Net Zero Shell House

BACKGROUND & CONCEPT

To explore innovative solutions for reducing carbon emissions at the University of Washington, we will develop a conceptual net-zero design for the ASUW Shell House. This design will envision how the building could achieve net-zero performance and serve as a sustainable, functional event space for UW students, faculty, and visitors to use and appreciate.

Background
- P2S is working on the mechanical design for the renovation of the historic UW Shell House to transform it into a event space.
- The project's goal was to provide a high performance building, but a net zero building was not within the budget.
- As such, P2S is working with the ME Department to explore innovative strategies to reach net-zero.


Significance
As the consequences of climate change begin to take effect, it is clear that we need to reduce our carbon footprint. The built environment is responsible for ~39% of global carbon emissions, making reducing building emissions critical to our survival.

Critical Requirements
- Achieve Net-Zero emissions: energy consumed on-site balanced by renewable energy generated, resulting in zero net carbon emissions
- An HVAC system that meets code, ensuring occupant comfort
- An energy efficient HVAC system

We explored 5 systems:

	Air-Water		Water-Water		Air-Air
Central Equipment	Heat Pump		Heat Pump		VRF or VRV
Source/Sink	Ambient Air		Ground Well, Ground Loop, Lake Loop		Ambient Air
Distribution to Building	4 Pipe		4 Pipe		Refrigerant Circuits
Inside Building Distribution	Radiant Floor w/ DOAS	AHU w/ DOAS	Radiant Floor w/ DOAS	AHU w/ DOAS	DX system w/ DOAS

Selection criteria:
- Energy Efficiency – will impact operational cost and contribute to emissions
- Project lifetime emissions
- Life expectancy/maintenance – will significantly impact both cost and carbon emissions
- Historical preservation – system integration and mechanical space requirement to minimize impact
- Occupant comport – how well the system is able to ventilate and condition the space as well as acoustics
- Cost – can be prohibitive and is the driving force in all projects

