EDITH GREEN - WENDELL WYATT FEDERAL BUILDING MODERNIZATION

Energy Analysis Report

Energy Performance Update

July 19, 2013 Version 7.0

Prepared by

[redacted]

EDITH GREEN-WENDELL WYATT
FEDERAL BUILDING MODERNIZATION

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Energy Analysis Report

Executive Summary & Results

Overview

This report summarizes the whole building energy analysis performed by [redacted] for the Edith Green - Wendell Wyatt (EGWW) Federal Building located in Portland, Oregon. This report serves as an update to the previous energy work documented in the Energy Analysis Report dated November 23, 2011, Version 6.0. For the purposes of this report and to avoid confusion between previous energy modeling efforts, the current building energy model has been referenced as EGWW Energy Analysis Report Version 7.0.

The energy analysis described herein reflects development of the project design as represented by the IOC-010 (Item of Change) submission documents dated September 16, 2011, associated revision updates to this submission in the form of RFI (Request for Information) revisions or partial trade IOC submissions available as of November 2012, and available submittal information to provide an update on the anticipated building's Energy Use Intensity (EUI). Tenant Improvement documentation available as of November 2012 has been incorporated into the energy model.

While this report focuses on the building energy modeling used to progress the projected Energy Use Intensity (EUI) estimations, additional modeling has been completed to support the following requirements;

- A baseline and proposed energy model using ASHRAE standard 90.1-2007 Appendix G and LEED protocol has been created and submitted to LEED online for review by the Green Building Certification Institute (GBCI).The project has documented a 39.12% energy cost savings and 14 LEED credit points.
- A baseline and proposed energy model using ASHRAE standard 90.1-2007 Appendix G and the Energy Trust of Oregon (ETO) Technical Guidelines version 8 for new construction was created. This has been reviewed and approved at the time of issuing this report. Projected incentives prior to the ETO verification walk through are $320,055 plus $30,000 for Measurement and Verification (M&V).

Explanation of Version Changes

The energy model and this document have been updated throughout the course of the project design and construction process. Estimated energy use has evolved over time as the project team has refined design and developed deeper understanding of intended uses and operation of the building. This list briefly summarizes the changes between versions of the report and model.

When the EGWW project was restarted in 2009, the Energy Analysis Report from the 2006 design was considered Version 1.

Energy Analysis Report, Version 2.0 issued September 25, 2009
Prepared by [redacted]

- Restart of the project in 2009.
- Evaluated the design changes recommended in the Energy and Water Conservation Measures studies—the HPGB design.
- Compared two mechanical systems to the 2006 design:

  - Optimized variable air volume system (VAV) with central plant.
  - Hydronic radiant heating & cooling ceiling panel system with dedicated outside air system (DOAS).

Energy Analysis Report, Version 3.0 issued November 24, 2009
Prepared by

- Updated energy model and report based on comments from 3rd Party Peer Review by .

Snapshot #3 Energy Analysis Report, Version 1.0 issued April 28, 2010
Prepared by

- Report doesn't conform to versioning convention. Should have been **Version 4.0**
- Energy performance update based on Snapshot #3 issued March 5, 2010.
- First version of the energy model based on the approved concept design for EGWW.
  - Radiant heating and cooling with DOAS on floors 2-17
  - Basement, Ground and First Floors with a VAV system.

Energy Analysis Report, Version 5.0 not issued

- Circulated for internal edits only.

Energy Analysis Report, Version 5.1 issued October 7, 2010
Prepared by

- Energy performance update based on Snapshot #6 issued June 25, 2010.
- Included sensitivity analyses of various operational and design options.

Energy Analysis Report, Version 6.0 issued 23 November 2011
Prepared by

- Energy performance update and LEED check point based on IOC-005 (Item of Change) issued May 3, 2011.
- A baseline energy model using ASHRAE standard 90.1-2007 Appendix G was created to provide the team with insight into the building's performance with respect to LEED v3-2009 Energy and Atmosphere credit 1 – Optimize Energy Performance.

Energy Analysis Report, Version 7.0 issued July 19, 2013
Prepared by

- Based on project documents dated August 2012 and available submittal information.
- Tenant Improvements and survey information included.
- The baseline energy model using ASHRAE standard 90.1-2007 Appendix G was updated to provide the team with insight into the building's performance with respect to LEED v3-2009 Energy and Atmosphere credit 1 – Optimize Energy Performance.
- Energy model submitted to ETO for Path to Net Zero incentive and reservation of incentives.

Energy Use Intensity (EUI) Update

The project's EUI is defined as the total annual building energy use in kBTU divided by the building area (SF). EUI is expressed as kBTU/SF/yr.

The EGWW EUI **excludes** the parking garage to make it a balanced comparison with other office buildings. It is based on 438,952 GSF.

The table below summarizes the evolution of the EUI range for the project.

	PHASE	EUI RANGE kBTU/SF/yr	Solar PV % contribution
National Office Buildings Average (CBECS 2003)		94	
EGWW Existing Building 7 year range	Existing	74-85 (Average 79)	n/a
EGWW Modernization	SD	28-34 +/- 20%*	*Included in EUI range***
EGWW Modernization	DD	32-38 +/- 20%*	
EGWW Modernization	SS#6	33-38 +/- 15%	5-6%
EGWW Modernization	50% Construction	33-38 +/- 15%	5-6%
EGWW Modernization	100% Construction + TI	30-35 +/- 10%	3-4%

Table 1 EUI Tracking

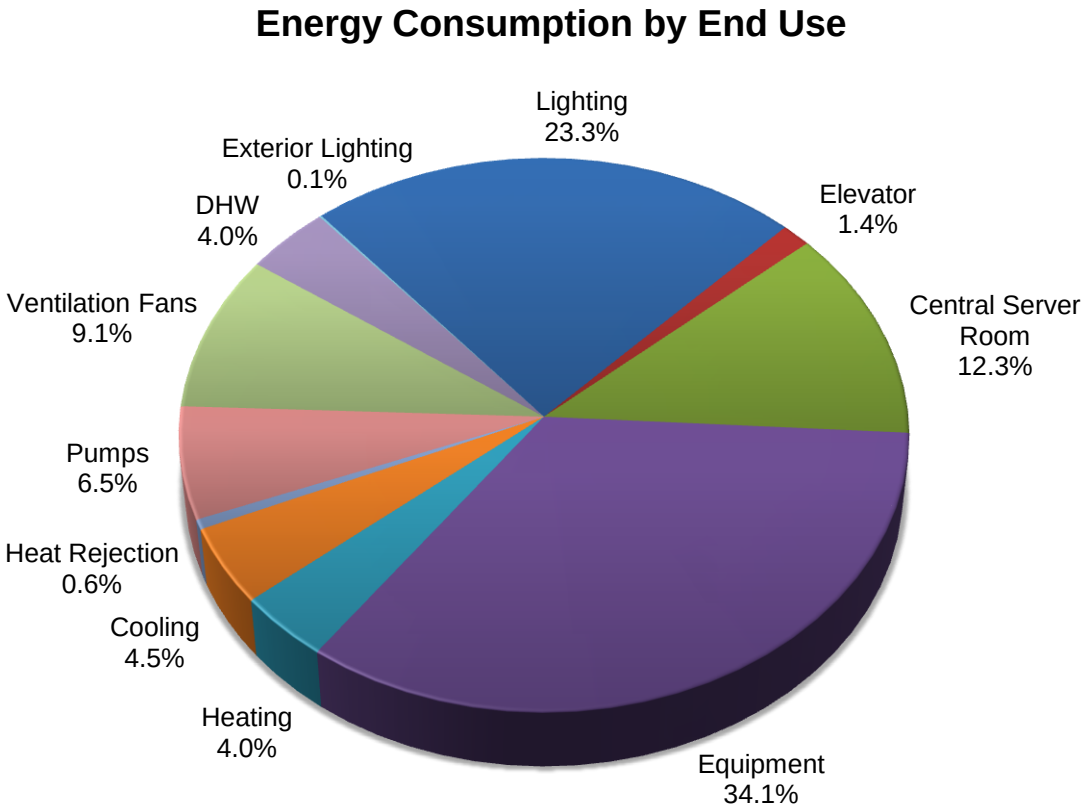
* We've identified our current target at major project milestones / phases, consistent with the information created to that date, and have developed a series of target refinements as the design has been articulated. This has served to tighten the range as well as increase the confidence we have in the data/outcome. Energy savings, computed during schematics, are based on incomplete design and engineering efforts. In addition, various schedule and operational adjustments during occupancy can contribute to variance in actual performance. Given the underlying requirement set is imperfect; computations based on that data will be less than 100% accurate too.

** SD and DD reporting of EUI targets included a deduction for the contribution of on-site renewable energy generation. Beginning at SS#6 and later submissions, EUI reported is the total energy used by the project site (regardless of on-site generation or grid purchase). On-site renewable electricity generation from the rooftop photovoltaic system for these phases is reported as a % of the total estimated energy consumption.

This update incorporates Tenant Improvement designs. Previous versions reflected Core & Shell design with assumptions about future Tenant Improvement design parameters. The project team made an effort to understand all tenants moving into the building, with particular detail for the largest tenants and their usage requirements in order to tighten the anticipated EUI range from previous Energy Analysis reporting milestones. The project maintains an EUI range to account for a number of factors outside of the control of the design and construction team such as weather variation, ongoing tenant improvements, potential variations in building operating parameters, tenant behavioral patterns, and evolving building usage patterns and system tuning. For example, the Central Server Room (CSR) load is a significant end-use contributor that has a wide range of potential energy performance based on actual operational use profiles (as described in more detail in the "Building Description and General Modeling Parameters" section of this report). The assumptions for this end use alone represent a potential

2 to 5.5 kBTU/SF impact on the EUI range. While the EUI range could be even greater than indicated, we believe the published range reflects a reasonable range in these variables.

A Sensitivity Analysis performed as part of the Version 5.1 energy model was used to establish the effects on building EUI based on tenant usage characteristics as well as design parameters that were in flux at that time. This sensitivity analysis has been included (Appendix C) to emphasize that during actual building operation, a range of different tenant behaviors, operational schedule adjustments and support requirements can be expected. The Version 5.1 report looks into the impacts of several scenarios and can be used as a reference for future energy expectations that encompass evolving tenant needs.



	Lighting	Elevator	Central Server Room	Equipment	Heating	Cooling	Heat Rejection	Pumps	Ventilation Fans	Domestic Hot Water	Exterior Lighting	Totals
Electricity Use- kWh	915,849	54,615	483,998	1,339,925	1,169	176,595	22,335	256,958	358,492	0	4,180	3,614,116
Natural Gas Use- Therms	0	0	0	0	5,258	0	0	0	0	5,424	0	10,682
Total Energy Use- MBTU	3,125	186	1,651	4,572	530	603	76	877	1,223	542	14	13,400

Figure 1 EGWW Energy Consumption by End Use

Introduction

The Edith Green Wendell Wyatt Federal Building (EGWW) was the subject of a modernization design effort spanning from 2004 to 2006 when final documentation was halted due to lack of project funding.

The American Recovery and Reinvestment Act of 2009 (ARRA) signed into law on 17 February 2009 included funding to improve the energy and water conservation performance of Federal Buildings. A portion of that funding was made available for the EGWW project. [redacted] has stated that EGWW building project shall be required to meet certain energy targets to receive ARRA funding.

Between May and July 2009, the design team evaluated a variety of energy conservation measures that were identified as part of the two-day High Performance Green Building Workshop. Using an eQuest energy model originally developed as part of the 2006 design effort as the primary evaluation tool, the team identified the most promising measures for more intensive technical analysis and refinement of conservation metrics. These measures were further studied and evaluated through detailed analysis in July, August and September of 2009, and a number of recommended design changes were developed as a result of that analysis. These analysis efforts and resulting design recommendations are described in the September 2009 “Parametric Design Analysis of Energy and Water Conservation Measures” report. The design resulting from these recommendations is referred to as the High Performance Green Building (HPGB) Design.

Between August and November 2009 the design team completed additional energy analysis to compare the 2006 Design to the HPGB Design using two different HVAC distribution system options for Floors 2-17; an optimized, central VAV system and a radiant heating/cooling panel with DOAS. These analysis efforts and results are described in the “EGWW Energy Model Report V3.0” report.

In February 2010 the design team completed an additional energy analysis comparing the radiant heating/cooling panel system with DOAS to the P100 baseline HVAC system, a floor-by-floor VAV system coupled with an OAVS. Throughout 2010 the design team provided two updates to the energy model that corresponded to design milestones Snapshot #3 and Snapshot #6.

As part of the ongoing updating of the energy model through the design and construction process, this report summarizes the modeling assumptions, methodologies and results for energy performance based on the project documents dated August 2012 and available submittal information from both the Core & Shell and Tenant Improvement. Tenant survey information regarding building use has also been incorporated.

ASHRAE 90.1-2007 Appendix G Energy Use Comparison

ASHRAE 90.1-2007 Appendix G Performance Rating Method (PRM) is the energy modeling reference criteria that LEED v2009 Energy and Atmosphere credit 1 uses to determine a proposed buildings performance versus an industry standard building and has been selected as the basis for ETO incentives. The PRM is intended for use in rating the energy efficiency of building designs that exceed the requirements of the standard. This allows a project team to quantify the anticipated performance improvement of a proposed building versus a standard industry baseline. The metric used for comparison is annual energy operating costs; the utility rates used to determine annual energy operating costs for this analysis are as follows. These rates were determined using averages provided by the Energy Information Administration.

- Natural Gas – $0.995/Therms
- Electricity – $0.085/kWh

The 90.1 Baseline PRM building utilizes the same building geometry, occupancy, process loads, areas, and schedules as the proposed building however, uses industry standard building envelope, systems, and lighting power. This allows the proposed building to take credit for areas where it has gone above and beyond what ASHRAE 90.1-2007 considers industry standard.

Envelope

Baseline performance for envelope is determined by project location. Portland's climate is classified as a heating dominated marine environment (climate zone 4C). A detailed comparison between the proposed building and this baseline envelope has been included in later sections of this report.

Systems

The baseline building systems are defined based on building type, size, and primary heating source. The EGWW project ASHRAE 90.1 PRM Baseline building uses a variable volume (VAV) fan system with chilled water for cooling and hot water for heating (PRM System 7). For spaces that have process loads that differ significantly from the rest of the building, an alternative baseline system was used in accordance with noted exceptions. In these ancillary spaces, the baseline model uses DX cooling, a furnace section for heating, and a constant volume fan (PRM System 3). These spaces include the Data center, electrical, and security rooms.

Lighting

The Building Area method, corresponding to 1 W/SF for office buildings, was used to determine the baseline building lighting use in the tower and 0.3 W/SF was used to determine the baseline building lighting power use in the parking areas. The PRM baseline building does not incorporate any daylight dimming systems. The space by space method was also investigated however, the building area method projected higher savings.

LEED NC-2009 Results

An ASHRAE 90.1-2007 Appendix G Energy Model was built incorporating LEED modeling protocol used for comparing the proposed building's annual energy operating costs to a baseline building annual energy operating cost. This comparison was used to confirm the LEED v3-2009 Energy and Atmosphere credit 1 point status and Platinum Target.

Based on this analysis, the energy cost savings of the EGWW building design as compared to the ASHRAE Baseline, including on-site generation from the photovoltaic canopy, is approximately 39%, and will provide 14 points under LEED v2009 Energy and Atmosphere credit 1 (EAc1). The projected estimate of savings as compared to ASHRAE 90.1 takes credit for exceptional calculations including reduced outdoor air quantity for DOAS, increased space temperature dead band for equivalent comfort in radiant panel system, regenerative elevators, variable speed garage ventilation, energy star rated equipment and appliances, and demand control ventilation. Though the design team is confident that a majority of these exceptional measures will be accepted by the LEED GBCI reviewers, final energy cost savings with respect to LEED modeling protocol is at the discretion of review process. The complete LEED v3-2009 Energy and Atmosphere credit 1/Prerequisite 2 template has been included under Appendix A.

ETO Path to Net Zero Incentive Pilot Program

An ASHRAE 90.1-2007 Appendix G Energy Model was built incorporating the Energy Trust of Oregon (ETO) Technical Guidelines version 8 for New Construction protocol. This information was used for comparing the proposed building's annual operating energy to a baseline building annual operating energy. This comparison was used to determine incentives for building performance improvements and if the project would meet the Path to Net Zero performance requirements (50% better then baseline).

Based on this analysis the proposed building is projected to qualify for $320,055 from the ETO. The final incentive amount still requires a successful commissioning effort and ETO verification walk through on completion before funds can be released. The modeling effort also determined that the projects anticipated energy savings would be in the vicinity of 46-48%, though this is shy of the 50% requirement the ETO has deemed it within range of the target and allowed the project to remain a part of the Path to Net Zero Pilot Program. This will allow the project to apply for up to an additional $25,000 in incentives for Measurement and Verification infrastructure. The executive summary and incentive calculation sheets from the report issued to the ETO are included under Appendix B.

Results

The following table summarizes the results between the proposed and baseline buildings

Baseline 0 Degree Rotation vs Proposed Energy Use													
	LIGHTS	ELEVATOR*	CSR*	MISC EQUIP*	SPACE HEATING	SPACE COOLING	HEAT REJECT	PUMPS & AUX	VENT FANS	DOMEST HOT WTR	EXT USAGE	TOTAL ENERGY USE	Total Energy Cost ($)
LEED Code Baseline, Electricity Use- kWh	1,581,765	129,910	483,998	1,504,441	0	339,073	10,788	178,481	809,995	0	10,882	5,049,333	$ 429,193
LEED Code Baseline, Natural Gas Use- Therms	0	0	0	0	55,258	0	0	0	0	6,583	0	61,841	$ 61,532
LEED Code Baseline, Total Energy Use- MBTU	5,397	443	1,651	5,133	5,526	1,157	37	609	2,764	658	37	**23,412**	$ 490,725
Percent of Total Use	23.1%	1.9%	7.1%	21.9%	23.6%	4.9%	0.2%	2.6%	11.8%	2.8%	0.2%		
Proposed Building, Electricity Use- kWh	906,297	54,615	483,998	1,339,925	1,122	182,270	22,615	256,672	361,888	0	4,180	3,613,582	$ 307,154
Proposed Building, Natural Gas Use- Therms	0	0	0	0	4,918	0	0	0	0	5,424	0	10,342	$ 10,290
Proposed Building, Total Energy Use- MBTU	3,092	186	1,651	4,572	496	622	77	876	1,235	542	14	**13,364**	$ 317,445
Percent of Total Use	23.1%	1.4%	12.4%	34.2%	3.7%	4.7%	0.6%	6.6%	9.2%	4.1%	0.1%		
*Indicates process load											**Electricity Cost Savings**		$ 122,039
											Natural Gas Cost Savings		$ 51,242
											Renewables Cost Savings (PV)		$ 18,275
											Total Cost Savings		$ 191,555
											Percent Cost Savings		39.04%
											Percent Energy Savings		46.05%

Table 2 LEED Results

Note – Usage for the proposed building indicated above is not identical to that shown in the executive summary. This is due to site shading which cannot be included for the ASHRAE 90.1-2007 Appendix G comparison process, but is included in the Executive Summary. Note also that the savings values differ between what is shown in the LEED NC-2009 Results and ETO Path to Net Zero Incentive Pilot Program. This is because of slightly different rules regarding modeling methods in comparison to the standard that are allowed and/or required for the various entities. For example, how credit for exceptional measures is handled affects results.

Explanation of Results

Lighting

EGWW is targeting aggressive lighting goals which are yielding high energy savings. These goals are achieved through an advanced daylight control system, extensive used of occupancy sensors, and a very low lighting power densities.

Space Heating

The high performance curtainwall system reduces heating load. The mechanical plant utilizes condensing hot water boilers and energy recovery in the air handling units significantly reducing heating loads and improving heating efficiency. The baseline ventilation system that the EGWW project is being compared to also incurs a reheat penalty for the variable volume terminal units. The radiant panel system does not incur this same penalty further increasing heating savings. Using a radiant system the building is also capable of taking advantage of extended temperature deadbands. The Central Server Room (CSR) utilizes a heat recovery chiller which reuses the waste heat to heat the building.

Space Cooling

The building's exterior shading devices, and high performance glazing system both account for significant reductions in cooling loads and energy use. In addition, high efficiency chillers, water side economizer, and the radiant cooling system all contribute to the space cooling savings shown above. Using a radiant system the building is also capable of taking advantage of extended temperature deadbands.

Pumps

With a radiant system the proposed EGWW mechanical pumps must move a significantly larger amount of water then the baseline system. However, EGWW uses primary variable flow for heating, cooling, and heat rejection compared to the baselines primary variable flow for heating, constant primary variable secondary for cooling, and constant flow for heat rejection minimizing the additional energy use for pumping of the radiant system.

Ventilation Fans

Another benefit of the radiant panel + DOAS system is that it decouples ventilation from thermal comfort, thereby reducing the air moved through the building to what is required for ventilation. In contrast, the ASHRAE baseline VAV systems recirculate a large percentage of air for thermal comfort conditioning, thereby pushing much larger quantities of air through the building and using more fan energy. In addition, because of the high heating supply temperature of a VAV system and overhead distribution, the baseline building ventilation system is 20% less effective at providing ventilation to the breathing zone of the space as the proposed system. As a result of this the baseline must over-ventilate the building which results in higher energy use.

