# Ft. Detrick Defense Medical Logistics Center

# Frederick, MD

## Building and Plant Energy Analysis

Technical Assignment 2

Prepared for: Dr. William Bahnfleth

Prepared by: Domenica Ferraro, Mechanical Option

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# Executive Summary

Ft. Detrick Defense Medical Logistics Center (DMLC) is a three-story office building in Frederick, MD. This report analyzes how well it utilizes energy. The first investigation performed is a LEED Certification study. In this analysis, the building was rated according to LEED-NC version 2.2. This measures the buildings sustainability. Since Ft. Detrick is a military structure, its sustainability is measured using the SPiRiT rating scale. Ft. Detrick will receive a Silver SPiRiT rating when construction is complete (40 out of 100 credits), but if a LEED rating was applied, it would not be certified (19 out of 69 credits). Details of how a LEED rating could be acquired are outlined in this report.

The second investigation, an ASHRAE 90.1 Analysis, can be broken down into three parts: Building Envelope Compliance, HVAC Systems Compliance, and Power, Lighting, & Motor Compliance. Results of this study are summarized in Table 1, below.

**Table 1**
**ASHRAE 90.1 Compliance Summary**

| | Building Envelope | | | | | HVAC Systems | | | Power, Lighting, & Motors | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Roof | Walls | Floors | Doors | Fenestration | Efficiencies | Insulation | Service Water Heat | Power | Lighting | Motors |
| Comply | YES | YES | NO | YES | YES | YES | YES | YES | YES | NO | NO |

Ft. Detrick is a 129,900 $ft^2$ structure with six mechanical rooms housing the air handling units, one boiler room, and one mechanical chase. 5.2% of potentially rentable space is lost due to mechanical space. The cost of the building's HVAC system is approximately $1,084,037 ($8.36/$ft^2$).

The Design Load Estimation and the Annual Energy Consumption and Cost Analysis were conducted in Trane Trace 700. The results of this assessment reveal that three of the systems analyzed have design airflows drastically different from airflows on the design documents. Further, the total annual utility consumption is 1,557,197 kWh of Electricity and 3902 Therms of gas consumption. This is much less than the HVAC design engineer calculated in their analysis. Trace computes the cost to operate the HVAC systems is $156,209 ($1.28/$ft^2$).

# LEED-NC Version 2.2 Certification

LEED stands for Leadership in Energy and Environmental Design. Developed by the US Green Building Council (USGBC), the LEED rating system is used to measure a building's sustainability. A summary of the LEED points that can be obtained for Ft. Detrick is found in Appendix A. Since Ft. Detrick is a military building, the SPiRiT rating system is used to rank sustainability. SPiRiT stands for Sustainable Project Rating Tool. The format is similar to LEED in that it gives a rating based on a certain amount of credits obtained. SPiRiT however is out of 100 credits where as LEED is out of 69. Ft. Detrick cannot receive LEED certification because it only meets the criteria for 19 credits, but it can receive 40 credits according to the SPiRiT rating system. This is known as a Silver SPiRiT rating. The extra credits could be obtained because there are three additional categories in the SPiRiT system: Facility Delivery Process, Current Mission, and Future Missions.

The credits under the Facility Delivery Process category are achieved by a holistic delivery of the facility. On Ft. Detrick, this is met by including the entire project team in the delivery process. The project team includes the future occupants of the building, contracting staff, owner representatives, project manager, architects, and engineers. Project goals were identified early, and charrettes were executed at different stages of delivery to get everyone involved in the design. This increased communication relates to sustainability because the project is completed efficiently. The design process for Ft. Detrick actually finished ahead of the original schedule, which saves time and energy for everyone involved.

The credits in the Current Mission category break into two parts. The first is to develop an Operations and Maintenance program. Frequent maintenance is important to sustainability because a building may be heating and cooling sufficiently for occupant comfort, but the equipment may be using more energy than is required to do so. The second part of this category is Soldier and Workplace Productivity and Retention. The theory behind this credit is that a high quality indoor environment is directly related to the productivity of the workers in that environment.

The third category, Future Missions, awards credits based on the functional life of the building and the ability of the building to adapt to future usages. Ft. Detrick is mostly open office space, so it can accommodate a wide range of future occupancies. With a rectangular footprint, it is efficient in shape, so there is a possibility for expansion. The facility is also designed for recycling of materials and systems.

For Ft. Detrick to receive LEED Certification, designers need to obtain seven more points. There are four "Innovation in Design" credits listed as "?" in the chart in Appendix A. The design points from the SPiRiT rating system that are not found in the LEED rating system may count for these innovation credits. Another credit that cannot be obtained with the current design is "Chemical and Pollutant Source Control." The only factor keeping Ft. Detrick from meeting these criteria is that no exhaust system is designed for the copy rooms. This would be a simple fix because the copy rooms are stacked vertically, so an exhaust main could pick up all copy rooms and run straight through the roof. Two more credits could potentially be obtained by developing a Construction Indoor Air Quality (IAQ) Management plan. I listed this as a "?" on the LEED Checklist because on the SPiRiT checklist, it was noted that this would add moderate cost. It is then up to the owner to decide if these credits are worth paying for to achieve LEED Certification.

