The Try Street Terminal Building

620 Second Avenue
Pittsburgh, PA

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Architectural Engineering
Mechanical Option

Senior Thesis 2007

Try Street Terminal Building
Renovation Project
Art Institute of Pittsburgh (AIP)

- Presentation Outline
  - Building Introduction
  - Mechanical Analysis
  - CFD Model
  - IAQ Study
  - Conclusion

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Building History

- Existing industrial warehouse
- Originally constructed in 1910
- 230,000 SF with 20,500 SF building footprint
- 9 stories above ground

Second Avenue

First Avenue

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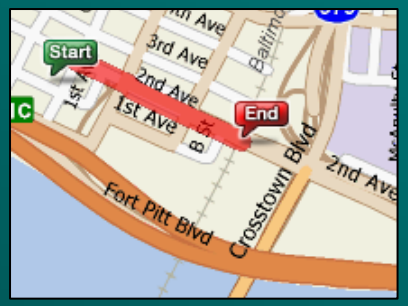
Renovations

- *Reasons*
  - AIP degree program change
  - Relocation of AIP campus
- *Benefits*
  - Meet housing needs of AIP
  - Closer to campus
  - Restores older building
  - Brings younger people back to city



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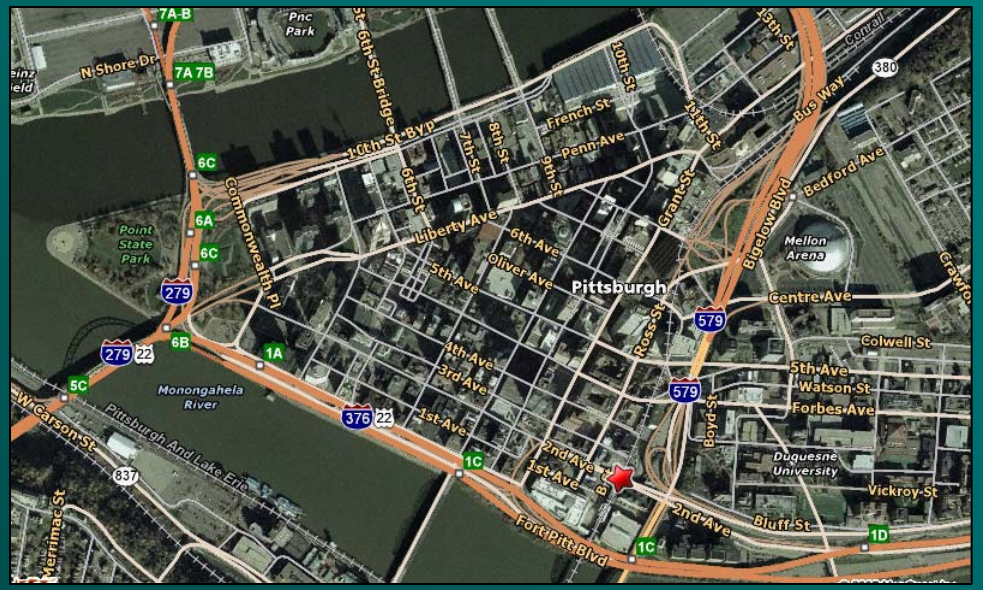
Building Site

- *Downtown Pgh – between 1st & 2nd Ave.*
- *Surroundings/Neighbors*
  - AIP campus
  - PNC Bank Data Center
  - Station Square & Southside
  - Public transportation
  - Public Parking Authority's First Side Garage



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Project Team

- Architect: TKA Architects
- General Contractor: Massaro Corporation
- Mechanical Engineer: McKamish
- Electrical Engineer: Star Electric Company
- Structural Engineer: The Kachelle Group
- Plumbing Engineer: Sauer, Inc.
- Fire Protection: Ruthrauff, Inc

Construction Dates

- October 2005 – June 2007

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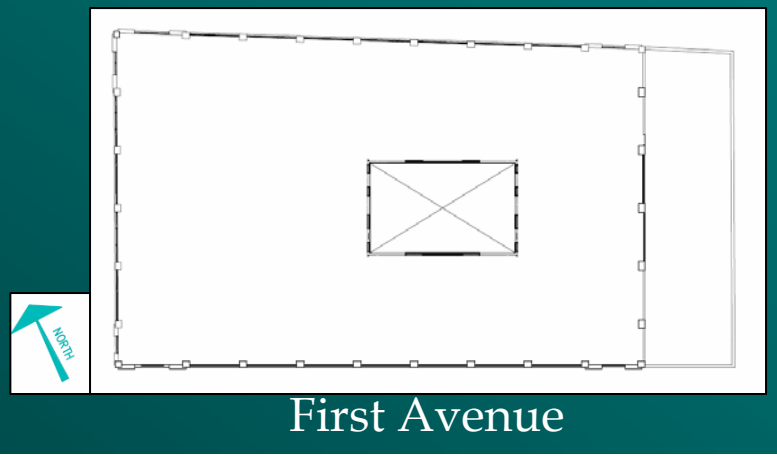
Features & Functions