Building Description and General Modeling Parameters

EGWW is an 18 story office building located in the heart of Portland owned by [redacted]. The building was originally constructed in the early 1970's and is currently undergoing an extensive modernization which includes a new facade and mechanical, electrical, and plumbing systems. The building has two underground floors that include parking, loading dock, mail delivery, storage, office, conference, security, and general amenity spaces. The building's main entrance lobby is located on Level 1, with office space on the floors above. The main mechanical and electrical rooms that serve the building can be found on level 18, and there are additional support spaces within the underground levels.

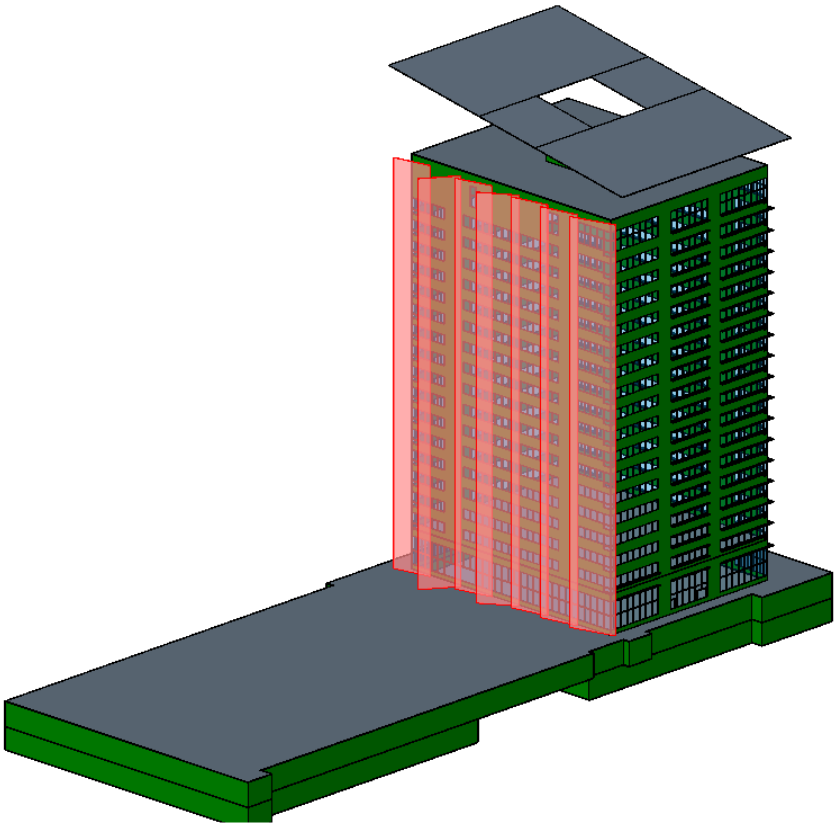


Figure 2 Screen shot of the EGWW energy model used for this analysis

Building Area and Space Assignments

Below is a summary of the general building areas and the cumulative areas of each space use in the model. Note that the energy model areas are intended to be within several percent of the areas calculated in the architectural models. The table below has been generated directly from the Revit model used to create the energy models geometry and does not include areas associated with walls and partitions.

Model Input Parameter	Thermal Zones	Area (SF)
Break Room	30	5,278
Conference	58	21,461
Corridor	106	48,520
Data Center	3	3,142
Dining	1	1,818
Elevator	60	12,575
Gymnasium	1	1,839
Laboratory	1	451
Lobby	2	5,775
Mail Room	4	2,016
Mech or Elec	97	27,481
Multipurpose	3	4,641
Parking	4	80,835
Reception	13	4,864
Restroom	25	10,613
Retail	1	215
Riser	63	5,533
Security	2	1,002
Stairs	43	8,357
Storage	92	35,015
Trash	1	1,292
BLM Open Office	24	34,838
BLM Enclosed Office	16	3,831
FS Open Office	25	46,574
FS Enclosed Office	16	3,837
IRS Open Office	20	28,644
IRS Enclosed Office	29	9,848
Other Agencies Open Office	34	48,633
Other Agencies Enclosed Office	34	11,763
Copy Room	23	4,643
Focus Room	11	1,494
Filing/Working Area	44	13,521
Courtroom	3	2,605
Waiting Area	1	2,110
Café	1	878
TOTALS	**891**	**495,942**

Table 3 Building areas and number of thermal zones by space end use

Occupancy

EGWW occupancies have been defined to reflect the stacking plan provided by [redacted] in November 2012. Based on the stacking plan, a study was conducted to accurately reflect the anticipated tenant occupancies and their usage characteristics. As part of this study, it was determined that the building would be broken into four key usage groups. Three of these usage groups cover the larger tenant agencies within the building inclusive of the Bureau of Land Management (BLM), Forestry Service (FS), and Internal Revenue Service (IRS). The remaining

tenant agencies have been grouped into a general tenancy category (CS). The following table represents information extracted from the stacking plan and used in this study.

Area (SF) by Level	FS	BLM	IRS	TIGTA	DOI OVS	NLRB	DOJ EOIR	HUD	USDA OGC	USDA LG	USDA FV	DHS OPLA	COLD SHELL	STOC SHELL	JOINT USE	COM MON	ASSIG N	TOTAL	OCC	Future Occ	COURT /WAIT	Total	SF/Per
MECH													7,728					7,728		38		38	203
Level 17	15,863														93	2,629		18,585	96			96	194
Level 16	15,863														93	2,629		18,585	91			91	204
Level 15	12,907	2,057		850											93	2,629		18,536	91			91	204
Level 14	15,863														93	2,629		18,585	75			75	248
Level 13	7,905	7,958													93	2,629		18,585	59			59	315
Level 12		15,863													93	2,629		18,585	102			102	182
Level 11		15,863													93	2,629		18,585	112			112	166
Level 10		9,103			2,926										93	2,629	3,834	18,585	74	18		92	202
Level 9			15,863												93	2,629		18,585	104			104	179
Level 8			15,863												93	2,629		18,585	101			101	184
Level 7			15,863												93	2,629		18,585	51			51	364
Level 6			10,346			4,171									93	2,629	1,346	18,585	65	7	20	92	202
Level 5							8,593							7,270	93	2,629		18,585	16	35	105	156	119
Level 4								15,863							93	2,629		18,585	67			67	277
Level 3									4,128	1,172	2,518	4,401		3,644	93	2,629		18,585	38	18		56	332
Level 2														15,863	93	2,629		18,585		80		80	232
Level 1																13,171		13,171	6		70	6	
Level 0																38,629		38,629	24	6	53	30	
Level B1																40,267		40,267				0	
Total	**68,401**	**50,844**	**57,935**	**850**	**2,926**	**4,171**	**8,593**	**15,863**	**4,128**	**1,172**	**2,518**	**4,401**	**7,728**	**26,777**	**1,488**	**134,131**	**5,180**	**397,106**	**1,172**	**202**	**248**	**1,499**	**265**

Table 4 Building Areas by Level and Tenant Agency

Each of the four occupancy groups were then analyzed specific to the amount of open and private office areas they had planned. This information was used to generate occupant densities for each usage group. The following table summarizes the outcome of this effort and reflects the occupancy densities used in the energy model. Through occupancy scheduling this building population was then spread throughout all support spaces under the premise that if occupants are not at their work stations then they are in support/circulation spaces such as a conference room, copy room, or break room.

	Total SF	Total Occ	Open Office	Occupancy	SF/Occ	Enclosed Office	Occupancy	SF/Occ
Forestry Service	68,401	366	46,574	338	138	3,837	28	133
Bureau of Land Management	50,844	373	34,838	345	101	3,831	28	133
Internal Revenue Service	57,935	298	28,644	224	128	9,848	74	133
Miscellaneous Agencies	79,127	462	48,633	374	130	11,763	88	133

Table 5 General building occupancies used for occupied spaces

Once peak occupancy information was established each of the major tenant groups was surveyed to understand what percentage would be working remotely for a portion of the week, typical working hours, and what percentage of the office would be using laptop computer technology instead of desktops. This information was used to define occupancy, lighting, and equipment loads and schedules. The survey results were as follows;

	BLM	FS	IRS
What time does a typical workday start	6 a.m.	7 a.m.	7 a.m.
What time does a typical workday end	6 p.m.	5 p.m.	4:30 p.m.
Will any 'after-hours' schedules be required regularly	Yes[1]	No	Yes[2]
What percentage of the space is occupied, on average	80%	70%	75%
What percentage of employees use laptops/desktop computers	48/52	80/20	-
Is there an obvious or observable trend toward more mobile work	Yes	Yes	-
Is there an obvious or observable trend toward laptop usage	Yes	Yes	-

Notes:
1 - 24/7 required for the server room; During Fiscal Year end the Procurement Office has people working outside of normal business hours from May through September; the Budget Office will require "after-hours" schedules in August and September of each year.

2 - Possibly IRS CI, Counsel and TAC space.

Table 6 Tenant agency usage pattern survey results

For the remainder of spaces throughout the building the occupancy densities in the table on the following page have been used and reflect information from either standard practice or design documentation such as the Basis of Design (BOD) or Owners Project Requirements (OPR).

Model Input Parameter	SF/Person
Break Room	40
Conference	20
Corridor	2,000
Lobby	100
Mail Room	200
Multipurpose	20
Reception	100
Retail	125
Storage	1,000
Copy Room	1,000
Focus Room	80
Filing/Working Area	200
Courtroom	25
Waiting Area	40
Café	26

Table 7 General building occupant densities

Interior Lighting

EGWW lighting levels have been input based on both the Core & Shell and Tenant Improvement design packages. A detailed count of all areas was conducted to ensure the modeled lighting levels reflected what was designed. As part of this exercise each fixture within the building was then assigned operational characteristics which included whether it was on emergency power for egress, occupancy controlled, included daylight dimming, or a combination or occupancy control and daylight dimming. The following two tables are reports that were used to determine the performance of the interior lighting system by occupancy category and how that related to the building as a whole with respect to the ASHRAE baseline.

Daylight Harvesting & Occupancy Controlled Lighting

Daylight Study

Daylight control was modeled using the results of a daylighting analysis performed by [redacted] in conjunction with the Energy Studies in Buildings Laboratory (ESBL) as described in the 21 September 2009 “Parametric Design Analysis of Energy and Water Conservation Measures” report. [redacted] provided detailed hourly schedules to modify the lighting power density for perimeter zones on each façade. These schedules presented typical weekdays for each month to accurately reflect how daylight control is anticipated to reduce electric lighting power throughout the year. This information was used to calibrate inputs into the eQuest daylight tool to model the effects of the daylight control system.

Occupancy Controlled Lighting

Based on research performed by the Pacific Northwest National Laboratory (PNNL), lighting schedules were used to adjust lighting power levels to reflect anticipated savings as a result of occupancy controlled areas.

				Baseline		Proposed	
Description	**Type**	**Zones**	**Area**	**Power kW**	**LPD W/sf**	**Power kW**	**LPD W/sf**
BRAK	Break Room	30	5,278	5.28	1.00	4.76	0.90
CONF	Conference	58	21,461	18.41	1.00	20.57	0.96
CORR	Corridor	106	48,520	49.03	1.00	44.94	0.93
DATA	Data Center	3	3,142	3.14	1.00	1.35	0.43
DINN	Dining	1	1,818	1.82	1.00	0.72	0.40
ELEV	Elevator	60	12,575	0.00	0.00	0.00	0.00
GYMN	Gymnasium	1	1,839	1.84	1.00	1.44	0.78
LABO	Laboratory	1	451	0.45	1.00	0.57	1.26
LOBB	Lobby	2	5,775	5.78	1.00	3.76	0.65
MAIL	Mail Room	4	2,016	2.02	1.00	1.53	0.76
MEEL	Mech or Elec	97	27,481	27.48	1.00	17.01	0.62
MULT	Multipurpose	3	4,641	4.64	1.00	2.94	0.63
PARK	Parking	4	80,835	24.25	0.30	7.57	0.09
RECP	Reception	13	4,864	4.86	1.00	4.01	0.82
REST	Restroom	25	10,613	10.61	1.00	8.27	0.78
RETL	Retail	1	215	0.22	1.00	0.13	0.60
RISE	Riser	63	5,533	0.00	0.00	0.00	0.00
SECU	Security	2	1,002	1.00	1.00	0.60	0.60
STAR	Stairs	43	8,357	8.25	1.00	2.70	0.32
STOR	Storage	92	35,015	32.37	1.00	25.94	0.74
TRAS	Trash	1	1,292	1.29	1.00	1.02	0.79
BOOF	BLM Open Office	24	34,838	34.84	1.00	27.73	0.80
BEOF	BLM Enclosed Office	16	3,831	3.83	1.00	2.94	0.77
FOOF	FS Open Office	25	46,574	46.57	1.00	34.12	0.73
FEOF	FS Enclosed Office	16	3,837	3.84	1.00	3.30	0.86
IOOF	IRS Open Office	20	28,644	28.64	1.00	23.36	0.82
IEOF	IRS Enclosed Office	29	9,848	9.85	1.00	8.28	0.84
COOF	CS Open Office	34	48,633	51.30	1.00	47.67	0.98
CEOF	CS Enclosed Office	34	11,763	11.76	1.00	9.14	0.78
COPY	Copy Room	23	4,643	4.64	1.00	4.54	0.98
FOCU	Focus Room	11	1,494	1.49	1.00	1.37	0.92
FILE	Filing/Working Area	44	13,521	13.52	1.00	11.84	0.88
COUR	Courtroom	3	2,605	2.61	1.00	2.25	0.86
WAIT	Waiting Area	1	2,110	2.11	1.00	1.23	0.58
CAFF	Café	1	878	0.88	1.00	0.18	0.21
	TOTALS	**891**	**495,942**	**418.63**		**327.77**	

Table 8 Lighting Power Densities (LPD) by space type

	Baseline		Proposed	
Total Lite Area	477,834	sf	477,834	sf
Installed Power	418.6	kW	327.8	kW
Overall Power Density	0.88	W/sf	0.69	W/sf
Tower (Building Area) Area	393,067	sf	393,067	sf
Tower (Building Area) Installed Power	393.2	kW	318.4	kW
Tower (Building Area) Power Density	1.00	W/sf	0.81	W/sf
Parking (Building Area) Area	84,767	sf	84,767	sf
Parking (Building Area) Installed Power	25.43	kW	9.4032	kW
Parking (Building Area) Power Density	0.3	W/sf	0.11	W/sf
Tower Level 2-17 Area	286,940	sf	286,940	sf
Tower Level 2-17 Installed Power	286.9	kW	240.6	kW
Tower Level 2-17 Power Density	1.00	W/sf	0.84	W/sf
Number of Lite Zones Total	768		768	
Number of Zones with Occ Sensors	91		584	
Number of Zones with Daylight Control	N/A		98	
Fixture Power Daylight Controlled	N/A		55.7692	kW
Fixtures Controlled in Daylight Zones	N/A		66.6%	

Table 9 Lighting performance metrics for whole building

Exterior Lighting

Exterior lighting power was calculated to be 958 W and has been modeled as a direct load for the exterior of the building. Exterior lighting is controlled by a photocell which activates exterior lighting during night hours.

Plug and Equipment Loads

EGWW plug and equipment loads have been defined to reflect the tenant improvement space use characteristics. An extensive plug load study was completed by [redacted] as part of the early stages of the energy modeling process in determining projected loads. Plug loads for the four usage groups were determined using the same methods as the [redacted] study by applying usage group specific information. The results of this update, and information for areas outside of the usage groups has been shown in the tables below.

Model Input Parameter	Proposed Case	
Forestry Service	0.63	W/sf
Bureau of Land Management	0.77	W/sf
Internal Revenue Service	0.67	W/sf
Miscellaneous Agencies	0.63	W/sf
Break Rooms	1.54	W/sf
Conference Rooms	0.62	W/sf
Copy Rooms/File/Working Areas	0.65	W/sf
IDF Rooms/Servers	12.50	W/sf

Table 10 Plug and equipment loads general spaces

Space	Elec	
Security Monitoring Room	1.30	W/sf
Seismic Monitoring Room	1.30	W/sf
N ELEC.Room , 1st FLOOR	2.70	kW
N ELEC.Room , 2nd FLOOR	5.40	kW
N ELEC.Room , 3rd FLOOR	4.10	kW
TR.Room , 3rd FLOOR	1.50	kW
N ELEC.Room , 4th FLOOR	2.70	kW
N ELEC.Room , 6th FLOOR	4.10	kW
TR.Room , 6th FLOOR	1.50	kW
N ELEC.Room , 7th FLOOR	3.59	kW
N ELEC.Room , 8th FLOOR	3.59	kW
N ELEC.Room , 9th FLOOR	4.10	kW
TR.Room , 9th FLOOR	1.50	kW
N ELEC.Room , 11th FLOOR	1.81	kW
N ELEC.Room , 12th FLOOR	4.10	kW
TR.Room , 12th FLOOR	1.50	kW
N ELEC.Room , 14th FLOOR	5.40	kW
N ELEC.Room , 15th FLOOR	4.10	kW
TR.Room , 15th FLOOR	1.50	kW
N ELEC.Room , 17th FLOOR	3.59	kW
Penthouse Electrical Room	4.10	kW
Penthouse Switch Gear Room	5.3	kW
Elevator Machine Room	42.5	kW

Table 11 Plug and equipment loads electric and TR rooms

Central Server Room

The expansion of the Central Server Room (CSR) is the single most significant upgrade to the building that has taken place since the Version 6 Report. This has seen the server load increase from 20kW to 120kW. A large portion of this load increase was a result of moving what would have been small data rooms throughout the tenancies into a central location where the load can be managed more efficiently. The anticipated load could exceed this initial allowance, depending on how heavily the tenancies utilize their servers. The assumptions made here are intended to be a realistic prediction given the best available information.

The energy use of the CSR has been based on 30% energy use during unoccupied hours and 65% occupied during occupied hours. This is based on servers having a predominately occupied energy usage pattern and energy saving features for unoccupied hours. Server energy use is end user specific, and based on industry experience this load has the ability to range from a consistent 30% loading 24/7 to 70% loading 24/7. This range in server intensity alone represents a possible EUI impact range of 2 to 5.5 kBtu/sf. The following tables show the anticipated day 1 CSR loading that has been assumed and the growth that may occur based on design documentation. The “day 2 load” represents the potential for the second floor tenants data requirements and expansion of the BLM and FS rack counts. The “future load” represents the CSR maximum potential loading as designed.

Design Loads	Area (sf)	Load Day 1	Density (W/sf)
Central Server Room	2515	120	47.71
UPS (168kW@99%)	370	1.68	4.54
Switch (222kW@99%)	257	2.57	10.00

Table 12 CSR Model Inputs for day 1

Tenant	Panel	Racks Day 1	kW/Rack	Load Day 1 kW	Racks Day 2	kW/Rack	Load Day 2 kW	Racks Future	kW/Rack	Future Load kW
IRS	CSRA	8	4	32	8	4	32	8	4	32
Tenant	CSRB	0	6	0	5	6	30	10	6	60
BLM	CSRC	10	6	60	12	6	72	15	6	90
FS	CSRD	7	4	28	8	4	32	10	6	60
Totals		25	20	120	33	20	166	43	22	242

Table 13 CSR Future Loading Possibility

Schedules

Schedules in the energy model represent how the building is expected to be used on a day-to-day basis. Hourly schedules are used to represent typical (or average) daily use profiles for occupancy, lighting power usage, and equipment power usage. Sample occupancy, lighting and equipment schedules have been provided below. Schedules are also used to define temperature set points and mechanical control sequencing within the energy model. All schedules used in this energy analysis are based on the survey that was completed on the key usage groups and best industry practice. The hourly loads imposed on the building for occupancy, lighting, and equipment is equal to the densities or loads above multiplied by the respective schedule below.

