# ENERGY AND WATER AUDIT

# U.S. EMBASSY LIMA, PERU

**PREPARED FOR:**

The Bureau of Overseas Buildings Operations
U.S. Department of State

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# EXECUTIVE SUMMARY

An energy and water audit was conducted of the Annex and Chancery buildings at the US Embassy in Lima, Peru in July 2014 that is consistent with ASHRAE Level 2 guidelines. This report documents the findings of that audit.

Lima, Peru is the site of the 2014 COP20, the latest Conference of the Parties to the UN Framework Convention on Climate Change. Peru was identified in the IPCC Report as one of the countries at the most risk to the detrimental impacts to climate change.[1] Lima is also in a precarious environmental situation. Climate change threatens to dry up the snow packs that provide Lima its water, exploitation of natural resources for energy development poses another set of risks, as does its location on the Pacific Rim.

Post staff has made strides to reduce energy use and increase cost savings. No sustainability or energy audits have been conducted at the Post in the past. Prior to the audit, interior and exterior lighting and maintaining building pressurization have been identified by Post and/or OBO as areas of concern.

Total energy use for the post for the year ending June 2014 was 5,880 MWh at a cost of $477,355. Total water use for the same period was 56,047 $m^3$ at a cost of $72,944. The energy use intensity of the Chancery and Annex buildings is 71 kbtu/SF and 66.2 kbtu/SF, respectively. The meter data was not reliable enough to calculate water use intensity of the Chancery and Annex buildings.

While there are 10 buildings on the Post, this energy and water audit focused on two: The 146,385 square foot Chancery building and 71,077 square foot Annex building. The Chancery was opened in 1995 and the Annex opened in 2002. None of the buildings on Post are LEED certified.

Energy Audit Schedule:

| | |
|---|---|
| 7/5/2014 | Notice to Proceed |
| 7/16/2014 to 7/22/2014 | On site assessment, Lima, Peru |
| 9/8/2014 | 90% Draft Report |
| 10/17/2014 | Final Report |

The Post and the equipment in the Chancery and Annex buildings are generally very well maintained. Mechanical rooms are clean and uncluttered. Documentation is available and organized. Preventive maintenance appears to be on track with no major backlog of deferred items. Both buildings are equipped with direct digital control systems. Most equipment is operating in accordance with best management practices. No major HVAC equipment is facing end-of-life in the next 5 years.

However, the Chancery and Annex buildings do not use energy as efficiently as they could as compared to standard office buildings. Energy Star ratings for the buildings are 41 and 49, respectively. This means the buildings are in the 41st and 49th percentile when compared to trends derived from the CBECS 2003 data set. Both ratings are below the threshold of 75 to achieve Energy Star certification. The below-average energy performance can be explained by the following:

- 24x7 building pressurization requirements
- Very limited day-lighting
- No opportunity for economizer-driven cooling

[1] http://resilient-cities.iclei.org/fileadmin/sites/resilient-cities/files/Resilient_Cities_2011/Presentations/E/E2_Miranda.pdf

- Space use efficiency below Federal standards
- Energy use in classified areas was not included in this audit

In 2011, an environmental security upgrade was completed that included air handler replacement in Chancery, new building automation system, and meter infrastructure installation. Based on our observations and discussions with locally employed staff, the new air handlers (10 in total) that were installed as part of an environmental security package were not tested or balanced, building automation system integration was never commissioned, and contractor training was not provided to the Post following the upgrade to effectively operate and optimize the equipment.

There are number of immediate actions or Field Observed Deficiencies. These items should be resolved as soon as possible and may impact operations at the post. The full list is provided starting on page 21. FOD6 is of particular concern – the Chancery's air handling units do not currently meet ventilation requirements of ASHRAE 62.1, but all have been deemed capable of meeting those requirements. The air handlers should be rebalanced according to recommended flow rates in Appendix F.

Additional items include Operations and Maintenances Recommendations and Meter Assessment Recommendations. Several recommendations are made relating to how the DDC system is used. There is a very robust infrastructure for metering, data collection, and analysis that is recommended be utilized to assist in tracking and improving the performance of the Chancery and Annex buildings.

The most recent annual snap shot of energy and water use at the Post is shown on the next page in **Error! Reference source not found.**and **Error! Reference source not found.**.

Paladino identified 23 energy and water conservation measures (ECMs & WCMs) that are the result of the ASHRAE Level 2 audit that included a detailed utility analysis, an on-site facility investigation, and non-dynamic modeling (refer to the Table of Contents for location of specific analysis).

The measures are sorted by cost and offer the following savings potential as summarized in Figure 1 and Table 2. The most financially attractive scenarios are the low-cost and medium-cost measures, which, together, can achieve energy savings more than 12% and a payback within 3 years. For reference, the following guidelines were used to sort ECMs:

- No- and low-cost measures = measures that have very little to no first cost associated with it and that post staff may implement easily. In this study, the maximum cost for a measure to be considered "No- and low cost" is $8,000.
- Medium cost measures = measures that require OBO funding and/or permit. In this study, the costs range from $6,000 to $100,000.
- High-cost measures = measures that may require alternative financing such as an Energy Savings Performance Contracts with support from ICASS and OBO. In this study, costs would exceed $100,000.

**Key ECM Findings:**

- No- and low-cost energy and water conservation measures that could result in 3.1% energy savings at a cost of $23,123 with a payback of 1 year and 13% water savings at a cost of $15,235 with a payback of less than one year.
- Medium-cost measures that could result in 9.2% energy savings at a cost of $140,000 with a payback of 3 years and a significant non-potable water savings (absolute savings not defined due to inoperable metering).
- High-cost measures that could result in 2.3% energy savings at a cost of $2.6 million with a payback of 41 years and no additional water savings.

## Using this report

This audit report is a guide to understanding energy and water consumption in the Chancery and Annex and presents a pathway to improve building performance. There are six types of recommendations presented:

- **Operations and Maintenance Recommendations:** Items that can be completed with little or no cost implications. These can be considered best management practices that, if adopted, would improve the facility's performance.
- **Field Observed Deficiencies:** Items that should be corrected as soon as possible. These are items related to safety, operational requirements, or OBO standard operating procedures.
- **Meter Assessment Recommendations:** Items that would improve the usefulness of the extensive metering network installed at the Post and bring the Post into full compliance with OBO's Facility Meter Application Guideline.
- **Energy Conservation Measures**: Recommended projects that should be implemented to improve the energy efficiency of the Post. Recommended low cost/no cost measures should be implemented by the post as an expense item. Medium and high cost items should be entered into OBO's project management platform for approval and funding.
- **Water Conservation Measures:** Recommended projects that should be implemented to improve the water efficiency of the Post. Recommended low cost/no cost measures should be implemented by the post as an expense item. Medium and high cost items should be entered into OBO's project management platform for approval and funding.
- **Renewable Energy Measures**: Recommended projects that should be implemented that generate renewable energy at the post. Solar PV and wind generation were evaluated. As a result of cloud cover, low wind availability, relatively low electricity rates, and net-metering not being available, a solar PV system would not pay for itself within the equipment lifetime. Consequently, it is not recommended that the Post invest in renewables at this time.

Prior to implementing any energy conservation measures, it is extremely important to include a measurement and verification plan in the project. Measurement and verification is a means of determining what savings were realized as a result of implementing the conservation measure. This information is critical to evaluating if the project was successful, to inform future projects, and to contribute to OBO's body of knowledge on energy efficiency best practices. It also requires facilities teams to pay attention to an implemented measure over an extended period of time, increasing the likelihood that the savings realized will persist.

The audit report is intended to be a tool to bolster the knowledge base of the energy savvy FAC staff and should be shared with mechanical and electrical maintenance staff.

This report also meets the energy audit requirements prescribed by LEED for Existing Buildings: Operations and Maintenance v2009 for EAp1 Energy Efficiency Best Management Practices and EAc2.1 Existing Building Commissioning – Investigation and Analysis.

# PROJECT CONTEXT REVIEW

The Compound is located in the Surco section of Lima, Peru. Lima is situated between the foothills of the Andes and the Pacific Ocean and along three rivers: the Rimac, Chillon and Lurin. Lima is on an active fault zone. This city is home to some nine million people – about a third of Peru's population. The Compound is located in an affluent neighborhood east and south of the city center. Privately operated public transportation includes *combis* of various sizes and taxis. No government sponsored public transportation serves the Compound. An image showing the Compounds location in Lima is shown in Figure 3 below.

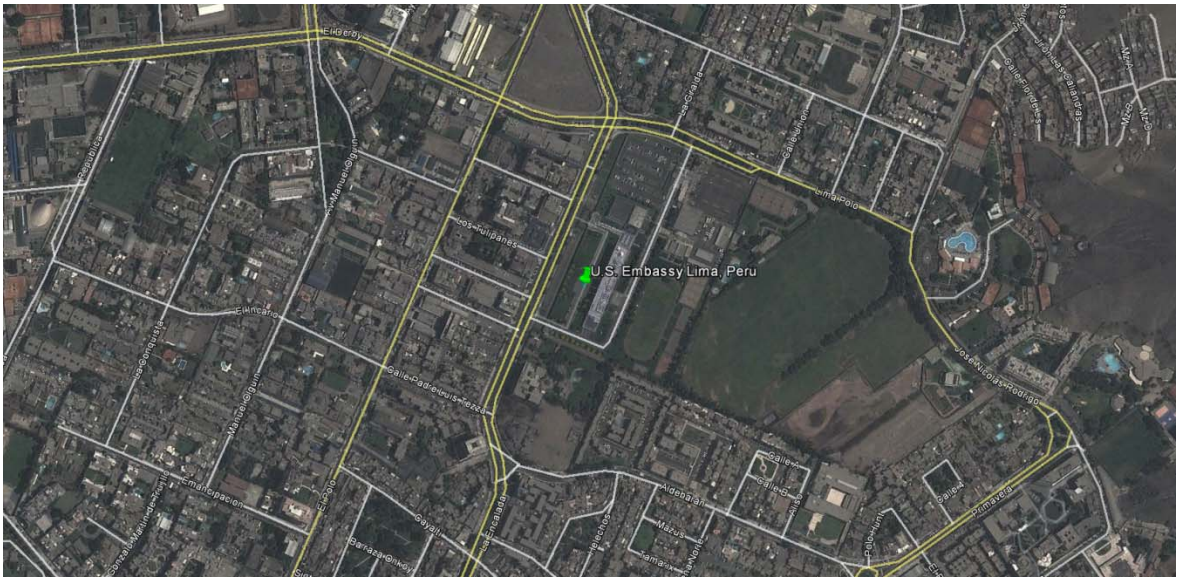



**Figure 1 Embassy Compound location in Surco (Google Earth)**

The Compound is locate in climate zone 2, details about the Compound's location are shown in Table 1. The weather is marine, humid, and mild, with very little precipitation. The high humidity in Lima requires dehumidification of outside air year round, which renders economizer sequences ineffective.