- *New Architectural Features*
  - Façade Restoration – Historic Landmark
  - Mezzanine level between floors 1 & 2
  - 2-story atrium
  - Lightwell in core of building (floors 2-9)
- *Building Functions*
  - 650 Residents in 140 Apartments
  - 2,750 ft^2 exercise room
  - 9,000 ft^2 of retail space



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Existing Mechanical System

- *Conventional WSHP System*
  - (1) 1 to 3 ton water source heat pump (WSHP) in each apartment
  - (1) 10 ton heat pump serves exercise room
  - 60-90F building loop
  - Cooling – (1) 370 ton closed circuit cooling tower
  - Heating – (2) gas-fired boilers, 1340 MBH ea.

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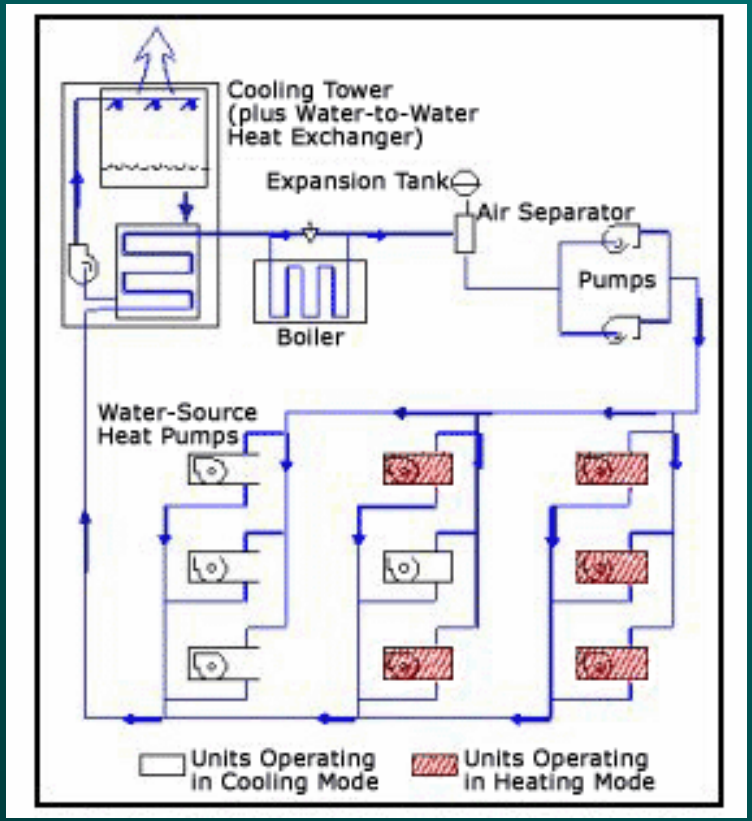
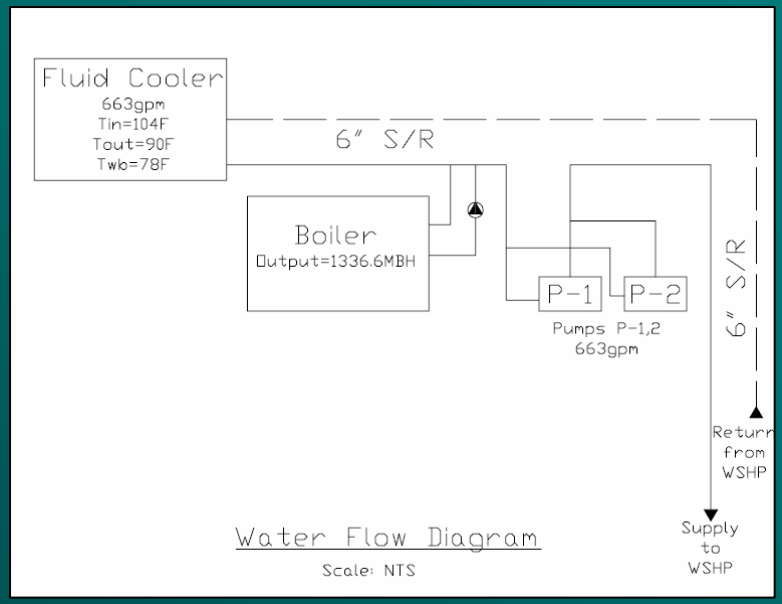
Conventional WSHP





