ENERGY CONSUMPTION EVALUATION OF

UNITED STATES NAVY

LEED CERTIFIED BUILDINGS

FOR FISCAL YEAR 2009

by

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This thesis is dedicated to my wife, Misty Ann Mangasarian.

Without her patience, understanding, caring support and most of all love, the completion of this work would not have been possible.

Abstract

As of October 1, 2008, the Department of the Navy inserted the requirement that all new buildings constructed for the United States Navy and United States Marine Corps would have an additional requirement to become Leadership in Energy and Environmental Design (LEED) Silver certified by the United States Green Building Council (USGBC). The goal of this effort is in compliance with Executive Order (EO) 13423, which provides that all Government departments must reduce energy consumption by 30% by 2015. The objective of this research is to find if the eleven buildings for the United States Navy that have already received a LEED certification or higher, have achieved the expected energy consumption savings in comparison to other similar non-LEED certified facilities. To accomplish this effort, these buildings have been compared to other United States Navy and Marine Corps commercial buildings of comparable size, usage, and within the same region as chosen by the respective Public Works Departments. The data being compared for this study will be electricity and water consumption, based upon what could be received from the current building's meters. Additionally, these LEED certified buildings will be compared to the national averages for electricity consumption as expressed by the Commercial Building Energy Consumption Survey (CBECS) to find if any energy savings is achieved to buildings of similar size.

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Chapter 1: Introduction

The basis of this research begins with Executive Order (EO) 13423, which provided the guidance, establishing the policy to govern federal agencies with respect to conducting their environmental, transportation, and energy-related activities (EO 13423 2007). The policy breaks down the requirements for the agencies into eight distinct areas, of which three (listed below) are applicable to this research. The remaining five are along the same lines with respect to energy consumption; however they discuss items like electronic purchasing and transportation requirements (e.g. hybrid cars).

- improve energy efficiency and reduce greenhouse gas emissions of each federal agency, through reduction of energy intensity (amount of energy used) by (i) 3 percent annually through the end of fiscal year (FY) 2015, or (ii) 30 percent by the end of FY 2015, relative to the baseline of the agency's energy use in FY 2003, which is the baseline reviewed throughout this project;
- beginning in FY 2008, reduce water consumption intensity for all federal agencies, relative to the baseline of the agency's water consumption in FY 2007, through lifecycle cost-effective measures by 2 percent annually through the end of fiscal year 2015 or 16 percent by the end of fiscal year 2015;
- ensure that (i) new construction and major renovation of agency buildings comply with the *Guiding Principles for Federal Leadership in High Performance and Sustainable Buildings set forth in the Federal Leadership in High Performance and Sustainable Buildings Memorandum of Understanding (2008)*, and (ii) 15 percent of

the existing Federal capital asset building inventory of the agency as of the end of FY 2015 incorporates the sustainable practices in the Guiding Principles (2008);

Following the policy executed through EO 13423, the *Guiding Principles for Federal Leadership in High Performance and Sustainable Buildings* provides for five areas of distinct principles for all Government agencies: employ integrated design principles; optimize energy performance; protect and conserve water; enhance indoor environmental quality; and reducing the environmental impact of materials. The whole lifecycle discussion from the inclusion of commissioning practices at the beginning of the construction process through deconstruction is utilized to ensure all stages of the building process are reviewed.

In further review of the this policy, it provides guidance for agencies, and in this case, specifically Naval Facilities Engineering Command (NAVFAC) for the United States Navy, to reduce the energy cost budget by 30% for new construction projects, and by at least 20% for major renovations. The 30% reduction for new construction is compared to the baseline building performance per the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., (ASHRAE) and the Illuminating Engineering Society of North America (IESNA) Standard 90.1-2004. The 20% reduction is compared to the pre-renovation 2003 baseline. Preceding this policy, NAVFAC issued an instruction (NAVFACINST 9830.1) in June 2003 that highlighted guidance for the use of Leadership in Energy and Environmental Design (LEED) for new construction, with LEED Certified as the basis for design. It also allowed for the flexibility that should LEED versions adjust over time, so shall NAVFAC policy to accommodate any changes. This policy was later adjusted in 2008 from LEED Certified to a LEED Silver requirement.

Though this policy is only issued as guidance, it does provide direction for the continual monitoring and improvement of energy performance. The installation of utility meters and the follow-up after one year of performance to ensure that continual improvement of the use of utilities are reviewed for maximum efficiency of the system. The policy specifically states that the Energy Star 7 Benchmarking Tool be utilized for this effort. The benefits of this tool according to the Energy Star program are to improve and understand energy consumption patterns and the key drivers of energy consumption use (EPA 2005). This also serves to quantify the performance of the buildings metrics against the common market to understand where the building stands with respect to the other buildings of similar use.

The policy further discusses the protection and conservation of water for all construction practices, both new and retrofit. The goal is to use 20% less potable water than the indoor water use 2007 baseline calculated for the building. For the outdoor water, the goal is to use 50% less than conventional means by designing landscaping with local plant species. And the last measure to ensure a maximum reduction of stormwater runoff and polluted site runoff.

The last two items discuss enhancing indoor environmental quality and reducing the environmental impact of materials. Daylighting, moisture control, recycled content, and construction waste are highlighted at the end of this memorandum, and though important to sustainability and the improvement of the indoor environment for personnel within a building, it is outside the scope of this study.

The goal of this research is to assess the energy consumption of the currently completed United States Navy LEED certified buildings that have sufficient utility data available for comparison. Multiple approaches will be utilized to verify if any savings has occurred against the expected savings stated in EO 13423 using both a Navy commercial counterpart as well as comparing the Navy building energy consumption to the national averages. To verify the results, a statistical analysis will be performed to substantiate the numerical data being used.

Chapter 2: Literature Review

2.1 – Government Agency Studies

Researchers have studied the effectiveness of the Leadership in Energy and Environmental Design (LEED) program as a viability standpoint for energy conservation in both the commercial and residential sectors. Though no research found has directly correlated to United States Navy buildings who have received a LEED accreditation, there have been studies conducted for the United States Government, specifically for the General Services Administration (GSA). Fowler and Rauch (2008) evaluated twelve GSA buildings that were designed with this standard across the nation. Eight of the buildings were designed to meet or exceed the basic LEED criteria, while the other four were designed to meet other programs like the Energy Star and California Title 24 programs. Table 1 shows the cross-section of GSA buildings used for this study and their corresponding certifications (Fowler and Rauch 2008). The study reviewed four factors across each building: one year of operating data, a survey of building occupants, an interview of the building manager, and an engineering expert walkthrough. When comparing these metrics, the twelve GSA buildings (eight of which are LEED Certified or greater) outperformed similar commercial private building types against the national average.

Table 1 – Buildings and Certification Level within GSA Study

Building Name	**Certification Category/Level**
Davenport Courthouse	LEED Registered
Cleveland Courthouse	LEED-NC Certified
Youngstown Courthouse and Federal Building	LEED-NC Certified
Knoxville Federal Building	LEED-EB Silver, Energy Star
Ogden Federal Building	LEED-NC Silver
Lakewood Federal Building	LEED-NC Silver
Omaha DHS Federal Building	LEED-NC Gold
Omaha NPS Federal Building	LEED-NC Gold
Santa Ana Federal Building	California Energy Standard Title 24
Fresno Courthouse and Federal Building	California Energy Standard Title 24
Greeneville Courthouse	Energy Star 2007
Denver Courthouse	Green Building Challenge

The key findings from this study illustrated that the twelve buildings used, on the average, 26% less energy (65 kBtu/sf/yr vs. 88 kBtu/sf/yr), had 13% lower aggregate maintenance costs ($2.88/sf vs. $3.30/sf), 27% higher occupant satisfaction, and 33% fewer CO_2 emissions (19 lbs/sf/yr vs. 29 lbs/sf/yr) when compared to the national average. What is not included in these results is how these twelve buildings were chosen out of the GSA inventory, which performed so well in this study versus the national average. Though the buildings do provide a good cross-section of the United States from coast-to-coast, it could be argued that these buildings were chosen as some of the best performers from the United States' largest landowner. Though this research does discuss the buildings that fall below the national average, it does not discuss the buildings that fell above for the areas studied (1- CO_2, 4-Water Use, and

4-Maintenance Costs) or even at the average (3-Maintenance Costs, 3-Water Use, 1- CO_2, and 2-Energy Use Intensity). With the amount of buildings that fell within this range, it seems that much more could be discussed and taken from this research for those buildings.

With a larger population, this assessment may have provided a much more useful tool to the GSA, but the amount of subjective input hampers the results presented. It appears to the outsider that twelve above average buildings were chosen for the study, with no comparison to other buildings in the same area. What these buildings would produce when placed against these standards is not discussed or offered. The GSA states that they are the largest landowners in the United States, so twelve buildings do not provide a benchmark by any means.

2.2 – Energy Performance of LEED for New Construction Buildings

Several authors have documented the energy performance of new buildings that attained LEED buildings. Most interesting is when multiple researchers have reviewed the same material, but come up with very different results. Three of the studies detailed below have this in common, where the results, when looked at through different eyes, have surprisingly different answers for the bottom line with the same results presented.

Turner and Frankel (2008) performed a study that requested to incorporate all 552 LEED buildings that were certified through 2006. Of these 552 buildings, 121 participated and were further reduced by Turner and Frankel (2008) to 100, eliminating those with excessively high energy consumption. The only requirement for inclusion in this study was the ability to provide at least one full year of measured post-occupancy energy usage data for the entire LEED project. The goal of the project was to measure the whole building energy performance of the LEED buildings against commercial counterparts by region and building type. Turner and Frankel (2008) were able to gain similar results when they looked at the Energy Use Intensity (EUI) comparison of LEED and the national building stock, Energy Star ratings, and measuring the results compared to the initial design and baseline modeling (Turner and Frankel 2008). This project does show progress in the area of looking at LEED buildings and the comparative counterparts with energy consumption as the basis. Figure 1 below shows the certifications of LEED buildings through 2006 that were requested to participate in this study, and the year they achieved certification.

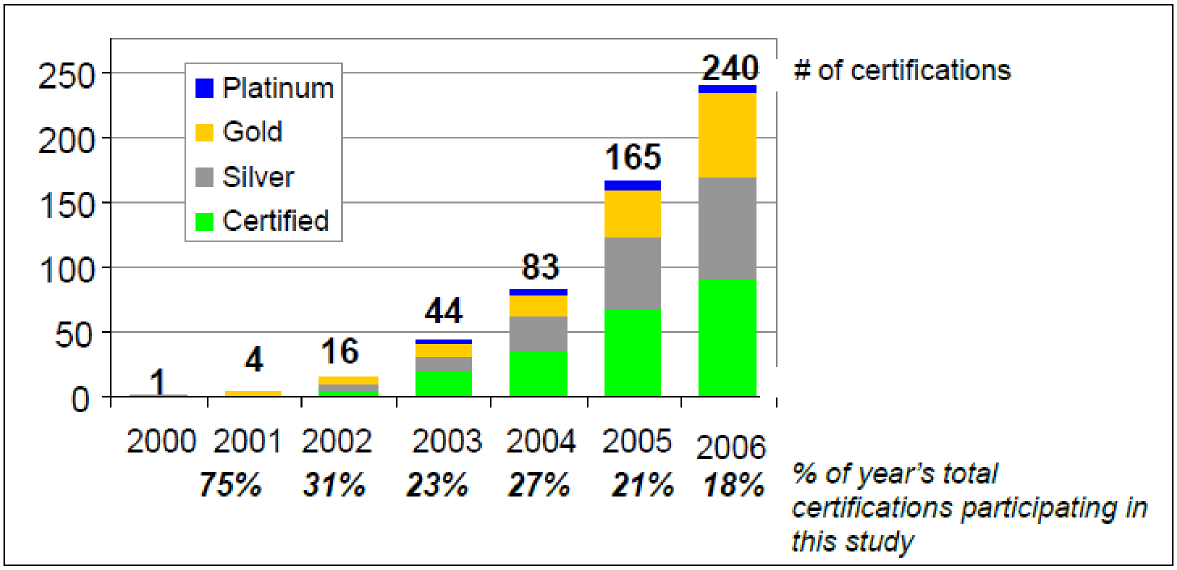

Figure 1– LEED-NC Certifications by Year, and Percent for Each Year (Turner and Frankel 2008)

To perform this research, Turner and Frankel (2008) used the Energy Use Index (EUI), Energy Star Rating, and Measured Performance in Relation to Modeling as their basis for measurement and comparison. The results of this study are described here below:

a. EUI (kBtu/sf/yr)

- National data comes from the Commercial Building Energy Consumption Survey (CBECS), which is completed every four years by the Federal Energy Information Administration.

- All 100 buildings median measured was 69 kBtu/sf, which was 24% below the CBECS national average, with offices measuring 33% below. Figure 2 shows the measured EUI for each of the buildings studied and their relative median versus the commercial counterparts taken from the CBECS.

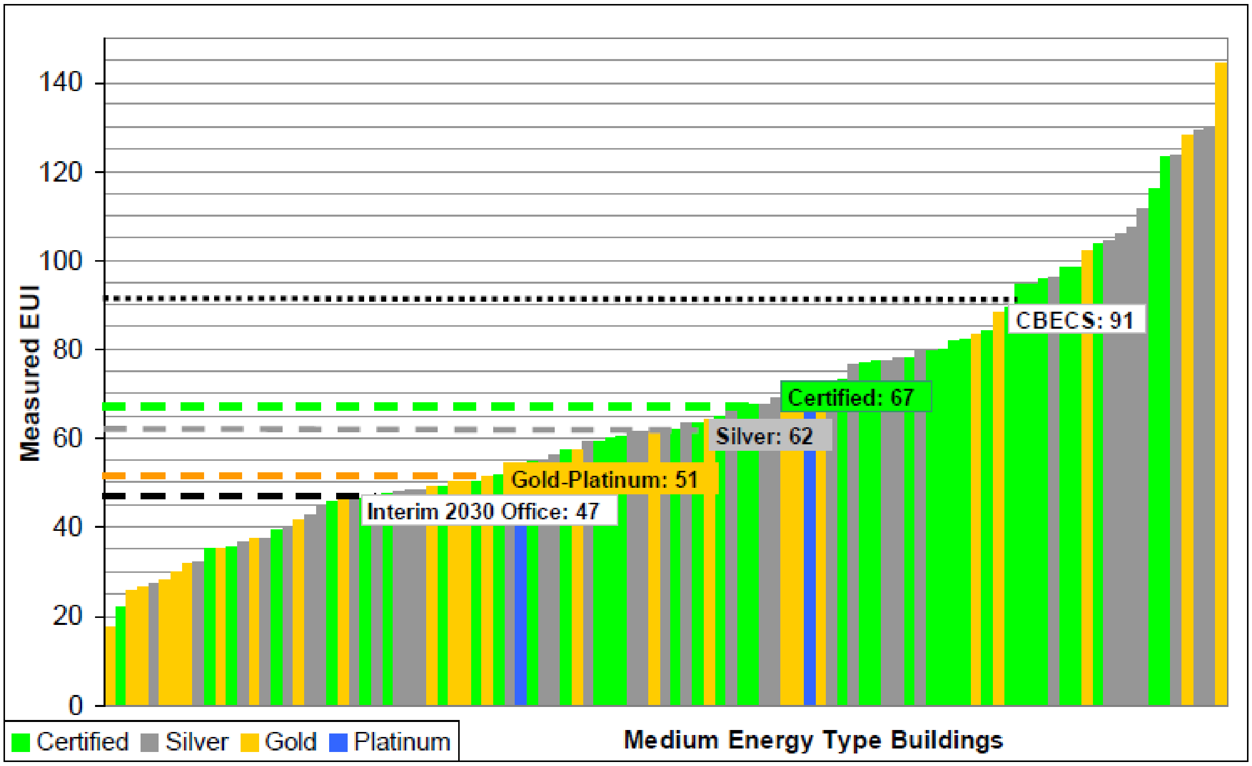

Figure 2 – EUI (kBtu/sf) Distribution (Turner and Frankel 2008)

b. Energy Star Rating (by the EPA)

- Rates a buildings energy use in relation to existing national building stock for the same activity type.

- Average energy star rating of LEED buildings was 68% better than similar buildings. Half of the LEED were at least 75%, which is the requirement to meet the Energy Star level. Figure 3 shows the distribution of the buildings versus the national average for the Energy Star rating.

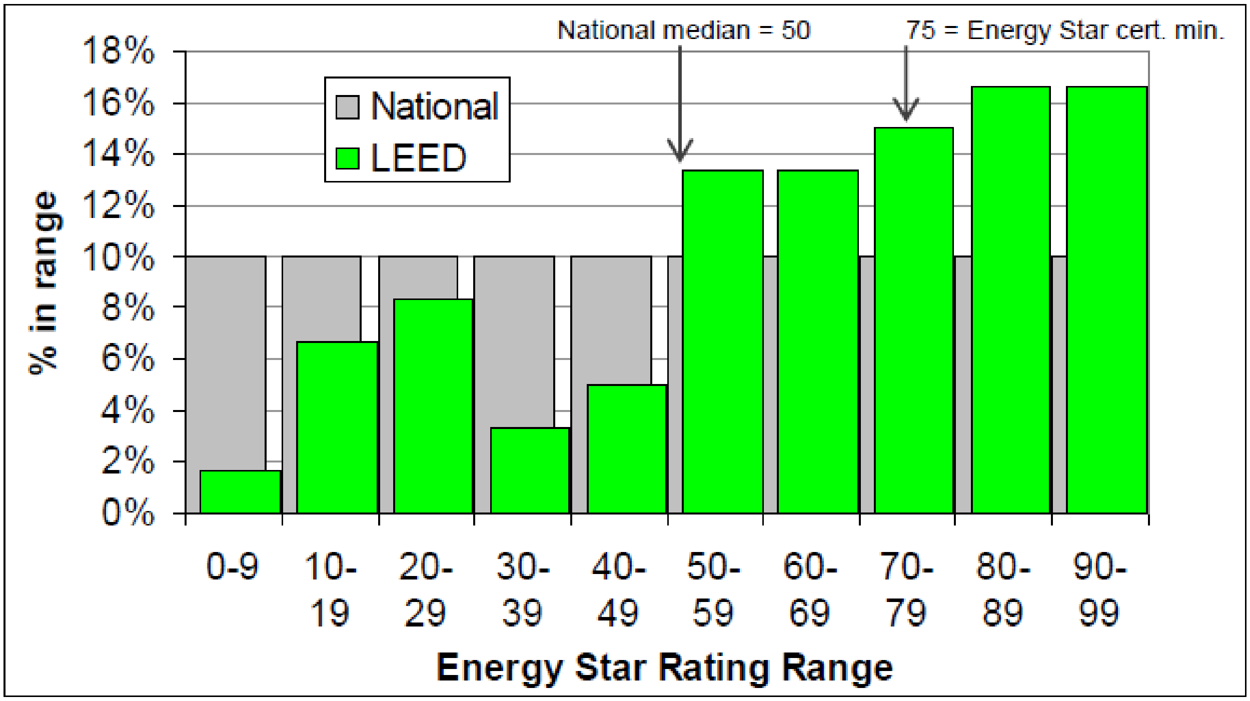

Figure 3 – Distribution of Energy Star Ratings (Turner and Frankel 2008)

c. Measured Performance in Relation to Modeling

- Baseline is generated using the Energy Cost Budget (ECB) approach and performance requirements in ASHRAE 90.1, with buildings using the 1999 version.
- Measured energy saved equated to 28%, which was close to the 25% predicted.
- The degree of scatter suggests significant improvement can be made in predicting the accuracy for an individual project. Figure 4 shows the scatter of design EUI versus the measured EUI for the 100 buildings within the study of Turner and Frankel (2008).
- Variations in results come from a difference in operational practices and schedules, equipment, and construction changes.

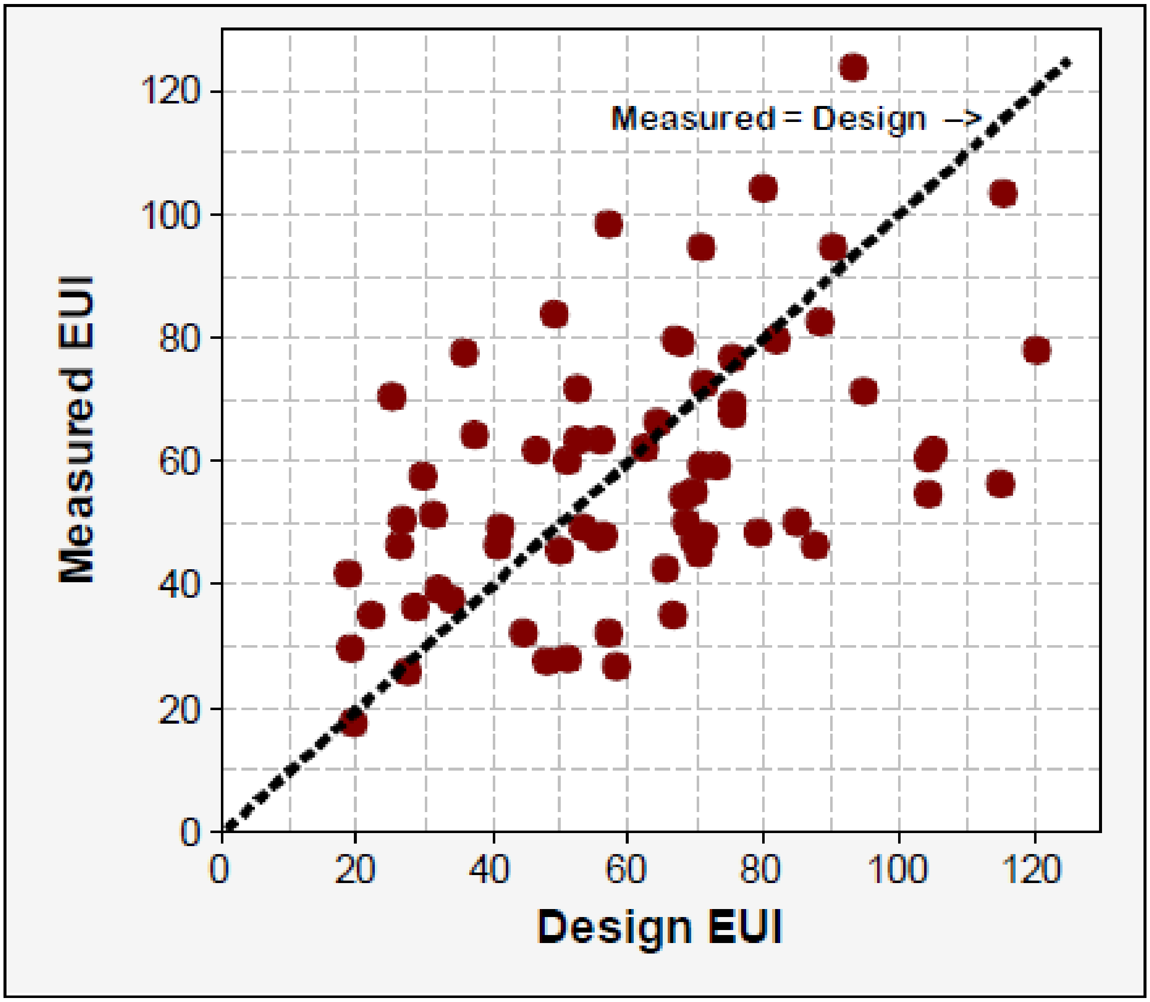

Figure 4 – Measured versus Design EUIs (Turner and Frankel 2008)

This research concludes that the 100 LEED buildings, ranging from just certified through the platinum level, are delivering more savings than that of their commercial counterparts for this study. Turner and Frankel (2008) found that the average savings was 25-30% greater, which is a promising statistic for the use of LEED. Though this does not translate across all of the buildings, as the 21 high energy use buildings were left out of the final findings, it does show reduced energy consumption over the study period. They also found that there was much area for improvement to standardize the results across the board. With additional feedback, a better analysis could be provided for the designs that are working and the areas that need improvement within the realm of the GSA program.

Newsham et. al. (2009) analyzed the above data, and provided different results than those presented by Turner and Frankel (2008). This new study illustrates that the LEED buildings are using 18-39% less energy per floor (Newsham et. al. 2009) than the conventional buildings compared using the CBECS. When taken as a whole building approach to energy consumption, the buildings actually did not fare as well, showing a 28-35% increase (Newsham et. al. 2009) over the same period of time. Another important finding of this research is that the energy consumption achieved in all of the 100 buildings has no correlation to the LEED certification level. An example of this can be seen when looking at the EUI comparison made. One of the LEED Gold buildings falls above the comparison models presented from the CBECS more than 50 kBtu/sf above that of the CBECS baseline of 91 kBtu/sf (Turner and Frankel 2008).

Further research was also completed that discounted the basis of the research presented by Turner and Frankel (2008) and the comparison provided by Newsham et. al. (2009). In this study, Scofield (2009) shows that there is no evidence that LEED certification level has collectively lowered either site or source energy for office buildings. Focusing on source energy, which includes the energy used on-site as well as the off-site losses associated with generation and distribution, Scofield (2009) finds that there is no primary energy savings with the same 100 LEED certified buildings measured over their commercial counterparts as presented by the CBECS. The findings for site energy also report a smaller percent increase of 10-17% (Scofield 2009) compared with that of Turner and Frankel (2008).

To illustrate his point, Scofield (2009) provided a graphical presentation (see Figure 2.2.5 below) of the cumulative contribution of total site energy of the 100 medium energy LEED buildings. Figure 5 shows that the first 58 buildings combine for 10% of the total energy consumption of all the buildings surveyed, and the top 10 are taking up more than 50% (Scofield 2009). This figure also shows that the mean is not reached until building 76. With the range of these buildings, Scofield (2009) believes that the results are not indicative of telling the story for the LEED buildings. The buildings with a larger square footage gained LEED status points easier with bike racks and employee showers, while the smaller buildings can show an improved energy performance using photovoltaic arrays, where the purchase of power is reduced by 17%, according to Scofield (2009). What his results show is that LEED buildings for the most part are using less site energy, but that because larger buildings use the majority of energy consumption, the overall result is that LEED is lower than their commercial counterparts.

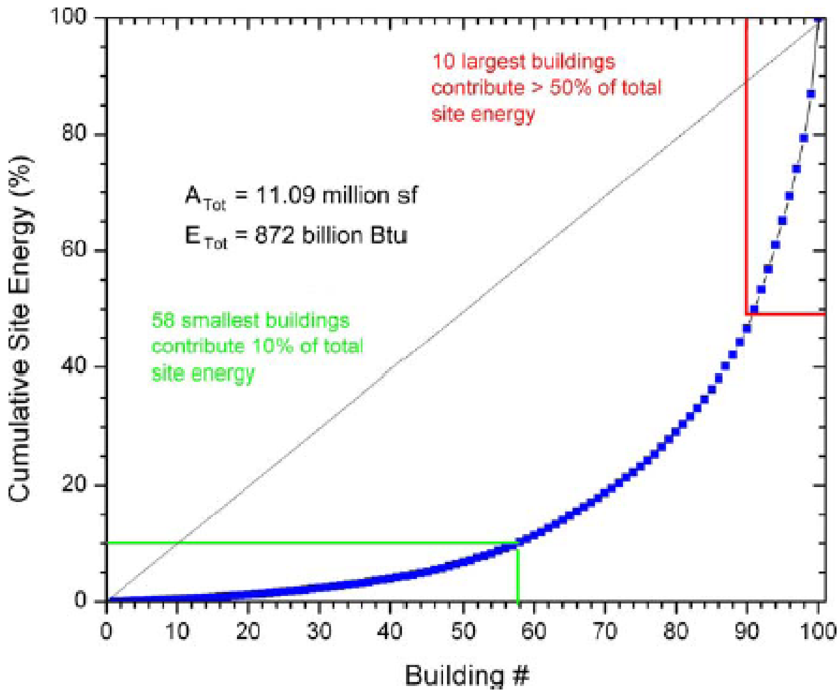

Figure 5 - The cumulative contribution to the total site energy of the 100 medium energy LEED buildings sorted by building site energy (Scofield 2009)

2.3 – Measuring Performance of Sustainable Buildings

In addition to the above research on energy performance of LEED certified buildings; several researchers studied the cost and performance metrics of sustainably designed buildings, Fowler et. al. (2005) broke down the metrics for each building into the areas that are important to identify specific characteristics for sustainable design. Metrics were chosen based on ease of collection, usefulness or relevance of the information to sustainability and the expected quality of the data to be collected (Fowler et. al. 2005). Fowler et. al. (2005) reduced the information down to what could be compared and what was easily collected during the timeframe for their research.

What this research does provide is a breakdown of the metrics of each building and its relative associated benefits to sustainability within the design of new construction. Total building potable water use, stormwater management, total building energy use (with respect to electricity consumption), source energy use, maintenance (with respect to hazardous chemicals distributed), and waste generation. Each aspect of these metrics is broken down to its component parts, to provide a complete understanding of what comprises understanding the whole building consumption. Other items reviewed included indoor air quality and occupant satisfaction. Though most of these could not be included in this research due to the limited time available they should be beneficial towards future research.

One of the interesting factors associated with this study was the discussion that seven of the fourteen public buildings were starting to use this data methodology (Fowler et. al. 2005). However, there was no discussion of the results found. Furthermore, there is no indication that this data protocol was effective to finding if the breakdown of results as suggested by this protocol would be effective for the Government buildings discussed.

What they did discuss, with respect to the United States Navy's sustainable buildings was that cost was the largest consideration for the Navy implementation of sustainable design across Naval Facilities Engineering Command. As was found during the course of this project, collecting the data for actual cost and performance is proving to be difficult to demonstrate the benefits of sustainable design for the Navy due to a lack of metering or monitoring.

Other research completed on LEED building performance in the Cascadia region, found much of the same interesting occurrences seen above and in the research of this project with respect to acquiring data, and determining a baseline (Turner 2006). The report is based on all of the LEED certified or greater buildings within the Cascadia region, and compares the electricity and water use data. All of the buildings within the region could not be used in the study due to a lack of metering, or a lack of a pre-established baseline during design (Turner 2006).

Within the region there were a total of 31 buildings that had achieved a LEED certification as a minimum. Of these 31 buildings, only 11 could be utilized for the study, either because of data or a lack of participation (Turner 2006). The study also went further than the electricity and water data, and surveyed occupants on satisfaction within the buildings. The occupant survey provided very favorable results for the occupant experience in the buildings, with the exception of overall noise and sound control within the buildings (Turner 2006).

When the actual energy used to the baseline was compared for the region, all buildings presented a 40% reduction below the baseline (see Figure 6) (Turner 2006). It is important to note that two of the buildings were not able to be compared with this method. One building had a baseline established during design and the other did not apply for the energy optimization credit and was removed from this portion of the study. Additionally, even though Traugott

Terrace (TT) shows a minimal savings, it did have the lowest baseline compared with the field and the two with the greatest savings had the highest projected baselines to start.

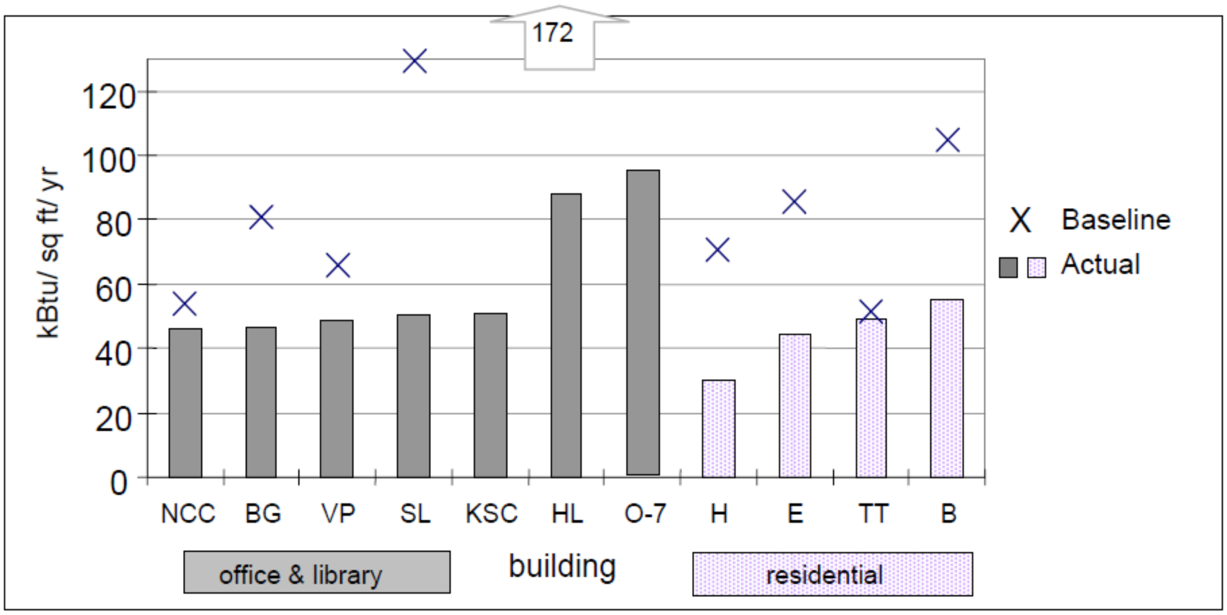

Figure 6 – Actual and Baseline Energy Use Intensities (Turner 2006)

For the water efficiency results, only seven of the buildings were compared because they had sufficient data for the purpose of research (Turner 2006). Of the seven buildings, all but one proved to perform better than predicted baselines (see Figure 7). Part of the reason for the differences is due to the different fixture flow rates. It was also found that the design projections varied in their assumptions regarding fixture use frequencies and duration. Much of this may be due to fixture performance and occupant behavior (Turner 2006).

