PORTLAND STATE UNIVERSITY
ENGINEERING BUILDING EXPANSION FEASIBILITY STUDY

Nicole Dunbar, MS Mech. Engineering, Graduate Student

Portland State University

ZGF

GLUMAC engineers for a sustainable future™

RESEARCH ADVISORS

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RESEARCH ABSTRACT

Built in 1994, the Engineering Building at Portland State University houses the Maseeh College of Engineering and Computer Science. The building was certified LEED (Leadership in Energy and Environmental Design) Gold after its construction, achieving a 45% reduction in energy use from the original building. A geothermal (ground source heat pump) cooling system is the primary cooling device in the building, along with operable windows in classrooms for natural ventilation and cooling (PSU).

Portland State University's commitment to sustainability sparked the impetus to push for a design that would achieve the LEED Gold standard. Originally designed by Zimmer Gunsul Frasca (ZGF) Architects and PAE Engineering, the building serves as the main space for all of the branches of Portland State's engineering department. In 2012, Maseeh College dean Renjeng Su solicited a call for proposals to add to the main atrium space at the entry to the building. Citing a desire for further event and student social space, ZGF and Glumac Engineering were contracted to create a design.

This research attempts to address pre-design issues by identifiying potential solar energy production values and detailing high performing facade systems that the design team could choose for the addition. The research is divided into three sections: Collaboration Analysis, Facade Systems Research, and Initial Site Solar Analysis.

DESIGN TIMELINE

PSU Expansion Partners:

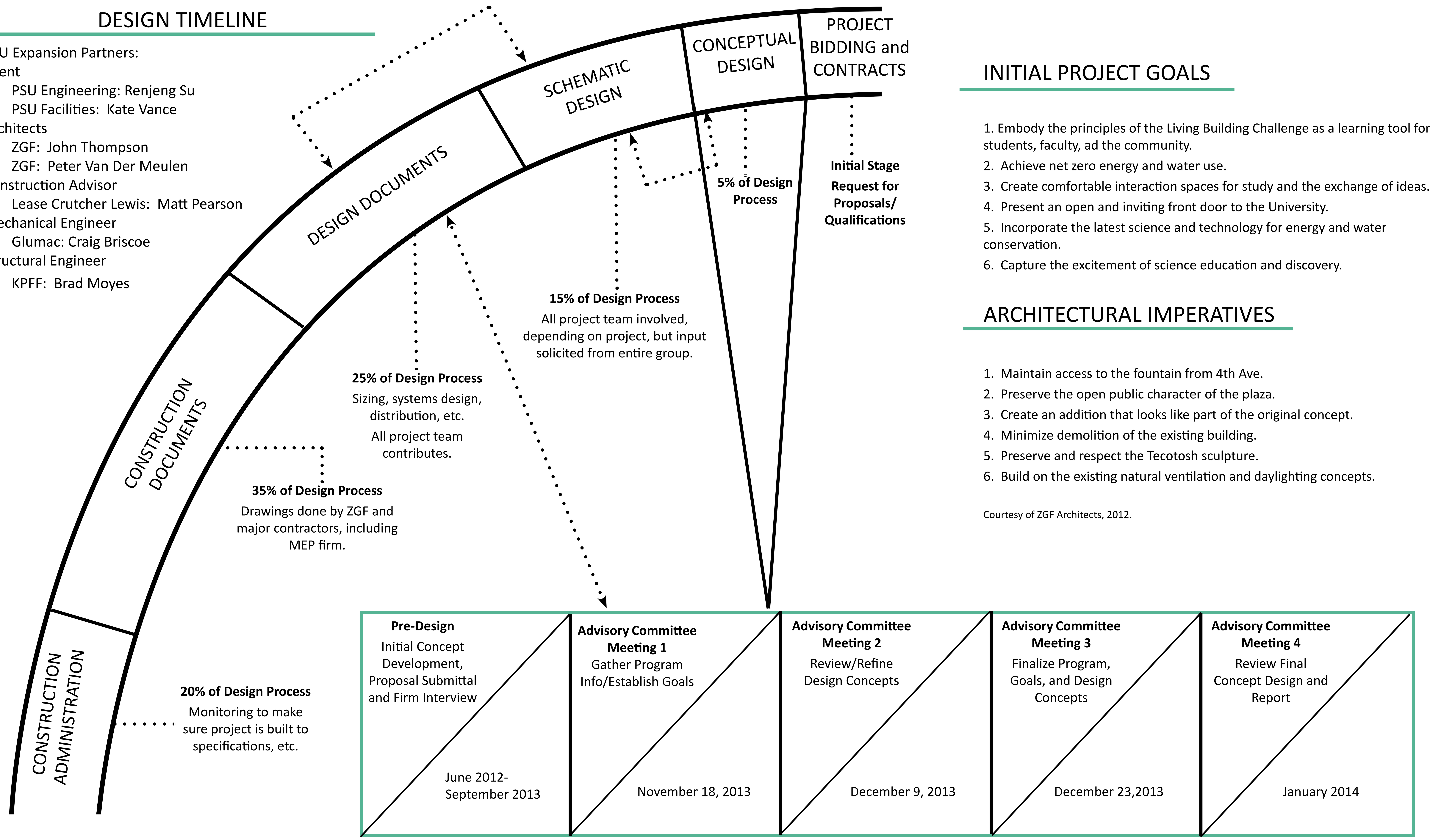
Client
- PSU Engineering: Renjeng Su
- PSU Facilities: Kate Vance