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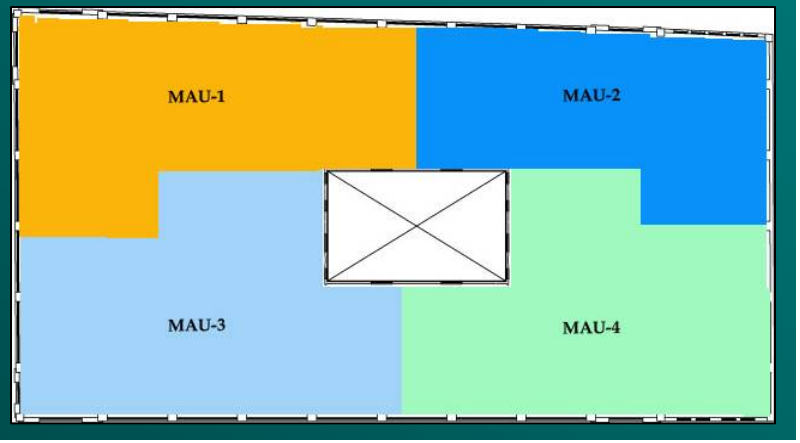
Existing Mechanical System - Airside

- *(4) Make-up Air Units (MAU)*
  - 100% OA rooftop units
  - Provide ventilation for corridors & apartments on floors 1-9
  - 4,620 to 7,550 cfm per unit
  - 122 tons total cooling capacity
  - 2,285 MBH total heating capacity



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Existing Mechanical System - Airside

- *(4) Air Handling Units (AHU)*
  - Indoor self contained, air-cooled vertical package units
  - Supply constant volume cooling of 47 tons
  - Serve basement & 1st floor unassigned spaces
  - 3,000 to 6,000 cfm per unit
  - Electric duct heaters provide 125 kW of heating
- *(1) 10 ton heat pump*
  - Supplies 4,000 cfm OA to exercise room

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Alternative Mechanical Systems

- *Design Focus*
  - Apartments on Floors 1-9
- *Objectives*
  - Implement geothermal system
  - Reduce energy consumption
  - Maintain thermal comfort
  - Reduce maintenance

Geothermal Heat Pumps

- *Benefits*
  - Decrease energy consumption
  - Less O&M compared to conventional
- *Disadvantage*
  - Installation cost
- *Types investigated: closed/open loop*
  - Closed: ground coupled heat pumps (GCHP)
  - Open: ground water heat pumps (GWHP)

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GCHP System

- *Heat exchanged between water in pipes and ground soil*
- *Vertical System*
  - Requires 250 to 300 ft² per ton cooling
- *Horizontal System*
  - Requires 2,500 ft² per ton cooling
- *Closed loop system not selected*
  - Site limitations

GWHP System

- *Open loop – water not confined to loop of pipes*
- *Groundwater – source of cooling*
- *Pumping well – moves groundwater*
- *Possible arrangements*
  - Direct use
  - Standing column
  - Indirect use

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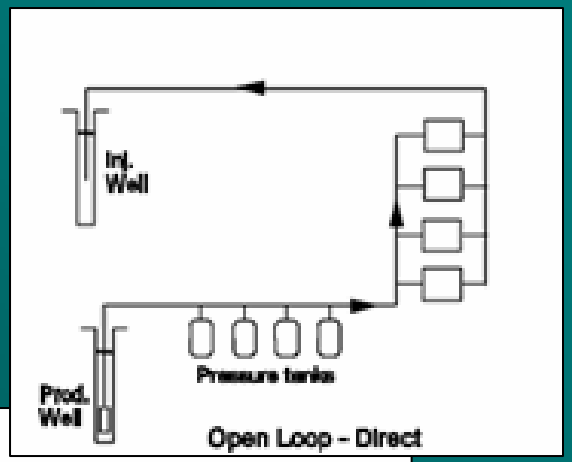
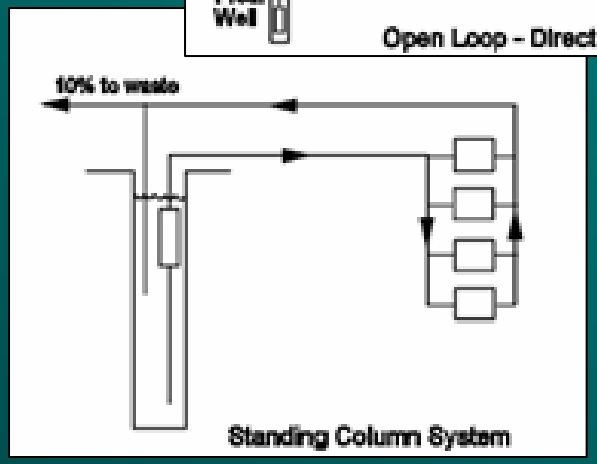
GWHP System