# ASHRAE Standard 90.1-2004 Compliance

## Building Envelope Compliance

There are two compliance paths in ASHRAE 90.1-2004 that can be used to evaluate the building envelope. Ft. Detrick meets the requirements of the Prescriptive Building Envelope Option. This option can be used when a building's vertical fenestration is less than 50% of the gross wall area and the skylight fenestration is less than 5% of the gross roof area. Ft. Detrick has no skylights, so the second requirement was met automatically. Table 2 summarizes the total glass area versus the total wall area, and shows that the first requirement is also met.

**Table 2**

**Vertical Fenestration Summary**

| Window Quantity | Area Per Window | Total Glass Area | Total Wall Area | Percent Vertical Fenestration |
|---|---|---|---|---|
| 213 | 24.89 $ft^2$ | 5302 $ft^2$ | 33,182 $ft^2$ | 15.98% |

The Prescriptive Building Envelope Option is described in Section 5.5 of ASHRAE 90.1-2004. Ft. Detrick is located in Frederick, MD. This is classified as climate zone 4A, so Table 5.5-4 is used to determine the building envelope requirements. Ft. Detrick is categorized as 'nonresidential' in this chart. Tables 3 and 4 compare actual material characteristics with ASHRAE values. The

actual insulation R-values and fenestration values are taken from the specifications for Ft. Detrick provided by Baker and Associates.

**Table 3**
**Building Envelope Compliance - Opaque Elements**

| Building Component | | Insulation Minimum R-Value | Actual Insulation R-value | Comply |
|---|---|---|---|---|
| Roofs | | | | |
| | Insulation Entirely Above Deck | R-15 | R-20 | YES |
| Walls, Above Grade | | | | |
| | Mass | R-5.7 | R-13 | YES |
| Floors | | | | |
| | Mass | R-6.3 | R-5 | NO |
| Opaque Doors | | | | |
| | Swinging | R-2 (U-0.7) | R-10 | YES |

**Table 4**
**Building Envelope Compliance - Fenestration**

| Vertical Glazing 15.98% of Wall | Maximum per ASHRAE | Actual per Design Documents | Comply |
|---|---|---|---|
| U-Value Fixed | 0.57 | 0.29 | YES |
| U-Value Operable | 0.57 | 0.29 | YES |
| SHGC All Orientations | 0.39 | 0.38 | YES |
| SHGC North-Oriented | 0.49 | 0.38 | YES |

# HVAC Systems Compliance

Since Ft. Detrick is a new construction and not an addition or renovation, HVAC systems compliance is determined by Section 6.2 of ASHRAE 90.1-2004. It is greater than two stories, so sections 6.4 and 6.5 are the compliance path. Table 5 summarizes the building's compliance with the minimum equipment efficiencies listed in Section 6.4.

**Table 5**
**Minimum Equipment Efficiency Compliance**

| Equipment | Quantity | Minimum Efficiency (ASHRAE) | ASHRAE 90.1-2004 Table Reference | Actual Efficiency | Comply |
|---|---|---|---|---|---|
| Rotary Screw Water Cooled Chiller | 2 | COP = 4.90 | 6.8.1 C | COP = 5.39 | YES |
| Gas-Fired Boilers | 2 | $E_T$ = 75% | 6.8.1 F | $E_T$ = 80% | YES |
| Centrifugal Fan Cooling Towers | 2 | gpm/hp = 20.0 | 6.8.1 G | gpm/hp = 42 | YES |

Unit heaters and air conditioning units are not listed in the table above, but are designed to comply with ASHRAE 90.1-2004. It is called out in specification section 15700A-14 of the design documents that "Units shall have an efficiency meeting or exceeding ASHRAE 90.1 requirements" (Baker). However, the SEER value for the air conditioning units (manufactured by Liebert) and the efficiency of the unit heaters (manufactured by Trane) are not included in the manufacturer's cut sheets in the engineer's design analysis.

Ft. Detrick is also in compliance with the standards for insulation. Its ductwork is insulated with 1" thick rigid mineral fiber per the design documents. An R-value was not specified for this material in the design documents, but ROXUL, a manufacturer of rigid mineral fiber, list the R-value as 4.2. For an unvented attic with roof insulation, the minimum R-value listed in ASHRAE 90.1-2004 is 3.5. Therefore, the ductwork insulation complies. The piping insulation is also in compliance with ASHRAE 90.1-2004, as seen in Table 6.

**Table 6**
**Minimum Pipe Insulation Thickness Compliance**

| | Heating Hot Water | | | Domestic Hot Water | | | Chilled Water | | |
|---|---|---|---|---|---|---|---|---|---|
| Nominal Pipe Size (in) | Min. Thick. | Actual Thick. | Comply | Min. Thick. | Actual Thick. | Comply | Min. Thick. | Actual Thick. | Comply |
| <1 | 1 | 1 | YES | 0.5 | 1 | YES | 0.5 | 1 | YES |
| 1 to <1 1/2 | 1 | 1 | | 0.5 | 1 | | 0.5 | 1 | |
| 1 1/2 to <4 | 1 | 1.5 | | 1 | 1 | | 1 | 1 | |
| 4 to <8 | 1.5 | 1.5 | | 1 | 1 | | 1 | 1 | |
| Operating Temperature Range (°F) | 141-200 | | | 105+ | | | 40-60 | | |

The service water heating is also in compliance with ASHRAE 90.1-2004. The required performance for an electric hot water heater is determined by the energy factor (EF). For all four electric hot water heaters, the EF is above the minimum requirement, as is illustrated in Table 7.

