



Design for Off In Practice

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Bellevue Youth Theatre

Theater In The Round Underground

Invisible HVAC

Client Goals:

1. Silent
2. Hidden
3. Comfortable
4. Energy Efficient

Challenges:

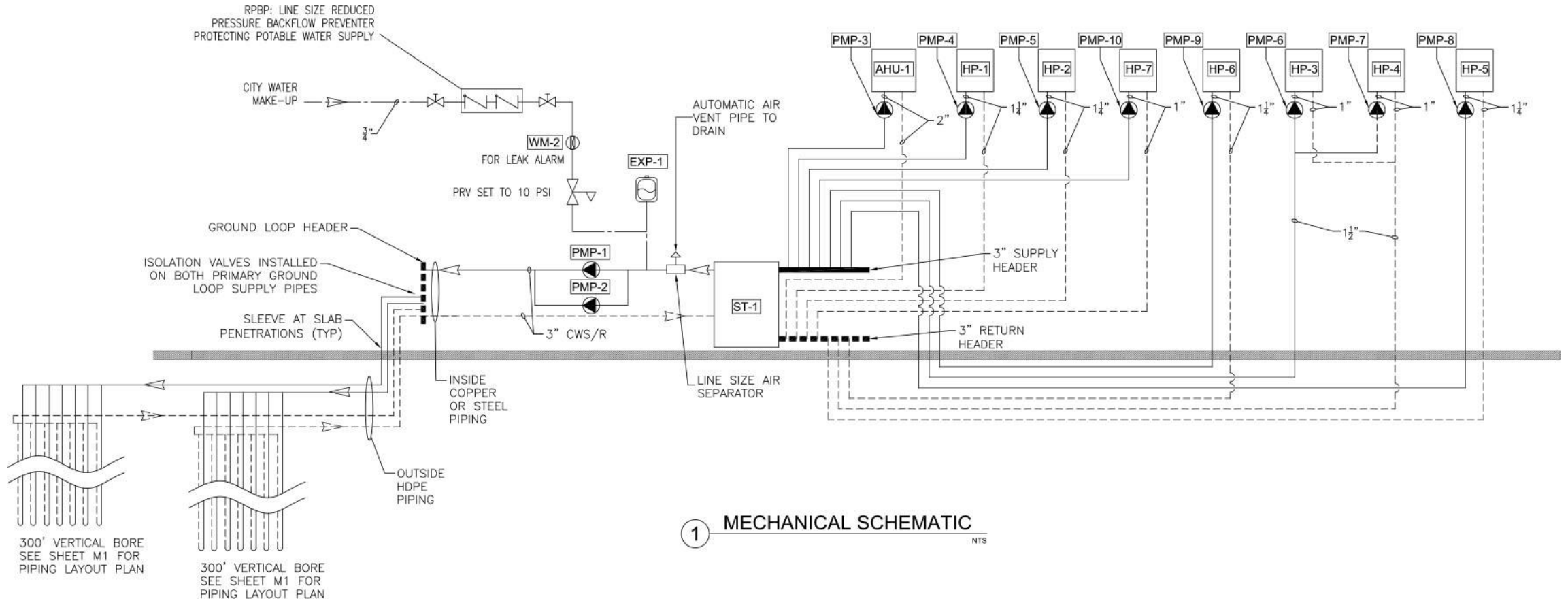
1. Variable Occupancy
2. High Occupant Densities
3. High Lighting Power Densities (100kW)
4. Connected Indoor/Outdoor Spaces
5. High Usage





System Selection

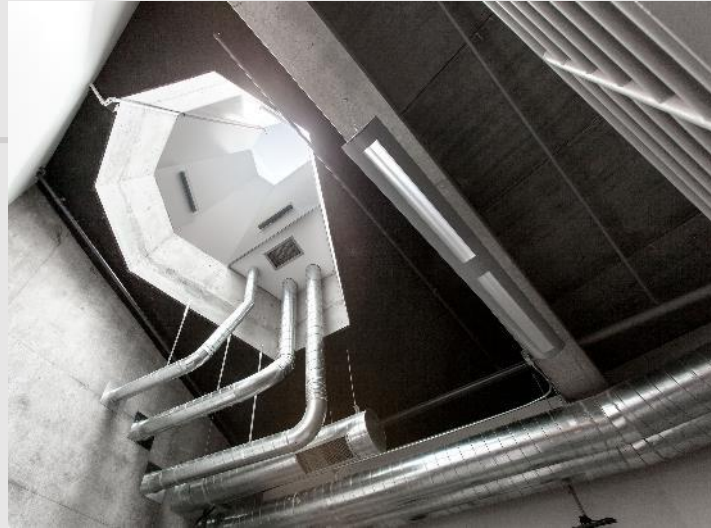
1. High Performance Envelope
2. Ground Loop HX with water to Air Heat Pumps.
3. Heat Recovery (DOAS)
4. Delta-T variable pumping
5. Economizers
6. Below-grade Ductwork Displacement Ventilation
7. Structural Integration
8. Occupancy Sensors



1 MECHANICAL SCHEMATIC
NTS

Schematic

Decoupled ground loop pumping
Dedicated Heat Pump pumping.



