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Portland Metro Building Performance: Optimizing Energy Performance and Occupant Comfort at Portland Metro

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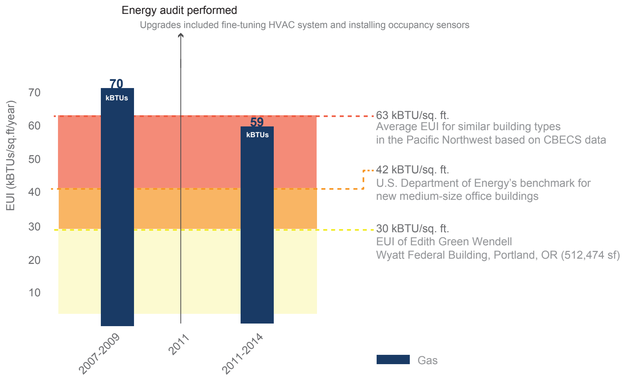
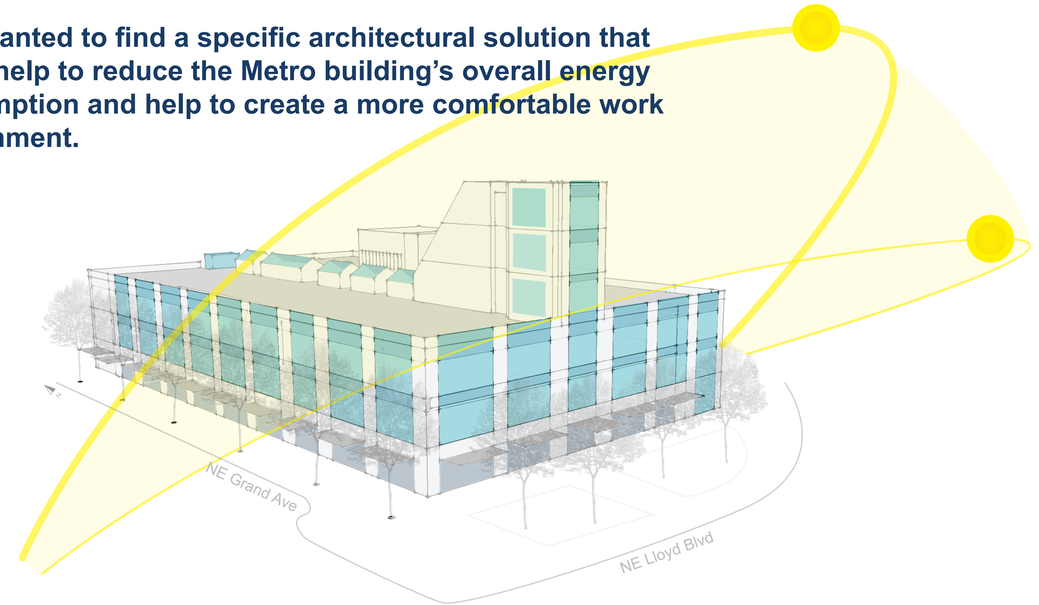
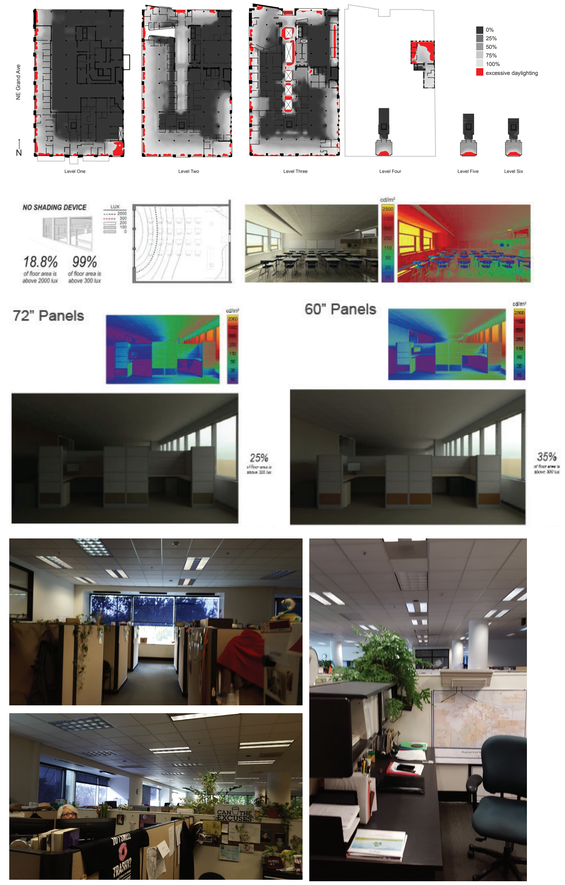
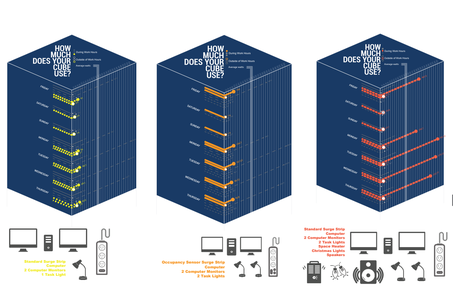
Metro YOST GRUBE HALL ARCHITECTURE Portland State UNIVERSITY