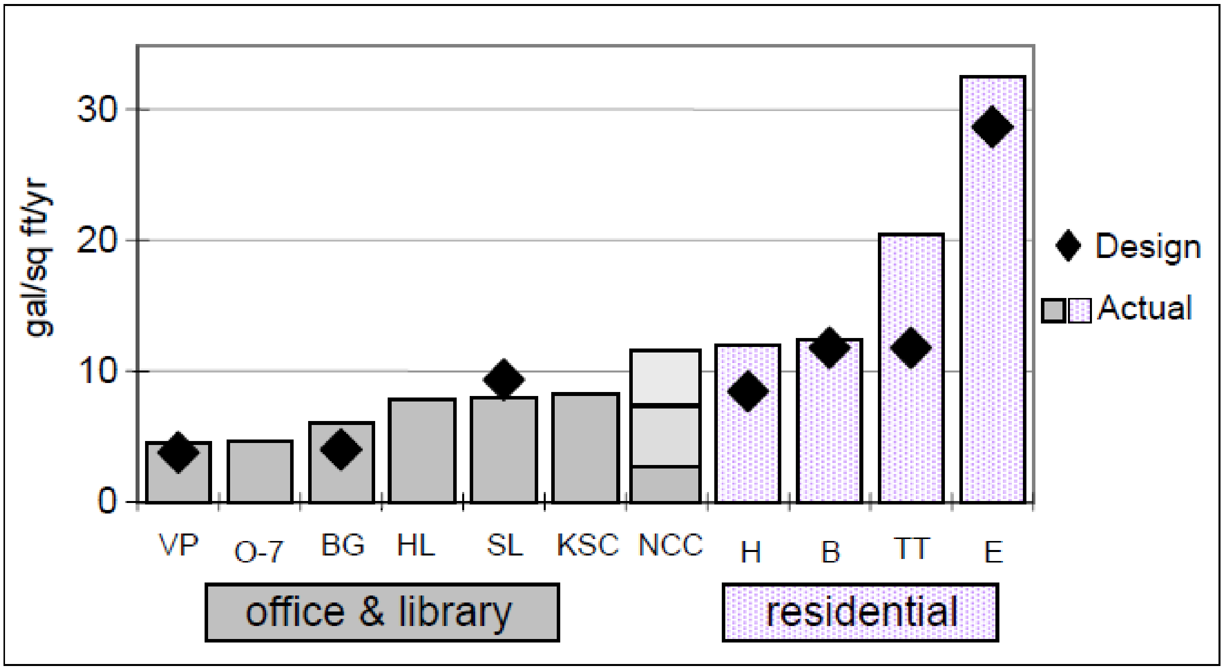

Figure 7 – Actual and Design Water Use per Square Foot (Turner 2006)

This research further concludes that without enough utilities information gathered, even a simple report will have trouble producing good results. She also recommends that more effort be placed on public studies to provide a better baseline for all to use when providing a comparison and modeling building utility information (Turner 2006).

Further research from Pacific Northwest National Laboratory discusses the different methods that have been used to measure the sustainability approach for building construction. The methods discussed include: financial/business aspects of performance; environmental aspects of performance; and the focus on the social, health, and community aspects of performance (Todd and Fowler 2009). They go on to discuss the conceptual and practical challenges associated with designing for sustainability and how to account for performance. Table 2 presents the practical challenges and the associated difficulties provided through this research.

Table 2 – Practical Challenges of Performance Measurement (Todd and Fowler 2009)

Challenge	*Difficulties Associated*
Actual vs. Modeled Performance	When looking at a new facility it is sometimes difficult to get all of the metrics one may want to fully compare the performance data. If a model is necessary, the actual data should be utilized where possible.
Data Availability	The availability due to a lack of metering can sometimes be a problem. This is especially prevalent on military and campus type facilities.
Feasibility/Effort Required to Gather Data	In some cases, it might be possible to gather data but it might require more effort or cost than an agency or organization is willing to expend.
Data Quality and Consistency	The quality and consistency of the data is dependent on the tracking system for collecting data and the method for accumulating the information.
Isolating Effects of Individual Buildings	Dependent on the aspect of performance that one is looking at, it may be difficult to determine the performance of an individual building, compared to measuring the performance of a community or development.
Benchmarks for Comparison	In order to understand building performance, a baseline must be established as a benchmark for the standard to which others are compared within the same region and with typical occupancy.

One of the major contributions of the article by Todd and Fowler (2009) is the large amount of related research that has been accomplished and listed. The research breaks this down into the applicable areas of financial/business aspects of performance; environmental aspects of performance; and the focus on the social, health, and community aspects of performance, with research presented for each area. Lastly, there is a mention of a United States Navy study being conducted on seven LEED certified buildings that are to be measured over the next year with a continuous monitoring of utility data. Figure 8 lists the building cost and performance metrics that are being measured for this research (Todd and Fowler 2009). Reviewing the measures being reviewed for this research, this should provide further confirmation of the results received under the project presented.

Metric	Required	Optional
Water	Total Building Water Use	Indoor Potable Water Outdoor Water Use Total Storm Sewer Output
Energy	Total Building Energy Use	Source Energy Peak Electricity Demand
Maintenance & Operations	Building Maintenance Requests	Grounds Maintenance Churn Cost
Waste Generation	Solid Sanitary Waste	Recycled Materials
Purchasing		Environmentally Preferable Purchasing
Occupant Health & Productivity	Occupant Turnover Rate Absenteeism Building Occupant Satisfaction Self-Rated Productivity	
Transportation	Regular Commute	

Figure 8 – Building Cost and Performance Metrics for Navy Facilities (Todd and Fowler 2009)

2.4 – Green Initiatives

Many other researchers have documented building using sustainable methods besides LEED. Efforts include those of the International Federation of Consulting Engineers (FIDIC), whose Project Sustainability Method (PSM) assists project engineers and other stakeholders in setting sustainable development goals for their projects that are recognized and accepted by, as being in the interests of society as a whole (FIDIC Geneva 2005). In another approach the research looks at how each of the personnel associated with a project (architect, constructor, and owner) view the project, and why what is important to one may not be as important to another (Wilson 2005).

Other efforts include those by the Green Building Initiative (GBI), Build It Green, and the National Green Building Certification. The GBI approach to sustainability utilizes the Green Globes System, which is an environmental design and management tool. Similar to LEED which utilizes a commissioning agent to assist with certification through the USGBC, Green Globes provides environmental assessment through a third-party (GBI 2009). In the residential sector, Build It Green promotes resourceful energy conserving homes in California through sustainable building efforts. Similar to LEED as well is the National Green Building Certification, which has multiple levels of certification (Gold, Silver, and Bronze) for residential homes.

Summarizing, multiple resources are available to recognize the efforts of sustainability with respect to new construction and renovation. The Government, and specifically the Department of the Navy has chosen the USGBC approach of LEED as the method to achieve their objective, and this research hopes to quantify the efforts thus far with respect to the United States Navy buildings that have been certified to date. Utilizing a combination of the strategies reviewed above, this research hopes to gain insight into what has been achieved by using LEED as a method of sustainability and how much energy consumption has been saved with this effort.

Chapter 3: Research Objectives

3.1 – Objectives

To establish the objectives for the research in this pilot study, it was necessary to first understand what research had been accomplished in this area. Since the inception of Leadership in Energy and Environmental Design (LEED) in 1993 by the United States Green Building Council (USGBC), research has been accomplished for both the commercial and residential sectors with respect to understanding the basis of LEED as an environmental design approach (USGBC 2008). However, there is a lack of research related to this topic within the Department of Defense and more specifically for this research for the Department of the Navy. After reviewing the applicable research to this topic within the literature review, the following objectives for this project were defined:

- Establish which United States Navy buildings have achieved LEED certification.

- Collect energy consumption data for the period of October 2008 to September 2009.

- Find suitable building comparison models based on recommendations from the base Utility Directors or Energy Managers. Buildings should be within the same region, be of comparable size, and similar usage.

- Compare the energy consumption to the 30% reduction expected for all Government facilities by 2015 under Executive Order 13423.

- Based on the information attained from this research, determine if the current mechanics of gathering the utility data are the most efficient, and provide recommendations based on the findings.

- How does the United States Navy LEED certified building stock compare to the national averages for private commercial buildings presented by the CBECS?

- Has certifying United States Navy buildings with LEED helped to achieve an energy savings as expected by EO 13423?

Chapter 4: Methodology

The methodology followed for this research consisted of three main steps. First step consisted of gathering all available utility data for United States Navy LEED certified buildings. The second step was to find suitable Navy commercial comparison buildings within the same region, of comparable size, and similar usage. The last step was to compare the Navy LEED certified buildings to their counterparts as well as to the national averages obtained from the 2003 CBECS to see if an energy savings could be construed from the data received.

4.1 – Data Gathering: United States Navy LEED Buildings

The effort to gather data began with contacting all of the Public Works Departments associated with the list of LEED projects provided by Naval Facilities Engineering Command Headquarters. Once contact was made, I was directed to either the Utilities Director or Base Energy Manager who would be able to provide the data requested. All available utility data was requested for each building, to include electricity, water, steam, and natural gas. Upon receiving all available information, the data had to be sorted to see the full picture (e.g. which buildings used steam and which used natural gas). In doing so, it became evident that a complete comparison of all utilities consumed for these buildings could not be accomplished (refer to Appendix A for a complete listing of all data gathered for this project). Though this is not optimal for a comparison of the sustainability provided by LEED, it does provide a useful baseline for research in this area for the United States Navy in the quest to reduce the energy consumed as they forge ahead towards 2015.

The list of LEED certified buildings used for this project, shown in Table 3, was provided by the Sustainable Development Program Manager at Naval Facilities Engineering Command (NAVFAC) Headquarters. Figure 9 shows the geographical disbursement of buildings across the United States.

Table 3 – United States Navy USGBC Certified Buildings

Building	Base	City and State	Certification
Bachelor Quarters	Naval Training Center	Great Lakes, IL	LEED Certified
Drill Hall	Naval Training Center	Great Lakes, IL	LEED Gold
Bachelor Quarters	Naval Base Kitsap-Bremerton	Bremerton, WA	LEED Certified
Personnel Support Facility	Naval Amphibious Base	Little Creek, VA	LEED Silver
Police and Special Operations Facility	Naval Amphibious Base	Little Creek, VA	LEED Silver
Airborne Mine Countermeasures Facility	Naval Station	Norfolk, VA	LEED Certified
Aircraft Maintenance Hangar	Naval Station	Norfolk, VA	LEED Certified
Bachelor Quarters	Naval Weapons Station	Yorktown, VA	LEED Certified
Child Development Center	Naval Air Station	Oceana, VA	LEED Silver
Bachelor Enlisted Quarters	Marine Corps Base Camp Lejeune	Jacksonville, NC	LEED Silver
Reserve Training Center & Vehicle Maintenance Facility	Marine Corps Base Camp Lejeune	Jacksonville, NC	LEED Silver
Public Works Department	Naval Base Ventura County	Port Hueneme, CA	LEED Gold
Naval Facilities Engineering Service Command	Naval Base Ventura County	Port Hueneme, CA	LEED EB Silver
Memorial Golf Course Clubhouse	Marine Corps Air Station	Miramar, CA	LEED Gold

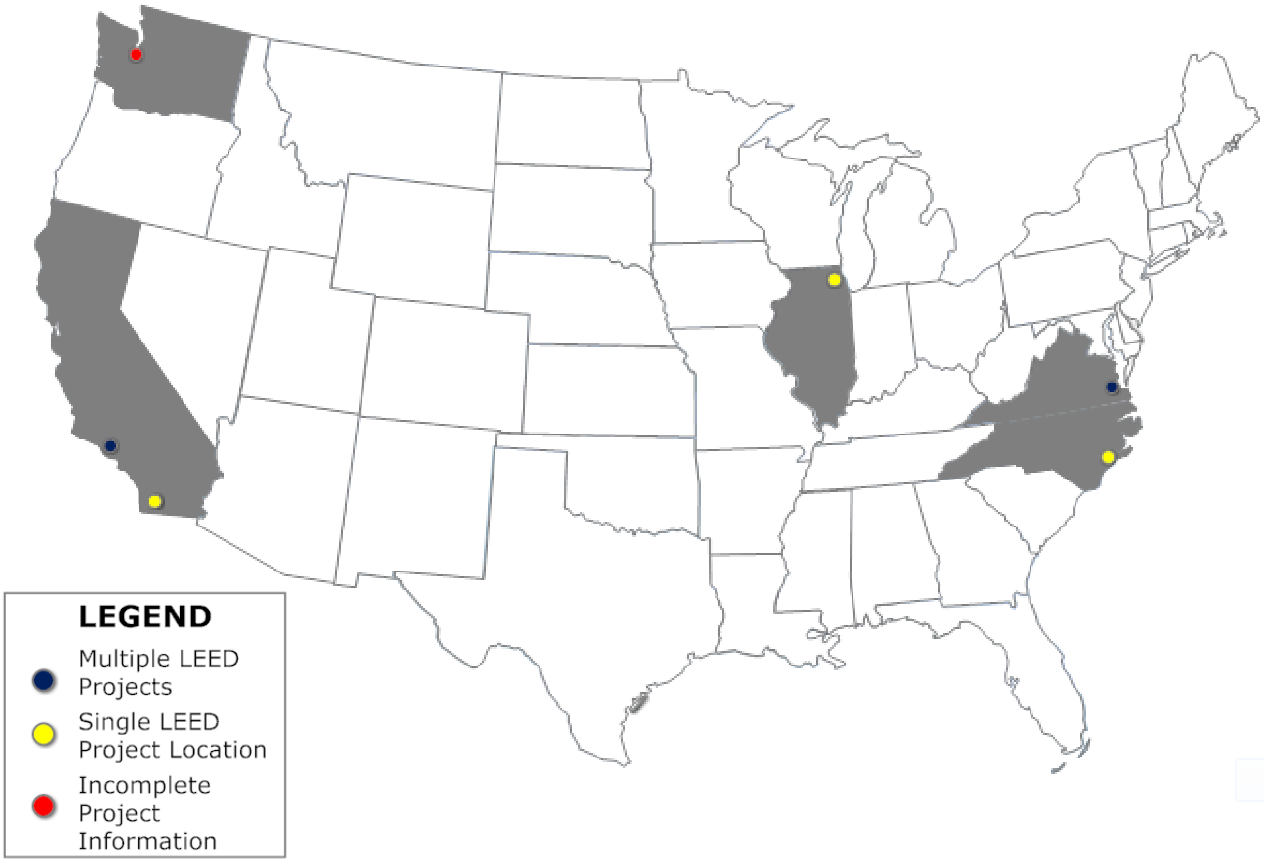

Figure 9 – Map of LEED Project Locations

For some utility information presented, the Utilities Director or Base Energy Manager provided caveats. One example of this would be with respect to the steam information received. Though monthly data was provided, I was informed that the data could not be relied upon as accurate due to the aging steam lines, the inaccuracy of the meters that measured the flow rate (and were not always calibrated correctly), and the method of presenting the data as steam when it is actually condensate flow. Another example of a caveat presented is the electricity data that was extracted. This was most evident specifically in the Camp Lejeune Reserve Training Center and Vehicle Maintenance Facility. The data provided was extruded by assuming metering over the course of a year, with only one month's data provided. As this facility is not monitored and tracked on a monthly basis, this was the only way to receive any information for that building.

Due to this lack of consistency with the energy consumption data received, and the inconsistency in the heating method (some utilizing natural gas, while others utilized steam) across the buildings, this study will just look at the electricity and fresh water consumption. This provided the most amount of information, as well as the most consistent data from building to building, when comparing the LEED certified buildings to a Navy commercial counterpart.

4.2 – Non-LEED United States Navy Commercial Building Comparison

This research is only utilizing buildings owned and operated by the United States Navy, which means that finding a useful commercial comparison model posed to be difficult for areas where there were not two of the same buildings (e.g. Police Stations). To overcome this obstacle, commercial buildings were drawn from a regional perspective. While there is only one Police Station at Naval Amphibious Base Little Creek, there is a comparable Police Station facility at Naval Station Norfolk. Table 4 below provides the list of LEED buildings and their commercial comparisons. The only difficulty with all of the buildings came with the Reserve Training Center and Vehicle Maintenance Facility at Marine Corps Base Camp Lejeune. As this is a tank maintenance facility, there was not another comparable Navy or Marine Corps facility that is utilized in the same fashion and within the same region for the United States Navy when discussing this with the personnel at Marine Corps Base Camp Lejeune.

Table 4 – Commercial Counterparts

LEED Certified	Commercial Counterpart
Atlantic Fleet Drill Hall	Pacific Fleet Drill Hall
Airborne Mine Countermeasures Facility	Aircraft Maintenance Hangar (HSC-22/C12)
Aircraft Maintenance Hangar (HM14)	Aircraft Maintenance Hangar (HSC-22/C12)
Child Development Center (Oceana)	Child Development Center (Norfolk)
Bachelor Enlisted Quarters (Yorktown)	Bachelor Enlisted Quarters (Norfolk)
Personnel Support Facility	Morale, Welfare, and Recreation Facility
Police and Special Operations Facility (Little Creek)	Police Station (Norfolk)
Marine Corps Bachelor Enlisted Quarters	Marine Corps Bachelor Enlisted Quarters
Public Works Department (NBVC)	Public Works Department (Point Magu)
Naval Facilities Engineering Service Command	NAVSEA Laboratory
Memorial Golf Course Clubhouse (Miramar)	Golf Course Clubhouse (NBVC)
Reserve Training Center & Vehicle Maintenance	None Available

The other notable impacts with the Navy commercial buildings received include the Moral, Welfare, and Recreation (MWR) Facility as a comparison for the Personnel Support Facility. The MWR Facility though within the same region and utilized for similar purposes, is very different in size (more than ten times smaller), which will be evident when comparing the water and electricity usage. On a positive note, no other major issues arose other than the lack of a comparison building for the Reserve Training Center and Vehicle Maintenance Facility were found with respect to finding a building within the same region and of comparable use.

4.3 – Energy Savings

The final step is to compare the FY 2009 data provided to find if an energy savings has been achieved when looking at a LEED building versus a Navy commercial counterpart. For comparing the electricity data, only site energy is being reviewed, as other source energy information is not available for this research. The water data will be compared as well based on the information provided. The electricity will be compared to the 2003 CBECS to see if any savings exists against the national average for the private commercial building stock for each of the United States Navy LEED certified buildings in this study. This comparison will not be made for water consumption, as the same type of data was not available for comparison based on the private commercial building national stock. Though it states in EO 13423 to reduce water consumption intensity 2% per year from the 2007 baseline, this research has taken a different approach to review savings due to a lack of data for the 2007 baseline for each LEED building, as well as making the comparison of a Navy LEED building to a commercial counterpart, vice the baseline of the LEED building itself.

Lastly, to analyze the data and verify the statistical significance of the comparisons being made, a paired t-test will be completed for each of the buildings data in this research. To establish the testing based on comparable results, 70% of the counterpart buildings data will be used in the comparison. This provides the assumption that the two data sets of the Navy LEED certified building (x_1) and its respective Navy commercial counterpart building (x_2) are equal, and that the Navy LEED certified building achieved a 30% savings as expected. For this paired t-test the following will be true for the null hypothesis (H_0) or its rejection (H_1) at a 95% confidence level:

H_0: $x_1 = x_2$; therefore the expected savings may have been achieved if the p-value ≥ 0.05

H_1: $x_1 \neq x_2$; therefore the null hypothesis is rejected if the p-value < 0.05

To complete the paired t-test for each of the comparisons, *The R Project for Statistical Computing* will be utilized to perform the functions. Appendix A contains an example (Atlantic Fleet Drill Hall and the Pacific Fleet Drill Hall) of the data input and output utilizing the software.

Chapter 5: Results

With the data received from all projects, the next step was to analyze the data and the findings. All electricity and water information, which was received in kilowatt-hours (KWH) and kilo-gallons (KGal) respectively, was converted to British Thermal units as a common derivative of energy consumption, using the following conversions:

1000 KWH = 3.412 Btu

1 KGal = 124.2619 Btu

As stated previously, the goal of this project is to see if the energy consumption in the 11 LEED certified buildings was 30% less than the energy consumption in their commercial counterparts. It should be noted that the baseline year for the commercial counterpart buildings corresponded to the same year that the energy was collected for the LEED certified buildings contained in this study. The numbers received for the LEED buildings are additionally to be compared to the national averages for similar buildings, as presented by the 2003 *Commercial Building Energy Consumption Survey* (CBECS) to find if there is a significant difference. Additionally, to verify the results found, a paired t-test is performed for each of the building pairings to verify if the expected savings is realized as seen graphically.

5.1 – Atlantic Fleet Drill Hall vs. Pacific Fleet Drill Hall

At Naval Station Great Lakes, onboard Recruit Training Command, the Atlantic Fleet and Pacific Fleet Drill Halls are both very similar in size (both are 58,000 SF), same location (Naval Station Great Lakes), and architectural design. The major difference in these two buildings is that in August 2009, the Atlantic Fleet Drill Hall received the LEED Gold certification by the USGBC. Of the 11 buildings being reviewed for this project, there are no two that are more alike than these two, with the major difference being the LEED Gold certification, achieved in August 2009, held by the Atlantic Fleet Drill Hall. Table 5 below presents the electricity and water consumption monthly data received for the two buildings from the Public Works Department, and Table 6 presents the same data per 1,000 SF, which ensures that all data is compared equally for buildings with different square footages. Figure 10 and Figure 11 provide a graphical representation of the monthly data.

Table 5 – Drill Halls FY 2009 Monthly Energy Consumption Data

	Electricity (Btu)		Water (Btu)	
	Atlantic Fleet Drill Hall (LEED)	Pacific Fleet Drill Hall	Atlantic Fleet Drill Hall (LEED)	Pacific Fleet Drill Hall
October	182.34	210.04	3901.82	2485.24
November	132.93	128.15	695.87	4473.43
December	120.92	131.43	633.74	3976.38
January	130.75	158.45	907.11	4597.69
February	123.92	150.67	2733.76	4473.43
March	128.02	159.95	994.10	4224.90
April	114.37	120.78	919.54	4349.17
May	139.76	106.45	994.10	3976.38
June	163.50	144.12	1814.22	3230.81
July	184.79	227.79	882.26	3976.38
August	211.54	227.79	2522.52	4224.90
September	187.25	220.69	931.96	4846.21
Totals	1820.10	1986.19	17930.99	48834.93

Table 6 – Drill Halls FY 2009 Monthly Energy Consumption Data per 1,000 Square Feet

	Electricity (Btu/1000 SF)		Water (Btu/1000 SF)	
	Atlantic Fleet Drill Hall (LEED)	Pacific Fleet Drill Hall	Atlantic Fleet Drill Hall (LEED)	Pacific Fleet Drill Hall
Square Footage	58,000	58,000	58,000	58,000
October	3.14	3.62	67.27	42.85
November	2.29	2.21	12.00	77.13
December	2.08	2.27	10.93	68.56
January	2.25	2.73	15.64	79.27
February	2.14	2.60	47.13	77.13
March	2.21	2.76	17.14	72.84
April	1.97	2.08	15.85	74.99
May	2.41	1.84	17.14	68.56
June	2.82	2.48	31.28	55.70
July	3.19	3.93	15.21	68.56
August	3.65	3.93	43.49	72.84
September	3.23	3.81	16.07	83.56

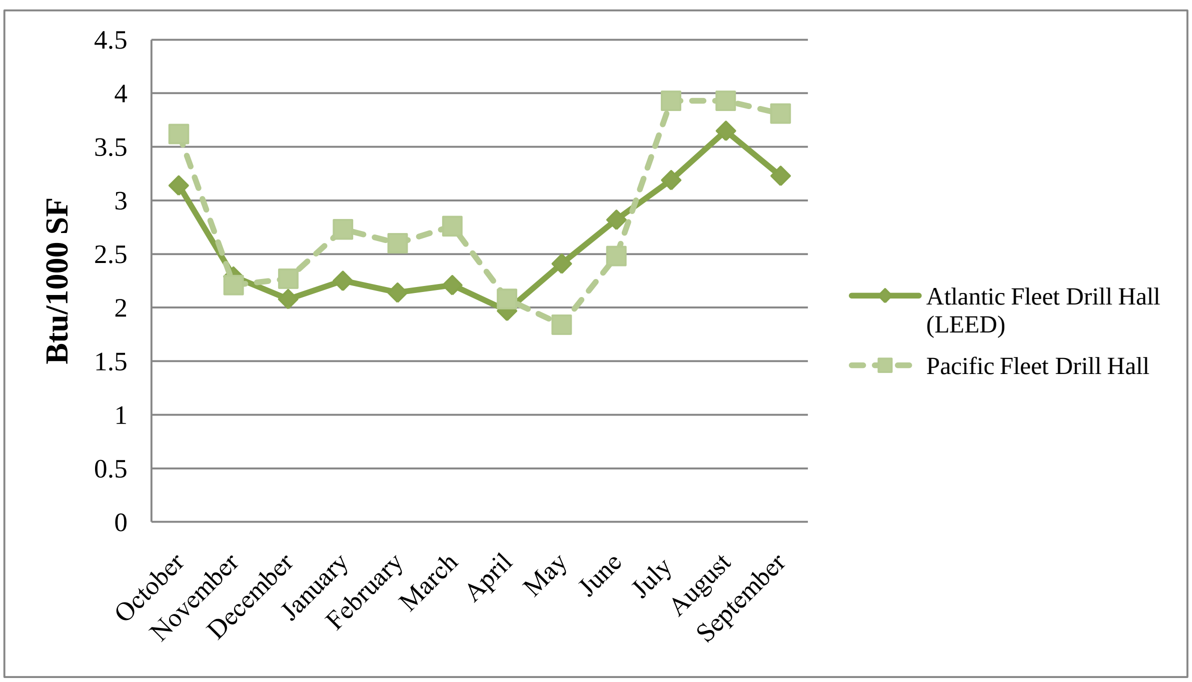

Figure 10 – Drill Halls Monthly Electricity Consumption Data (Btu/1000 SF)

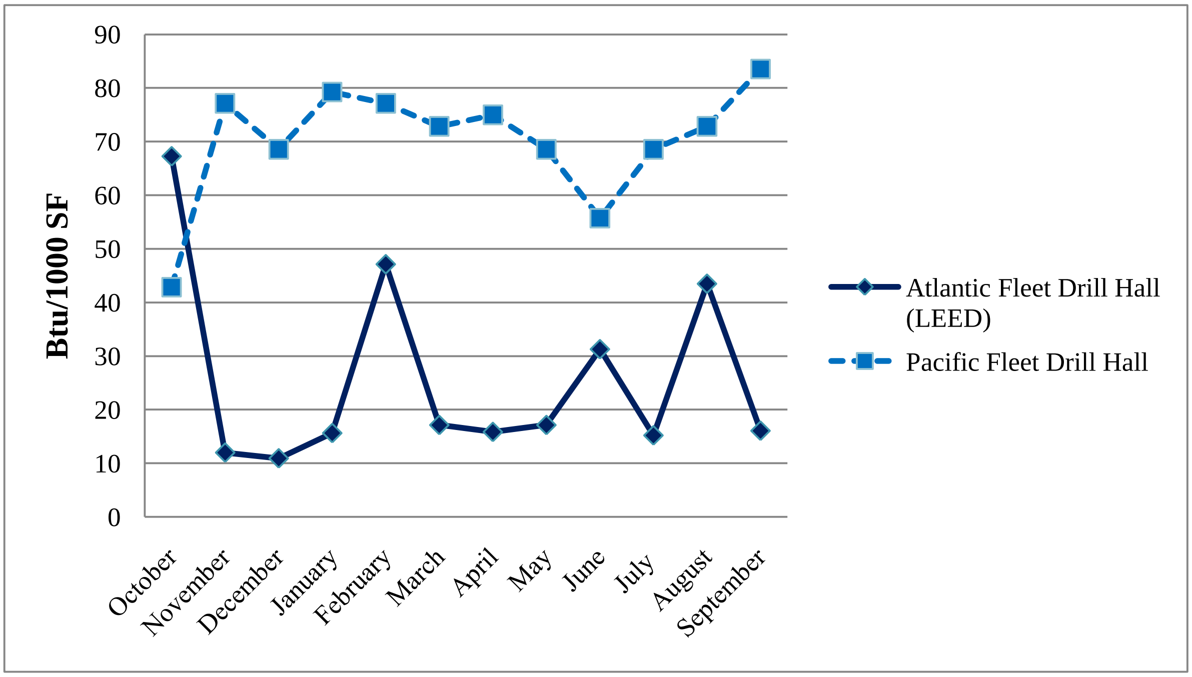

Figure 11 – Drill Halls Monthly Water Consumption Data (Btu/1000 SF)

Figures 10 and 11 indicate a visible difference in the water consumption data over the year, but not much can be taken initially from the electricity consumption data. To find if there is any savings associated with this data, a review of the electricity and water consumed as a percentage is reviewed against the expected 30% savings on a month-by-month basis. Figure 12 and Figure 13 display the projected savings against the expected savings.

$$Percent\ Energy\ Saved = \frac{Commercial\ Building - LEED\ Building}{Commercial\ Building}\ X\ 100$$

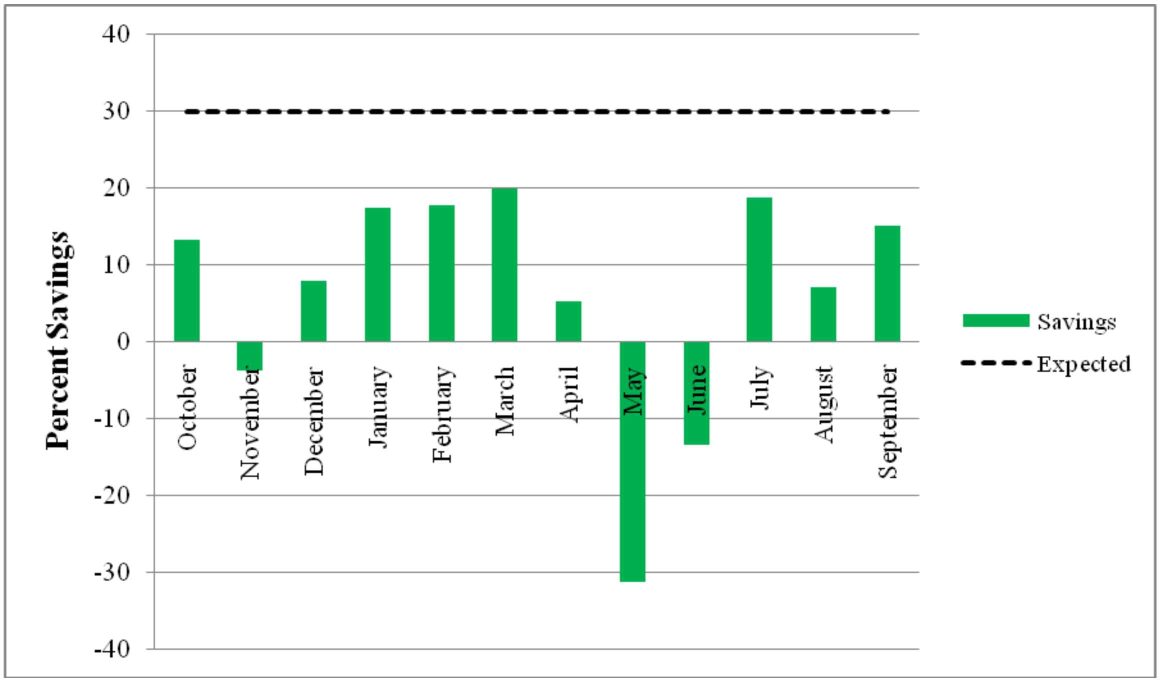

Figure 12 – Drill Halls Electricity Consumption Percent Savings

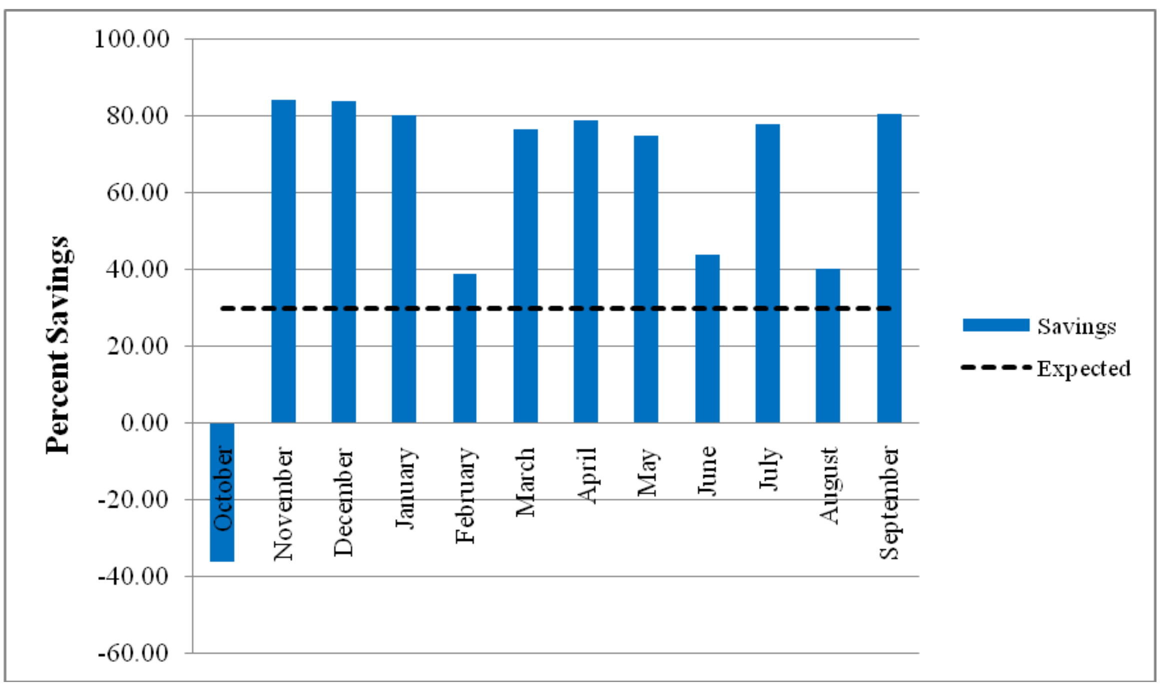

Figure 13 – Drill Halls Water Consumption Percent Savings

To verify if the differences in consumption for the above data are statistically significant, the next step is to perform a paired t-test analysis (Appendix B provides an example of the paired t-test results). As described in the methodology, in order to make the data comparable, and verify that the 30% savings can be achieved; 70% of the energy usage data for the Pacific Fleet Drill Hall is compared to the data gathered for the Atlantic Fleet Drill Hall using a paired t-test. The result of the paired t-test for electricity shows that the true difference is not equal to zero, and the null hypothesis is rejected for a savings of 30%, based on the data from the Pacific Fleet Drill Hall being greater than the data from the Atlantic Fleet Drill Hall when comparing them equally. The p-value associated with testing the differences between criteria weights is 0.001424, which is much smaller than 0.05. This extremely small p-value suggests that the criteria weights are different, and the null hypothesis is rejected at a 95% confidence level. The explanation for this falls in line with the consumption data, which is extremely close for both buildings, regardless of the LEED Gold certification, and did not achieve the expected savings of 30%.

