Technical Report 2

FDA Building One – White Oak, MD

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Technical Report 2 demonstrates a clear understanding of building HVAC load and energy analysis procedures. Block load and energy estimates were performed using a computer-based method, and the results are shown within. These results show an estimation of the design load, annual energy consumption, and operating costs.

Executive Summary:

Energy consumption and environmental pollutants from commercial buildings are becoming more important in the measure of how successful a building's HVAC system performs. In order to quantify these values before the building is constructed the design engineer should create and analyze an energy model which represents the proposed HVAC system. Once an energy model is created it can not only be used for energy consumption it can also be used to calculate the annual building utility bills. Energy models can play an important role in the design phase when they are used to compare and contrast different system options and to see how different equipment set points affect the whole HVAC system design.

There are many different metrics on how to quantify a building's proposed system energy savings such as comparing it against ASHRAE Standard 90.1 baseline models, or against the Commercial Building Energy Consumption Survey report. The program that was used to calculate the plant load data as well as the yearly energy consumption was Trane TRACE 700. The data inputs were taken from the building as-builts and reasonable assumptions made after speaking to engineers involved with similar projects on the FDA Campus.

After creating a block load energy model for FDA Building One, the resulting cost analysis of energy consumption for heating and cooling loads was calculated. The block load energy consumption that was calculated is unknown to what degree this is accurate with the engineers design conditions. Since the campus is serviced by a Central Utility plan, an estimated cost of generation was computed for the consumed electricity and steam is $212,000 or $2.12/sf. This yearly utility cost is under the average utility cost for buildings of this type by $0.13/sf. Knowing the characteristics of a buildings utility usage can provide insight into areas of improvement within the mechanical system to provide reduced energy consumption and source emissions.

Mechanical System Overview

FDA Building One receives conditioned supply air from three air handling units (AHU's). The first of the AHU's (OAHU-1) is strictly providing 100% outside air to the peripheral office spaces, the AHU supplying the security pavilion and VAV boxes serviced in part by the third AHU; sized at 5,300 CFM with an energy recovery wheel. The AHU servicing the security pavilion (AHU-2) is provided at constant volume, sized at approximately 7,300 CFM with reheat. The AHU servicing conference rooms and interior areas (AHU-1) through VAV and CAV boxes as well as Dual Duct Air Terminal Units, sized at 19,000 CFM with pre-heat. Two-pipe fan coil units (FCU's) are used in both the electrical closets and telecommunications closets, as well as around the perimeter in private offices.

The building is a part of the larger campus which is serviced by a Central Utility Plant containing a co-generation plant, chillers, boilers, cooling towers, etc. This is in part of an energy saving strategy, in conjunction with reliability concerns, to provide the entire campus with electricity, heating and air conditioning. The utility plant will be able to monitor loads amongst the various buildings and ramp up or down the supply of utilities based on the demand loads. In this manner, the utility plant itself can function with utmost efficiency, allow for redundancy and extreme load scenarios.

System Design Load Estimation

Trane TRACE 700 was used to determine the design load energy consumption of FDA Building One located at the FDA White Oak Research Center in Silver Spring, MD. TRACE was used for this energy analysis due to the relative ease of system inputs and user knowledge. A full 8,760 hour energy analysis was performed to determine the peak design heating and cooling loads of the system and also the date of their occurrence.

Block Load Assumptions

A block load analysis as opposed to a full space by space analysis was performed for this assignment. The advantages of using a block analysis for a building of this size is that the model calculation time is greatly reduced, the model file sizes are more manageable, and results are still accurate within reason. The information that was used to generate the block load model was taken directly from the as-built drawings (line and control diagrams) and other related engineering documents to determine things such as room areas, equipment characteristics, and building construction materials. Some of the assumptions that were made during the creation of this block model are listed below.