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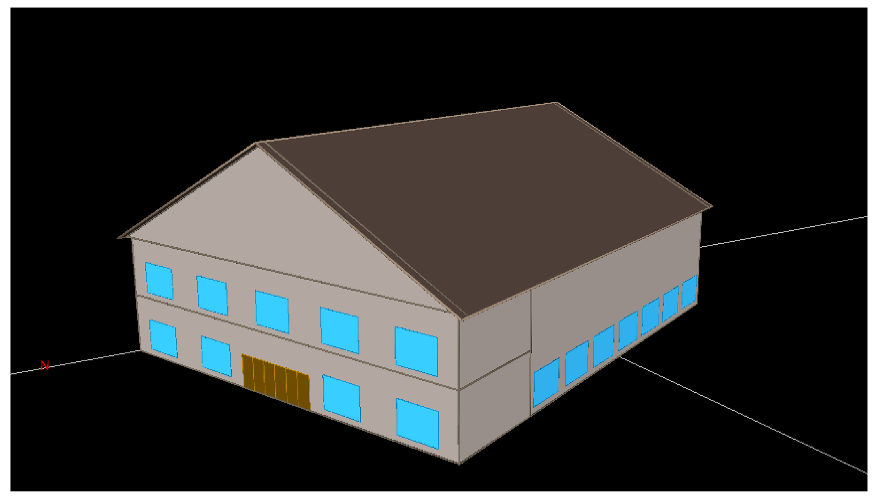
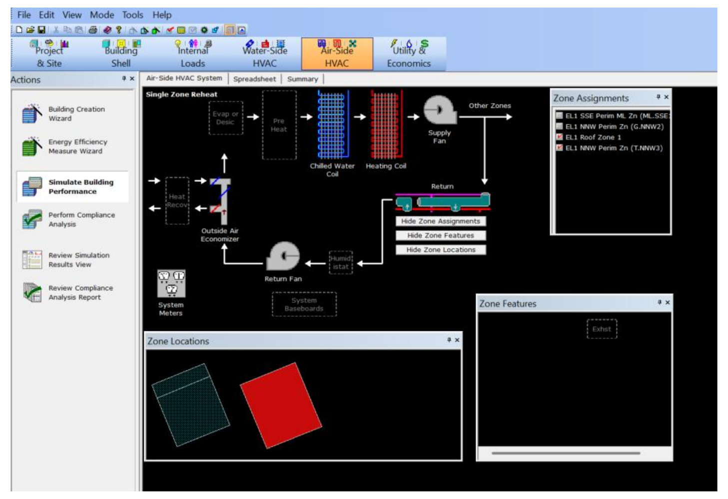
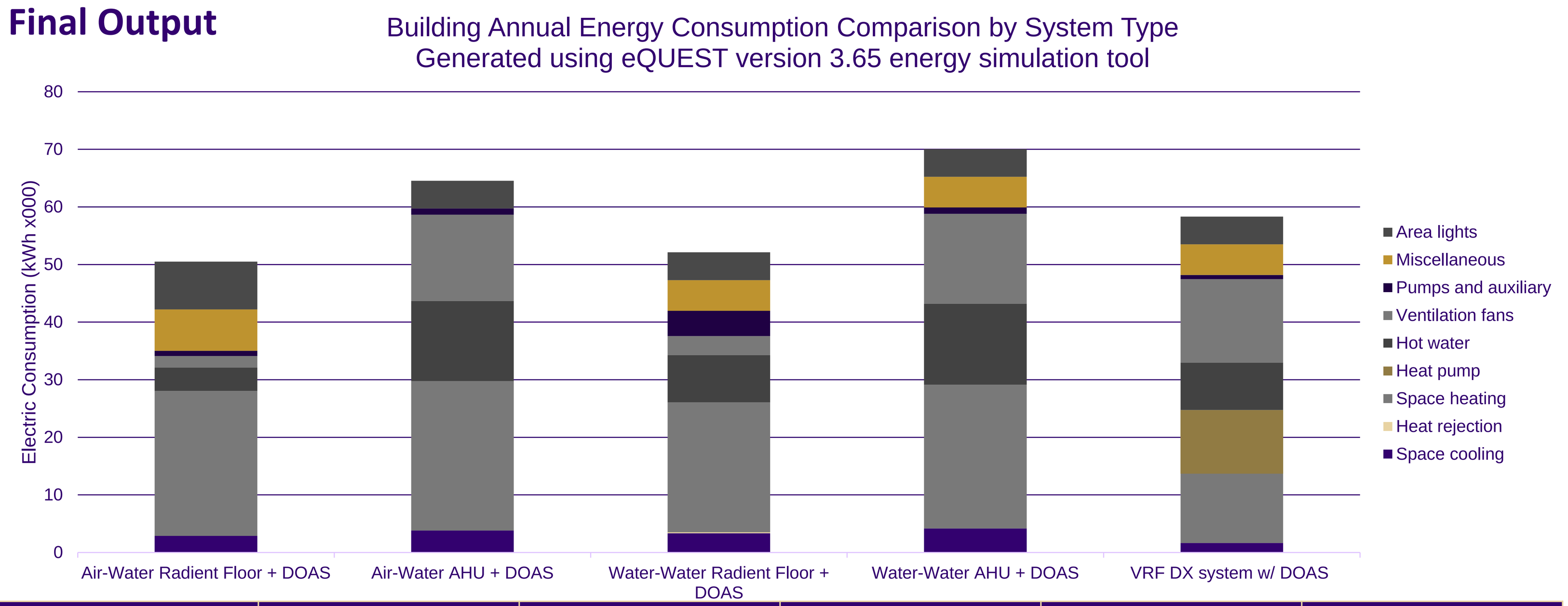
SYSTEM SELECTION

Energy Modeling: eQUEST
Building geometry
- Building footprint
- Building construction (U values)
- Fenestration (doors and glazing)

HVAC inputs
- System definition
- Zoning temperatures and airflows
- Equipment type, capacity, and efficiency (CHW, HW, DHW)
- Building controls and schedule