**Table 1 Compound Location Details**

| | |
|---|---|
| Latitude | -12.01 deg. |
| Longitude | 76.9 deg. |
| Elevation | 602 ft. at front door to Chancery |
| Heating Degree Days | 576 (2013, base 65°F) |
| Cooling Degree Days | 6074 (2013, base 50°F) |
| Climate Zone | 2 |
| Seismic Zone | Very High Hazard (Global Seismic Hazard Map)[2] |

[2] http://gmo.gfz-potsdam.de/pub/poster/GSHAP_World_Map_Poster.pdf

## Climate Assessment

Degree day data has been assembled to understand weather-based drivers for energy use at the Compound. The data is summarized in Table 2.

**Table 2 Degree Days for Lima Peru, CDD base 50°F, HDD base 65°F. Source: Weather Underground, wunderground.com**

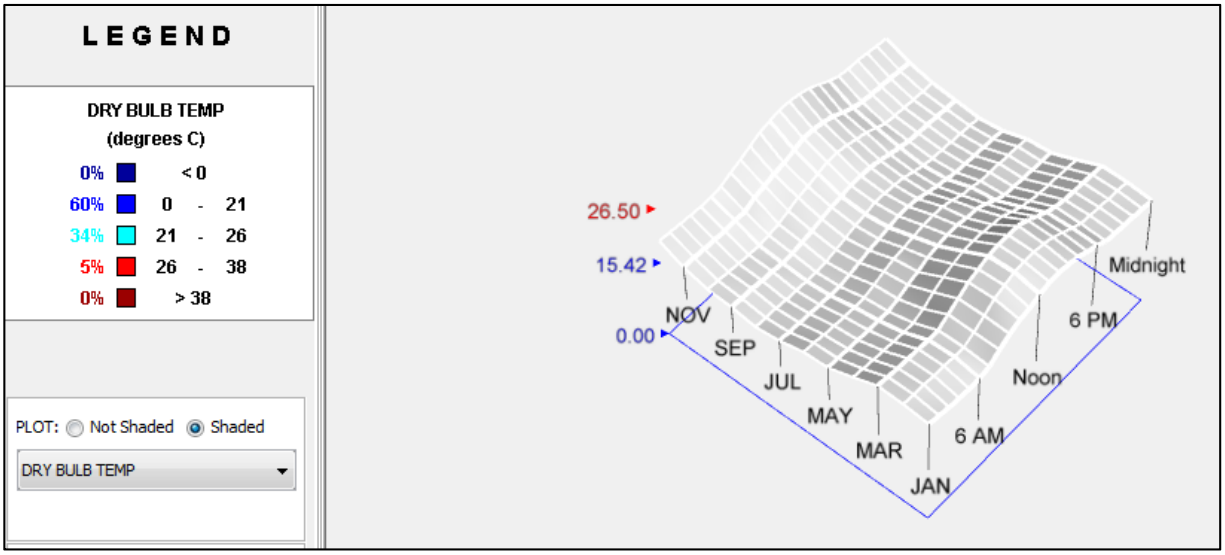
| Month | 2011 | | 2012 | | 2013 | | 2014 | |
|---|---|---|---|---|---|---|---|---|
| | Cooling Degree Days | Heating Degree Days | Cooling Degree Days | Heating Degree Days | Cooling Degree Days | Heating Degree Days | Cooling Degree Days | Heating Degree Days |
| Jan | 685 | 0 | 681 | 2 | 742 | 0 | 764 | 0 |
| Feb | 680 | 0 | 718 | 0 | 701 | 0 | 664 | 0 |
| Mar | 653 | 0 | 752 | 0 | 737 | 0 | 736 | 0 |
| Apr | 585 | 0 | 680 | 0 | 564 | 0 | 548 | 0 |
| May | 548 | 0 | 579 | 0 | 484 | 18 | 607 | 0 |
| Jun | 521 | 0 | 558 | 0 | 369 | 82 | 560 | 0 |
| Jul | 428 | 38 | 554 | 0 | 319 | 147 | | |
| Aug | 356 | 104 | 378 | 93 | 323 | 140 | | |
| Sep | 364 | 82 | 406 | 48 | 350 | 97 | | |
| Oct | 440 | 33 | 445 | 23 | 390 | 72 | | |
| Nov | 520 | 0 | 512 | 0 | 463 | 20 | | |
| Dec | 630 | 0 | 640 | 0 | 632 | 0 | | |
| Total | 6410 | 257 | 6903 | 166 | 6074 | 576 | | |

There is a very small heating demand. Most of the heating for the building is provided by internal gains. There is a significant cooling demand that is present all year. Internal heat gains – lights, people, and equipment – drive the cooling requirements for the principal buildings on post.

A more detailed look at different climate parameters was also conducted. This overview is summarized on pages 10 through 12 and very little precipitation. This also means a high degree of cloud cover and dust from the hills. Prevailing winds are southerly but with velocities below what is required for electricity generating wind turbines.

The visuals on pages 10 through 12 were generated using Climate Consultant 5.5 – Climate Consultant was developed by the UCLA Energy Design Tools Group and is copyrighted 1976, 1986, 2000, 2006, 2008, and 2010 through 2014 by the Regents of the University of California.

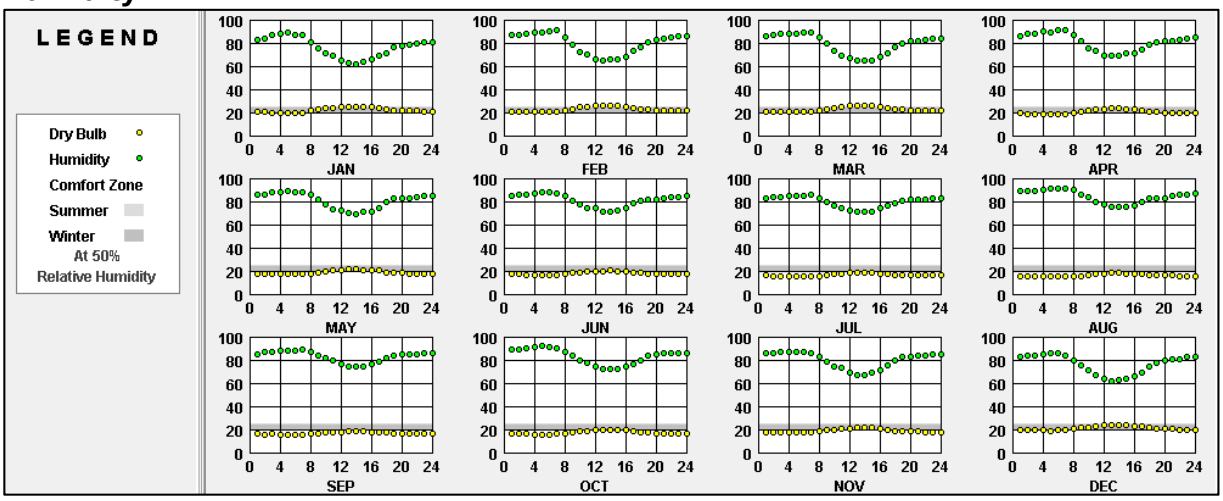
## Temperature




### Key Observations

- Often, outdoor ambient temperature is comfortable
- 60% of the time, temperatures are between 11 and 21°C , 34% of the time, temperatures are between 21 and 26°C
- No temperature extremes – record high is 30°C, record low is 11°C
- No opportunity for water-side economizer