- The exterior shell of the building was modeled as having a uniform wall construction as opposed to modeling the precast and panels as separate pieces.
- The connector link was not taken into account for calculation purposes as it does not serve as more than a historical hallway from Building One to the Central Shared Unit.
- Washington DC weather data was used.

The weather data from the ASHRAE Handbook of Fundamentals (HOF) for Washington D.C. was used in this load analysis due to its close proximity to White Oak. The table below shows the design heating and cooling weather data that was used for this calculation.

	Indoor Design (F)	Outdoor Design (F)	TRACE 700 Default (F)
Summer	75	94.5	93.2
Winter	68	15.9	9.6

Miscellaneous and Lighting Loads

The lighting power densities and the miscellaneous equipment loads that were used in this calculation are shown in the table below. All of the values that are listed have been used in the creation of room templates that were used in the energy model. In order to provide an accurate representation for the building load conditions schedules were made for the occupancy, lighting, and miscellaneous loads. Some of these schedules were taken from ASHRAE data that is loaded within TRACE as well as assumptions made based on equipment schedules.

Room Type	Lighting Load (W/sf)	Misc Load (W/sf)	People (sf/person)	Min ACH
Conference	0.7	1	20	6
Corridor	0.6	0.25	0	4
Comm/Mech	0.55	10	0	-
Office	0.75	1	120	4

Load Analysis Results

Table 5 details cooling, heating, and ventilation check values. These values can't be guaranteed as concurrent with design conditions as put forth by the engineers due to the simplifying room assumptions that were made for the block load energy model. Even though rooms may be classified under the same occupancy the specific equipment within each space varies significantly. Very detailed information for each individual room must be known and modeled precisely in order to get the most accurate model of the buildings heating and cooling loads. With all of the simplifying assumptions that were made for this block load model the results still give a reasonably accurate representation of the loads that were used for actual system design.

	Cooling (sf/ton)	Heating (Btuh/sf)	Supply/Ventilation (CFM/sf)
As Model	211.54	28.77	0.84
As Designed (Assumed)	233.5	22.8	0.8

System Energy Consumption and Operating Cost

The full year energy simulation was calculated using the same TRACE model that was used to determine the building design cooling and heating loads. The cooling equipment in the building uses electricity to operate while the heating equipment uses district steam from the campus steam generation plant.

Load Sources

There are many things within all commercial buildings that contribute to the overall net heat gain within occupied spaces. A large increase in building plant cooling capacity in recent years can be attributed to the increasing demand and utilization of computers with higher processing power.

Lighting

With improvements in lighting fixtures, the cooling load attributed to this building component has reduced greatly from what it has been in the past. Fortunately the building uses occupancy sensors and allows for great amounts of natural light deep into the building. Nevertheless the lights are operable and operated on a 24 hour schedule as part of security measure, during the night especially.

People

The design occupancies have had schedules applied to them for the percentage of the total amount of people that are assumed to be within the buildings during certain hours. The heat generation from building occupants varies widely due to different metabolic activity levels.

Infiltration

The building has been designed to maintain a total building pressurization in order to prevent unconditioned air from entering building spaces. All rooms with exterior walls have been assumed to have a pressurization leakage from the occupied space to the outdoors of 0.06 cfm/sf of exterior wall. Doing so helps to reduce heating or cooling load associated with unconditioned air entering occupied spaces through walls or windows.

Air Change Requirements

The RFP stated minimum air change requirements for all of the different room templates used. These minimum air change requirements were set forth in order to ensure adequate ventilation and reduce the spread of disease or pollutants throughout the building. Due to the high internal heat load within the spaces the minimum air change requirements rarely determined the ventilation air flow. But when the ventilation air flow was increased due to this requirement the total load increased from having to condition a greater volume outside air.

System Energy Breakdown

The category that consumes the largest amount of electricity in the HVAC system is the complete cooling system. While the chilled water system alone consumes only 11.8% of the total energy when the supply fans and pumps are added in the percentage jumps to 32.7% of the buildings yearly energy consumption. Also, a fan must overcome a large pressure drop to push the air through the total energy wheel. The annual energy consumption is listed which breaks out the energy usage from separate parts of the HVAC system.