When the same paired t-test is run for the water consumption data the true difference in means is greater than 0.3, and the test passes for a 30% savings. The p-value associated with testing the differences between criteria weights is 0.9973, which is greater than 5% and falls within the accepted confidence level for this test. The percent savings is varied above the 30% expected savings, and the null hypothesis is accepted at the 95% confidence level. Though the savings shown in Figure 5.1.4 show a greater average savings of more than 60%, 30% above the expected savings, additional data should be collected to further verify the above findings.

The Atlantic Fleet Drill Hall falls in the Midwest region as it was constructed at Naval Station Great Lakes in Illinois. The average KWH usage per square-foot (KWH/SF) for the

Atlantic Fleet Drill Hall equate to 9.2 KWH/SF. In comparison, the 2003 CBECS data shows that Non-Mall Buildings with a building floor-space between 50,001 and 100,000 SF have a median electricity usage of 9.9 KWH/SF. When these two numbers are compared directly, we find a 7.07% savings based on the national average from the 2003 CBECS.

5.2 – Airborne Mine Countermeasures Facility vs. Aircraft Maintenance Hangar

At Naval Station Norfolk, the Airborne Mine Countermeasures Facility (SP 36) and the Aircraft Maintenance Hangar (LP 33) are both at the same location (Naval Station Great Lakes), have similar architectural design, but vary in size with the Airborne Mine Countermeasures Facility approximately 73% larger. In May 2006 the Airborne Mine Countermeasures Facility received the LEED Certified certification by the USGBC. Table 7 below presents the electricity and water consumption monthly data received for the two buildings from the Public Works Department, and Table 8 presents the same data per 1,000 SF, which ensures that all data is compared equally for buildings with different square footages. Figure 14 and Figure 15 provide a graphical representation of the monthly data.

Table 7 – Airborne Mine Countermeasures/Aircraft Hangar FY 2009 Monthly Energy Consumption Data

	Electricity (Btu)		Water (Btu)	
	Airborne Mine Countermeasures Facility (SP 37) (LEED)	Aircraft Maintenance Hangar (LP 33)	Airborne Mine Countermeasures Facility (SP 37) (LEED)	Aircraft Maintenance Hangar (LP 33)
October	188.34	262.04	1988.19	2485.24
November	140.57	165.14	2236.71	4721.95
December	135.12	193.80	1366.88	3603.60
January	131.02	211.54	1366.88	2485.24
February	147.06	248.39	1242.62	1739.67
March	132.39	229.29	1491.14	2360.98
April	124.20	222.46	869.33	5964.57
May	168.55	227.92	1366.88	3479.33
June	116.69	169.24	1118.36	3355.07
July	124.88	156.95	1366.88	3603.60
August	182.54	247.03	1739.67	4100.64
September	161.39	201.99	2236.71	3230.81
Totals	1752.74	2535.80	18390.76	41130.69

Table 8 – Airborne Mine Countermeasures/Aircraft Hangar FY 2009 Monthly Energy Consumption Data per 1,000 Square Feet

	Electricity (Btu/1000 SF)		Water (Btu/1000 SF)	
	Airborne Mine Countermeasures Facility (SP 37) (LEED)	Aircraft Maintenance Hangar (LP 33)	Airborne Mine Countermeasures Facility (SP 37) (LEED)	Aircraft Maintenance Hangar (LP 33)
Square Footage	40,376	23,297	40,376	23,297
October	4.66	11.25	49.24	106.68
November	3.48	7.09	55.40	202.68
December	3.35	8.32	33.85	154.68
January	3.25	9.08	33.85	106.68
February	3.64	10.66	30.78	74.67
March	3.28	9.84	36.93	101.34
April	3.08	9.55	21.54	256.02
May	4.17	9.78	33.85	149.35
June	2.89	7.26	27.70	144.01
July	3.09	6.74	33.85	154.68
August	4.52	10.60	43.09	176.02
September	4.00	8.67	55.40	138.68

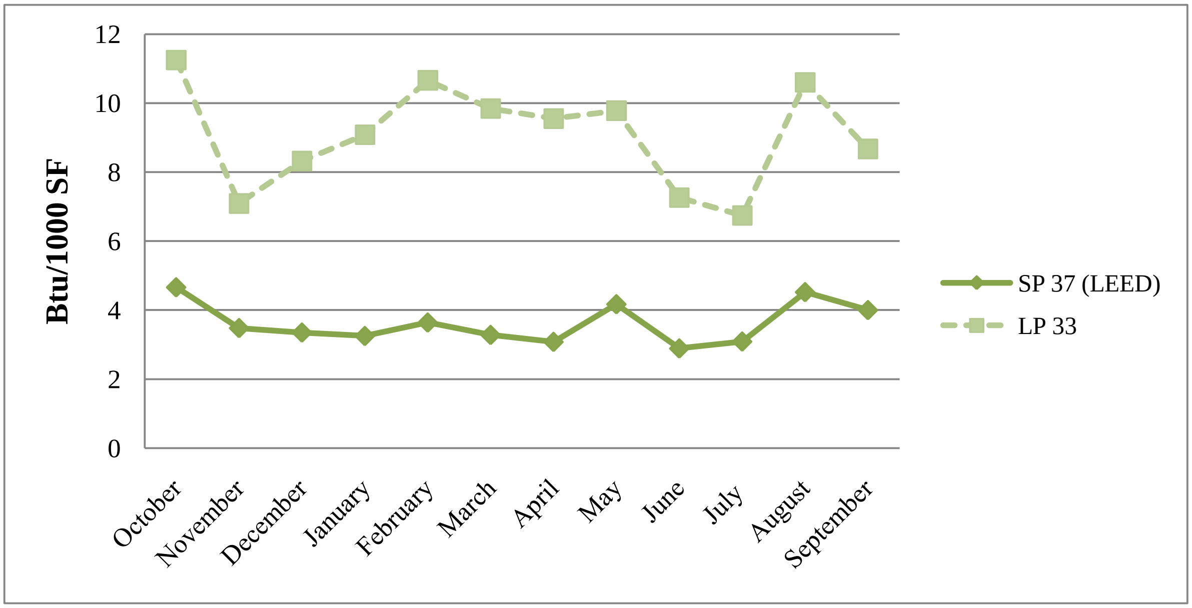

Figure 14 – Airborne Mine/Aircraft Hangar Monthly Electricity Consumption Data (Btu/1000 SF)

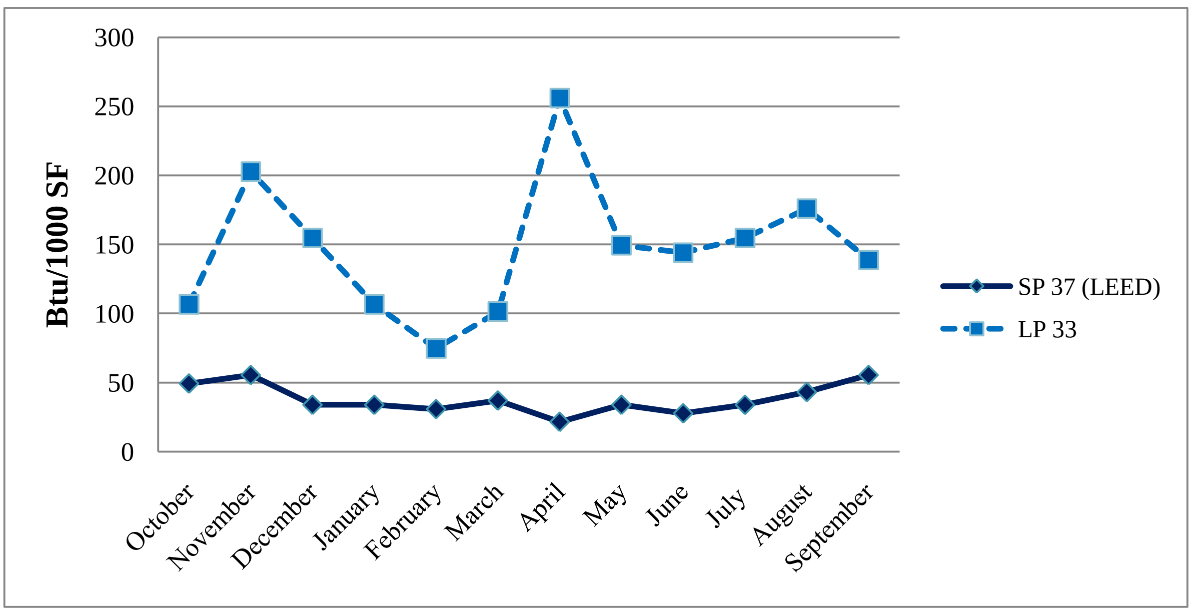

Figure 15 – Airborne Mine/Aircraft Hangar Monthly Water Consumption Data (Btu/1000 SF)

Figures 14 and 15 indicate a visible difference in the electricity and water consumption data over the year. To find if there is any savings associated with this data, a review of the electricity and water consumed as a percentage is reviewed against the expected 30% savings on a month-by-month basis. Figure 16 and Figure 17 display the projected savings against the expected savings.

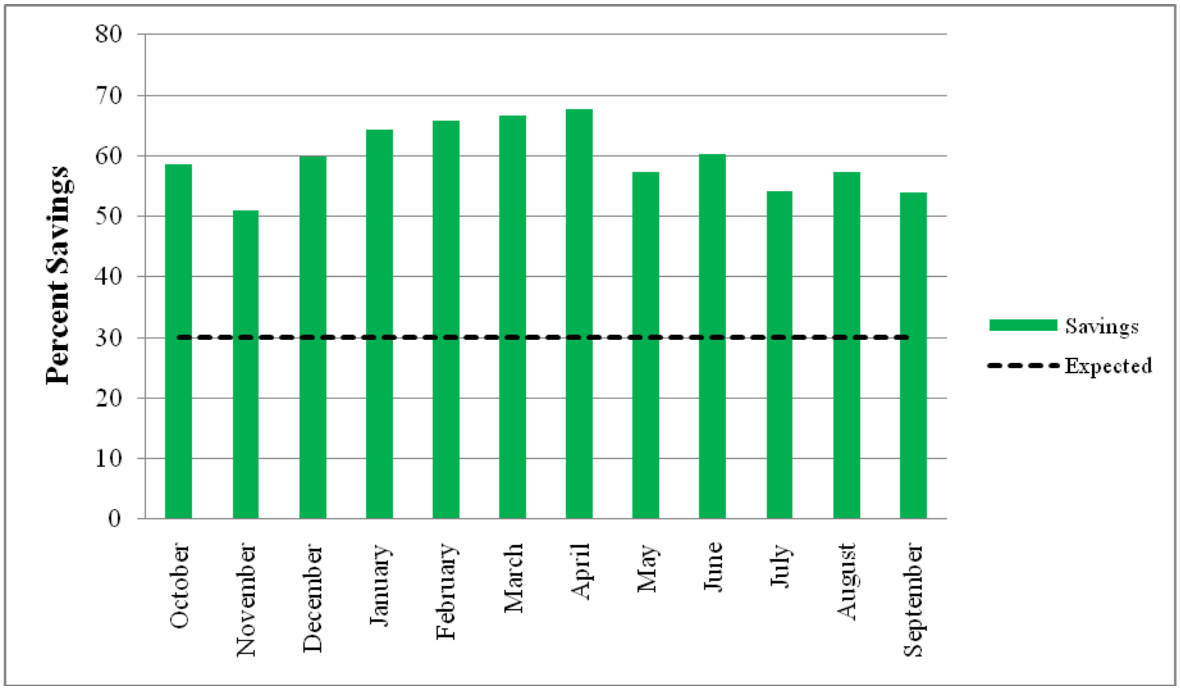

Figure 16 – Airborne Mine/Aircraft Hangar Electricity Consumption Percent Savings

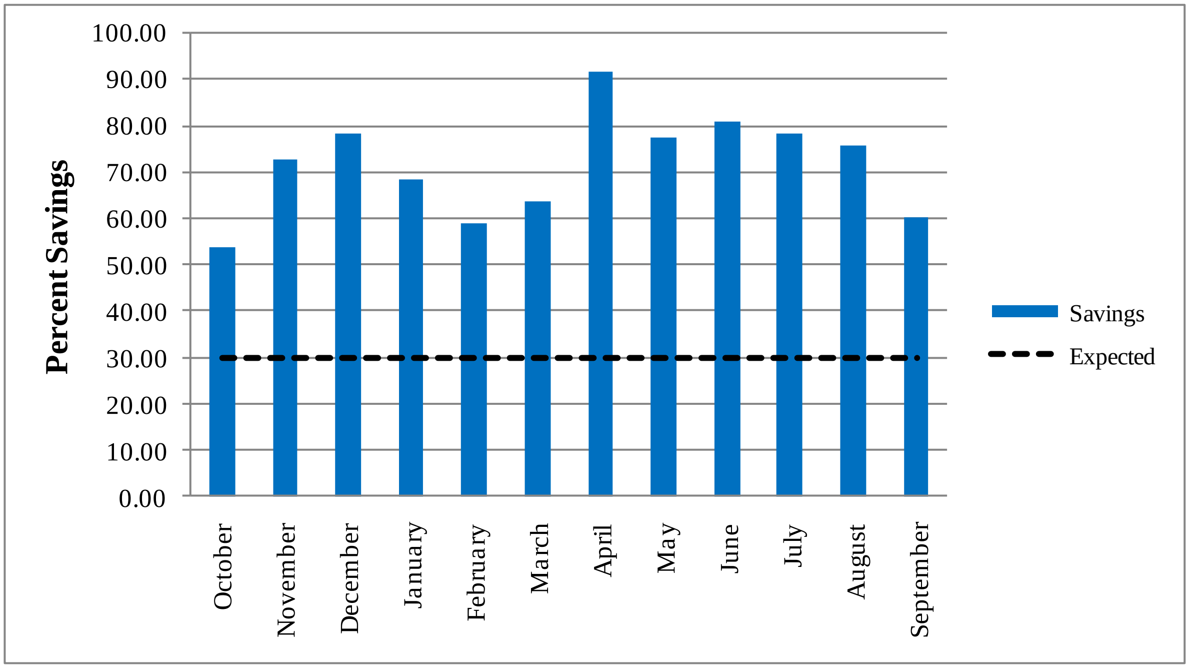

Figure 17 – Airborne Mine/Aircraft Hangar Water Consumption Percent Savings

Utilizing the same basis for the paired t-test analysis as the previous section and verify that the 30% savings can be achieved; 70% of the energy usage data for the Aircraft Maintenance Hangar is compared to the data gathered for the Airborne Mine Countermeasures Facility using a paired t-test. The result of the paired t-test for electricity shows that the true difference is greater than zero, and the test passes for a 30% savings, based on the data from the Aircraft Maintenance Hangar being greater than the data from the Airborne Mine Countermeasures Facility when comparing them equally. The p-value associated with testing the differences between criteria weights is 1.00, which is greater than 5% and falls within the accepted confidence level for this test.

When the same paired t-test is run for the water consumption data the true difference in means is greater than zero, and the test passes for a 30% savings. The p-value associated with testing the differences between criteria weights is 1.00, which is greater than 5% and falls within the accepted confidence level for this test.

The Airborne Mine Countermeasures Facility falls in the Midatlantic region as it was constructed at Naval Station Norfolk in Virginia. The average KWH usage per square-foot (KWH/SF) for the Airborne Mine Countermeasures Facility equates to 12.7 KWH/SF. In comparison, the 2003 CBECS data shows that Non-Mall Buildings with a building floor-space between 25,001 and 50,000 SF have a median electricity usage of 8.8 KWH/SF. When these two numbers are compared directly, we find that the Airborne Mine Countermeasures Facility used 44.32% more electricity than the national average from the 2003 CBECS.

5.3 – Aircraft Maintenance Hangar vs. Aircraft Maintenance Hangar

Also at Naval Station Norfolk, the Aircraft Maintenance Hangar (SP 37) will be compared to the Aircraft Maintenance Hangar (LP 33) with similar architectural design, but vary in size with the Aircraft Maintenance Hangar (SP 37) approximately 22% larger. In June 2006 the Aircraft Maintenance Hangar (SP 37) received the LEED Certified certification by the USGBC. Table 9 below presents the electricity and water consumption monthly data received for the two buildings from the Public Works Department, and Table 10 presents the same data per 1,000 SF, which ensures that all data is compared equally for buildings with different square footages. Figures 18 and 19 provide a graphical representation of the monthly data.

Table 9 – Aircraft Hangars FY 2009 Monthly Energy Consumption Data

	Electricity (Btu)		Water (Btu)	
	Aircraft Maintenance Hangar (SP 36) (LEED)	Aircraft Maintenance Hangar (LP 33)	Aircraft Maintenance Hangar (SP 36) (LEED)	Aircraft Maintenance Hangar (LP 33)
October	340.18	262.04	22615.67	2485.24
November	205.74	165.14	15408.48	4721.95
December	217.34	193.80	15905.52	3603.60
January	203.70	211.54	18639.29	2485.24
February	247.37	248.39	8201.29	1739.67
March	244.98	229.29	9816.69	2360.98
April	210.86	222.46	11307.83	5964.57
May	281.15	227.92	13793.07	3479.33
June	190.05	169.24	10065.21	3355.07
July	209.16	156.95	9940.95	3603.60
August	284.90	247.03	21000.26	4100.64
September	224.51	201.99	21000.26	3230.81
Totals	2859.94	2535.80	177694.52	41130.69

Table 10 – Aircraft Hangars FY 2009 Monthly Energy Consumption Data per 1,000 Square Feet

	Electricity (Btu/1000 SF)		Water (Btu/1000 SF)	
	Aircraft Maintenance Hangar (SP 36) (LEED)	Aircraft Maintenance Hangar (LP 33)	Aircraft Maintenance Hangar (SP 36) (LEED)	Aircraft Maintenance Hangar (LP 33)
Square Footage	28,379	23,297	28,379	23,297
October	11.99	11.25	796.92	106.68
November	7.25	7.09	542.95	202.68
December	7.66	8.32	560.47	154.68
January	7.18	9.08	656.80	106.68
February	8.72	10.66	288.99	74.67
March	8.63	9.84	345.91	101.34
April	7.43	9.55	398.46	256.02
May	9.91	9.78	486.03	149.35
June	6.70	7.26	354.67	144.01
July	7.37	6.74	350.29	154.68
August	10.04	10.60	739.99	176.02
September	7.91	8.67	739.99	138.68

Figure 18 – Aircraft Hangars Monthly Electricity Consumption Data (Btu/1000 SF)

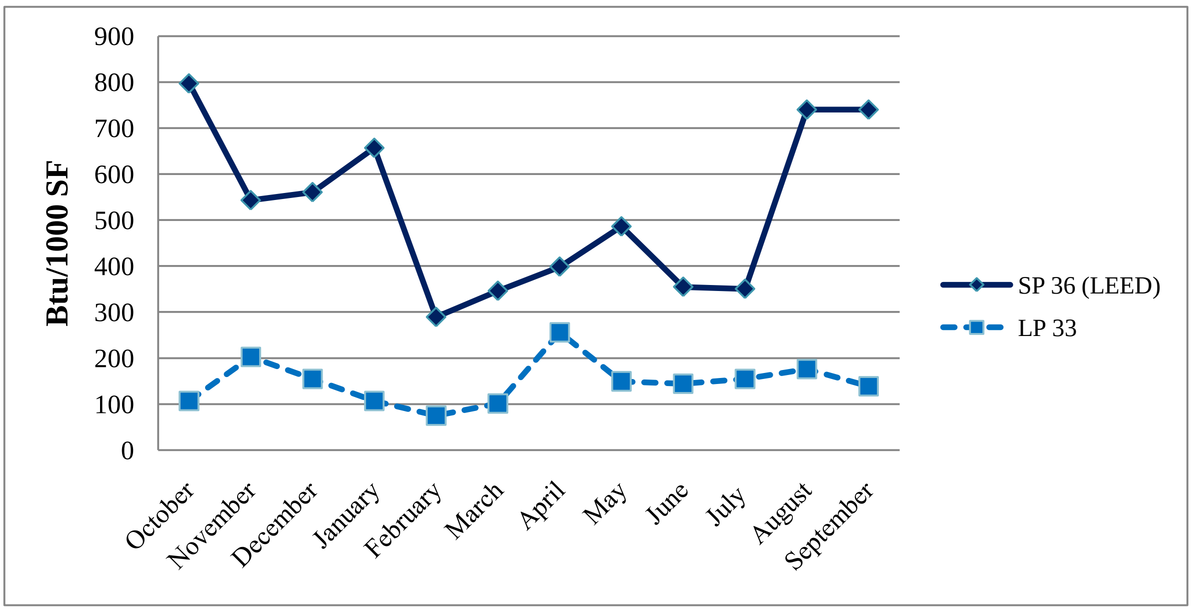

Figure 19 – Aircraft Hangars Monthly Water Consumption Data (Btu/1000 SF)

Figure 18 does not show a noticeable difference for the monthly electricity data, but Figure 19 does indicate a visible difference in the water consumption data over the year. To find if there is any savings associated with this data, a review of the electricity and water consumed as a percentage is reviewed against the expected 30% savings on a month-by-month basis. Figure 20 and Figure 21 display the projected savings against the expected savings.

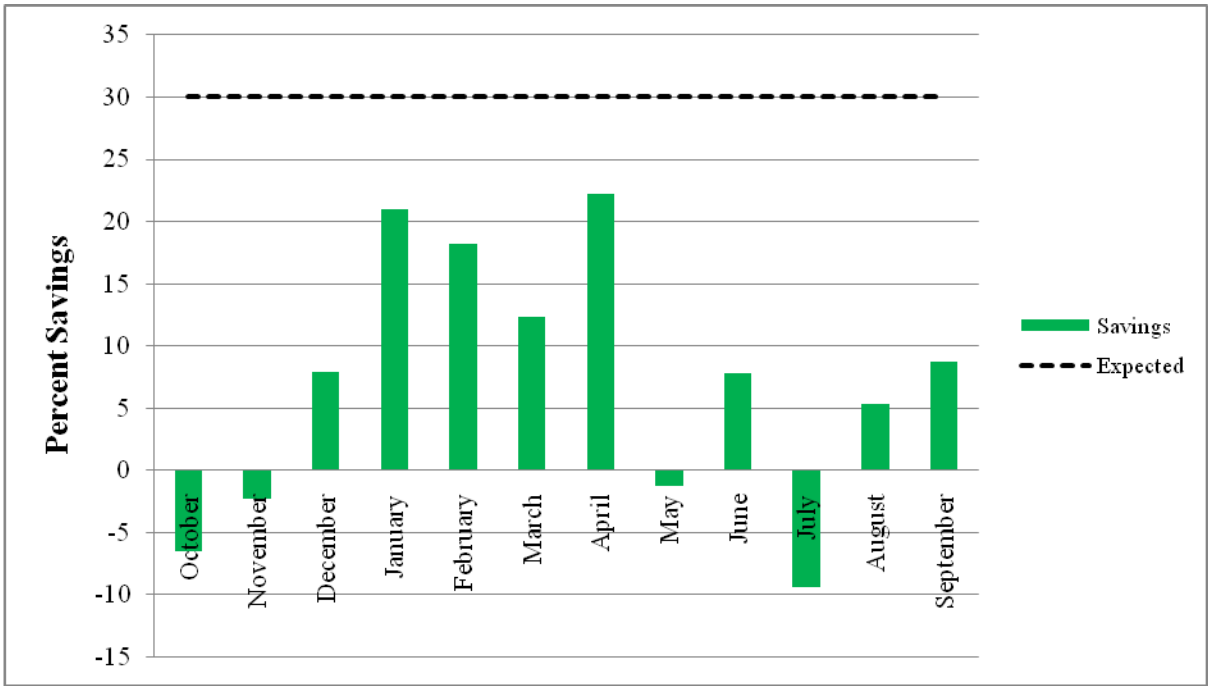

Figure 20 – Aircraft Hangars Electricity Consumption Percent Savings

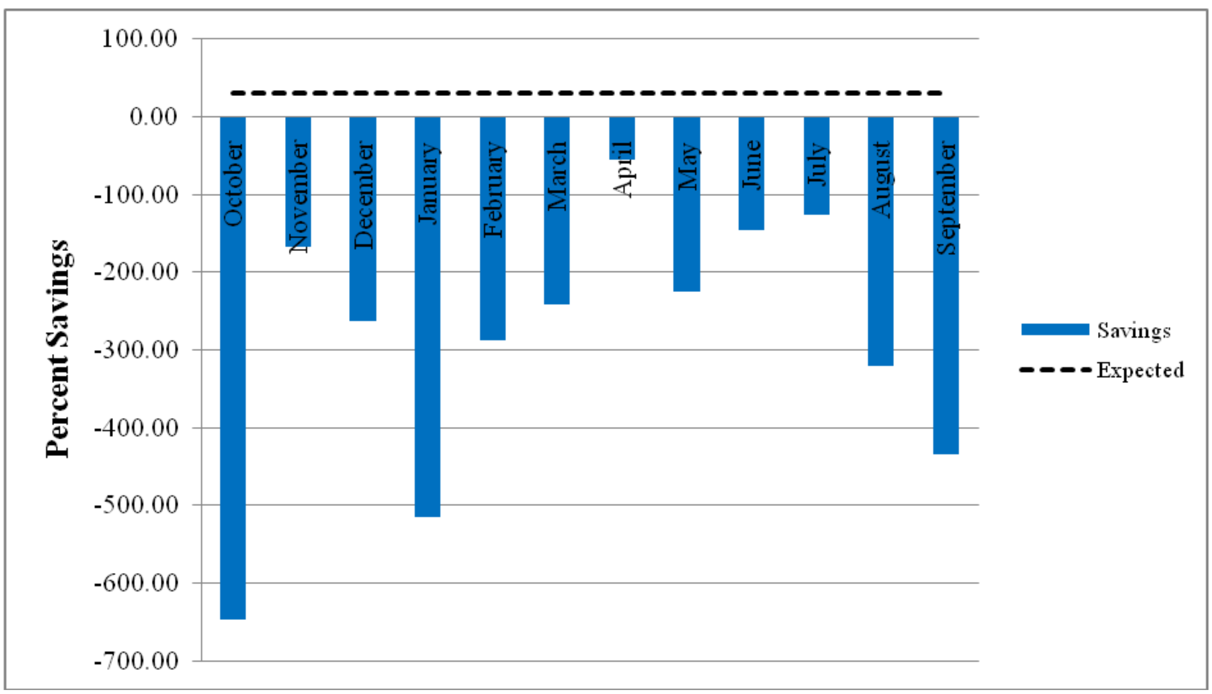

Figure 21 – Aircraft Hangars Water Consumption Percent Savings

Utilizing the same basis for the paired t-test analysis as the previous section and verify that the 30% savings can be achieved; 70% of the energy usage data for the Aircraft Maintenance Hangar (LP 33) is compared to the data gathered for the Aircraft Maintenance Hangar (SP 36) using a paired t-test. The result of the paired t-test for electricity shows that the true difference is not equal to zero, and the null hypothesis is rejected for a savings of 30%, based on the data from the Aircraft Maintenance Hangar (LP 33) being greater than the data from the Aircraft Maintenance Hangar (SP 36) when comparing them equally. The p-value associated with testing the differences between criteria weights is 7.134e-06, which is much smaller than 0.05. This extremely small p-value suggests that the criteria weights are different, and the null hypothesis is rejected at a 95% confidence level.

The result of the paired t-test for water shows that the true difference is not equal to zero, and the null hypothesis is rejected for a savings of 30%, based on the data from the Aircraft Maintenance Hangar (LP 33) being greater than the data from the Aircraft Maintenance Hangar (SP 36) when comparing them equally. The p-value associated with testing the differences between criteria weights is 3.325e-06, which is much smaller than 0.05. This extremely small p-value suggests that the criteria weights are different, and the null hypothesis is rejected at a 95% confidence level.

The Aircraft Maintenance Hangar (SP 36) falls in the Midatlantic region as it was constructed at Naval Station Norfolk in Virginia. The average KWH usage per square-foot (KWH/SF) for the Aircraft Maintenance Hangar (SP 36) equates to 29.5 KWH/SF. In comparison, the 2003 CBECS data shows that Non-Mall Buildings with a building floor-space between 25,001 and 50,000 SF have a median electricity usage of 8.8 KWH/SF. When these two numbers are compared directly, we find that the Aircraft Maintenance Hangar (SP 36) used 235.23% more electricity than the national average from the 2003 CBECS.

5.4 – Bachelor Enlisted Quarters (2075) vs. Bachelor Enlisted Quarters (R61)

The Bachelor Enlisted Quarters (2075) at Naval Weapons Station Yorktown and the Bachelor Enlisted Quarters (R61) at Naval Station Norfolk are both within the same region separated by 35 miles, have similar architectural design, but vary greatly in size, with the Bachelor Enlisted Quarters (R61) approximately 110% larger. In February 2007 the Bachelor Enlisted Quarters (2075) received the LEED Certified certification by the USGBC. Table 11 below presents the electricity and water consumption monthly data received for the two buildings from the Public Works Department, and Table 12 presents the same data per 1,000 SF, which ensures that all data is compared equally for buildings with different square footages. Water consumption data was not available for the Bachelor Enlisted Quarters (R61) at Naval Station Norfolk. Figure 22 provides a graphical representation of the monthly electricity data.

Table 11 – BEQs FY 2009 Monthly Energy Consumption Data

	Electricity (Btu)		Water (Btu)	
	BEQ (Yorktown) (LEED)	BEQ (Norfolk)	BEQ (Yorktown) (LEED)	BEQ (Norfolk)
October	301.62	487.23	19757.64	No water data provided for this building.
November	233.38	292.07	15035.69	
December	159.68	206.43	15905.52	
January	186.98	181.18	18266.50	
February	204.72	190.39	18639.29	
March	161.05	194.14	12177.67	
April	165.14	193.46	15781.26	
May	208.81	211.20	21497.31	
June	201.99	199.26	15532.74	
July	222.46	250.44	18142.24	
August	307.08	359.62	11929.14	
September	277.05	328.58	24231.07	
Totals	2629.97	3094.00	206896.06	

Table 12 – BEQs FY 2009 Monthly Energy Consumption Data per 1,000 Square Feet

	Electricity (Btu/1000 SF)		Water (Btu/1000 SF)	
	BEQ (Yorktown) (LEED)	BEQ (Norfolk)	BEQ (Yorktown) (LEED)	BEQ (Norfolk)
Square Footage	48,700	101,837	48,700	101,837
October	6.19	4.78	405.70	No water data provided for this building.
November	4.79	2.87	308.74	
December	3.28	2.03	326.60	
January	3.84	1.78	375.08	
February	4.20	1.87	382.74	
March	3.31	1.91	250.05	
April	3.39	1.90	324.05	
May	4.29	2.07	441.42	
June	4.15	1.96	318.95	
July	4.57	2.46	372.53	
August	6.31	3.53	244.95	
September	5.69	3.23	497.56	

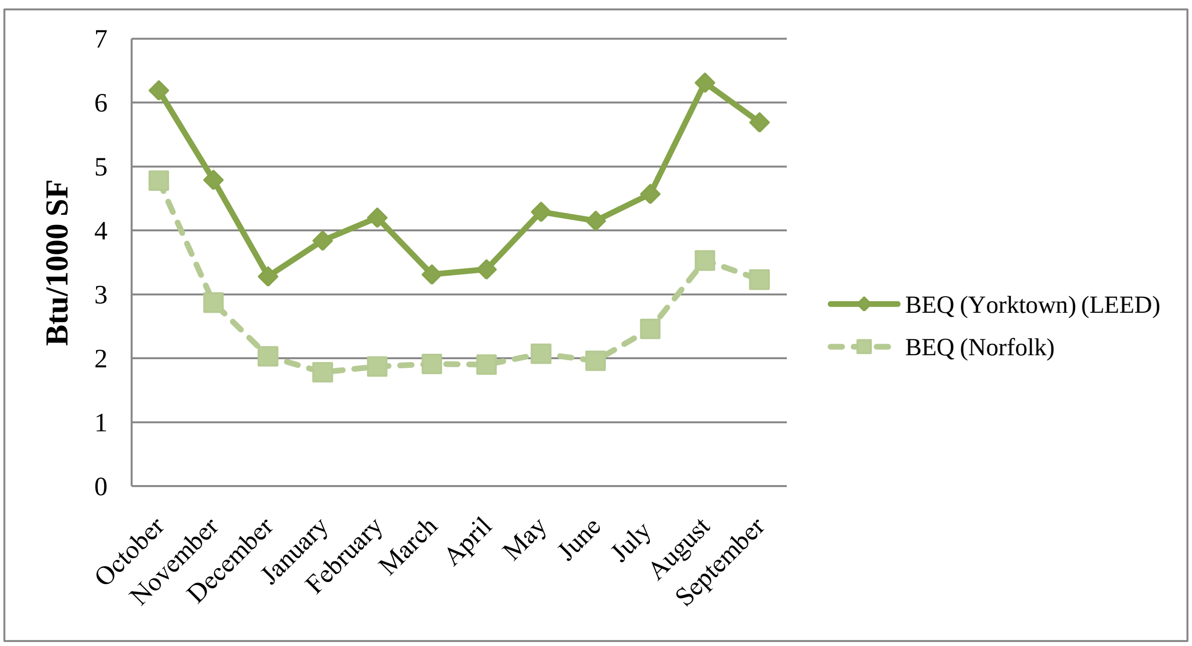

Figure 22 – BEQs Monthly Electricity Consumption Data (Btu/1000 SF)

Figure 22 indicates a visible difference in the electricity consumption data over the year. To find if there is any savings associated with this data, a review of the electricity consumed as a percentage is reviewed against the expected 30% savings on a month-by-month basis. Figure 23 displays the projected savings against the expected savings.