To give an idea of how the building schedules are interrelated the following schedule map has been provided along with graphical representation of each schedule

#	SPACE IDENTIFIER	SPACE TYPE	OCC	EQU	LTG
1	BRAK	Break Room	SCAFEOCC	SLOBBLTG	STRANSLTG
2	CONF	Conference	SCONFOCC	SCONFEQU	SCONFLTG
3	CORR	Corridor	SALLOFF	SLOWEQU	SEGRLTG
4	DATA	Data Center	SALLOFF	SDATAEQU	SLOWLTG
5	DINN	Dining	SCAFEOCC	SLOWEQU	SCAFELTG
6	ELEV	Elevator	SLOBBOCC	SALLOFF	SALLOFF
7	GYMN	Gymnasium	STRANSOCC	SCSEQU	SCSOOFLTG
8	LABO	Laboratory	SCSOCC	SCSEQU	SCSOOFLTG
9	LOBB	Lobby	SLOBBOCC	SLOWEQU	SLOBBLTG
10	MAIL	Mail Room	SCSOCC	SCSEQU	SCSOOFLTG
11	MEEL	Mech or Elec	SALLOFF	SMEELEQU	SLOWLTG
12	MULT	Multipurpose	SCONFOCC	SCONFEQU	SCONFLTG

#	SPACE IDENTIFIER	SPACE TYPE	OCC	EQU	LTG
13	PARK	Parking	SALLOFF	SALLOFF	SPARKLTG
14	RECP	Reception	SCSOCC	SCSEQU	SRECPLTG
15	REST	Restroom	STRANSOCC	SLOWEQU	STRANSLTG
16	RETL	Retail	SALLOFF	SMEELEQU	STRANSLTG
17	RISE	Riser	SALLOFF	SALLOFF	SALLOFF
18	SECU	Security	SCSOCC	SMEELEQU	SCSEOFLTG
19	STAR	Stairs	SALLOFF	SALLOFF	SEGRLTG
20	STOR	Storage	SALLOFF	SALLOFF	SLOWLTG
21	TRAS	Trash	SALLOFF	SALLOFF	SLOWLTG
22	BOOF	BLM Open Office	SBLMOCC	SBLMEQU	SCSOOFLTG
23	BEOF	BLM Enclosed Office	SBLMOCC	SBLMEQU	SCSEOFLTG
24	FOOF	FS Open Office	SFSOCC	SFSEQU	SCSOOFLTG
25	FEOF	FS Enclosed Office	SFSOCC	SFSEQU	SCSEOFLTG
26	IOOF	IRS Open Office	SIRSOCC	SIRSEQU	SCSOOFLTG
27	IEOF	IRS Enclosed Office	SIRSOCC	SIRSEQU	SCSEOFLTG
28	COOF	CS Open Office	SCSOCC	SCSEQU	SCSOOFLTG
29	CEOF	CS Enclosed Office	SCSOCC	SCSEQU	SCSEOFLTG
30	COPY	Copy Room	STRANSOCC	STRANSEQU	STRANSLTG
31	FOCU	Focus Room	STRANSOCC	STRANSEQU	STRANSLTG
32	FILE	Filing/Working Area	STRANSOCC	STRANSEQU	STRANSLTG
33	COUR	Courtroom	SCONFOCC	SCONFEQU	SCONFLTG
34	WAIT	Waiting Area	SWAITOCC	SLOWEQU	SRECPLTG
35	CAFF	Café	SCAFEOCC	SCAFEEQU	SCAFELTG

Table 14 Project Schedule Map

Occupancy Schedules

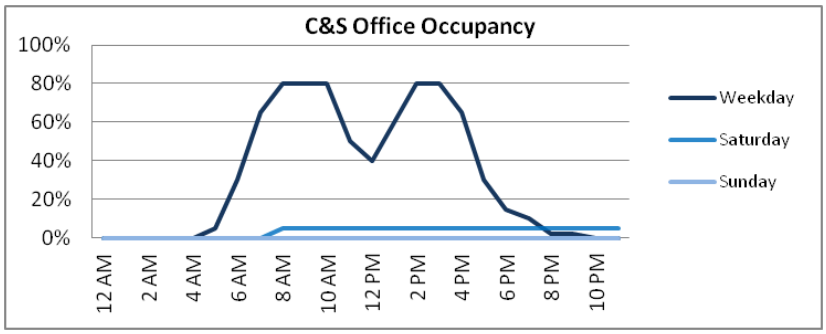


Figure 3 SCSOCC Occupancy Schedule

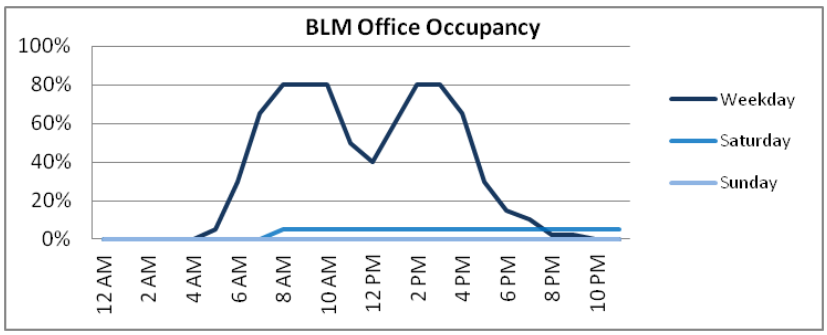


Figure 4 SBLMOCC Occupancy Schedule

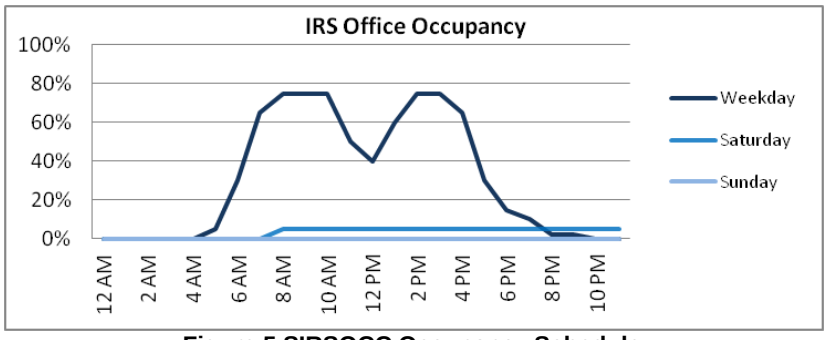


Figure 5 SIRSOCC Occupancy Schedule

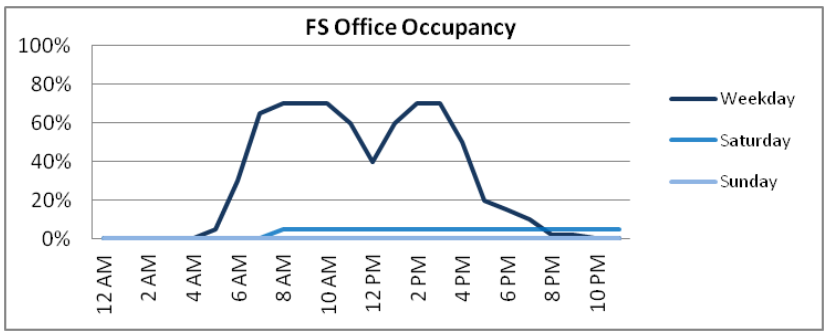


Figure 6 SFSOCC Occupancy Schedule

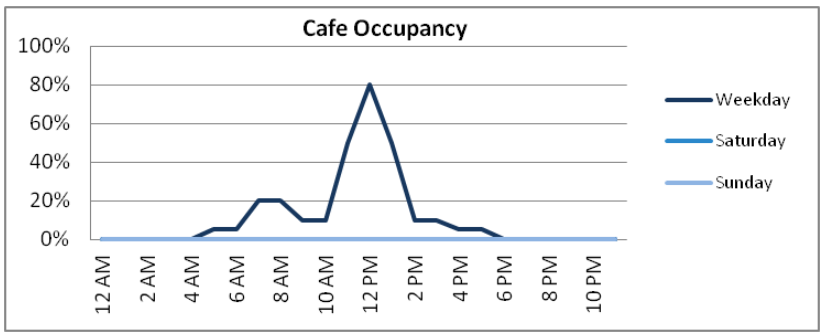


Figure 7 SCAFEOCC Occupancy Schedule

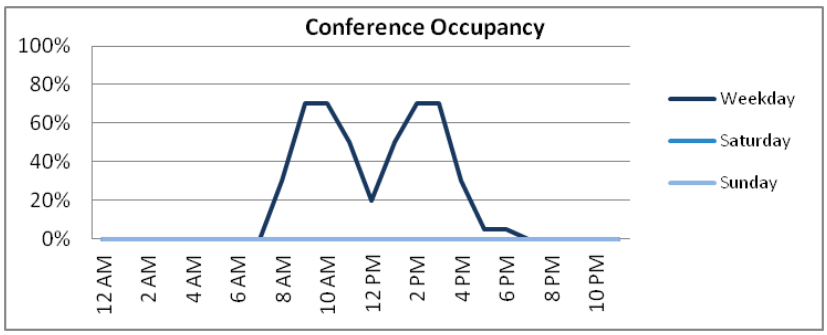


Figure 8 SCONFOCC Occupancy Schedule

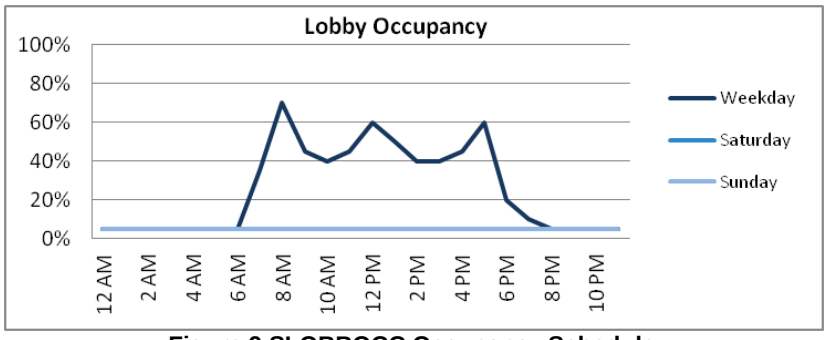


Figure 9 SLOBBOCC Occupancy Schedule

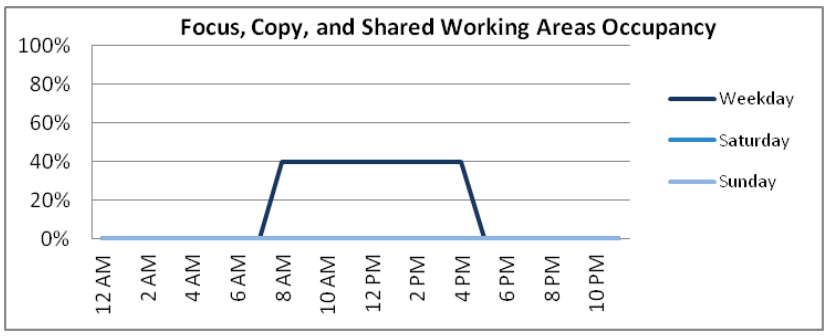


Figure 10 STRANSOCC Occupancy Schedule

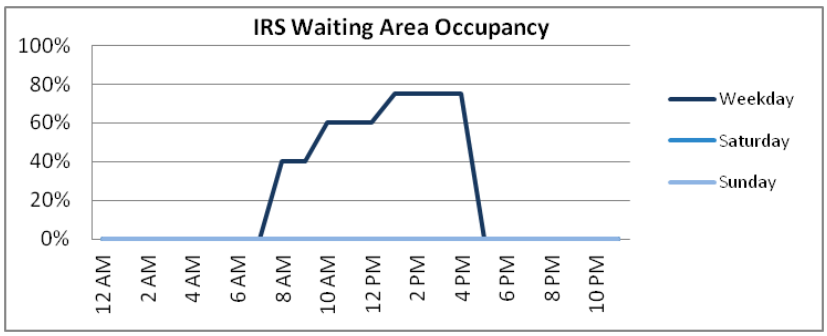


Figure 11 SWAITSOCC Occupancy Schedule

Lighting Schedules

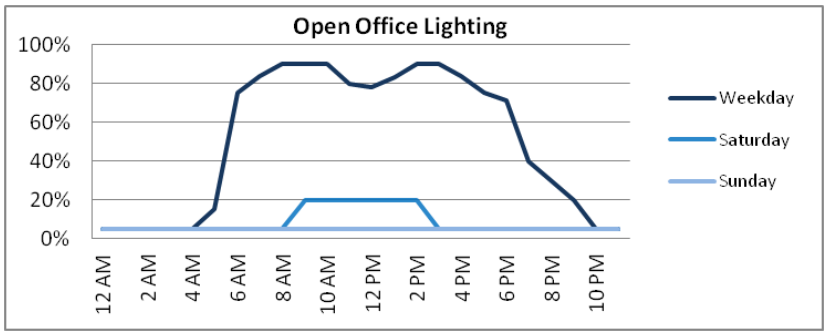


Figure 12 SCSOOFLTG Lighting Schedule (not including daylighting effects)

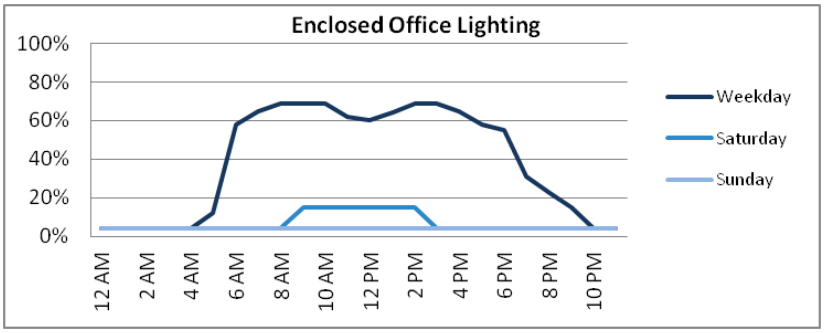


Figure 13 SCSEOFLTG Lighting Schedule (not including daylighting effects)

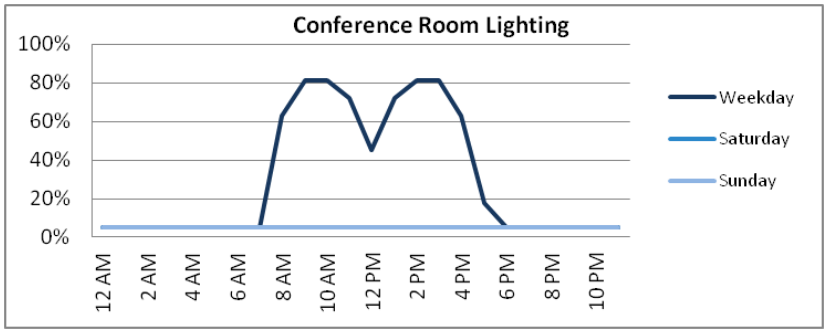


Figure 14 SCONFLTG Lighting Schedule (not including daylighting effects)

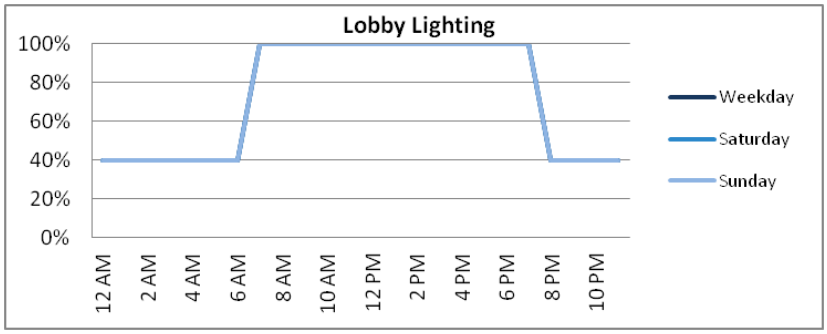


Figure 15 SLOBBLTG Lighting Schedule (not including daylighting effects)

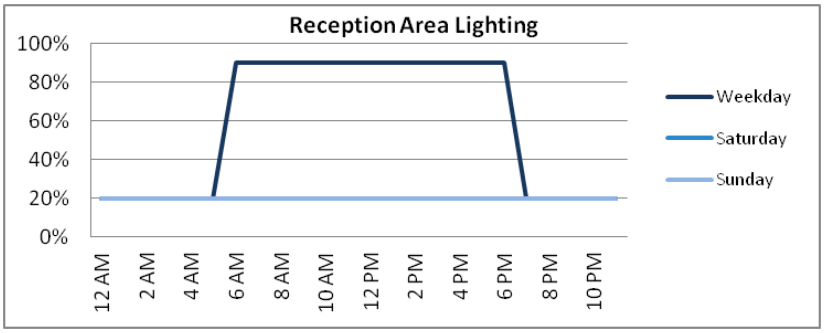


Figure 16 SRECPLTG Lighting Schedule (not including daylighting effects)

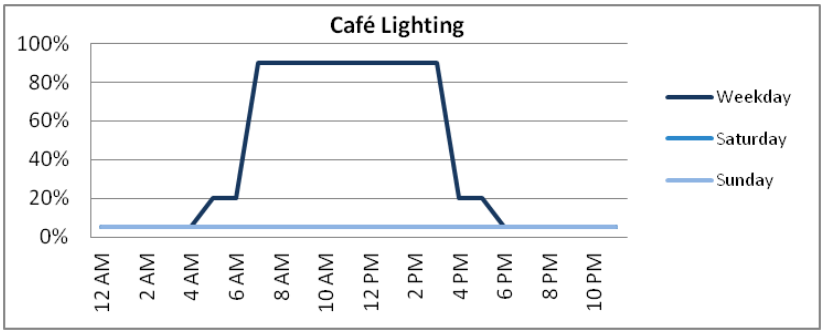


Figure 17 SCAFELTG Lighting Schedule (not including daylighting effects)

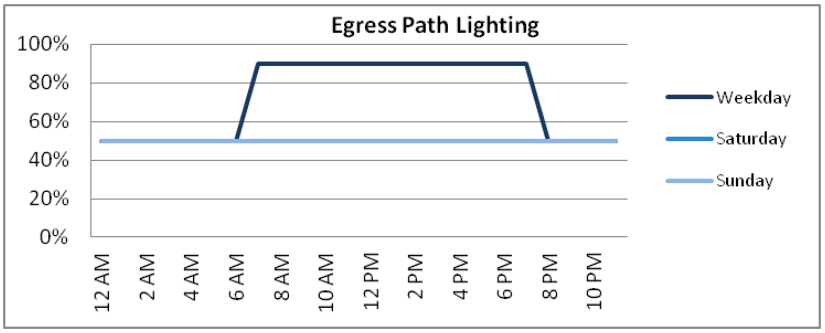


Figure 18 SEGRLTG Lighting Schedule (not including daylighting effects)

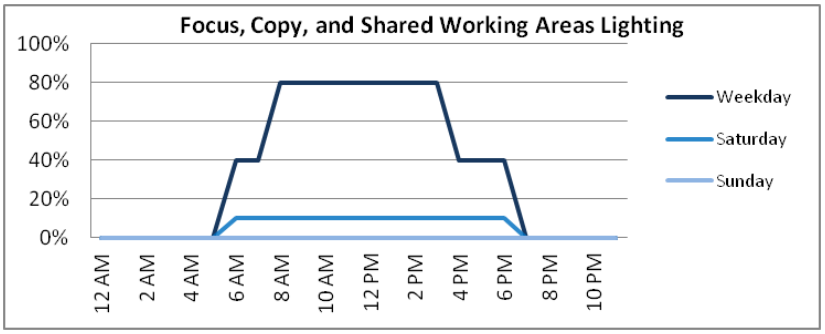


Figure 19 STRANSLTG Lighting Schedule (not including daylighting effects)

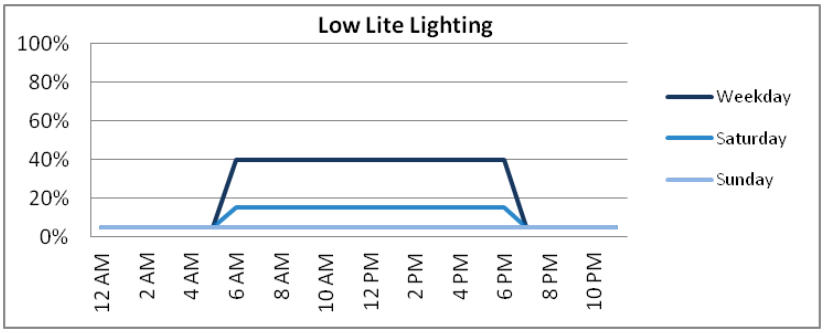


Figure 20 SLOWLTG Lighting Schedule (not including daylighting effects)