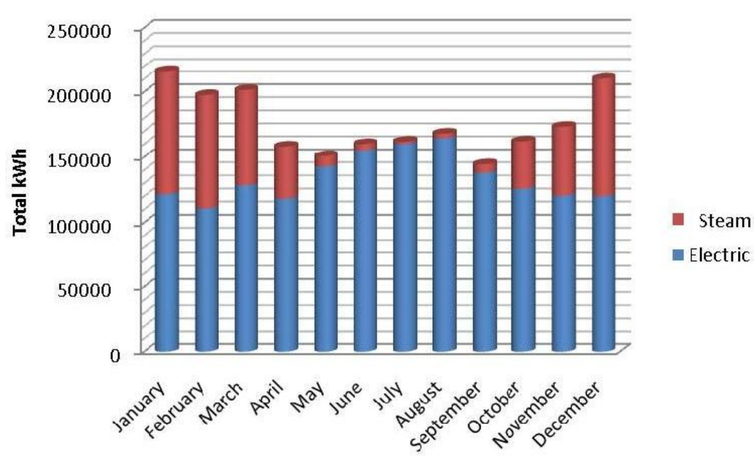
	Electric Consumption (Btu)	Steam Usage (Btu)	Total Energy %
Heating System	363102	369457	22.80%
Cooling System	293183		32.70%
Auxillary (Stand Alone, Ltg, Receptacles)	2121168		44.50%

Building Energy Costs

The utility rates that FDA is charged for electricity and steam were not made known for this project. The electricity rates shown are from Pepco and the steam rates were assumed to get an educated idea of the costs.

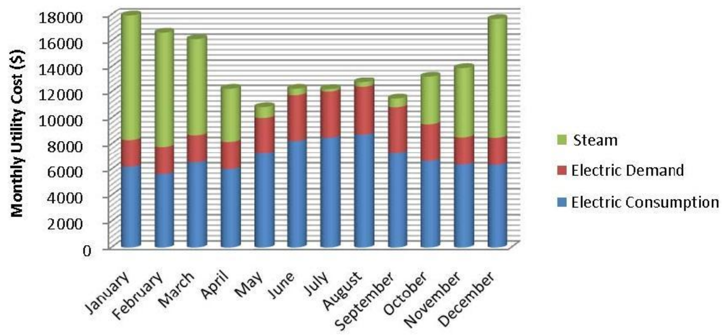
	Jan- May	June- Dec
Electric Peak ($/kWh)	0.051	0.053
Electric Off Peak ($/kwh)	0.048	0.048
Steam ($/therm)	2.985	2.985

The total energy consumption are shown together for each month during the year. As thought, the electricity peaks through the summer due to the need for the chillers to run near their peak in order to provide the cooling capacity required to keep the building within the space set points. The steam consumption peaks through the winter months when the steam usage is highest due to the large demand on heat exchangers. The electric consumption is still a significant portion of the total energy usage throughout the winter due to the high miscellaneous loads that are relatively constant year round.



Monthly Utility Consumption

The actual total cost to operate the HVAC system for an entire year was not calculated due to lack of data provided by GSA. However, based on load calculations the highest monthly utility cost is during the month of January due to the large amount of steam. It's interesting to note that steam is the most expensive energy utilized at $0.030/kBtu compared to an average electricity cost of $0.015/kBtu for all of the consumption rates.



With an assumed yearly utility cost of nearly $212,000, the system breaks down to having an operating cost of $2.12/sf. This utility cost was compared to data compiled from the 2003 Commercial Buildings Energy Consumption Survey (CBECS) which is performed by the Energy Information Administration (EIA). The data pulled from the CBECS survey is shown to yield an average cost of $2.25/sf for site utilities.

