU)
4,262,701	1,283	1,219	4.0	206	159	38,027

➢**Total energy cost reduced by $342,422.28**

Energy Cost Summary

Electric			Natural Gas	Chilled Water	Total
Consumption	Demand	Total	Consumption	Consumption	Consumption
$426,270.10	$140,820.00	$567,080.10	$10,427.46	$293,382.14	$870,899.70



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Initial Cost: $5,128,882
Annual Savings: $342,422
Simple Payback: 15 Years
20 Year LCC: $17,880,987

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    - Column Savings
    - Façade Savings
    - Updated DOAS/ACB Economics
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➢DOAS/ACB system conversion frees up space in large plenums

➢Allows plenum spaces to be reduced in height, therefore reducing overall floor-to-floor height

➢Analyzed for a 4 foot reduction in plenum height for each floor

➢Equates to a total building height reduction of 28 feet

➢Analyzed material and schedule savings for structural columns and façade materials.

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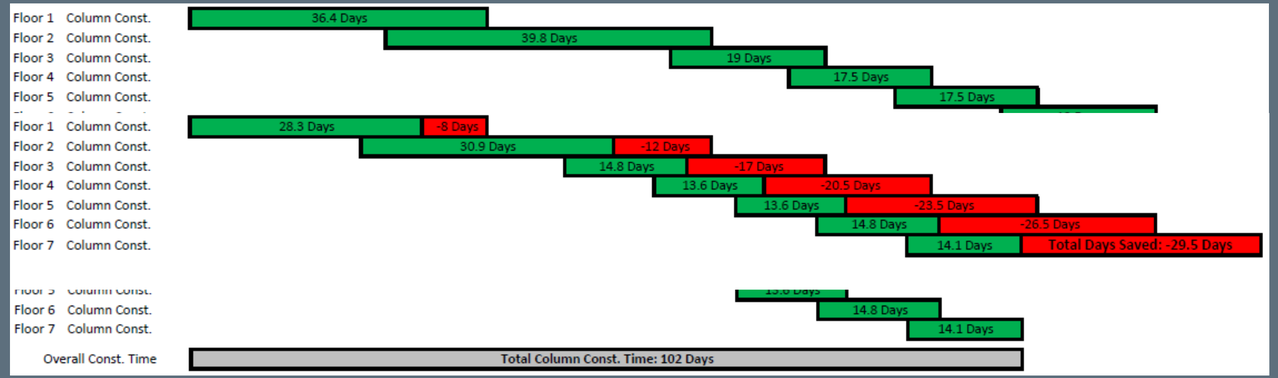
Cast-in-Place Concrete Columns

Total Concrete Saved: 666 Cubic Yards
Total Column Cost Reduction: $849,150.00

Construction Time Saved: 29.5 Days



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Precast Concrete Architectural Panels

Total Panel Façade Saved: 31,330 Square Feet
Total Panel Cost Reduction: $1,366,298.51

Façade Glazing

Total Glazing Façade Saved: 23,635 Square Feet
Total Glazing Cost Reduction: $2,138,955.19