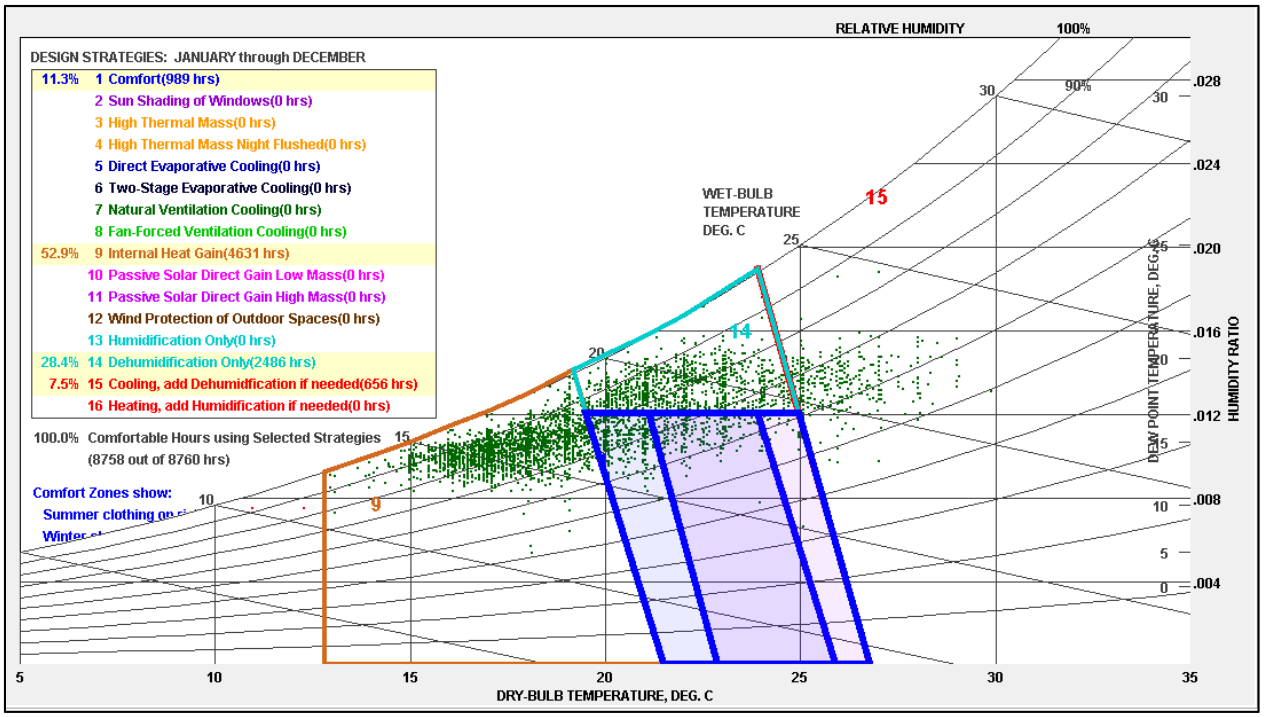
## Humidity




### Key Observations

- Very humid location
- Always 60-100% RH
- Challenge for air-side economizers
- Decreases effectiveness of evaporative cooling devices

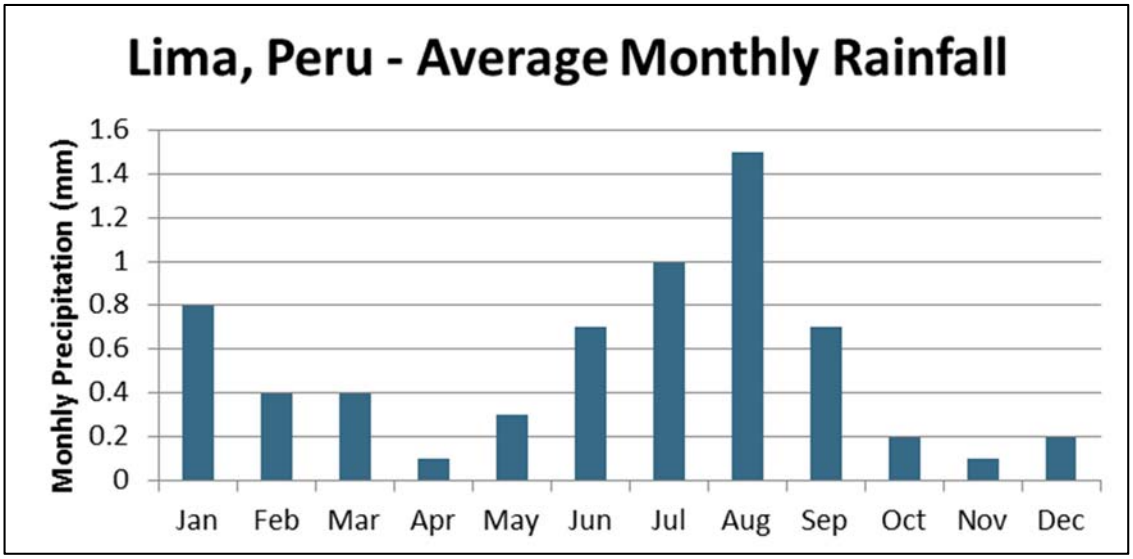
## Thermal Comfort




### Key Observations

- During 11% of operating hours ambient conditions alone are comfortable,
- 53% of the time, comfort can be achieved via internal heat gain.
- There is an abundance of humidity. This requires dehumidification 28% of the time, and cooling 8% of the time.
- OBO practices, particularly around security requirements, narrow the possibility for natural ventilation or passive systems.

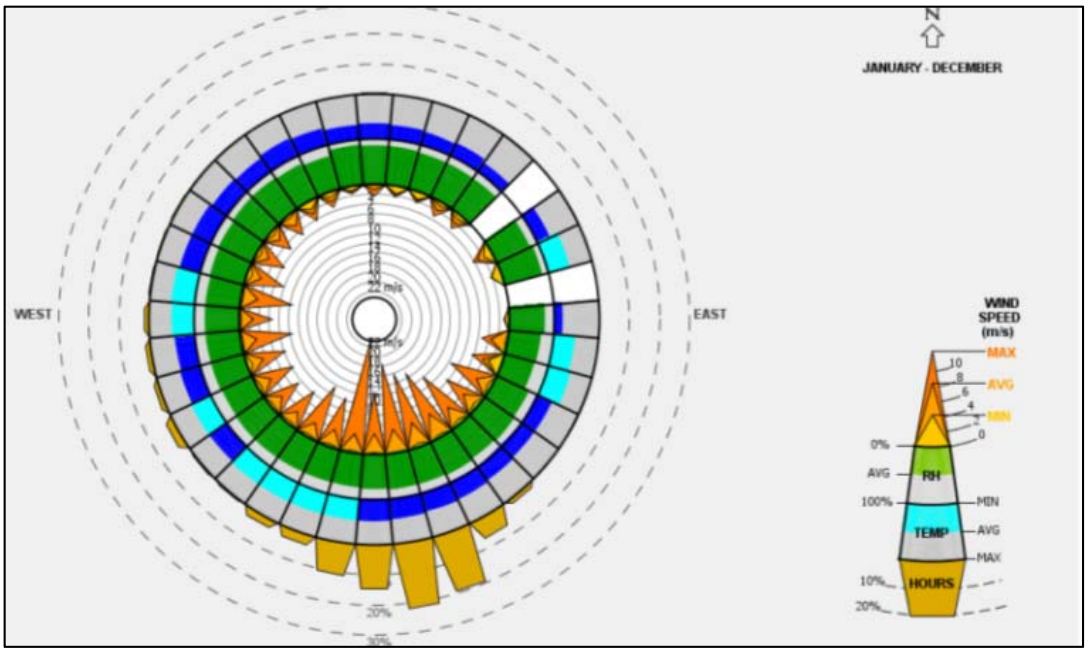
## Rainfall[3]




**Key Observations**

- Very little precipitation
- Total annual precipitation of 6.4 mm
- Dust accumulates on equipment and surfaces
- Precipitation increases significantly during El Nino – causing flooding and landslides during significant cycles.

## Wind




**Key Observations**

- Average wind speed approximately 4 to 5 m/s
- Southerly winds prevail.
- Wind speeds do not provide a significant potential for wind energy.

[3] http://www.lima.climatemps.com/precipitation.php

## Environmental Issues Assessment

Lima, Peru is the site of the 2014 COP20, the latest Conference of the Parties to the UN Framework Convention on Climate Change. Peru was identified in the IPCC Report as one of the countries at the most risk to the detrimental impacts to climate change.[4] Lima is also in a precarious environmental situation. Climate change threatens to dry up the snow packs that provide Lima its water, exploitation of natural resources for energy development poses another set of risks, as does its location on the seismically active Pacific Rim.

### ENERGY SECURITY/RISK

This risk is categorized as moderate – most electricity comes from hydropower. Distribution is provided by a state-owned monopoly. Major projects to increase generating capacity are in the pipeline. Peru has significant quantities of minable coal. In addition, natural gas extraction is rapidly developing in the country. Finally, renewables are becoming increasingly cost-effective. Lima is a moderate candidate for renewables. Energy prices are relatively stable and supplies are not threatened by political or economic instability. However, the reliability of hydropower resources are at great risk to changes in snow pack and river flow resulting from climate change. In general, energy production in Peru is about half as carbon-intense as in the US. A comparison to the US and world average is shown in Table 5.

**Table 5 Carbon Profile for Electricity Sector in Peru[5]**

| Country | gCO2e/kWh | % different from US |
|---|---|---|
| World | 565 | +8.2% |
| Peru | 289 | -44.6% |
| US | 522 | n/a |

### WATER SCARCITY/RISK

The risk related to water scarcity and water pollution is high – water for Lima comes from surface sources, principally, the Rimac River. The river is dependent upon glacial melt in the Andes to recharge its sources. Rapid glacial retreat is threatening this source of meltwater. The majority of wastewater is discharged into the Pacific Ocean. One treatment plant is operating and additional projects are in the pipeline. Treated wastewater is reused as irrigation water. The area sees very little rainfall annual and depends upon the periodic El Nino to recharge glaciers and snow pack. Many Limeans do not trust the city water – on Post, for example, a reverse osmosis system is operated to provide drinking water. The Rimac River is at further risk from pollution from mining operations upstream of Lima.

[4] http://resilient-cities.iclei.org/fileadmin/sites/resilient-cities/files/Resilient_Cities_2011/Presentations/E/E2_Miranda.pdf
[5] http://www.iea.org/co2highlights/co2highlights.pdf

### DROUGHT RISK

Peru is at risk from drought.[6] The country just started monitoring droughts this year.[7] Lima is the 2nd driest city in the world. Glaciers that feed Lima's rivers have been in retreat for the past 25 years. Studies considering the impacts of climate change on Lima indicate that the city "would face drought to extreme drought."[8]

### SEISMIC RISK

The seismic risk in Lima is high. The city is located on the Pacific Rim. The risk to the building is low based on OBO design standards, but, if there is a seismic event, impacts to the security of energy and water infrastructure serving the post would be significant.

