Energy Demand Reduction for FSU's Central Utility Plant

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Team 521 Introductions

Juan Villalobos
Energy Auditor

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Mira Meyers
Quality Control Engineer

Keaton Zargham
Data Analyst

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Project Manager

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Solutions Advisor, LEED AP, CEM, CDSM

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Academic Advisor
Dr. Juan Ordonez, Ph.D.
Professor of Thermodynamic Optimization for Advanced Energy Systems

Juan Villalobos

Objective

To research, study, evaluate, and propose a project that reduces FSU Facility's Electric Utility bill by reducing peak demand and/or the overall electric consumption to generate a financial payback to FSU.

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FSU Energy Overview

Average Monthly Energy Usage (2019):

- Consumption (kWh). **13,500,000**
- Demand (kW). **24,500**

Electric Utility Rate Structure (2019):

- Consumption ($/kWh). **0.049**
- Demand ($/kW). **11.32**

Average Monthly Energy Bill (2019):

- Consumption ($). **660,000**
- Demand ($). **280,000**

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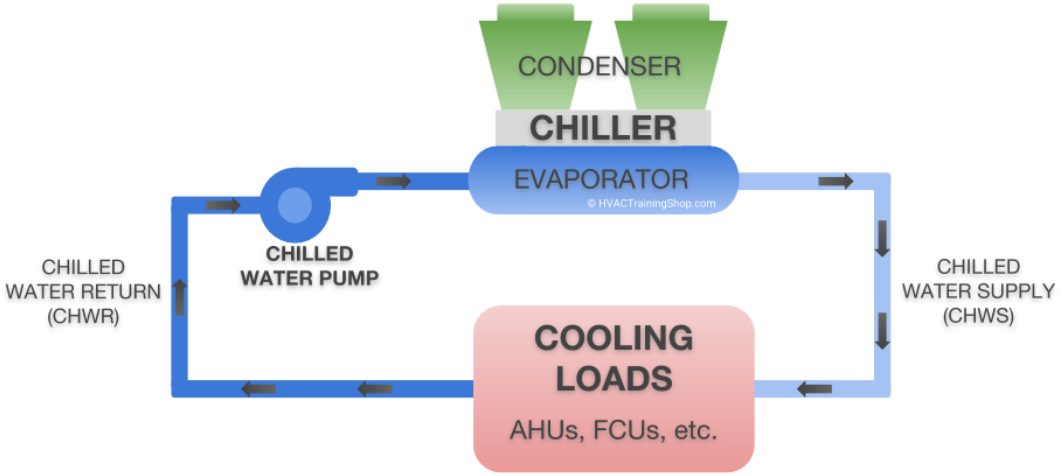
HVAC System

- Over **50%** of energy spend is from heating, ventilation, and cooling systems on campus
- FSU relies on **21** chillers to cool campus buildings
- Chillers produce cold water that is pumped around campus to air handling units to supply cold air to buildings
- The compressors of the chillers, as well as the fans and pumps consume large amounts of electricity to operate



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HVAC System

- Capacity of AC units are measured in Tons
- The **6** chillers in the Central Utility Plant are **1,200** tons each
- Typical load on the CUP during a hot summer day is between **2,990** and **4,660** tons
- Current operating efficiency of the CUP is **0.69 [kW/ton]**

Calculating Demand Charge

- 4,660 [tons] * 0.69 [kW/ton] **=** 3,215 [kW] * 11.32 [$/kW] **= $36,400**

Calculating Consumption Charge

- 3,850 [avg tons] * 0.69 [kW/ton] * 720 [hours] **=** 1,900,000 [kWh] * 0.049 [$/kWh] **= $93,700**

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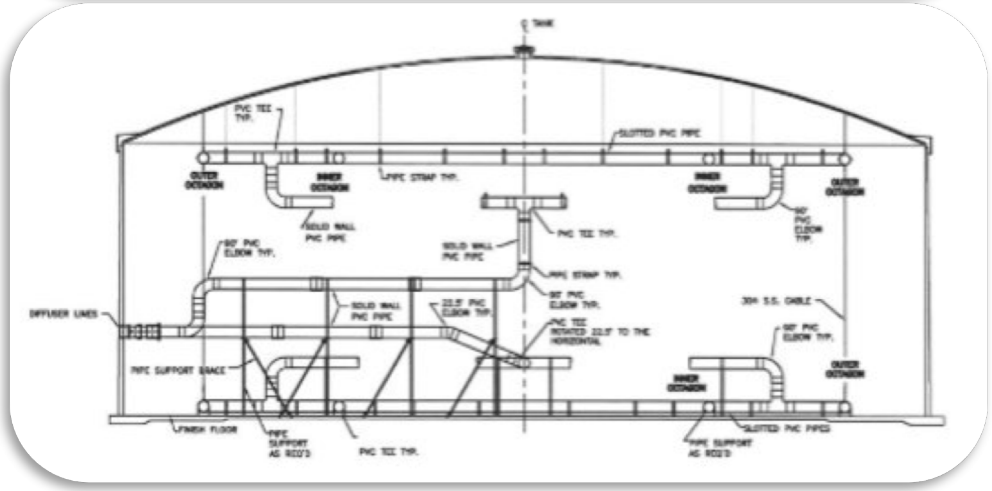
Demand Reduction Solution