Total Construction Time Saved: 81 Days

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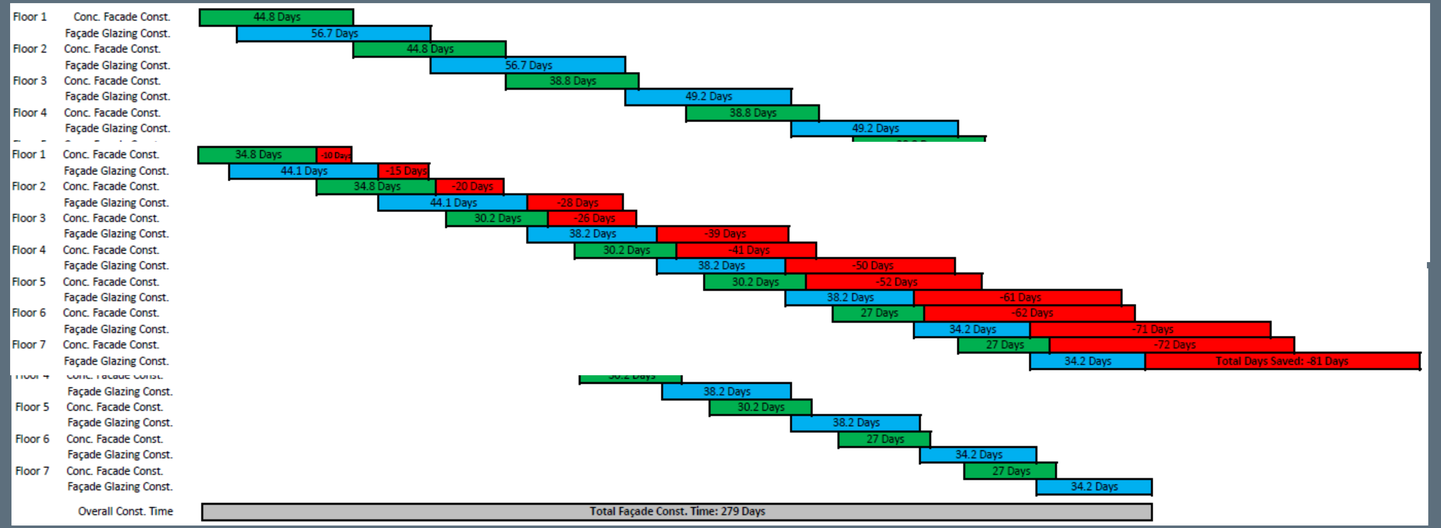

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Total Cost Reduction: $4,354,403

New DOAS/ACB Initial Cost: $774,478
New Simple Payback: 2.3 Years
New 20 Year LCC: $13,526,583

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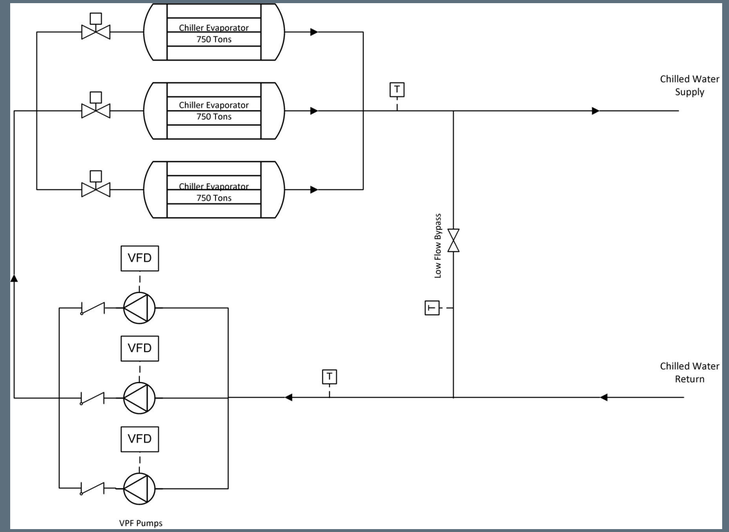
    - Energy Consumption Results
    - Economics
- Conclusion

➢Variable Primary Flow Parallel Chiller Plant

➢Three 750 ton two-stage centrifugal chillers
➢Three 750 ton VFD controlled cooling towers
➢Three 150 HP Variable Flow chilled water pumps

➢Advantages of VPF system over primary/secondary
- ▪Lower First Cost
- ▪Lower energy and operating costs
- ▪Better chiller optimization
- ▪Less operation of chiller auxiliary equipment



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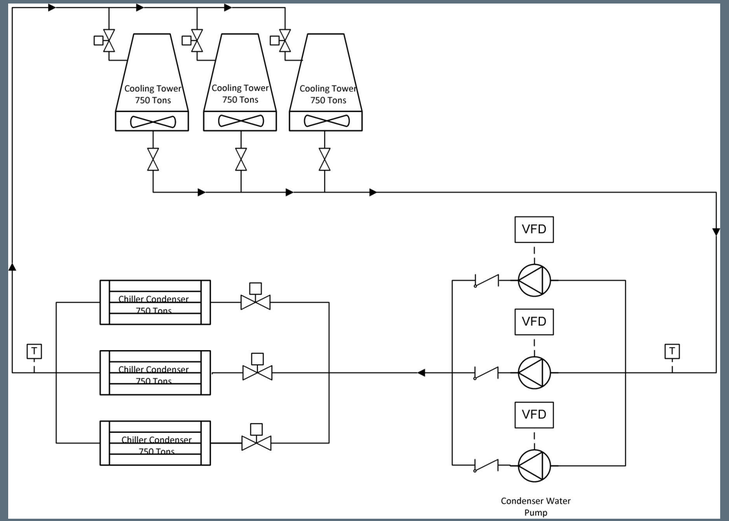
- ▪Better chiller optimization
- ▪Less operation of chiller auxiliary equipment