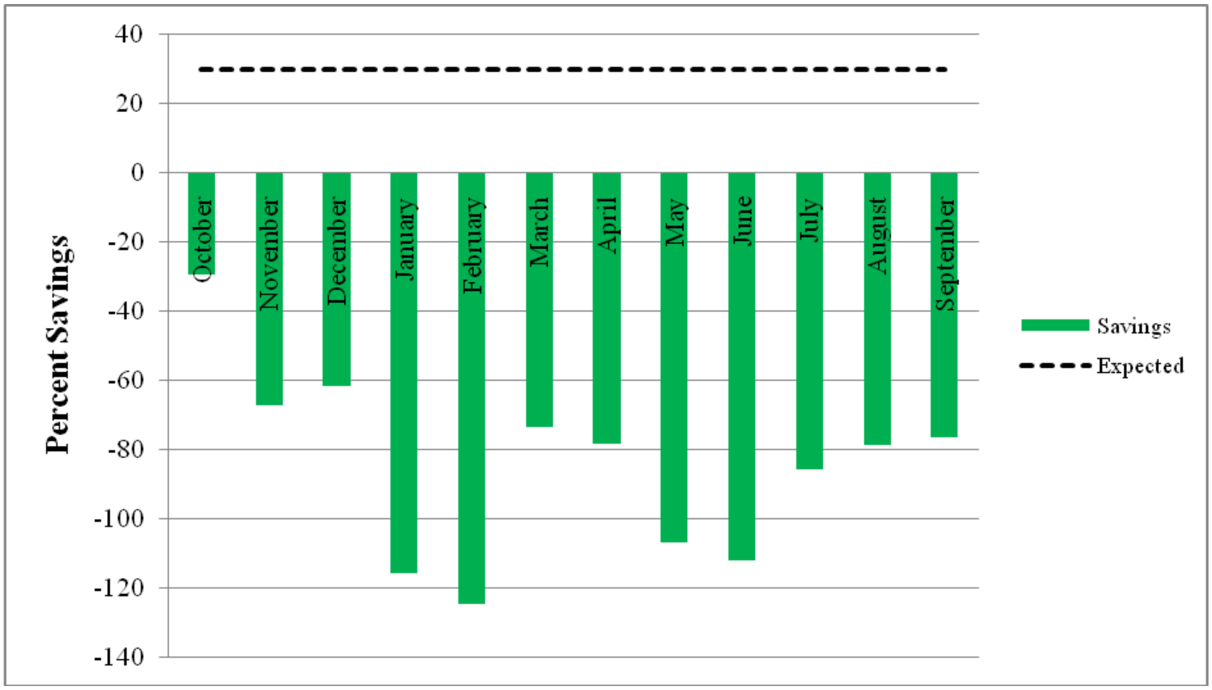

Figure 23 – BEQs Electricity Consumption Percent Savings

Utilizing the same basis for the paired t-test analysis as the previous section to verify that the 30% savings can be achieved; 70% of the energy usage data for the Bachelor Enlisted Quarters (R61) is compared to the data gathered for the Bachelor Enlisted Quarters (2075) using a paired t-test. The result of the paired t-test for water shows that the true difference is not equal to zero, and the null hypothesis is rejected for a savings of 30%, based on the data from the Bachelor Enlisted Quarters (R61) being greater than the data from the Bachelor Enlisted Quarters (2075) when comparing them equally. The p-value associated with testing the differences between criteria weights is 1.991e-09, which is much smaller than 0.05. This extremely small p-value suggests that the criteria weights are different, and the null hypothesis is rejected at a 95% confidence level.

The Bachelor Enlisted Quarters (2075) falls in the Midatlantic region as it was constructed at Naval Weapons Station Yorktown in Virginia. The average KWH usage per square-foot (KWH/SF) for the Bachelor Enlisted Quarters (2075) equates to 15.8 KWH/SF. In comparison, the 2003 CBECS data shows that Non-Mall Buildings with a building floor-space between 25,001 and 50,000 SF have a median electricity usage of 8.8 KWH/SF. When these two numbers are compared directly, we find that the Bachelor Enlisted Quarters (2075) used 79.55% more electricity than the national average from the 2003 CBECS.

5.5 – Personnel Support Facility vs. Morale, Welfare, and Recreation Facility

The Personnel Support Facility (PSF) at Naval Amphibious Base Little Creek in Virginia and the Moral, Welfare, and Recreation (MWR) Facility at Naval Station Norfolk are both within the same region separated by 18 miles, but vary greatly both in architectural design and in size, with the PSF approximately 1500% larger. In October 2005 the PSF received the LEED Silver certification by the USGBC. Table 13 below presents the electricity and water consumption monthly data received for the two buildings from the Public Works Department, and Table 14 presents the same data per 1,000 SF, which ensures that all data is compared as equally as possible for these two widely different buildings, with respect to square footages. Figure 24 and Figure 25 provide a graphical representation of the monthly electricity and water consumption data.

Table 13 – PSF/MWR FY 2009 Monthly Energy Consumption Data

	Electricity (Btu)		Water (Btu)	
	Personnel Support Facility (LEED)	MWR Facility	Personnel Support Facility (LEED)	MWR Facility
October	299.57	6.14	2112.45	124.26
November	228.95	6.14	1863.93	124.26
December	170.67	6.14	1863.93	124.26
January	152.86	6.14	2112.45	248.52
February	187.32	6.14	1863.93	248.52
March	141.94	6.14	2112.45	124.26
April	146.03	6.14	1988.19	248.52
May	204.04	6.14	1988.19	248.52
June	219.73	6.14	1863.93	124.26
July	219.39	6.14	1615.41	124.26
August	307.08	6.14	2112.45	248.52
September	240.20	6.14	1988.19	248.52
Totals	2517.71	73.70	23485.50	2236.72

Table 14 – PSF/MWR FY 2009 Monthly Energy Consumption Data per 1,000 Square Feet

	Electricity (Btu/1000 SF)		Water (Btu/1000 SF)	
	Personnel Support Facility (LEED)	MWR Facility	Personnel Support Facility (LEED)	MWR Facility
Square Footage	37,800	2,520	37,800	2,520
October	7.93	2.44	55.88	49.31
November	6.06	2.44	49.31	49.31
December	4.51	2.44	49.31	49.31
January	4.04	2.44	55.88	98.62
February	4.96	2.44	49.31	98.62
March	3.76	2.44	55.88	49.31
April	3.86	2.44	52.60	98.62
May	5.40	2.44	52.60	98.62
June	5.81	2.44	49.31	49.31
July	5.80	2.44	42.74	49.31
August	8.12	2.44	55.88	98.62
September	6.35	2.44	52.60	98.62

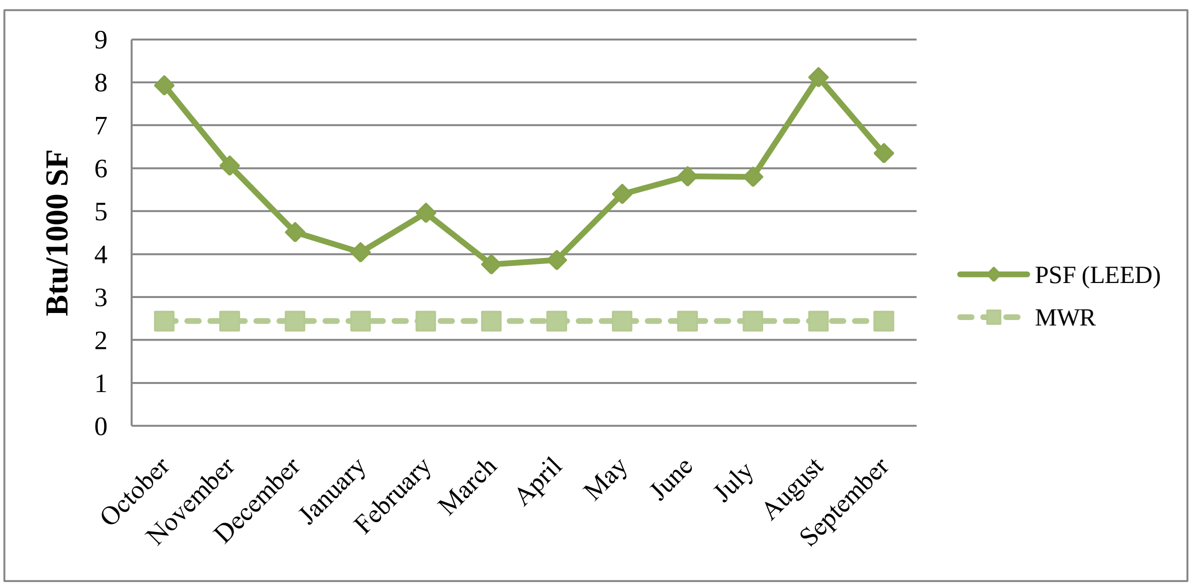

Figure 24 – PSF/MWR Monthly Electricity Consumption Data (Btu/1000 SF)

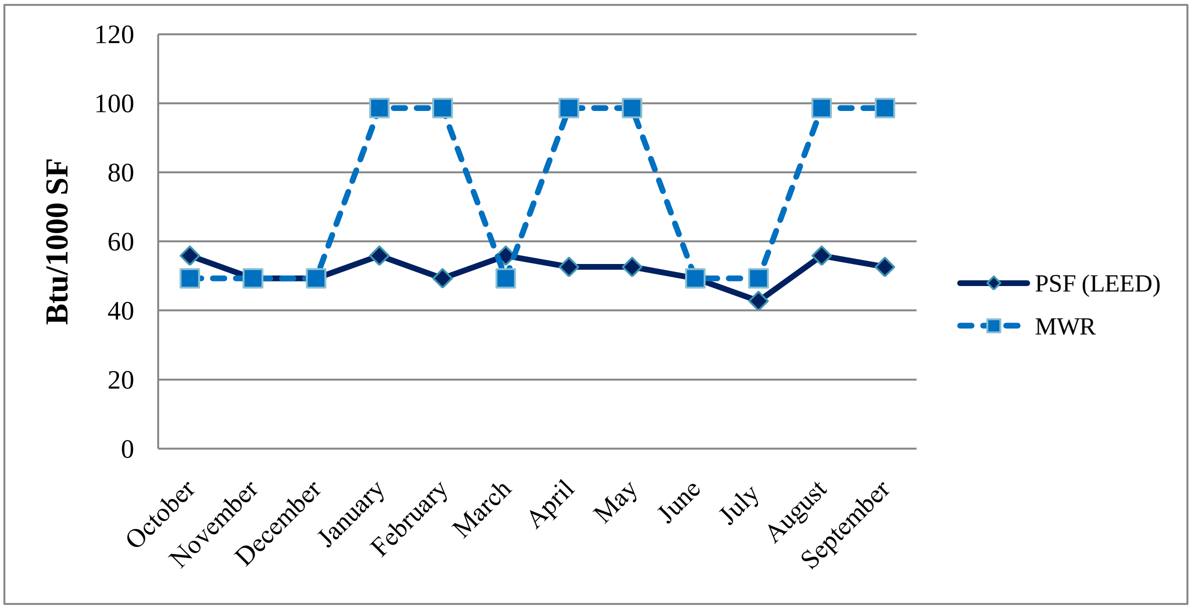

Figure 25 – PSF/MWR Monthly Water Consumption Data (Btu/1000 SF)

Figures 24 and 25 indicate visible differences in both the electricity and water consumption data over the year, and with this large difference in size of the buildings this was an anticipated outcome. Even with the difference in size, the next step is to find if there is any savings associated with this data, by reviewing the electricity and water consumed as a percentage, reviewed against the expected 30% savings on a month-by-month basis. Figure 26 and Figure 27 display the projected savings against the expected savings.

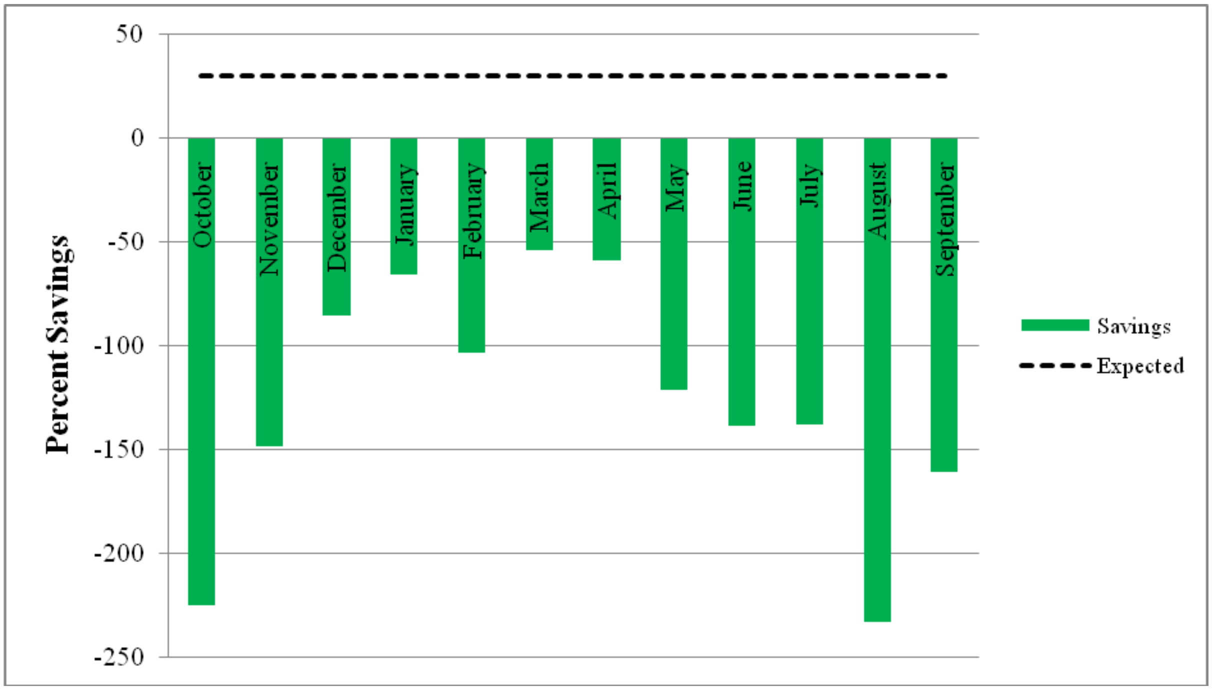

Figure 26 – PSF/MWR Electricity Consumption Percent Savings

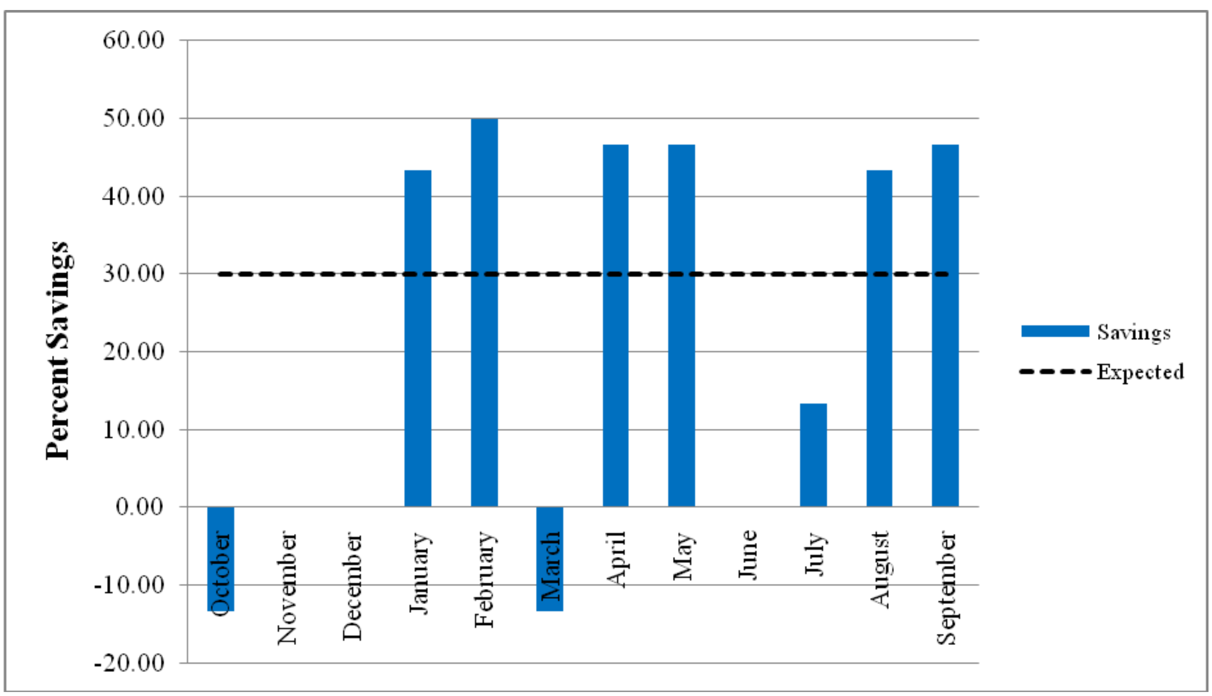

Figure 27 – PSF/MWR Water Consumption Percent Savings

Utilizing the same basis for the paired t-test analysis as each of the previous sections is to verify that the 30% savings can be achieved; 70% of the energy usage data for the MWR Facility is compared to the data gathered for the PSF using a paired t-test. The result of the paired t-test for electricity shows that the true difference is not equal to zero, and the null hypothesis is rejected for a savings of 30%, based on the data from the PSF being greater than the data from the MWR Facility when comparing them equally. The p-value associated with testing the differences between criteria weights is 8.622e-07, which is much smaller than 0.05. This extremely small p-value suggests that the criteria weights are different, and the null hypothesis is rejected at a 95% confidence level.

When the same paired t-test is run for the water consumption data the true difference in means is greater than zero, and the test passes for a 30% savings. The p-value associated with testing the differences between criteria weights is 0.5, which is greater than 5% and falls within the accepted confidence level for this test.

The PSF falls in the Midatlantic region as it was constructed at Naval Amphibious Base Little Creek in Virginia. The average KWH usage per square-foot (KWH/SF) for the Airborne Mine Countermeasures Facility equates to 19.5 KWH/SF. In comparison, the 2003 CBECS data shows that Non-Mall Buildings with a building floor-space between 25,001 and 50,000 SF have a median electricity usage of 8.8 KWH/SF. When these two numbers are compared directly, we find that the Airborne Mine Countermeasures Facility used 121.59% more electricity than the national average from the 2003 CBECS.

5.6 – Police and Special Operations Facility vs. Police Station

At Naval Amphibious Base Little Creek, the Police and Special Operations Facility received the LEED Silver certification from the USGBC in June 2008. These buildings are comparable in usage and size, with the major difference being the 18 miles separating the two Naval Stations and the architectural designs. Table 15 below presents the electricity and water consumption monthly data received for the two buildings from the Public Works Department, and Table 16 presents the same data per 1,000 SF, which ensures that all data is compared equally for buildings with different square footages. Figure 28 and Figure 29 provide a graphical representation of the monthly data.

Table 15 – Police Stations FY 2009 Monthly Energy Consumption Data

	Electricity (Btu)		Water (Btu)	
	Police and Special Operations Facility (LEED)	Police Station	Police and Special Operations Facility (LEED)	Police Station
October	215.64	275.69	17769.45	5467.52
November	150.47	182.88	2982.29	6461.62
December	142.62	150.13	124.26	5219.00
January	94.51	108.50	2236.71	7704.24
February	145.69	141.26	2733.76	5840.31
March	143.99	132.04	2236.71	4597.69
April	152.86	116.69	5467.52	8325.55
May	171.62	164.80	2733.76	11183.57
June	172.65	140.92	2858.02	7331.45
July	122.83	151.15	9940.95	6337.36
August	213.25	197.90	10438.00	8574.07
September	183.57	215.64	5467.52	6213.10
Totals	1909.70	1977.60	64988.97	83255.47

Table 16 – Police Stations FY 2009 Monthly Energy Consumption Data per 1,000 Square Feet

	Electricity (Btu/1000 SF)		**Water (Btu/1000 SF)**	
	Police and Special Operations Facility (LEED)	Police Station	Police and Special Operations Facility (LEED)	Police Station
Square Footage	25,000	24,909	25,000	24,909
October	8.63	11.07	710.78	219.50
November	6.02	7.34	119.29	259.41
December	5.70	6.03	4.97	209.52
January	3.78	4.36	89.47	309.30
February	5.83	5.67	109.35	234.47
March	5.76	5.30	89.47	184.58
April	6.11	4.68	218.70	334.24
May	6.86	6.62	109.35	448.98
June	6.91	5.66	114.32	294.33
July	4.91	6.07	397.64	254.42
August	8.53	7.94	417.52	344.22
September	7.34	8.66	218.70	249.43

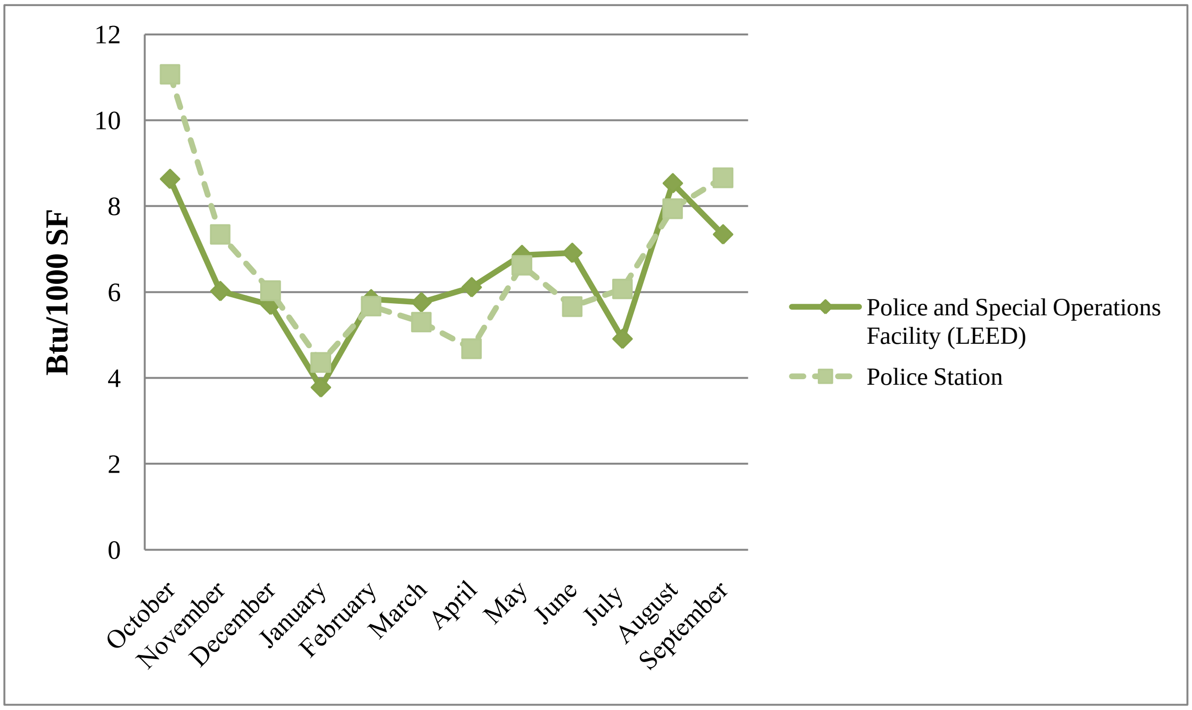

Figure 28 – Police Stations Monthly Electricity Consumption Data (Btu/1000 SF)

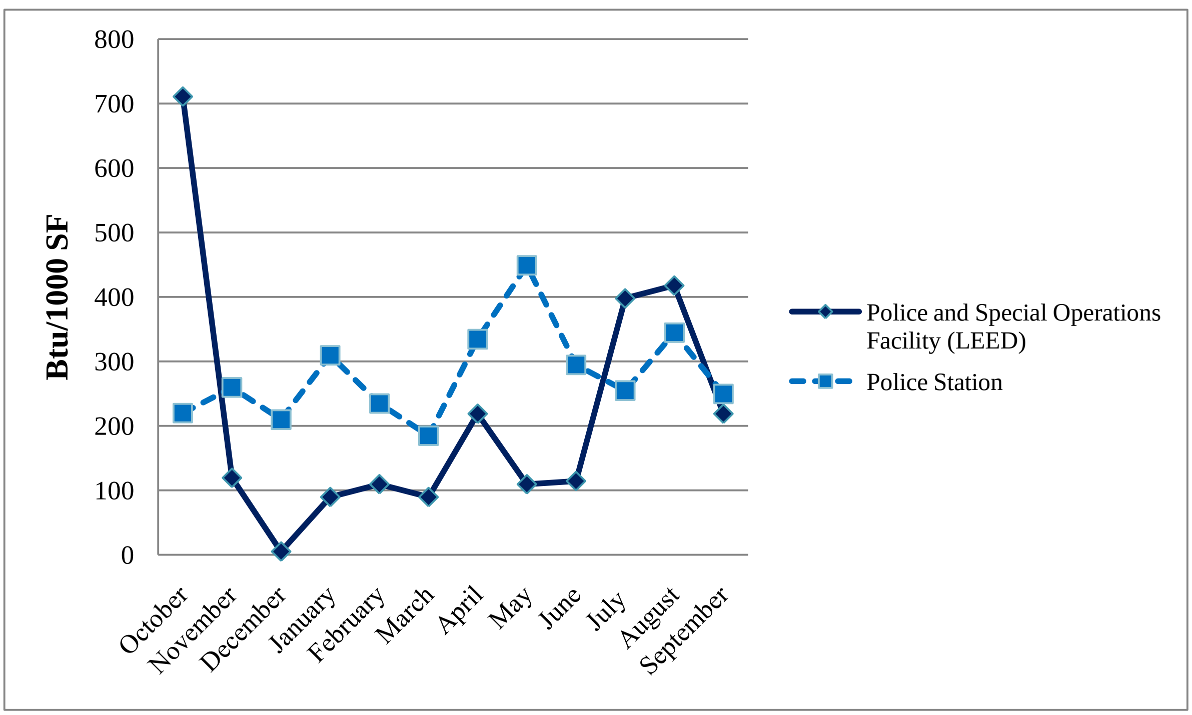

Figure 29 – Police Stations Monthly Water Consumption Data (Btu/1000 SF)

Figures 28 and 29 do not indicate a visible difference in the electricity and water consumption data over the year. To find if there are any savings associated with this data, a review of the electricity and water consumed as a percentage is reviewed against the expected 30% savings on a month-by-month basis. Figure 30 and 31 display the projected savings against the expected savings.

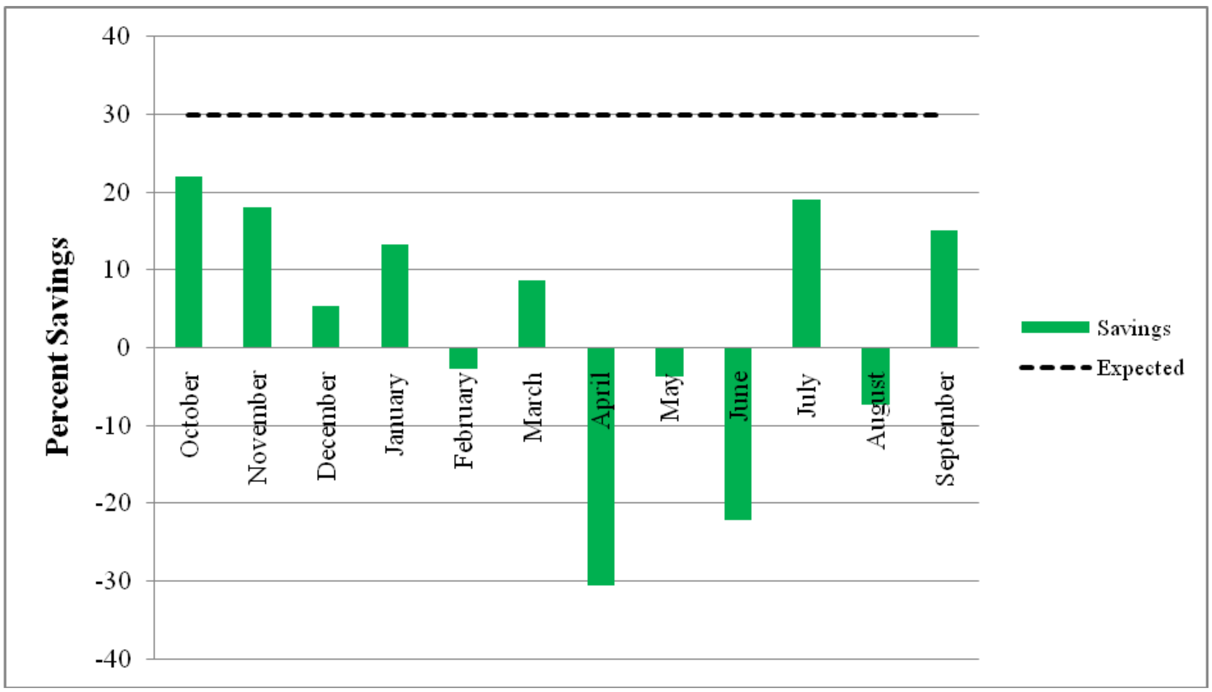

Figure 30 – Police Stations Electricity Consumption Percent Savings

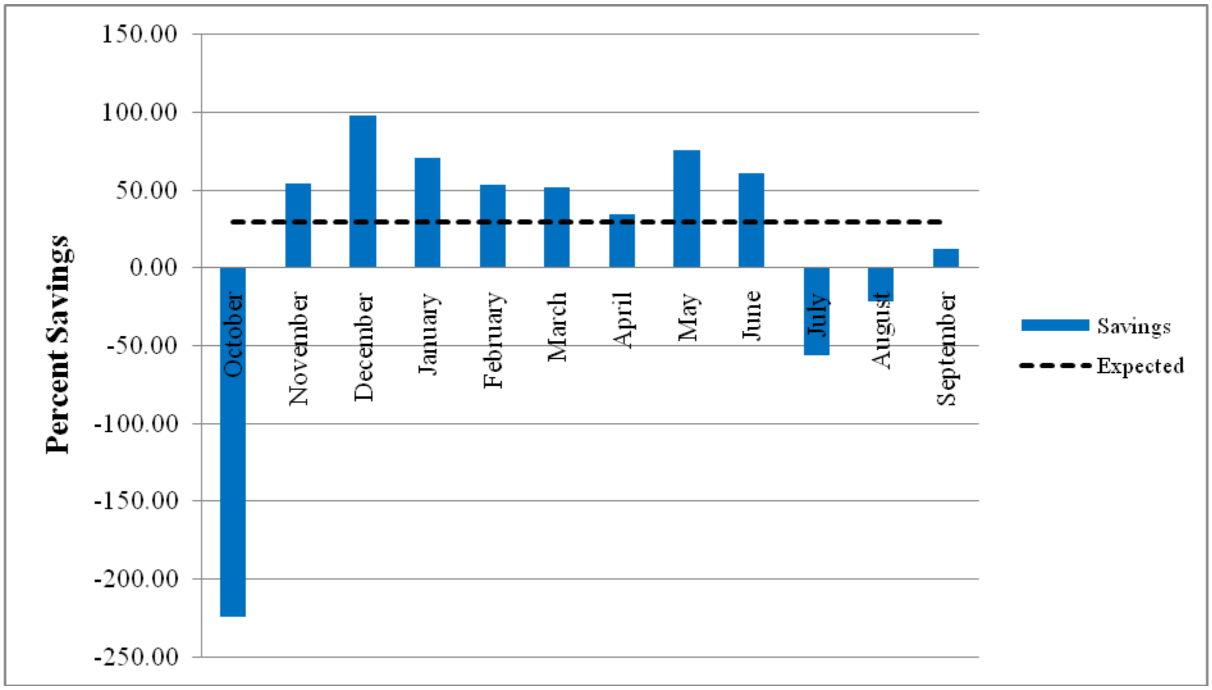

Figure 31 – Police Stations Water Consumption Percent Savings

Utilizing the same basis for the paired t-test analysis as the previous sections and to verify that the 30% savings can be achieved; 70% of the energy usage data for the Naval Station Norfolk Police Station is compared to the data gathered for the Police and Special Operations Facility using a paired t-test. The result of the paired t-test for electricity shows that the true difference is not equal to zero, and the null hypothesis is rejected for a savings of 30%, based on the data from the Naval Station Norfolk Police Station being greater than the data from the Police and Special Operations Facility at Naval Amphibious Base Little Creek when comparing them equally. The p-value associated with testing the differences between criteria weights is 1.388e-05, which is much smaller than 0.05. This extremely small p-value suggests that the criteria weights are different, and the null hypothesis is rejected at a 95% confidence level.

When the same paired t-test is run for the water consumption data the true difference in means is greater than zero, and the test passes for a 30% savings. The p-value associated with testing the differences between criteria weights is 0.3633, which is greater than 5% and falls within the accepted confidence level for this test.

The Police and Special Operations Facility is in the Midatlantic region as it was constructed at Naval Amphibious Base Little Creek in Virginia. The average KWH usage per square-foot (KWH/SF) for the Police and Special Operations Facility equates to 22.4 KWH/SF. In comparison, the 2003 CBECS data shows that Non-Mall Buildings with a building floor-space between 25,001 and 50,000 SF have a median electricity usage of 8.8 KWH/SF. When these two numbers are compared directly, we find that the Airborne Mine Countermeasures Facility used 154.55% more electricity than the national average from the 2003 CBECS.

5.7 – Marine Bachelor Enlisted Quarters vs. Marine Bachelor Enlisted Quarters

At Marine Corps Base Camp Lejeune, two Bachelor Enlisted Quarters for Marines will be compared, buildings FC 507 and FC 504. FC 507 received the LEED Certified certification from the USGBC in July 2008. These two buildings are comparable in usage, size, and architectural design, with the major difference being the LEED Certified certification for FC 507. Unfortunately, no water data was available for these two buildings due to a lack of metering for either building. Table 17 below presents the electricity consumption monthly data received for the two buildings from the Public Works Department with no information available for January, and Table 18 presents the same data per 1,000 SF, which ensures that all data is compared equally for buildings with different square footages. Figure 32 provides a graphical representation of the monthly data.