### ENERGY POLICY INITIATIVES AND ECO-DIPLOMACY

This audit was conducted with several goals in mind. Compliance with federal energy policy initiatives is one of those goals.

The Greening Diplomacy Initiative (GDI) – started by Secretary Clinton in 2009, this initiative is focused on improving performance of diplomatic facilities by improving energy and water efficiency and elevating sustainability in US foreign policy. www.state.gov/green

The Energy Independence and Security Act (EISA 2007)[9] was passed by congress and signed by President Bush. It includes a number of provisions related to the energy performance of federal government buildings. While diplomatic facilities are exempt, the Bureau of Overseas Buildings Operations has the following goals for their facilities:

- 30% reduction in energy use by 2015 based on a 2003 baseline.
- Energy use evaluation for each facility on a four year cycle
- Tracking and evaluation of energy conservation measures implemented
- Energy benchmarking using Energy Star or other system
- 100% reduction in fossil fuel energy use by 2030 based on a 2003 baseline
- LCCA based on 40 year life cycle

Executive Order 13423[10] – Strengthening Federal Environmental, Energy, and Transportation Management

Executive Order 13514[11] – Federal Leadership in Environmental, Energy, and Economic Performance

Energy Policy Act of 2005 (EPAct 2005)[12]

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[6] *www.gfdrr.org/sites/gfdrr.org/files/documents/**Peru**-2010.pdf*
[7] http://www.unesco.org/new/en/santiago/press-room/single-new/news/observatorios_agroclimaticos_se_expanden_en_america_latina_peru_hara_monitoreo_de_situaciones_de_sequia/#.U_OZ_GPP2iY
[8] http://www.chance2sustain.eu/fileadmin/Website/Dokumente/Dokumente/Publications/Publications_Sept_2012/Chance2Sustain_-_Policy_Brief_5_-_Do_Inclusive_Scenarios_Contribute_to_Reduce_Water_Vulnerabilities_Facing_Climate_Change_in_Metropolitan_Cities.pdf
[9] http://energy.gov/eere/femp/energy-independence-and-security-act
[10] http://www.gpo.gov/fdsys/pkg/FR-2007-01-26/pdf/07-374.pdf
[11] http://www.whitehouse.gov/assets/documents/2009fedleader_eo_rel.pdf
[12] http://energy.gov/eere/femp/energy-policy-act-2005

## Sustainability History and Vision

This energy audit was conducted alongside of a Leadership in Energy and Environmental Design Existing Buildings: Operations and Maintenance (LEED EB:O&M) gap analysis assessment (See accompanying report dated August 2014). As Post staff has made strides to reduce energy use and increase cost savings, they indicated that a LEED rating would validate their commitment to sustainable building operations. No sustainability or energy audits have been conducted at the facilities in the past. Prior to the audit, interior and exterior lighting and maintaining ventilation pressurization had been identified by Post and/or OBO as areas of concern.

### Recent and Ongoing Projects

2015 – Fire alarm system upgrade for compound

2014/2015 – AHU replacement for Annex

2014 – LED lighting in main lobby

2014 March – Installed variable speed domestic water booster pump

2013 – Waterless urinals installation starts in Chancery

2011 – Environmental security upgrade. Project included air handler replacement in Chancery, new building automation system, and meter infrastructure installation.

## Building and Site Information

Detailed information about the buildings investigated in this study is shown in Table 6.

**Table 6 Detailed Building Information**

| Building Name and Post | Lima Chancery | Lima Annex |
|---|---|---|
| Address | Avenida La Encalada, cdra. 17, Monterrico, Surco, Lima, Peru | |
| Audit Date | 7/16-22/2014 | 7/16-22/2014 |
| Building Type | Office | Office |
| Building Use Summary | COM, DAO, Consular Services, Political Office, Admin, Cafeteria, FAC, Mail, MSG | USAID, FAC, DEA |
| Year of Construction | 1996 | 2002 |
| Date of Last Major Renovation | n/a | n/a |
| Gross Floor Area (m2) | 13,600 | 6,603 |
| Conditioned Area (m2) | 13,600 | 6,603 |
| Number of Floors | 6 | 3 |
| Design Occupancy (FTE) based on federal efficiency standards | 681 | 331 |
| Actual Occupancy (as of July 2014) | 437 | 172 |
| Typical Building Schedule Summary (business hours, continuous, seasonal, 24/7, etc.) | 7am-6pm | 7am-6pm |
| Interval Data Available (Y/N) | Interval data for the compound is available from the utility. Post has provided audit team with a copy of year ending June 2014. | |
| Submeter Description | Meters installed, data not being logged and archived. | Meters installed, data not being logged and archived. |
| General Lighting Description | Overhead 32W, 4ft T8s and 28 W CFL downlights | Overhead 32W, 4ft T8s and 28 W CFL downlights |
| Plumbing Fixtures Description | 3.5 GPF WCs, 1.0 GPF URNs, 2.2 GPM LAVs | 3.5 GPF WCs, 0 GPF URNs, 0.5 GPM LAVs |
| Power Service and Distribution Description | 10kV primary service, owned substation, 100% diesel backup, 480V 50Hz distribution, submeters installed | |
| Mechanical System Description | Constant volume multizone, modular chilled water air handlers, water cooled chillers | VAV chilled water air handlers, electric reheat, air cooled chillers |
| Controls and Building Automation Description | Tridium Niagara circa 2011 | Johnson Metasys circa 2002 |
| Water Supply Description | Potable: Municipal 5-10psi, Irrigation: Municipal, intermittent | |
| Wastewater Treatment Description | None | |
| Fire Suppression Systems Description | 100% Sprinklered | |
| Vertical and Horizontal Transportation Systems Description | 3 Passenger, 1 Freight Elevator | 1 Passenger Elevator |
| Notes | | |

### EMBASSY COMPOUND

The embassy compound is composed of ten buildings. The two principal buildings are the Chancery and USAID Annex. Additional buildings include: three Compound Access Control buildings, the Warehouse/Commissary, the Power Plant/Motorpool, Metal/Carpentry Shops, the Coffee Conex, and, outside of the secure area, the Cosmos Conexes. These buildings are described in brief in Table 7. The scope of this Audit includes only the Chancery and Annex buildings.

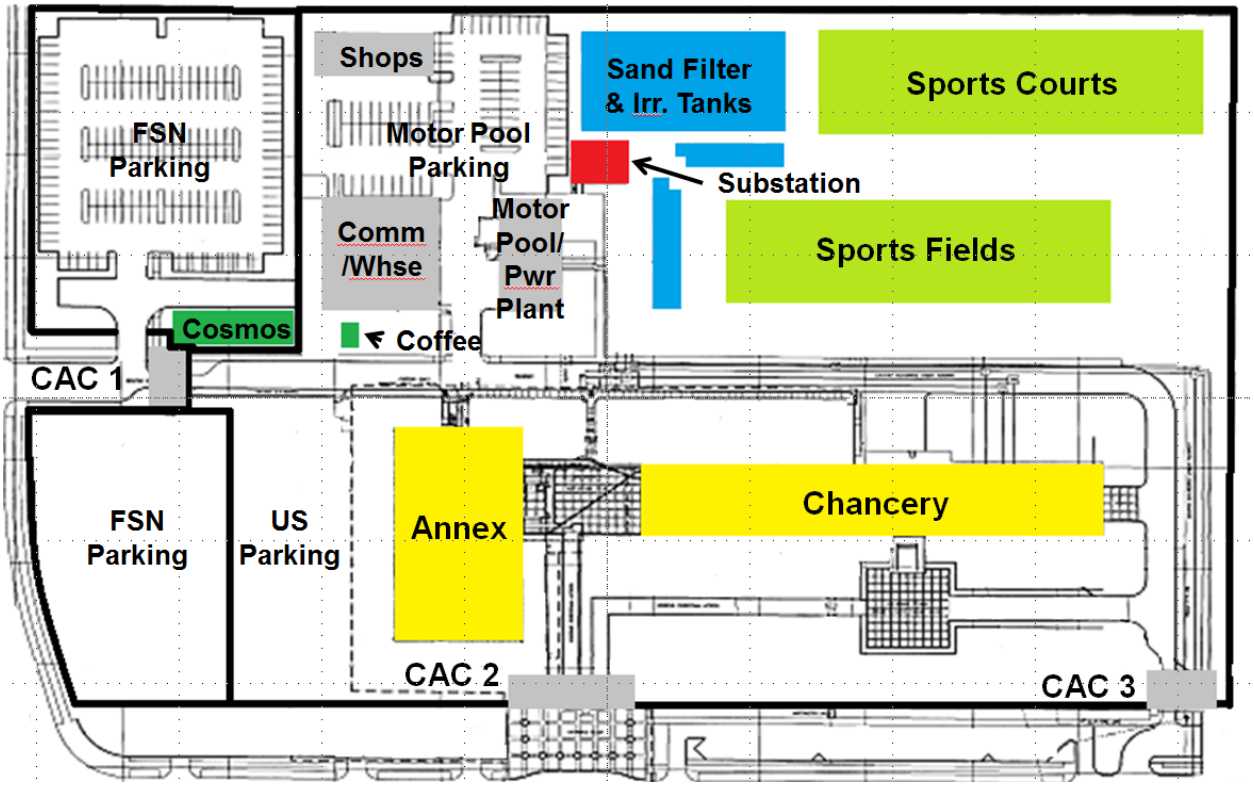



Figure 2 Lima Compound Layout

Table 7 Lima Compound – Principal Buildings

| Building Name | Area (GSF) | FTEs | Schedule | Hours/week |
|---|---|---|---|---|
| Chancery | 146,385 | 437 | 7am-6pm, M-F | 55 |
| Annex | 71,077 | 172 | 7am-6pm, M-F | 55 |

## Detailed Systems Description - Chancery

The Chancery building is a 5 story plus basement secure office building housing diplomatic, consular, and administrative functions for the Embassy. The building, opened in 1995, is reinforced concrete with punched windows and an external membrane roof. The Chancery was designed and built prior to the development of Standard Embassy Design and is not LEED certified.