- *Direct-use*
  - Water used directly in heat pump
  - Limited to smallest applications
- *Standing Column*
  - Water used directly
  - Water produced & returned to same well
- *Problems*
  - Scaling of building equipment
  - Size of project





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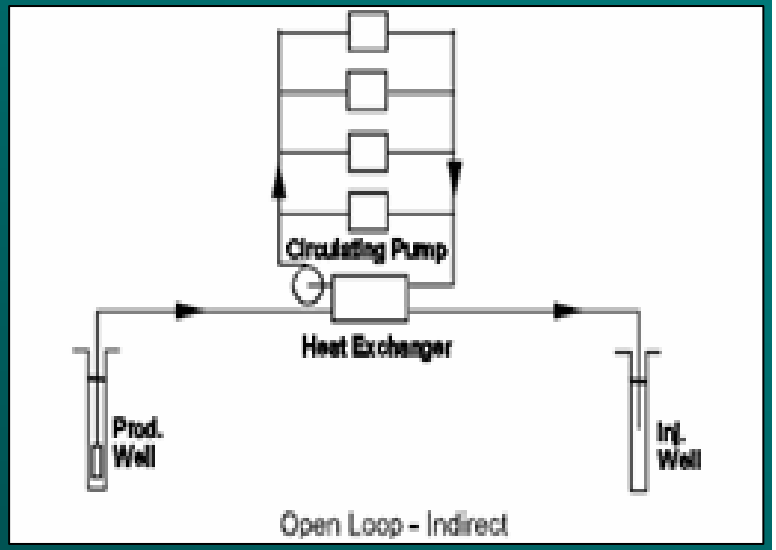
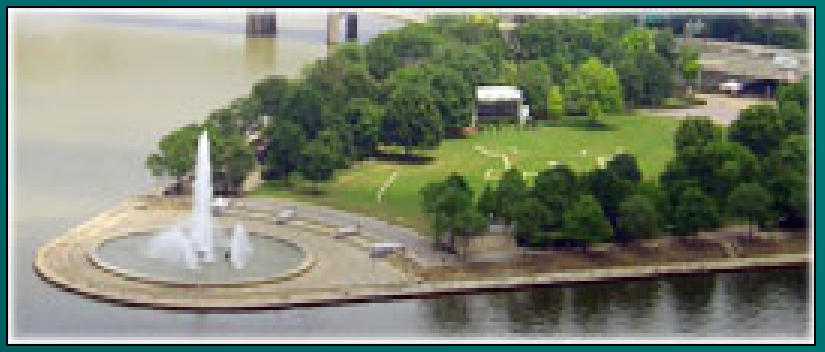
GWHP – Primary Focus

- *Indirect-use*
  - Utilizes plate heat exchanger
  - Isolates building & ground loops
- *Two Well System*
  - Production & Injection Wells
  - National Pollutant Discharge Elimination System (NPDES) permit
- *PA – Class V, no additives*
  - *NPDES permit –not required!*



Groundwater source

- *Underground River*
  - Other names:
    - Wisconsin Glacial Flow
    - Aquifer
  - Constant 55F
  - Fresh, pure drinking source
  - 15 to 50 feet below surface
  - Aquifer construction
    - Like oval tunnel filled with rocks and gravel
    - Sides & bottom - solid rock
    - Top - silt and clay
  - Water source for Point State Park Fountain



Heat Exchanger Sizing

- *Optimum Flow Rates*
  - Building loop: 2 to 3 gpm/ton
  - Groundwater loop: 1 to 2.25 gpm/ton
- *Heat of rejection = 4,200 MBH (controlling case)*
- *Heat of absorption = 1,053 MBH*
- *ARI 325 rating for GWHP*
  - Both EER & COP have 70F & 50F entering water temperature
- *Approach of 3-7F*
- $\Delta T_{groundwater}$ *typ. less than 10F*

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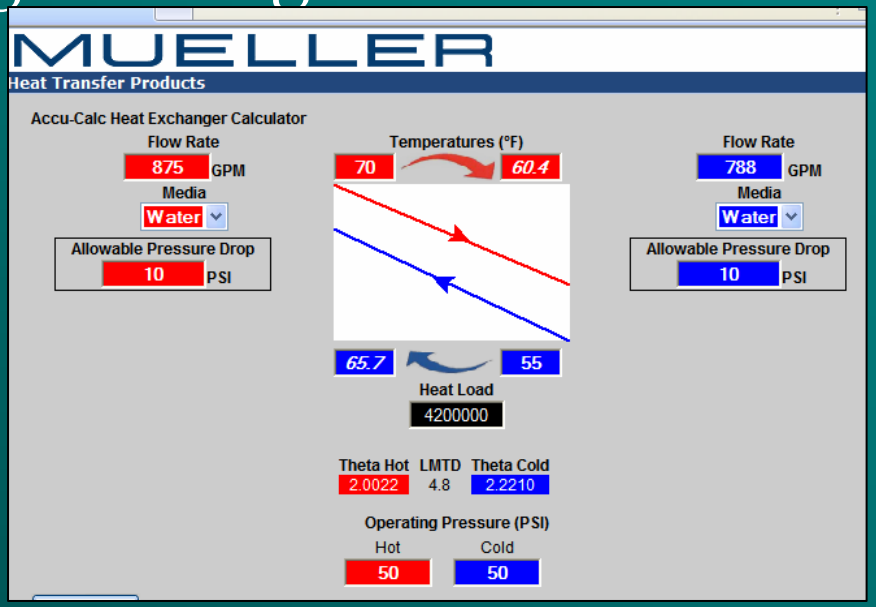
Heat Exchanger Sizing