Table 17 – Marine BEQs FY 2009 Monthly Energy Consumption Data

	Electricity (Btu)		Water (Btu)	
	Marine BEQ (FC507) (LEED)	Marine BEQ (FC504)	Marine BEQ (FC507) (LEED)	Marine BEQ (FC504)
October	238.84	206.08	No water data provided for this building.	No water data provided for this building.
November	171.96	143.30		
December	221.10	148.76		
January	0	0		
February	139.21	139.21		
March	155.59	169.24		
April	192.44	178.79		
May	199.26	191.07		
June	200.63	191.07		
July	218.37	199.26		
August	221.10	211.54		
September	222.46	210.18		
Totals	2180.95	1988.51		

Table 18 – Marine BEQs FY 2009 Monthly Energy Consumption Data per 1,000 Square Feet

	Electricity (Btu/1000 SF)		Water (Btu/1000 SF)	
	Marine BEQ (FC507) (LEED)	Marine BEQ (FC504)	Marine BEQ (FC507) (LEED)	Marine BEQ (FC504)
Square Footage	90,948	90,948	90,948	90,948
October	2.63	2.27	No water data provided for this building.	No water data provided for this building.
November	1.89	1.58		
December	2.43	1.64		
January	0	0		
February	1.53	1.53		
March	1.71	1.86		
April	2.12	1.97		
May	2.19	2.10		
June	2.21	2.10		
July	2.40	2.19		
August	2.43	2.33		
September	2.45	2.31		

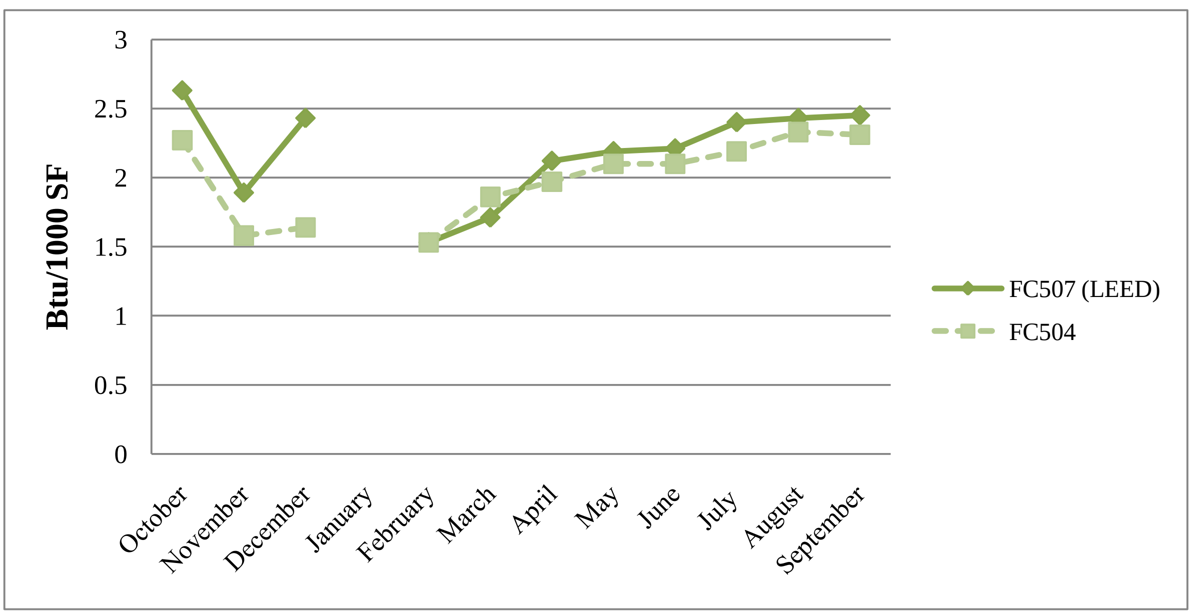

Figure 32 – Marine BEQs Monthly Electricity Consumption Data (Btu/1000 SF)

Figure 32 does not indicate a visible difference in the electricity consumption data over the year. To find if there is any savings associated with this data, a review of the electricity consumed as a percentage is reviewed against the expected 30% savings on a month-by-month basis. Figure 33 display the projected savings against the expected savings.

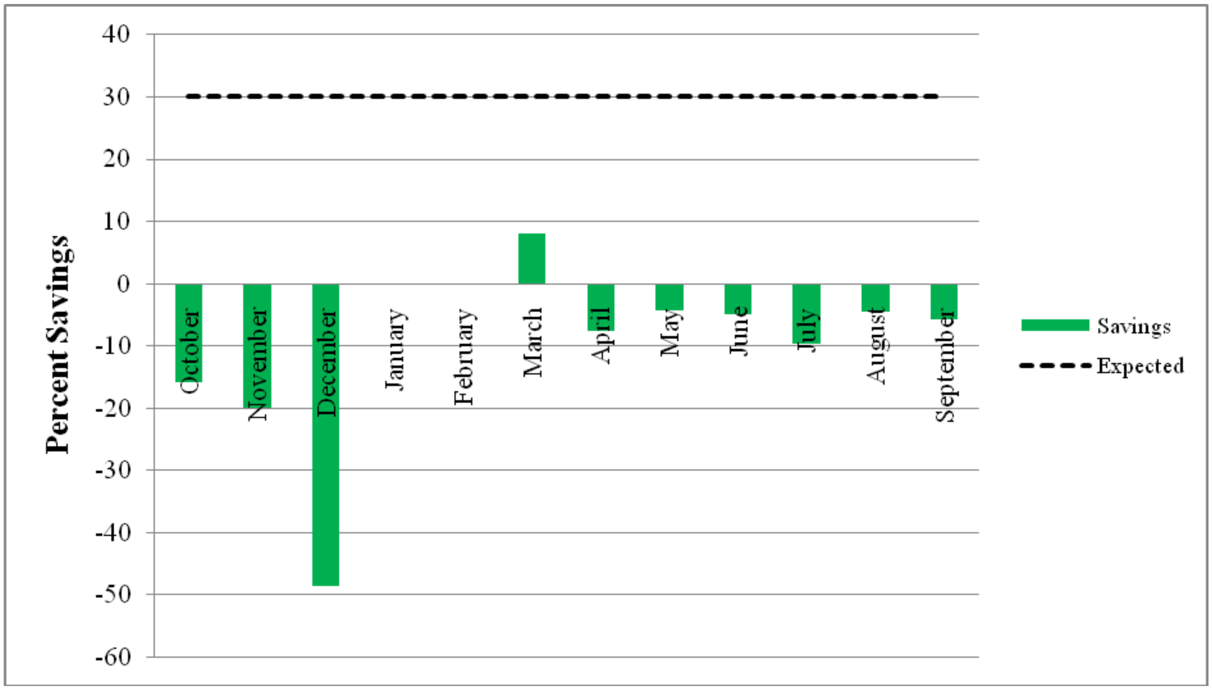

Figure 33 – Marine BEQs Electricity Consumption Percent Savings

Utilizing the same basis for the paired t-test analysis as the previous section and verify that the 30% savings can be achieved; 70% of the energy usage data for FC 504 is compared to the data gathered for FC 507 using a paired t-test. The result of the paired t-test for electricity shows that the true difference is not equal to zero, and the null hypothesis is rejected for a savings of 30%, based on the data from FC 507 being greater than the data from FC 504 when comparing them equally. The p-value associated with testing the differences between criteria weights is 4.472e-06, which is much smaller than 0.05. This extremely small p-value suggests that the criteria weights are different, and the null hypothesis is rejected at a 95% confidence level.

FC 507 falls in the Midatlantic region as it was constructed at Marine Corps Base Camp Lejeune in Jacksonville, North Carolina. The average KWH usage per square-foot (KWH/SF) for the Marine Bachelor Enlisted Quarters equates to 7.0 KWH/SF. In comparison, the 2003 CBECS data shows that Non-Mall Buildings with a building floor-space between 50,001 and 100,000 SF have a median electricity usage of 9.9 KWH/SF. When these two numbers are compared directly, we find that FC 507 used 29.29% less electricity than the national average from the 2003 CBECS.

5.8 – Memorial Golf Course Clubhouse vs. NBVC Golf Course Clubhouse

In California, at Marine Corps Air Station Miramar, the Memorial Golf Course Clubhouse, which received the LEED Gold certification from the USGBC, is being compared to the Naval Base Ventura County (NBVC) Golf Course Clubhouse. These two buildings are comparable in usage, size, and architectural design, with the major difference being that the bases are separated by 171 miles. Table 19 below presents the electricity and water consumption monthly data received for the two buildings from the Public Works Department, and Table 20 presents the same data per 1,000 SF, which ensures that all data is compared equally for buildings with different square footages. As the project was completed and turned over to the Marine Course Air Station in February, all data will be compared from March through September 2009. Figure 34 and 35 provides a graphical representation of the monthly data.

Table 19 – Golf Course Clubhouses FY 2009 Monthly Energy Consumption Data

	Electricity (Btu)		Water (Btu)	
	Memorial Golf Course Clubhouse (LEED)	NBVC Golf Course Clubhouse	Memorial Golf Course Clubhouse (LEED)	NBVC Golf Course Clubhouse
October	0	40.94	0	1789.37
November	0	50.84	0	2075.17
December	0	39.24	0	1217.77
January	0	47.43	0	1478.72
February	0	39.24	0	1491.14
March	29.00	38.21	186.39	1491.14
April	102.70	37.87	2336.12	1627.83
May	159.34	41.97	7182.34	1926.06
June	144.67	44.70	7194.76	1640.26
July	201.99	37.19	5902.44	1776.95
August	165.48	39.24	5629.06	1727.24
September	215.30	46.74	8114.30	2025.47
Totals	1018.48	503.61	36545.42	20267.12

Table 20 – Golf Course Clubhouses FY 2009 Monthly Energy Consumption Data per 1,000 Square Feet

	Electricity (Btu/1000 SF)		Water (Btu/1000 SF)	
	Memorial Golf Course Clubhouse (LEED)	NBVC Golf Course Clubhouse	Memorial Golf Course Clubhouse (LEED)	NBVC Golf Course Clubhouse
Square Footage	13,437	11,760	13,437	11,760
October	0	3.48	0	152.16
November	0	4.32	0	176.46
December	0	3.34	0	103.55
January	0	4.03	0	125.74
February	0	3.34	0	126.80
March	2.16	3.25	13.87	126.80
April	7.64	3.22	173.86	138.42
May	11.86	3.57	534.52	163.78
June	10.77	3.80	535.44	139.48
July	15.03	3.16	439.27	151.10
August	12.32	3.34	418.92	146.87
September	16.02	3.97	603.88	172.23

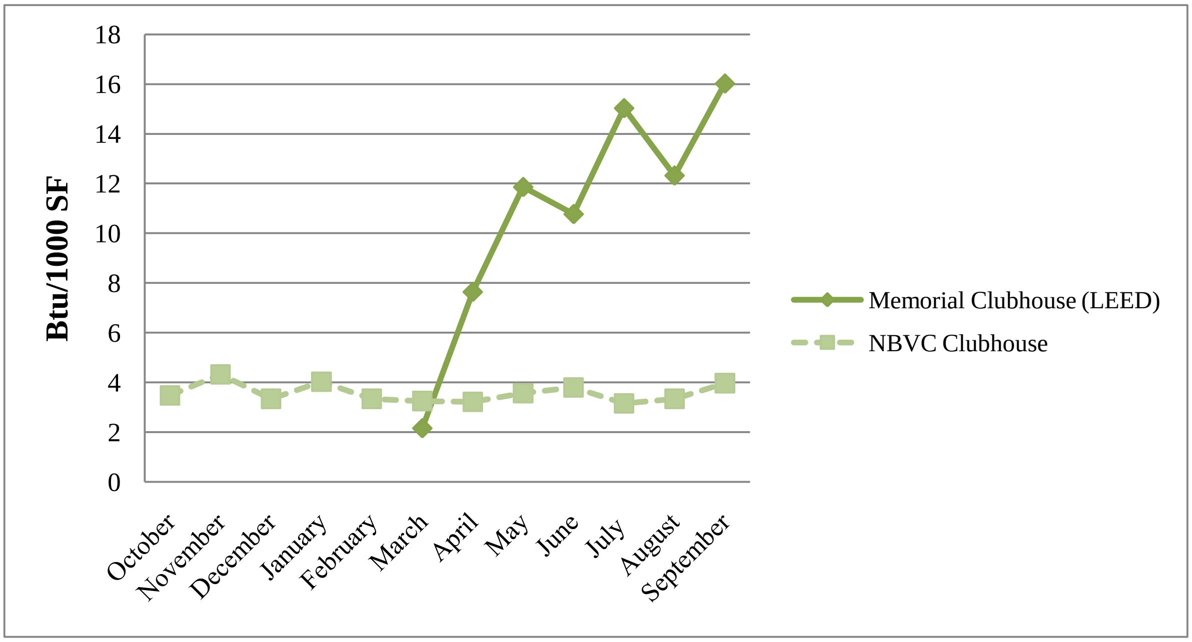

Figure 34 – Golf Course Clubhouses Monthly Electricity Consumption Data (Btu/1000 SF)

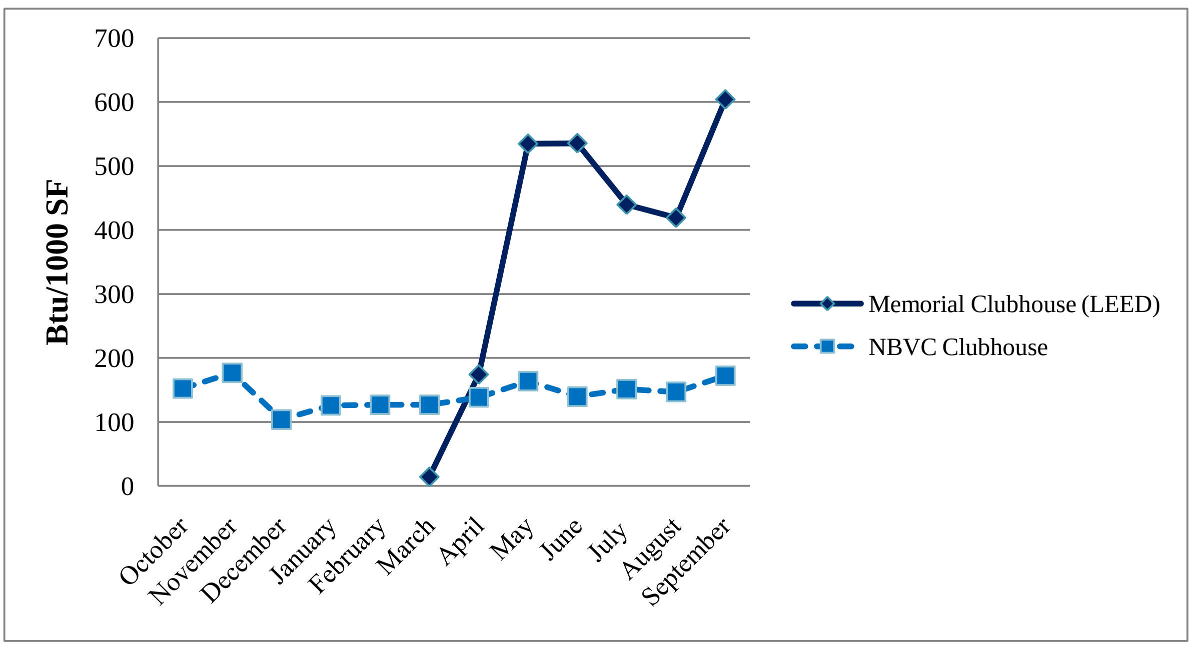

Figure 35 – Golf Course Clubhouses Monthly Water Consumption Data (Btu/1000 SF)

Figures 34 and 35 indicate a visible difference in the electricity and water consumption data from March to September 2009. To find if there is any savings associated with this data, a review of the electricity and water consumed as a percentage is reviewed against the expected 30% savings on a month-by-month basis. Figure 36 and 37 display the projected savings against the expected savings.

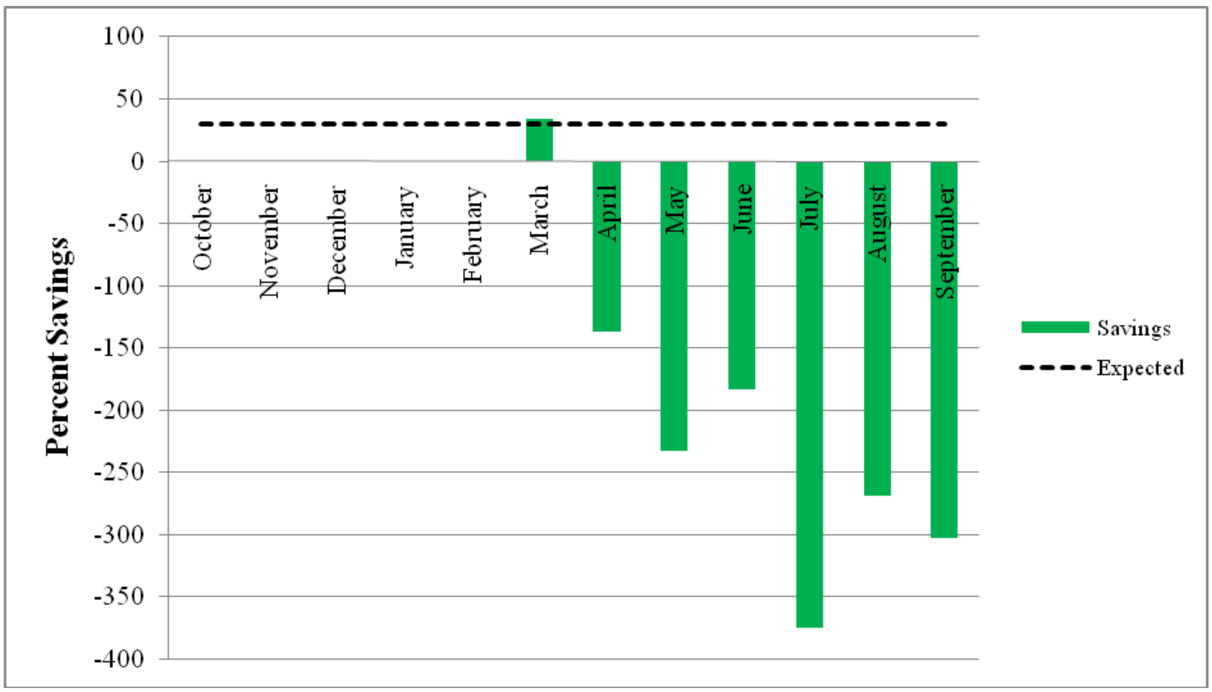

Figure 36 – Golf Course Clubhouses Electricity Consumption Percent Savings

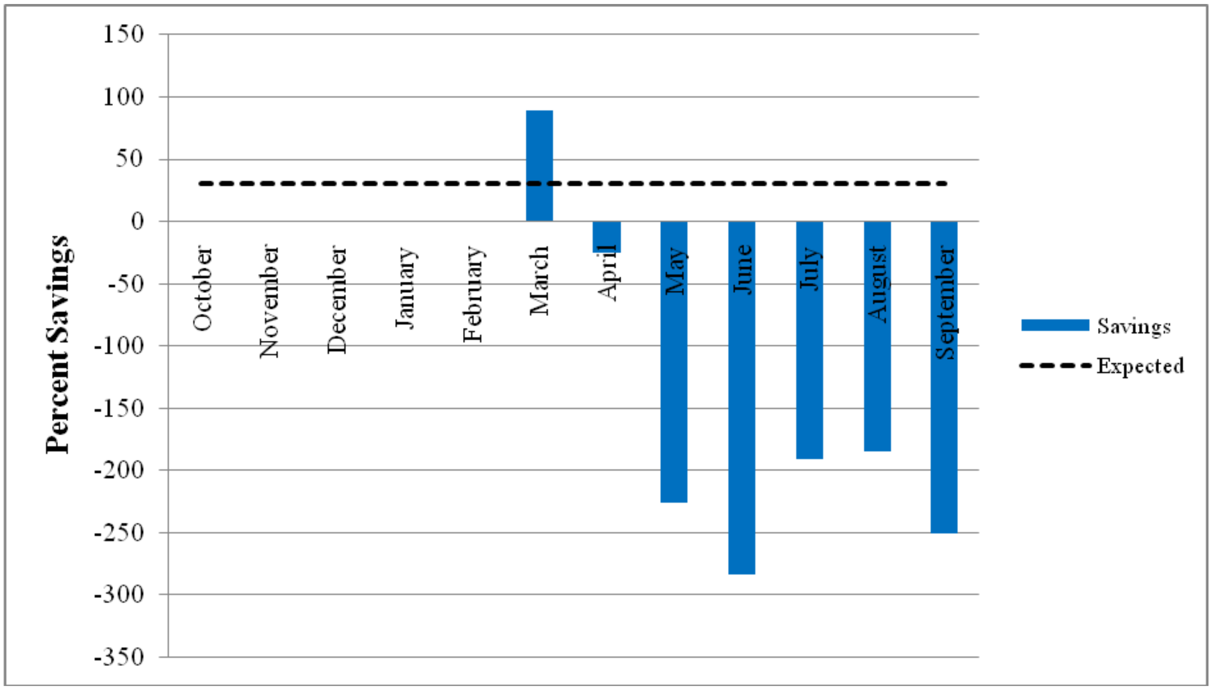

Figure 37 – Golf Course Clubhouses Water Consumption Percent Savings

Though the no energy savings is displayed above in Figure 36 and Figure 37, a paired t-test analysis was performed to verify that the 30% savings can be achieved; 70% of the energy usage data for the NBVC Golf Course Clubhouse is compared to the data gathered for the Memorial Golf Course Clubhouse using a paired t-test. The result of the paired t-test for electricity shows that the true difference is not equal to zero, and the null hypothesis is rejected for a savings of 30%, based on the data from the Memorial Golf Course Clubhouse being greater than the data from the NBVC Golf Course Clubhouse when comparing them equally. The p-value associated with testing the differences between criteria weights is 0.001482, which is smaller than 0.05. This small p-value suggests that the criteria weights are different, and the null hypothesis is rejected at a 95% confidence level.

When the same paired t-test is run for the water consumption data the true difference in means is not equal to zero, and the null hypothesis is rejected for a savings of 30%, based on the data from the Memorial Golf Course Clubhouse being greater than the data from the NBVC Golf Course Clubhouse when comparing them equally. The p-value associated with testing the differences between criteria weights is 0.005422, which is smaller than 0.05. This small p-value suggests that the criteria weights are different, and the null hypothesis is rejected at a 95% confidence level.

The Memorial Golf Course Clubhouse falls in the Southwestern region as it was constructed at Marine Corps Air Station Miramar in California. The average KWH usage per square-foot (KWH/SF) for the Memorial Golf Course Clubhouse equates to 22.2 KWH/SF. In comparison, the 2003 CBECS data shows that Non-Mall Buildings with a building floor-space between 10,001 and 25,000 SF have a median electricity usage of 6.3 KWH/SF. When these two numbers are compared directly, we find that the Memorial Golf Course Clubhouse used 252.38% more electricity than the national average from the 2003 CBECS.

5.9 – Naval Facilities Engineering Service Command vs. NAVSEA Lab

Also in California, this time at Naval Base Ventura County in Port Hueneme, California, the Naval Facilities Engineering Service Command (NFESC) building, which received the LEED for Existing Buildings (EB) certification from the USGBC, is being compared to a Naval Sea Systems Command (NAVSEA) Lab also in Port Hueneme, California. These two buildings are comparable in usage with laboratory and office space, with the differences being that the NFESC building is 71% larger and have different architectural designs. Table 21 below presents the electricity and water consumption monthly data received for the two buildings from the Public Works Department, and Table 22 presents the same data per 1,000 SF, which ensures that all data is compared equally for buildings with different square footages. Figure 38 and 39 provides a graphical representation of the monthly data.

Table 21 – NFESC/NAVSEA FY 2009 Monthly Energy Consumption Data

	Electricity (Btu)		Water (Btu)	
	NFESC (LEED)	NAVSEA Lab	NFESC (LEED)	NAVSEA Lab
October	346.32	357.24	4249.76	6250.37
November	397.50	414.22	4734.38	6797.13
December	318.68	321.75	4212.48	4920.77
January	373.96	391.02	3442.05	5740.90
February	311.86	345.29	4386.45	5902.44
March	332.67	328.58	3988.81	6126.11
April	332.67	320.39	3976.38	6498.90
May	433.32	395.45	4995.33	8487.09
June	313.90	565.37	3690.58	5728.47
July	351.44	554.79	5442.67	5914.87
August	354.85	621.33	4411.30	7107.78
September	529.20	648.96	6237.95	5566.93
Totals	4396.36	5264.37	53768.12	75041.76

Table 22 – NFESC/NAVSEA FY 2009 Monthly Energy Consumption Data per 1,000 Square Feet

	Electricity (Btu/1000 SF)		**Water (Btu/1000 SF)**	
	NFESC (LEED)	NAVSEA Lab	NFESC (LEED)	NAVSEA Lab
Square Footage	192,028	112,184	192,028	112,184
October	1.80	3.18	22.13	55.72
November	2.07	3.69	24.65	60.59
December	1.66	2.87	21.94	43.86
January	1.95	3.49	17.92	51.17
February	1.62	3.08	22.84	52.61
March	1.73	2.93	20.77	54.61
April	1.73	2.86	20.71	57.93
May	2.26	3.53	26.01	75.65
June	1.63	5.04	19.22	51.06
July	1.83	4.95	28.34	52.72
August	1.85	5.54	22.97	63.36
September	2.76	5.78	32.48	49.62

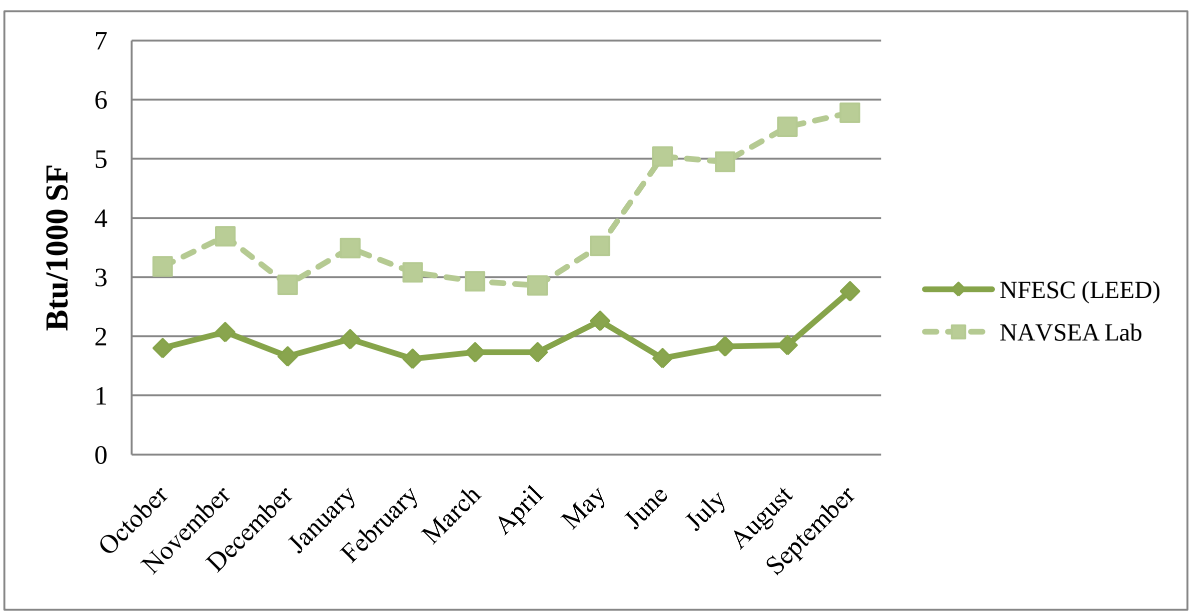

Figure 38 – NFESC/NAVSEA Monthly Electricity Consumption Data (Btu/1000 SF)

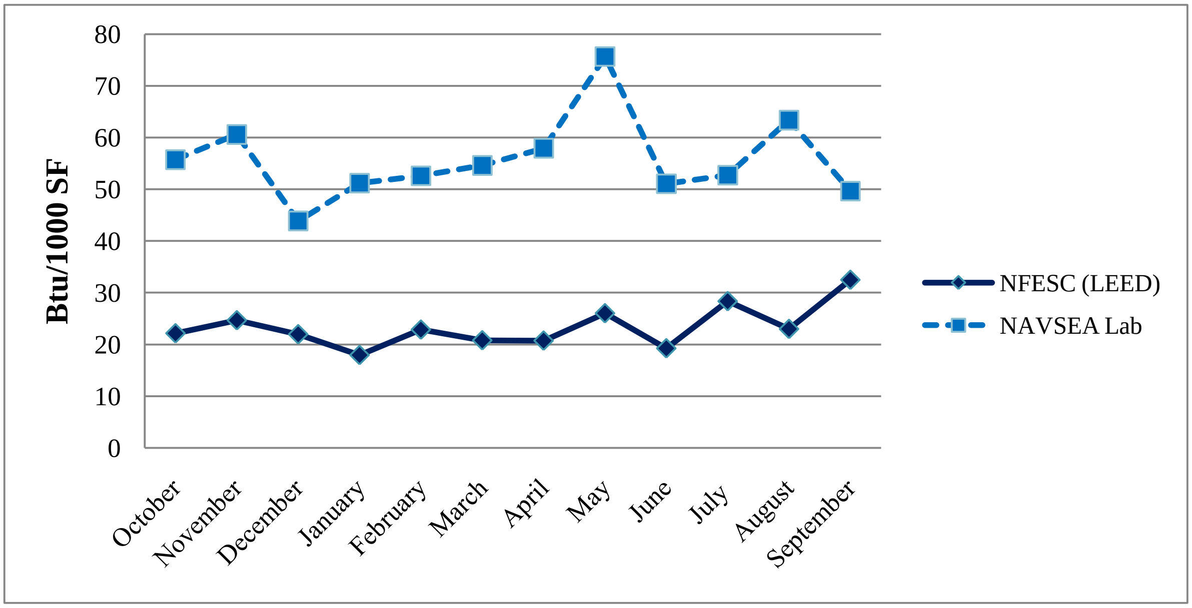

Figure 39 – NFESC/NAVSEA Monthly Water Consumption Data (Btu/1000 SF)

Figures 38 and 39 indicate a visible difference in the electricity and water consumption data over the year. To find if there is any savings associated with this data, a review of the electricity and water consumed as a percentage is reviewed against the expected 30% savings on a month-by-month basis. Figure 40 and 41 display the projected savings against the expected savings.

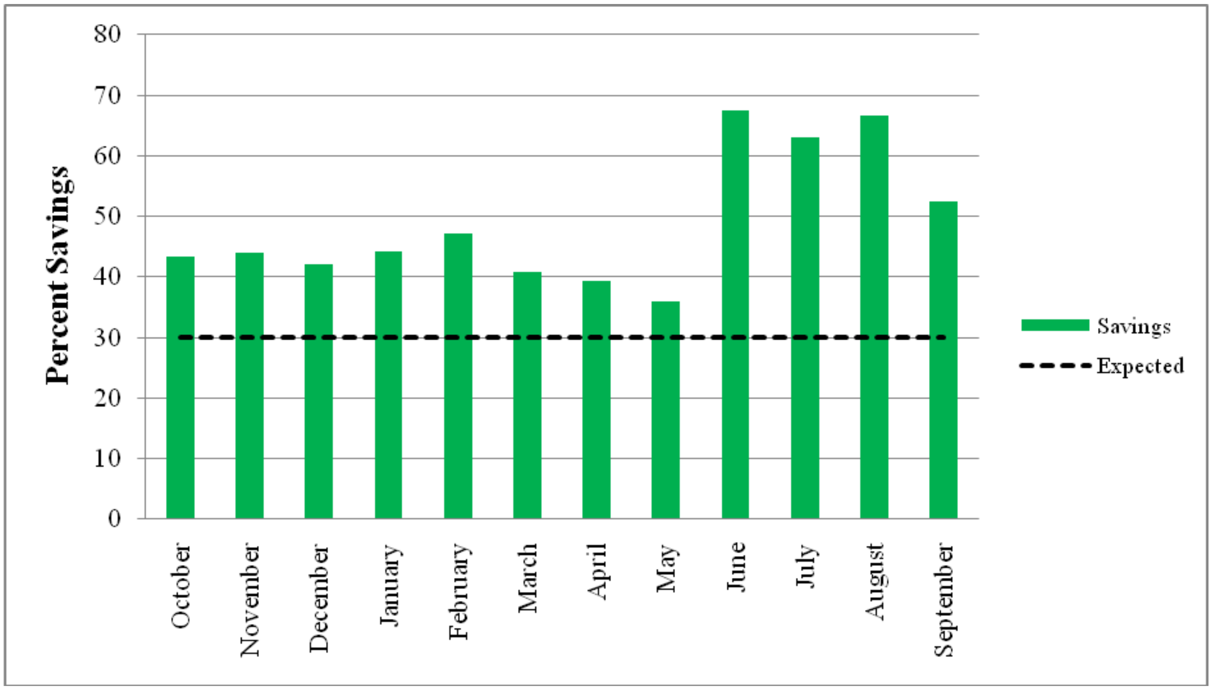

Figure 40 – NFESC/NAVSEA Electricity Consumption Percent Savings

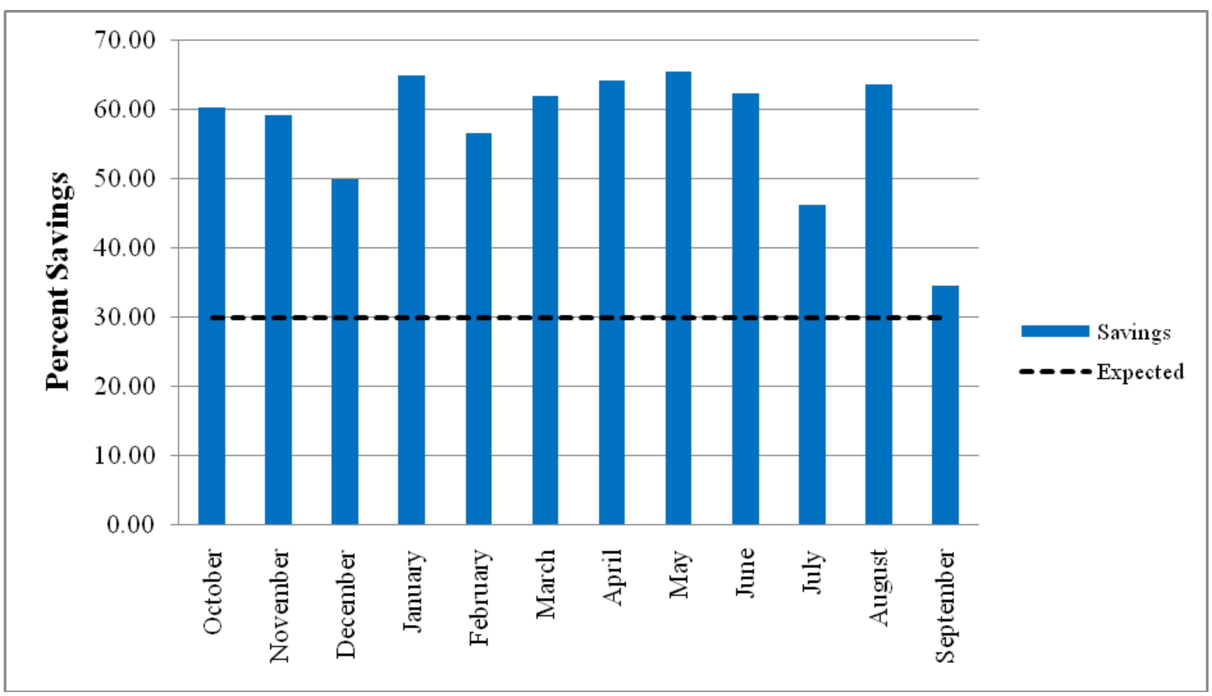

Figure 41 – NFESC/NAVSEA Water Consumption Percent Savings

As both the electricity and water data show a visible savings in Figure 40 and 41, a paired t-test analysis is performed with the same basis as the previous section to verify that the 30% savings can be achieved; 70% of the energy usage data for the NAVSEA Lab is compared to the data gathered for the NFESC building using a paired t-test. The result of the paired t-test for electricity shows that the true difference is greater than zero, and the test passes for a 30% savings, based on the data from the NAVSEA Lab being greater than the data from the NFESC building when comparing them equally. The p-value associated with testing the differences between criteria weights is 0.9993, which is greater than 5% and falls within the accepted confidence level for this test.