Performance

- Comfortable & Quiet
- 35 kBtu/SF Actual
- 64% savings over typical theater project
- Low maintenance Costs





Skokomish Community Center

Net-Zero Community Center

Community Center

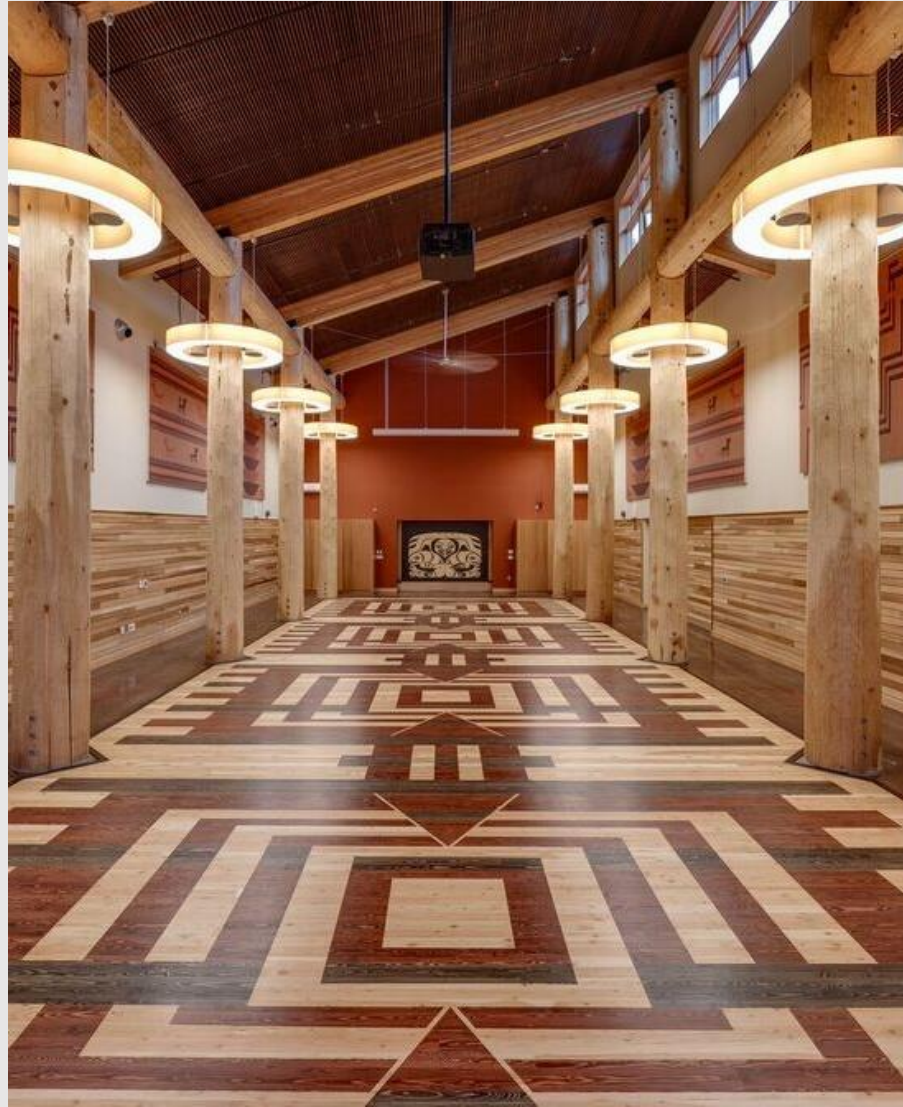
Client Goals:

1. Net-zero
2. Low-cost
3. Comfortable

Challenges:

1. Variable Occupancy
2. Commercial Kitchen (100 meals/day)
3. High Usage





System Selection

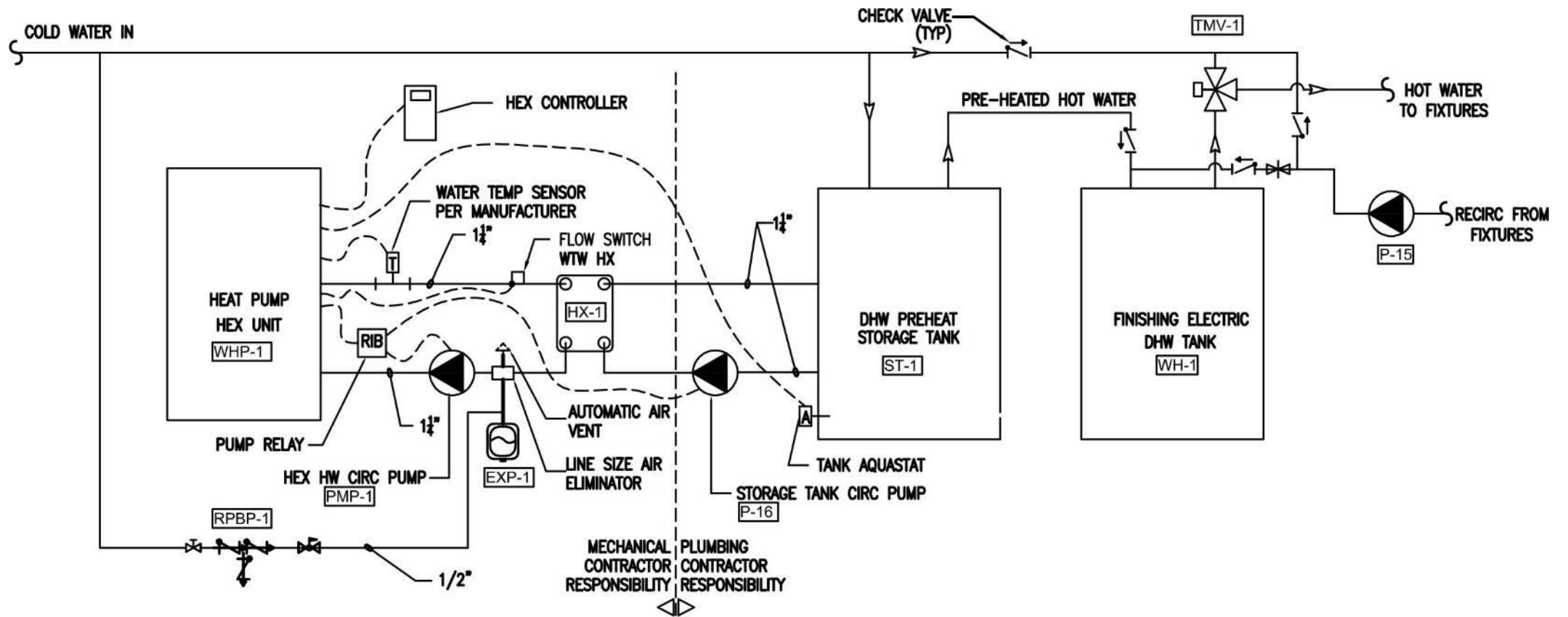
1. Central Dedicated Outdoor Air System (DOAS)
2. Demand Controlled Ventilation (CO2)
3. Variable Capacity Air-Source Split System Heat Pumps (Ductless)
4. Heat pump pre-heat for Domestic Hot Water