**Table 7**
**Minimum Service Water Heater Efficiency Compliance**

| Heater Location | Volume (gal) | Minimum EF | Actual EF | Comply |
|---|---|---|---|---|
| Janitor Closets | 40 | 0.877 | 0.897 | YES |
| Under Sinks | 6 | 0.922 | 0.942 | YES |

EF=0.93-(0.00132*gal)

# Power, Lighting, & Motor Compliance

The power compliance requirements are outlined in Section 8 of ASHRAE 90.1-2004. It states that the feeder conductors must be sized for a maximum 2% voltage drop, and the branch circuit conductors must be sized for a maximum 3% voltage drop, both at design load conditions. The power distribution system for Ft. Detrick is designed to comply with these criteria.

The lighting compliance requirements are outlined in Section 9. The goal of this section is to establish a maximum interior lighting power allowance. The Space-By-Space Method

Compliance Path was chosen for analysis. Table 8 summarizes the compliance of different area types within Ft. Detrick.

**Table 8**
**Maximum Interior Lighting Power Allowance**

| Building Area Type | Area ($ft^2$) | $W/ft^2$ (Table 9.5.1) | Required Watts | Actual Watts | Comply |
|---|---|---|---|---|---|
| Cafeteria | 801 | 0.9 | 721 | 592 | YES |
| Classroom | 2646 | 1.2 | 3175 | 3564 | NO |
| Conference | 5406 | 1.3 | 7028 | 7284 | NO |
| Corridor | 1558 | 0.5 | 779 | 3788 | NO |
| Electrical/Mechanical Room | 8148 | 1.5 | 12,222 | 6048 | YES |
| Lobby | 3246 | 1.3 | 4220 | 3264 | YES |
| Office - Enclosed/Open | 98,377 | 1.1 | 108,215 | 138,885 | NO |
| Restrooms | 2655 | 0.9 | 2390 | 3240 | NO |
| Stairs | 1823 | 0.6 | 1094 | 1632 | NO |
| Storage | 5300 | 0.9 | 4770 | 5288 | NO |
| **Total** | **129,960** | - | **144,613** | **173,585** | **NO** |

Motor efficiency compliance is determined by the standards in Section 10. Efficiency is calculated by dividing the brake horsepower by the input horsepower. These values are from the mechanical schedules and manufacturer's cut sheets, and are summarized in Table 9. Return fan data is from the manufacturer's (Loren Cook) cut sheets. Motors not listed in the chart are smaller than 1 hp, and thus are not required to comply with the standard.

**Table 9**
**Minimum Motor Efficiency Compliance**

| Equipment | Input HP | BHP | Actual Efficiency | Required Efficiency per Table 10.8 | Comply |
|---|---|---|---|---|---|
| Return Fan 1 | 5 | 3.29 | 65.8% | 87.5% | NO |
| Return Fan 2 | 5 | 3.29 | 65.8% | 87.5% | NO |
| Return Fan 3 | 5 | 3.45 | 69.0% | 87.5% | NO |
| Return Fan 4 | 5 | 3.17 | 63.4% | 87.5% | NO |
| Return Fan 5 | 5 | 4.12 | 82.4% | 87.5% | NO |
| Return Fan 6 | 5 | 4.12 | 82.4% | 87.5% | NO |
| Supply Fan 1 | 25 | 21.88 | 87.5% | 91.7% | NO |
| Supply Fan 2 | 25 | 22.04 | 88.1% | 91.7% | NO |
| Supply Fan 3 | 30 | 26.40 | 88.0% | 93.0% | NO |
| Supply Fan 4 | 30 | 25.11 | 83.7% | 93.0% | NO |
| Supply Fan 5 | 30 | 29.03 | 96.8% | 93.0% | YES |
| Supply Fan 6 | 30 | 29.78 | 99.3% | 93.0% | YES |
| Supply Fan 7 | 2 | 1.23 | 61.5% | 86.5% | NO |
| Pumps 1, 2 | 3 | 2.30 | 76.7% | 87.5% | NO |
| Pumps 3, 4 | 10 | 9.34 | 93.4% | 89.5% | YES |
| Pumps 5, 6 | 10 | 8.17 | 81.7% | 89.5% | NO |
| Pumps 7, 8 | 15 | 11.83 | 78.9% | 91.0% | NO |
| Pumps 9, 10 | 10 | 8.75 | 87.5% | 89.5% | NO |

# Lost Rentable Space Break Down

Ft. Detrick is a three-story building with a 43,320 square foot footprint. The total square footage is 129,900 square feet. Six mechanical rooms house the air handling units, and there is one boiler room and one mechanical chase. Each mechanical room is 655 square feet, and the boiler room is 2790 square feet. The mechanical chase contains the boiler flues and is located within the mechanical rooms. Therefore, it adds no additional square footage. Since air handling units only serve the floor that they are located on, no vertical duct shafts are required. Additionally, all hot water, chilled water, and glycol piping is run vertically within the mechanical rooms. The total square footage taken up by mechanical space is 6720 square feet. This is 5.2% of the total area, so 5.2% of the building's rentable space is lost.