Architects
- ZGF: John Thompson
- ZGF: Peter Van Der Meulen

Construction Advisor
- Lease Crutcher Lewis: Matt Pearson

Mechanical Engineer
- Glumac: Craig Briscoe

Structural Engineer
- KPFF: Brad Moyes



COLLABORATION ANALYSIS

The collaboration analysis project was intended to look at the specific design project being researched and understand the context and larger placement of the project in terms of a typical design timeline. The documentation of the integrated design process would then serve as a visual way for students to understand the integrated design process and could inform the firm about where changes in specific activities within the timeline could improve efficacy of the process or speed incorporation of sustainable design goals.

Collaboration Analysis Tasks:

1. Participate in project meetings and the collaborative design process; document process timeline and activities.
2. Relate specific project timeline to ZGF's overall timeline for a more typical design project.
3. Create "Collaboration Timeline" visual graphic to represent the overall design process and the specific project process.

INITIAL PROJECT GOALS

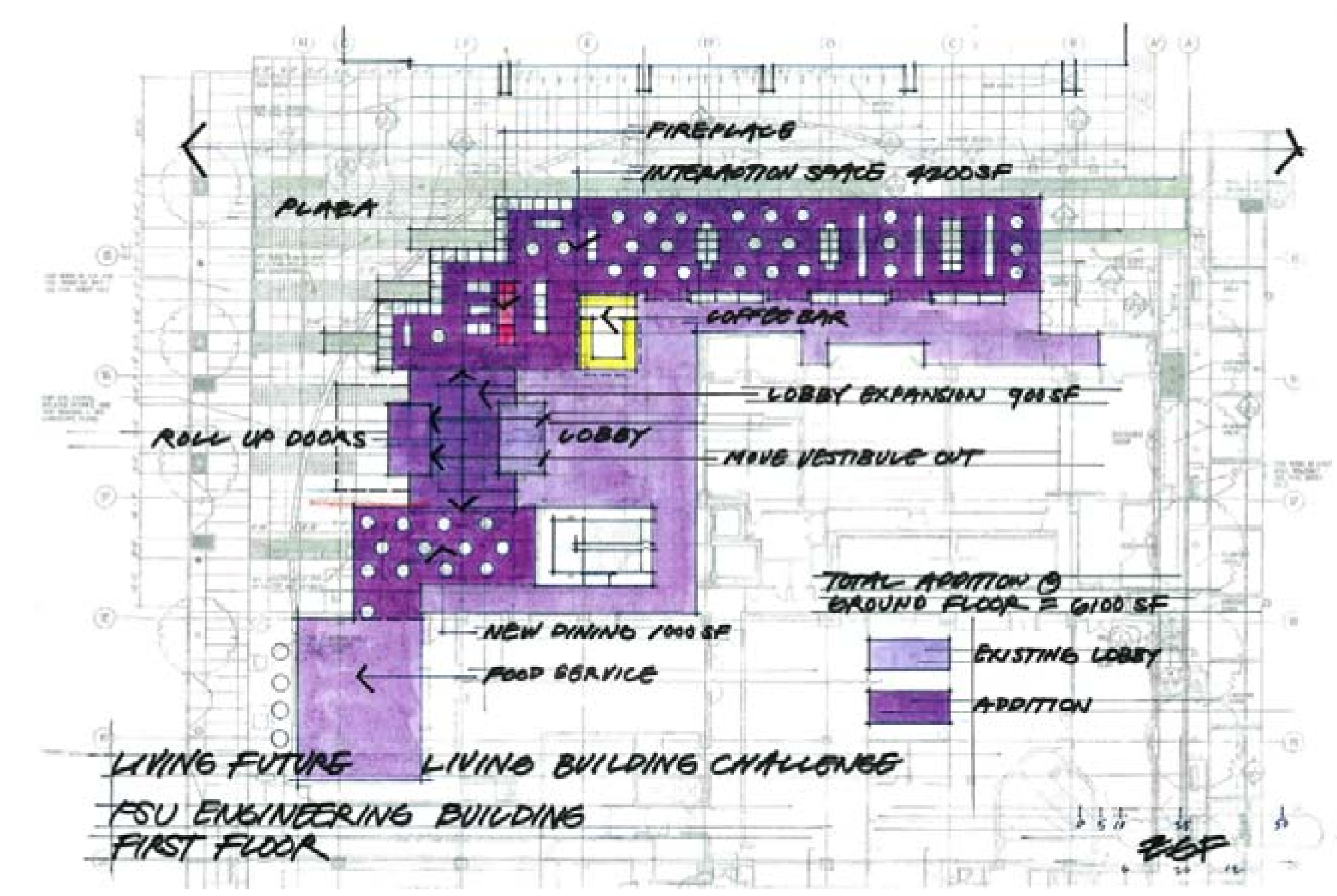
1. Embody the principles of the Living Building Challenge as a learning tool for students, faculty, ad the community.
2. Achieve net zero energy and water use.
3. Create comfortable interaction spaces for study and the exchange of ideas.
4. Present an open and inviting front door to the University.
5. Incorporate the latest science and technology for energy and water conservation.
6. Capture the excitement of science education and discovery.