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    - *Energy Consumption Results*
    - Economics
- Conclusion

➢Total energy use reduced by 32,958 MMBTU

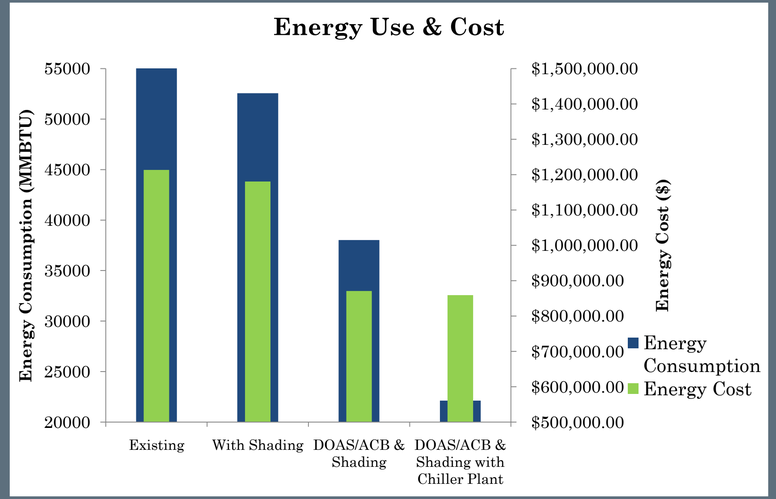
Energy Use Summary

Electric		Natural Gas		Total
Consumption (kWh)	Peak Demand (kW)	Consumption (MCF)	Peak Demand (MCF/hr)	Consumption (MMBTU)
6,115,746	2,363	1,219	4.0	22,123

➢Total energy cost reduced by $354,001.56

Energy Cost Summary

Electric			Natural Gas	Chilled Water	Total
Consumption	Demand	Total	Consumption	Consumption	Consumption
$611,574.56	$226,460.00	$838,034.56	$10,427.46	$293,382.14	$859,320.34



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Initial Plant Cost: $1,867,550
Additional DOAS/ACB Cost: $5,003,482
Total Savings: $354,001
Simple Payback: 19 Years
20 Year LCC: $19,766,007

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With Construction Cost Reduction

New DOAS/ACB & Chiller Plant Initial Cost: $2,516,628
New Simple Payback: 7.1 Years
New 20 Year LCC: $15,411,603

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Initial Cost Comparison

Alternative	Initial Cost	Rating
Existing VAV System	$2,608,539	3
Existing VAV System with Internal Shading	$3,762,944	4
DOAS/ACB with Internal Shading	$5,128,882	5
DOAS/ACB with Internal Shading and Height Reduction	$774,478	1
Chiller Plant with DOAS/ACB with Internal Shading	$6,871,032	6
Chiller Plant with DOAS/ACB with Internal Shading and Height Reduction	$2,516,628	2

LCC Comparison

Alternative	LCC	Rating
Existing VAV System	$20,575,135	5
Existing VAV System with Internal Shading	$21,244,274	6
DOAS/ACB with Internal Shading	$17,880,987	3
DOAS/ACB with Internal Shading and Height Reduction	$13,526,583	1
Chiller Plant with DOAS/ACB with Internal Shading	$19,766,007	4
Chiller Plant with DOAS/ACB with Internal Shading and Height Reduction	$15,411,603	2