# Mechanical System First Cost

Ft. Detrick's HVAC system consists of six air handling units (AHU-1 through AHU-6) that are on during regular operation and one emergency air handling unit (AHU-7) that runs by generator power. All AHUs are controlled by variable frequency drives (VFDs) and distribute air through variable air volume (VAV) hot-water reheat boxes. Stairwells, vestibules, and mechanical rooms are heated only and are served by electric cabinet unit heaters. IT/Communication rooms are cooled only and are served by air conditioning units in each room. The chiller plant contains two rotary screw water cooled chillers that are evaporatively cooled by two induced draft cooling towers, and the boiler plant contains two gas-fired hot water boilers.

The first cost of Ft. Detrick's HVAC system is provided by Baker and Associates. This cost is an estimate since the construction manager, Mascaro, wishes to keep bid numbers private. The initial cost estimated by Baker and Associates is $1,084,037. The building is 129,900 square feet, and therefore the cost per square foot is about $8.36/ft$^2$.

# Design Load Analysis

The design loads for Ft. Detrick are estimated using Trane's Trace 700. The outdoor air ventilation rates, electrical loads, weather data and design occupancies are taken from the design documents provided by Baker and Associates. The lighting W/ft$^2$ is taken from Table 7. The occupancy, lighting, and equipment schedules are not stated in the design documents, so Trace's default office schedules are used. Infiltration is neglected in this calculation since it is also neglected in the design documents. Appendix B shows the Trace inputs in further detail. Tables 10 and 11 compare Trace's computed loads and ventilation indices with those found in the design documents.

**Table 10**
**Cooling Load Comparison**

| System | Trace Load ($ft^2$/ton) | Design Load ($ft^2$/ton) | Percent Difference |
|---|---|---|---|
| AHU-1 | 517.2 | 492.9 | 5% |
| AHU-2 | 539.6 | 496.4 | 8% |
| AHU-3 | 511.6 | 585.9 | 13% |
| AHU-4 | 613.6 | 536.5 | 13% |
| AHU-5 | 371.1 | 555.2 | 33% |
| AHU-6 | 392.5 | 551.7 | 29% |
| Heating Only | - | - | - |
| Cooling Only | 695.7 | 102.5 | 85% |

The actual load is determined by dividing the square footage the unit serves by the unit's capacity in tons, which for all air handling units is 35 tons. The result is that four of the six cooling systems exceeded Trace's recommendations. AHU-3 may require more load because it covers the largest square footage of the six air handling units. It is also important to note that AHU-5 and AHU-6 may require more cooling load because they are on the top floor. Because of this, the roof load factors into the total cooling load.

**Table 11**
**Supply and Ventilation Air Comparison ($cfm/ft^2$)**

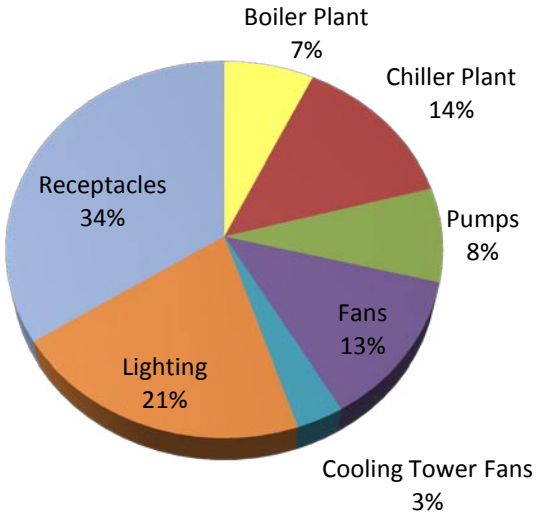
| System | Trace Supply Air | Design Supply Air | Trace % Outdoor Air | Trace Outdoor Air | Design Outdoor Air |
|---|---|---|---|---|---|
| AHU-1 | 0.6 | 0.83 | 27.54% | 0.17 | 0.26 |
| AHU-2 | 0.6 | 0.83 | 28.71% | 0.17 | 0.24 |
| AHU-3 | 0.63 | 0.79 | 28.47% | 0.18 | 0.24 |
| AHU-4 | 0.57 | 0.83 | 19.96% | 0.11 | 0.24 |
| AHU-5 | 1.04 | 0.91 | 16.87% | 0.18 | 0.24 |
| AHU-6 | 1.03 | 0.93 | 12.92% | 0.13 | 0.26 |
| Heating Only | - | - | - | - | - |
| Cooling Only | - | - | - | - | - |

For four of the six air handling units, the supply air cfm/ft$^2$ is less than the actual value. Again, more cfm/ft$^2$ is needed for spaces on the top floor (AHU-5 and AHU-6). All units supply the building with adequate outdoor air.

# Annual Energy Consumption and Operating Cost

An annual energy consumption analysis was performed in Trane's Trace 700 using the same ventilation rates, internal generations, and envelope characteristics as in the design load estimation. Fuel costs and equipment performance characteristics are taken from the design documents and are outlined in Appendix C. Figure 1 summarizes the results of the energy consumption analysis.

**Figure 1 - Annual Energy Consumption Summary**




The HVAC system requires 45% of total energy, lighting requires 21%, and miscellaneous loads require 34%. Table 12 breaks down the cost of energy for each of these components.