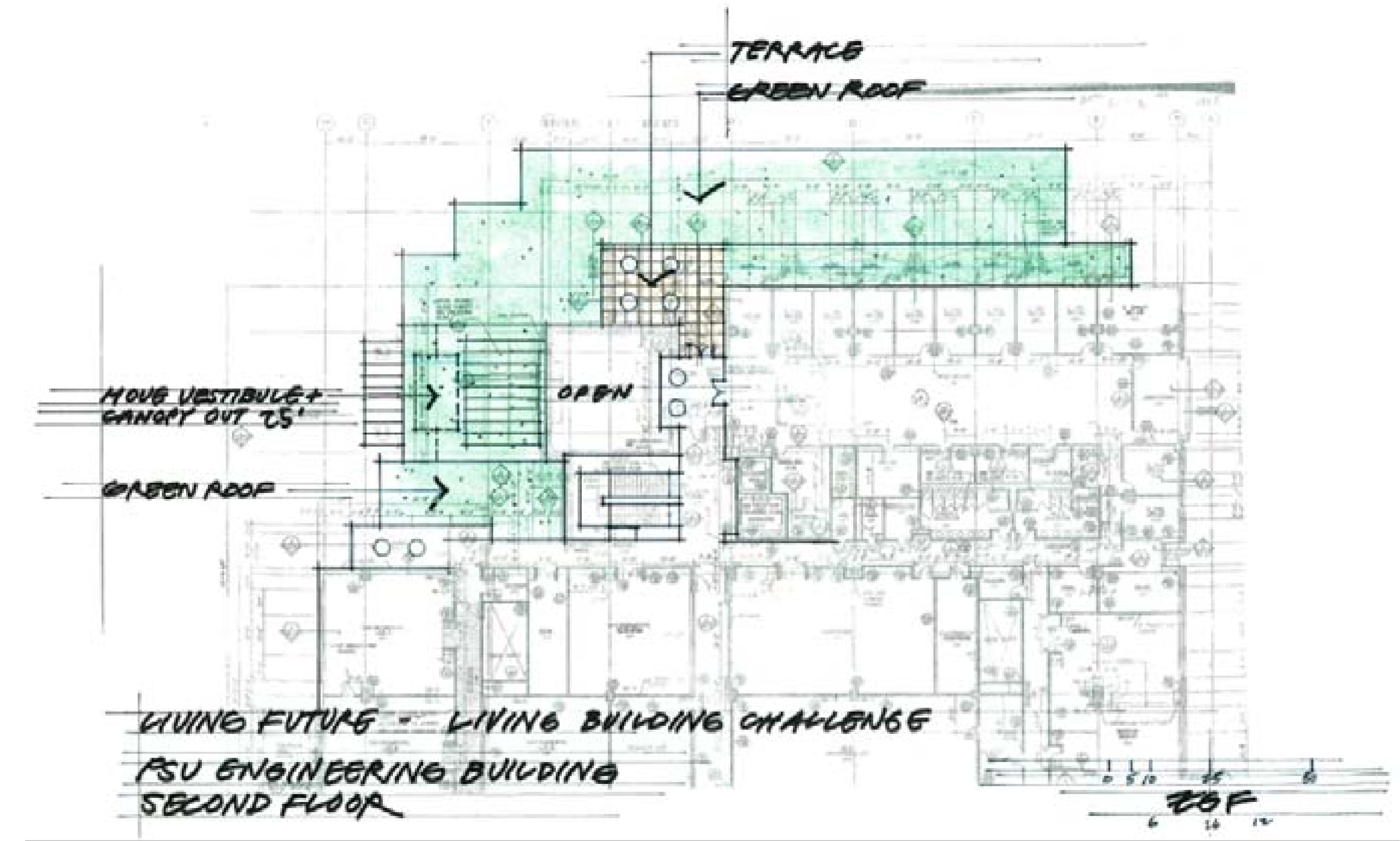
ARCHITECTURAL IMPERATIVES

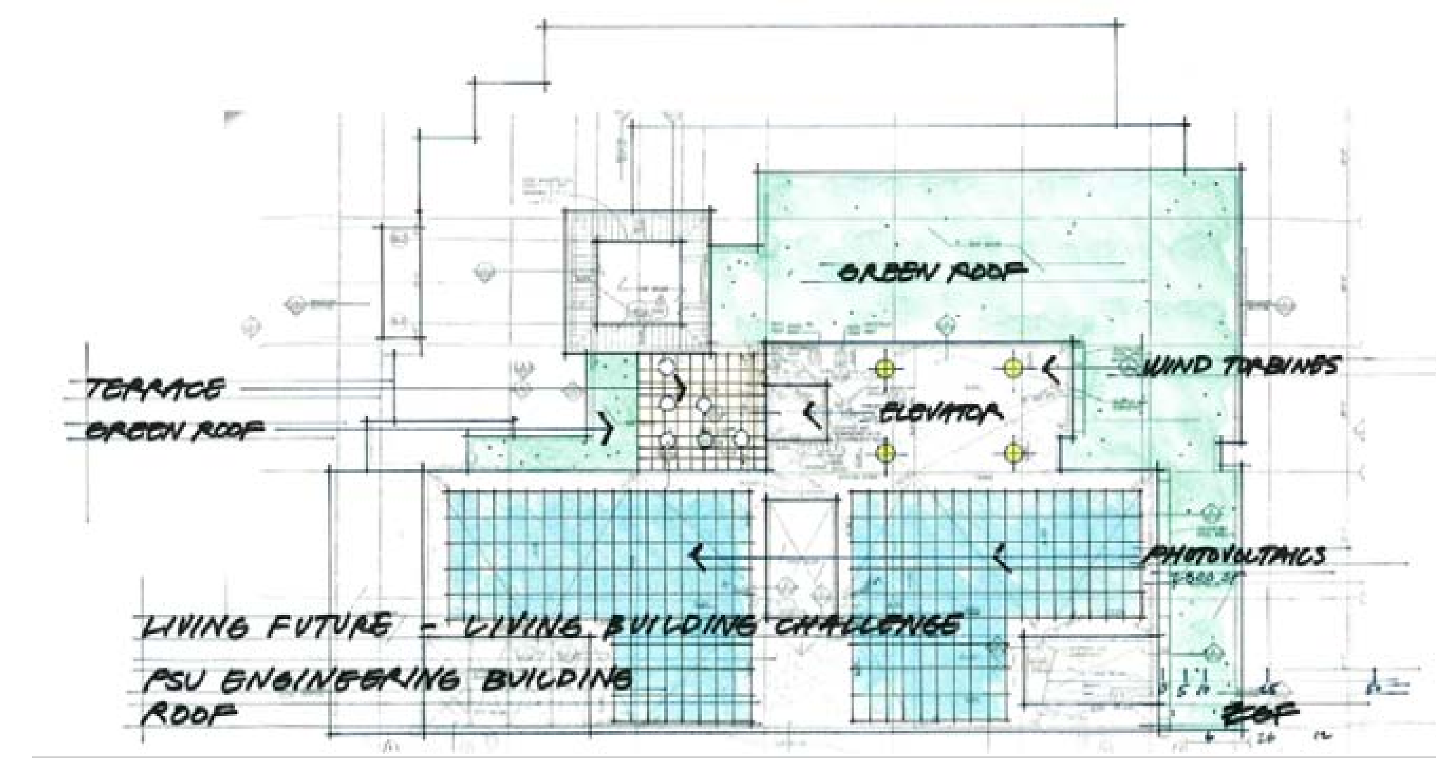
1. Maintain access to the fountain from 4th Ave.
2. Preserve the open public character of the plaza.
3. Create an addition that looks like part of the original concept.
4. Minimize demolition of the existing building.
5. Preserve and respect the Tecotosh sculpture.
6. Build on the existing natural ventilation and daylighting concepts.