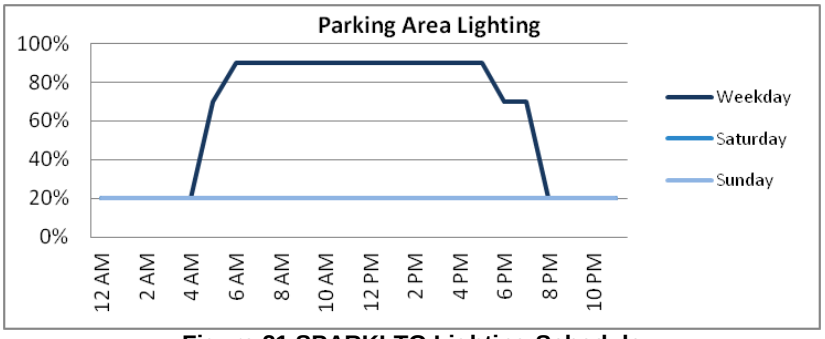


Figure 21 SPARKLTG Lighting Schedule

Equipment Schedules

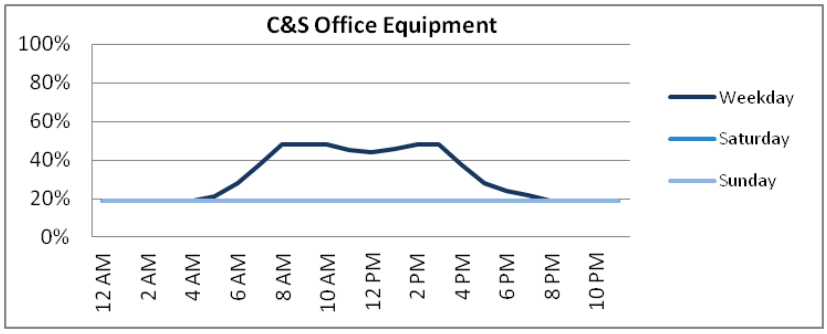


Figure 22 SCSEQU Equipment Schedule

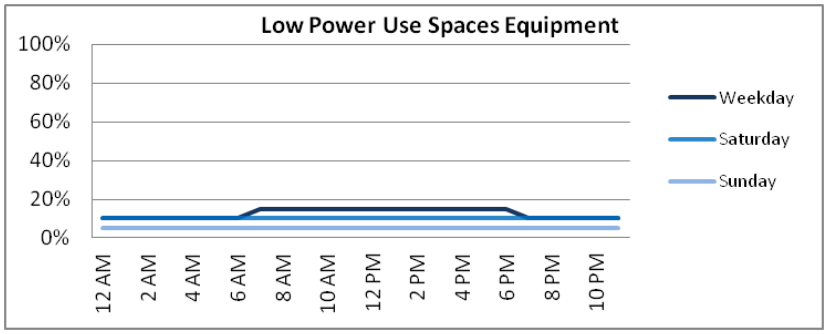


Figure 23 SLOWEQU Equipment Schedule

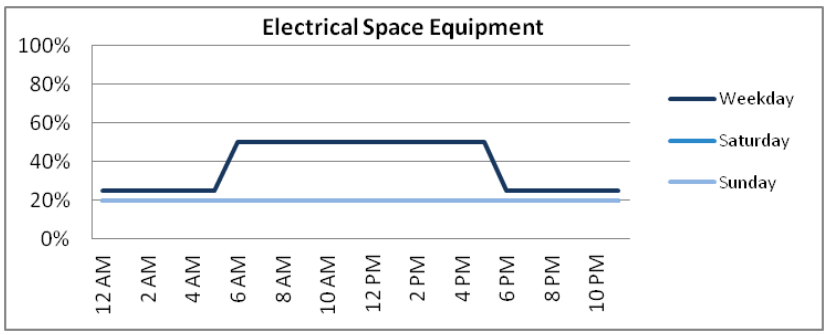


Figure 24 SMEELEQU Equipment Schedule

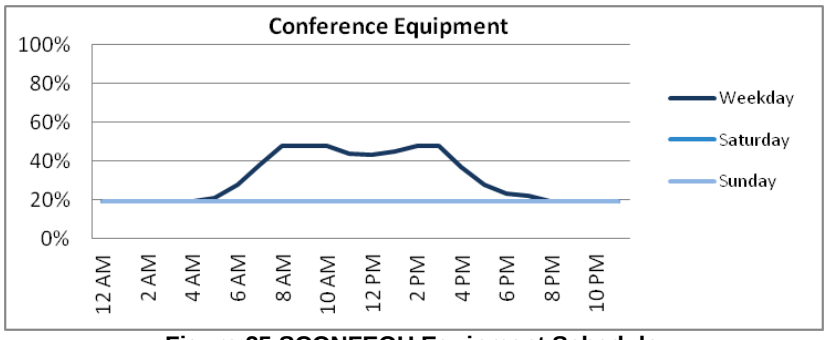


Figure 25 SCONFEQU Equipment Schedule

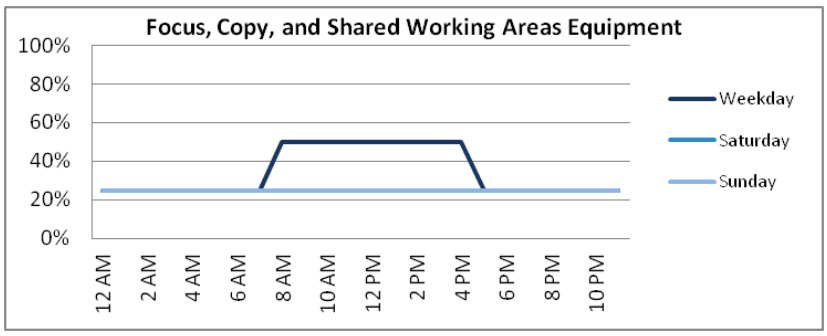


Figure 26 STRANSEQU Equipment Schedule

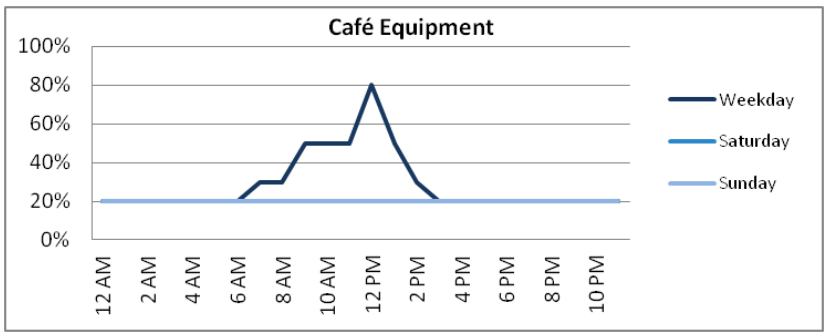


Figure 27 SCAFEEQU Equipment Schedule

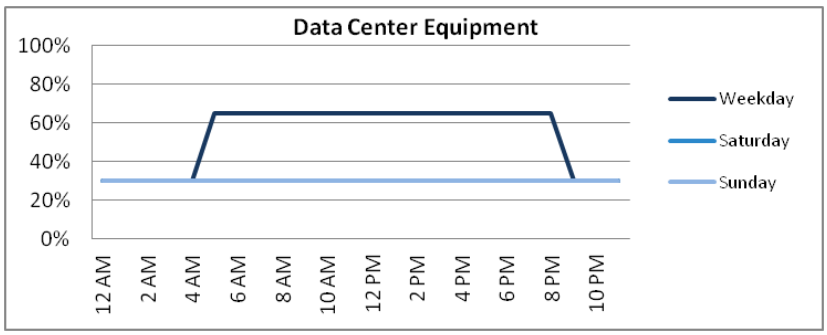


Figure 28 SDATAEQU Equipment Schedule

Temperature Set Points

For conditioned spaces electrical, mechanical, and data rooms are set to maintain 85°F. Other occupied areas are set to maintain 75°F cooling and 70°F heating for occupied hours. During unoccupied hours night cycling is enabled when space temperatures rise above 82°F or fall below 65°F.

Building Envelope and Systems

The envelope of the office tower is made up of a high performance spandrel and vision glazing curtain wall façade with exterior vertical and horizontal shading devices on the East and South, and extensive vertical fins made up of staggered reeds for shading on the West.

The proposed HVAC distribution system for Floors 2-17 are served by a hydronic radiant heating & cooling ceiling panel system with a dedicated outdoor air system (DOAS) providing ventilation air. The DOAS includes heat recovery through heat wheels which utilize exhaust air coming from the floors and restrooms to reheat outdoor air in the units. The Basement, Ground and First Floors are served by a Variable Air Volume (VAV) system with outdoor air for ventilation supplied by one of the DOAS units servicing the typical floors. Storage spaces on the basement level that only require minimum outside air are served by the DOAS units.

Building Envelope

The following table describes the assembly performance used to model the building. All assemblies have been modeled using construction layers to accurately account for thermal mass effects. Shading devices have been included on the East and South facades, the complex geometry of the Western shading structure was modeled as a shade with opacity and is described further in the methodology section of this report. Outdoor air infiltration into the building has been modeled at 0.06CFM/sf of building façade in exposed areas except the lobby which has been modeled at 0.12CFM/sf to account for entrances and typical ground floor use.

Model Input Parameter	Proposed	
	Description	Assembly U-Value
Roofs	Built up 6" Concrete with continuous insulation	0.025
Walls - Above Grade	Built up Insulated Spandrel with continuous insulation	0.040
Walls - Below Grade	6" Concrete plus 16"oc Steel Studd + R19Batt	0.07
Floors	4" Concrete w/matt&Pad	0.735
Slab-On-Grade Floors	6" Concrete w/matt	0.010
Vertical Vision Glazing Assembly U-Value	Double glazed window with thermally broken frame	0.39
Vertical Vision Glazing SHGC		0.27
Vertical Vision Glazing Visual Transmittance		51%
Vertical Vision Glazing / Wall Area		40.9%

Table 15 Details of opaque constructions & vertical glazing

Ventilation

The DOAS system delivers 100% outdoor air directly to occupied spaces, allowing the system to supply the precise quantity of outdoor air needed through demand control ventilation. The table below reflects the air balance that was undertaken to establish the minimum and maximum ventilation levels.

Unit	Level	Serves	Tag	Reference	Box	Min	Max
AHU-2	B1	C&S	(E)TB-B1-01	SUPPLY BOX		2,013	3,020
AHU-2	B1	C&S	(E)TB-B1-02	SUPPLY BOX		1,040	1,450
AHU-2	B1	C&S	(E)TB-B1-05	DOAS SUPPLY TO AHU-3		1,400	5,160
AHU-2	B1	C&S	(E)TB-B1-06	DOAS SUPPLY TO AHU-3		1,400	5,160
AHU-2	B1	C&S	(E)TB-B1-09	SUPPLY BOX		45	120
AHU-2	B1	C&S	(E)TB-B1-10	SUPPLY BOX		45	120
AHU-2	B1	C&S	(E)TB-B1-11	SUPPLY BOX		125	220
AHU-2	LEVEL 3	STOC SHELL	SV-3S-03	L3 SOUTH SUPPLY	NAILOR - 3001 -08	213	442
AHU-1	LEVEL 3	USDA FV	SV-3N-02	USDA F&V	NAILOR - 30RW -05	285	285
AHU-1	LEVEL 3	DHS OPLA	(E) SV-3N-01	DHS ICE OPLA	TITUS - DESV-10	527	527
AHU-2	LEVEL 3	USDA LG	SV-3S-02	USDA-LIVESTOCK	NAILOR - 3001 -05	120	120
AHU-2	LEVEL 3	USDA OGC	SV-3S-03	L03-SHELL SPACE	NAILOR - 3001 -08	210	560
AHU-2	LEVEL 3	USDA OGC	SV-3S-01	L3-USDA OGC	NAILOR - 3001 -08	242	512
AHU-1	LEVEL 4	HUD	(E) SV-4N-01	L4 NORTH SUPPLY	NAILOR-D3001-12	1,042	1,387
AHU-2	LEVEL 4	HUD	(E) SV-4S-01	L4 SOUTH SUPPLY	NAILOR-D3001-10	438	937
AHU-1	LEVEL 5	DOJ EOIR	(E) SV-5N-01	L05 NORTH SUPPLY	NAILOR-D3001-12	335	995
AHU-1	LEVEL 6	IRS	(E) SV-6N-01	NLRB - SUPPLY NORTH	TITUS DESV-12	375	375
AHU-1	LEVEL 6	IRS	SV-6N-02	NLRB - HEARING ROOM	NAILOR D3001-05	80	280
AHU-1	LEVEL 6	IRS	SV-6N-03	NLRB - CONFERENCE ROOM	NAILOR D3001-04	50	110
AHU-1	LEVEL 6	IRS	SV-6N-05	IRS - CONF 657 / EAST OFFICES	NAILOR D3001-07	345	535
AHU-2	LEVEL 6	IRS	(E) SV-6S-01	S&C - SUPPLY SOUTH	TITUS DESV-10	1100	1230
AHU-1	LEVEL 6	ASSIGN	SV-6N-04	L6 EAST SUPPLY - UNASSIGNED SPACE	NAILOR-D3001-5	78	148
AHU-1	LEVEL 6	NLRB	SV-6N-01 (E)	L6 NORTH S&C - SUPPLY - OFFICE	TITUS - DESV-10	170	355
AHU-1	LEVEL 6	NLRB	SV-6N-02	HEARING ROOM	NAILOR - 3001 -05	55	280
AHU-1	LEVEL 6	NLRB	SV-6N-03	CONFERENCE ROOM	NAILOR - 3001 -04	17	85
AHU-1	LEVEL 7	IRS	(E) SV-7N-01	S&C - SUPPLY NORTH	TITUS DESV-12	1150	1445
AHU-1	LEVEL 7	IRS	SV-7N-02	LARGE CONFERENCE ROOM 743	NAILOR 30RW-05	40	115
AHU-2	LEVEL 7	IRS	(E) SV-7S-01	S&C - SUPPLY SOUTH	TITUS DESV-10	795	1060
AHU-2	LEVEL 7	IRS	SV-7S-02	LARGE CONFERENCE ROOM 786	NAILOR 30RW-05	40	115
AHU-1	LEVEL 8	IRS	(E) SV-8N-01	L8 NORTH SUPPLY	NAILOR-D3001-12	642	1218
AHU-1	LEVEL 8	IRS	SV-8N-02	L8 MEDIUM CONFERENCE ROOM 840	NAILOR-30RW-5	45	95
AHU-2	LEVEL 8	IRS	(E) SV-8S-01	L8 SOUTH SUPPLY	NAILOR-D3001-10	481	1258
AHU-2	LEVEL 8	IRS	SV-8S-02	L8 SHARED CONFERENCE ROOM 865	NAILOR-30RW-5	45	100
AHU-1	LEVEL 9	IRS	(E) SV-9N-01	L9 NORTH SUPPLY	NAILOR-D3001-12	680	1,414
AHU-2	LEVEL 9	IRS	(E) SV-9S-01	L9 SOUTH & WEST SUPPLY	NAILOR-D3001-10	475	1,283
AHU-2	LEVEL 10	ASSIGN	(E) SV-10S-01	L10 SOUTH SUPPLY	NAILOR-D3001-10	220	411

Unit	Level	Serves	Tag	Reference	Box	Min	Max
AHU-2	LEVEL 10	DOI OVS	SV-10S-02	L10 SOUTH SUPPLY	NAILOR-D3001-06	225	373
AHU-1	LEVEL 10	BLM	(E) SV-10N-01	L10 NORTH SUPPLY	NAILOR-D3001-12	772	1,228
AHU-1	LEVEL 11	BLM	(E) SV-11N-01	L11 NORTH SUPPLY	NAILOR-D3001-12	585	1,006
AHU-1	LEVEL 11	BLM	SV-11N-02	CONFERENCE ROOM 1102	NAILOR-30RW-04	25	60
AHU-2	LEVEL 11	BLM	(E) SV-11S-01	L11 SOUTH & WEST SUPPLY	NAILOR-D3001-10	524	1,066
AHU-1	LEVEL 12	BLM	(E) SV-12N-01	L12 NORTH SUPPLY	NAILOR-D3001-12	497	845
AHU-1	LEVEL 12	BLM	SV-12N-02	CONFERENCE ROOM 1206	NAILOR - 30RW -04	25	60
AHU-2	LEVEL 12	BLM	(E) SV-12S-01	L12 SOUTH & WEST SUPPLY	NAILOR-D3001-10	993	1,273
AHU-2	LEVEL 13	FS	(E) SV-13S-01	L13 SOUTH SUPPLY	TITUS - DESV-10	990	1,100
AHU-1	LEVEL 14	FS	(E) SV-14N-01	L14 NORTH SUPPLY	NAILOR-D3001-12	523	1,253
AHU-1	LEVEL 14	FS	SV-14N-02	L14 PNW CAP CONFERENCE 1439	NAILOR - 30RW -04	25	100
AHU-1	LEVEL 14	FS	SV-14N-03	L14 PNW SDO CONFERENCE 1440	NAILOR - 30RW -04	30	125
AHU-2	LEVEL 14	FS	(E) SV-14S-01	L14 SOUTH SUPPLY	NAILOR-D3001-10	419	897
AHU-2	LEVEL 14	FS	SV-14S-02	L14 CONFERENCE 1453	NAILOR - 30RW -04	25	70
AHU-1	LEVEL 15	FS	(E) SV-15N-01	L15 NORTH SUPPLY	NAILOR - 3001-10	800	1,225
AHU-2	LEVEL 15	FS	(E) SV-15S-02	L15 SOUTH SUPPLY	NAILOR - 3001-10	800	1,241
AHU-2	LEVEL 15	FS	SV-15S-03	L15 CONFERENCE RM 1549	NAILOR - 30RW -04	40	60
AHU-2	LEVEL 15	FS	SV-15S-04	L15 CONFERENCE RM 1545	NAILOR - 30RW -04	40	60
AHU-1	LEVEL 15	TIGTA	SV-15N-05	OPEN OFFICE	NAILOR - 3001 -04	50	118
AHU-1	LEVEL 16	FS	(E) SV-16N-01	L14 NORTH SUPPLY	NAILOR - D3001 - 10	450	1,361
AHU-2	LEVEL 16	FS	(E) SV-16S-01	L14 SOUTH SUPPLY	NAILOR - D3001 - 10	527	1,284
AHU-1	LEVEL 17	FS	(E) SV-17N-01	L17 NORTH SUPPLY	NAILOR - D3001 - 12	450	1,305
AHU-1	LEVEL 17	FS	SV-17N-02	CONF 1751	NAILOR - 30RW -04	25	85
AHU-1	LEVEL 17	FS	SV-17N-03	CONF 1752	NAILOR - 30RW -04	25	85
AHU-2	LEVEL 17	FS	(E) SV-17S-01	L17 SOUTH SUPPLY	NAILOR - D3001 - 10	495	1,190
AHU-2	LEVEL 17	FS	SV-17S-02	CONF 1736	NAILOR - 30RW -04	25	103
AHU-2	LEVEL 17	FS	SV-17S-03	CONF 1739	NAILOR - 30RW -04	25	60
Totals						23031.7	38636.7

Table 16 Outdoor air delivery rates to various building locations

Air Handling Equipment

DOAS Air Handling Units 1&2

Each dedicated air handling unit provides 100% outdoor air to the spaces it serves. On the supply side of the units Outdoor air passes through a pre-heat coil, cooling coil, heat recovery wheel, and finally a reheat coil. Heat is recovered from the exhaust side of the system drawing exhaust from the restrooms and general exhaust for each floor. The heat wheel has been scheduled only to operate in the winter months to avoid overheating supply air in summer operation.

Model Input Parameter	Proposed
Primary HVAC Type	100% OA
Supply Fan Type	Centrifugal
Control	Variable
Flow/Fan	8545L/s (18100CFM)
Drive	Variable
Motor Power	18.6kW (25hp)
Operating Power	14.74kW (19.77bhp)
Motor Efficiency	0.94
Preheat coil capacity	130kW (0.445MBH)
Cooling coil capacity	279kW (1.014MBH)
Sensible Heat Wheel Flow	8545L/s (18100CFM)
Sensible Efficiency	89.50%
Heating coil capacity	173kW (0.592MBH)

Table 17 AHU-1 Details

Model Input Parameter	Proposed
Primary HVAC Type[1]	100% OA
Supply Fan Type	Centrifugal
Flow/Fan	16754L/s (35500CFM)
Drive	Variable
Motor Power	37.2kW (50hp)
Operating Power	28.8kW (38.64hp)
Motor Efficiency	0.94
Preheat coil capacity	263kW (0.897MBH)
Cooling coil capacity	557kW (1.903MBH)
Sensible Heat Wheel Flow	16754L/s (35500CFM)
Sensible Efficiency	89.20%
Heating coil capacity	316kW (1.080MBH)

Table 18 AHU-2 Details

Air Handling Unit 3

Air handling unit 3 is located on the basement level and serves a majority of the spaces located no level 00 and level 01. The unit consists of a conventional variable air volume unit with fan powered and single damper terminal units. Outdoor air to the unit is delivered from AHU-2 however there is a damper arrangement that allows outdoor air to bypass the unit when AHU-3 is not operational.

Model Input Parameter	Proposed
Primary HVAC Type	41% OA VAV
Supply Fan Type	Centrifugal
Supply Flow/Fan	11800L/s (25000CFM)
Supply Fan Drive	Variable
Supply Motor Power	22.3kW (30hp)
Supply Operating Power	16.7kW (22.39hp)
Supply Motor Efficiency	0.94
Return Fan Type	Centrifugal
Return Flow/Fan	6390L/s (14685CFM)
Return Fan Drive	Variable
Return Motor Power	11.2kW (15hp)
Return Operating Power	5.85kW (7.84hp)
Return Motor Efficiency	0.95
Cooling coil capacity	150kW (0.512MBH)

Table 19 AHU-3 Details

Chilled Water Cooling Plant

The chilled water system is a primary secondary loop system that provides two different temperatures of chilled water, 58^{o}F to the radiant panels on the secondary loop and 44^{o}F to the air handling units on the primary loop. The primary chilled water circuit is also capable of resetting the supply temperature to maximize chiller performance when conditions allow. The modeling approach is described in the methodology section of this report.

Model Input Parameter	Proposed
Number of Chillers	2
Type	Screw
Chiller Part-Load Controls	Variable
Chiller Capacity/Chiller	1547kW (440Tons)
Chiller Efficiency Peak COP	7.9 (0.445kW/Ton) @ Design Conditions
Chilled Water Loop Supply Temperature	6.6ºC (44ºF)
Chilled Water Loop Return Temperature	17ºC (62ºF)
Minimum Condenser Flow	30%
Minimum Evaporator Flow	30%

Table 20 Chilled water plant details

Model Input Parameter	Proposed
Number of Chillers	1
Type	Heat Recovery - Scroll
Chiller Part-Load Controls	Constant HG Bypass
Chiller Capacity/Chiller	316kW (90Tons)
Chiller Efficiency Peak COP	4.1 (0.86kW/Ton) @ Design Conditions
Combined Heating and Cooling COP	9.2
Chilled Water Loop Supply Temperature	6.6ºC (44ºF)
Hot Water Loop Supply Temperature	40.6ºC (105ºF)

Table 21 Heat recovery chiller details

Model Input Parameter	Proposed
Loop Type	Primary
Number of Primary CHW Pumps	2
Primary CHW Motor Power	18.6kW (25hp)
Primary CHW Pump Operating Power	13.7kW (18.4hp)
Mechanical Efficiency	81.1%
Primary CHW Pump Flow	39.5L/s (625GPM)
Primary CHW Pump Speed Control	Variable
Loop Minimum Flow	10%

Table 22 Low temperature chilled water circuit details

Model Input Parameter	Proposed
Loop Type	Secondary
Waterside Economizer	Yes
Number of Primary CHW Pumps	2
Primary CHW Motor Power	37kW (50hp)
Primary CHW Pump Operating Power	30.9kW (41.4hp)
Mechanical Efficiency	82.10%
Primary CHW Pump Flow	94.6L/s (1500GPM)
Primary CHW Pump Speed Control	Variable
Chilled Water Loop Supply Temperature	14.4ºC (58ºF)
Chilled Water Loop Return Temperature	17.2ºC (63ºF)
Loop Minimum Flow	10%

Table 23 High temperature chilled water circuit details

Hot Water Plant

The hot water system is a primary secondary loop system that provides two different temperatures of hot water, 105^{o}F to the radiant panels on the secondary loop and 160^{o}F to the air handling units on the primary loop. Both hot water circuits are also capable of resetting the

supply temperature to maximize heater performance when conditions allow, as described in the tables below.