- *Mueller 60MH model*
  - 286 plates
  - 1904 ft^2 total area
  - 875 gpm – bldg loop
  - 788 gpm – gw loop
  - Approach = 4.8F
  - $\Delta T_{groundwater}$ = 10.7F



- *Convention Center*
  - Approx. 1 mile away
  - Drawdown test – 1100gpm available

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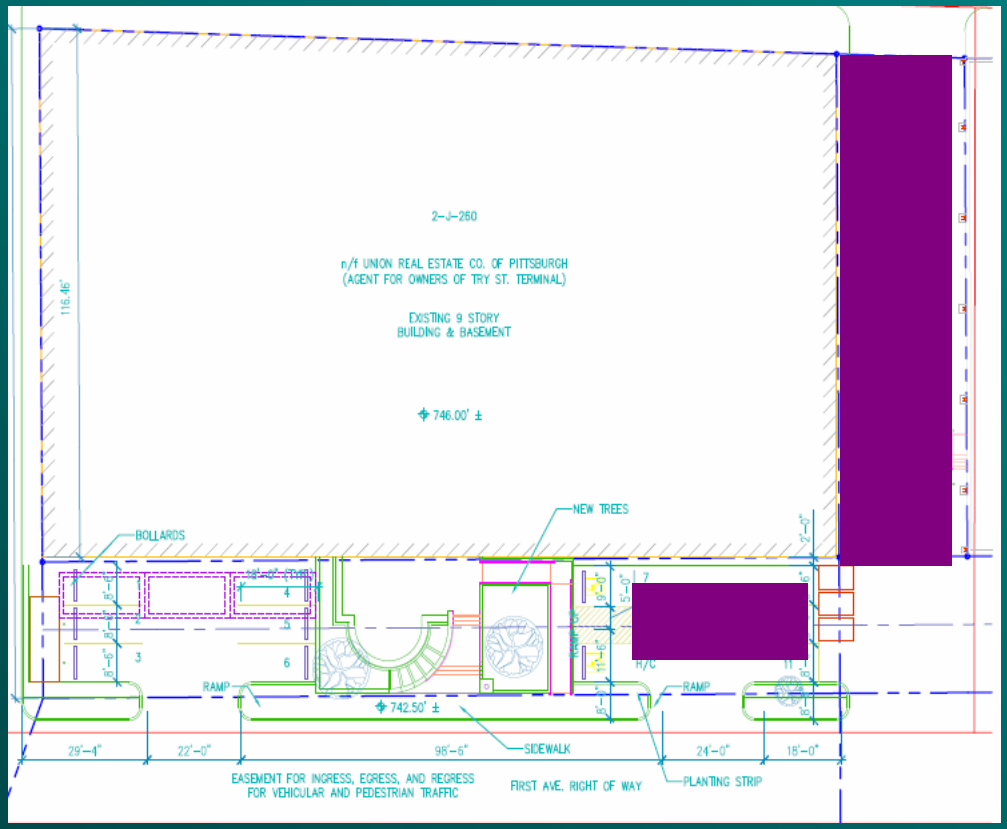
Well Design

- *Well Spacing*
  - Flow from injection to production well doesn't need to be prevented
  - Inter-well flow needs to be sufficiently low
- *~ 4,400 ft² available*
  - 'driveway' & parking
  - RETScreen requires ~2,500 ft²



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GWHP - Energy Analysis

- *HAP model*
  - Direct-use
  - 30% reduction in cooling cmpt. cost
  - Increased pumping cost
- *RETScreen model*
  - Indirect-use
  - Similar heating & cooling loads to HAP
  - Reduced emissions