- Reduces energy costs by lowering the peak electric demand during the day
- Reduces energy consumption by shifting operation time to nighttime which improves efficiency of chillers
- Allows the campus to keep up with increasing cooling loads without adding a new chiller
- Provides additional redundancy for the campus in case of an equipment failure

Thermal Energy Storage (TES) Tank



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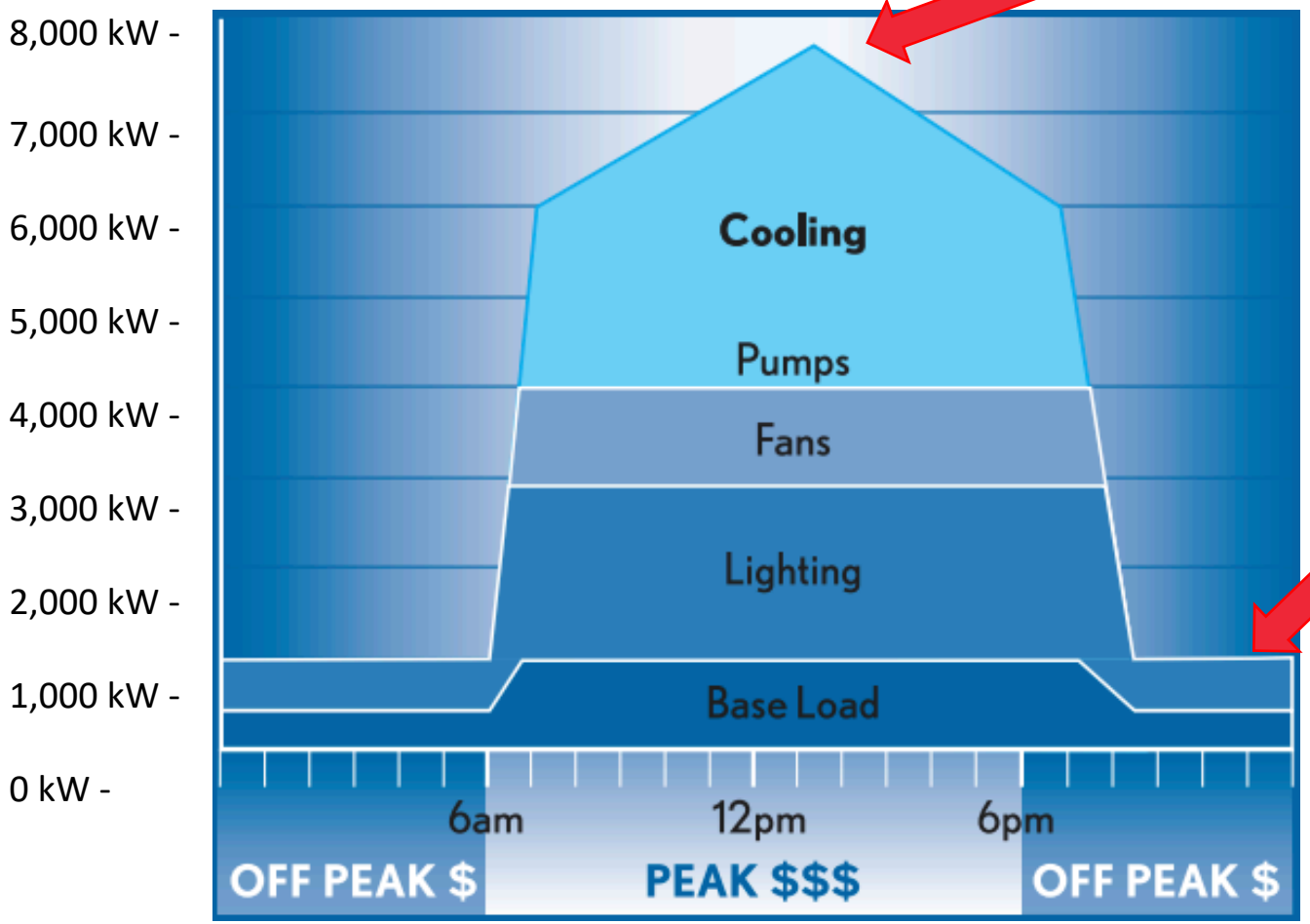
Thermal Energy Storage Tanks