### HEATING, VENTILATION, AND AIR CONDITIONING

HVAC is provided by constant volume multi-zone chilled water air handling units, self-contained, water cooled, packaged units, and air cooled split systems. Ventilation is provided by a number of dedicated fans along with the constant volume multi-zone units. Building pressure control is provided by the constant volume multi-zone units. The air handlers were replaced in 2011 as part of an environmental security upgrade. This upgrade also included a new automatic temperature control system. Fans and belts appear to be well maintained. Issues observed during the site visit, specifically non-functioning damper actuators and control loops that had not been tuned indicate a lack of proper maintenance of control elements.

A chilled water plant is located in the basement of the facility. The plant houses two, 250 Trane CenTraVac chillers. These machines are original to the building but have had a controls and refrigerant upgrade. Both are low pressure, centrifugal machines operating with R-123 refrigerant. The chillers are original to the building. Initially, these were R-11 machines but have been rebuilt in the last ten years. The chilled water plant is a constant flow primary, variable flow secondary arrangement. Condenser water is provided by two induced draft, counter-flow cooling towers and constant speed pumps. Each cooling tower operates with a single speed fan. Each chiller has a dedicated tower/pump pair. Under typical conditions, one chiller is sufficient to provide cooling for the building. While the chillers will reach the end of their life in the next ten years they are in good condition and appear to be well-maintained. The cooling towers have scale build-up on the fill due to the hardness of the water. Fill replacement, more frequent cleaning, and improved water treatment may improve the life of the cooling towers.

### AUTOMATIC TEMPERATURE CONTROLS

The Chancery was built with pneumatic controls. These were replaced in 2011 along with many of the air handlers as part of an Environmental Security Upgrade (ESU). The primary reason for the upgrade was the installation of high efficiency particulate air and high efficiency gas air (HEPA and HEGA) filters. These filters required air handling unit fans that could develop a higher static pressure. Based on our observations and discussions with locally employed staff, this upgrade was never tested and balanced or commissioned and sufficient training was not provided to the post to effectively operate and optimize the equipment. This also means that post staff does not have the training to readily discover and remedy control element based issues. The ESU project included installation of a Honeywell branded Tridium Niagara control platform. This is an extremely flexible platform that allows a high degree of customization and reliability. However, many of the features could be utilized more fully by the post.

### DOMESTIC WATER

Domestic water is provided from Sedapal via a meter vault north of CAC-2 on Avenida Encinida. Water enters an 1175 $m^3$ concrete cistern under the ceremonial plaza with a 275 $m^3$ fire water reserve. Flow into the cistern is controlled by a float valve and is metered by the post with an ultrasonic flow meter. Pressure from Sedapal is very low – between 5 and 10 psi according to Eduardo Ramirez, the post's Mechanical Engineer. 85 psi of boost is provided by a new (installed in 2014), variable speed, triplex booster pump. The pump package includes three, 15 hp pumps and is rated at 250 gpm. A pressured tank is located on the roof of the building to improve system performance. Water then flows through a softening and filter package before being distributed to the compound. A project is in the planning/procurement stage to

replace the softening and filter package. A small reverse osmosis system is provided for drinking water. The post cleans, fills, and distributes five gallon plastic bottles for use in water coolers throughout the post. The system appeared well maintained.

#### DOMESTIC HOT WATER

Central domestic hot water is provided to the Chancery. There are three domestic hot water tanks. One is heated primarily by heat recovery self-contained units serving the chiller plant room and has an electric backup heater. The domestic hot water system for the chancery is set up in a cascade configuration. Water enters a 49 °C (120 °F) storage tank heated by a pair of heat pumps and an electric heating element. Then water enters a pair of storage tanks each equipped with 30 kW electric heaters that maintain the water between 60-71 °C (140-160 °F). These are equipped with timers that shut off the heating elements at from 6pm to 6am Monday through Saturday and all day on Sunday. Last, water enters the hot water distribution piping. This piping is equipped with a return to maintain hot water temperature and reduce water waste. Recirculation is driven by a 0.187 kW (1/3 hp) centrifugal pump controlled by an aquastat set at 66 °C (150 °F). The pump is not controlled by a timer. The system appeared original to the building and well-maintained.

#### LIGHTING

Interior lighting is a combination of overhead, three lamp T-8 fixtures and CFLs. Interior lighting is well maintained. Control is by local switches and occupancy sensors. Most private offices, enclosed rooms, and office areas had occupancy sensors installed. Based on walks through the building at 7pm, the combination of local switches and occupancy sensors resulted in appropriate lights shutting off overnight.

Compound exterior lighting is fed by and controlled from the Chancery. Exterior lighting includes pole lights, building façade wash lights, sports area lighting, and walkway bollards. At least three exterior fixtures had a non-functioning lamp. The pole lights, bollards, and façade wash lights appear to be original to the building. The pole lights are KLM OTS series fixtures with 250 W high pressure sodium luminaires. Control is based on photocell and timer in parallel. The timer is seasonally adjusted, but generally set from 6pm to 6am. Sports field lighting appears to have been installed in the last 5 years and are 175 W metal halide luminaires. Control is by timer switches located at the sports fields.

Observations made while walking the site after dark indicate that, according to OBO staff participating in the site visit, site lighting was found to be not meeting standards for illumination, controllability, or lighting power density requirements.

## Detailed Systems Description - Annex

The Annex was built in 2002. It is a two story plus basement and mechanical penthouse secure office building housing diplomatic, immigration, and administrative functions for the Embassy.

#### HEATING, VENTILATION, AND AIR CONDITIONING

HVAC is provided by seven variable air volume chilled water air handling units located in the mechanical penthouse. Ventilation is provided by the VAV AHUs along with a handful of dedicated fans. All heating is provided by electric reheat in perimeter VAV boxes. The airside equipment is original to the building except for AHU-4LO, which appears to have been replaced in 2011.

Two 175 ton, air-cooled, rotary chillers are located on the roof of the Annex. Chilled water is distributed in a variable primary configuration to the AHUs in the mechanical penthouse. The chillers and pumps appear original to the building.

When built, the domestic water cistern was used as a thermal energy storage device. It would be charged at night by the chillers in the Chancery and discharged during the day to cool the Annex. Per conversation with Eduardo Ramirez, the system was abandoned in place when it was found to be too costly to operate in 2004 or 2005. The piping terminates at the wall to the cistern anteroom in the Chancery and on the roof of the Annex. Pumps, valves, and heat exchangers associated with the system have been removed except for the heat exchangers in the cistern.

#### AUTOMATIC TEMPERATURE CONTROLS

A Johnson Controls Metasys DDC building automation system controls VAV boxes, AHUs, pumps, and provides an enable/disable to the chillers.

#### DOMESTIC WATER

Domestic water is provided from the Chancery. Flow and use are measured by an ultrasonic flow meter located in the Chancery cistern anteroom and monitored by the building automation system.

#### DOMESTIC HOT WATER

Domestic hot water is provided by electric, point of use heaters throughout the building. These are original to the building. No issues with domestic hot water in the Annex were observed.

#### LIGHTING

Interior lighting is provided by T-8s and CFL down lights. Work stations are equipped with task lights. Most spaces are over lit. Occupancy sensors and local switches are provided throughout. Most private offices, enclosed rooms, and office areas had occupancy sensors installed. Based on walks through the building at 7pm, the combination of local switches and occupancy sensors resulted in appropriate lights shutting off overnight.

## Field Observed Deficiencies (FOD)

**FOD1** - In the Chancery, GX-B-10 is missing a service disconnect within sight of the equipment. The closest point to turn off unit is at the breaker in an electrical room that requires moving through three locked set of doors. The deficiency can be resolved by installing a lockable disconnect on the wall adjacent to the fan in the water cistern anteroom.

**FOD2** - In the Chancery, the room housing the chilled water plant does not meet ASHRAE Standard 15 requirements. The most recent iteration of the Standard, ASHRAE 15-2013 provides for exhaust and refrigerant gas detection in mechanical rooms.

**FOD3** – In the Chancery, there is a smoke control sequence defined in the building automation system programming. Based on a cursory investigation, this sequence is missing an enable point.

**FOD4** - The damper position control loops for AHU-3-1 and AHU-3-2 in the Chancery were tuned to be too fast. The cycle time was observed as 0.02 seconds. Normally this value is at least 1 minute and generally more than 2 minutes. The result is premature failure of damper actuators. Three were replaced by the post in coordination with Paladino during the audit site visit. In a failure condition, the outside air damper is closed, the return air damper is open, and the relief air damper is closed. This could create a neutral pressure condition on a portion of the floor and makes the purge mode inoperative.

**FOD5** – Repair airflow monitoring stations installed in VAV AHUs in Annex. During contractor's site visit all sensors were reporting as unreliable in the building management system.

**FOD6**- Outside air ventilation minimum air flows have NOT been established in the Chancery or Annex. Minimum OSA flow is a requirement in order to maintain healthy indoor air quality and to meet ASHRAE 62.1 ventilation standards. The HVAC systems' outside air dampers now modulate from 0%-100% to maintain differential pressure set points ranges from 5.0pa to 9.0pa. It is recommended that the HVAC system be balanced by a certified Test, Adjust and Balancing (TAB) contractor and minimum OSA damper positions be defined and made operational during scheduled work hours. Please refer to Appendix G: Ventilation Study in the supplemental LEED EB:O&M Gap Assessment Report (August 2014) which demonstrates that HVAC systems as currently installed are able to meet minimum ventilation code requirements.