Courtesy of ZGF Architects, 2012.

INITIAL DESIGN CONCEPT







Images courtesy ZGF Architects, 2012

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INITIAL SITE SOLAR ANALYSIS

To determine whether achieving the Living Building Challenge principles would be feasible for the PSU Engineering Building addition, an initial site solar analysis was necessary to determine potential for energy generation on the building. Autodesk's Vasari program is an effective tool for modeling solar access and radiation on specific sites, and was utlized in this research to create a basic understanding of the available solar resources.

The existing building model (created in SketchUp by ZGF Architects) was too complex to import into Vasari for solar modeling, so a basic massing model was created over a map of the area. Large buildings immediately to the South and East of the PSU Engineering Building were included to understand the effect of surrounding mass on the shading of the Engineering Building roof. Building facades were not included in the study, given the low performance of most Building Integrated Photovoltaic systems and the high shading factor due to proximity of the adjacent structures.

Limitiations of this research include a lack of analysis on the effect of tilted solar panels instead of flat roof area for solar production, and limited site modeling. However, despite limitations, the results indicate that some photovoltaic energy production is possible on the roof of the building. Economic analysis on the costs versus payback of PV panels was not conducted.

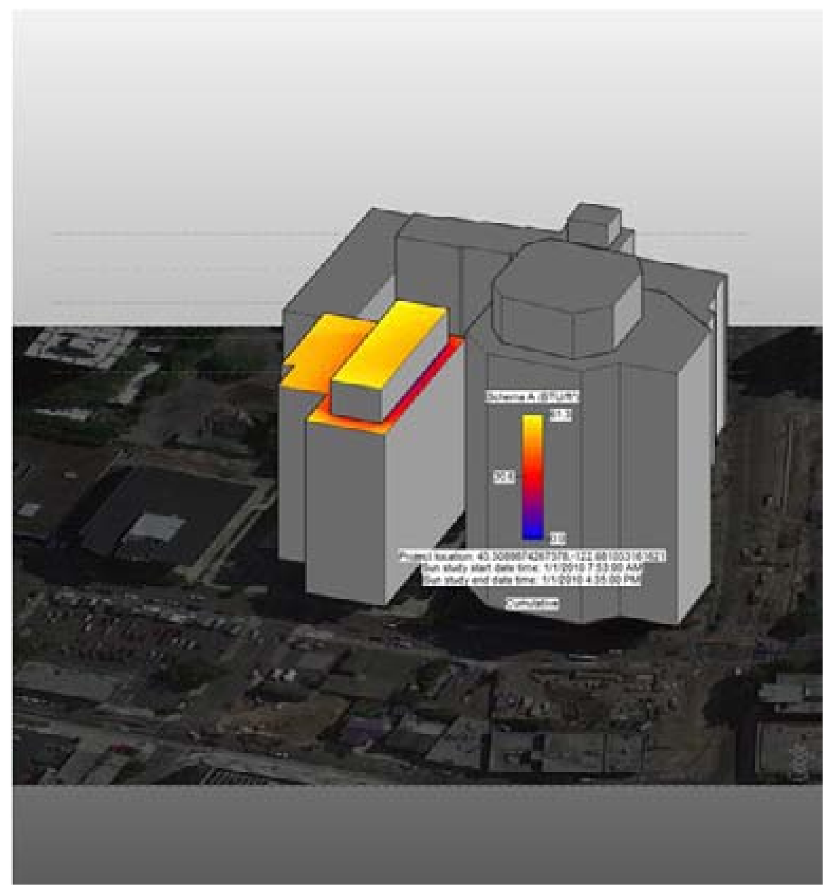

Fig. 1: Cumulative Yearly Solar Radiation

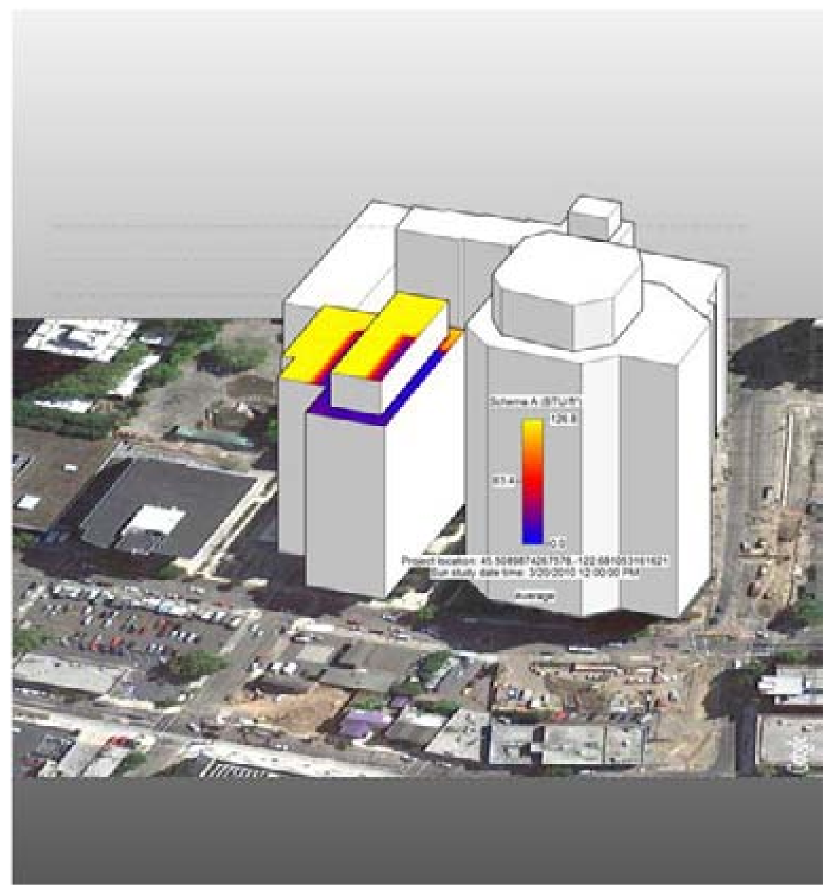

Fig. 2: Average Spring Equinox Solar Radiation

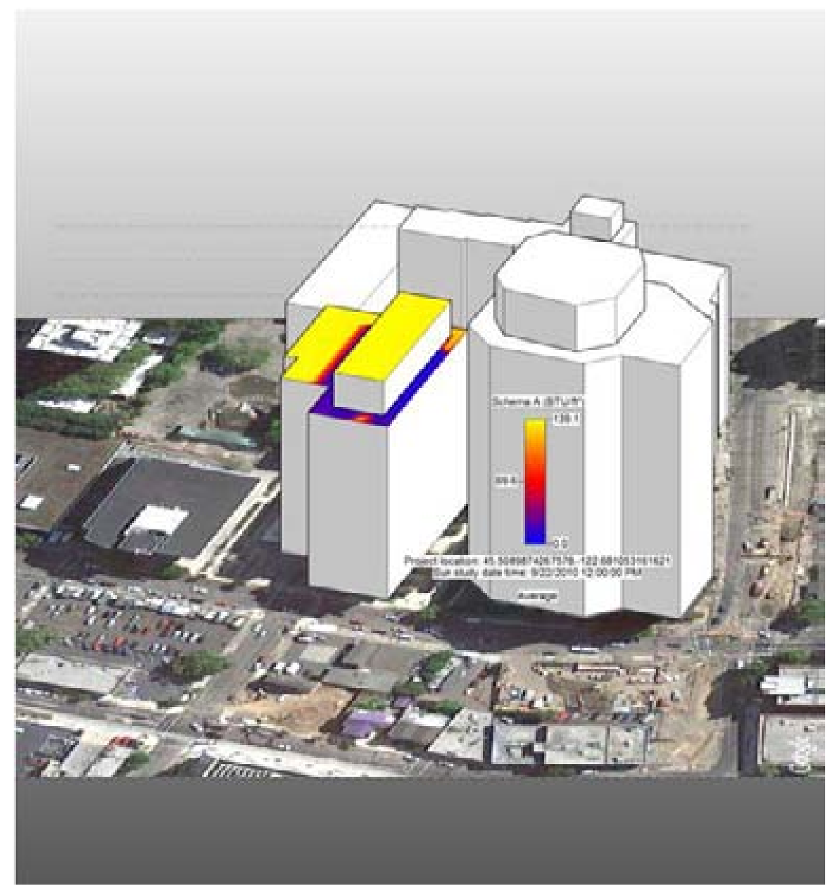

Fig. 3: Average Fall Equinox Solar Radiation

Figures 1-5 show visual solar radiation data for the times of year indicated. To get an understanding of the amount of solar energy hitting the roof through the course of the year, initial analysis was done for each season. The cumulative solar analysis allows a total amount of solar radiation to be determined, which is the value that would be used to size a solar photovoltaic system.

These figures indicate that despite a taller building to the South, the Engineering Buiding has the capacity to produce electricity through a rooftop solar panel array that could offset some of the energy used in building operation. These rough values would not be enough to meet the Net Zero Energy goal, but could offset electricity use for a portion of the building.