Model Input Parameter	Proposed
Hot Water Heaters	
Number of Boilers	3
Type	Condensing
Boiler Part-Load Controls	Modulating 5:1
Boiler Input/Boiler	879kW (3000MBH)
Boiler Output/Boiler	815kW (2781MBH)
Boiler Efficiency	92.70%
Boiler Water Loop Supply Temperature	71ºC (160ºF)
Boiler Water Loop Return Temperature	46ºC (115ºF)
HW Loop Temp Reset Parameters	OAT 32/65 = Supply Temp 160/110
Minimum Heat Exchanger Flow	30%

Table 24 Hot Water Plant Details

Model Input Parameter	Proposed
Loop Type	Primary
Number of Primary HW Pumps	3
Primary HW Motor Power	3.7kW (5hp)
Primary HW Pump Operating Head	224.2kW (75ft)
Mechanical Efficiency	64%
Primary HW Pump Flow	7.6L/s (120GPM)
Primary HW Pump Speed Control	Variable
HW Loop Temp Reset Parameters	OAT 32/65 = Supply Temp 105/95
Loop Minimum Flow	10%

Table 25 High temperature hot water circuit details

Model Input Parameter	Proposed
Loop Type	Secondary
Number of Primary HW Pumps	2
Secondary HW Motor Power	14.9kW (20hp)
Secondary HW Pump Operating Power	9.8kW (13.1hp)
Mechanical Efficiency	76.10%
Secondary HW Pump Flow	27.7L/s (440GPM)
Secondary HW Pump Speed Control	Variable
HW Loop Temp Reset Parameters	OA 32/65 ST 105/95
Loop Minimum Flow	10%
Hot Water Loop Supply Temperature	41ºC (105ºF)
Hot Water Loop Return Temperature	34ºC (93ºF)

Table 26 Low temperature hot water circuit details

Heat Rejection Plant

The heat rejection plant consists of a single cooling tower with two cells. The condenser water loop has been to provide free cooling to the high temperature chilled water circuit when conditions allow.

Model Input Parameter	Proposed
Number of Cooling Towers / Fluid Coolers	1
Type	Cross Flow
Cooling Tower Number of Cells/Tower	2
Cooling Tower Capacity/Tower	4744kW (3280GPM)
Cooling Tower Fan Power/Cell	30kW (40hp)
Cooling Tower Fan Control	Variable
Condenser Water Leaving Temperature	23.9ºC (75ºF)
Condenser Water Entering Temperature	29.4ºC (85ºF)

Table 27 Heat rejection plant details

Model Input Parameter	Proposed
Number of CW Pumps	2
Motor Power	55.9kW (75hp)
Pump Operating Power	44.8kW (60.1hp)
Mechanical Efficiency	85.3%
Pump Flow	103.5L/s (1640GPM)
Pump Speed Control	Variable
CW Loop Temp Reset Parameters	6 degree approach
Loop Minimum Flow	30%
Fee Cooling	Yes-HTCHW

Table 28 Condenser water circuit details

Mechanical & Electrical Room Cooling Systems

Included in the energy model are fan coil units that serve the telecommunications rooms, data center, and security rooms, and office areas requiring additional cooling as shown on the mechanical schedules.

Tag	Location/Serves	Fan Control	CFM	Input kW	kW/CFM	Chilled Water	Cooling Btu/h	Hot Water	Heating Btu/h
CRAH Units	ROOM B54, LEVEL B1	VARIABLE	35,000	23.87	0.000682	HTCHW	972,000	N/A	N/A
FC-B-1A	CER ROOM	CONSTANT VOLUME	600	0.20	0.000328	HTCHW	10,646	N/A	N/A
FC-B-1B	CER ROOM	CONSTANT VOLUME	600	0.20	0.000328	HTCHW	10,646	N/A	N/A
FCU-03-01	ROOM 315 IT CLOSET	CONSTANT VOLUME	320	0.20	0.000615	HTCHW	3,500	N/A	N/A
FCU-03-02	ROOM 352 COPY WORK SERVER	CONSTANT VOLUME	320	0.20	0.000615	HTCHW	3,500	N/A	N/A

Tag	Location/Serves	Fan Control	CFM	Input kW	kW/CFM	Chilled Water	Cooling Btu/h	Hot Water	Heating Btu/h
FCU-04-01	ROOM 495, SERVER ROOM	CONSTANT VOLUME	900	0.45	0.000497	HTCHW	10,000	N/A	N/A
FCU-05-01	530 SECURE WAITING	CONSTANT VOLUME	1,260	0.90	0.000710	LTCHW	33,100	LTHW	-34,000
FCU-05-02	533 -PRO BONO	CONSTANT VOLUME	1,200	0.90	0.000746	LTCHW	33,000	LTHW	-13,000
FCU-05-03	549-CASE FILE ROOM	CONSTANT VOLUME	1,200	0.90	0.000746	LTCHW	33,000	LTHW	-13,000
FCU-05-04	PRINT COPY RM 543	CONSTANT VOLUME	350	0.20	0.000563	HTCHW	4,400	N/A	N/A
FCU-05-05	ADP ROOM 554	CONSTANT VOLUME	1,035	0.45	0.000432	HTCHW	13,000	N/A	N/A
FCU-05-06	COURTROOM 532	CONSTANT VOLUME	600	0.30	0.000497	HTCHW	18,700	LTHW	-15,300
FCU-06-01	ROOM 639, CIMDF ROOM	CONSTANT VOLUME	450	0.45	0.000995	HTCHW	4,400	N/A	N/A
FCU-06-02	ROOM 631, IDF ROOM	CONSTANT VOLUME	450	0.45	0.000995	HTCHW	4,400	N/A	N/A
FCU-06-03	ROOM 633, COMMUNICATIONS	CONSTANT VOLUME	880	0.45	0.000509	HTCHW	10,000	N/A	N/A
FCU-06-04	ROOM 644, COFFEE/BREAK	CONSTANT VOLUME	230	0.20	0.000856	HTCHW	2,500	N/A	N/A
FCU-06-05	ROOM 683, OFFICE	CONSTANT VOLUME	400	0.20	0.000492	HTCHW	4,300	N/A	N/A
FCU-07-01	ROOM 759, IDF ROOM	CONSTANT VOLUME	450	0.45	0.000995	HTCHW	4,400	N/A	N/A
FCU-07-02	ROOM 791, BREAK ROOM	CONSTANT VOLUME	320	0.20	0.000615	HTCHW	3,500	N/A	N/A
FCU-08-01	ROOM 866, IDF ROOM	CONSTANT VOLUME	475	0.45	0.000942	HTCHW	5,200	N/A	N/A
FCU-09-01	ROOM 946, IDF ROOM	CONSTANT VOLUME	450	0.45	0.000995	HTCHW	5,200	N/A	N/A
FCU-09-02	ROOM 959, COPY ROOM	CONSTANT VOLUME	356	0.30	0.000838	HTCHW	4,000	N/A	N/A
FCU-09-03	ROOM 935, COPY ROOM	CONSTANT VOLUME	442	0.30	0.000675	HTCHW	5,000	N/A	N/A
FCU-10-01	ROOM 1002, IT WORK ROOM	CONSTANT VOLUME	1,230	0.90	0.000728	HTCHW	26,700	N/A	N/A
FCU-10-02	ROOM 1012, TELCO ROOM	CONSTANT VOLUME	1,035	0.45	0.000432	HTCHW	11,300	N/A	N/A
FCU-10-03	ROOM 1004, DEGAUSSER ROOM	CONSTANT VOLUME	645	0.30	0.000463	HTCHW	7,000	N/A	N/A
FCU-11-01	ROOM 1105, TELCO ROOM	CONSTANT VOLUME	1,035	0.45	0.000432	HTCHW	11,300	N/A	N/A
FCU-11-02	ROOM 1112, COPY ROOM	CONSTANT VOLUME	480	0.30	0.000622	HTCHW	7,000	N/A	N/A
FCU-12-01	ROOM 1209, TELCO ROOM	CONSTANT VOLUME	1,035	0.45	0.000432	HTCHW	11,300	N/A	N/A
FCU-12-02	ROOM 1220, WORK ROOM	CONSTANT VOLUME	415	0.30	0.000719	HTCHW	4,500	N/A	N/A
FCU-13-02	TELCO 1308	CONSTANT VOLUME	1,125	0.45	0.000398	HTCHW	12,700	N/A	N/A
FCU-13-03	GALLEY/COPY 1303	CONSTANT VOLUME	305	0.20	0.000646	HTCHW	3,300	N/A	N/A
FCU-13-04	ROOM 1340, COPY ROOM	CONSTANT VOLUME	535	0.30	0.000558	HTCHW	5,800	N/A	N/A
FCU-13-05	ROOM 1338 IT CLOSET	CONSTANT VOLUME	990	0.45	0.000452	HTCHW	10,700	N/A	N/A
FCU-13-06	ROOM 1333, RF BREAKROOM	CONSTANT VOLUME	590	0.30	0.000506	HTCHW	6,400	N/A	N/A
FCU-14-01	ROOM 1452, IT CLOSET	CONSTANT VOLUME	1,035	0.45	0.000432	HTCHW	11,300	N/A	N/A
FCU-15-01	RM1546-FS IT ROOM	CONSTANT VOLUME	1,035	0.45	0.000432	HTCHW	11,300	N/A	N/A
FCU-15-05	ROOM 1531 WIRE CLOSET	CONSTANT VOLUME	480	0.30	0.000622	HTCHW	7,000	N/A	N/A

Tag	Location/Serves	Fan Control	CFM	Input kW	kW/CFM	Chilled Water	Cooling Btu/h	Hot Water	Heating Btu/h
FCU-16-01	ROOM 1635, COPY ROOM	CONSTANT VOLUME	445	0.30	0.000671	HTCHW	5,000	N/A	N/A
FCU-16-02	ROOM 1637, IT CLOSET	CONSTANT VOLUME	1,055	0.45	0.000424	HTCHW	12,000	N/A	N/A
FCU-17-01	ROOM 1738, IT CLOSET	CONSTANT VOLUME	1,035	0.45	0.000432	HTCHW	11,300	N/A	N/A
FCU-17-02	ROOM 1733, WORK/FILING	CONSTANT VOLUME	320	0.20	0.000615	HTCHW	3,500	N/A	N/A
FCU-01-01	N ELEC.Room , 1st FLOOR	CONSTANT VOLUME	900	0.45	0.000497	HTCHW	11500	N/A	N/A
FCU-02-05	N ELEC.Room , 2nd FLOOR	CONSTANT VOLUME	1,500	0.90	0.000597	HTCHW	23000	N/A	N/A
FCU-04-02	N ELEC.Room , 4th FLOOR	CONSTANT VOLUME	900	0.45	0.000497	HTCHW	11500	N/A	N/A
FCU-07-03	N ELEC.Room , 7th FLOOR	CONSTANT VOLUME	1,100	0.90	0.000814	HTCHW	15300	N/A	N/A
FCU-08-02	N ELEC.Room , 8th FLOOR	CONSTANT VOLUME	1,100	0.90	0.000814	HTCHW	15300	N/A	N/A
FCU-11-03	N ELEC.Room , 11th FLOOR	CONSTANT VOLUME	600	0.45	0.000746	HTCHW	7700	N/A	N/A
FCU-14-02	N ELEC.Room , 14th FLOOR	CONSTANT VOLUME	1,500	0.90	0.000597	HTCHW	23000	N/A	N/A
FCU-17-03	N ELEC.Room , 17th FLOOR	CONSTANT VOLUME	1,100	0.90	0.000814	HTCHW	15300	N/A	N/A

Table 29 Fan Coil Units (FCU) summary

Exhaust Fans

The following exhaust fan systems have been modeled

Tag	Schedule	Location/Serves	CFM	Motor Hp	Power kW	kW/CFM
EF-03-01	S4HREXHFN	Electrical Room	635	1/2	0.30	0.000470
EF-03-02	S4HREXHFN	TR Room	700	1/4	0.15	0.000213
EF-06-01	S4HREXHFN	Electrical Room	635	1/2	0.30	0.000470
EF-06-02	S4HREXHFN	TR Room	700	1/4	0.15	0.000213
EF-09-01	S4HREXHFN	Electrical Room	635	1/2	0.30	0.000470
EF-09-02	S4HREXHFN	TR Room	700	1/4	0.15	0.000213
EF-12-01	S4HREXHFN	Electrical Room	635	1/2	0.30	0.000470
EF-12-02	S4HREXHFN	TR Room	700	1/4	0.15	0.000213
EF-15-01	S4HREXHFN	Electrical Room	635	1/2	0.30	0.000470
EF-15-02	S4HREXHFN	TR Room	700	1/4	0.15	0.000213
EF-18-01	S4HREXHFN	Electrical Room	635	1/2	0.30	0.000470
EF-18-02	S4HREXHFN	TR Room	700	1/4	0.15	0.000213
EF-19-03	SFNALLON	Basement Recycling/Trash	1,050	1/4	0.15	0.000142
EF-19-06	S6HREXHFN	Generator Exhaust	8,850	1 1/2	0.90	0.000101
EF-19-09	S6HREXHFN	Switch Room Exhaust	650	1/4	0.15	0.000230
EF-PARK	SPARKFN	Enclosed Parking	61,000		10.98	0.000180

Table 30 Building exhaust fan summary

Domestic Hot Water

Domestic hot water for the building is provided by two hot water storage heaters located on level 18. Hot water is then distributed down through the building by four recirculation pumps that serve 4 separate zones.

Model Input Parameter	Proposed
DHW Equipment Type	Gas
Number of Boilers	2
DHW Storage Tank Capacity	227 L (60 Gal)
DHW Heating Input Capacity[1]	36.6k W (125 kBTU)
Equipment Efficiency[1]	96%
Recirculation Pumps	4
Recirculation Pump Total Flow	1.9 L/s (30 GPM)
Recirculation Pump Total Power	1.2 kW (1.6 hp)

Table 31 Domestic hot water equipment summary

Methodology

This section of the report provides an overview of the general modeling tools and methods used. A detailed discussion is provided for the areas where industry-accepted modeling work-around methods were used to appropriately address the building design and systems.

Background

A number of eQuest building energy simulation models have been developed by for this project, has since been selected to continue this work. The starting point was an energy model that was created and used from 2003 to 2006 for a renovation design effort during that period. The 2006 Design, which was only a partial renovation, was halted due to lack of funding. This energy model was updated starting in May of 2009 for the larger, overall building modernization project scope now funded under ARRA, and included whole building strategies needed to meet or exceed high performance building targets. The current model and modeling assumptions that have been made are expected to undergo continual refinement as the building moves into operation and a measurement and verification phase is planned.

Software

The analysis was conducted by modeling the building geometry in Autodesk Revit, based on construction documents and the architectural Revit model provided by . This process assures greater accuracy than dimensional takeoffs and data entry by providing the ability to visualize walls, windows, roofs, floors, and spaces in three dimensions throughout design phases. Once complete, the building geometry was exported from Revit to eQuest version 3.64 using the gbXML file format. An in house energy modeling tool is then used to define space usage profiles, loads and HVAC systems.

Apart from improved geometric accuracy and the ability to model more complex shapes this process allows the design team to quickly apply revisions to building spaces as the project is updated.

eQuest is a widely accepted tool for whole building energy analysis. However, there are some limitations of the tool. Where necessary, industry-accepted work-arounds were used to model the systems included in the building design. Descriptions of these modeling methods are provided in this section.

Building Data

The following images show the progression in building geometry from Revit into eQuest.

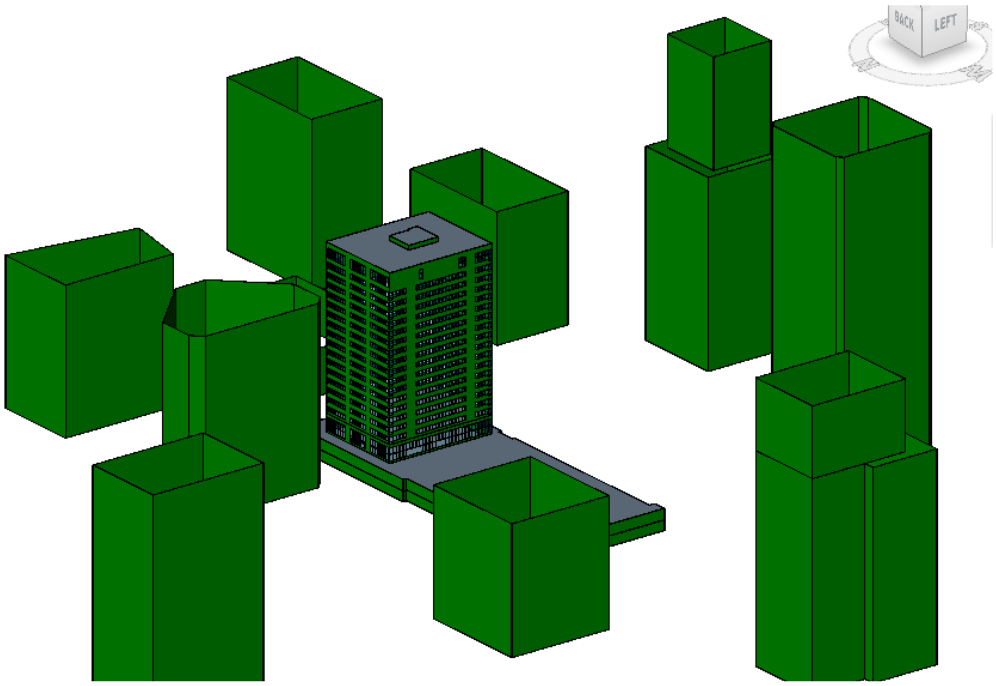


Figure 29 Revit model used to create geometry used in the energy model

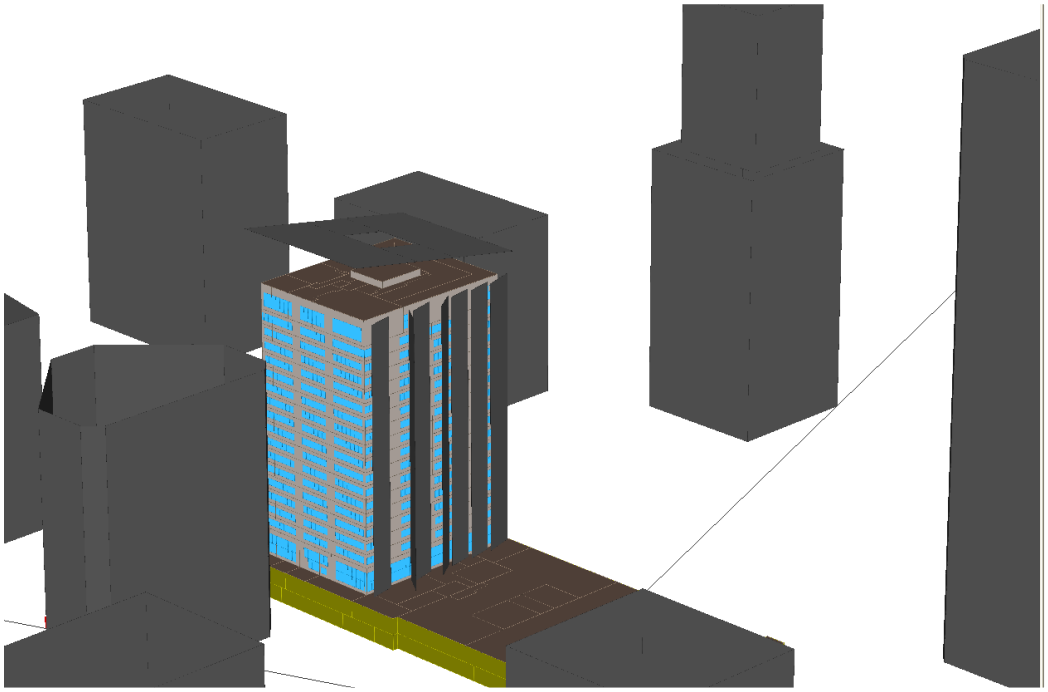


Figure 30 eQuest energy model with surrounding buildings

Dedicated Outdoor Air System (DOAS) & Heat Recovery

Each DOAS air handling unit provides 100% outdoor air to the spaces it serves. On the supply side of the unit outdoor air passes through a pre-heat coil, cooling coil, heat recovery wheel, and finally a reheat coil. Heat is recovered from the exhaust side of the system drawing exhaust from the restrooms and general exhaust for each floor. The heat wheel has been scheduled only to operate in the winter months to avoid the unit overheating supply air in summer operation.

A limitation to the eQuest modeling tool is that template air handling equipment must be used. As none of the available templates reflect the proposed system an alternative method is required. The preferred alternative in this case was to model the preheat coil, and chilled water coil as a single unit. A dummy space which acts as a section of the unit was then created, from which this dummy space supplies conditioned air into an induction style unit with heat recovery and a reheat coil. Trend data was then inspected to ensure the proposed energy modeling method accurately reflected the unit design.