**FOD7** – Annex AHU-1L1 VFD is set in "Hand" mode by operator. Supply and Return fans for this unit had respective VFDs set at 45 Hz (75% of fan speed), effectively turning this unit into a constant volume system. When the AHU stays in the override mode VAV zones it serves may not get sufficient air flow to maintain temperatures and indoor air quality. Note: With VFDs limited to 75% fan speed, the Johnson Controls BAS was demanding 100% fan speed to meet duct static pressure target (1.0"wc). It is recommended that this unit be re-commissioned to verify performance of associated BAS controller and field devices and then returned to auto operation.

## Operations and Maintenance Recommendations (OMR)

**OMR1** – Provide focused DDC system training for operators. The operators are able to manipulate some set points and schedules and read information from the head-end. Based on the ongoing preventive maintenance needs of the DDC systems and the potential for unlocking further improved operational and energy performance, both the Post and the staff would benefit from additional, hands-on DDC system training including basic programming of DDC systems. This recommendation applies to the Chancery and Annex buildings.

**OMR2** – The major project close-out process has significant room for improvement. Based on our site observations and available documentation, commissioning, testing and balancing, and contractor training had not been performed for the Environmental Security Upgrade. To improve the process, we recommend that the following activities are always included in major HVAC equipment replacement projects in the Chancery and Annex buildings:

- Independent commissioning
- Contractor provided training for Post facilities management office staff
- Certified testing, adjusting, and balancing

**OMR3** – Improve alarm lists. It is recommended that the following alarms be added to the building management system in the Chancery and Annex:

- Alarm if damper actuator command does not match position feedback after a delay.
- Alarm if fan command does not match fan status proof after a delay.
- Alarm if pressure limits out of range (+/- 20% of set point, after a 3 minute delay)
- Alarm if VFD enable does not correspond with current reference output from VFD
- Alarm if VFD faults are reported to the control system. This should be a general VFD fault alarm for each drive.
- Set up alarm conditions for air temperature points based on an out of range condition.
    - Space temp +/- 1°C (5 minute delay)
    - DAT set-points +/-1°C (5 minute delay)

**OMR4** – Compound – label all metering equipment. Some was labeled, but not consistently. This was not tracked systematically during the meter assessment.

**OMR5** – Maintain trend logs for key points in the Chancery and Annex. A list of recommended points is provided in Appendix F under the heading “OMR5 – Recommended Trend Logs.”

**OMR6** – Initial reading data received from the Post for electric and water sub meters included data that was not correct. Approximately 20% of the entries included various issues including transposed digits, added or removed order of magnitude, or out of sequence numbers. To correct these issues in the future and create an archive of data to reference, it is recommended that the Post implements automated meter reading using the DDC system and includes quality control step in the meter reporting process.

**OMR7** –Define and program a global view for the DDC systems in the Chancery and Annex buildings. This view would summarize the status of major equipment and provide operators a dynamic graphic to quickly understand the building’s operational status.

# METER ASSESSMENT

Working with the Post FAC staff and OBO, the audit team investigated the metering setup at the Lima Compound. The investigation compared the installed meters to OBO's Facility Meter Application Guideline.

## Overview

There are four utilities serving the post:

- Electricity – Luz Del Sur
- Potable water – Sedapal
- Non-potable water – Lima
- Diesel (delivered)

Meters for Luz Del Sur and Sedapal are owned by the respective utility. These meters measure total energy or potable water provided to the compound. Diesel is shared between back-up and emergency power and motor pool and is delivered periodically. The tanks have level measurement, but consumption by end-use (motor pool, back-up, emergency power, or fire pump) is not tracked. Non-potable water for irrigation is provided by canal that is flooded at intervals by the city. A post-owned meter is located between the slow-sand filters and the irrigation distribution system. This meter was not functioning at the time of the site visit. A site walk was conducted to investigate the installation, characteristics, and operating condition of the Post's meters.

Electric submeters are Honeywell 3-Phase class 500 Meters. These are power quality meters. Current transducers are located around feeders the meter is monitoring. Voltage transducers are also attached to each leg. An example is shown in Figure 5.

**Figure 3 Electric Submeters (Type 2 shown in Table 8)**

The Honeywell meters are networked to the builidng automation system in the Chancery. There are also four GE EPM 6000 meters installed on the Utilty and Electronics bus in each the Chancery and Annex.

These are shown in Figure 6. There are 16 electric meters on the post.The details of each type are shown in Table 8.

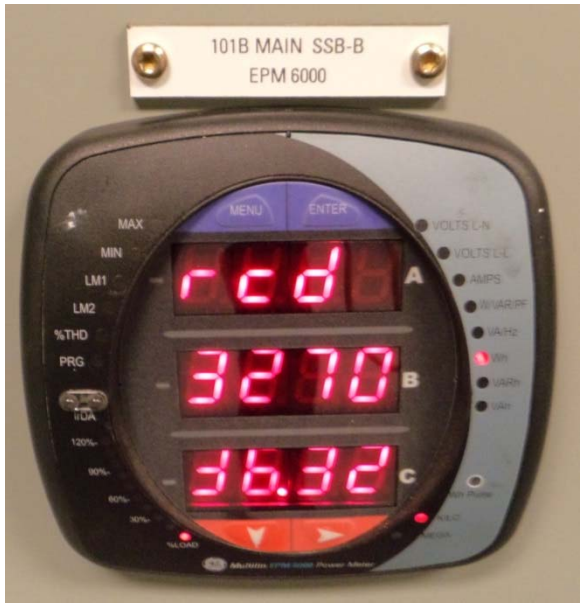



**Figure 4 GE EPM 6000 installed in switchgear**

**Table 8 Electric Meter Types**

*Meter Type #1*

| | |
|---|---|
| Metered Utility | Electricity |
| Location (e.g.) | Chancery Rm B38 |
| Standalone or connected to BAS? | Standalone |
| Building/area/ equipment served | Chancery and Annex |
| Circuit (e.g.) | Utility Bus |
| Make & Model | GE EPM6000 |
| Voltage and Amperage | 480V |
| Other characteristics | Not monitored |

*Meter Type #2*

| | |
|---|---|
| Metered Utility | Electricity |
| Location (e.g.) | Chancery Rm B38 |
| Standalone or connected to BAS? | Connected |
| Building/area/ equipment served | Annex |
| Circuit (e.g.) | Electronic Bus |
| Make & Model | Honeywell SUB480-800C |
| Voltage and Amperage | 480V |
| Other characteristics | Labeled "E4" by Post |

Water submeters are Spirax Sarco ultrasonic flowmeters. An example is shown in Figure 7. The flow transducers are situated outside of the pipe on rails. The distance between the transducers is a function of the pipe diameter and type of flow. The details for F3, a meter typical of all of those on the post is shown in Table 9.

**Figure 5 Ultrasonic Water Meter with Readout**

**Table 9 Typical Water Meter Detail**

| | |
|---|---|
| Metered Utility | Secondary Look Cooling Tower Makeup Water |
| Location | Chancery - Roof |
| Standalone or connected to BAS? | Connected to BAS |
| Building/area/ equipment served | CT 1&2 |
| Building area (m2) | 13,600 |
| Type and size of piping | 2 in. Copper |
| Make & Model | Spirax Sarco UTM10-S-D-00-0 |
| Serial Number | n/a |

All of the meters are connected to the Chancery building automation system for monitoring and archive. However, only two months of data is archived by the building automation system. It is highly recommended that the data from the extensive metering infrastructure be archived for at least a year

## Results

After compiling site observations the overall configuration of the meters was mapped. The meter layouts for electric meters and water meters are shown in Figure 8 and Figure 9, respectively. These diagrams show which meters are inclusive of energy metered by subsequent meters. For example, meter E1 includes energy tracked by meters E3, E6, E7, E8 etc. All of the meters indicated on the diagrams are

currently installed. In mapping what is metered, it was possible to determine what meters should be added. These are shown as metering assessment recommendations (MAR) is this report.

**MAR1** – Trend and archive data from all of the meters on the Compound for at least 3 years on intervals of at least 15 minutes.

## ELECTRICITY

**MAR2** – Add a meter, E17, on the feed to the PBX in the Chancery. The recommended specification is shown in Table 10.

**MAR3** – Add a meter, E18, on the feed to the JUCR in the Chancery. The recommended specification is shown in Table 10.

**Table 10 Meter Specifications for MAR2 and MAR3**

| Metered Utility | Electricity |
|---|---|
| Building/area to be served | PBX |
| Building/area (m2) | Approx. 20m2 |
| Occupancy (FTE) | none |
| Occupant Schedule | n/a |
| Recommended Location | At panel feeding PBX |
| Conductor number and size | 4 wire + ground |
| Voltage and Amperage | 480V/100A |
| Estimated Cost | $2,500 |
| Notes | This meter should be integrated with the building management system. |

| Metered Utility | Electricity |
|---|---|
| Building/area to be served | JUCR |
| Building/area (m2) | Approx. 40m2 |
| Occupancy (FTE) | none |
| Occupant Schedule | n/a |
| Recommended Location | At panel feeding JUCR |
| Conductor number and size | 4 wire + ground |
| Voltage and Amperage | 480V/75A |
| Estimated Cost | $2,500 |
| Notes | This meter should be integrated with the building management system. |

**MAR4** – Add a meter on the feed to each chiller (CH-1, CH-2, RM-1, and RM-2). Recommended specifications are shown in Table 11.