**Table 12**
**Utility Costs**

| Component | Annual Electric Cost | Annual Gas Cost | Total Cost | Cost /ft$^2$ |
|---|---|---|---|---|
| HVAC | $ 70,052 | $ 539 | $ 70,591 | $ 0.58 |
| Lighting | $ 32,691 | $ - | $ 32,691 | $ 0.27 |
| Receptacles | $ 52,928 | $ - | $ 52,928 | $ 0.43 |
| Total | $ 155,670 | $ 539 | $ 156,209 | $ 1.28 |

Another important factor to consider in an energy analysis is the emissions generated by the building. Table 13 summarizes the estimated emissions profile for Ft. Detrick.

**Table 13**
**Annual Emissions Summary**

| Emission | lb/ft$^2$ Electric Produced | Total lb Produced by Electric Power | lb/kWh Gas Produced | Total lb Produced by Gas Power | Total Amount Produced (lb) |
|---|---|---|---|---|---|
| Particulates | 1.02E-02 | 1,245.10 | 0.00E+00 | - | 1,245 |
| $NO_x$ | 7.02E-02 | 8,569.24 | 1.35E-05 | 1.54 | 8,571 |
| $SO_x$ | 1.19E-01 | 14,526.21 | 2.54E-03 | 290.39 | 14,817 |
| $CO_2$ | 2.18E+01 | 2,661,104.20 | 1.34E+00 | 153,200.32 | 2,814,305 |

Baker and Associates, the HVAC design engineer for the project, performed an energy analysis in Trane's System Analyzer for the design of Ft. Detrick. Table 14 compares the results of the HVAC engineer's analysis with the results from Trace.

**Table 14**
**Energy Consumption Comparison**

| Component | Annual Electric Consumption (kWh) | Annual Gas Consumption (Therms) |
|---|---|---|
| Trace Result | 1,557,197 | 3,902 |
| System Analyzer Result | 1,823,591 | 12,092 |
| Percent Difference | 15% | 68% |

There is a significant difference in energy consumption between this analysis and the analysis done by the HVAC design engineer. System Analyzer differs from Trace in that it provides a quick evaluation of a building rather than a room-by-room assessment. System Analyzer is used in early stages of design when individual room data is still unknown. Instead of room data, the user simply inputs the area of the entire building and picks a building occupancy, which in this case "office" is selected. Equipment and fuel costs are inputted in the same fashion as Trace. The amount of energy generated and the cost of energy is then computed.

System Analyzer is less accurate than Trace because it evaluates the building as a whole without taking the individual rooms into consideration. Because office occupancy is selected for the entire building in System Analyzer, the program interprets the entire building as office space. This results in a higher energy consumption value for two reasons. Office occupancy in System Analyzer receives a lighting load of 1.5 $W/ft^2$. In Trace, offices receive 1.1 $W/ft^2$ and most other occupancy types receive even lower values. Also, the miscellaneous equipment demand in System Analyzer is set at 2 $W/ ft^2$, and Trace sets it at 2 $W/ ft^2$ for Utility rooms only. All other spaces receive 1.5 $W/ft^2$ or less.

# References

ANSI/ASHRAE, Standard 90.1 – 2004, Energy Standard for Buildings Except Low-Rise Residential Buildings. American Society of Heating Refrigeration and Air Conditioning Engineers, Inc., Atlanta, GA. 2004.

Mechanical Construction Documents. Baker and Associates, Moon Township, PA. 2007.

LEED 2005 Green Building Rating System For New Construction & Major Renovations. Leadership in Energy & Environmental Design, Washington, DC. 2003.

Loren Cook Product Catalog. http://www.lorencook.com/products/prodmain.asp. October 23, 2007.

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# Appendix A – LEED-NC Version 2.2 Checklist

Project Name: Ft. Detrick Defense Medical Logistics Center

Project Location: Frederick, Maryland

| Yes | ? | No | | | |
|---|---|---|---|---|---|
| **7** | 1 | **6** | **Sustainable Sites** | | **14** Points |
| **Y** | | | Prereq 1 | **Construction Activity Pollution Prevention** | Required |
| **1** | | | Credit 1 | **Site Selection** | 1 |
| **1** | | | Credit 2 | **Development Density & Community Connectivity** | 1 |
| | | **1** | Credit 3 | **Brownfield Redevelopment** | 1 |
| | 1 | | Credit 4.1 | **Alternative Transportation**, Public Transportation Access | 1 |
| | | **1** | Credit 4.2 | **Alternative Transportation**, Bicycle Storage & Changing Rooms | 1 |
| | | **1** | Credit 4.3 | **Alternative Transportation**, Low-Emitting & Fuel-Efficient Vehicles | 1 |
| | | **1** | Credit 4.4 | **Alternative Transportation**, Parking Capacity | 1 |
| **1** | | | Credit 5.1 | **Site Development,** Protect or Restore Habitat | 1 |
| **1** | | | Credit 5.2 | **Site Development,** Maximize Open Space | 1 |
| **1** | | | Credit 6.1 | **Stormwater Design,** Quantity Control | 1 |
| **1** | | | Credit 6.2 | **Stormwater Design,** Quality Control | 1 |
| | | **1** | Credit 7.1 | **Heat Island Effect,** Non-Roof | 1 |
| | | **1** | Credit 7.2 | **Heat Island Effect,** Roof | 1 |
| **1** | | | Credit 8 | **Light Pollution Reduction** | 1 |
| Yes | ? | No | | | |
| **1** | | **4** | **Water Efficiency** | | **5** Points |
| | | **1** | Credit 1.1 | **Water Efficient Landscaping**, Reduce by 50% | 1 |