Free Cooling & Chilled Water Temperature Reset

In order to account for the effects of waterside free cooling a chilled water temperature set point schedule reset based on outdoor air temperature has been applied to the chilled water circuit. When outdoor air temperatures are above 55^{o}F the chilled water temperature set point is set at 43^{o}F, when outdoor air temperatures drop below 55^{o}F the chilled water temperature is raised to 50^{o}F to maximize the systems potential to provide free cooling. 55^{o}F was chosen based on trend information and finding an outdoor air temperature point where the chilled water temperature could be raised and still maintain adequate cooling.

West Shading

The fins on the West façade have been modeled using the building shades in eQuest. These have been modeled with 45% opacity throughout the year. This number was based on matching available information in the energy model with a shading study that was provided by .

Radiant Panels

Similar to the approach described in the DOAS work around, there is no eQuest template for radiant panels so an alternate approach is required. The accepted work around for this system type is either to use fan coil units and zero out the fan energy, or use induction units. The fan coil unit approach was chosen for this application as it reflected pump operation characteristics that better reflected the design compared to the induction unit method. Fan energy use by the fan coil units has been zeroed out to align with the radiant panel system operation.

Pumps

In some cases eQuest will have difficulty accounting for pump energy in primary secondary loop configurations. To ensure pump energy is accurately accounted for in the model, hourly trend information was reviewed to ensure modeled results make sense. The radiant panels were also modeled using an alternative induction unit method to compare energy use between the fan coil and induction unit approaches. Energy consumption between all three methods was within 10% which confirmed the design team’s approach to modeling the radiant system was accounting for pump energy correctly.

Photovoltaic

The EGWW roof canopy includes a photovoltaic array of approximately 180 kW capacity, and producing an estimated 215,000 kWh annually.

Electricity production from the photovoltaic (PV) array has been calculated using the 2011.06.30 release of NREL's Solar Advisor Model (the latest non-Beta Version). The component based model option was selected and populated with product data based on the basis of design equipment manufacturers. Hourly shading analysis by month was also incorporated in the calculations. The remaining de-rate factors were adjusted by , the Electrical Engineer of Record for Core & Shell design, based on experience and industry standard practice. Additional control are required based on restrictions imposed by the electrical grid in downtown Portland that serves the project. Because feedback of on-site generated electricity back into the grid is not permissible, the PV systems generation capacity is ramped down during periods of low building load. This generally occurs only during unoccupied periods during shoulder seasons (e.g. sunny days in spring or fall that are too cool to require chiller operation, a major electrical load). 's production calculations for the PV system account for these lowered production periods. The estimated annual production is 131,215 kWh, or approximately 4% of the building energy use.

Heat Recovery Chiller

The heat recovery chiller (HRC) was added to the project when the Data Center requirements were increased significantly and centralized. The Data Center's year-round cooling needs presented extended periods of simultaneous heating, and an opportunity for heat recovery operation of an HRC. Due to model instabilities caused by introducing the HRC into the tenant based energy model, the HRC energy impacts have been accounted for using an exception calculation in Microsoft excel. As the HRC operates at a constant lift condition and relatively constant part load conditions, the estimation used trend log information to calculate the energy use (and savings) of the HRC.

APPENDIX A – Energy Model Input Comparison

LEED 2009 for New Construction and Major Renovations

EA PREREQUISITE 2: MINIMUM ENERGY PERFORMANCE

Project # 1000003119 EDITH GREEN / WENDELL WYATT FOB

All fields and uploads are required unless otherwise noted.

THRESHOLD ATTEMPTED

Points Attempted: 0

ALL PROJECTS

TARGET FINDER

The following fields are required, but the values have no bearing on EA Prerequisite 2 compliance. Use the Target Energy Performance Results calculator on the ENERGY STAR website to generate the values. If using prescriptive compliance paths (Options 2 or 3), leave the Design energy consumption and cost values blank in the Target Finder website, and set the Design values equal to the Target values in this form.

	Design		Target	
Energy performance rating (1-100):	99		100	
CO_2-eq emissions:	1,321	metric tons/year	1,215	metric tons/year
CO_2-eq emissions reduction:	68	%	70	%

Upload EAp2-1. Provide the Target Finder Energy Performance Results (a screen capture or other documentation containing the same information) for the project building. (Optional) — Upload — *Files: 1*

☐ The building is not able to get a Target Finder score because the tool does not support the primary building type of the project building and/or the project is not located in the United States. (Optional)

PREREQUISITE COMPLIANCE

Total gross square footage: 449,822 sf

The content highlighted in yellow above is linked to PIf2, PIf3, SSc2, EAp1, EAc1, EAc2, EAc6, MRc1.1 & MRc1.2.

Principal project building activity: Office: Government

The content highlighted in yellow above is linked to PIf3 & EAc1.

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Select a compliance path:

- (●) **Option 1. Whole Building Energy Simulation.** The project team will document improvement in the proposed building performance rating for ANSI/ASHRAE/IESNA Standard 90.1-2007 or California Title 24-2005 Part 6. Non-US projects may use a USGBC approved equivalent standard.
  Note: Refer to "Credit Resources" for a list of USGBC approved equivalent standards.
- ( ) **Option 2. Prescriptive Compliance Path: ASHRAE Advanced Energy Design Guide.** The project team will document compliance with the ASHRAE Advanced Energy Design Guide.
- ( ) **Option 3. Prescriptive Compliance Path: Advanced Buildings Core Performance Guide.** The project team will document compliance with the Advanced Buildings™ Core Performance™ Guide.

The content highlighted in yellow above is linked to EAc1, EAc2 & EAc6.

OPTION 1. WHOLE BUILDING ENERGY SIMULATION

Complete the following sections:
Section 1.1A - General Information
Section 1.1B - Mandatory Requirements
Section 1.2 - Space Summary
Section 1.3 - Advisory Messages
Section 1.4 - Comparison of Proposed Design Versus Baseline Design Energy Model Inputs
Section 1.5 - Energy Type Summary
Section 1.6 - Performance Rating Method Compliance Report
Section 1.7 - Exceptional Calculation Measure Summary (if applicable)
Section 1.8- On-Site Renewable Energy (if applicable)
Section 1.9A - Total Building Performance Summary
Section 1.9B - Reports & Metrics

SECTION 1.1A - GENERAL INFORMATION

- ☒ **Compliant energy simulation software.** The energy simulation software used for this project has all capabilities described in EITHER section "G2 Simulation General Requirements" in Appendix G of ASHRAE 90.1-2007 OR the analogous section of the alternative qualifying energy code used.
- ☒ **Compliant energy modeling methodology.** Energy simulation runs for both the baseline and proposed building use the assumptions and modeling methodology described in EITHER ASHRAE 90.1-2007 Appendix G OR the analogous section of the alternative qualifying energy code used.

Simulation program:	eQuest
Principal heating source:	Fossil Fuel
Energy code used:	ASHRAE 90.1-2007

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List the ASHRAE addenda used in the modeling assumptions, if any. (Optional)

Zip/Postal Code:	97214

The content highlighted in yellow above is linked to SSc1 & SSc2.

Weather file:	Portland OR TMY2
Climate zone:	ASHRAE Climate Zone 4C

List the climatic data from ASHRAE Standard 90.1-2007 Table D-1. Specify if another source is referenced for HDD & CDD data.

Heating Degree Days:	4,522
Cooling Degree Days:	2,517
HDD and CDD data source, if other than ASHRAE: (Optional)	

New construction gross square footage:	364,657	
Existing, renovated gross square footage:	85,165	
Existing, unrenovated gross square footage:	0	
Total gross square footage:	449,822	
New construction percent:	81.07	%
Existing renovation percent:	18.93	%
Existing unrenovated percent:	0	%

The content highlighted in yellow above is linked to PIf2, PIf3, SSc2, EAp1, EAc1, EAc2, EAc6, MRc1.1 & MRc1.2.

Gross square footage used in the energy model, if different than gross square footage above: (Optional)	0

SECTION 1.1B - MANDATORY REQUIREMENTS

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☒ For all elements included in the Architect's scope of work for the project building, the project building design complies with all ASHRAE Standard 90.1-2007 mandatory provisions (Sections 5.4, 6.4, 7.4, 8.4, 9.4 and 10.4) or USGBC approved equivalent standard mandatory provisions, and the information provided regarding the proposed case energy model in Section 1.4 is consistent with the building design.

☒ For all elements included in the Mechanical Engineer's scope of work for the project building, the project building design complies with all ASHRAE Standard 90.1-2007 mandatory provisions (Sections 5.4, 6.4, 7.4, 8.4, 9.4 and 10.4) or USGBC approved equivalent standard mandatory provisions, and the information provided regarding the proposed case energy model in Section 1.4 is consistent with the building design.

☒ For all elements included in the Electrical Engineer's scope of work for the project building, the project building design complies with all ASHRAE Standard 90.1-2007 mandatory provisions (Sections 5.4, 6.4, 7.4, 8.4, 9.4 and 10.4) or USGBC approved equivalent standard mandatory provisions, and the information provided regarding the proposed case energy model in Section 1.4 is consistent with the building design.

Provide the following Interactive Compliance Forms:

Upload EAp2-2. Building Envelope Compliance Documentation (Optional) Upload *Files: 0*

Upload EAp2-3. HVAC Compliance Documentation (Optional) Upload *Files: 0*

Upload EAp2-4. Lighting Compliance Documentation (Optional) Upload *Files: 0*

Upload EAp2-5. Service Water Heating Compliance (Optional) Upload *Files: 0*

SECTION 1.2 - SPACE SUMMARY

Table EAp2-1. Space Usage Type

Space Name / Description	Space Usage Type	Space Area (sf)	Regularly Occupied Area (sf)	Unconditioned Area (sf)	Typical Hours/Week in Operation		
BRAK	Break Rooms	5,278	5,278	0	40	+	-
CONF	Conference	21,461	21,461	0	40	+	-
CORR	Corridor	48,520	48,520	0	40	+	-
DATA	Data Center	3,142	3,142	0	40	+	-
DINN	Dining	1,818	1,818	0	40	+	-
ELEV	Elevator	12,575	12,575	0	40	+	-
GYMN	Gymnasium	1,839	1,839	0	40	+	-
LABO	Laboratory	451	451	0	40	+	-
LOBB	Lobby	5,775	5,775	0	40	+	-
MAIL	Mail Room	2,016	2,016	0	40	+	-
MEEL	Mech or Elec	27,481	27,481	0	40	+	-
MULT	Multipurpose	4,641	4,641	0	40	+	-
PARK	Parking	80,835	0	80,835	0	+	-

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Space Name / Description	Space Usage Type	Space Area (sf)	Regularly Occupied Area (sf)	Unconditioned Area (sf)	Typical Hours/Week in Operation		
RECP	Reception	4,864	4,864	0	40	+	-
REST	Restroom	10,613	10,613	0	40	+	-
RETL	Retail	215	215	0	40	+	-
RISE	Riser	5,533	0	5,533	0	+	-
SECU	Security	1,002	1,002	0	40	+	-
STAR	Stairs	8,357	8,357	0	40	+	-
STOR	Storage	35,015	35,015	0	40	+	-
TRAS	Trash	1,292	1,292	0	40	+	-
BOOF	BLM Open Office	34,838	34,838	0	40	+	-
BEOF	BLM Enclosed Office	3,831	3,831	0	40	+	-
FOOF	FS Open Office	46,574	46,574	0	40	+	-
FEOF	FS Enclosed Office	3,837	3,837	0	40	+	-
IOOF	IRS Open Office	28,664	28,664	0	40	+	-
IEOF	IRS Enclosed Office	9,848	9,848	0	40	+	-
COOF	Smaller Agencies Enclosed Off	48,633	48,633	0	40	+	-
CEOF	Smaller Agencies Open Office	11,763	11,763	0	40	+	-
COPY	Copy Room	4,643	4,643	0	40	+	-
FOCU	Focus Room	1,494	1,494	0	40	+	-
FILE	Filing/Working Area	13,521	13,521	0	40	+	-
COUR	Courtroom	2,605	2,605	0	40	+	-
WAIT	Waiting Area	2,110	2,110	0	40	+	-
CAFF	Cafe	878	878	0	40	+	-
Totals		495,962	409,594	86,368			
Percentage of total (%)			82.59	17.41			

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SECTION 1.3 - ADVISORY MESSAGES

Table EAp2-2. Advisory Messages

Complete the table below based on information from the energy simulation output files.

	Baseline Design (0° Rotation)	Proposed Design
Number of hours heating loads not met[1]	12	24
Number of hours cooling loads not met[1]	50	67
Total	62	91
Difference[2] (Proposed minus baseline)		29
Number of warning messages	83	83
Number of error messages	0	0
Number of defaults overridden	500	500
Unmet load hours compliance	Y	

Notes:
1 Baseline design and proposed design unmet load hours each may not exceed 300
2 Unmet load hours for the proposed design may not exceed the baseline design by more than 50 hours.

SECTION 1.4 - COMPARISON OF PROPOSED DESIGN VERSUS BASELINE DESIGN ENERGY MODEL INPUTS

Download, complete, and upload "EAp2 Section 1.4 table.xls" (found under "Credit Resources") to document the baseline and proposed design energy model inputs for the project. Documentation should be sufficient to justify the energy and cost savings numbers reported in the Performance Rating tables.

Upload EAp2-7. Provide the completed EAp2 Section 1.4 tables available under "Credit Resources."

Upload *Files: 2*

SECTION 1.5 - ENERGY TYPE SUMMARY

List the energy types used by the project (i.e. electricity, natural gas, purchased chilled water or steam, etc.), and provide the the virtual energy rate from the baseline and proposed design energy model results or from manual calculations. *If revising the values in Table EAp2-3, reselect energy type in all affected rows in Table EAp2-4 and Table EAp2-5 to ensure that the revised values are propagated and that Table EAp2-4 and Table EAp2-5 calculations are refreshed.*

Table EAp2-3. Energy Type Summary

Energy Type	Utility Company Name	Utility Rate and Description of Rate Structure[1]	Baseline Virtual Rate[2] ($ per unit energy)	Proposed Virtual Rate[2] ($ per unit energy)	Units of Energy	Units of Demand
Electricity	Portland General	Utility Rates Based on ETO F	0.085	0.085	kWh	kW
Natural Gas	Northwest Natural G	Based on EIA Average 2012	0.995	0.995	therms	MBH
			0	0		

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Notes:
1 Per ASHRAE 90.1-2007 G2.4, project teams are allowed to use the state average energy prices published by DOE's EIA for commercial building customers, available on EIA's website (www.eia.gov). If project uses backup energy for on-site renewable energy, please specify the rate of backup source energy.
2 Rate is defined as the total annual charge divided by the metered energy from the plant for each resource.

If the proposed and baseline rates vary significantly, describe the building input parameters (e.g. demand reduction measures) leading to the variation in energy rates, and provide detailed information regarding the utility rate structure including all demand and energy charges, and the seasonal and time-of-use structure of the utility tariff. (Required when proposed and baseline rates vary by more than 10%)

Rates do not vary by more then 10%

Upload EAp2-8. Provide any documentation to support the proposed/baseline rate variance narrative. (Optional)

Upload *Files: 0*

SECTION 1.6 - PERFORMANCE RATING METHOD COMPLIANCE REPORT

Table EAp2-4. Baseline Performance - Performance Rating Method Compliance

In the table below, list each energy end use for the project (including all end uses reflected in the baseline and proposed designs). Then check whether the end-use is a process load, select the energy type, and list the energy consumption and peak demand for each end-use for all four baseline design orientations.

End Use	Process	Baseline Design Energy Type	Units of Annual Energy & Peak Demand		Baseline (0° rotation)	Baseline (90° rotation)	Baseline (180° rotation)	Baseline (270° rotation)	Baseline Building Results
Interior Lighting		Electricity	Energy Use	kWh	1,581,766	1,581,766	1,581,766	1,581,766	1,581,766
			Demand	kW	338.9	338.9	338.9	338.9	338.9
Exterior Lighting		Electricity	Energy Use	kWh	10,882	10,882	10,882	10,882	10,882
			Demand	kW	2.49	2.49	2.49	2.49	2.49
Space Heating		Natural Gas	Energy Use	therms	55,155	55,368	56,056	54,353	55,233
			Demand	MBH	11.6	11.2	11.5	11.4	11.43
Space Cooling		Electricity	Energy Use	kWh	342,188	332,468	342,468	339,025	339,037.25
			Demand	kW	367.61	358.84	357.95	356.76	360.29
Pumps		Electricity	Energy Use	kWh	180,996	163,427	174,122	173,845	173,097.5
			Demand	kW	64.37	62.29	63.58	62.13	63.09
Heat Rejection		Electricity	Energy Use	kWh	10,958	10,964	11,108	10,949	10,994.75
			Demand	kW	28.2	27.33	27.97	27.19	27.67

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Fans-Interior		Electricity	Energy Use	kWh	772,827	783,227	776,291	781,684	778,507.25
			Demand	kW	254.88	249.93	246.65	246.66	249.53
Fans - Parking Garage	X	Electricity	Energy Use	kWh	41,340	41,340	41,340	41,340	41,340
			Demand	kW	10.98	10.98	10.98	10.98	10.98
Service Water Heating		Natural Gas	Energy Use	therms	6,583	6,583	6,583	6,583	6,583
			Demand	MBH	0.3	0.3	0.3	0.3	0.3
Receptacle Equipment	X	Electricity	Energy Use	kWh	1,823,924	1,823,924	1,823,924	1,823,924	1,823,924
			Demand	kW	328.06	328.06	328.06	328.06	328.06
Interior Lighting - Process	X	Electricity	Energy Use	kWh	0	0	0	0	0
			Demand	kW	0	0	0	0	0
Refrigeration Equipment	X	Electricity	Energy Use	kWh	0	0	0	0	0
			Demand	kW	0	0	0	0	0
Cooking	X	Electricity	Energy Use	kWh	0	0	0	0	0
			Demand	kW	0	0	0	0	0
Industrial Process	X	Electricity	Energy Use	kWh	0	0	0	0	0
			Demand	kW	0	0	0	0	0
Elevators and Escalators	X	Electricity	Energy Use	kWh	129,910	129,910	129,910	129,910	129,910
			Demand	kW	54.12	54.12	54.12	54.12	54.12
Elec Heaters		Electricity	Energy Use	kWh	0	0	0	0	0
			Demand	kW	0	0	0	0	0
Total Energy Use (MMBtu/yr)					22,874.83	22,838.52	22,954.76	22,789.62	22,864.43
Annual Process Energy (MMBtu/yr)						6,807.53			
Process Energy Modeling Compliance[1]						Y			

+ -

Notes:
1 Determined using Section 1.9 cost calculations after Section 1.9A is complete. Annual process energy costs must be at least 25% of the total energy costs for the proposed design. Process energy costs should be modeled to accurately reflect the proposed building. To claim process cost savings, use an exceptional calculation in Section 1.7.

Table EAp2-5. Performance Rating - Performance Rating Method Compliance

Complete the table below. List the proposed design energy consumption and peak demand for each end use.

		Baseline			Proposed			
End Use	Process	Units of Annual Energy & Peak Demand		Building Results	Design Energy Type	Units of Annual Energy & Peak Demand		Building Results	% Savings
Interior Lighting		Energy Use	kWh	1581766	Electricity	Energy Use	kWh	1,054,055	33.36
		Demand	kW	338.9		Demand	kW	254.67	
Exterior Lighting		Energy Use	kWh	10882	Electricity	Energy Use	kWh	4,180	61.59
		Demand	kW	2.49		Demand	kW	0.96	

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Space Heating		Energy Use	therms	55233	Natural Gas	Energy Use	therms	10,500	80.99
		Demand	MBH	11.43		Demand	MBH	5.7	
Space Cooling		Energy Use	kWh	339037.25	Electricity	Energy Use	kWh	197,882	41.63
		Demand	kW	360.29		Demand	kW	253.42	
Pumps		Energy Use	kWh	173097.5	Electricity	Energy Use	kWh	249,900	-44.37
		Demand	kW	63.09		Demand	kW	50.05	
Heat Rejection		Energy Use	kWh	10994.75	Electricity	Energy Use	kWh	23,732	-115.85
		Demand	kW	27.67		Demand	kW	60	
Fans-Interior		Energy Use	kWh	778507.25	Electricity	Energy Use	kWh	407,956	47.6
		Demand	kW	249.53		Demand	kW	107.57	
Fans - Parking Garage	X	Energy Use	kWh	41340	Electricity	Energy Use	kWh	41,340	0
		Demand	kW	10.98		Demand	kW	10.98	
Service Water Heating		Energy Use	therms	6583	Natural Gas	Energy Use	therms	5,424	17.61
		Demand	MBH	0.3		Demand	MBH	0.2	
Receptacle Equipment	X	Energy Use	kWh	1823924	Electricity	Energy Use	kWh	1,823,924	0
		Demand	kW	328.06		Demand	kW	328.06	
Interior Lighting - Process	X	Energy Use	kWh	0	Electricity	Energy Use	kWh	0	0
		Demand	kW	0		Demand	kW	0	
Refrigeration Equipment	X	Energy Use	kWh	0	Electricity	Energy Use	kWh	0	0
		Demand	kW	0		Demand	kW	0	
Cooking	X	Energy Use	kWh	0	Electricity	Energy Use	kWh	0	0
		Demand	kW	0		Demand	kW	0	
Industrial Process	X	Energy Use	kWh	0	Electricity	Energy Use	kWh	0	0
		Demand	kW	0		Demand	kW	0	
Elevators and Escalators	X	Energy Use	kWh	129910	Electricity	Energy Use	kWh	129,910	0
		Demand	kW	54.12		Demand	kW	54.12	
Elec Heaters		Energy Use	kWh	0	Electricity	Energy Use	kWh	1,531	0
		Demand	kW	0		Demand	kW	0.05	
Total Energy Use (MMBtu/yr)				22,864.43				15016.61	
Process Energy (MMBtu/yr				6,807.53				6807.53	

Table EAp2-6. Section 1.6 Energy Use Summary

		Baseline		
Energy Type	Units	Process Subtotal	Total Energy Use	Proposed Energy Use
Electricity	kWh	1,995,174	4,889,458.75	3,934,410
Natural Gas	therms	0	61,816	15,924

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		Baseline		
Energy Type	Units	Process Subtotal	Total Energy Use	Proposed Energy Use
		0	0	0
Totals	MMBtu	6,807.53	22,864.43	15,016.61

Table EAp2-7. Section 1.6 Energy Cost Summary (Automatic)

		Baseline		
Energy Type	Units	Process Subtotal	Total Energy Cost	Proposed Energy Cost
Electricity		169,589.79	415,603.99	334,424.85
Natural Gas		0	61,506.92	15,844.38
		0	0	0
Total	$	169,589.79	477,110.91	350,269.23

Select one of the following:

- (•) **Section 1.6 Automatic Cost Calculation.** Total building energy costs will be based on the "virtual" energy rate defined in Section 1.5.
- ( ) **Section 1.6 Manual Cost Input.** The project team will analyze the total building energy costs based on local utility rate structures. Costs will be input separately from the energy model.