When the same paired t-test is run for the water consumption data the true difference in means is greater than zero, and the test passes for a 30% savings. The p-value associated with testing the differences between criteria weights is 1.00, which is greater than 5% and falls within the accepted confidence level for this test.

The NFESC building falls in the Southwestern region as it was constructed at Naval Base Ventura County in California. The average KWH usage per square-foot (KWH/SF) for the NFESC building equates to 6.7 KWH/SF. In comparison, the 2003 CBECS data shows that Non-Mall Buildings with a building floor-space between 100,001 and 200,000 SF have a median electricity usage of 13.0 KWH/SF. When these two numbers are compared directly, we find that the NFESC building used 48.46% less electricity than the national average from the 2003 CBECS.

5.10 – NBVC Public Works Department vs. Point Magu Public Works Department

Also in California, at Naval Base Ventura County in Port Hueneme, California, the Public Works Department (PWD) building, which received the LEED Gold certification in March 2005 from the USGBC, is being compared to the PWD building at Point Magu also in Port Hueneme, California. These two buildings are comparable in usage, with the differences being that the NBVC PWD building is 32% larger and they have different architectural designs. Table 23 below presents the electricity and water consumption monthly data received for the two buildings from the Public Works Department, and Table 24 presents the same data per 1,000 SF, which ensures that all data is compared equally for buildings with different square footages. Figure 42 and 43 provides a graphical representation of the monthly data.

Table 23 – PWDs FY 2009 Monthly Energy Consumption Data

	Electricity (Btu)		Water (Btu)	
	NBVC PWD (LEED)	Point Magu PWD	NBVC PWD (LEED)	Point Magu PWD
October	38.90	34.80	7219.62	11071.74
November	45.38	37.53	7778.79	12898.39
December	41.97	35.14	7319.03	11345.11
January	56.98	50.16	6001.85	11357.54
February	46.40	38.21	6474.04	10897.77
March	40.94	40.60	8748.04	10351.02
April	36.85	40.94	7194.76	12463.47
May	43.33	42.31	6834.40	16265.88
June	33.44	27.98	6933.81	13296.02
July	32.07	27.98	6076.41	13320.88
August	31.73	31.05	6672.86	12488.32
September	46.40	33.78	7232.04	13519.69
Totals	494.40	440.49	84485.67	149275.82

Table 24 – PWDs FY 2009 Monthly Energy Consumption Data per 1,000 Square Feet

	Electricity (Btu/1000 SF)		Water (Btu/1000 SF)	
	NBVC PWD (LEED)	Point Magu PWD	NBVC PWD (LEED)	Point Magu PWD
Square Footage	16,443	12,435	16,443	12,435
October	2.37	2.80	439.07	890.37
November	2.76	3.02	473.08	1037.26
December	2.55	2.83	445.11	912.35
January	3.47	4.03	365.01	913.35
February	2.82	3.07	393.73	876.38
March	2.49	3.27	532.02	832.41
April	2.24	3.29	437.56	1002.29
May	2.64	3.40	415.64	1308.07
June	2.03	2.25	421.69	1069.24
July	1.95	2.25	369.54	1071.24
August	1.93	2.50	405.82	1004.29
September	2.82	2.72	439.83	1087.23

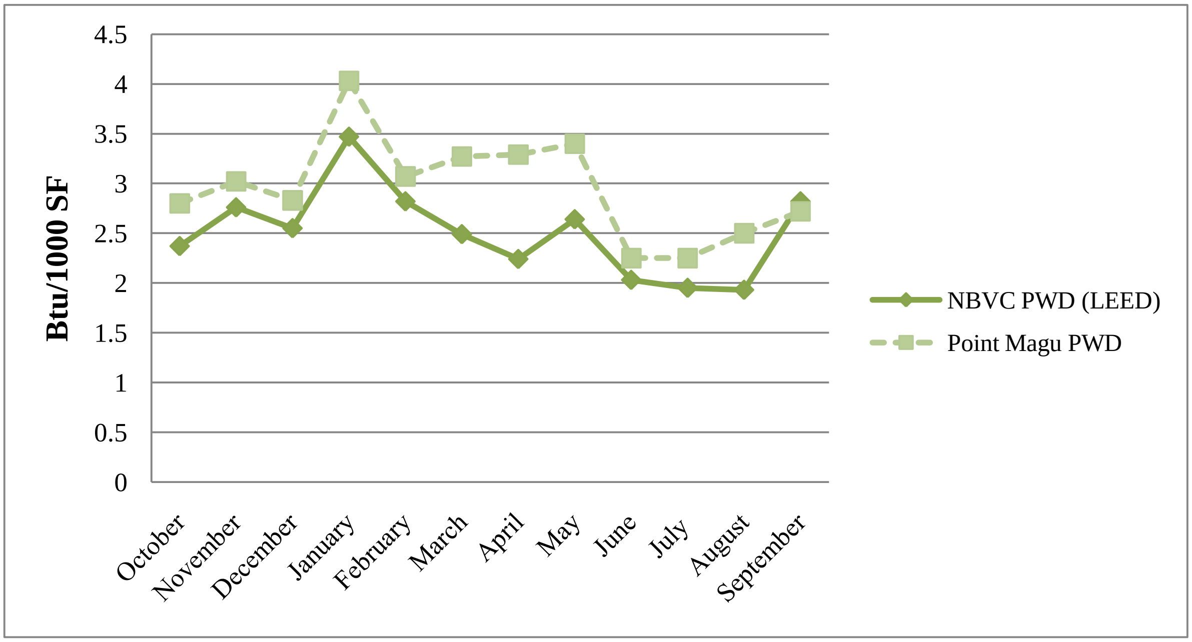

Figure 42 – PWDs Monthly Electricity Consumption Data (Btu/1000 SF)

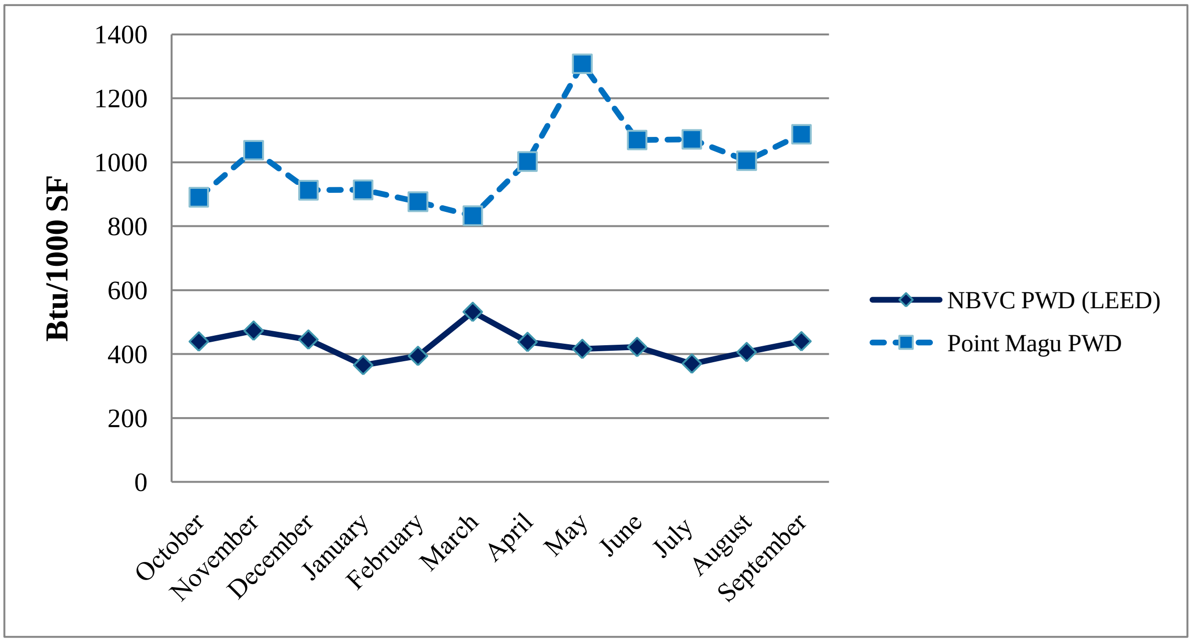

Figure 43 – PWDs Monthly Water Consumption Data (Btu/1000 SF)

Figures 42 and 43 indicate a visible difference in the electricity and water consumption data over the year. To find if there are any savings associated with this data, a review of the electricity and water consumed as a percentage is reviewed against the expected 30% savings on a month-by-month basis. Figure 44 and 45 display the projected savings against the expected savings.

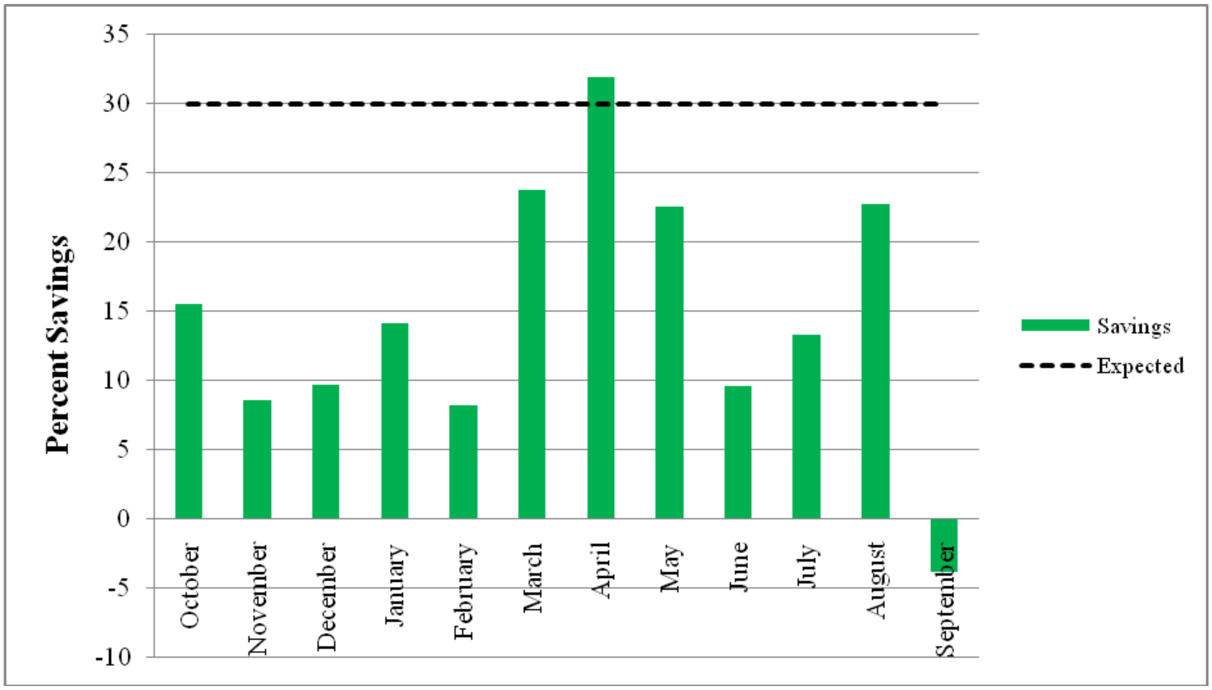

Figure 44 – PWDs Electricity Consumption Percent Savings

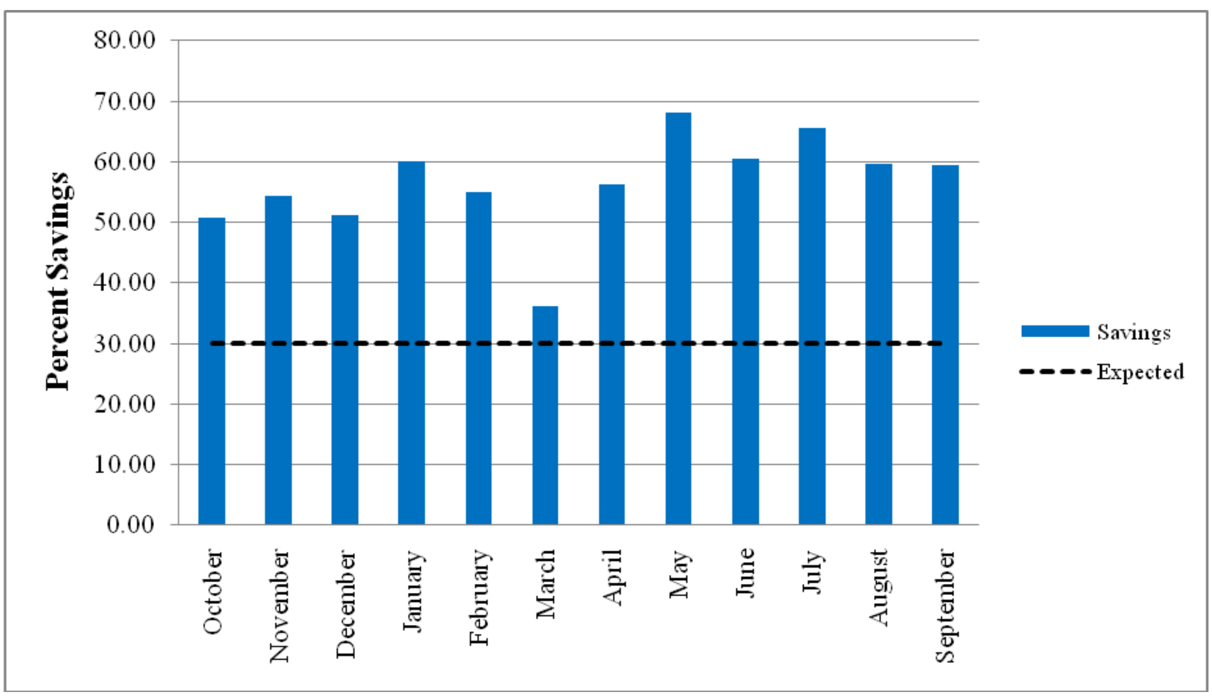

Figure 45 – PWDs Water Consumption Percent Savings

Utilizing the same basis for the paired t-test analysis as the previous section to verify that the 30% savings can be achieved; 70% of the energy usage data for the Point Magu PWD building is compared to the data gathered for the NBVC PWD building using a paired t-test. The result of the paired t-test for electricity shows that the true difference is not equal to zero, and the null hypothesis is rejected for a savings of 30%, based on the data from the Point Magu PWD building being greater than the data from the NBVC PWD building when comparing them equally. The p-value associated with testing the differences between criteria weights is 7.337e-05, which is much smaller than 0.05. This extremely small p-value suggests that the criteria weights are different, and the null hypothesis is rejected at a 95% confidence level.

When the same paired t-test is run for the water consumption data the true difference in means is greater than zero, and the test passes for a 30% savings. The p-value associated with testing the differences between criteria weights is 1.00, which is greater than 5% and falls within the accepted confidence level for this test.

The NBVC PWD building falls in the Southwestern region as it was constructed at Naval Base Ventura County in California. The average KWH usage per square-foot (KWH/SF) for the NBVC PWD building equates to 8.8 KWH/SF. In comparison, the 2003 CBECS data shows that Non-Mall Buildings with a building floor-space between 10,001 and 25,000 SF have a median electricity usage of 6.3 KWH/SF. When these two numbers are compared directly, we find that the NBVC PWD building used 39.68% more electricity than the national average from the 2003 CBECS.

5.11 – Child Development Center Oceana vs. Child Development Center Norfolk

At Naval Air Station (NAS) Oceana in Virginia Beach, Virginia, the Child Development Center (CDC) building, which received the LEED Silver certification from the USGBC, is being compared to the CDC building at Naval Station Norfolk in Norfolk, Virginia. These two buildings are comparable in usage, with the differences being that the NAS Oceana CDC is 35% larger and they have different architectural designs. Table 25 below presents the electricity and water consumption monthly data received for the two buildings from the Public Works Department. However, the data received for the NAS Oceana CDC was received as a yearly total, vice monthly consumption. To make the comparison, the same percentage per month for the consumption in the Naval Station Norfolk CDC was used to distribute the NAS Oceana CDC over the fiscal year. Table 26 presents the same data per 1,000 SF, which ensures that all data is compared equally for buildings with different square footages. Figure 46 and 47 provides a graphical representation of the monthly data.

Table 25 – CDCs FY 2009 Monthly Energy Consumption Data

	Electricity (Btu)		Water (Btu)	
	CDC Oceana (LEED)	CDC Norfolk	CDC Oceana (LEED)	CDC Norfolk
October	194.56	157.63	7558.54	14165.86
November	154.13	124.88	6696.60	12550.45
December	150.76	122.15	7028.11	13171.76
January	78.33	63.46	6829.20	12798.98
February	128.02	103.72	6895.51	12923.24
March	115.39	93.49	6431.39	12053.40
April	112.02	90.76	7293.32	13668.81
May	123.81	100.31	9216.11	17272.40
June	116.23	94.17	6829.20	12798.98
July	130.55	105.77	7359.63	13793.07
August	202.14	163.78	21216.94	39763.81
September	165.92	134.43	7558.54	14165.86
Totals	1671.85	1354.56	100913.09	189126.61

Table 26 – CDCs FY 2009 Monthly Energy Consumption Data per 1,000 Square Feet

	Electricity (Btu/1000 SF)		Water (Btu/1000 SF)	
	CDC Oceana (LEED)	CDC Norfolk	CDC Oceana (LEED)	CDC Norfolk
Square Footage	29,000	21,420	29,000	21,420
October	6.71	7.36	260.64	661.34
November	5.31	5.83	230.92	585.92
December	5.20	5.70	242.35	614.93
January	2.70	2.96	235.49	597.52
February	4.41	4.84	237.78	603.33
March	3.98	4.36	221.77	562.72
April	3.86	4.24	251.49	638.13
May	4.27	4.68	317.80	806.37
June	4.01	4.40	235.49	597.52
July	4.50	4.94	253.78	643.93
August	6.97	7.65	731.62	1856.39
September	5.72	6.28	260.64	661.34

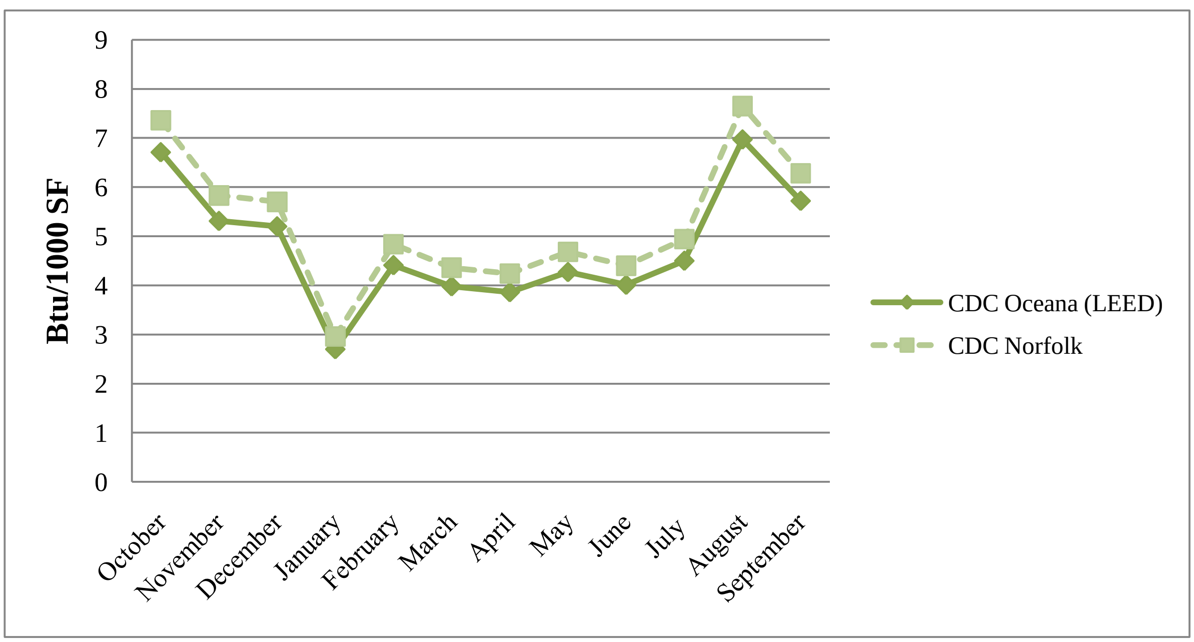

Figure 46 – CDCs Monthly Electricity Consumption Data (Btu/1000 SF)

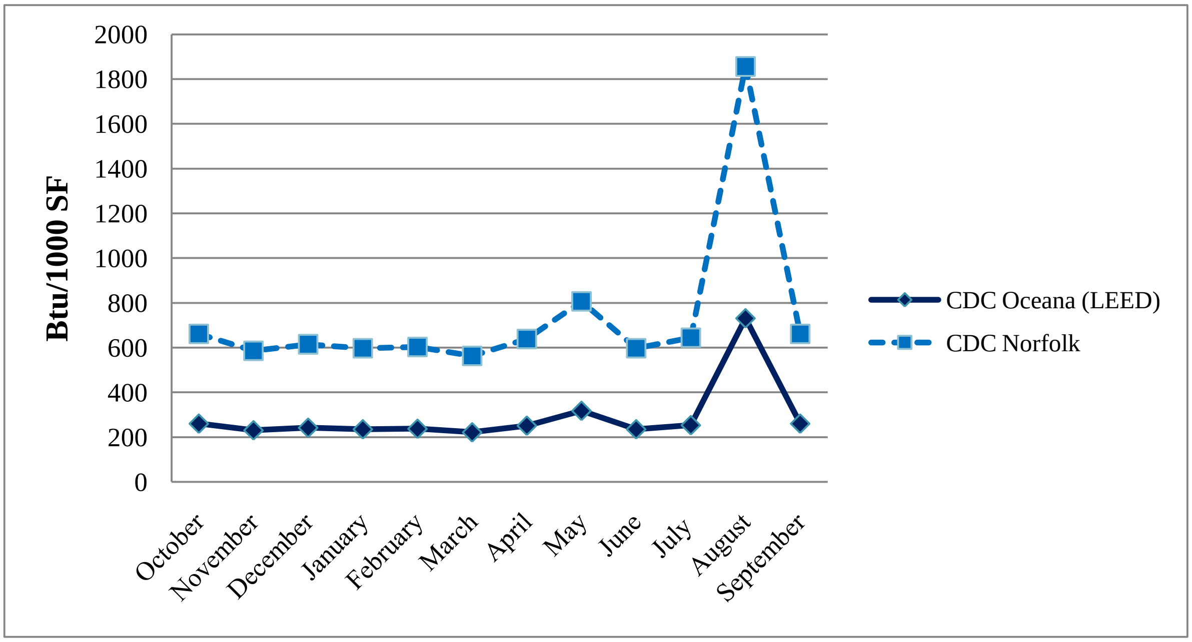

Figure 47 – CDCs Monthly Water Consumption Data (Btu/1000 SF)

Figures 46 and 47 indicate a visible difference in the electricity and water consumption data over the year. To find if there are any savings associated with this data, a review of the electricity and water consumed as a percentage is reviewed against the expected 30% savings on a month-by-month basis. Figure 48 and 49 display the projected savings against the expected savings.

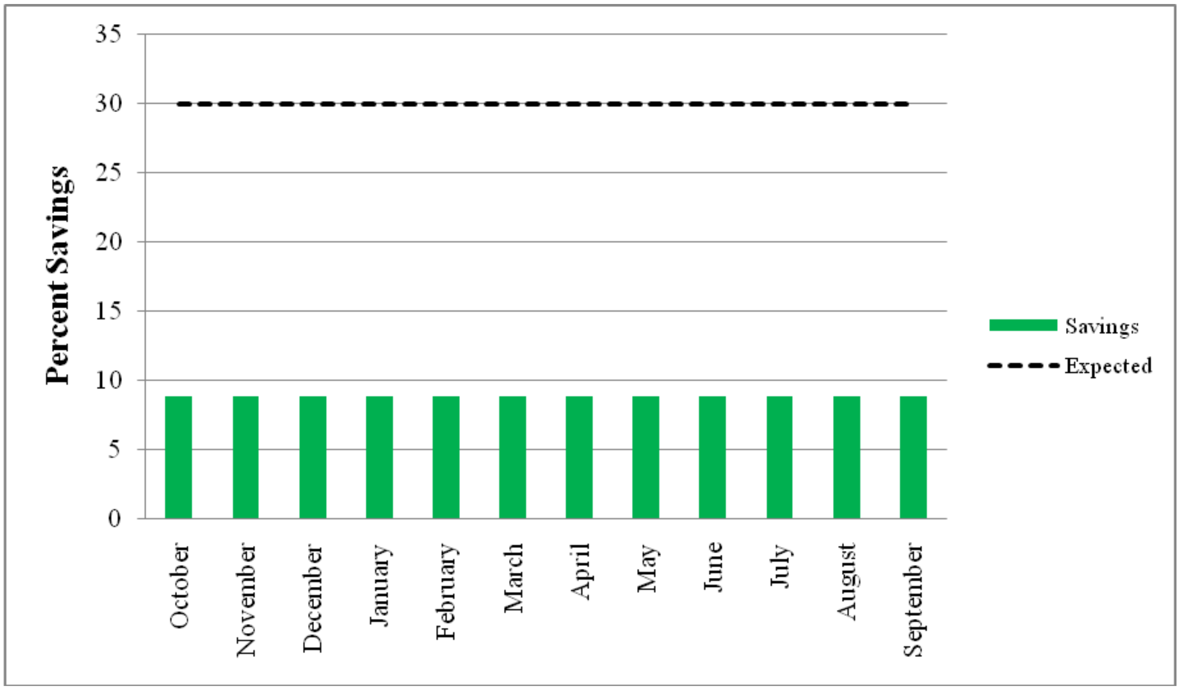

Figure 48 – CDCs Electricity Consumption Percent Savings

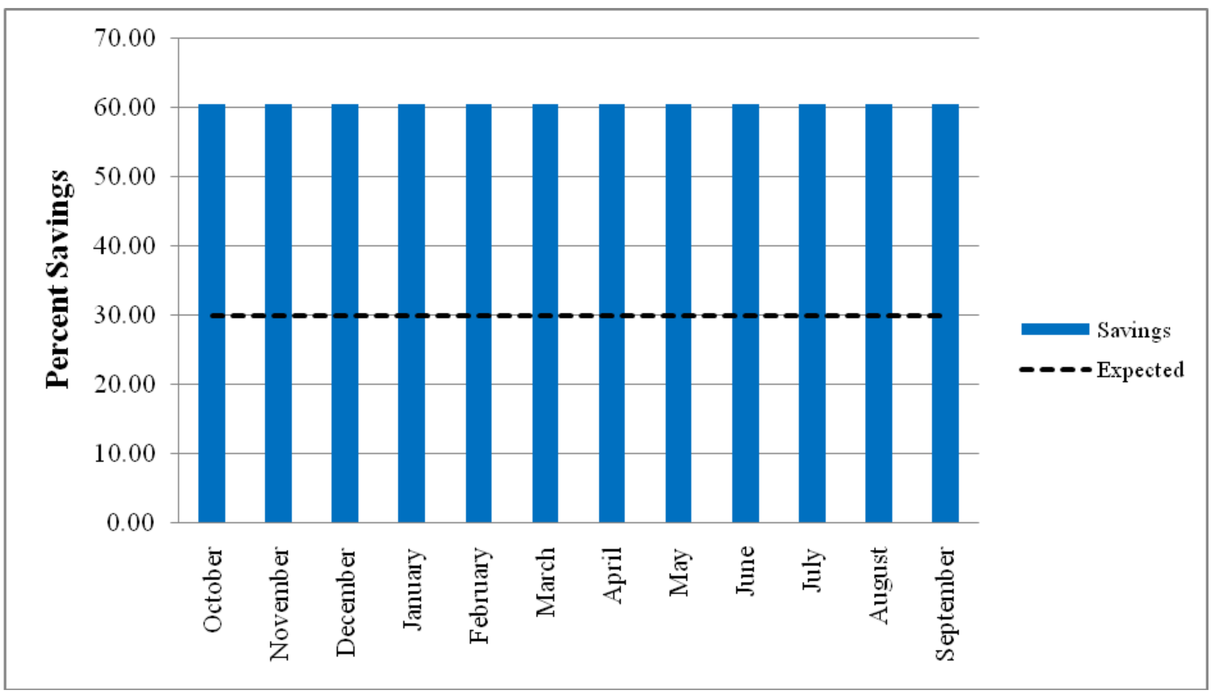

Figure 49 – CDCs Water Consumption Percent Savings

Utilizing the same basis for the paired t-test analysis as the previous sections and to verify that the 30% savings can be achieved; 70% of the energy usage data for the Naval Station Norfolk CDC is compared to the data gathered for the NAS Oceana CDC using a paired t-test. The result of the paired t-test for electricity shows that the true difference is not equal to zero, and the null hypothesis is rejected for a savings of 30%, based on the data from the Naval Station Norfolk CDC being greater than the data from the NAS Oceana CDC when comparing them equally. The p-value associated with testing the differences between criteria weights is 1.828e-08, which is much smaller than 0.05. This extremely small p-value suggests that the criteria weights are different, and the null hypothesis is rejected at a 95% confidence level.

When the same paired t-test is run for the water consumption data the true difference in means is greater than zero, and the test passes for a 30% savings. The p-value associated with testing the differences between criteria weights is 1.00, which is greater than 5% and falls within the accepted confidence level for this test.

The NAS Oceana CDC falls in the Midatlantic region as it was constructed at Naval Air Station Oceana in Virginia Beach, Virginia. The average KWH usage per square-foot (KWH/SF) for the NAS Oceana CDC equates to 16.9 KWH/SF. In comparison, the 2003 CBECS data shows that Non-Mall Buildings with a building floor-space between 25,001 and 50,000 SF have a median electricity usage of 8.8 KWH/SF. When these two numbers are compared directly, we find that the Airborne Mine Countermeasures Facility used 92.05% more electricity than the national average from the 2003 CBECS.

Chapter 6: Conclusions

6.1 – Objectives

All objectives for this study were accomplished with the eleven United States Navy LEED buildings that were analyzed during the course of this study. Based upon the results found, it can be determined that with LEED certification alone, the 30% savings stated in EO 13423, is not guaranteed to be accomplished for both electricity and water. Results indicated that for the majority of Navy LEED buildings analyzed, some percentage of energy savings was accomplished (as displayed in Table 27 below), when compared to the commercial counterparts provided by the respective Public Works Departments.

Table 27 – LEED Building Mean Savings vs. Commercial Counterpart

LEED Building	Commercial Counterpart	Electricity Savings %	Water Savings %
Atlantic Fleet Drill Hall	Pacific Fleet Drill Hall	6.20	60.37
Airborne Mine Countermeasures Facility	Aircraft Maintenance Hangar (HSC-22/C12)	59.72	71.55
Aircraft Maintenance Hangar (HM14)	Aircraft Maintenance Hangar (HSC-22/C12)	7.00	-285.76
Child Development Center (Oceana)	Child Development Center (Norfolk)	8.84	60.59
Bachelor Enlisted Quarters (Yorktown)	Bachelor Enlisted Quarters (Norfolk)	-84.19	N/A
Personnel Support Facility	Morale, Welfare, and Recreation Facility	-127.75	21.95
Police and Special Operations Facility (Little Creek)	Police Station (Norfolk)	2.92	17.49
Marine Corps Bachelor Enlisted Quarters	Marine Corps Bachelor Enlisted Quarters	-10.30	N/A
Public Works Department (NBVC)	Public Works Department (Point Magu)	14.66	56.44
Naval Facilities Engineering Service Command	NAVSEA Laboratory	48.88	57.49
Memorial Golf Course Clubhouse (Miramar)	Golf Course Clubhouse (NBVC)	-209.55	-89.45

Some of the results can be attributed to the differences found in the building sizes. Though an effort was made to negate this attribute by comparing the buildings on a per square foot basis, the result is still affected when a sizeable difference is encountered. This was the case for the comparison between the PSF and the MWR facility, where the PSF was fifteen times larger than its commercial counterpart. Additionally, though the comparison building for the Yorktown BEQ was the Norfolk BEQ, the Norfolk BEQ is more than twice in size for square footage, and will additionally result in a larger number of inhabitant Sailors consuming a greater amount of energy and water.

In contrast, the results were not affected by either the climate location or the usage of the building, as all commercial counterparts were a close match for both of these terms. In the case of the one of a kind building like NFESC, a comparable facility was utilized that contained both laboratory space as well as administrative offices. Though this provided a useful comparison, there are some changes that should be made based on building use for the commercial counterparts. An example of this is the MWR facility, which provided a comparison for the Little Creek PSF, where a better comparison would have been a PSF at another base within the Midatlantic region.