Innovation

1. Right Sized Ventilation
2. HVAC sized for heating
3. Heat pump DHW Pre-heat
4. \$17/SF Mechanical Budget





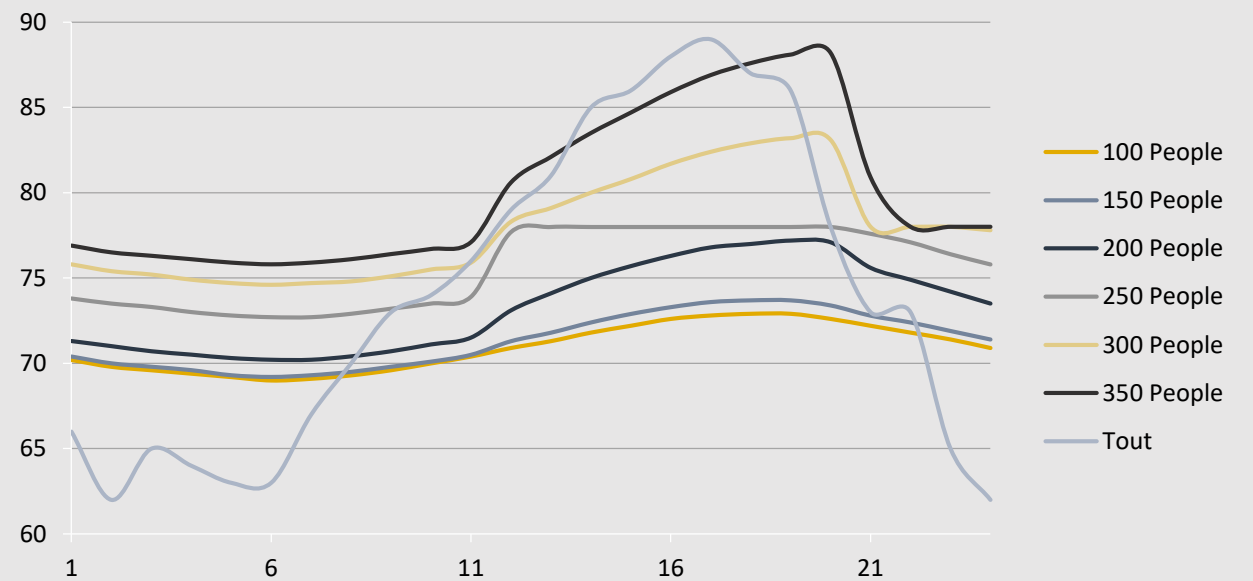
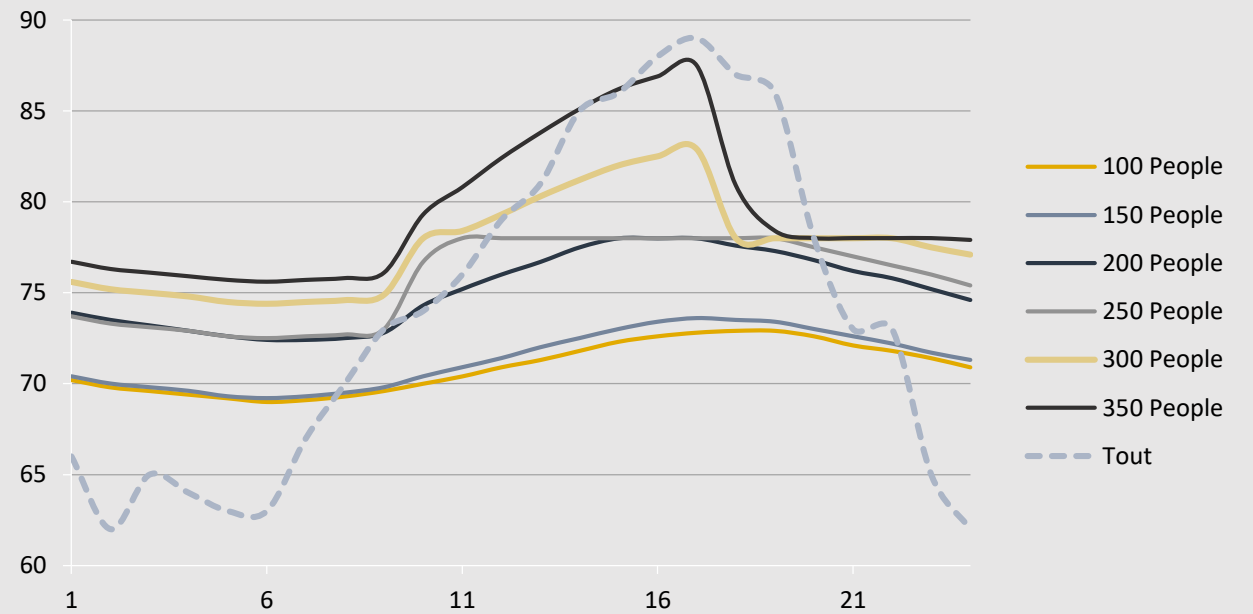
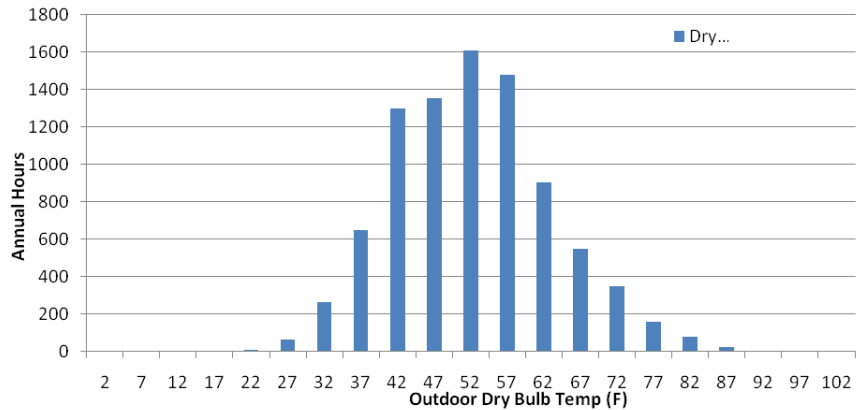
DHW Schematic