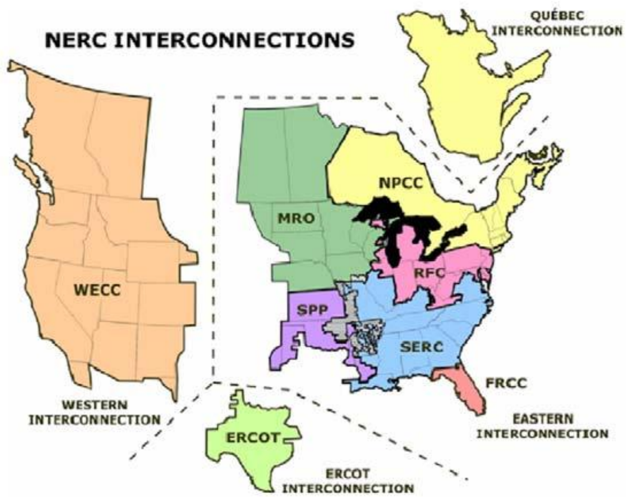
Building Energy Analysis

The design engineer most certainly performed a full building energy analysis for this building as part of the LEED® certification process. Due to this information not being made available for reporting, it's hard to compare the actual design versus the model's output. Though in the midst of this report, reasonable assumptions were made after speaking with several people related to the project. Reporting has been done on that basis.

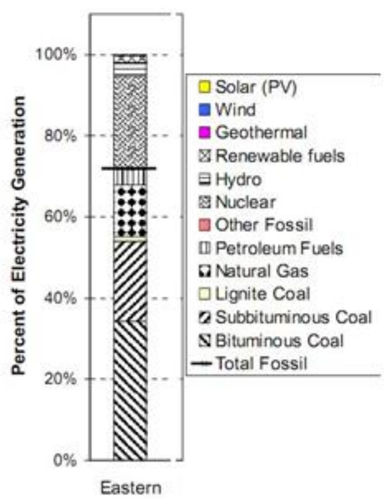
Discrepancies in the reported values may be caused from a few different assumptions. The difference in the loads calculated is most likely due to the room simplifying assumptions and the other assumptions that were stated earlier. Certain inputs, as minute as variations in weather data used may also be a contributing factor to inconsistency. Different program versions may have different equipment coding written within them and to be sure the program manufacturer should be consulted to answer if any code changes that have been made. In order to not have any potential problems from version updates, the same version of the program should be used in order to maintain consistency between energy model alternatives.

System Emission Rates

The emissions rates for pollutants such as CO2, NOx, SOx, and particulates have been calculated based upon the total energy consumption that was determined from the block load energy model. The typical source emission rates of electricity and natural gas for Maryland were taken from a report compiled by the National Renewable Energy Laboratory (NREL). Maryland is located within the Easter Interconnection region as shown.



The source emission rates for all the interconnection areas are determined based upon how the electricity in that specific region is produced. As you see below the breakdown of how electricity is produced within the region. This figure shows that the Eastern Interconnection produces over half of its electricity from bituminous and sub-bituminous coal.



The total source pollution emissions that are generated from FDA Building One is due to the use of electricity and natural gas associated with the Central Utility Plant. It's assumed that the equipment in the CUP utilizes natural gas for steam production. Based on conversations with a maintenance worker, the pollutant sources and amounts have been calculated.

	Electricity Emission Factor (lb pollutant/kWh)	**Nat Gas Emission Factor (lb pollutant/kWh)**	**Total lb of Pollution**
CO_2	1.82	122	317856
NO_X	0.0031	0.111	521
SO_X	0.0111	0.000632	1784.3
PM 10	0.0000925	0.0084	165

References:

-Administration, E. I. (n.d.). *Energy Star*. Retrieved October 22, 2010, from http://www.energystar.gov/ia/business/tools_resources/new_bldg_design/2003_CBECSPerformanceTargetsTable.pdf

-ASHRAE. (2009). *Handbook of Fundamentals.* Atlanta: ASHRAE.