In review of the energy savings as a comparison of the LEED points achieved there are differing results for the buildings reviewed during this research. For three of the eleven Navy LEED certified buildings, the LEED point's sheet was not able to be obtained from either the USGBC or the associated PWD, and therefore could not be reviewed for this portion of the analysis. Table 28 below details the total points achieved for each of the buildings and their respective points associated with the "Energy and Atmosphere" section for LEED. The conclusion that can be drawn from this information is that with more emphasis placed on getting points in the "Energy and Atmosphere" section, there is a more likely result in saving energy closer to or above the expected results from EO 13423. As an example of this, only 6.06% of the total points received for the PSF were associated with energy, and as a result there is a -127.75% non-energy savings. In opposition to this result, 35% of the points for the NBVC PWD were associated to energy, resulting in a 56.44% energy savings compared to the commercial counterpart.

Table 28 – LEED Building Energy Certification Points Achieved

LEED Building	LEED Points Received	LEED Energy Points	Associated Percentage of LEED Energy
Atlantic Fleet Drill Hall	41	11	26.83%
Airborne Mine Countermeasures Facility	28	3	10.71%
Aircraft Maintenance Hangar (HM14)	28	3	10.71%
Child Development Center (Oceana)	*	*	*
Bachelor Enlisted Quarters (Yorktown)	29	1	3.45%
Personnel Support Facility	33	2	6.06%
Police and Special Operations Facility (Little Creek)	34	5	14.71%
Marine Corps Bachelor Enlisted Quarters	27	7	25.93%
Public Works Department (NBVC)	40	14	35.00%
Naval Facilities Engineering Service Command	40	11	27.50%
Memorial Golf Course Clubhouse (Miramar)	*	*	*

*** - No LEED point's sheet to analyze received from USGBC or associated PWD.**

When the Navy LEED certified buildings were compared to the national averages presented in the CBECS for buildings of similar size, the results were not favorable, with a majority of the Navy LEED certified buildings having a negative percentage saved (as displayed in Table 28 below). The last item of the objectives was a review of the mechanics of gathering utility data, which also did not provide favorable results. Though some Public Works Departments did have all of the requested data, extracted from a utility gathering software called "Cubic" or inputted into Microsoft Excel, others like that of the Marine Corps Bachelor Enlisted

Quarters at Camp Lejeune could not provide all the data requested. The main reason for this was due to a lack of metering for all utilities being consumed by the buildings on each base, which can be seen in Appendix A displaying all of the utility data gathered.

Table 29 – LEED Building Savings Percentage vs. CBECS

LEED Building	KWH/SF	CBECS	Savings %
Atlantic Fleet Drill Hall	9.2	9.9	7.07
Airborne Mine Countermeasures Facility	12.7	8.8	-44.32
Aircraft Maintenance Hangar (HM14)	29.5	8.8	-235.23
Child Development Center (Oceana)	16.9	8.8	-92.05
Bachelor Enlisted Quarters (Yorktown)	15.8	8.8	-79.55
Personnel Support Facility	19.5	8.8	-121.59
Police and Special Operations Facility (Little Creek)	22.4	8.8	-154.55
Marine Corps Bachelor Enlisted Quarters	7.0	9.9	29.29
Public Works Department (NBVC)	8.8	6.3	-39.68
Naval Facilities Engineering Service Command	6.7	13.0	48.46
Memorial Golf Course Clubhouse (Miramar)	22.2	6.3	-252.38

6.2 – Paired t-Testing and the Null Hypothesis

As shown in Table 29 below, nine of the eleven LEED buildings do not achieve an acceptable p-value for electricity consumption above 0.05 and the null hypothesis is rejected for a 30% savings. Though these buildings did not pass for a 30% savings, only four of the buildings surveyed lost savings versus their commercial counterparts, as shown earlier in Table 27. In opposition, seven of the nine LEED buildings do achieve an acceptable p-value greater than 0.05 for water consumption, where the test passes for a 30% savings.

Table 30 – Associated P-Values for the Null Hypothesis

LEED Building	Commercial Counterpart	Electricity p-value	Water p-value
Atlantic Fleet Drill Hall	Pacific Fleet Drill Hall	0.001424	0.9973
Airborne Mine Countermeasures Facility	Aircraft Maintenance Hangar (HSC-22/C12)	1.00	1.00
Aircraft Maintenance Hangar (HM14)	Aircraft Maintenance Hangar (HSC-22/C12)	7.134e-06	3.325e-06
Child Development Center (Oceana)	Child Development Center (Norfolk)	1.828e-08	1.00
Bachelor Enlisted Quarters (Yorktown)	Bachelor Enlisted Quarters (Norfolk)	1.991e-09	N/A
Personnel Support Facility	Morale, Welfare, and Recreation Facility	8.622e-07	0.5
Police and Special Operations Facility (Little Creek)	Police Station (Norfolk)	1.388e-05	0.3633
Marine Corps Bachelor Enlisted Quarters	Marine Corps Bachelor Enlisted Quarters	4.472e-06	N/A
Public Works Department (NBVC)	Public Works Department (Point Magu)	7.337e-05	1.00
Naval Facilities Engineering Service Command	NAVSEA Laboratory	0.9993	1.00
Memorial Golf Course Clubhouse (Miramar)	Golf Course Clubhouse (NBVC)	0.001482	0.005422

6.3 – Recommendations for Future Research

What could be seen from the start of this study is that all new buildings must have complete metering of all utilities being consumed by the building in order to fully understand the energy consumption. If this could have been accomplished for this research, additional utility information could have been analyzed for energy consumption, including natural gas and steam consumption, which may have affected the final results when making the building comparisons. In coordination with meters for all utilities on any new or existing building renovated, a standardized method of collecting the data must be implemented in order to further analyze the energy consumption to ensure that what was set out to be accomplished (e.g. 30% savings) actually occurs.

Another effort that should be made is to use the data compiled from this study with these initial eleven buildings, to find what areas of the LEED certification process have provided the most success with respect to energy consumption. Utilize the compiled LEED data as a building block for constructing and maximizing energy efficiency for new and existing building renovations. With the initial findings from these LEED certified buildings, the lessons learned could not only provide benefits to all future acquisitions in the form of cost savings, where buildings only acquire the necessary items, they could also benefit energy savings as a database is built for each region to maximize energy efficiency. Continually reviewing the energy consumption process in each new building or renovation will ensure that the maximum energy efficiency that can be obtained is obtained, which is not currently the case.

As the Navy is using LEED as a form of energy consumption savings, a continual review of this process is necessary to ensure that maximum efficiency of energy consumption is necessary. As discussed in the conclusions, more focus is necessary on gaining points in the

"Energy and Atmosphere" section to utilize LEED as a building block to save energy as expected by EO 13423. Though the assumption can be made that this would raise the initial cost of the project, a review of the payback would have to be analyzed to ensure the added upfront costs could be saved through lower energy consumption over the lifespan of the building.

The last recommendation is that this study should be completed again with more United States Navy LEED certified buildings with a greater emphasis placed on providing as close a match as possible for the United States Navy and Marine Corps commercial counterparts in terms of energy usage. Additional emphasis should be placed on ensuring the counterpart buildings are of similar size, which was not the case for the MWR Facility that was used in comparison of the PSF.

Appendix A – Building Utility Information

Region	Building Number	LEED Buildings	LEED Rating	Base	Square Footage	Utilities			
						MWH	KGal	KCF	MBtu
Midwest	7230	Atlantic Fleet Drill Hall	Gold	Naval Station Great Lakes, IL	58,000	533.44	144.3		5908.6
Mid-Atlantic	450	Child Development Center	Silver	Naval Air Station Oceana, VA	29,000	489.99	812.1		
Mid-Atlantic	SP37	Airborne Mine Countermeasures Facility	Certified	Naval Station, Norfolk, VA	40,376	513.7	148	2575	
Mid-Atlantic	SP36	Aircraft Maintenance Hangar (HM14)	Certified	Naval Station, Norfolk, VA	28,379	838.2	1430	1984.2	
Mid-Atlantic	2075	Bachelor Enlisted Quarters	Certified	Naval Weapons Station, Yorktown, VA	48,700	770.8	1665	1261.6	
Mid-Atlantic	3016	Personnel Support Facility	Silver	Naval Amphibious Base Little Creek (NABLC), VA	37,800	737.9	189		1715
Mid-Atlantic	3537	Police and Special Operations Facility	Silver	Naval Amphibious Base Little Creek (NABLC), VA	25,000	559.7	523		
Mid-Atlantic	FC507	Marine Corps Bachelor Enlisted Quarters	Certified	MCB Camp Lejeune, Jacksonville, NC	90,948	639.2			
Mid-Atlantic	SR72	Reserve Training Center & Vehicle Maintenance Facility	Silver	MCB Camp Lejeune, Jacksonville, NC	12,000	202.32			
Southwest	850	NBVC Public Works Department	Gold	Naval Base Ventura County, Port Hueneme, CA	16,443	144.9	679.9		
Southwest	1100	Naval Facilities Engineering Service Command	Silver	Naval Base Ventura County, Port Hueneme, CA	192,028	1288.5	432.7		
Southwest		Child Development Center	Silver	Marine Corps Air Station (MCAS) Miramar, CA	17,500				
Southwest	3750	Memorial Golf Course Clubhouse	Gold	Marine Corps Air Station (MCAS) Miramar, CA	13,437	487.4	474.9	1345.3	
		Commercial Buildings							
Midwest	7210	Pacific Fleet Drill Hall		Naval Station Great Lakes, IL	58,000	582.12	393		3209.2
Southwest	1487	Child Development Center		Naval Base Ventura County, Port Hueneme, CA	11,520	64.8	1485		
Southwest	1537	NBVC Golf Course Clubhouse		Naval Base Ventura County, Port Hueneme, CA	11,760	147.6	163.1		
Southwest	66	PWD Point Magu		Naval Base Ventura County, Port Hueneme, CA	12,435	129.1	1201.3		
Southwest	475	Warehouse		Naval Base Ventura County, Port Hueneme, CA	103,826	254.6	133.9		
Southwest	1387	NAVSEA Lab		Naval Base Ventura County, Port Hueneme, CA	112,184	1542.9	603.9		
Southwest	4472	Officer's Club		Marine Corps Air Station (MCAS) Miramar, CA	23,514	763.3	331	3268.8	
Mid-Atlantic	LP33	Aircraft Maintenance Hangar (HSC-22/C12)		Naval Station, Norfolk, VA	23,297	743.2	966	1401.8	
Mid-Atlantic	SDA332	Child Development Center		Naval Station, Norfolk, VA	21,420	397	1522	1182.1	
Mid-Atlantic	CEP161	Police Station		Naval Station, Norfolk, VA	24,909	579.6	670	587.7	
Mid-Atlantic	CA290	Moral, Welfare, and Recreation Facility		Naval Station, Norfolk, VA	2,520	21.6	18	531.9	
Mid-Atlantic	R61	Bachelor Enlisted Quarters		Naval Station, Norfolk, VA	101,837	906.8			2205.8

Appendix B – Paired t-test Example

Atlantic vs. Pacific Drill Halls Paired t-test:

<u>*Electricity*</u>

```
a=c(3.14,2.29,2.08,2.25,2.14,2.21,1.97,2.41,2.82,3.19,3.65,3.23)

 b=c(2.53,1.55,1.59,1.91,1.82,1.93,1.46,1.28,1.74,2.75,2.75,2.66)

c=b-a

t.test(a,b,paired=T,alpha=.1,alternative=c("greater"),mu=0)

Paired t-test

data:  a and b

t = 3.8188, df = 11, p-value = 0.001424

alternative hypothesis: true difference in means is greater than 0.3

95 percent confidence interval:

 0.4681896       Inf

sample estimates:

mean of the differences

              0.6175
```

Water

```
a=c(67.27,12,10.93,15.64,47.13,17.14,15.85,17.14,31.28,15.21,43.49,16.07)

b=c(29.99,53.99,47.99,55.49,53.99,50.99,52.49,47.99,38.99,47.99,50.99,58.49)

c=b-a

t.test(a,b,paired=T,alpha=.1,alternative=c("greater"),mu=0)

Paired t-test

data:  a and b

t = -3.4502, df = 11, p-value = 0.9973

alternative hypothesis: true difference in means is greater than 0

95 percent confidence interval:

 -35.50781       Inf

sample estimates:

mean of the differences

              -23.3525
```

Appendix C – LEED Project Descriptions

Atlantic Fleet Drill Hall

Figure 50 – Atlantic Fleet Drill Hall

The Atlantic Fleet Drill Hall at Recruit Training Command, which is part of Naval Station Great Lakes, is a multi-functional space utilized for training the United States Navy recruits. The building space allows for classroom training, recruit drilling, administration offices, and most importantly, recruit graduation ceremonies. As part of the ten year plan to completely renovate the Navy's only Recruit Training Command, the $13M design-build project, which is the first LEED building for Naval Station Great Lakes, is an exact architectural duplicate to its counter-part, which was completed two years earlier.

Though the project was completed in 2007, it did not achieve its LEED Gold certification until 2009. To accomplish the goal of achieving a LEED Gold certification, according to the design team, they utilized the information gathered from the recently completed Pacific Fleet Drill Hall to enhance energy efficiency and performance. Also included in this project was a five-year maintenance plan, which was to be accomplished by the contractor.

The project team also focused on using local materials and resources and helped to support businesses in the area, selecting a small, minority-owned business for the construction of the building. They also maximized the value of the spaces by making the building multi-functional, allowing for variable occupancy, and maximizing the day-lighting throughout the building. This was accomplished by installing the controls that would adjust the artificial light based on the amount of day light available.

As part of their efforts to achieve LEED Gold, the group incorporated many unique design competencies as compared to the buildings counterpart built just two years earlier. In the area of heating and cooling of the building as compared to its architectural counterpart, they minimized heating and cooling loads by insulating thermal breaks, and preventing thermal bridging into the perimeter of the grade-level floor slabs. The designers also installed a building automation system to ensure maximum efficiency for the variable speed HVAC drives. For materials, the team utilized recycled content, local resources, and tried to maximize efficiency to accommodate all of the necessary needs for LEED Gold.

In looking at the design for the landscape, the team addressed the environmental concerns by incorporating an underground water storage system and a retention pond for stormwater management, which exceeded the expectations for the LEED Gold certification. The construction team also utilized stock-piled existing topsoil for the future planting areas and beautification.

As a comparison for modeling this building, I chose the Pacific Fleet Drill Hall at the same location. The Pacific Fleet Drill Hall is a duplicate in size, utilization, and location.

LEED for New Construction v2.2

Atlantic Fleet Drill Hall P-667 Recruit
Project # 10005096
Certification Level: Gold
8/17/2009

41 Points Achieved — Possible Points: 69

Certified 26 to 32 points Silver 33 to 38 points Gold 39 to 51 points Platinum 52 or more points

8	Sustainable Sites	Possible Points: 14
Y	Prereq 1 Construction Activity Pollution Prevention	
1	Credit 1 Site Selection	1
	Credit 2 Development Density & Community Connectivity	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
	Credit 4.3 Alternative Transportation, Low-Emitting & Fuel-Efficient Vehicles	1
1	Credit 4.4 Alternative Transportation, Parking Capacity	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
	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
	Credit 8 Light Pollution Reduction	1

4	Water Efficiency	Possible Points: 5
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
	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

11	Energy & Atmosphere	Possible Points: 17
Y	Prereq 1 Fundamental Commissioning of the Building Energy Systems	
Y	Prereq 2 Minimum Energy Performance	
Y	Prereq 3 Fundamental Refrigerant Management	
1	Credit 1.1 Optimize Energy Performance, 10.5% New / 3.5% Existing	1
1	Credit 1.2 Optimize Energy Performance, 14% New / 7% Existing	1
1	Credit 1.3 Optimize Energy Performance, 17.5% New / 10.5% Existing	1
1	Credit 1.4 Optimize Energy Performance, 21% New / 14% Existing	1
1	Credit 1.5 Optimize Energy Performance, 24.5% New / 17.5% Existing	1
1	Credit 1.6 Optimize Energy Performance, 28% New / 21% Existing	1
1	Credit 1.7 Optimize Energy Performance, 31.5% New / 24.5% Existing	1
1	Credit 1.8 Optimize Energy Performance, 35% New / 28% Existing	1
	Credit 1.9 Optimize Energy Performance, 38.5% New / 31.5% Existing	1
	Credit 1.10 Optimize Energy Performance, 42% New / 35% Existing	1
	Credit 2.1 Renewable Energy, 2.5%	1
	Credit 2.2 Renewable Energy, 7.5%	1
	Credit 2.3 Renewable Energy, 12.5%	1
1	Credit 3 Enhanced Commissioning	1
1	Credit 4 Enhanced Refrigerant Management	1
1	Credit 5 Measurement & Verification	1
	Credit 6 Green Power	1

7	Materials & Resources	Possible Points: 13
Y	Prereq 1 Storage & Collection of Recyclables	
	Credit 1.1 Building Reuse, Maintain 75% of Existing Walls, Floors, & Roof	1
	Credit 1.2 Building Reuse, Maintain 95% of Existing Walls, Floors, & Roof	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
	Credit 3.1 Materials Reuse, 5%	1
	Credit 3.2 Materials Reuse, 10%	1
1	Credit 4.1 Recycled Content, 10%	1
1	Credit 4.2 Recycled Content, 20%	1
1	Credit 5.1 Regional Materials, 10%	1
1	Credit 5.2 Regional Materials, 20%	1
	Credit 6 Rapidly Renewable Materials	1
1	Credit 7 Certified Wood	1

9	Indoor Environmental Quality	Possible Points: 15
Y	Prereq 1 Minimum IAQ Performance	
Y	Prereq 2 Environmental Tobacco Smoke (ETS) Control	
	Credit 1 Outdoor Air Delivery Monitoring	1
	Credit 2 Increase 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
	Credit 5 Indoor Chemical & Pollutant Source Control	1
1	Credit 6.1 Controllability of Systems, Lighting	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
	Credit 8.1 Daylight & Views, Daylight 75% of Spaces	1
	Credit 8.2 Daylight & Views, Views for 90% of Spaces	1

2	Innovation & Design Process	Possible Points: 5
1	Credit 1.1 Innovation in Design: Exemplary Performance, WEc3	1
	Credit 1.2 Innovation in Design:	1
	Credit 1.3 Innovation in Design:	1
	Credit 1.4 Innovation in Design:	1
1	Credit 2 LEED® Accredited Professional	1

Figure 51 – Atlantic Fleet Drill Hall LEED Checklist

Yorktown Bachelor Enlisted Quarters

The $11.5M Bachelor Enlisted Quarters built on Naval Weapons Station Yorktown in Virginia was constructed by the Hensel Phelps Construction Company. The building was built on the same location as a previous housing unit and provides housing for local sailors, stationed at Yorktown, VA. The footprint for the new building, as compared to its predecessor, only utilized 10% of the total available space.

Figure 52 – Yorktown Bachelor Enlisted Quarters

To also achieve the Certified LEED certification, the project team covered the landscape surrounding the disturbed area outside of the new building with native grasses. This limited the need for additional irrigation and helped to control the stormwater runoff and erosion for the area. Since this building is a housing unit for multiple personnel, the design allowed for each occupant to have individual controls for lighting, heating and air conditioning. They also installed sensors that would shut off the systems, when personnel are not present. To complement this system and also assist with the LEED certification, the design team utilized non-ozone depleting refrigerants for the building's conditioning systems. Also assisting in gaining the LEED certification, the team used interior finishes with low levels of volatile organic compounds. One of the largest contributors to the LEED certification was diverting more than 90% of the construction waste to recycling.

As one of the first of the United States Navy's housing units to receive a LEED certification in 2007, the team utilized many of the same techniques seen in many commercial buildings to reduce energy costs. Low flow toilet fixtures, stormwater management, and lighting controls throughout the facility are but a few of the items that helped to contribute to the building's reduced energy footprint.

As a comparison for modeling this building, I was provided data from Naval Station Norfolk, VA on another Bachelor Enlisted Quarters. Though the Bachelor Enlisted Quarters (Building R61) at Naval Station Norfolk is larger than its LEED counterpart at Naval Station Yorktown, it is located within the same region and has the same comparable use on a square footage basis.

The Navy Bachelor Enlisted Quarters
Project 1630
Certification Level: Certified
2/7/2007

LEED for New Construction v2.0/2.1

29 Points Achieved | Possible Points: 69

Certified 26 to 32 points Silver 33 to 38 points Gold 39 to 51 points Platinum 52 or more points

7 Sustainable Sites | Possible Points: 14

Y			
Y	Prereq 1	**Erosion & Sedimentation Control**	
1	Credit 1	**Site Selection**	1
	Credit 2	**Development Density**	1
	Credit 3	**Brownfield Redevelopment**	1
	Credit 4.1	**Alternative Transportation**, Public Transportation Access	1
	Credit 4.2	**Alternative Transportation**, Bicycle Storage & Changing Rooms	1
	Credit 4.3	**Alternative Transportation**, Alternative Fuel Vehicles	1
1	Credit 4.4	**Alternative Transportation**, Parking Capacity & Carpooling	1
	Credit 5.1	**Reduced Site Disturbance**, Protect or Restore Open Space	1
1	Credit 5.2	**Reduced Site Disturbance**, Development Footprint	1
1	Credit 6.1	**Stormwater Management**, Rate & Quantity	1
	Credit 6.2	**Stormwater Management**, Treatment	1
1	Credit 7.1	**Landscape & Exterior Design to Reduce Heat Islands**, Non-Roof	1
1	Credit 7.2	**Landscape & Exterior Design to Reduce Heat Islands**, Roof	1
1	Credit 8	**Light Pollution Reduction**	1

4 Water Efficiency | Possible Points: 5

Y			
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
	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

1 Energy & Atmosphere | Possible Points: 17

Y			
Y	Prereq 1	**Fundamental Building Systems Commissioning**	
Y	Prereq 2	**Minimum Energy Performance**	
Y	Prereq 3	**CFC Reduction in HVAC&R Equipment**	
	Credit 1.1	**Optimize Energy Performance**, 15% New / 5% Existing	1
	Credit 1.2	**Optimize Energy Performance**, 20% New / 10% Existing	1
	Credit 1.3	**Optimize Energy Performance**, 25% New / 15% Existing	1
	Credit 1.4	**Optimize Energy Performance**, 30% New / 20% Existing	1
	Credit 1.5	**Optimize Energy Performance**, 35% New / 25% Existing	1
	Credit 1.6	**Optimize Energy Performance**, 40% New / 30% Existing	1
	Credit 1.7	**Optimize Energy Performance**, 45% New / 35% Existing	1
	Credit 1.8	**Optimize Energy Performance**, 50% New / 40% Existing	1
	Credit 1.9	**Optimize Energy Performance**, 55% New / 45% Existing	1
	Credit 1.10	**Optimize Energy Performance**, 60% New / 50% Existing	1
	Credit 2.1	**Renewable Energy**, 5%	1
	Credit 2.2	**Renewable Energy**, 10%	1
	Credit 2.3	**Renewable Energy**, 15%	1
	Credit 3	**Additional Commissioning**	1
1	Credit 4	**Ozone Depletion**	1
	Credit 5	**Measurement & Verification**	1
	Credit 6	**Green Power**	1

6 Materials & Resources | Possible Points: 13

Y			
Y	Prereq 1	**Storage & Collection of Recyclables**	
	Credit 1.1	**Building Reuse**, Maintain 75% of Existing Shell	1
	Credit 1.2	**Building Reuse**, Maintain 100% of Shell	1
	Credit 1.3	**Building Reuse**, Maintain 100% Shell & 50% Non-Shell	1
1	Credit 2.1	**Construction Waste Management**, Divert 50%	1
1	Credit 2.2	**Construction Waste Management**, Divert 75%	1
	Credit 3.1	**Resource Reuse**, Specify 5%	1
	Credit 3.2	**Resource Reuse**, Specify 10%	1
1	Credit 4.1	**Recycled Content**, Specify 5%	1
	Credit 4.2	**Recycled Content**, Specify 10%	1
1	Credit 5.1	**Local/Regional Materials**, 20% Manufactured Locally	1
1	Credit 5.2	**Local/Regional Materials**, of 20% Above, 50% Harvested Locally	1
	Credit 6	**Rapidly Renewable Materials**	1
1	Credit 7	**Certified Wood**	1

9 Indoor Environmental Quality | Possible Points: 15

Y			
Y	Prereq 1	**Minimum IAQ Performance**	
Y	Prereq 2	**Environmental Tobacco Smoke (ETS) Control**	
	Credit 1	**Carbon Dioxide Monitoring**	1
	Credit 2	**Ventilation Effectiveness**	1
	Credit 3.1	**Construction IAQ Management Plan**, During Construction	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	1
1	Credit 4.3	**Low-Emitting Materials**, Carpet	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**, Perimeter	1
	Credit 6.2	**Controllability of Systems**, Non-Perimeter	1
1	Credit 7.1	**Thermal Comfort**, Comply with ASHRAE 55-1992	1
1	Credit 7.2	**Thermal Comfort**, Permanent Monitoring System	1
	Credit 8.1	**Daylight & Views**, Daylight 75% of Spaces	1
1	Credit 8.2	**Daylight & Views**, Views for 90% of Spaces	1

2 Innovation & Design Process | Possible Points: 5

Y			
1	Credit 1.1	**Innovation in Design**	1
	Credit 1.2	**Innovation in Design**	1
	Credit 1.3	**Innovation in Design**	1
	Credit 1.4	**Innovation in Design**	1
1	Credit 2	**LEED® Accredited Professional**	1

Figure 53 – Yorktown Bachelor Enlisted Quarters LEED Checklist

Port Hueneme Public Works Department (Building 850)

Figure 54 – Port Hueneme Public Works Department

The Public Works Department building in Port Hueneme, CA, completed in 2001, is labeled as the "energy showcase centerpiece" of sustainability in the United States Navy's Southwestern Region. The 17,000 square-foot facility, which achieved a LEED Gold certification, was designed utilizing 41% new construction on the same grounds, with the remaining 59% accomplished as renovation. One of the most interesting parts of this project lies in the parking area. The design team incorporated accommodations for five electric charging stations for fleet vehicles, and only created a parking area that would accommodate 73% of the building's capacity.

The team engaged in a series of meetings to establish goals and strategies, and conducted an iterative design process. Models of daylighting, energy use and air quality were used to analyze the impact of alternative designs and equipment. Partnerships were formed with research organizations such as California Polytechnic Institute at Pomona and the Lawrence Berkeley Laboratory to conduct detailed analyses of building systems and materials. The results of these analyses were then folded back into the design process until an optimal set of strategies was determined.

Located in the mild climate of southern California, the Public Works Department building was designed to make use of passive systems, which have been integrated into all of the functioning systems within the building. The design team hoped to achieve maximum energy efficiency and indoor environmental quality for the occupants. The team also hoped to test and validate new sustainable features that could one-day be replicated in other Navy buildings worldwide. The last goal for this project was to utilize this opportunity as a teaching tool for other Navy projects.

To address water efficiency on the site, the team addressed multiple areas to accomplish their goal. All non-native plants were removed, stormwater run-off is collected and reused in the building, and porous paving was used in the parking area to allow for groundwater recharge and stormwater runoff reduction. The team additionally designed the building to collect stormwater from the roof, which is reutilized for the toilet flushing throughout the building. Lastly they added an integrated control system to limit watering the exterior plants during rainy weather.

With the number of sustainable technologies introduced to this project, the team completed the effort with a strong internal recycling program. This compliment to the other features like natural ventilation and an enhanced day-lighting design, complete the link to the "Navy's showcase centerpiece".

As a comparison model for the Public Works Department on Naval Base Ventura County, I was able to receive comparable data for the Public Works Department building at Point Magu. The Public Works Department building at Point Magu is comparable in size, utilization, and regional area.

LEED
LEADERSHIP IN ENERGY & ENVIRONMENTAL DESIGN

Navy's Energy & Sustainable Design Demonstration Fac.
Project Name, LEED® Project # 0115
LEED Version 2 Certification Level: GOLD
March 3, 2005

40 Points Achieved — Possible Points: 69

Certified 26 to 32 points Silver 33 to 38 points Gold 39 to 51 points Platinum 52 or more points

8 Sustainable Sites — Possible Points: 14

Y			
Y	Prereq 1	**Erosion & Sedimentation Control**	
1	Credit 1	**Site Selection**	1
	Credit 2	**Urban Redevelopment**	1
	Credit 3	**Brownfield Redevelopment**	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**, Alternative Fuel Refueling Stations	1
1	Credit 4.4	**Alternative Transportation**, Parking Capacity	1
	Credit 5.1	**Reduced Site Disturbance**, Protect or Restore Open Space	1
1	Credit 5.2	**Reduced Site Disturbance**, Development Footprint	1
1	Credit 6.1	**Stormwater Management**, Rate and Quantity	1
	Credit 6.2	**Stormwater Management**, Treatment	1
1	Credit 7.1	**Landscape & Exterior Design to Reduce Heat Islands**, Non-Roof	1
	Credit 7.2	**Landscape & Exterior Design to Reduce Heat Islands**, Roof	1
1	Credit 8	**Light Pollution Reduction**	1

3 Water Efficiency — Possible Points: 5

Y			
	Credit 1.1	**Water Efficient Landscaping**, Reduce by 50%	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

14 Energy & Atmosphere — Possible Points: 17

Y			
Y	Prereq 1	**Fundamental Building Systems Commissioning**	
Y	Prereq 2	**Minimum Energy Performance**	
Y	Prereq 3	**CFC Reduction in HVAC&R Equipment**	
2	Credit 1.1	**Optimize Energy Performance**, 20% New / 10% Existing	2
2	Credit 1.2	**Optimize Energy Performance**, 30% New / 20% Existing	2
2	Credit 1.3	**Optimize Energy Performance**, 40% New / 30% Existing	2
2	Credit 1.4	**Optimize Energy Performance**, 50% New / 40% Existing	2
2	Credit 1.5	**Optimize Energy Performance**, 60% New / 50% Existing	2
1	Credit 2.1	**Renewable Energy**, 5%	1
1	Credit 2.2	**Renewable Energy**, 10%	1
1	Credit 2.3	**Renewable Energy**, 20%	1
	Credit 3	**Additional Commissioning**	1
	Credit 4	**Ozone Depletion**	1
	Credit 5	**Measurement & Verification**	1
1	Credit 6	**Green Power**	1

2 Materials & Resources — Possible Points: 13

Y			
Y	Prereq 1	**Storage & Collection of Recyclables**	
	Credit 1.1	**Building Reuse**, Maintain 75% of Existing Shell	1
	Credit 1.2	**Building Reuse**, Maintain 100% of Existing Shell	1
	Credit 1.3	**Building Reuse**, Maintain 100% Shell & 50% Non-Shell	1
	Credit 2.1	**Construction Waste Management**, Divert 50%	1
	Credit 2.2	**Construction Waste Management**, Divert 75%	1
	Credit 3.1	**Resource Reuse**, Specify 5%	1
	Credit 3.2	**Resource Reuse**, Specify 10%	1
1	Credit 4.1	**Recycled Content**	1
1	Credit 4.2	**Recycled Content**	1
	Credit 5.1	**Local/Regional Materials**, 20% Manufactured Locally	1
	Credit 5.2	**Local/Regional Materials**, of 20% Above, 50% Harvested Locally	1
	Credit 6	**Rapidly Renewable Materials**	1
	Credit 7	**Certified Wood**	1

8 Indoor Environmental Quality — Possible Points: 15

Y			
Y	Prereq 1	**Minimum IAQ Performance**	
Y	Prereq 2	**Environmental Tobacco Smoke (ETS) Control**	
1	Credit 1	**Carbon Dioxide (CO_2) Monitoring**	1
	Credit 2	**Increase Ventilation Effectiveness**	1
	Credit 3.1	**Construction IAQ Management Plan**, During Construction	1
	Credit 3.2	**Construction IAQ Management Plan**, Before Occupancy	1
	Credit 4.1	**Low-Emitting Materials**, Adhesives & Sealants	1
	Credit 4.2	**Low-Emitting Materials**, Paints	1
1	Credit 4.3	**Low-Emitting Materials**, Carpet	1
	Credit 4.4	**Low-Emitting Materials**, Composite Wood	1
	Credit 5	**Indoor Chemical & Pollutant Source Control**	1
1	Credit 6.1	**Controllability of Systems**, Perimeter	1
1	Credit 6.2	**Controllability of Systems**, Non-Perimeter	1
1	Credit 7.1	**Thermal Comfort**, Comply with ASHRAE 55-1992	1
1	Credit 7.2	**Thermal Comfort**, Permanent Monitoring System	1
1	Credit 8.1	**Daylight & Views**, Daylight 75% of Spaces	1
1	Credit 8.2	**Daylight & Views**, Views for 90% of Spaces	1

5 Innovation & Design Process — Possible Points: 5

Y			
1	Credit 1.1	**Innovation in Design**: Sustainable Education	1
1	Credit 1.2	**Innovation in Design**: Exemplary Performance WEc3	1
1	Credit 1.3	**Innovation in Design**: Exemplary Performance EAc1	1
1	Credit 1.4	**Innovation in Design**: Exemplary Performance EAc2	1
1	Credit 2	**LEED® Accredited Professional**	1

Figure 55 – Port Hueneme Public Works Department LEED Checklist

Virginia Beach Personnel Support Facility

The Personnel Support Facility located at Naval Amphibious Base Little Creek, was constructed for $7.22M in 2004 and achieved a LEED Silver certification. The building is utilized as a commercial office, library, and classroom space for Naval Sailors to support the administration requirements of the base.

Figure 56 – Personnel Support Facility

For the location of the building, the design team chose to demolish three older facilities and reutilize part of the waste from these buildings into the new structure. They also used much of the waste from the demolition, which was diverted from the landfill, at other construction locations for the General Contractor, Hourigan Construction Company. The team also made use of recycled, rapidly renewable, and local materials, ensuring a lack of volatile organic compounds.

For the exterior landscaping of the building, the design team utilized native and drought-tolerant plant species to limit the need for excessive irrigation and pesticides. The project team also incorporated their sustainable approach into the stormwater management plan, which utilized low impact development techniques to maximize the efficiency of water gathered from the site. Interior to the building, the team used waterless urinals and low-flow toilets, sinks and showers to also reduce the overall amount of potable water consumed.

To adjust for the energy consumption from lighting, which is normally a great deal of the consumed portion of electricity in an office environment, the team created a uniform lighting scheme that optimized light levels throughout the building. They also installed occupancy sensors to reduce the amount of lighting that stayed on in unoccupied classrooms and offices. The team also hoped to take advantage of natural lighting to account for the lighting load of the building.

As a comparison model for the Naval Amphibious Base Little Creek Personnel Support Facility, I was provided data on the Moral, Welfare, and Recreation facility building at Naval Station Norfolk. Though these buildings are not comparable in size, they provide much of the same basic services, needs, and utilization within the same region.