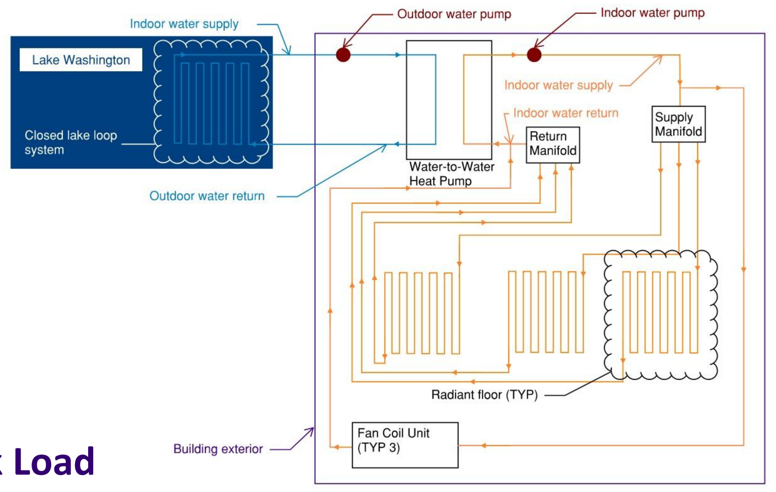



Final Output



	Air-Water RAD + DOAS	Air-to-Water AHU + DOAS	Water-Water RAD +DOAS	Water-Water AHU + DOAS	VRF + DOAS
EUI (kBtu/ft^2-yr)	14.24	18.20	14.70	19.75	16.45
GHG Emissions (kgCO2e/SF/yr)	0.0826	0.1056	0.0852	0.1146	0.0954

Water-Water w/ Radiant Floors and DOAS
- Minimal refrigerants, reduces GWP
- Supports electrification
- Low Energy Use (14.70 kBtu/ft^2·yr)
- Lower fan energy
- Longer life expectancy
- Minimal maintenance
- Minimal visual/audio impact



Load and ventilation calculations: Carrier Block Load
- Ventilation CFM based on 2021 Seattle Mechanical Code Table 403.4.1.1
- Area takeoffs for walls, windows, flooring, roofing, and doors
- 2021 Seattle Energy code gave loads for lighting, infiltration, shading coefficients and misc.
- U-factors from 2021 SEC baseline values

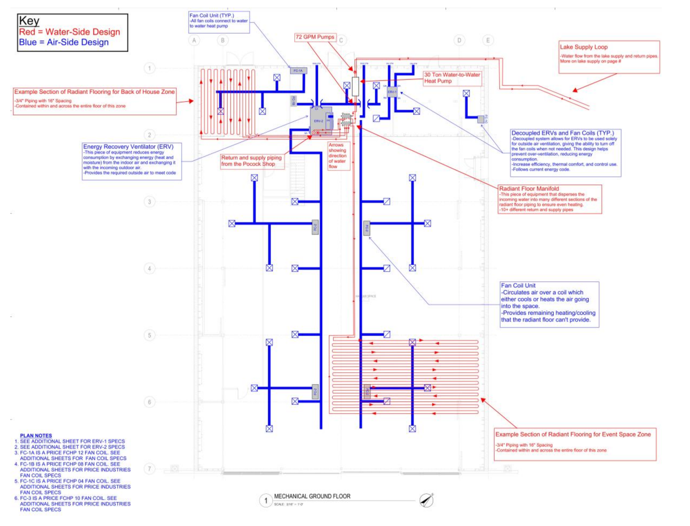
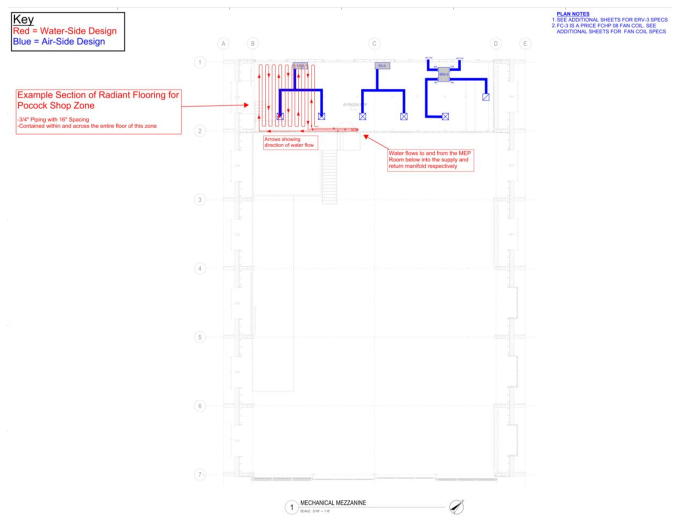
Output Summary

Loads (BTU/hr)	Cooling		Heating
	Sensible	Latent	Sensible
Zone 1 Total	27,353	2,050	33,475
Zone 2 Total	259,089	82,000	114,401
Zone 3 Total	29,862	10,701	13,301
Total Zone Loads	**301,428**	**94,751**	**161,177**
Total System Loads	**354,650**	**86,461**	**362,341**
Total Coil Loads	**354,650**	**86,529**	**362,341**