| | | | | | |
|---|---|---|---|---|---|
| 1 | | | Credit 1.2 | **Water Efficient Landscaping**, No Potable Use or No Irrigation | 1 |
| | | 1 | Credit 2 | **Innovative Wastewater Technologies** | 1 |
| | | 1 | Credit 3.1 | **Water Use Reduction**, 20% Reduction | 1 |
| | | 1 | Credit 3.2 | **Water Use Reduction**, 30% Reduction | 1 |

| | | | | |
|---|---|---|---|---|
| | | 17 | **Energy & Atmosphere** | 17 Points |

| | | | | |
|---|---|---|---|---|
| Y | | Prereq 1 | **Fundamental Commissioning of the Building Energy Systems** | Required |
| Y | | Prereq 2 | **Minimum Energy Performance** | Required |
| Y | | Prereq 3 | **Fundamental Refrigerant Management** | Required |

***Note for EAc1**: All LEED for New Construction projects registered after June 26th, 2007 are required to achieve at least two (2) points under EAc1.

| | | | | | |
|---|---|---|---|---|---|
| | | 10 | Credit 1 | **Optimize Energy Performance** | 1 to 10 |
| | | | | 10.5% New Buildings or 3.5% Existing Building Renovations | 1 |
| | | | | 14% New Buildings or 7% Existing Building Renovations | 2 |
| | | | | 17.5% New Buildings or 10.5% Existing Building Renovations | 3 |
| | | | | 21% New Buildings or 14% Existing Building Renovations | 4 |
| | | | | 24.5% New Buildings or 17.5% Existing Building Renovations | 5 |
| | | | | 28% New Buildings or 21% Existing Building Renovations | 6 |
| | | | | 31.5% New Buildings or 24.5% Existing Building Renovations | 7 |
| | | | | 35% New Buildings or 28% Existing Building Renovations | 8 |
| | | | | 38.5% New Buildings or 31.5% Existing Building Renovations | 9 |
| | | | | 42% New Buildings or 35% Existing Building Renovations | 10 |
| | | 3 | Credit 2 | **On-Site Renewable Energy** | 1 to 3 |
| | | | | 2.5% Renewable Energy | 1 |
| | | | | 7.5% Renewable Energy | 2 |
| | | | | 12.5% Renewable Energy | 3 |
| | | 1 | Credit 3 | **Enhanced Commissioning** | 1 |
| | | 1 | Credit 4 | **Enhanced Refrigerant Management** | 1 |

| | | | | | |
|---|---|---|---|---|---|
| | | 1 | Credit 5 | **Measurement & Verification** | 1 |
| | | 1 | Credit 6 | **Green Power** | 1 |

| Yes | ? | No | | | |
|---|---|---|---|---|---|
| 4 | | 9 | | **Materials & Resources** | 13 Points |
| Y | | | Prereq 1 | **Storage & Collection of Recyclables** | Required |
| | | 1 | Credit 1.1 | **Building Reuse**, Maintain 75% of Existing Walls, Floors & Roof | 1 |
| | | 1 | Credit 1.2 | **Building Reuse**, Maintain 100% of Existing Walls, Floors & Roof | 1 |
| | | 1 | Credit 1.3 | **Building Reuse**, Maintain 50% of Interior Non-Structural Elements | 1 |
| | | 1 | Credit 2.1 | **Construction Waste Management**, Divert 50% from Disposal | 1 |
| | | 1 | Credit 2.2 | **Construction Waste Management**, Divert 75% from Disposal | 1 |
| | | 1 | Credit 3.1 | **Materials Reuse**, 5% | 1 |
| | | 1 | Credit 3.2 | **Materials Reuse**,10% | 1 |
| 1 | | | Credit 4.1 | **Recycled Content**, 10% (post-consumer + ½ pre-consumer) | 1 |
| 1 | | | Credit 4.2 | **Recycled Content**, 20% (post-consumer + ½ pre-consumer) | 1 |
| 1 | | | Credit 5.1 | **Regional Materials**, 10% Extracted, Processed & Manufactured Regionally | 1 |
| 1 | | | Credit 5.2 | **Regional Materials**, 20% Extracted, Processed & Manufactured Regionally | 1 |
| | | 1 | Credit 6 | **Rapidly Renewable Materials** | 1 |
| | | 1 | Credit 7 | **Certified Wood** | 1 |

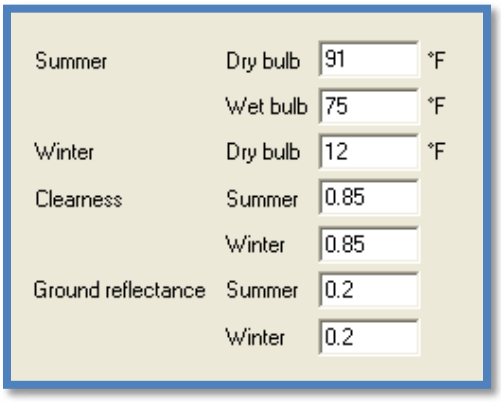
| Yes | ? | No | | | |
|---|---|---|---|---|---|
| 6 | 2 | 7 | | **Indoor Environmental Quality** | 15 Points |
| Y | | | Prereq 1 | **Minimum IAQ Performance** | Required |
| Y | | | Prereq 2 | **Environmental Tobacco Smoke** (ETS) **Control** | Required |
| 1 | | | Credit 1 | **Outdoor Air Delivery Monitoring** | 1 |
| | | 1 | Credit 2 | **Increased Ventilation** | 1 |