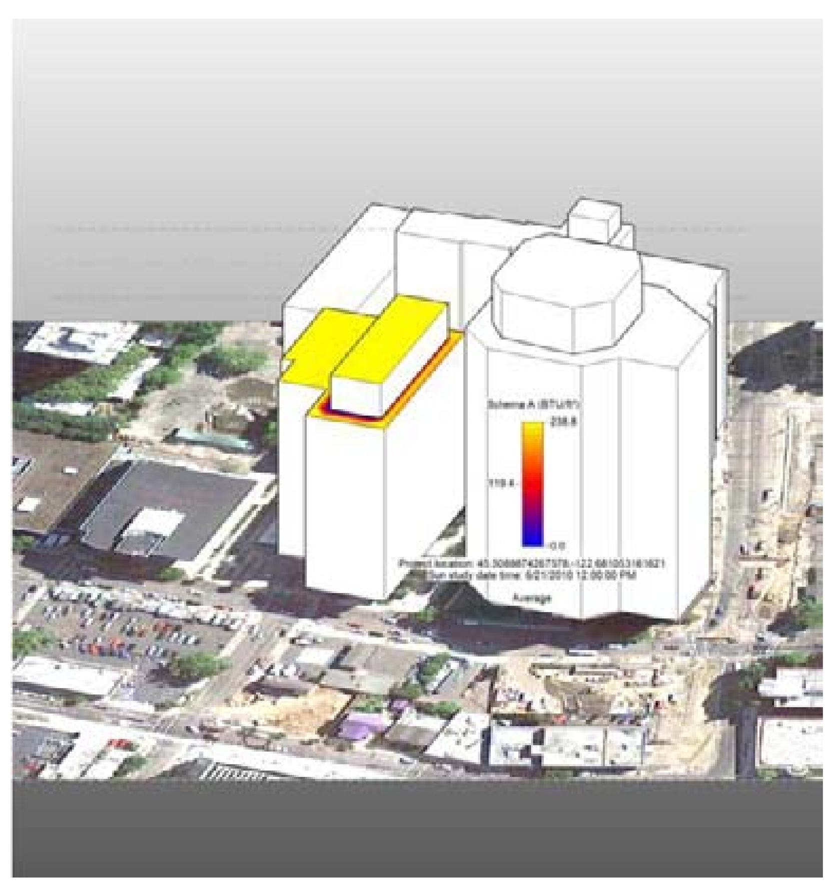

Fig. 4: Average Summer Solstice Solar Radiation

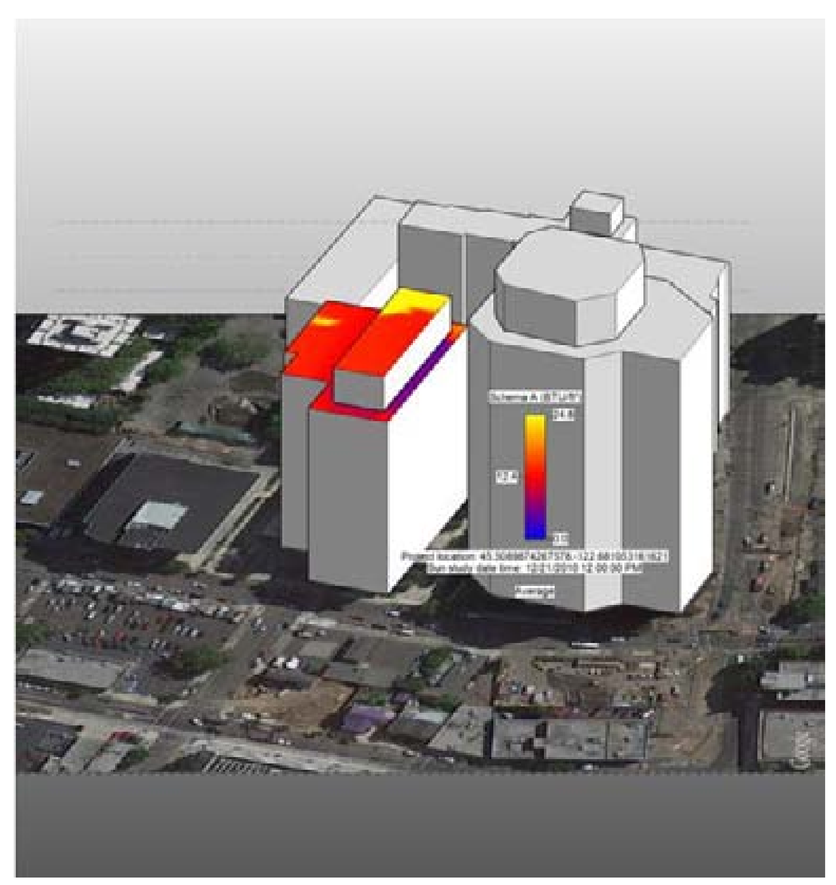

Fig. 5: Average Winter Solstice Solar Radiation

SOLAR ANALYSIS CONCLUSION

The values given in Table 1 indicate that energy production is indeed possible on the roof of the buidling over the course of the year. The individual values shown demonstrate that the energy is variable over the course of the year, but that in total, the insolation received on the surface of the roof over a year is nearly 25 kWh of energy per square foot of roof area. Not taken into account in this analysis is the efficiency of photovoltaic units at generating electricity, or the corresponding amount of energy that could be produced from the associated insolation energy received.

Estimated Yearly Solar Energy Potential		
Cumulative (total yearly)	85,927.05	BTU/ft²
Average (per hour)	3.80	BTU/ft²
Peak (per hour)	7.50	BTU/ft²
Average (per hour)	87.59	BTU/ft²
Average (per hour)	16.35	BTU/ft²

FACADE SYSTEMS RESEARCH

One of the most important pieces of a high performing building is the building facade. To reduce the amount of energy used to condition a building, the facade should be optimized so that energy losses are minimized. The existing Engineering Building atrium is a fully glass wall on both North and West sides. One of the architectural imperatives in designing an addition to the structure is to match the architectural style of the existing walls, but energy performance and solar shading are also important factors to consider. Initial research was conducted into the performance of various facade systems to aid designers in choosing the best product for the addition's design.

Key factors detailed in the research were the availability of the product in the United States (Germany is currently producing some of the most high-performing facade systems in the world, and two of those manufacturers have begun to make their product available in the United States), the materials used for the insulation, and the overall U-Value of the facade system. Multiple facade systems were chosen to research, based on the available high-performance models on the market. Initial research was based on the high-performance systems reviewed in the GreenSpec Guide produced by Environmental Building News.

Limitations on the research conducted include lack of accessibility to desired information, including manufacturing location. To meet the Living Building Challenge, products used in building construction must be locally sourced. Without making a direct request to the manufacturer, this information can be difficult to find. In this research, manufacturing information was not available. In addition, manufacturers make material information available at different levels of specification. In order to fully understand the materials of the product researched, a direct request to the manufacturer must be made. Finally, many manufacturers offer their products in modular form or with many design options. Without specifying all of the details associated with the facade, an accurate representation of the U-value and thus the performance of the facade system is difficult to achieve.