DHW Preheat (110 F), Electric Finishing

Local stand-alone controls

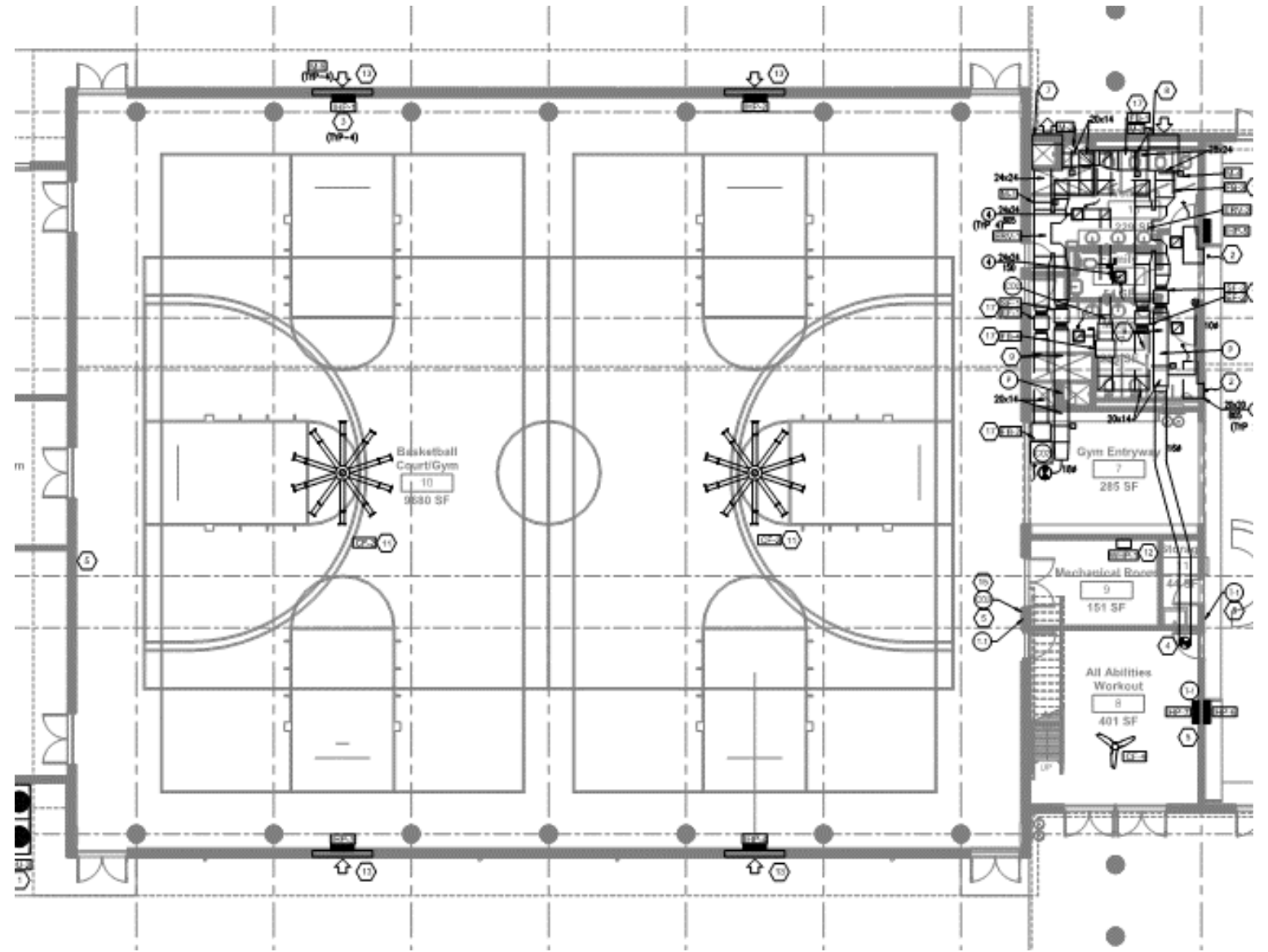
Heating & Cooling Right Sizing

Seattle Outdoor Temperatures (Drybulb)



Hybrid Ventilation Design

- Stack driven natural ventilation
- Occupancy peaked served by natural ventilation
- Base occupancy served by DOAS unit with ERV
- Demand control on ventilation