| | | | | | |
|---|---|---|---|---|---|
| | 1 | | Credit 3.1 | **Construction IAQ Management Plan**, During Construction | 1 |
| | 1 | | Credit 3.2 | **Construction IAQ Management Plan**, Before Occupancy | 1 |
| 1 | | | Credit 4.1 | **Low-Emitting Materials**, Adhesives & Sealants | 1 |
| 1 | | | Credit 4.2 | **Low-Emitting Materials**, Paints & Coatings | 1 |
| 1 | | | Credit 4.3 | **Low-Emitting Materials**, Carpet Systems | 1 |
| | | 1 | Credit 4.4 | **Low-Emitting Materials**, Composite Wood & Agrifiber Products | 1 |
| | | 1 | Credit 5 | **Indoor Chemical & Pollutant Source Control** | 1 |
| | | 1 | Credit 6.1 | **Controllability of Systems**, Lighting | 1 |
| | | 1 | Credit 6.2 | **Controllability of Systems**, Thermal Comfort | 1 |
| 1 | | | Credit 7.1 | **Thermal Comfort**, Design | 1 |
| | | 1 | Credit 7.2 | **Thermal Comfort**, Verification | 1 |
| 1 | | | Credit 8.1 | **Daylight & Views**, Daylight 75% of Spaces | 1 |
| | | 1 | Credit 8.2 | **Daylight & Views**, Views for 90% of Spaces | 1 |
| Yes | ? | No | | | |
| 1 | 4 | | **Innovation & Design Process** | | **5** Points |
| | 1 | | Credit 1.1 | **Innovation in Design**: Provide Specific Title | 1 |
| | 1 | | Credit 1.2 | **Innovation in Design**: Provide Specific Title | 1 |
| | 1 | | Credit 1.3 | **Innovation in Design**: Provide Specific Title | 1 |
| | 1 | | Credit 1.4 | **Innovation in Design**: Provide Specific Title | 1 |
| 1 | | | Credit 2 | **LEED® Accredited Professional** | 1 |
| Yes | ? | No | | | |
| 19 | 7 | 43 | **Project Totals (pre-certification estimates)** | | **69** Points |

**Certified:** 26-32 points, **Silver:** 33-38 points, **Gold:** 39-51 points, **Platinum:** 52-69 points

# Appendix B – Trace Inputs for Design Load Estimation

**Weather Data:**




**Internal Generation Inputs:**

**Heat Generation from People**

| Occupancy Type | Sensible Load (BTUh) | Latent Load (BTUh) |
|---|---|---|
| Cafeteria/Alcove | 275 | 275 |
| Classroom | 250 | 200 |
| Conference Room | 245 | 155 |
| General Office Space | 250 | 200 |
| Lobby/Corridor | 250 | 200 |
| Storage, Equipment Rooms | 275 | 275 |

**Heat Generation from Electrical Equipment**

| Room Type | Heat Generation |
|---|---|
| Cafeteria/Alcove | 7800 BTUh |
| Classroom | 150 W |
| Conference Room | 150 W |
| Open Office | 1.5 W/SF |
| Enclosed Office | 150 W |
| Equipment Rooms | 2 W/SF |

**Construction Material Inputs:**

**Construction U-values**

| Surface | U-value |
|---|---|
| Floor | 0.21261 |
| Roof | 0.04301 |
| Exterior Wall | 0.05000 |
| Interior Partition | 0.38795 |
| Window | 0.32000 |

**Occupancy Schedule:**

**Vent - Office** — Simulation type: Reduced year

| | | Start time | End time | Percentage | Utilization |
|---|---|---|---|---|---|
| January - December | Cooling design to Weekday | | | | |
| | | Midnight | 7 a.m. | 0.0 | |
| | | 7 a.m. | 6 p.m. | 100.0 | |
| | | 6 p.m. | Midnight | 0.0 | |
| Heating Design | | Start time | End time | Percentage | Utilization |
| | | Midnight | Midnight | 100.0 | |
| January - December | Saturday to Sunday | Start time | End time | Percentage | Utilization |
| | | Midnight | Midnight | 0.0 | |

**Lighting Schedule:**

**Lights - Office** — Simulation type: Reduced year

| | | Start time | End time | Percentage | Utilization |
|---|---|---|---|---|---|
| January - December | Cooling design to Weekday | | | | |
| | | Midnight | 6 a.m. | 0.0 | |
| | | 6 a.m. | 7 a.m. | 10.0 | |
| | | 7 a.m. | 8 a.m. | 50.0 | |
| | | 8 a.m. | 5 p.m. | 100.0 | |
| | | 5 p.m. | 6 p.m. | 50.0 | |
| | | 6 p.m. | 7 p.m. | 10.0 | |
| | | 7 p.m. | Midnight | 0.0 | |
| Heating Design | | Start time | End time | Percentage | Utilization |
| | | Midnight | Midnight | 0.0 | |
| January - December | Saturday to Sunday | Start time | End time | Percentage | Utilization |
| | | Midnight | Midnight | 0.0 | |