Detailed below is the initial table of research conducted to show the performance of the selected building assemblies. U-values were found to vary greatly depending on manufacturer and product configuration, but low range estimates of 0.14 Btu/hr*ft²*F were available. These products correlate to an R-value of 7 or 8 Btu/hr*ft²*F.

Product	Manufacturer	Insulation Material	Overall U-Value
1600 UT	Kawaneer	Fiberglass pressure plate	0.22-0.53 Btu/hr*ft^2*F
YCW 750 XT	YKK	Nylon polyamide glass fiber rein-forced bars	0.18-0.37 Btu/hr*ft^2*F
HP Wall	Wasau Window	EPDM Gaskets/ Rigid XPS foam	0.18-0.52 Btu/hr*ft^2*F
Therm+	Raico (Germany), distributed by Peak BP	Not available.	0.14- 0.16 Btu/hr*ft^2*F
FW 50+/60+ or 50+/60+ HI	Shuco USA	Not available.	0.16-0.40 Btu/hr*ft^2*F

CONCLUSION

The Portland State University project is a unique project in terms of the typical design timeline used by ZGF and partners. Because it is a feasibility study, the design work happening within the project is occurring in the 'Conceptual Design" phase and depending on fundraising solutions, the timeline for creating design documents and construction documents could be lengthy. The project provides an interesting opportunity, however, to understand how pre-design decision like facade choices and an understanding of site solar access can inform sustainability choices during the actual design of the project.

Here, preliminary research into design opportunities for the expansion project shows that facade systems and solar energy generation potential exist and may be enough to help meet the high-performance goals set by the project team. The initial investigation shows that total solar insolation on the roof surface reaches 85,927 BTU/ft² each year, indicating that some of the building's energy use could be offset by installation of a photovoltaic system. This energy generation could allowe the building addition to reach the goal of embodying the Living Building Challenge principles as related to energy use. In addition, high-performance facade systems exist that could allow the addition to maintain the architectural style of the original building while achieving better energy performance than a typical glass system. Further research, however, must be conducted to determine the most appropriate facade and photovoltaic system to meet the needs of the specific design.

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