Skokomish Performance

EUI Before Solar: 38 kBtu/SF/yr

Last 6 Months Before Solar: 20 kBtu/SF/yr

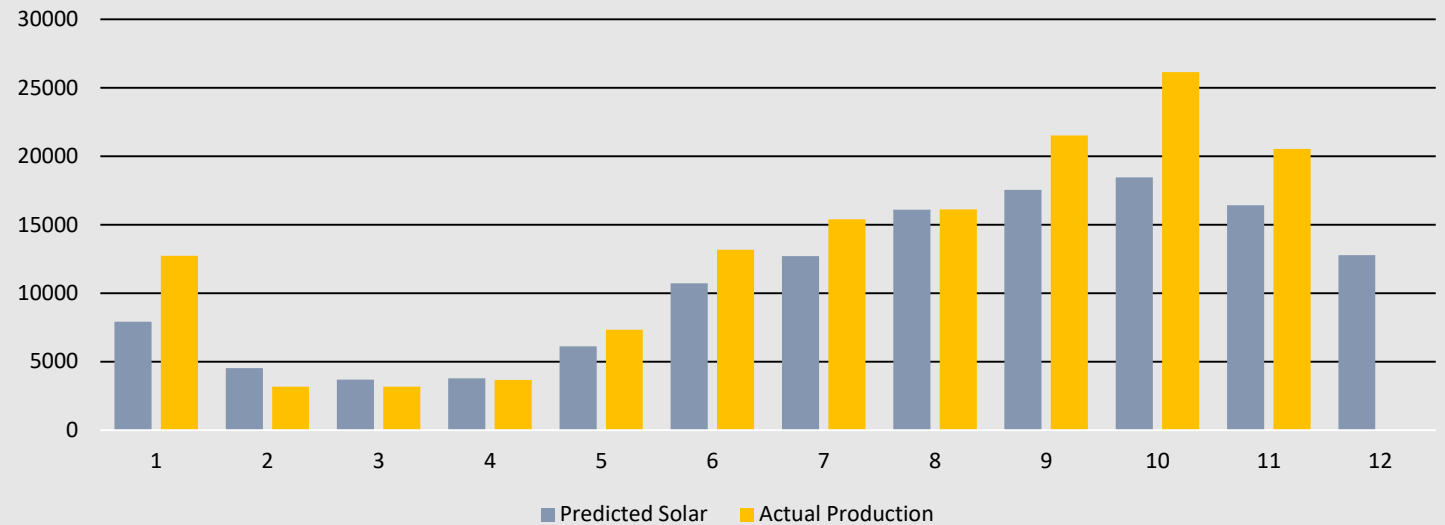
EUI After Solar: 12 kBtu/SF/yr

Last 6 Months After Solar: -6 kBtu/SF/yr

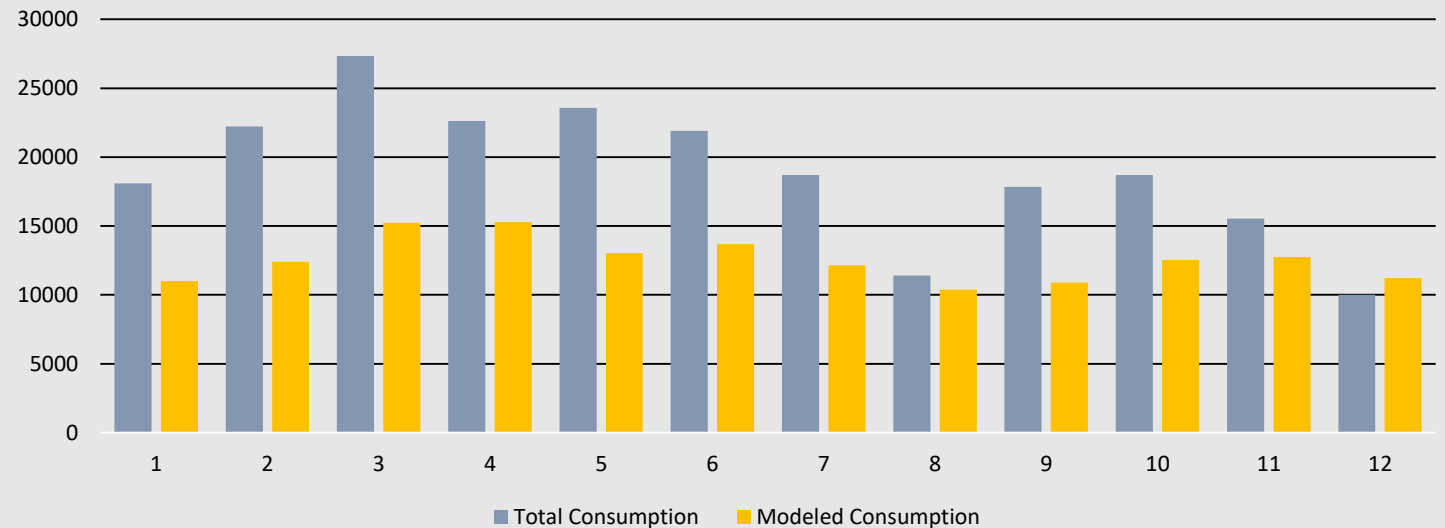
What went wrong:

1. HVAC Maintenance Contractor Changed things.
2. The building is so nice that everyone wants to have events there.

Actual Production per Month (kWh)



Total Consumption per Month (kWh)





Westside School

Most Efficient K-8 School in the nation?