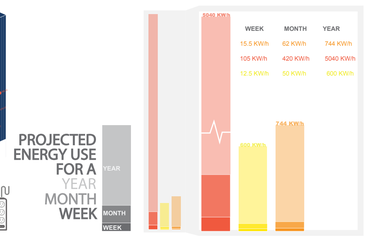
The objective of this research is to investigate potential existing building retrofits to improve the work environment for building occupants as well as the overall building energy performance. Beginning with the building skin and moving to the individual cubicle, our team wanted to find a specific architectural solution that would help to reduce the Metro building's overall energy consumption and help to create a more comfortable work environment.







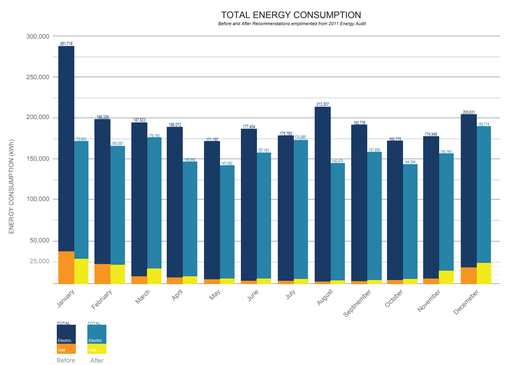




Current Building Energy Use

In order to understand the buildings current energy perofrmance we gathered energy bills ranging from 2007-2009 and 2011-2014.

Energy consumption at a micro scale was evaluated using three employees that were selected to have their workstations monitored for a week period. Energy consumption was collected via "WattsUp" Meters, which measured power used throughout the day in kilowatt hours.