**Table 11 Recommended Specifications – Chiller and Refrigeration Machine Meters**

| Metered Utility | Electricity |
|---|---|
| Building/area to be served | Refrigeration Machine 1 and 2 |
| Building/area (m2) | n/a |
| Occupancy (FTE) | n/a |
| Occupant Schedule | n/a |
| Recommended Location | At panel feeding RM-1 and RM-2 |
| Conductor number and size | 3x250kCM |
| Voltage and Amperage | 480V/75A |
| Estimated Cost | $2,500 each |
| Notes | These meters should be integrated with the building management system. |

| Metered Utility | Electricity |
|---|---|
| Building/area to be served | Chiller 1 and 2 |
| Building/area (m2) | n/a |
| Occupancy (FTE) | n/a |
| Occupant Schedule | n/a |
| Recommended Location | At panel feeding CH-1 and CH-2 |
| Conductor number and size | 3x500kCM |
| Voltage and Amperage | 480V/75A |
| Estimated Cost | $2,500 |
| Notes | This meter should be integrated with the building management system. |

**MAR5** – Integrate to the GE power quality meters installed in the switchgear in the Chancery instead of the Honeywell meters. Abandon the duplicate Honeywell meters.

## WATER

**MAR6** – Repair F-12, the flow meter monitoring irrigation in the irrigation water pumping pit.

**MAR7** – Add a domestic hot water meter downstream of F-1 to measure total Chancery hot water production

**MAR8 –** Add a meter for raw irrigation water to monitor the evaporation losses of the slow sand filter.

### BACKUP POWER

**MAR9** – Generator meters – add electric meters downstream of each generator. These should be the same specification as the Honeywell Sub460 meters.

**MAR10** – Diesel meters for generator – add diesel meters upstream of each generator in the Power Plant.

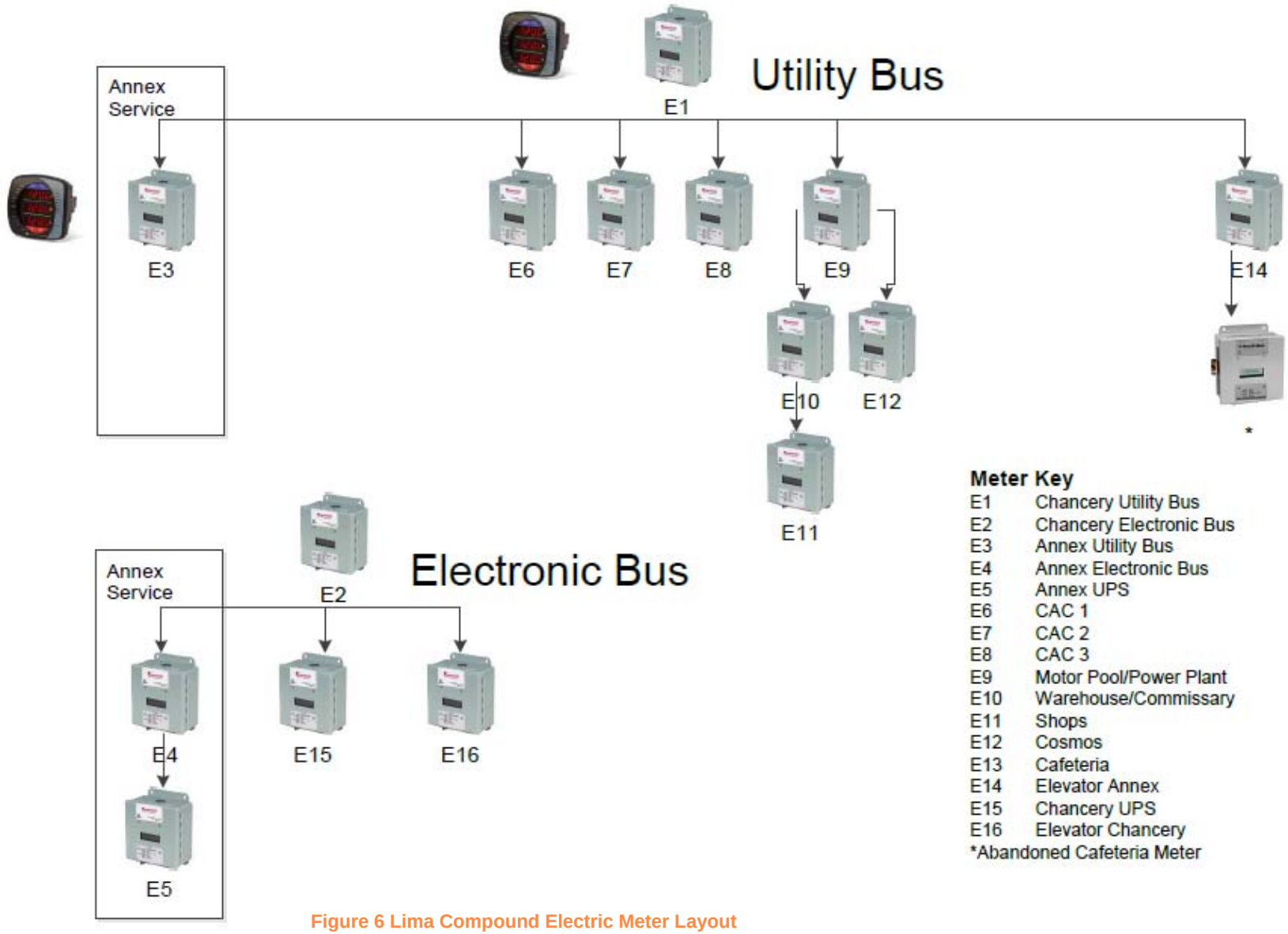



**Figure 6 Lima Compound Electric Meter Layout**

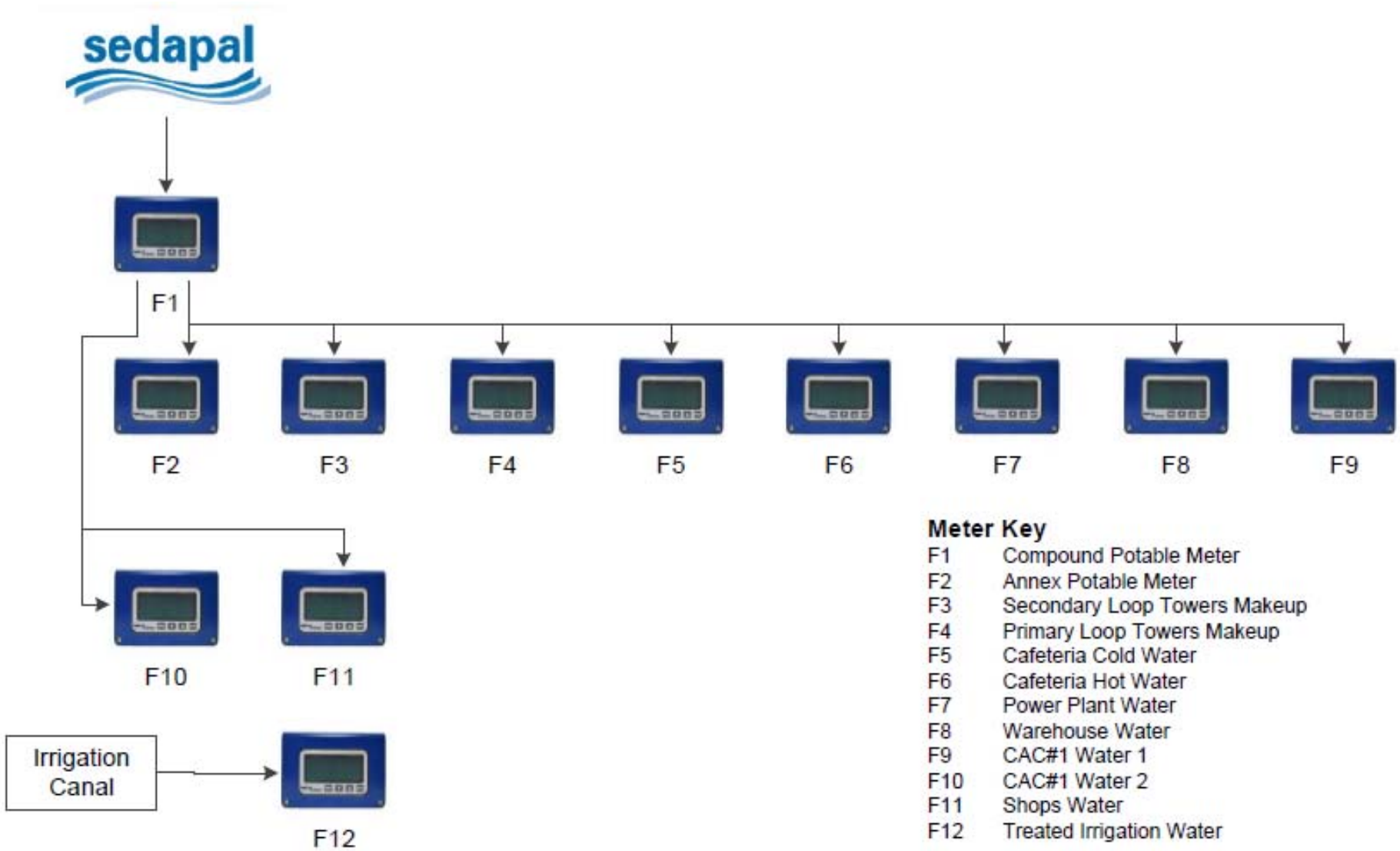



**Figure 9 Lima Compound Water Meter Layout**

# UTILITY USE ANALYSIS

The audit team conducted an onsite review of the building systems and operation and a detailed analysis of energy and water use and opportunities for consumption reduction and cost savings. Prior to the site visit, the audit team obtained electronic copy of water and electricity bills to understand the tariff and service structure.