## Equipment Schedule:

**Misc - Low rise office** — Simulation type: Reduced year

| | | | | | |
|---|---|---|---|---|---|
| January - December | Cooling design to Weekday | Start time | End time | Percentage | Utilization |
| | | Midnight | 7 a.m. | 5.0 | |
| | | 7 a.m. | 8 a.m. | 80.0 | |
| | | 8 a.m. | 10 a.m. | 90.0 | |
| | | 10 a.m. | noon | 95.0 | |
| | | noon | 2 p.m. | 80.0 | |
| | | 2 p.m. | 4 p.m. | 90.0 | |
| | | 4 p.m. | 5 p.m. | 95.0 | |
| | | 5 p.m. | 6 p.m. | 80.0 | |
| | | 6 p.m. | 7 p.m. | 70.0 | |
| | | 7 p.m. | 8 p.m. | 60.0 | |
| | | 8 p.m. | 9 p.m. | 40.0 | |
| | | 9 p.m. | 10 p.m. | 30.0 | |
| | | 10 p.m. | Midnight | 20.0 | |
| Heating Design | | Start time | End time | Percentage | Utilization |
| | | Midnight | Midnight | 0.0 | |
| January - December | Saturday to Sunday | Start time | End time | Percentage | Utilization |
| | | Midnight | Midnight | 5.0 | |

# Appendix C – Trace Inputs for Energy Analysis

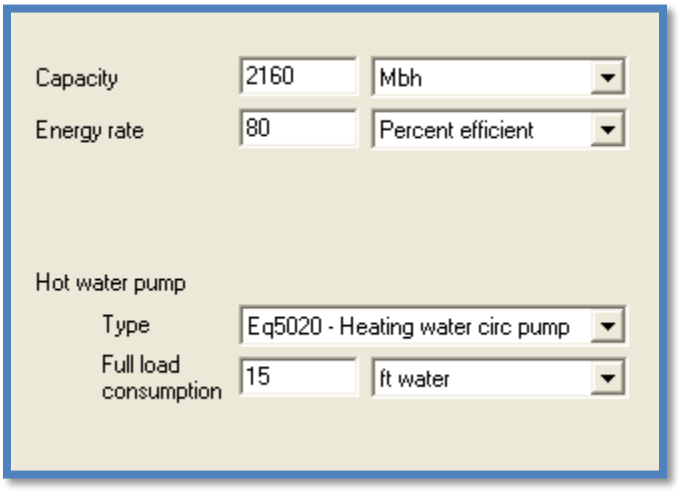
**Fuel Cost Inputs:**

**Utility Rates - Baltimore Gas and Electric**

| Utility Type | Rate Type | Summer Charge | Winter Charge |
|---|---|---|---|
| Electric Consumption | On Peak | $0.07/kWh | $0.055/kWh |
| Electric Consumption | Off Peak | $0.044/kWh | $0.04/kWh |
| Electric Demand | On Peak | $10.22/kW | $4.94/kW |
| Electric Demand | Off Peak | $4.94/kW | $4.94/kW |
| Gas Consumption | - | $0.4165/therm | |

Note that yearly energy utilization data could not be obtained since the building is currently under construction. These rates are estimates used by Baker and Associates in their energy analysis. A summer charge is applied from the start of June until the end of September. A winter charge is applied to utilities for all other months.

**Boilers B-1 and B-2 Inputs:**



**Chillers CH-1 and CH-2 Inputs:**

| Operating mode | Capacity | | Energy rate | |
|---|---|---|---|---|
| Cooling | 168 | tons | 0.52 | kW/ton |
| Heat recovery | | tons | | kW/ton |
| Tank charging | | tons | | kW/ton |
| Tank charging & heat recovery | | tons | | kW/ton |

| Pumps | Type | Full load consumption | |
|---|---|---|---|
| Primary chilled water | Eq5003 - Var vol chill water pump | 25 | ft water |
| Condenser water | Eq5007 - Var vol chill water pump | 75 | ft water |
| Heat recovery or aux condenser | None | 0 | ft water |

**Typical Airside Equipment Inputs:**

| | Type | Static Pressure (in. wg) | Full Load Energy Rate | Full Load Energy Rate Units | Schedule |
|---|---|---|---|---|---|
| Primary | Eq4223 - FC Centrifugal var freq drv | 6.06 | 0.000351 | kW/Cfm-in wg | Available (100%) |
| Secondary | None | 0 | 0 | kW/Cfm | Cooling Only (Design) |
| Return | Eq4223 - FC Centrifugal var freq drv | 0.5 | 0.000351 | kW/Cfm-in wg | Cooling Only (Design) |
| System exhaust | None | 0 | 0 | kW/Cfm | Cooling Only (Design) |
| Room exhaust | None | 0 | 0 | kW/Cfm | Available (100%) |
| Optional ventilation | None | 0 | 0 | kW/Cfm | Available (100%) |
| Auxiliary | None | 0 | 0 | kW/Cfm | Available (100%) |

These are the actual inputs for AHU-1. All other AHUs have the same type of supply and return fan, and all return fans have the same static pressure. The only difference between AHU-1 and the other AHUs is the static pressure. The input static pressure for the other five AHU's are as follows:

| Unit | Static Pressure (in. wg) |
|---|---|
| AHU-2 | 6.04 |
| AHU-3 | 6.47 |
| AHU-4 | 6.33 |
| AHU-5 | 6.51 |
| AHU-6 | 6.57 |

**Monthly Cooling and Heating Coil Profile:**