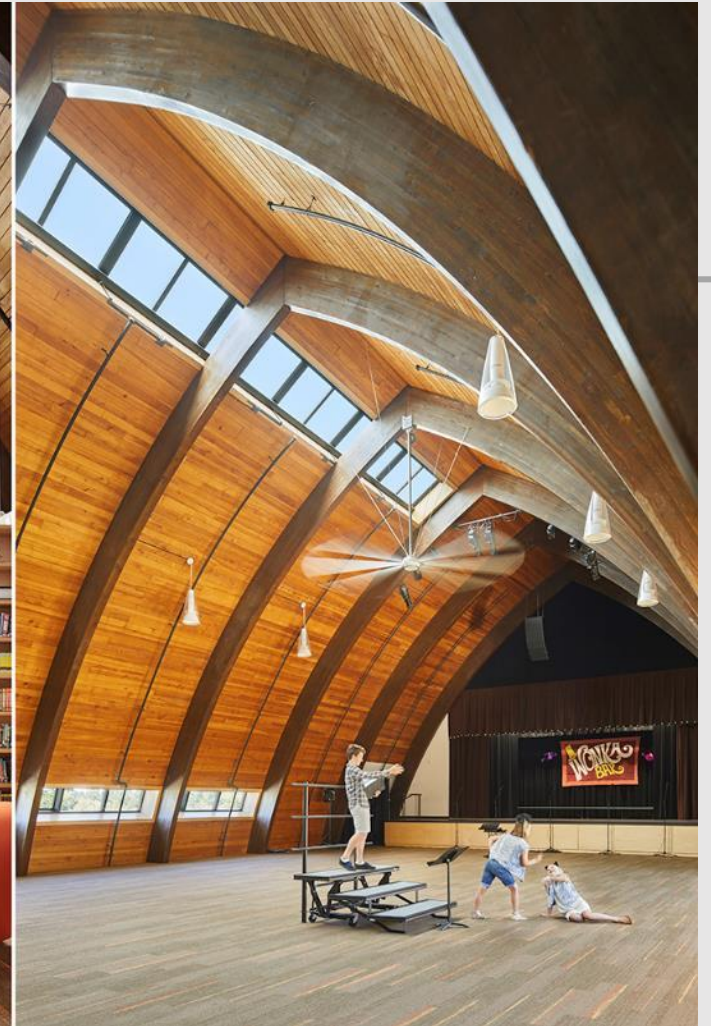
Remodeling for Efficiency

Client Goals:

1. Low cost
2. Student comfort
3. Energy Efficiency

Challenges:

1. Remodel of existing building
2. Tight budget





System Selection

1. Distributed Dedicated Outdoor Air Systems (DOAS)
2. Demand Controlled Ventilation (CO₂)
3. Variable Capacity Air-Source Split System Heat Pumps (Ductless)
4. Heat pump pre-heat for Domestic Hot Water