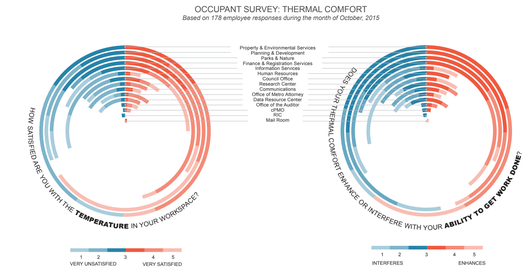


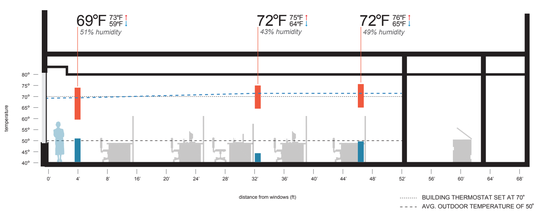
Envelope Analysis of Existing Building

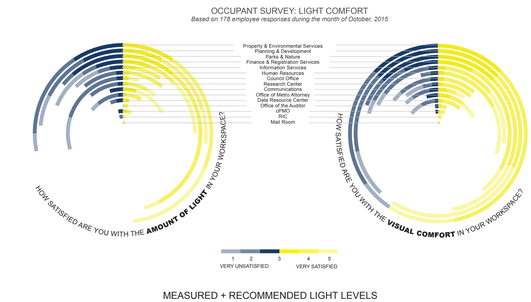
We assessed the current condition of the Metro Building by studying the building envelope and reviewing an Energy Audit performed by R&W Engineering, Inc. in 2011, then further investigation through digital simulation. We also conducted an occupant survey of employees regarding their thoughts and feelings about their workplace environment.

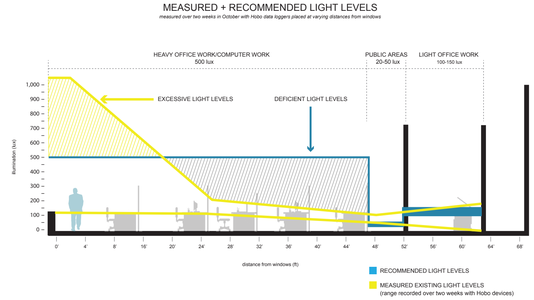
Digital simulation in Sefaira daylight visualization and SketchUp 3D modeling software quickly gave us an idea of the building's overall daylight conditions. The shades of gray represent the percentage of occupied hours where illuminance is at least 28 footcandles, which is the recommended light level for an office space. The large curtain wall windows will provide ample light, even excessive lighting once partitioned cubicles are gone, making most work areas too bright.

Currently the high partition of the workstations block out all the light entering the large open office rooms. But for those directly next to the window the solar gains can create an over heated and high glare workspace. Measured light levels were found to be insuficient, and the florecent lights were flickering at a low constant pace, making for a very uncomfortable lighting.









Occupant Survey and Indoor Conditions

The user survey was distributed to all 400 Metro employees during the month of October 2015. The 10-15 minute survey included questions related to thermal comfort, visual comfort, temperature controls, and personal habits. We received 173 responses from employees across 14 departments. We compared these responces with measured values for temperature, light levels in lux, and humidity by HOBO data loggers during the same time frame as the survey.

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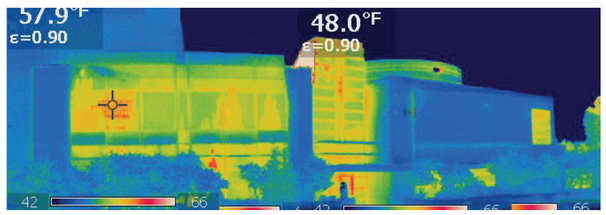
Opportunity of Saving Energy in Existing Building

Building Component	Commercial	
	Heating	Cooling
Roofs	0.88	0.05
Walls	**1.48**	-0.03
Foundation	0.79	-0.21
Infiltration	**1.29**	-0.15
Windows (Conduction)	**1.60**	-0.30
Windows (Solar Heat Gain)	-0.97	1.38

Primary Energy Consumption Attributable to Fenestration and Building Envelope Components in 2010 (Quads)

Information was gathered through thermal imaging and a variety of lighting sensors and modeling software. Using FLIR Thermal Imaging cameras, we were able to compare how quickly heat was lost through different areas of the building facade. Light levels in different areas of the building were compared in one visit using Verneer sensors. To understand how light affected the building over long time periods, we used Hobo data loggers to measure light levels for two weeks at varying distances from the windows.

Results were largely as expected: large windows provide large amounts of daylight, which in turn provides excessive lighting in close proximity to the windows. The large windows also result in a higher temperature range, in which the building perimeter is hotter or colder than the building core depending on the outdoor temperature, and hotter under direct sunlight. Renovation to existing buildings is one of the biggest opportunities to have an impact on energy consumption. Office buildings use more energy than any other building type, and lighting demand can make up from anywhere from 20-60% of a buildings total energy consumption.