LEED-NC

Personnel Support Facility, U.S. Navy
LEED® Project # 0656
LEED Version 2 Certification Level: SILVER
25 October 2005

33 Points Achieved — Possible Points: 69

Certified 26 to 32 points   Silver 33 to 38 points   Gold 39 to 51 points   Platinum 52 or more points

4 Sustainable Sites — Possible Points: 14

Y			
Y	Prereq 1	Erosion & Sedimentation Control	
	Credit 1	Site Selection	1
	Credit 2	Urban Redevelopment	1
	Credit 3	Brownfield Redevelopment	1
	Credit 4.1	Alternative Transportation, Public Transportation Access	1
1	Credit 4.2	Alternative Transportation, Bicycle Storage & Changing Rooms	1
	Credit 4.3	Alternative Transportation, Alternative Fuel Refueling Stations	1
	Credit 4.4	Alternative Transportation, Parking Capacity	1
1	Credit 5.1	Reduced Site Disturbance, Protect or Restore Open Space	1
1	Credit 5.2	Reduced Site Disturbance, Development Footprint	1
	Credit 6.1	Stormwater Management, Rate and Quantity	1
	Credit 6.2	Stormwater Management, Treatment	1
	Credit 7.1	Landscape & Exterior Design to Reduce Heat Islands, Non-Roof	1
	Credit 7.2	Landscape & Exterior Design to Reduce Heat Islands, Roof	1
1	Credit 8	Light Pollution Reduction	1

4 Water Efficiency — Possible Points: 5

Y			
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
	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

2 Energy & Atmosphere — Possible Points: 17

Y			
Y	Prereq 1	Fundamental Building Systems Commissioning	
Y	Prereq 2	Minimum Energy Performance	
Y	Prereq 3	CFC Reduction in HVAC&R Equipment	
2	Credit 1.1	Optimize Energy Performance, 20% New / 10% Existing	2
	Credit 1.2	Optimize Energy Performance, 30% New / 20% Existing	2
	Credit 1.3	Optimize Energy Performance, 40% New / 30% Existing	2
	Credit 1.4	Optimize Energy Performance, 50% New / 40% Existing	2
	Credit 1.5	Optimize Energy Performance, 60% New / 50% Existing	2
	Credit 2.1	Renewable Energy, 5%	1
	Credit 2.2	Renewable Energy, 10%	1
	Credit 2.3	Renewable Energy, 20%	1
	Credit 3	Additional Commissioning	1
	Credit 4	Ozone Depletion	1
	Credit 5	Measurement & Verification	1
	Credit 6	Green Power	1

6 Materials & Resources — Possible Points: 13

Y			
Y	Prereq 1	Storage & Collection of Recyclables	
	Credit 1.1	Building Reuse, Maintain 75% of Existing Shell	1
	Credit 1.2	Building Reuse, Maintain 100% of Existing Shell	1
	Credit 1.3	Building Reuse, Maintain 100% Shell & 50% Non-Shell	1
1	Credit 2.1	Construction Waste Management, Divert 50%	1
1	Credit 2.2	Construction Waste Management, Divert 75%	1
	Credit 3.1	Resource Reuse, Specify 5%	1
	Credit 3.2	Resource Reuse, Specify 10%	1
1	Credit 4.1	Recycled Content	1
1	Credit 4.2	Recycled Content	1
1	Credit 5.1	Local/Regional Materials, 20% Manufactured Locally	1
1	Credit 5.2	Local/Regional Materials, of 20% Above, 50% Harvested Locally	1
	Credit 6	Rapidly Renewable Materials	1
	Credit 7	Certified Wood	1

13 Indoor Environmental Quality — Possible Points: 15

Y			
Y	Prereq 1	Minimum IAQ Performance	
Y	Prereq 2	Environmental Tobacco Smoke (ETS) Control	
1	Credit 1	Carbon Dioxide (CO_2) Monitoring	1
1	Credit 2	Increase Ventilation Effectiveness	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	1
1	Credit 4.3	Low-Emitting Materials, Carpet	1
	Credit 4.4	Low-Emitting Materials, Composite Wood	1
1	Credit 5	Indoor Chemical & Pollutant Source Control	1
1	Credit 6.1	Controllability of Systems, Perimeter	1
	Credit 6.2	Controllability of Systems, Non-Perimeter	1
1	Credit 7.1	Thermal Comfort, Comply with ASHRAE 55-1992	1
1	Credit 7.2	Thermal Comfort, Permanent Monitoring System	1
1	Credit 8.1	Daylight & Views, Daylight 75% of Spaces	1
1	Credit 8.2	Daylight & Views, Views for 90% of Spaces	1

4 Innovation & Design Process — Possible Points: 5

Y			
1	Credit 1.1	Innovation in Design	1
1	Credit 1.2	Innovation in Design	1
	Credit 1.3	Innovation in Design	1
1	Credit 1.4	Innovation in Design	1
1	Credit 2	LEED® Accredited Professional	1

Figure 57 – Personnel Support Facility LEED Checklist

Norfolk Police and Security Operations Facility

Figure 58 – Police and Security Operations Facility

Completed in 2008 for $6.85M, the Police and Security Operations Facility achieved a LEED Silver certification for its efforts in sustainability according to the United States Green Building Council. The VIRTEXCO Company, contracted by the local construction field office, constructed the building for not only Police Operations, but also for administration functions, classroom training, laboratory functions, personnel detention, and a fully functioning dog kennel on the exterior of the building.

Unlike many of the other buildings completed and analyzed in this study, the Police and Security Operations Facility budgeted allocation for this project did not include as many environmentally friendly materials. To account for this difference, the design-build team found several areas to increase the project's environmental performance without adding significant cost to the project. Energy saving features included an efficient boiler and chiller, a highly reflective roof, a high performance building envelope, and occupancy sensor controls for the electric lighting. Some of the points to achieve the LEED Silver certification additionally came from the use of locally procured materials and the use of recycled content from the demolished building where the new one lies. Additional points for the certification came from the use of built-in walk off mats to limit the introduction of pollutants to the interior environment, and bicycle racks for commuters.

The design team also took advantage of natural lighting for much of the offices and other spaces, and reduced the overall lighting requirement for the building. With the addition of the occupancy lighting sensors, the team was able to reduce the overall electric requirements for this building. Other conservation for the building came in the form of utilizing waterless urinals, low flow toilets, and other low flow fixtures throughout the building. With the irrigation for the landscaping at a minimum due to the use of indigenous plant species, the team was able to reduce the overall water consumption for the buildings spaces.

As this is a high value facility for the base, there was an additional requirement for a generator. To maintain the constant power requirement for this building the design team procured and installed a natural gas generator to only be used for emergency purposes.

As a comparison model for the Police and Security Operations Facility at Naval Amphibious Base Little Creek, I was provided data on the Police Station at Naval Station Norfolk. Comparable in size, utilization, and regional location, this facility provided a useful match for comparing the energy data collected.

LEED for New Construction v2.0/2.1

Police and Security Operations
Project # 10003226
Certification Level: Silver
6/19/08

34 Points Achieved — **Possible Points: 69**

Certified 26 to 32 points Silver 33 to 38 points Gold 39 to 51 points Platinum 52 or more points

8 Sustainable Sites — Possible Points: 14

Y			
Y	Prereq 1	Erosion & Sedimentation Control	
1	Credit 1	Site Selection	1
	Credit 2	Development Density	1
	Credit 3	Brownfield Redevelopment	1
	Credit 4.1	Alternative Transportation, Public Transportation Access	1
1	Credit 4.2	Alternative Transportation, Bicycle Storage & Changing Rooms	1
	Credit 4.3	Alternative Transportation, Alternative Fuel Vehicles	1
1	Credit 4.4	Alternative Transportation, Parking Capacity & Carpooling	1
	Credit 5.1	Reduced Site Disturbance, Protect or Restore Open Space	1
1	Credit 5.2	Reduced Site Disturbance, Development Footprint	1
1	Credit 6.1	Stormwater Management, Rate & Quantity	1
1	Credit 6.2	Stormwater Management, Treatment	1
	Credit 7.1	Landscape & Exterior Design to Reduce Heat Islands, Non-Roof	1
1	Credit 7.2	Landscape & Exterior Design to Reduce Heat Islands, Roof	1
1	Credit 8	Light Pollution Reduction	1

4 Water Efficiency — Possible Points: 5

Y			
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
	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

6 Energy & Atmosphere — Possible Points: 17

Y			
Y	Prereq 1	Fundamental Building Systems Commissioning	
Y	Prereq 2	Minimum Energy Performance	
Y	Prereq 3	CFC Reduction in HVAC&R Equipment	
1	Credit 1.1	Optimize Energy Performance, 15% New / 5% Existing	1
1	Credit 1.2	Optimize Energy Performance, 20% New / 10% Existing	1
1	Credit 1.3	Optimize Energy Performance, 25% New / 15% Existing	1
	Credit 1.4	Optimize Energy Performance, 30% New / 20% Existing	1
	Credit 1.5	Optimize Energy Performance, 35% New / 25% Existing	1
	Credit 1.6	Optimize Energy Performance, 40% New / 30% Existing	1
	Credit 1.7	Optimize Energy Performance, 45% New / 35% Existing	1
	Credit 1.8	Optimize Energy Performance, 50% New / 40% Existing	1
	Credit 1.9	Optimize Energy Performance, 55% New / 45% Existing	1
	Credit 1.10	Optimize Energy Performance, 60% New / 50% Existing	1
	Credit 2.1	Renewable Energy, 5%	1
	Credit 2.2	Renewable Energy, 10%	1
	Credit 2.3	Renewable Energy, 15%	1
	Credit 3	Additional Commissioning	1
1	Credit 4	Ozone Depletion	1
	Credit 5	Measurement & Verification	1
1	Credit 6	Green Power	1

4 Materials & Resources — Possible Points: 13

Y			
Y	Prereq 1	Storage & Collection of Recyclables	
	Credit 1.1	Building Reuse, Maintain 75% of Existing Shell	1
	Credit 1.2	Building Reuse, Maintain 100% of Shell	1
	Credit 1.3	Building Reuse, Maintain 100% Shell & 50% Non-Shell	1
1	Credit 2.1	Construction Waste Management, Divert 50%	1
	Credit 2.2	Construction Waste Management, Divert 75%	1
	Credit 3.1	Resource Reuse, Specify 5%	1
	Credit 3.2	Resource Reuse, Specify 10%	1
1	Credit 4.1	Recycled Content, Specify 5%	1
1	Credit 4.2	Recycled Content, Specify 10%	1
1	Credit 5.1	Local/Regional Materials, 20% Manufactured Locally	1
	Credit 5.2	Local/Regional Materials, of 20% Above, 50% Harvested Locally	1
	Credit 6	Rapidly Renewable Materials	1
	Credit 7	Certified Wood	1

12 Indoor Environmental Quality — Possible Points: 15

Y			
Y	Prereq 1	Minimum IAQ Performance	
Y	Prereq 2	Environmental Tobacco Smoke (ETS) Control	
	Credit 1	Carbon Dioxide Monitoring	1
	Credit 2	Ventilation Effectiveness	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	1
1	Credit 4.3	Low-Emitting Materials, Carpet	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, Perimeter	1
1	Credit 6.2	Controllability of Systems, Non-Perimeter	1
1	Credit 7.1	Thermal Comfort, Comply with ASHRAE 55-1992	1
1	Credit 7.2	Thermal Comfort, Permanent Monitoring System	1
	Credit 8.1	Daylight & Views, Daylight 75% of Spaces	1
1	Credit 8.2	Daylight & Views, Views for 90% of Spaces	1

1 Innovation & Design Process — Possible Points: 5

Y			
	Credit 1.1	Innovation in Design: Credit Title	1
	Credit 1.2	Innovation in Design: Credit Title	1
	Credit 1.3	Innovation in Design: Credit Title	1
	Credit 1.4	Innovation in Design: Credit Title	1
1	Credit 2	LEED® Accredited Professional	1

Figure 59 – Police and Security Operations Facility LEED Checklist

<u>Naval Facilities Engineering Service Command</u>

Figure 60 – NFESC

The Naval Facilities Engineering Service Command (NFESC) Center building, constructed in 1994, is a unique operations facility, providing specialized facilities engineering, technology, and facilities expertise. Upon completion of their new facility, the team achieved the LEED-EB Silver certification. The team took advantage of the opportunity to achieve a LEED-EB certification by utilizing over 40 opportunities for credits. The implementation of these sustainable features was the key to the success of the project, which was completed for $131,700.

Utilized as a combination of office space, laboratories, and warehouse space, building 1100 at Naval Base Ventura County planned the LEED certification through the renovation process for the facility. The team at NFESC incorporated the use of a bike rack, spaces for alternative fueled vehicles, low-flow efficient plumbing fixtures throughout the facility, occupant motion sensors for lighting, entryway mats to enhance indoor air quality, and a highly reflective roof.

The team actively monitored the indoor air quality to ensure maximum health and comfort for the building occupants. By performing this service for the building the team also was able to add to their efforts for sustainability on the LEED front. The project team also had a new low environmental impact detergent mixing station. The new mixing station reduced the costs by applying the proper concentration of cleaning solution and less harsh chemicals to accomplish the job. For the site erosion control, the project team added new groundcover plants to reduce the loss of topsoil and prevent the potential for stormwater pollution runoff.

As a comparison model for the NFESC building, I was provided data for building 1387 on Naval Base Ventura County, which is utilized as a NAVSEA Lab. Comparable in location, size and utilization, this building provided an opportunity for a useful match in comparing the energy data.

Miramar Memorial Golf Course Clubhouse

Figure 61 – Memorial Golf Course Clubhouse

The Marine Corps Air Station Miramar Golf Course is ranked as one of the top eight military golf courses in the United States by Travel and Leisure magazine. The new clubhouse, which was completed $6.6M in 2009, is one of the first Marine Corps facilities to receive a LEED certification.

Constructed by Stronghold Engineering, Inc., the project team incorporated many sustainable features into the 16,000 square-foot facility, which housed the clubhouse, a catering pavilion, an indoor/outdoor dining area, and the Senior Non-Commissioned Officers Club. The major portion of the sustainable features seen in this project included low-flow plumbing fixtures and recycled materials. The project team was able to use recycled building materials and reclaimed non-potable water, which was essential for the golf course sprinkler system.

As a comparison model for the Marine Corps Air Station Miramar Golf Course Clubhouse, I was provided data for the Naval Base Ventura County Golf Course Clubhouse. Comparable in location, size and utilization, this building provided an opportunity for a useful match in comparing the energy data.

Oceana Child Development Center

Figure 62 – Oceana Child Development Center

The Naval Air Station Oceana Child Development Center was the first of its kind to receive a LEED certification within the Department of Defense. The 29,000 square-foot facility completed in 2005 by the Dick Corporation, utilized the services of CJL Engineering as the commissioning agent for the LEED certification.

The new facility will accommodate up to 280 children, which is a significant increase from 88 that the previous facility held. The complex includes training and curriculum offices, five infant activity rooms, four pre-toddler rooms, four toddler activity rooms, six pre-school rooms, a kitchen, laundry, and reception area.

The sustainable features incorporated into this facility included water efficient landscaping that required zero potable water use, diverting over 75% of the construction waste from the landfill, utilizing more than 20% of local manufactured materials during construction to minimize transportation costs, and enhanced daylighting for the entire facility. Occupant sensor controls were also installed for lighting and energy efficient heated hardwood flooring added to the interior comfort and environment for the facilities personnel.

As a comparison model for the Oceana Child Development Center, I was provided data for building SDA 332, the Child Development Center at Naval Station Norfolk. With no other Child Development Center available at Naval Air Station Oceana, the Norfolk facility was comparable in location, size and utilization, providing an opportunity for a useful match in comparing the energy data.

Airborne Mine Countermeasures Facility

The Airborne Mine Countermeasures Facility at Naval Station Norfolk was completed for helicopter minesweeping squadron HM-14. The $22.3M design-build 93,000 square-foot facility was constructed by Mortenson Construction, through their Federal Government division. The work included a 54,000 square-foot Module Aircraft Maintenance Hangar (next project on this listing) and a 38,890 square-foot Airborne Mine Countermeasures Facility, including airfield paving, vehicle parking, security fencing, and site development.

Figure 63 – Airborne Mine Countermeasures Facility

The project team delivered the LEED certification with 75% of the construction waste diverted from the landfill; utilizing 20% recycled materials; 20% regionally procured materials; low-emitting materials for adhesives, sealants, carpet and composite wood. They also maximized saving stormwater runoff through the site development and area management plan. The point distribution for this project was achieved by water efficiency, materials and resources utilized, indoor environmental quality and innovation and design process.

As a comparison model for this project, I was provided data for building LP 33, an Aircraft Maintenance Hangar at Naval Station Norfolk. Though the hangar provided was not the same size as this project, it does provide a useful match for both location and utilization to compare the energy data.

LEED-NC

P-526, Airborne Mine Countermeasures Facility
LEED® Project # 2610
LEED Version 2 Certification Level: Certified
5/9/06

28 Points Achieved — Possible Points: 69

Certified 26 to 32 points Silver 33 to 38 points Gold 39 to 51 points Platinum 52 or more points

3 Sustainable Sites — Possible Points: 14

Y			
Y	Prereq 1	Erosion & Sedimentation Control	
	Credit 1	Site Selection	1
	Credit 2	Urban Redevelopment	1
	Credit 3	Brownfield Redevelopment	1
	Credit 4.1	Alternative Transportation, Public Transportation Access	1
1	Credit 4.2	Alternative Transportation, Bicycle Storage & Changing Rooms	1
	Credit 4.3	Alternative Transportation, Alternative Fuel Refueling Stations	1
1	Credit 4.4	Alternative Transportation, Parking Capacity	1
	Credit 5.1	Reduced Site Disturbance, Protect or Restore Open Space	1
	Credit 5.2	Reduced Site Disturbance, Development Footprint	1
	Credit 6.1	Stormwater Management, Rate and Quantity	1
	Credit 6.2	Stormwater Management, Treatment	1
	Credit 7.1	Landscape & Exterior Design to Reduce Heat Islands, Non-Roof	1
1	Credit 7.2	Landscape & Exterior Design to Reduce Heat Islands, Roof	1
	Credit 8	Light Pollution Reduction	1

4 Water Efficiency — Possible Points: 5

Y			
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
	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

3 Energy & Atmosphere — Possible Points: 17

Y			
Y	Prereq 1	Fundamental Building Systems Commissioning	
Y	Prereq 2	Minimum Energy Performance	
Y	Prereq 3	CFC Reduction in HVAC&R Equipment	
2	Credit 1.1	Optimize Energy Performance, 20% New / 10% Existing	2
	Credit 1.2	Optimize Energy Performance, 30% New / 20% Existing	2
	Credit 1.3	Optimize Energy Performance, 40% New / 30% Existing	2
	Credit 1.4	Optimize Energy Performance, 50% New / 40% Existing	2
	Credit 1.5	Optimize Energy Performance, 60% New / 50% Existing	2
	Credit 2.1	Renewable Energy, 5%	1
	Credit 2.2	Renewable Energy, 10%	1
	Credit 2.3	Renewable Energy, 20%	1
	Credit 3	Additional Commissioning	1
1	Credit 4	Ozone Depletion	1
	Credit 5	Measurement & Verification	1
	Credit 6	Green Power	1

6 Materials & Resources — Possible Points: 13

Y			
Y	Prereq 1	Storage & Collection of Recyclables	
	Credit 1.1	Building Reuse, Maintain 75% of Existing Shell	1
	Credit 1.2	Building Reuse, Maintain 100% of Existing Shell	1
	Credit 1.3	Building Reuse, Maintain 100% Shell & 50% Non-Shell	1
1	Credit 2.1	Construction Waste Management, Divert 50%	1
1	Credit 2.2	Construction Waste Management, Divert 75%	1
	Credit 3.1	Resource Reuse, Specify 5%	1
	Credit 3.2	Resource Reuse, Specify 10%	1
1	Credit 4.1	Recycled Content	1
1	Credit 4.2	Recycled Content	1
1	Credit 5.1	Local/Regional Materials, 20% Manufactured Locally	1
	Credit 5.2	Local/Regional Materials, of 20% Above, 50% Harvested Locally	1
	Credit 6	Rapidly Renewable Materials	1
	Credit 7	Certified Wood	1

7 Indoor Environmental Quality — Possible Points: 15

Y			
Y	Prereq 1	Minimum IAQ Performance	
Y	Prereq 2	Environmental Tobacco Smoke (ETS) Control	
1	Credit 1	Carbon Dioxide (CO_2) Monitoring	1
	Credit 2	Increase Ventilation Effectiveness	1
	Credit 3.1	Construction IAQ Management Plan, During Construction	1
	Credit 3.2	Construction IAQ Management Plan, Before Occupancy	1
1	Credit 4.1	Low-Emitting Materials, Adhesives & Sealants	1
	Credit 4.2	Low-Emitting Materials, Paints	1
1	Credit 4.3	Low-Emitting Materials, Carpet	1
1	Credit 4.4	Low-Emitting Materials, Composite Wood	1
1	Credit 5	Indoor Chemical & Pollutant Source Control	1
	Credit 6.1	Controllability of Systems, Perimeter	1
	Credit 6.2	Controllability of Systems, Non-Perimeter	1
1	Credit 7.1	Thermal Comfort, Comply with ASHRAE 55-1992	1
1	Credit 7.2	Thermal Comfort, Permanent Monitoring System	1
	Credit 8.1	Daylight & Views, Daylight 75% of Spaces	1
	Credit 8.2	Daylight & Views, Views for 90% of Spaces	1

4 Innovation & Design Process — Possible Points: 5

Y			
1	Credit 1.1	Innovation in Design	1
1	Credit 1.2	Innovation in Design	1
1	Credit 1.3	Innovation in Design	1
	Credit 1.4	Innovation in Design	1
1	Credit 2	LEED® Accredited Professional	1

Figure 64 – Airborne Mine Countermeasures Facility LEED Checklist

Aircraft Maintenance Hangar

Completed under the same project as the Airborne Mine Countermeasures Facility by Mortenson Construction, the Aircraft Maintenance Hangar at Naval Station Norfolk was constructed for $34.7M. It also achieved a LEED certification by the United States Green Building Council, receiving the exact same points given for the Airborne Mine Countermeasures Facility.

Figure 65 – Aircraft Maintenance Hangar (HM 14)

LEED-NC

P526 Aircract Maintenance Hangar
LEED® Project # 2609
LEED Version 2 Certification Level: CERTIFIED
6/20/2006

26 Points Achieved — **Possible Points: 69**

Certified 26 to 32 points   Silver 33 to 38 points   Gold 39 to 51 points   Platinum 52 or more points

3 Sustainable Sites — **Possible Points: 14**

Y			
Y	Prereq 1	**Erosion & Sedimentation Control**	
	Credit 1	**Site Selection**	1
	Credit 2	**Urban Redevelopment**	1
	Credit 3	**Brownfield Redevelopment**	1
	Credit 4.1	**Alternative Transportation**, Public Transportation Access	1
1	Credit 4.2	**Alternative Transportation**, Bicycle Storage & Changing Rooms	1
	Credit 4.3	**Alternative Transportation**, Alternative Fuel Refueling Stations	1
1	Credit 4.4	**Alternative Transportation**, Parking Capacity	1
	Credit 5.1	**Reduced Site Disturbance**, Protect or Restore Open Space	1
	Credit 5.2	**Reduced Site Disturbance**, Development Footprint	1
	Credit 6.1	**Stormwater Management**, Rate and Quantity	1
	Credit 6.2	**Stormwater Management**, Treatment	1
	Credit 7.1	**Landscape & Exterior Design to Reduce Heat Islands**, Non-Roof	1
	Credit 7.2	**Landscape & Exterior Design to Reduce Heat Islands**, Roof	1
1	Credit 8	**Light Pollution Reduction**	1

4 Water Efficiency — **Possible Points: 5**

Y			
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
	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

3 Energy & Atmosphere — **Possible Points: 17**

Y			
Y	Prereq 1	**Fundamental Building Systems Commissioning**	
Y	Prereq 2	**Minimum Energy Performance**	
Y	Prereq 3	**CFC Reduction in HVAC&R Equipment**	
2	Credit 1.1	**Optimize Energy Performance**, 20% New / 10% Existing	2
	Credit 1.2	**Optimize Energy Performance**, 30% New / 20% Existing	2
	Credit 1.3	**Optimize Energy Performance**, 40% New / 30% Existing	2
	Credit 1.4	**Optimize Energy Performance**, 50% New / 40% Existing	2
	Credit 1.5	**Optimize Energy Performance**, 60% New / 50% Existing	2
	Credit 2.1	**Renewable Energy**, 5%	1
	Credit 2.2	**Renewable Energy**, 10%	1
	Credit 2.3	**Renewable Energy**, 20%	1
	Credit 3	**Additional Commissioning**	1
1	Credit 4	**Ozone Depletion**	1
	Credit 5	**Measurement & Verification**	1
	Credit 6	**Green Power**	1

6 Materials & Resources — **Possible Points: 13**

Y			
Y	Prereq 1	**Storage & Collection of Recyclables**	
	Credit 1.1	**Building Reuse**, Maintain 75% of Existing Shell	1
	Credit 1.2	**Building Reuse**, Maintain 100% of Existing Shell	1
	Credit 1.3	**Building Reuse**, Maintain 100% Shell & 50% Non-Shell	1
1	Credit 2.1	**Construction Waste Management**, Divert 50%	1
1	Credit 2.2	**Construction Waste Management**, Divert 75%	1
	Credit 3.1	**Resource Reuse**, Specify 5%	1
	Credit 3.2	**Resource Reuse**, Specify 10%	1
1	Credit 4.1	**Recycled Content**	1
1	Credit 4.2	**Recycled Content**	1
1	Credit 5.1	**Local/Regional Materials**, 20% Manufactured Locally	1
	Credit 5.2	**Local/Regional Materials**, of 20% Above, 50% Harvested Locally	1
	Credit 6	**Rapidly Renewable Materials**	1
	Credit 7	**Certified Wood**	1

7 Indoor Environmental Quality — **Possible Points: 15**

Y			
Y	Prereq 1	**Minimum IAQ Performance**	
Y	Prereq 2	**Environmental Tobacco Smoke (ETS) Control**	
1	Credit 1	**Carbon Dioxide (CO_2) Monitoring**	1
	Credit 2	**Increase Ventilation Effectiveness**	1
	Credit 3.1	**Construction IAQ Management Plan**, During Construction	1
	Credit 3.2	**Construction IAQ Management Plan**, Before Occupancy	1
1	Credit 4.1	**Low-Emitting Materials**, Adhesives & Sealants	1
	Credit 4.2	**Low-Emitting Materials**, Paints	1
1	Credit 4.3	**Low-Emitting Materials**, Carpet	1
1	Credit 4.4	**Low-Emitting Materials**, Composite Wood	1
1	Credit 5	**Indoor Chemical & Pollutant Source Control**	1
	Credit 6.1	**Controllability of Systems**, Perimeter	1
	Credit 6.2	**Controllability of Systems**, Non-Perimeter	1
1	Credit 7.1	**Thermal Comfort**, Comply with ASHRAE 55-1992	1
1	Credit 7.2	**Thermal Comfort**, Permanent Monitoring System	1
	Credit 8.1	**Daylight & Views**, Daylight 75% of Spaces	1
	Credit 8.2	**Daylight & Views**, Views for 90% of Spaces	1

4 Innovation & Design Process — **Possible Points: 5**

Y			
1	Credit 1.1	**Innovation in Design**	1
1	Credit 1.2	**Innovation in Design**	1
1	Credit 1.3	**Innovation in Design**	1
	Credit 1.4	**Innovation in Design**	1
1	Credit 2	**LEED® Accredited Professional**	1

Figure 66 – Aircraft Maintenance Hangar (HM 14) LEED Checklist

Camp Lejeune Bachelor Enlisted Quarters (French Creek)

Figure 67 – Camp Lejeune Bachelor Enlisted Quarters

The design-build project completed by Whiting-Turner Construction achieved a LEED certification in 2008. The 90,948 square-foot housing facility is placed in the center of an entire bachelor quarters complex.

The 100 BEQ rooms in the new four story building will add to the quality of life for Marines by providing them with semi-private bathrooms, individual storage closets and shelving, shared microwave and refrigerator appliances with a food preparation niche, and an individual wall unit with desk. Each BEQ room will accommodate two Marines and is essential to the increase of Marine Corps forces occurring in the next few years.

The housing complex was designed for maximum energy and water conservation, with auto sensing interior room lighting and a low maintenance landscape with plant materials chosen on the basis of drought resistance and their ability to thrive on minimal maintenance. The majority of the points received for this project came from the Energy and Atmosphere and Indoor Environmental Quality areas required by the United States Green Building Council for LEED certification.

As a comparison model for the LEED certified Camp Lejeune Bachelor Enlisted Quarters, I was provided data for a neighboring Bachelor Enlisted Quarters that was not certified. An exact duplicate in size, location, and utilization by the personnel of Camp Lejeune, this model provided a useful match for comparing the data presented. Unfortunately, water consumption data was not available for either facility, due to a lack of metering.

CAMP LEJEUNE FRENCH CREEK BACHELOR ENLIS
Project # 10003811
Certification Level: Certified
7/21/2008

LEED for New Construction v2.0/2.1

27	Points Achieved	Possible Points: 69

Certified 26 to 32 points   Silver 33 to 38 points   Gold 39 to 51 points   Platinum 52 or more points

3		Sustainable Sites	Possible Points: 14
Y	Prereq 1	Erosion & Sedimentation Control	
	Credit 1	Site Selection	1
	Credit 2	Development Density	1
	Credit 3	Brownfield Redevelopment	1
	Credit 4.1	Alternative Transportation, Public Transportation Access	1
	Credit 4.2	Alternative Transportation, Bicycle Storage & Changing Rooms	1
	Credit 4.3	Alternative Transportation, Alternative Fuel Vehicles	1
1	Credit 4.4	Alternative Transportation, Parking Capacity & Carpooling	1
	Credit 5.1	Reduced Site Disturbance, Protect or Restore Open Space	1
1	Credit 5.2	Reduced Site Disturbance, Development Footprint	1
	Credit 6.1	Stormwater Management, Rate & Quantity	1
	Credit 6.2	Stormwater Management, Treatment	1
	Credit 7.1	Landscape & Exterior Design to Reduce Heat Islands, Non-Roof	1
1	Credit 7.2	Landscape & Exterior Design to Reduce Heat Islands, Roof	1
	Credit 8	Light Pollution Reduction	1

3		Water Efficiency	Possible Points: 5
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
	Credit 2	Innovative Wastewater Technologies	1
1	Credit 3.1	Water Use Reduction, 20% Reduction	1
	Credit 3.2	Water Use Reduction, 30% Reduction	1

7		Energy & Atmosphere	Possible Points: 17
Y	Prereq 1	Fundamental Building Systems Commissioning	
Y	Prereq 2	Minimum Energy Performance	
Y	Prereq 3	CFC Reduction in HVAC&R Equipment	
1	Credit 1.1	Optimize Energy Performance, 15% New / 5% Existing	1
1	Credit 1.2	Optimize Energy Performance, 20% New / 10% Existing	1
1	Credit 1.3	Optimize Energy Performance, 25% New / 15% Existing	1
1	Credit 1.4	Optimize Energy Performance, 30% New / 20% Existing	1
1	Credit 1.5	Optimize Energy Performance, 35% New / 25% Existing	1
1	Credit 1.6	Optimize Energy Performance, 40% New / 30% Existing	1
	Credit 1.7	Optimize Energy Performance, 45% New / 35% Existing	1
	Credit 1.8	Optimize Energy Performance, 50% New / 40% Existing	1
	Credit 1.9	Optimize Energy Performance, 55% New / 45% Existing	1
	Credit 1.10	Optimize Energy Performance, 60% New / 50% Existing	1
	Credit 2.1	Renewable Energy, 5%	1
	Credit 2.2	Renewable Energy, 10%	1
	Credit 2.3	Renewable Energy, 15%	1
	Credit 3	Additional Commissioning	1
1	Credit 4	Ozone Depletion	1
	Credit 5	Measurement & Verification	1
	Credit 6	Green Power	1

4		Materials & Resources	Possible Points: 13
Y	Prereq 1	Storage & Collection of Recyclables	
	Credit 1.1	Building Reuse, Maintain 75% of Existing Shell	1
	Credit 1.2	Building Reuse, Maintain 100% of Shell	1
	Credit 1.3	Building Reuse, Maintain 100% Shell & 50% Non-Shell	1
1	Credit 2.1	Construction Waste Management, Divert 50%	1
1	Credit 2.2	Construction Waste Management, Divert 75%	1
	Credit 3.1	Resource Reuse, Specify 5%	1
	Credit 3.2	Resource Reuse, Specify 10%	1
1	Credit 4.1	Recycled Content, Specify 5%	1
1	Credit 4.2	Recycled Content, Specify 10%	1
	Credit 5.1	Local/Regional Materials, 20% Manufactured Locally	1
	Credit 5.2	Local/Regional Materials, of 20% Above, 50% Harvested Locally	1
	Credit 6	Rapidly Renewable Materials	1
	Credit 7	Certified Wood	1

8		Indoor Environmental Quality	Possible Points: 15
Y	Prereq 1	Minimum IAQ Performance	
Y	Prereq 2	Environmental Tobacco Smoke (ETS) Control	
	Credit 1	Carbon Dioxide Monitoring	1
	Credit 2	Ventilation Effectiveness	1
	Credit 3.1	Construction IAQ Management Plan, During Construction	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	1
1	Credit 4.3	Low-Emitting Materials, Carpet	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, Perimeter	1
1	Credit 6.2	Controllability of Systems, Non-Perimeter	1
1	Credit 7.1	Thermal Comfort, Comply with ASHRAE 55-1992	1
	Credit 7.2	Thermal Comfort, Permanent Monitoring System	1
	Credit 8.1	Daylight & Views, Daylight 75% of Spaces	1
1	Credit 8.2	Daylight & Views, Views for 90% of Spaces	1

2		Innovation & Design Process	Possible Points: 5
1	Credit 1.1	Innovation in Design: Exemplary Performance of MRc4	1
	Credit 1.2	Innovation in Design:	1
	Credit 1.3	Innovation in Design:	1
	Credit 1.4	Innovation in Design:	1
1	Credit 2	LEED® Accredited Professional	1

Figure 68 – Camp Lejeune Bachelor Enlisted Quarters LEED Checklist

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