Current Peak Demand = 7,500 kW = **$85,000**

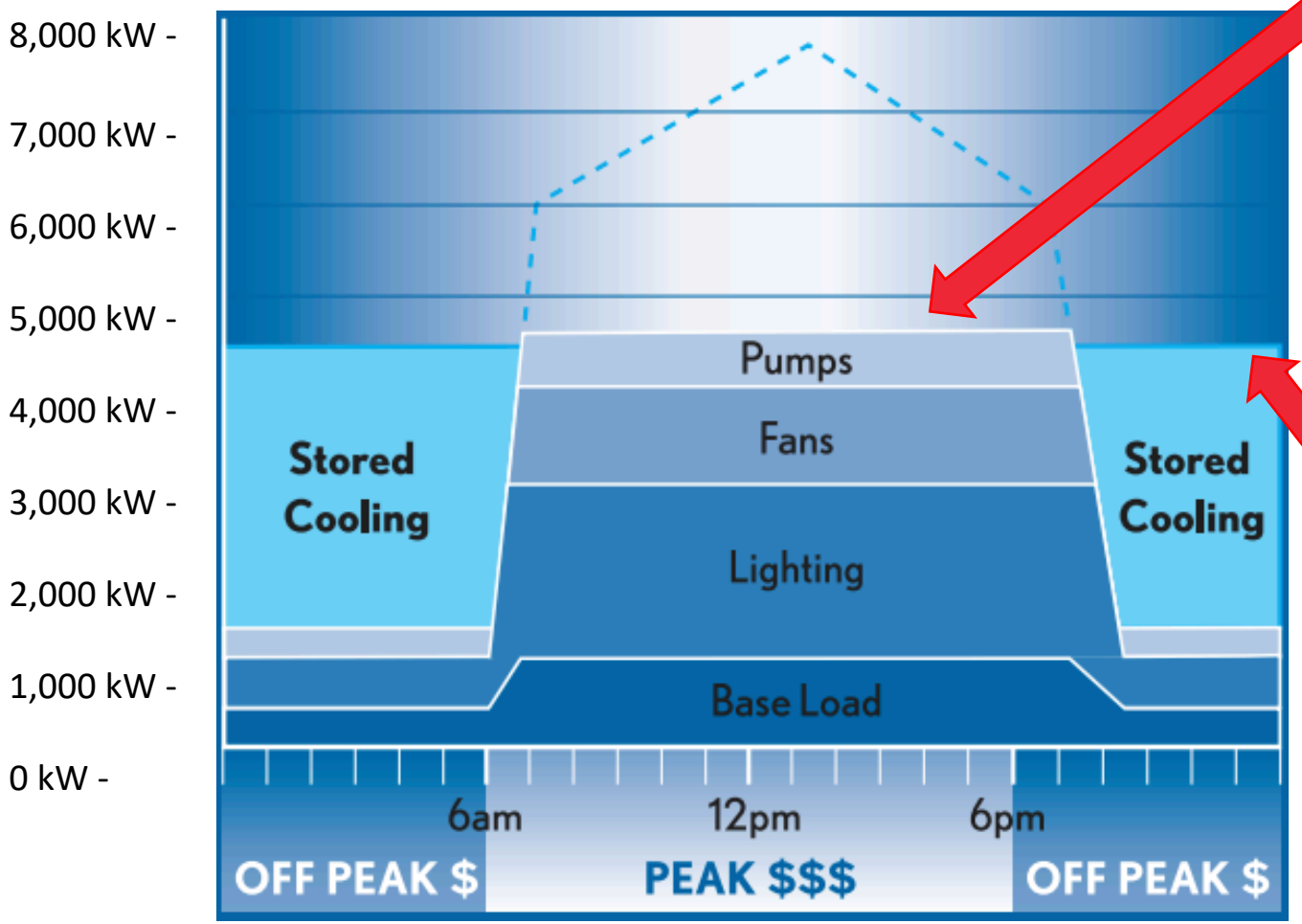


Difference of 6,500 kW between Peak and Off-Peak Energy Demand

Alec Schoengrund

Thermal Energy Storage Tanks

Reduced Peak Demand = 4,500 kW = **$51,000**