Note: Energy cost savings are summarized in Section 1.9A Total Building Performance Summary.

SECTION 1.7 - EXCEPTIONAL CALCULATION MEASURE SUMMARY

Select one of the following:

- (•) The energy analysis includes exceptional calculation method(s) (ASHRAE 90.1-2007, G2.5).
- ( ) The energy analysis does not include exceptional calculation methods.

For each exceptional calculation method employed, document the predicted energy savings by energy type. If an end-use has an energy loss rather than an energy savings, enter it as a negative number.

Table EAp2-10. Exceptional Calculations

End Use	Exceptional Calculation Method Description	Energy Type(s)	Unit	Annual Energy Savings		
Interior Lighting	Increased Savings for Occupancy S	Electricity	kWh	161,146	+	-
Interior Lighting	Increased Savings for Occupancy S	Natural Gas	therms	-38	+	-
Space Heating	Extended Deadband for Radiant Sys	Natural Gas	therms	2,742	+	-
Space Cooling	Extended Deadband for Radiant Co	Electricity	kWh	17,991	+	-

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End Use	Exceptional Calculation Method Description	Energy Type(s)	Unit	Annual Energy Savings
Miscellaneous	Regenerative Elevators	Electricity	kWh	76,119
Receptacle Equipment	Energy Star Equipment	Electricity	kWh	164,516
Space Cooling	Demand Control Ventilation	Electricity	kWh	30,810
Space Heating	Demand Control Ventilation	Natural Gas	therms	424
Space Cooling	DOAS Ventilation Effectiveness	Electricity	kWh	37,610
Space Heating	DOAS Ventilation Effectiveness	Natural Gas	therms	815
Space Cooling	Heat Recovery Chiller	Electricity	kWh	-8,395
Space Heating	Heat Recovery Chiller	Natural Gas	therms	2,187
Miscellaneous	Variable Speed Enclosed Parking E	Electricity	kWh	20,669
Electricity			kWh	500,466
Natural Gas			therms	6,130
				0
Total			MMBtu	2,320.59

Upload EAp2-10. Provide a narrative explaining the exceptional calculation method(s) performed, and theoretical or empirical information supporting the accuracy of the method(s). Reference any applicable Credit Interpretation Rulings.

Upload *Files: 9*

Table EAp2-11. Section 1.7 Energy Cost Savings Summary (Automatic)

Energy Type	Units	Proposed Energy Savings
Electricity		42,539.61
Natural Gas		6,099.35
		0
Total	$	48,638.96

Select one of the following:

- (●) **Automatic Cost Calculation.** Exceptional calculation measure cost savings will be based on the "virtual" energy rate defined in Section 1.5.
- ( ) **Manual Cost Input.** The project team will analyze exceptional calculation measure costs for each exceptional calculation measure based on local utility rate structures. Costs will be input separately from the energy model.

Note: The same method has to be used for all the measures in this section. Energy cost savings are summarized in Section 1.9A Total Building Performance Summary. Calculated cost savings will be automatically subtracted from the proposed design energy model results when determining the Proposed Building Performance Rating.

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SECTION 1.8 - ON-SITE RENEWABLE ENERGY

Select one of the following

(•) The project uses on-site renewable energy produced on-site.

( ) The project does not use on-site renewable energy.

Table L-1. Renewable Energy Source Summary

Renewable Source	Renewable Energy Source Allocation	Renewable System Owner	Backup Energy Type[1]	Rated Capacity	Annual Energy Generated	Units	Annual Energy Cost ($) (Optional[2])
PV	On-Site only	Building Owner	Electricity	178.75	131,215	kWh	11,153.27
Energy savings - Electricity					131,215	kWh	11,153.27
Energy savings - Natural gas					0		0
Energy savings -					0		0
Total energy savings					447.71	MMBtu	11,153.27

+ -

Notes:
1 Per ASHRAE 90.1 G2.4 Exception, baseline performance shall be based on the energy source used as backup energy or on the use of electricity if no backup energy source is specified.
2 Annual energy cost is required to document credit compliance with EA Credit 2, if attempted.

The content highlighted in yellow above is linked to EAc2.

Table EAp2-13 Section 1.8 Energy Cost Savings Summary (Automatic)

Energy Type	Units	Proposed Renewable Energy Savings
Electricity		11,153.28
Natural Gas		0
		0
Total	MMBtu	11,153.28

Select one of the following:

(•) **Automatic Cost Calculation.** Renewable energy cost savings will be based on the "virtual" energy rate defined in Section 1.5.

( ) **Manual Cost Input.** The project team will analyze the renewable energy cost for on-site renewable sources based on local utility rate structures. Costs will be input separately from the energy model.

( ) **Energy Model Includes Renewables.** On-site renewable energy is modeled directly in the energy model. Renewable Energy Cost is already credited in the proposed design energy model results (i.e. the energy model already reflects zero cost for on-site renewable energy, and this form will NOT subtract the Renewable Energy Cost a second time.

Note: The same method must be used for all the measures in this section. Energy cost savings are summarized in Section 1.9A Total Building Performance Summary. Calculated cost savings will be automatically subtracted from the proposed design energy model results when determining the Proposed Building Performance Rating UNLESS "Energy Model Includes Renewables" is selected.

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SECTION 1.9A - TOTAL BUILDING PERFORMANCE SUMMARY

Table EAp2-15. Total Building Energy Use Performance

		Baseline		Proposed			
Energy Type	Units	Process Subtotal	Section 1.6 Total Energy Use	Section 1.6 Energy Use	Section 1.7 Energy Savings	Section 1.8 Renewable Energy Savings	Total Energy Use
Electricity	kWh	1,995,174	4,889,458.75	3,934,410	500,466	131,215	3,302,729
Natural Gas	therms	0	61,816	15,924	6,130	0	9,794
		0	0	0	0	0	0
Totals	MMBtu	6,807.53	22,864.43	15,016.61	2,320.59	447.71	12,248.31
Energy use savings (%)							46.43

Table EAp2-16. Total Building Energy Cost Performance

The values below are automatically calculated using the virtual energy rate from Section 1.5 unless the project team has opted to manually input costs in Section 1.6, 1.7, and/or 1.8. To modify these values and/or to see automatically calculated results for reference see Sections 1.6, 1.7 or 1.8.

		Baseline		Proposed			
Energy Type	Units	Process Subtotal	Section 1.6 Total Energy Cost	Section 1.6 Energy Cost	Section 1.7 Energy Savings	Section 1.8 Renewable Energy Savings	Total Energy Cost
Electricity	$	169,589.79	415,603.99	334,424.85	42,539.61	11,153.28	280,731.97
Natural Gas	$	0	61,506.92	15,844.38	6,099.35	0	9,745.03
	$	0	0	0	0	0	0
Totals	$	169,589.79	477,110.91	350,269.23	48,638.96	11,153.28	290,477
Baseline process energy costs as percent of total energy costs (%)							35.55
Energy cost savings (%)							39.12
EA Credit 1 points documented							14

The content highlighted in yellow above is linked to EAc1.

Section 1.9B - REPORTS AND METRICS

Table EAp2-17. Energy Use Intensity

	Baseline EUI	Proposed EUI
Electricity (kWh/sf)		
Interior Lighting	3.516	1.985

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Space Heating	0	0
Space Cooling	0.754	0.266
Fans - Interior	1.731	0.907
Service Water Heating	0	0
Receptacle Equipment	4.055	3.689
Miscellaneous	0.814	0.787
Subtotal	10.87	7.634
Natural Gas (kBtu/sf)		
Space Heating	12.279	2.287
Service Water Heating	1.463	1.206
Miscellaneous	0	-1.316
Subtotal	13.742	2.177
Other (kBtu/sf)		
Miscellaneous	0	0.001
Subtotal	0	0.001
Total Energy Use Intensity (kBtu/sf)		
Total	50.83	28.225

Table EAp2-18. End Use Energy Percentage

	Baseline Case (%)	Proposed Case (%)	End Use Energy Savings (%)
Interior Lighting	23.6	24	23.11
Space Heating	24.16	8.1	44.2
Space Cooling	5.06	3.22	7.37
Fans - Interior	11.62	10.96	12.44
Service Water Heating	2.88	4.27	1.14
Receptacle Equipment	27.22	44.59	5.52
Miscellaneous	5.46	4.85	6.22

Select one of the following:

- (●) The project used DOE2, eQuest or Visual DOE.
- ( ) The project used EnergyPlus.
- ( ) The project team used EnergyPro.
- ( ) The project team used HAP.
- ( ) The project team used Trace.
- ( ) The project team used other modeling software.

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ADDITIONAL DETAILS

☐ Special circumstances preclude documentation of prerequisite compliance with the submittal requirements outlined in this form.

☐ The project team is using an alternative compliance approach in lieu of standard submittal paths.

SUMMARY

EA Prerequisite 2: Minimum Energy Performance Compliance Documented: Y Check Compliance

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APPENDIX B – ETO – Energy Analysis Report

EEM Savings Overview

EGWW is an 18 story office building located in the heart of Portland that is owned by . The building was originally constructed in the early 1970's and is currently undergoing an extensive modernization which includes a new facade and mechanical, electrical, and plumbing systems. The building has two underground floors that include parking, loading dock, mail delivery, storage, office, conference, security, and general amenity spaces. Level 1 is home to the building's main entrance lobby with core and shell office space on the floors above. The main mechanical and electrical rooms that serve the building can be found on level 18 though there are support spaces also within the underground levels.

As the building is owned and operated by it is not governed by any state or industry referenced energy codes. The project has been active with initial building programming and design completed in 2006, where it went on hold for a period of time. The American Recovery and Reinvestment Act of 2009 (ARRA) signed into law on 17 February 2009 included funding to improve the energy and water conservation performance of Federal Buildings. A portion of that funding was made available for the EGWW project bringing it back to life. has stated that EGWW building project shall be required to meet certain energy targets to receive ARRA funding. Based on the history of the project and discussions with PECI ASHRAE 90.1-2007 has been established as the baseline of comparison for this project.

Per the Energy Trust of Oregon New Buildings Program Technical Guidelines Ver. 8 120809 section 2.4.2 Interactions between Modeled Measures the Incremental or rolling baseline method has been chosen. This method was chosen due to the highly interactive nature of the measures and how they had to be bundled, each measure in most cases relies on the previous in order to function from a practical, and modeling standpoint.

Baseline eQuest model run – EGWW NC Baseline ETO v3

Bundle 1 – Lighting
Included in the design is a high performance lighting control system that incorporates the following measures and the methods in accounting for savings;

1. Aggressive Lighting Power Densities
2. Task Lighting
3. Exterior Lighting
4. Occupancy Sensors
5. Daylight Control Systems

eQuest model run – EGWW NC Baseline ETO v3 Bundle 1

These measures are recommended and are included in the design.

Bundle 2a – Building Envelope
Included in the design is a high performance envelope that incorporates the following measures and methods in accounting for savings;

1. High performance Envelope with thermal performance of 0.04 walls and 0.025 for Roof and high performance argon filled glazing.

eQuest model run – EGWW NC Baseline ETO v3 Bundle 2a

Bundle 2b – HVAC
Included in the design is a high performance HVAC that incorporates the following measures and methods in accounting for savings;

1. Dedicated Outside Air System (DOAS) with heat recovery wheel. Unit specifics have been documented in the above section
2. Demand Control Ventilation
3. Radiant Panel Extended Temperature Deadband
4. High Efficiency Chilled Water System
5. Waterside Economizer for High Temperature Chilled Water Circuit
6. High Efficiency Hot Water System
7. Variable speed enclosed parking exhaust fan

eQuest model run – EGWW NC Baseline ETO v3 Bundle 2b

These measures are recommended and are included in the design.

Bundle 3 – Domestic Hot Water
1. High Efficiency Condensing Hot Water Heaters
2. Water Saving Fixtures

These measures are recommended and are included in the design.

eQuest model run – EGWW NC Baseline ETO v3 Bundle 3

Bundle 4 – Regenerative Elevators
1. Regenerative Elevators

eQuest model run – EGWW NC Baseline ETO v3 Bundle 4

This measure is recommended and included in the design.

Bundle 5 – Energy Star Equipment
Due to difficulties in defining a cost delta this has been excluded from this analysis

This bundle has not been included in the Cost Effectiveness Calculations as it is listed in the technical guidelines are a pre-approved measure.

Bundle 6 – Centralized Server Room Heat Recovery Chiller
1. Energy Recovery Chiller

This measure is recommended and included in the design.

eQuest model run – EGWW NC Baseline ETO v3 Bundle 6

As the rolling baseline method has been used the final bundle, bundle 6 is can also be considered the interactive run with all measures.

All bundles noted above have been recommended and incorporated in the project. These bundles are the result of an initial Life Cycle Cost Analysis and measure analysis in the Parametric Design Analysis of Energy and Water Conservation Measures report 21st September, 2009.

Savings Summary

	Usage		Savings		Cost Savings	Non Energy	Total	Incremental	Simple	Potential
	Gas (Therms)	Elec (kWh)	Gas	Elec		Benefit	Savings	Cost	Payback	Incentives
Baseline	62,517	4,755,453								
Bundle 1	72,657	4,011,314	-10,140	744,139	$43,978	$0	$43,978	$87,800	2.0	$135,872
Bundle 2a	69,362	3,978,255	3,295	33,059	$4,950	$0	$4,950	$4,259,453	860.5	$0
Bundle 2b	13,687	3,681,303	55,675	296,952	$65,327	$308,000	$373,327	$3,313,893	8.9	$163,318
Bundle 3	12,529	3,681,303	1,158	0	$926	$0	$926	$5,246	5.7	$1,836
Bundle 4	12,529	3,605,187	0	76,116	$5,328	$0	$5,328	$39,000	7.3	$19,029
Bundle 6	8,178	3,627,246	4,351	-22,059	$1,937	$0	$1,937	$246,334	127.2	$0
Totals			54,339	1,128,207	$122,446					$320,055

EEM #	Energy Efficiency Measure Description	Business Type	Measure Lifetime (yrs) Max. 70 Yrs see row 95	Electric Measure Description	Natural Gas Load Profile	Select Project Type	Electric Energy (kWh/yr)	Gas Energy (therms/yr)	Adjusted Electric Energy (kWh/yr)	Adjusted Gas Energy (therms/yr)	Annual Non-Energy Benefits $ (if any)	Measure Incremental Cost	Is this measure eligible for commissioning? (COLUMN FOR PROGRAM USE ONLY)
1	Bundle 1 - Lighting Measure	Large Office	15	Daylighting	Space Heat	Renovation lighting	744,139	(10,140)	744,139	0	$0	$135,872	No
2	Bundle 2a - Interatctive Envelope	Large Office	20	HVAC	Space Heat	Renovation non-lighting	33,059	3,295	33,059	3,295	$0	$4,259,453	
3	Bundle 2b - HVAC	Large Office	45	Insulation	Space Heat	Renovation non-lighting	296,952	55,675	296,952	55,675	$308,000	$3,313,893	
4	Bundle 3 - DHW	Large Office	20	None	SolarDHWZ1	Renovation non-lighting	0	1,158	0	1,158	$0	$5,246	
5	Bundle 4 - Regenerative Elevators	Large Office	15	Processes	None	Renovation non-lighting	76,116	0	76,116	0	$0	$39,000	
6	Bundle 6 - Decentralized Server Room w/Heat Recovery Chiller	Large Office	23	HVAC	Space Heat	Renovation non-lighting	(22,059)	4,351	0	4,351	$0	$246,334	
7													
8													
9													
10													
11													
12													
13													
14													
15													
16													
17													
18													
19													
20													
						Sub-Totals	1,128,207	54,339	1,150,266	64,479	$308,000	$7,999,798	

Total Interactive Model Savings	1,128,207	54,339
Total Interactive Model Savings (kBtu)	9,283,342	
Total Baseline Energy Use (kBtu)	22,481,900	
% more efficient than code	41%	

EEM #	Energy Efficiency Measure Description	Electric Energy (kWh/yr)	Electric Cost ($/yr)	Gas Energy (therms/yr)	Gas Cost ($/yr)	Annual Non-Energy Benefits	Measure Incremental Cost	Potential Incentives	Combined Societal BCR	CEC Pass/ Fail	Payback before incentive	Payback after incentive	Acceptable EEM?	Eligible Incentives	Eligible Cx Incentive
1	Bundle 1 - Lighting Measure	744,139	$49,857	(10,140)	($8,112)		$135,872	$135,872	4.55	PASS	3.3	0.0	YES	$135,872	
2	Bundle 2a - Interatctive Envelope	33,059	$2,215	3,295	$2,636		$4,259,453	$13,537	0.02	FAIL	878.1	875.3	NO		
3	Bundle 2b - HVAC	296,952	$19,896	55,675	$44,540	$308,000	$3,313,893	$163,318	2.08	PASS	8.9	8.5	YES	$163,318	
4	Bundle 3 - DHW	0		1,158	$926		$5,246	$1,836	2.45	PASS	5.7	3.7	YES	$1,836	
5	Bundle 4 - Regenerative Elevators	76,116	$5,100				$39,000	$19,029	1.76	PASS	7.6	3.9	YES	$19,029	
6	Bundle 6 - Decentralized Server Room w/Heat Recovery Chiller	(22,059)	($1,478)	4,351	$3,481		$246,334	$6,962	0.12	FAIL	123.0	119.5	NO		
7															
8															
9															
10															
11															
12															
13															
14															
15															
16															
17															
18															
19															
20															
	Sub-Total	1,128,207	$75,590	54,339	$43,471	$308,000	$7,999,798	$340,553			**67.2**	**64.3**		$320,055	
	Acceptable Measures Total	**1,117,207**	**$74,853**	**46,693**	**$37,354**	**$308,000**	**$3,494,011**	**$320,055**	**2.2**		**31.1**	**28.3**		**$320,055**	

APPENDIX C – Sensitivity Analysis Report

Executive Summary

Overview

Following the release of Snapshot #6 documentation, [redacted] performed a sensitivity analysis of the energy model for the modernization of the Edith Green Wendell Wyatt Federal Building located in Portland, Oregon. This study assesses the sensitivity of the energy model to a range of design, operational and modeling uncertainties that affect energy performance. The results inform estimates of the amount of uncertainty associated with building design and operational parameters, while also providing insight into which areas of uncertainty have the largest impact on energy use. Ultimately, the results are used to inform development of the Target Range of energy performance for the project.

The sensitivity analysis performed to date focuses on Core & Shell design parameters that are in flux, and limited operational parameters related to expected generic tenant use patterns. It does not provide an impact analysis related to specific tenant programming or operational needs, as this information is not currently available. Future operational or behavioral departures from the assumptions included in the energy analysis and sensitivity analysis could cause a shift of the energy performance Target Range for the project. The energy analysis and associated sensitivity analysis will be updated throughout the project's duration; assumptions on specific tenant programming and operations will be included when that information becomes available.