Annual Compt. Costs	Existing GWHP			Alternative WSHP		
Component	Annual Cost ($)	($/ft²)	Percent of Total (%)	Annual Cost ($)	($/ft²)	Percent of Total (%)
Air System Fans	18,554	0.131	2.2	18,554	0.131	2.3
Cooling	184,884	1.308	21.8	129,843	0.919	16.0
Heating	30,214	0.214	3.6	30,234	0.214	3.7
Pumps	56,924	0.403	6.7	75,128	0.532	9.3
Cooling Tower Fans	3,201	0.023	0.4	0	0.000	0.0
HVAC Sub-Total	**293,777**	**2.079**	**34.6**	**253,758**	**1.796**	**31.4**
Lights	116,317	0.823	13.7	116,317	0.823	14.4
Electric Equipment	439,187	3.108	51.7	439,187	3.108	54.3
Non-HVAC Sub-Total	**555,505**	**3.931**	**65.4**	**555,505**	**3.931**	**68.6**
Grand Total	**849,282**	**6.010**	**100.0**	**809,263**	**5.727**	**100.0**

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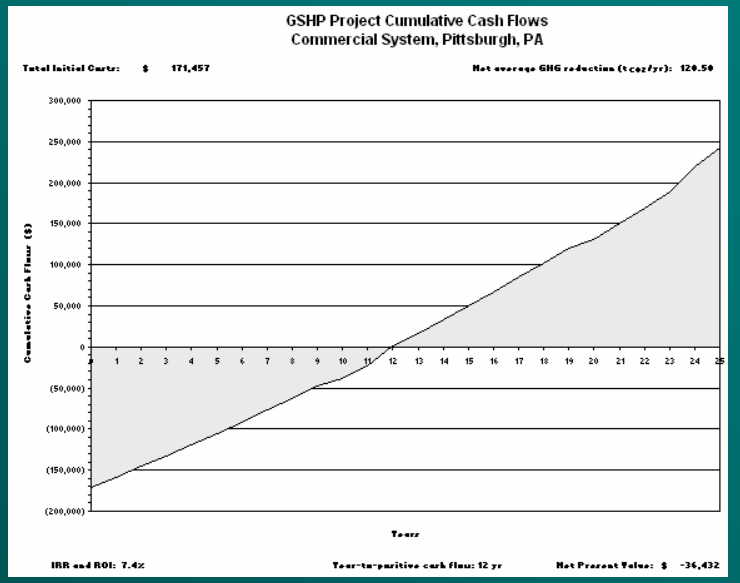
Cost Comparison

- *RETScreen*
  - 12 years-to-positive cash flow
  - AIP – 20 year property commitment
  - Although great initial cost, would recommend system



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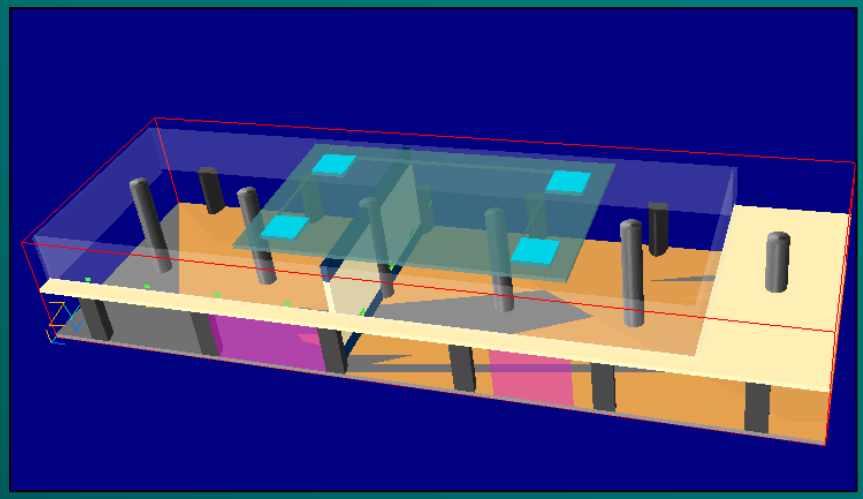
Computational Fluids Model

- *Problem*
  - Air & Temp. distribution in atrium spaces
- *Spaces evaluated*
  - 2-story lobby (1,650 ft^2)
  - 2-story exercise room (1,800 ft^2)
  - Total first floor area of 4,700 ft^2
  - (4) 30 ft^2 skylights
- *Objectives*
  - Use Phoenics VR to generate 3-D model
  - Analyze effectiveness of diffuser placement & supply air flow rate