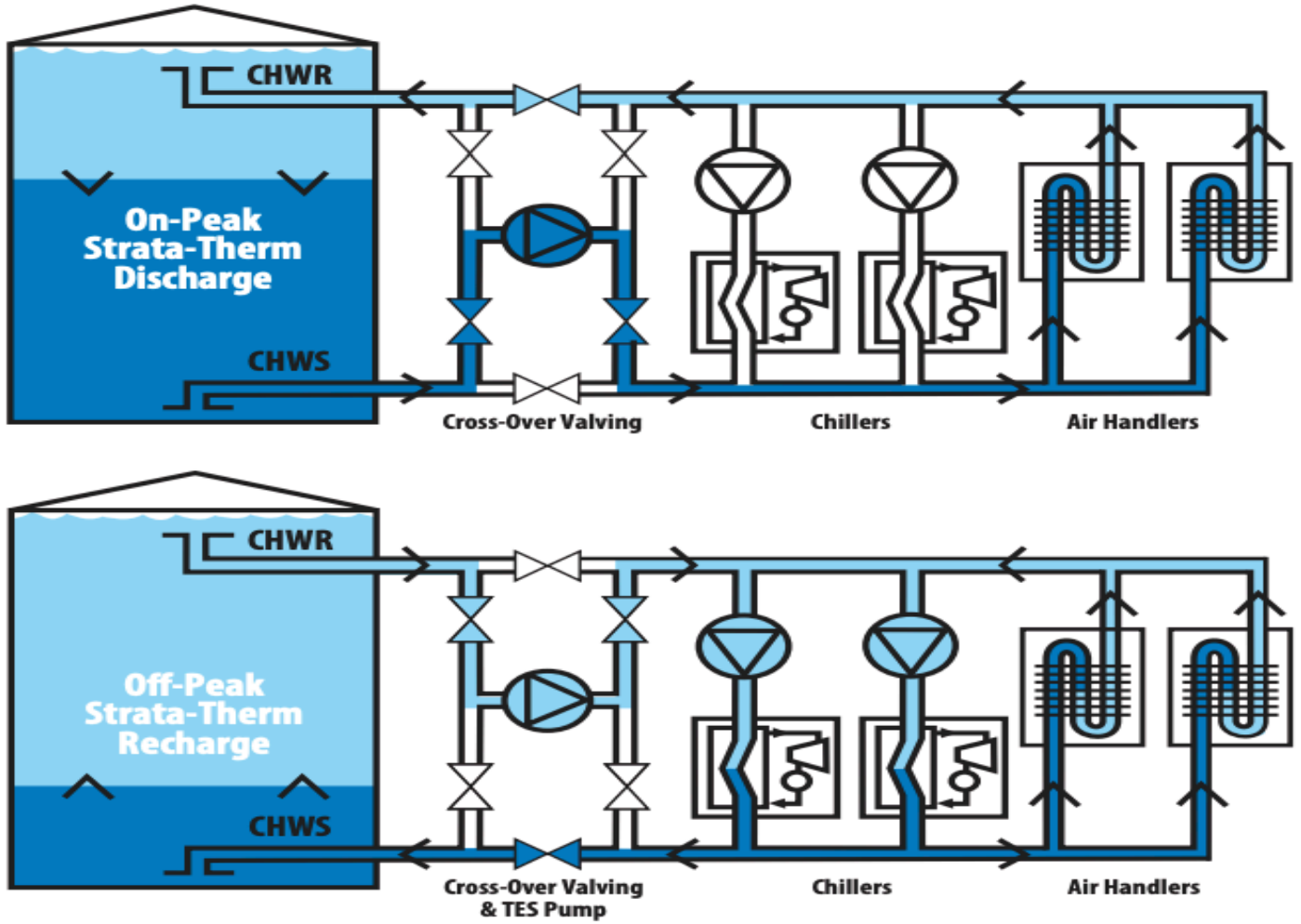


$34,000 monthly savings

Difference of 500 kW between Peak and Off-Peak Energy Demand

Alec Schoengrund

Thermal Energy Storage Tanks



Alec Schoengrund

Tank Composition

Stratified TES main structure

- Steel, concrete, and plastic