AFTER



BEFORE



Innovation

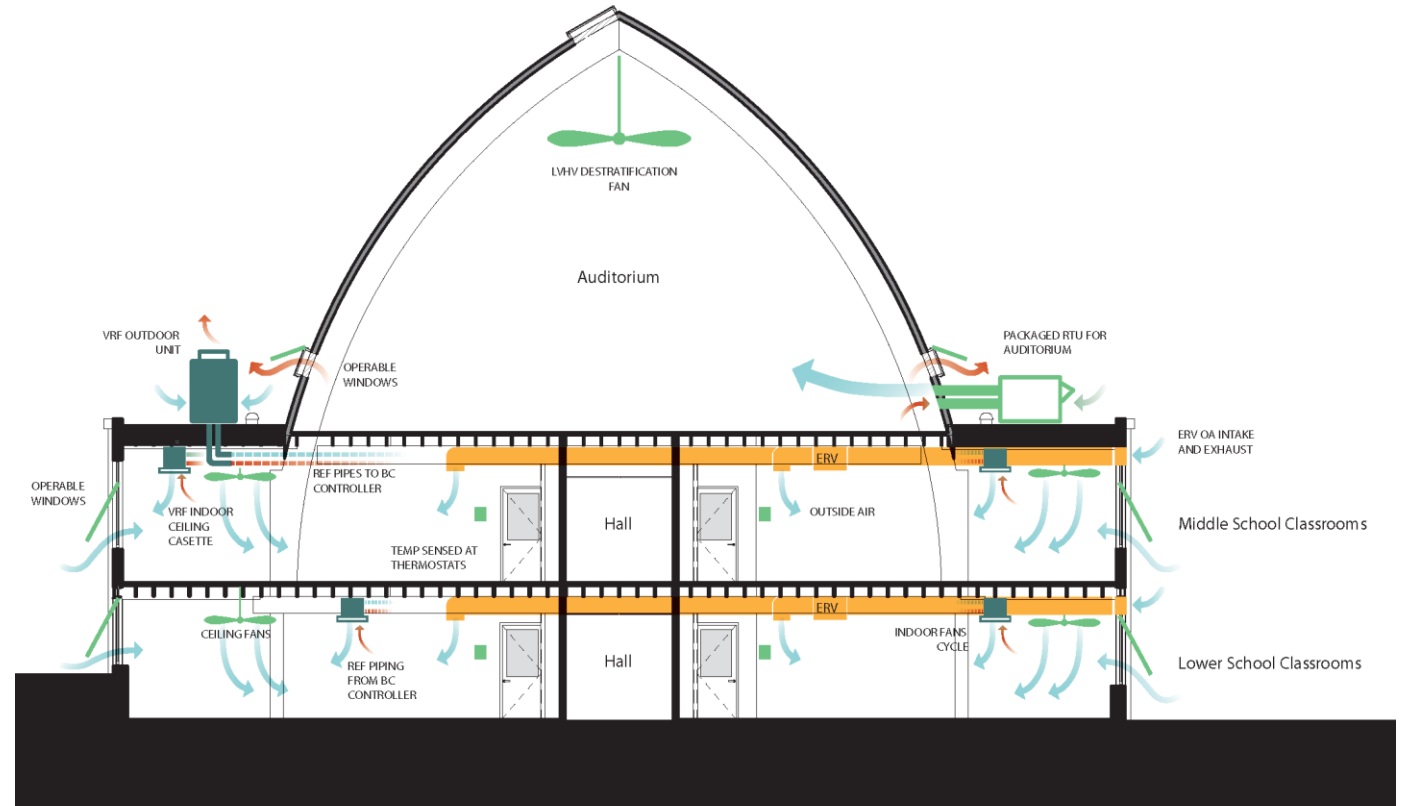
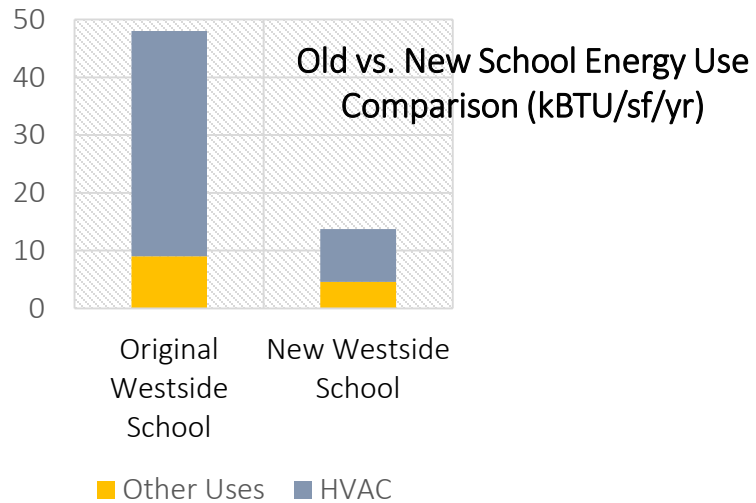
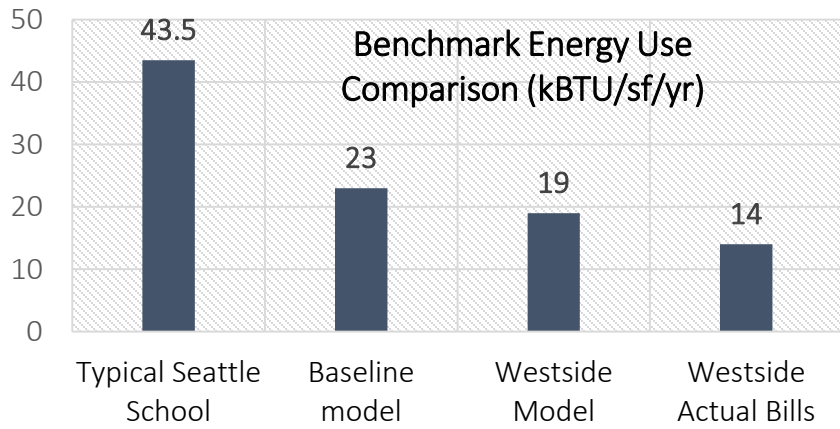
1. Classroom ERVs
2. Ductless Indoor Units
3. Ceiling Fans for Distribution
4. Occupant based control
5. Hybrid ventilation



BEFORE



AFTER



Performance

14 kBtu/sf/year – Net Zero Ready!

\$13/SF HVAC installed cost

Take Away Messages

- Envelopes are important, but HVAC is where the energy is.
- 1st Step is to select a system that can be turned off
- 2nd Step is to “right-size”
- Net-zero ready can be cheap
- Heat pump DHW heating can be implemented cost effectively.
- DOAS systems do not require tempering if careful attention is paid to HX selection

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Questions?



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