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Energy Use Comparison

Alternative	Energy Use (MMBTU)	Rating
Existing VAV System	55,081	4
Existing VAV System with Internal Shading	52,552	3
DOAS/ACB with Internal Shading	38,027	2
DOAS/ACB with Internal Shading and Height Reduction	-	-
Chiller Plant with DOAS/ACB with Internal Shading	22,123	1
Chiller Plant with DOAS/ACB with Internal Shading and Height Reduction	-	-

Energy Cost Comparison

Alternative	Energy Cost	Rating
Existing VAV System	$1,213,321.98	4
Existing VAV System with Internal Shading	$1,180,381.33	3
DOAS/ACB with Internal Shading	$870,899.70	2
DOAS/ACB with Internal Shading and Height Reduction	-	-
Chiller Plant with DOAS/ACB with Internal Shading	$859,320.34	1
Chiller Plant with DOAS/ACB with Internal Shading and Height Reduction	-	-

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Simple Payback Comparison

Alternative	SPB	Rating
Existing VAV System	-	-
Existing VAV System with Internal Shading	35	5
DOAS/ACB with Internal Shading	15	3
DOAS/ACB with Internal Shading and Height Reduction	2.3	1
Chiller Plant with DOAS/ACB with Internal Shading	19	4
Chiller Plant with DOAS/ACB with Internal Shading and Height Reduction	7.1	2

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Emissions Comparison

Alternative	Emissions ($lb_m CO_{2e}$)	Rating
Existing VAV System	13,294,874.11	4
Existing VAV System with Internal Shading	13,062,795.68	3
DOAS/ACB with Internal Shading	10,111,410.78	1
DOAS/ACB with Internal Shading and Height Reduction	-	-
Chiller Plant with DOAS/ACB with Internal Shading	10,791,278.39	2
Chiller Plant with DOAS/ACB with Internal Shading and Height Reduction	-	-

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LEED Comparison

Alternative	LEED Credits	Rating
Existing VAV System	32	4
Existing VAV System with Internal Shading	33	3
DOAS/ACB with Internal Shading	39	1
DOAS/ACB with Internal Shading and Height Reduction	-	-
Chiller Plant with DOAS/ACB with Internal Shading	39	1
Chiller Plant with DOAS/ACB with Internal Shading and Height Reduction	-	-

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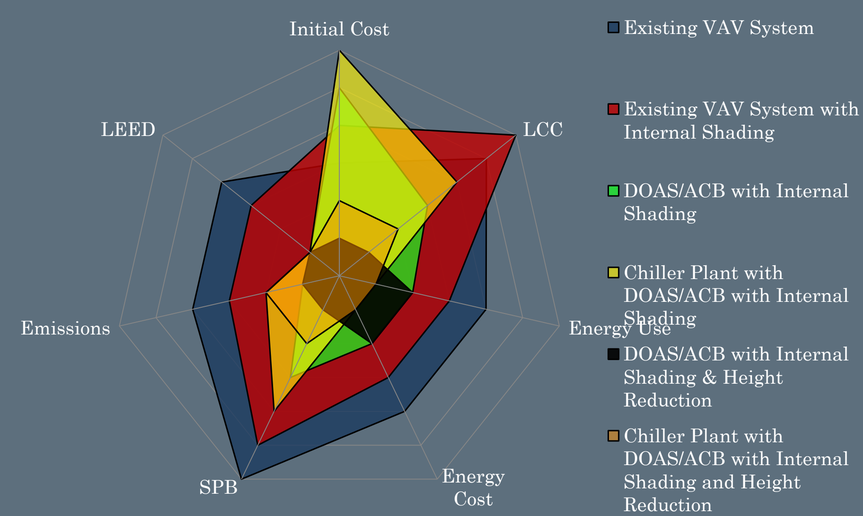
System Selection Scoring

Alternative	Average Score	**Rating**
Existing VAV System	4.000	**6**
Existing VAV System with Internal Shading	3.857	**5**
DOAS/ACB with Internal Shading	2.428	**3**
DOAS/ACB with Internal Shading and Height Reduction	1.000	**1**
Chiller Plant with DOAS/ACB with Internal Shading	2.714	**4**
Chiller Plant with DOAS/ACB with Internal Shading and Height Reduction	2.000	**2**



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Questions?