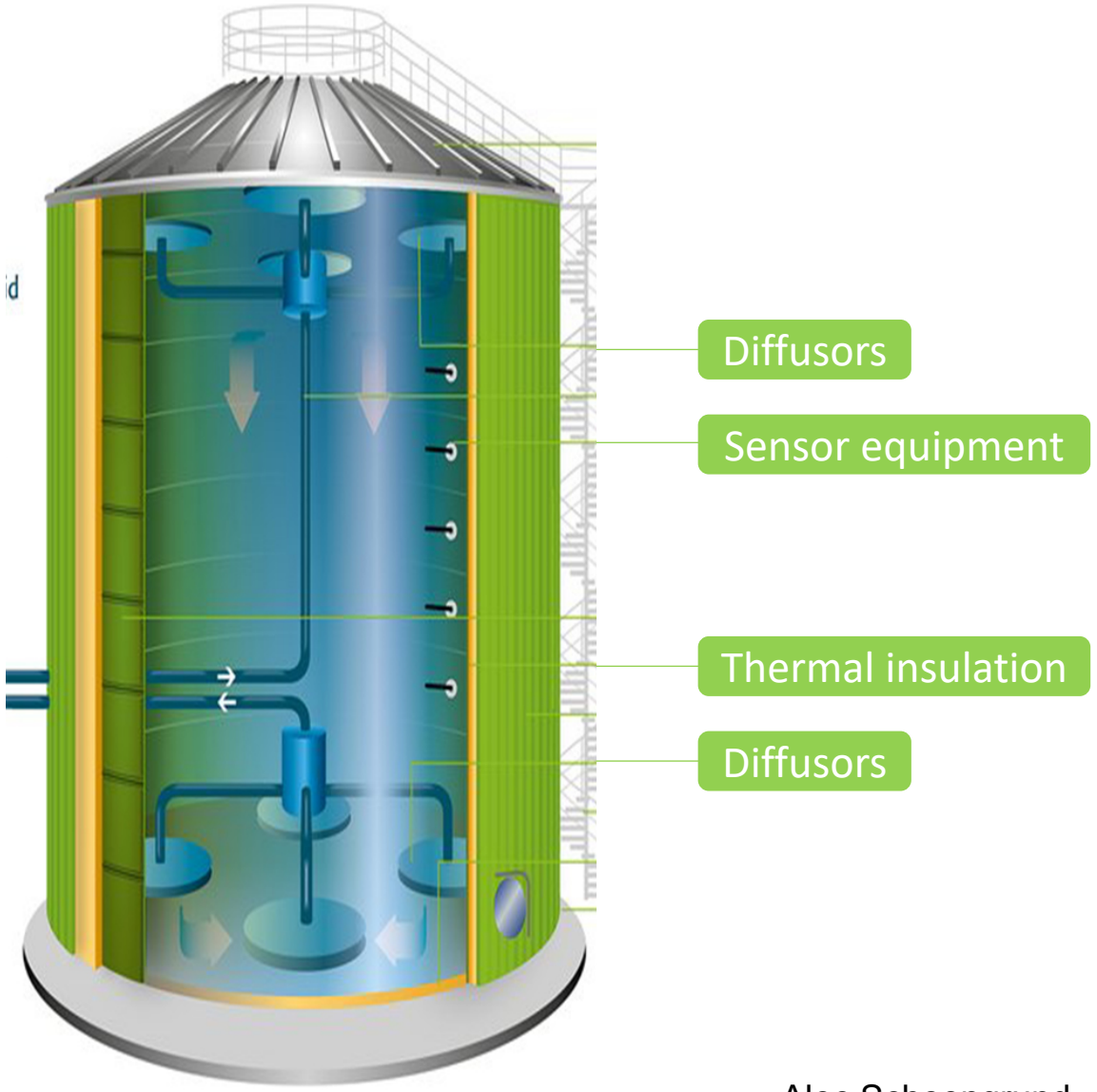
Diffusers

- Warm and chilled water enter and exit the tank through diffusers
- Coated steel piping
- Key to thermocline
- Spreads radially to reduce heat transfer between the hot and cold bodies of water.