Summary of Analysis

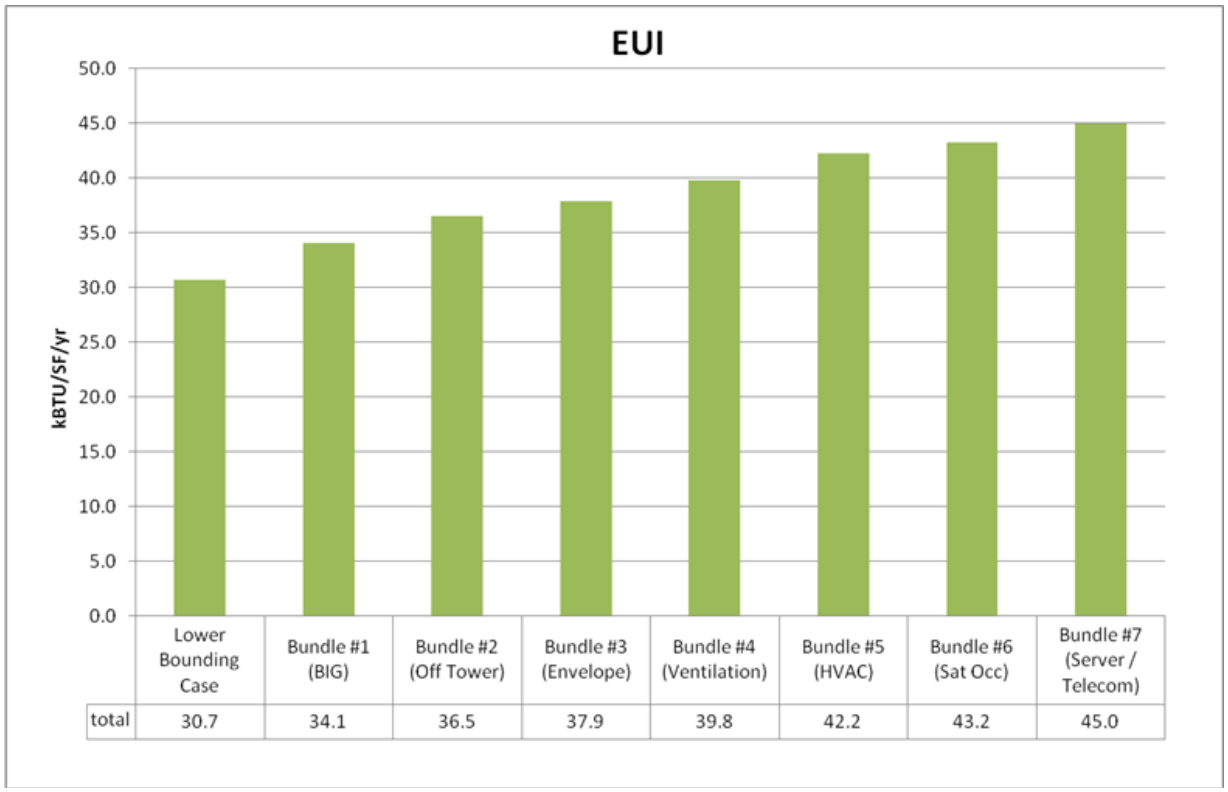
For each of the design and operational parameters included in the sensitivity analysis, a set of assumptions were developed to represent a lower and higher energy use range for that parameter. The model run that includes only the lower energy use assumptions is the "Lower Bounding Case." The input parameters were grouped into bundles of measures impacting a similar area of the building, and then the changes for that bundle were applied simultaneously. Each successive bundle of measures was applied cumulatively, such that the final bundle represents all of the higher energy use assumptions in the analysis, and therefore is the "Upper Bounding Case."

The groups or bundles of input parameters included changes in intensity of use in the lower floors and tower, changes in envelope parameters including amount of uncontrolled infiltration, HVAC system efficiencies and operating parameters, amount of weekend occupancy, and the extent of server room cooling.

Lower Bounding Case: includes the lower energy use assumptions in lighting, insulation, equipment efficiencies and some operational parameters. This case would reflect a very aggressive "best case scenario" where all of the uncertainties studied would be resolved in favor of lower building energy use.
Bundle #1 – BIG: changes the Basement, First and Ground level (B1G) program information including activity, occupant density and resulting outside air supplied, lighting and plug load etc.
Bundle #2 – Tower: changes the Tower levels (2-17) occupant density, outside air, plug load, lighting etc in the tower office floors, and changing penthouse level storage area to tenant office.

Bundle #3 – Envelope: modifies the building envelope wall U-factor, and changes the infiltration modeling methodology and lobby infiltration assumptions
Bundle #4 – Ventilation: changes the outdoor air supply rates on perimeter zones of levels floors 2-17, and removes the demand control ventilation from the café, conference and lobby on the ground and first floor
Bundle #5 – HVAC: changes the HVAC system performance criteria, including modifications to boiler and heat exchanger efficiency, additional fan energy for 30% enclosed offices and changes to thermostat set point temperatures
Bundle #6 – Weekend Occupancy: changes how much area of the building is operated on Saturdays from one to two floors of the tower. The Saturday operating schedule includes limited occupancy, lighting, equipment and HVAC operation, with fewer hours of operation and lower levels of activity than a typical weekday.
Bundle #7 – Server / Telecom: includes additional server/telecom equipment and changes assumptions regarding diversity of use.
Upper Bounding Case: includes the higher energy use assumptions in lighting, insulation, equipment efficiencies and some operational parameters. *The results for this case are represented as Bundle #7 results* (i.e. the cumulative impacts of all of the higher energy use affects from Bundle #7 and all previous bundles). This case reflects a scenario where all of the uncertainties included in the study are resolved towards increased building energy use.

The chart below summarizes the results in energy use intensity for the different bundles. The EGWW EUI excludes the parking garage to make it a balanced comparison with other office buildings. It is based on 438,952 GSF.



The bundles that had the maximum increase in energy use were Bundle #1 and #2 which included a change in the internal loads for the B1G and the Office tower. Between the Lower

and Upper bounding cases, the greatest increases in energy by end use were to Heating, followed by Plug Loads. The Results section of the report provides further discussion.

Assumptions

The following table lists the assumptions that have been modified from Snapshot #6 energy model assumptions to the bounding cases. Other assumptions are listed in the main body of the Snapshot #6 energy analysis report. Note that items formatted with grey italics in the Upper case have not changed from the Lower bounding case.

		Lower Bounding Case	Upper Bounding Case
Bundle #1 - B1G: includes changing the Basement, First and Ground level (B1G) program information including activity, occupant density and resulting outdoor air for ventilation, lighting, and plug loads			
1a.	Cafeteria Area Occupant Density Lighting OA	 3660 SF 50 SF/p 0.9 W/SF 12 cfm/p (based on ASHRAE 62 plus 30%)	 *3660 SF* 15 SF/p *0.9 W/SF* *12 cfm/p (based on ASHRAE 62 plus 30%)*
1b.	Kitchen Plug	 50 W/SF	 100 W/SF
1c.	Fitness Center Area Occupant Density Plug Lighting Outdoor Air	 1500 SF 100 SF/p 0.7 KW 0.75 W/SF 33.8 CFM/person (based on ASHRAE 62 plus 30%)	 *1500 SF* 50 SF/p 1.4 KW *0.75 W/SF* *33.8 CFM/person (based on ASHRAE 62 plus 30%)*
1d.	Office – Tenant Occupant Density	 250 SF/person	 200 SF/person
2.	Lighting Power Density Lobby Storage MEP Toilet Rooms Server Rooms Office Tenant	 0.9 W/SF 0.45 W/SF 1 W/SF 0.9 W/SF 0.6 W/SF 0.5 W/SF	 1 W/SF 0.7 W/SF 1.2 W/SF 1.2 W/SF 1 W/SF 0.62 W/SF

Bundle #2 – Tower: changes the Tower levels (2-17) occupant density, outside air, plug load, lighting etc in the tower office floors, and changing penthouse level storage area to tenant office.			
3.	Occupant Density Office Space	 250 SF/person	 200 SF/person
4.	Lighting Power Density	0.5 W/SF	0.7 W/SF
5.	Daylighting (North, East and South Perimeter Spaces)	0.5 W/SF (use daylighting schedules for North, East and South Perimeter Spaces)	0.88 W/SF *(use daylighting schedules for North, East and South Perimeter Spaces)*
6.	Plug load Office Space	 0.78 W/SF	 1.1 W/SF
Bundle #3 – Envelope: modifies the building envelope wall U-factor, and changes the infiltration modeling methodology and lobby infiltration assumptions			
7.	Wall U-factor	0.05	0.06
8.	Infiltration	0.06 CFM/SF of exterior wall area	0.33 Air Changes per Hour (keeping the base rate the same, the method of modeling the infiltration was modified in the model)
9.	Entrance doors infiltration besides main entry lobby	0.06 CFM/SF of exterior wall area	0.12 CFM/SF of exterior wall area
10.	Entry Lobby infiltration	1.15 CFM/SF of ext wall during peak periods 0.27 CFM/SF of ext wall during off peak lobby infiltration schedule used	3.45 CFM/SF ext wall during peak periods 0.8 CFM/SF ext wall during off peak *lobby infiltration schedule used*
Bundle #4 – Ventilation: changes the outdoor air supply rates on perimeter zones of levels floors 2-17, and removes the demand control ventilation from the café, conference and lobby on the ground and first floor			
11.	Office Outside Air from DOAS	0.11 CFM/SF in all perimeter spaces	– *0.11 CFM/SF in North perimeter spaces* – 0.16 CFM/SF in East and West perimeter spaces – 0.16 CFM/SF in South perimeter spaces on Floors 2 through 6

			– 0.21 CFM/SF in in South perimeter spaces on Floors 7 through 12 – 0.33 CFM/SF in South perimeter spaces on Floors 13 through 17
Bundle #5 – HVAC: changes the HVAC system performance criteria, including modifications to boiler and heat exchanger efficiency, additional fan energy for 30% enclosed offices and thermostat setpoint temperatures			
12.	Chiller	EIR (screw) = 0.13,	EIR (screw) = 0.145
13.	Pumps	motor class - premium	motor class - standard
14.	Boilers	Eff = 94%	Eff = 88%
15.	Water Economizer	Effectiveness =0.80	Effectiveness =0.51
16.	Cooling Tower Fan	30 HP	40 HP
17.	Thermostat Temperature	- Cooling 78F setback 85F - Heating 68F *setback 65F*	- Cooling 75F setback 82F - Heating 72F *setback 65F*
Bundle #6 – Weekend Occupancy: changes how much area of the building is operated on Saturdays from one to two floors of the tower.			
18.	Weekend Occupancy	Only Sunday closed Use reduced workday schedule for Saturday for one floor in office tower.	*Only Sunday closed* *Use reduced workday schedule for Saturday for* two floors *in office tower.*
Bundle #7 – Server / Telecom: includes additional server/telecom equipment and changes assumptions regarding diversity of use			
19.	CER Room	20 KW	25 KW
20.	Telecom / server / IDF rooms	50% diversity	75% diversity

Discussion of Assumptions

Bundle #1

This group or bundle includes changes or modifications to the lower floors basement, ground floor and 1st floor (AKA "B1G"). The lower floors in the model were modified with regards to intensity of use as described below.

Based on floor areas provided by [redacted] for different activities the lower and upper bounding cases; both included a fitness center and the office tenant space on the first floor was modeled as the cafe. The change in the activities included higher peak occupancy rates for which ventilation must be provided. The resulting higher outdoor air requirements are a major driver of increased energy use in this bundle. The other assumptions included in this bundle reflect anticipated bounding cases for plug, miscellaneous and lighting loads on these levels.

For the Kitchen the miscellaneous load was modified. The type of café service that will be provided is unclear but is expected to be low. The upper bounding case chose a load based on what literature suggests is at a lower end of the range for restaurants, or 100 W/SF. This was decreased to 50 W/SF for the lower bounding case.

Bundle #2

This bundle includes changes made to the office tower floors 2-17. The occupant density was modified as per input from for the upper bounding case. The Lighting power density and the plug load for the office tower were increased for the upper bounding case as per input from . The Penthouse storage area was modified to be an office space for the upper bounding case.

Bundle #3

This group or bundle includes modifications of envelope assumptions. The wall U-value was modified. All glazing values and percentage glazing were held constant as these are considered by the project team to be fixed. As infiltration is an area that is very difficult to test and ensure accuracy on, this assumption was tested for sensitivity in this bundle. The infiltration for the upper bounding case for all perimeter spaces besides the entryways was modeled using a different modeling methodology based on input from . Lobby infiltration was included in the upper bounding case as per calculations for automatic doors done by ; this was reduced by one third for the lower bounding case. Other entrance doors were modeled to have double infiltration in the upper bounding case, as per input from .

Bundle #4

The amount of outdoor air supplied to the spaces was increased in the upper bounding case for the east, west and south perimeter office zones to account for the possibility of additional cooling load in these spaces. The Snapshot #6 mechanical design provides for this flexibility. The additional cooling load that this increased air supply would offset is related to uncertainties of specific tenant fit-out requirements, such as higher interior loads due to equipment or occupant density. .

In addition, this bundle removes the strategy of demand control ventilation from various mult-occupant spaces on the B1G level to reflect more consistently high usage rates of these spaces than currently reflected on the occupancy schedules.

Bundle #5

This bundle includes for the upper bounding case reduced chiller, pump, heat exchanger and boiler efficiency and more conservative temperature set points for heating and cooling as well as additional fan energy for 30% enclosed offices which may require fan coil units. All modifications in efficiencies were based on input by . These assumptions are intended to reflect bounding cases based on the following: items where the design is still in flux, as well as assumptions to reflect the uncertainty associated with the modeling techniques (largely related to work-arounds required to model a radiant heating and cooling system and DOAS in eQuest).

The chillers modeled in the upper bounding case are as per their existing efficiency without taking benefit of improved efficiency due to higher water temperatures with a radiant panel system. This has been done to account for potential inaccuracies of the modeling method based on limitations of the tool.

The heat exchanger or water economizer included in the lower bounding case is modeled with a higher efficiency as a modeling work around. This has been done to account for potential inaccuracies of the modeling method based on limitations of the modeling method or tools available to model such systems.

The boiler is modeled with a reduced efficiency in the upper bounding case to incorporate operational uncertainty.

The upper bounding case includes additional fan energy for 30% enclosed offices as per input from . This has been included to reflect the design uncertainty as a result of the tenant fit out enclosed offices not being reflected in current core and shell design for Snapshot #6 documentation.

The temperature set points used for the lower bounding case are more aggressive and these have been set to more conservative heating and cooling temperature set points for the upper bounding case. This reflects an operational choice that is more likely in a radiant heating and cooling system due to the thermal comfort affects of this system on “operative” or perceived temperature in the space (an affect of mean radiant temperature).

Bundle #6

This bundle includes Saturday as a partial working day on one floor for the lower bounding case and on two floors for the upper bounding case such that the fans and set point temperatures are set to reflect 5 hours of operation per Saturday.

Bundle #7

The upper bounding case includes a higher load in the CER room and provides for 75% diversity in the telecom and IDF rooms. The assumptions with regards to the load for the IDF, Telecom Rooms and the CER room were determined with based on discussions with regarding electrical design assumptions.

Upper Bounding Case

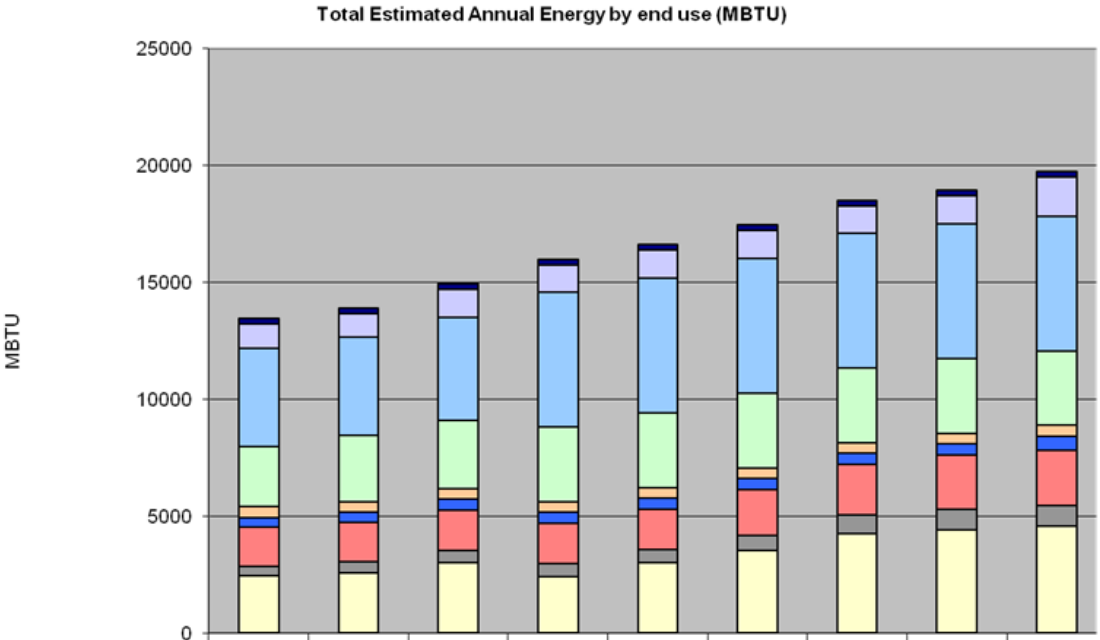
The results of Bundle #7 reflect the cumulative application of all upper bounding case assumptions to the lower bounding case. However, there are a couple of additional assumptions that are included in these cumulative results for a conservative overall estimate of the upper bounding case.

To address the modeling work-around for exhaust air heat recovery, the upper bounding case does not reflect a revised analysis of heat recovery. Since heating energy and outdoor air supplied are substantially higher in the upper bounding case, this reflects a conservative assumption regarding savings available from heat recovery.

To address the modeling work-around for pump energy (as described in methodology section of main report) a separate eQUEST file was used to determine the additional pumping for the upper bounding case for bundle 7. This was done to incorporate any additional pumping energy due to the increase in heating and cooling for the upper bounding case.

Results

The chart below indicates the predicted energy by end use of each of the bundles modeled, with the Lower Bounding Case represented on the far left, and the Upper Bounding Case represented by Bundle #7 results on the far right.



	Lower Bounding Case	SnapShot #6	Bundle #1 (BIG)	Bundle #2 (Off Tower)	Bundle #3 (Envelope)	Bundle #4 (Ventilation)	Bundle #5 (HVAC)	Bundle #6 (Sat Occ)	Bundle #7 (Server / Telecom)
Elevators	237	237	237	237	237	237	237	237	237
Misc Loads	1033	1024	1186	1186	1186	1186	1186	1204	1665
Plug Loads	4218	4195	4430	5773	5773	5773	5773	5776	5776
Lighting	2568	2837	2906	3177	3177	3177	3177	3177	3177
Domestic Hot Water	458	458	458	458	458	458	458	458	458
Pumps	419	430	455	466	469	469	474	477	593
Fans	1657	1664	1737	1737	1740	1972	2159	2326	2383
Space Cooling	399	472	499	566	565	639	813	863	886
Space Heating	2485	2606	3041	2407	3012	3549	4253	4440	4576

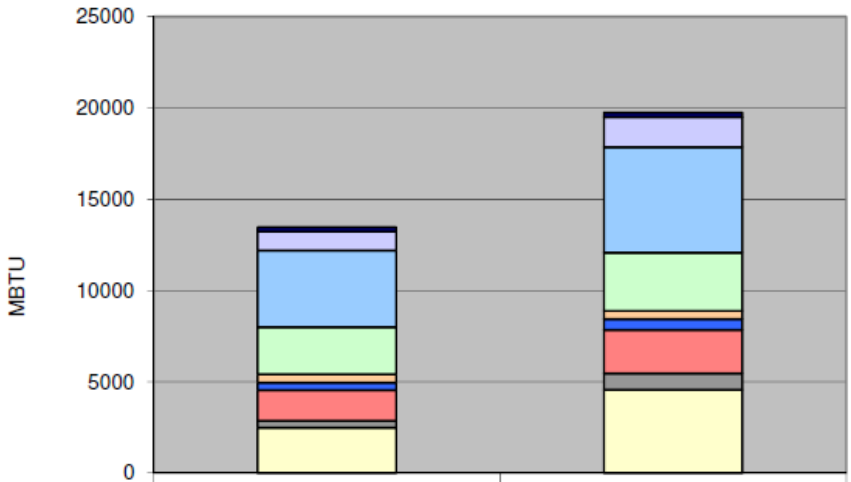
The chart below indicates the predicted energy by end use of each of the bundles modeled, with the Lower Bounding Case represented on the far left, and the Upper Bounding Case represented by Bundle #7 results on the far right.

The following table compares the Lower and Upper bounding cases, and provides insights into the change in energy by end use. The energy End Uses are listed in the order of largest to smallest impact to change in energy use between the Lower and Upper bounding cases.

End Use	Lower Bounding Case (MBTU)	Upper Bounding Case (MBTU)	Explanation of Savings
Space Heating	2485	4576	Heating energy is increased due primarily to the following: higher heating set point temperature, higher lobby infiltration, reduced boiler efficiency, Sat occupancy and increase in outside air.
Plug Loads	4218	5776	Plug loads is increased in due to increase in plug loads in the café, fitness center, office tower and Saturday occupancy.
Fans	1657	2383	Fan energy is increased due primarily to the following: increased outside air supply in the South and East perimeter spaces, increase in fan energy for 30% enclosed offices and Saturday occupancy
Misc Loads	1033	1665	Miscellaneous loads increased due to higher server and telecom equipment loads.
Lighting	2568	3177	Lighting energy increased due to increase in the lighting power density in the office areas as well as Saturday occupancy
Space Cooling	399	886	Cooling energy is increased due primarily to the following: reduced chiller efficiency, reduced heat exchanger (water economizer) efficiency, increase in internal loads (equipment, lighting and occupancy), increased server and telecom load, and Saturday occupancy.
Pumps	419	593	Pump energy is increased due primarily to the following: reduced heat exchanger (water economizer) efficiency and the increase in heating and cooling requirement due to reasons listed above
Domestic Hot Water	458	458	DHW systems are assumed to remain constant between the two models
Elevators	237	237	Elevator loads are assumed to remain constant between the two models.

The chart below summarizes and graphically displays the energy use by end use for the Lower and Upper bounding cases.

Total Estimated Annual Energy by end use (MBTU)



	Lower Bounding Case	Upper Bounding Case
Elevators	237	237
Misc Loads	1033	1665
Plug Loads	4218	5776
Lighting	2568	3177
Domestic Hot Water	458	458
Pumps	419	593
Fans	1657	2383
Space Cooling	399	886
Space Heating	2485	4576