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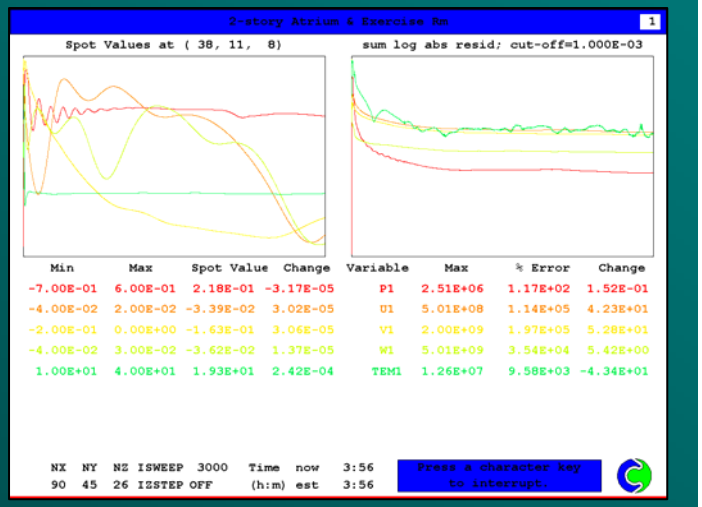
Phoenics VR

- *Model*
  - Blockages – columns, floors, walls, etc.
  - Inlet/Outlet – diffusers/doorways
  - Heat source – flat plate evenly distributed over floor surface (5,000 & 12,000 W)
- *Results after 3,000 iterations*
  - Left convergence monitor
    – not constant
  - Okay for education purposes



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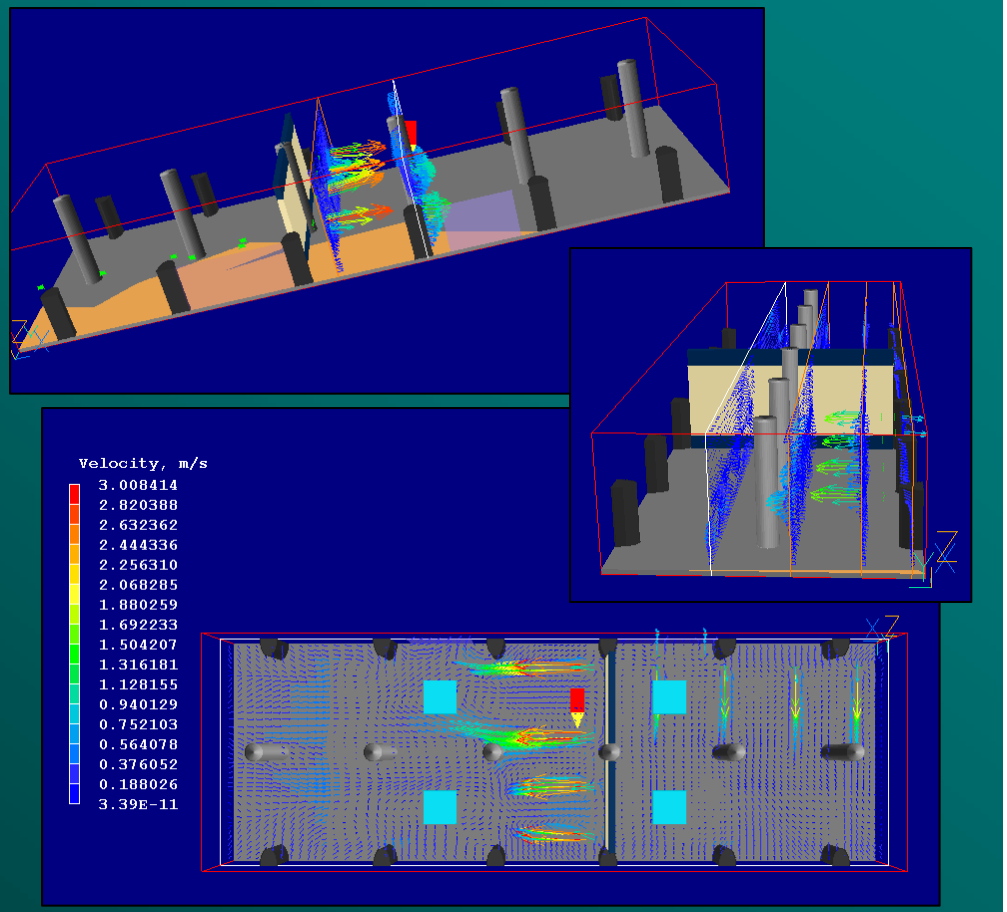
Phoenics Model

- *Velocity Slices*
  - Direction of air flow is correct
  - At occupant level - air flow <= 1 m/s

Air Velocity - Comfort	
m/s	**Occupant Comfort**
0.25	unnoticed
0.25-0.51	pleasant
0.51-1.02	geneally aware of air movement
1.02-1.52	drafty
>1.52	problem