Insulation Material

- Polyurethane foam, mineral, wool
- Assists with maintaining temperature

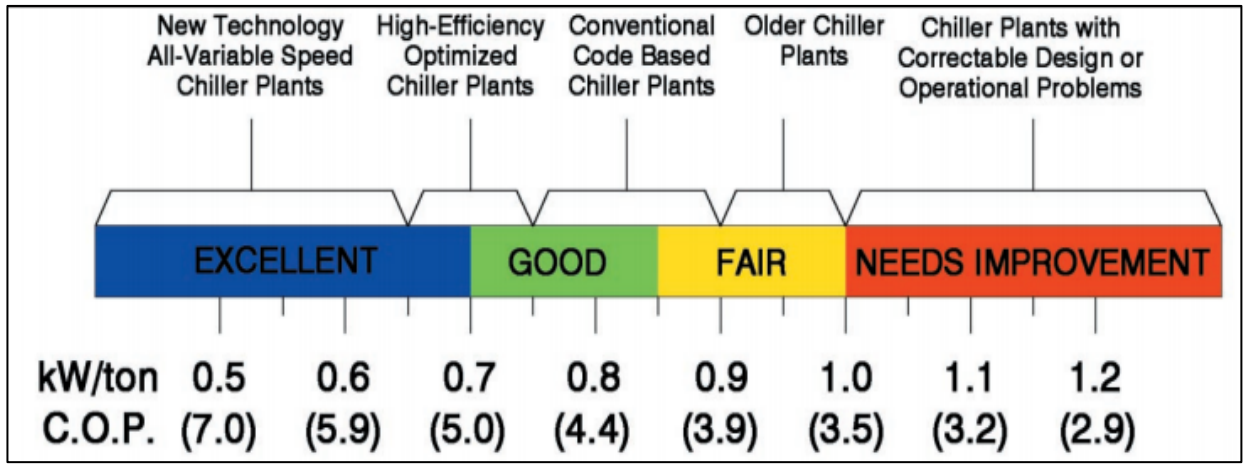
Service life: > 50 years

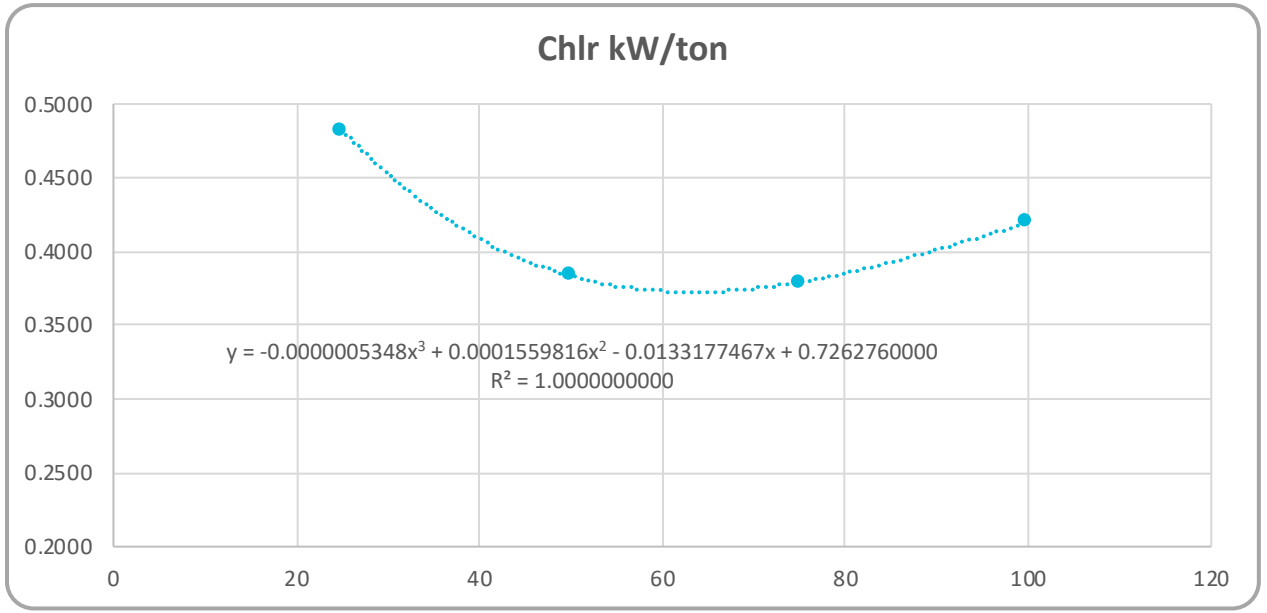


Alec Schoengrund

Tank Efficiency

- Thermal efficiency is 90%
- Dependent on stratification, thermocline, and insulation
- Insulation Methods
  1. Spray on polyurethane foam
  2. Injecting insulation between structural layers
  3. Mineral wool, fiber glass, or ceramic fiber used as external wrap.
- Running the chillers at night when the ambient temperature is lower will improve the Chillers' efficiency