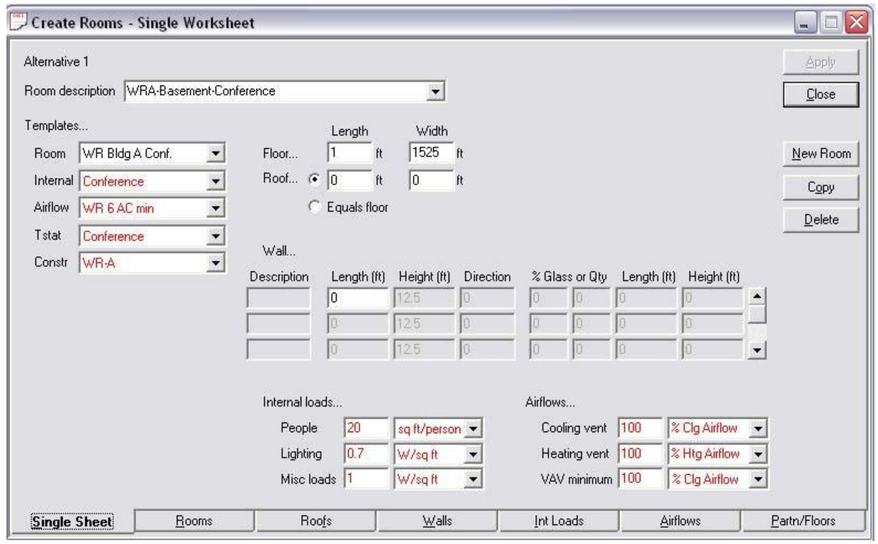
-Star, E. (n.d.). *Target Finder*. Retrieved October 22, 2010, from Energy Star: http://www.energystar.gov/index.cfm?c=new_bldg_design.bus_target_finder

-Torcellini, M. D. (June 2007). Source Energy and Emission Factors for Energy Use in Buildigns. Golden, Colorado: National Renewable Energy Laboratory.

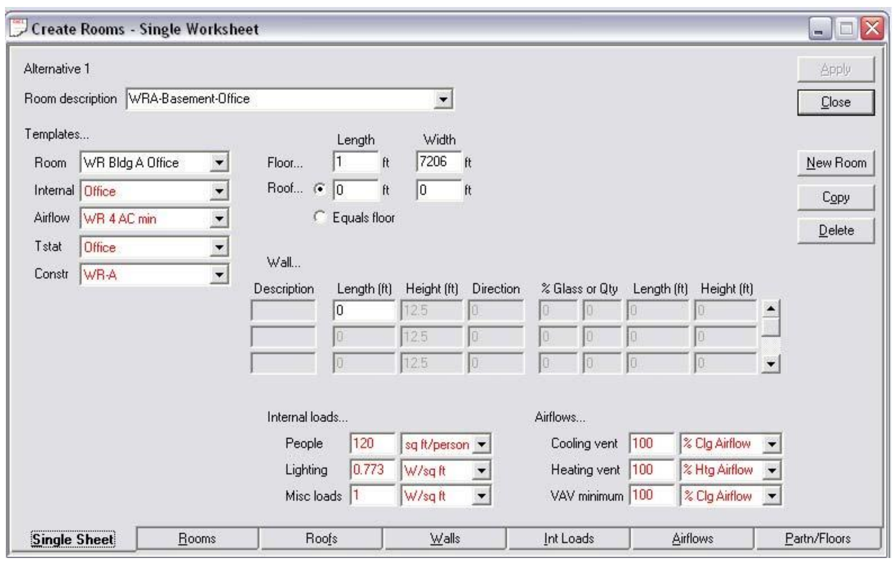
-KlingStubbins w/ RTKL. Architectural Construction Documents. Washington, DC.

Typical Room Templates

Typical Conference Room Template



Typical Office Template



Typical Corridor Template