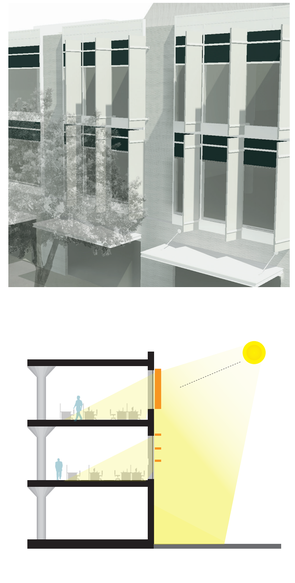


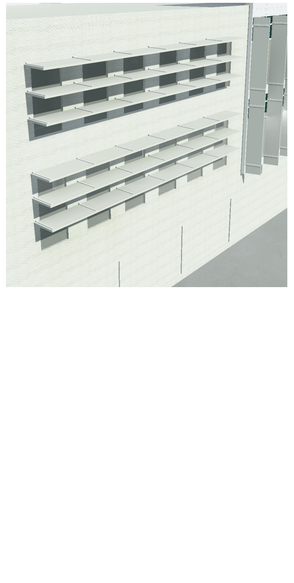
Opportunity of Saving Energy in Existing Building

The addition of solar shelves to the building facade will help control the about of sunlight entering the space by blocking direct gains while diffusing the sunlight in to the space. This will reduce electric light loads and reduce heat gains thus decrease cooling loads. The result is a workplace that uses less energy in cooling and lighting, provides healthier lighting conditions, and gives users enough control to determine the comfort of their individual space.

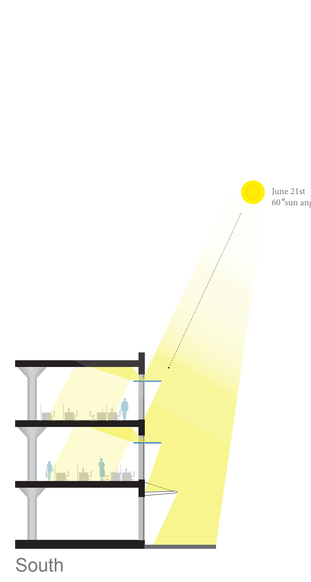
Utilizing a sun shade-light shelf combination on the south facade will prevent summer heat gains, while facilitating daylight deeper into the building with the application of white reflective surfaces and a removed drop ceiling. This shading and daylighting strategy will reduce overall lighting and cooling loads through proper admittance.

The addition of exterior shading to the south, east, and west facades, particularly on the south and southern corners of east and west facades will dramatically improve thermal comfort and reduce direct solar gains while still providing natural light. Integrate shading with reflective light shelves, as well as removing the existing drop ceiling and altering furniture style and configuration, to facilitate daylight towards the building core. Recommend replacing existing T5 florescent lighting with more energy efficient and non-flickering LED lights, as well as recommending/providing LED lights for task lighting in individual workstations.

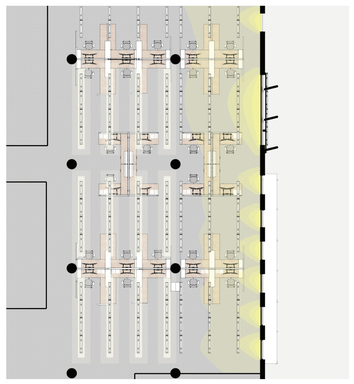


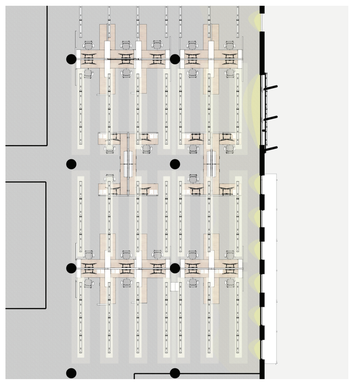


East & West



South





A smarter lighting design will help to provide even adequate lighting throughout the day, without over exposing those by the window or leaving others in the dark. Having lights running parallel to the exterior wall and set to different controls will allow for artificial lighting to be used by the window only when the sunlight in not sufficient.