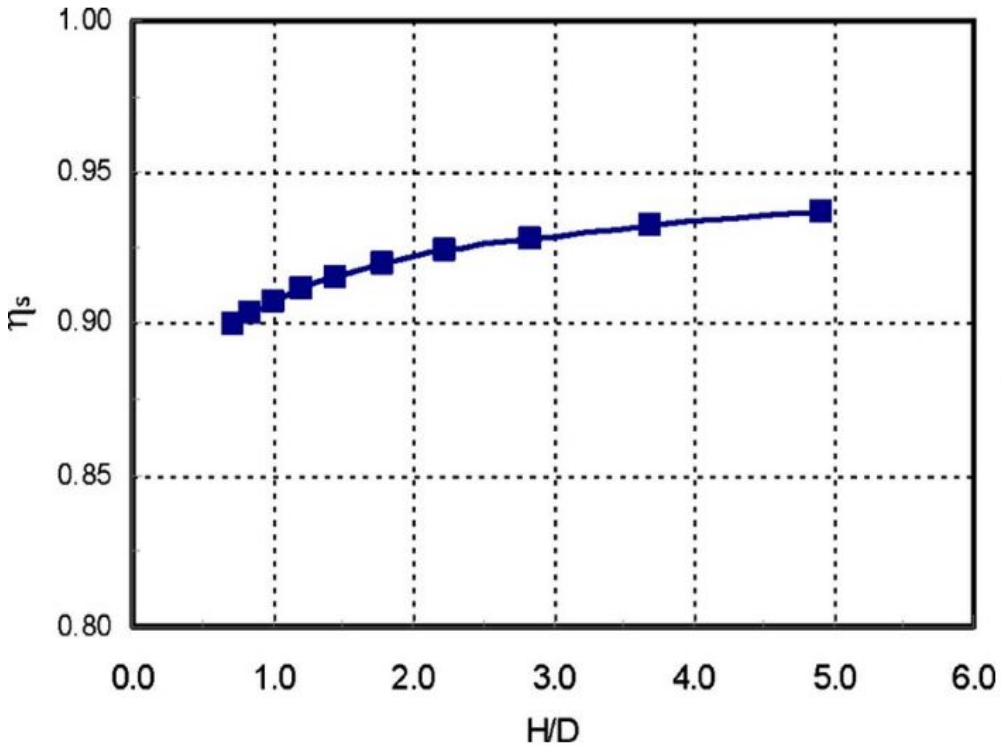




Alec Schoengrund

Tank Sizing

- 7,300 [gpm] flow rate of CUP * 8-hour cycle = 3.5M Gallons required
- Larger height is more efficient
- Environment constrains the diameter more than the height
- 100 ft of available space behind the C.U.P
- Height would have to be 51 feet (a little less than a 4-story building)
- System schematics and energy balance is currently being researched to provide accurate dimensions and validation for the tank.
- Most efficient TES Tank would be 50 ft wide and 250 ft tall
- We will be more practical; our tank will be 100 ft wide and 50 ft tall



Alec Schoengrund

Project Comparison

UCF

- Project Cost: **6,000,000 [$]**
- Tank Size: **3M [gal]**
- Cooling Capacity: **26,200 [ton-hours]**
- Chilled Water Flow Rate: **8,300 [gpm]**
- Peak Electric Load Reduction: **3,000 [kW]**
- Demand Rate: **9.50 [$/kW]**
- On-Peak Consumption Rate: **7.002 [¢/kWh]**
- Off-Peak Consumption Rate: **5.170 [¢/kWh]**
- Annual Savings: **700,000 [$]**
  - Demand Charge Savings: **340,000 [$]**
  - Consumption Charge Savings: **360,000 [$]**

FSU

- Project Cost: **6,470,000 [$]**
- Tank Size: **3.5M [gal]**
- Cooling Capacity: **30,800 [ton-hours]**
- Chilled Water Flow Rate: **7,366 [gpm]**
- Peak Electric Load Reduction: **3,215 [kW]**
- Demand Rate: **11.32 [$/kW]**
- Flat Consumption Rate: **4.9 [¢/kWh]**
- Annual Projected Savings: **400,000 [$]**
  - Demand Charge Savings: **350,000 [$]**

Mira Meyers

Project Logistics

Mira Meyers

Project Financials

- $6.5M Total Project Cost / $400,000 Annual Savings = 16-year ROI
  - Study from Texas A&M supports the team's sizing and assumptions

Tank (M gal)	Annual billing cost savings ($)	Annual cost savings percentage	Annual energy cost savings ($)	Annual demand cost savings ($)	Total elec. consumption reduction (kWh)	Demand reduction (kW)	Annual cooling increase (ton-hr)
1.0	$ 471,298	10.1%	$ 223,536	$ 247,762	2,863,909	2059	6,007,818
2.0	$ 627,097	13.5%	$ 240,909	$ 386,188	2,688,822	3127	6,051,099
3.0	$ 798,285	17.1%	$ 256,078	$ 542,207	2,478,769	4345	6,094,219
3.5	$ 907,231	19.5%	$ 264,109	$ 643,121	2,377,427	5036	6,114,129
4.0	$ 912,437	19.6%	$ 269,598	$ 642,838	2,326,156	5036	6,123,930
5.0	$ 922,487	19.8%	$ 280,153	$ 642,335	2,211,959	5036	6,144,385
6.0	$ 932,876	20.0%	$ 290,422	$ 642,454	2,095,404	5036	6,164,696
7.0	$ 940,319	20.2%	$ 297,746	$ 642,573	2,008,835	5036	6,180,300