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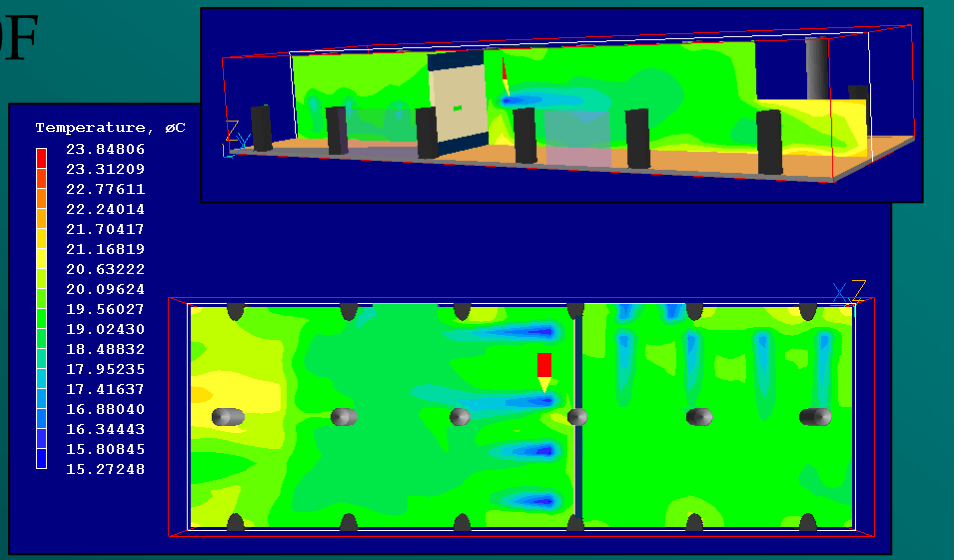
Phoenics Model

- *Temperature Slices*
  - Diffuser stream – 59F
  - At occupant level - 66-70F

Temperature	
C	F
15	59
17	63
19	66
21	70
23	73



- *Diffuser placement & supply flow rates – acceptable!*

Indoor Air Quality Study

- *Objective*
  - Contaminant free apartments (select)
- *Ultraviolet Germicidal Irradiation (UVGI) System*
  - Complicated technology
  - Used for air & surface disinfection
  - Common types: in-duct, in-AHU, upper air distribution, standalone recirculation unit
  - Destroy microbes: bacteria, mold, spores, germs

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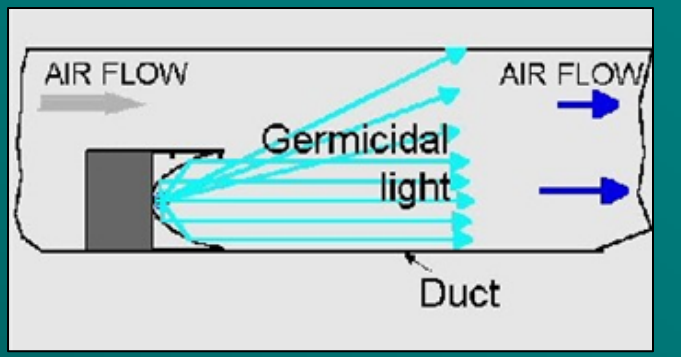
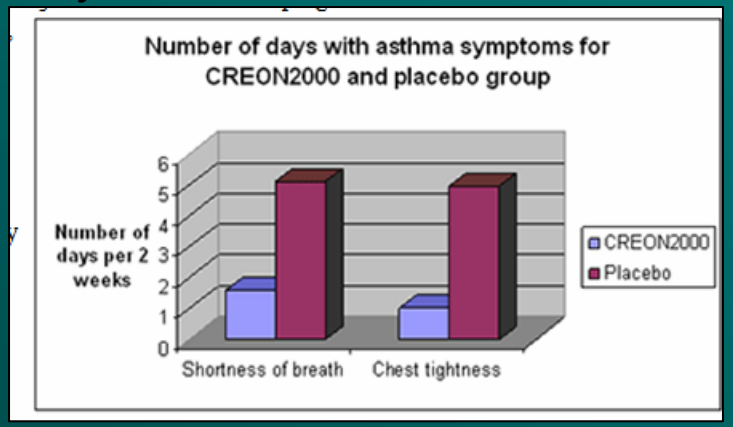
CREON2000 Room Unit

- *Patented Technology*
  - Focuses power of UV light on microbes
- *Study – Journal of Asthma*
  - Asthma symptoms
    – less frequent & severe
- *Low maintenance design*
  - Replacement of bulb & filter – once a year
- *Microbe Reduction*
  - HEPA - by 2-3 times
  - CREON2000 – by 20 times
- *Room Unit – offers flexibility in number of units installed*





Conclusion

- *GWHP indirect-use system*
  - Reduces energy consumption
  - Reduces emissions
  - Maintains thermal comfort
  - Lowers maintenance
- *Based on information available and calculations completed – Recommend!*

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Thank You

- Penn State AE Mechanical Faculty – especially my advisors: James Freihaut & Jelena Srebric
- Classmates – Malory & Patrick
- Dave Lyon & Jim Synan at McKamish
- My family & friends

Questions?