FINAL DESIGN

HVAC Equipment
Water side
- Heat source/rejection: closed lake loop
  - Source heating & cooling load from lake
- Water to water heat pump
  - Exchange heat between lake and indoor water loop serving radiant floors and fan coils.
- Indoor distribution system: radiant floor
  - Distribute heating & cooling to occupants

Air side
- Energy Recovery Ventilator, ERV
  - Recovers heat and moisture from exhaust air, provide required fresh outdoor air to meet 2021 Seattle Mechanical Code.
- Air handling unit: fail coils and diffusers
  - Fan coils provide remaining heat and cooling loads and diffusers distribute air-side conditioning.

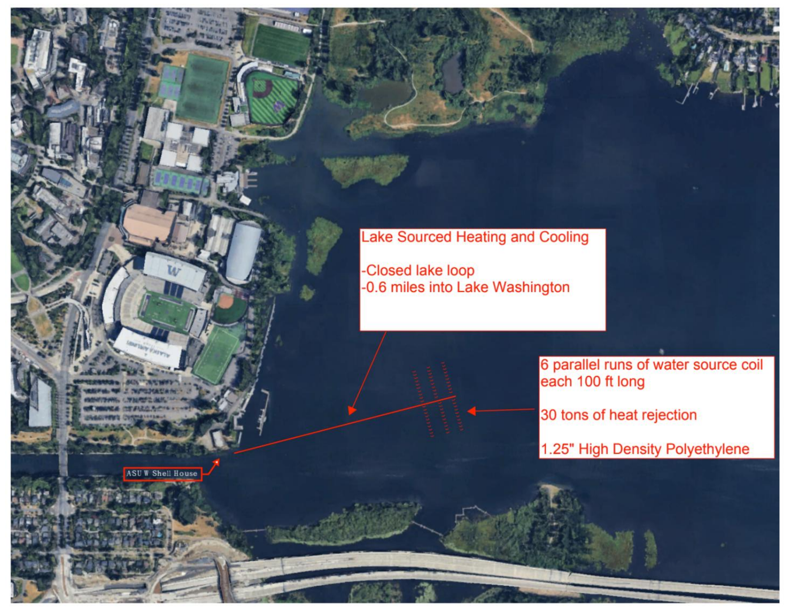



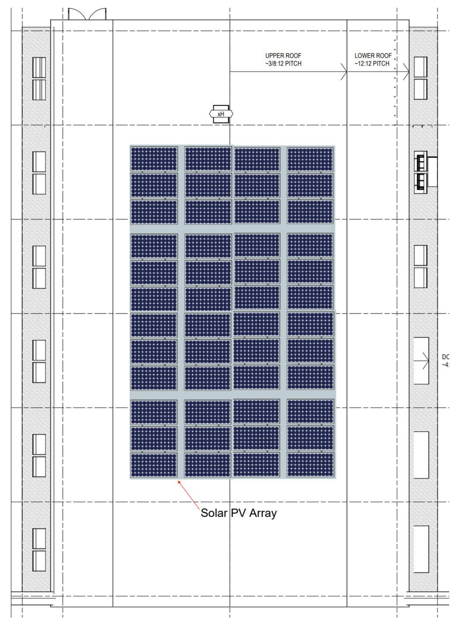
Photovoltaic (PV) Panel Array
A 2,906 sf rooftop PV array will generate 57,431 kWh per year to completely power and operate the building.

*Calculations performed using the NREL's PVWatts Calculator.

	Solar PV Specs
DC System Size (kW)	54
Module Type	Premium
Array Type	Fixed (open rack)
System Loses (%)	14.08
Tilt (°)	20
Azimuth (°)	180
AC Energy (kWh/year)	**57,431**

Net Zero Measures: Lake Sourcing and PV Array





- Sourcing the heating and cooling loads from the lake allows us to save on energy (costs) and reduce carbon emissions
- A rooftop PV array will generate an equivalent load to the building's operational demand. On-site solar energy sold back to the grid to offset carbon emissions, enabling the project to achieve net-zero status.

A special thanks to Peter Sloane, Mike Thomson, and Scott Rushing for your support and mentorship

Mechanical Engineering Capstone Exposition
May 29th 2024, Husky Union Building, University of Washington, Seattle