Mira Meyers

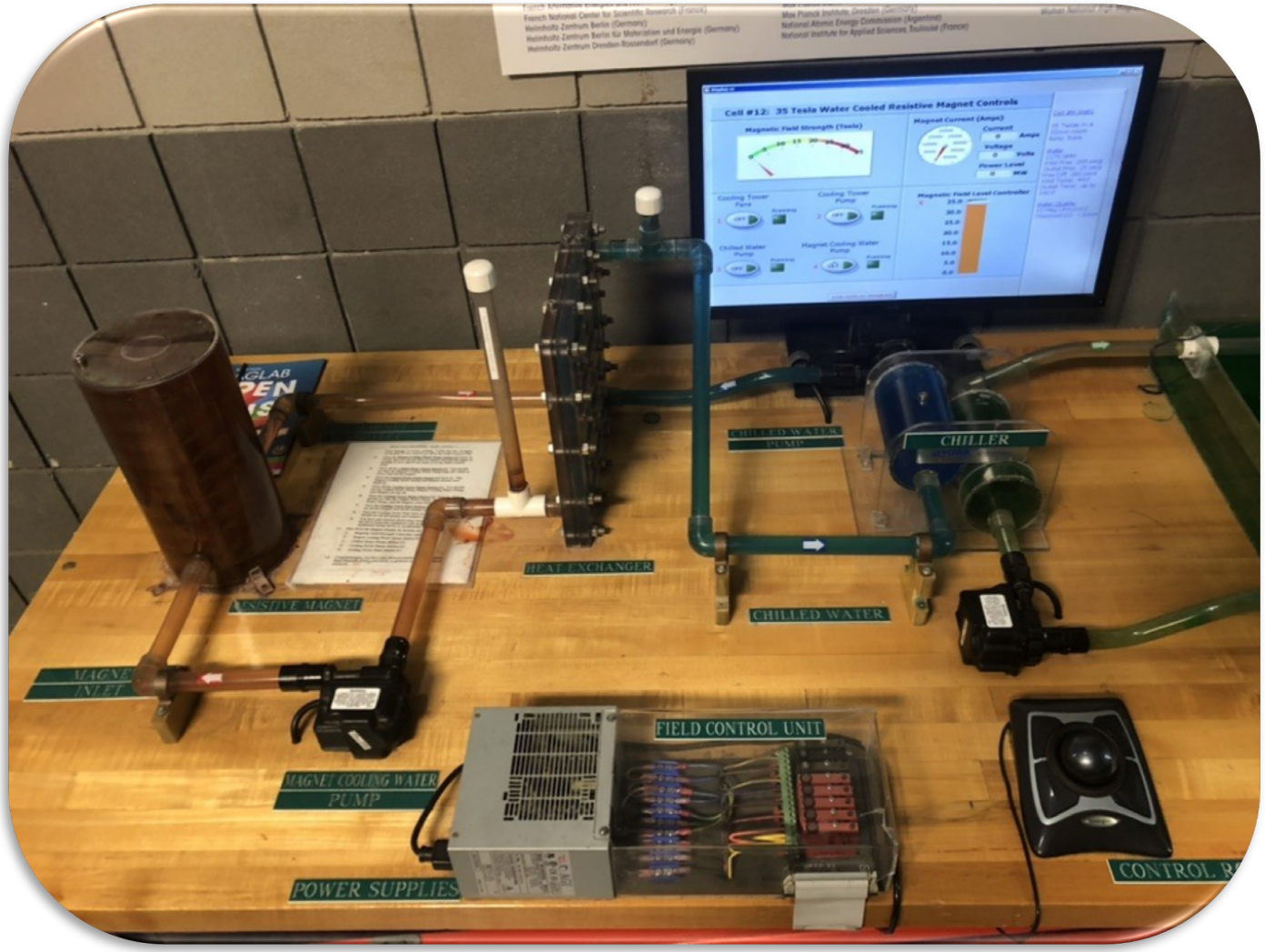
Budget Report

- Budget: $2000
- Spent: $0
- Budget will be used for our Engineering day demonstration
- Projected total cost: $158.00

Product	Quantity	Cost
Arduino	1	$18
Arduino cable	1	$6
8 Channel Relay Module	2	$20
Breadboard Jumper Wires	1	$7
LED Light Strip	1	$20
LCD Counter Displays	4	$40
6-pack of LED Lightbulbs	2	$20
6-pack of E26 Sockets	2	$27

Mira Meyers

Demonstration



- Current system demonstration present at the National High Magnetic Field Laboratory
- The team will attempt to create a demonstration that resembles their system but redesigned to our needs

Mira Meyers

Conclusion

- FSU spends more than 20 million per year on electric utilities (Over 50% is from HVAC)
- Thermal energy storage reduces cost by running chillers at night when electricity is cheaper
- Implementation of tank would cost $6.5M and provide an annual savings of $400,000 with an ROI of 16 years
- UCF is currently working towards a 2nd TES Tank project because of the success they have had with 1st Tank

Mira Meyers

Questions?

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