## Utility Data Gathering

Electricity is provided by Luz Del Sur. Primary service is provided to the post. There is a utility owned meter on the primary side of the facility-owned substation. Water is provided by Sedapal via a 90 mm connection. There is a utility owned meter in a vault just outside the north wall of the post. A copy of each bill with translation is provided in Appendix G.

Hard-copies of previously paid utility bills are archived by the post. These bills are stored along with operations and maintenance binders in the FAC office section of the Annex building. In addition, one year of fifteen minute interval data was available from the electric utility. The interval data request was submitted to Luz Del Sur by Hernan Gallo as part of this audit. Hard copies of bills are filed by the Administrative Assistant to the Facility Management Office.

Electricity bills were available from 2003 to 2014. Water data was gathered from 2011 to 2014. Data from TREES for 2011-2014 was made available by OBO in spreadsheet form.

Sub-meter data for the post was available via the building management system, but the data is only archived for the previous eight weeks.

Diesel is used for backup power generators and motor pool. There is one storage system that both users share. There are no meters installed that measure the amount of fuel that goes to each end user. The power supply is stable and the backup generators are rarely used. Some diesel is consumed by the generators to exercise the machines, but the Post does not measure or collect the data required determining this quantity. In addition, no electric meters are installed downstream of the generators, so the efficiency of the machines was not directly measured during the audit. The energy generated in the power plant is distributed through the compound electrical infrastructure to all facilities on the post. An estimate for diesel consumption is provided below. Because the backup generators are rarely used and located outside of the Chancery and Annex, Diesel energy use is not considered as a contribution to total energy use for either building.

The power plant houses three 1,100 kW Cummins Onon 1250 DFLC gensets. Based on a monthly exercise for each generator of 20 minutes and a nominal diesel flow rate of 330.5 L/hr, it is estimated that 3970 L of diesel are used to exercise the generators each year.[13][14] Based on average diesel costs in Peru, to annual fuel cost to exercise the generators is approximately $4,400/year.

[13] http://www.cumminspower.com/www/Commercial/Datasheets/Emissions/eds-125.pdf
[14]http://www.hsb.com/HSBGroup/uploadedFiles/HSB_COM/Information_Resources/447%20%20%20Recommended%20Practice%20for%20Maintaining%20Emergency%20and%20Standby%20Engine-Generator%20Sets.pdf

## Utility Benchmarking

TREES data is available for both the Annex and Chancery buildings. A full TREES report not yet been provided by OBO. Therefore the buildings have been analyzed as if they do not have TREES data.

There is not enough information to determine how accurate the TREES data is. While there are sub-meters, there is no data archive to check the readings. MAR1 and OMR6 are two recommendations, which, if implemented by the Post will provide the data required to evaluate the integrity of the TREES data.

The Post is a fairly unique building for Lima considering the extent its security requirements drive operational practices. To compare the Annex and Chancery building to other buildings, similarly sized secure buildings in the Washington, DC area were chosen. The comparison is shown in Table 12. One key energy use factor that is different between the Post and the buildings selected for comparison is the number of heating degree days. Conditions in Lima do not allow for economizer cooling that saves significant energy at buildings A, B, and C during the winter.

All of the buildings in Table 12 have significant computing requirements. Building A, for example, is a headquarters building for government agency and was constructed with similar blast and CBR risk mitigation features as the Post. Building A has submetered all high density computing equipment and is able to consider the energy use from that equipment separately in Portfolio Manager. Despite the building's significantly higher EUI than the buildings on Post, approximately 20% of that energy is for computing equipment.

**Table 12 Comparison with Similar Buildings**

| Building | Year Built | Occupant Density Sq. ft./FTE | Weekly Op Hours | EUI (Site) kBTU/sq. ft./yr | Cost $/sq. ft./yr. | Energy Star Rating |
|---|---|---|---|---|---|---|
| A | 2012 | 294 | 78 | 108.7 | $2.59 | 81 |
| B | 1999 | 459 | 72 | 66 | $2.48 | 84 |
| C | 1991 | 509 | 56 | 66 | $3.29 | 79 |
| Lima Annex | 2002 | 413 | 55 | 66.2 | $1.64 | 47 |
| Lima Chancery | 1996 | 335 | 55 | 71 | $2.00 | 39 |

## Energy Use Analysis

The facility has eleven electricity meters and seven water meters. These meters are read on a monthly basis and tracked in an excel spreadsheet by the post.

The electricity and water meter reading spreadsheets appear to have significant data recording errors. 15% of the data points are either missing or not correct. Where errors exist, the data appears to be missing a digit or is provided with one too many. (e.g. 8755102 instead of 87551)

Electricity meters appear to have been installed per the Facility Meter Application Guideline for US DOS BOBO dated 2/28/2009. The previous section discusses metering infrastructure at the Compound in greater detail.

Utility bills from Luz Del Sur, the electric utility providing service to the Post, are a second source of information for this analysis. Paper copies of past bills were available for 1998, 1999, and 2002 to present. Full years of bills were not available for 1995, 1996, 1997, 2000, and 2001. The baseline year for compliance with federal sustainability regulations is 2003. Total annual energy use for the compound is shown below in Table 14.

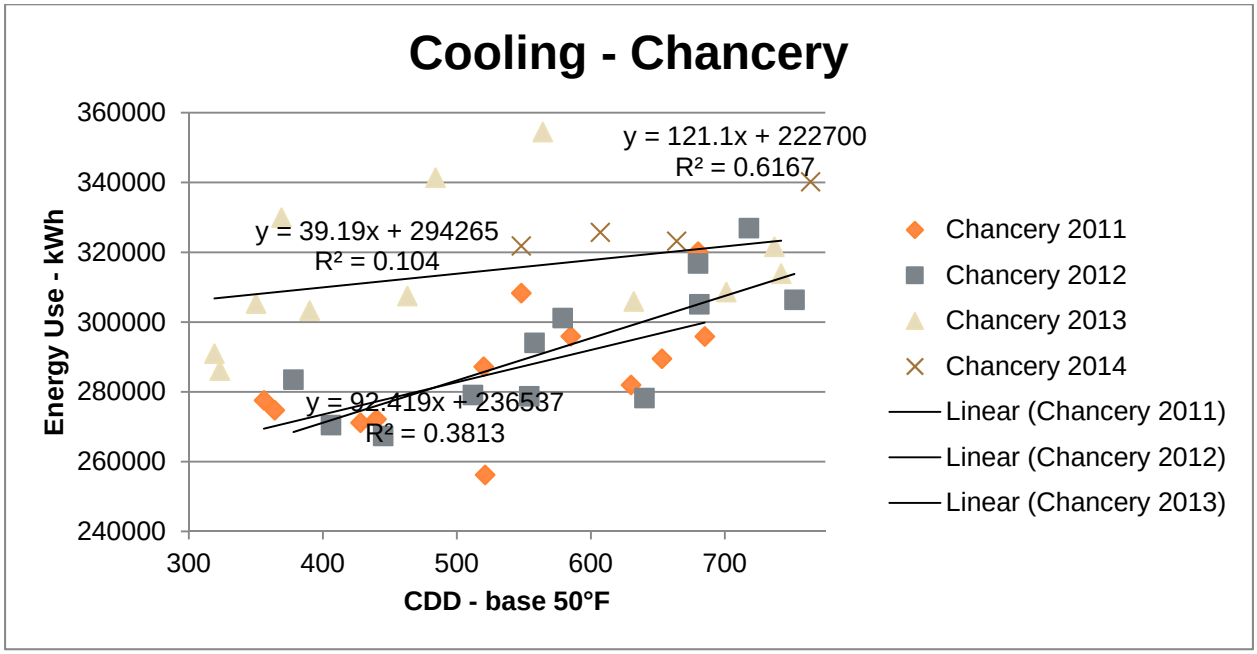
I investigation of the utility bills began with a weather normalization exercise. The correlation between monthly energy use and heating and cooling degree days was tested. It was determined that there is no significant correlation between energy use and weather at the facility. $R^2$ values for a linear regression of HDD or CDD and energy use are all less than 0.8. These $R^2$ values indicate that HDD and CDD do not explain the variations in month to month energy use. See Figure 8 and Figure 9 for scatter plots showing the analysis. The conclusion from this step is that factors other than weather are more useful in explaining the month to month variation in energy use. Some of these factors likely include lighting, plug loads, and number of occupants.

The second step in a weather normalization exercise is to determine if a constant base use can be set aside and the remaining variable energy use be compared against weather conditions. The meter read dates provided appear to be estimated as they always fall on the first day of the month. Considering weekends, holidays, and days off, this is very unlikely. Full months were assumed in this analysis.

A simplified model based on 2011 energy consumption and weather was created to determine if there have been any significant changes to the facilities performance in the last three years. The model is a spreadsheet that assumes energy use is proportional to the days of service, number of CDD, and number of HDD. The specific parameters are shown in Table 11. In 2012, the facility consumed 13% less energy than predicted by this model. In 2013, the facility consumed 1% less energy than predicted by this model. As shown in Figure 9 and Table 11 Simplified Normalization Parameters, however, there is very low correlation between weather and energy use. This is because most of the energy use is based on the internal loads of the building. In the year ending June 2014, the analysis period for this audit, buildings showed an energy use 36% less than the model based on a 2011 Baseline. A new baseline was created to show where energy use shifted during this period. The weather normalization analysis shows a shift from weather dependent variables to steady state loads (lighting, plugs, computing, internal cooling). This can be explained by a reduction in outside air intake as a result of the environmental security upgrade.

**Table 11 Simplified Normalization Parameters**

| Parameter | 2011 Baseline | 2014 Baseline |
|---|---|---|
| **kWh/day** | 11248 | 14462 |
| **kWh/CDD** | 283 | 82 |
| **kWh/HDD** | 369 | 103 |



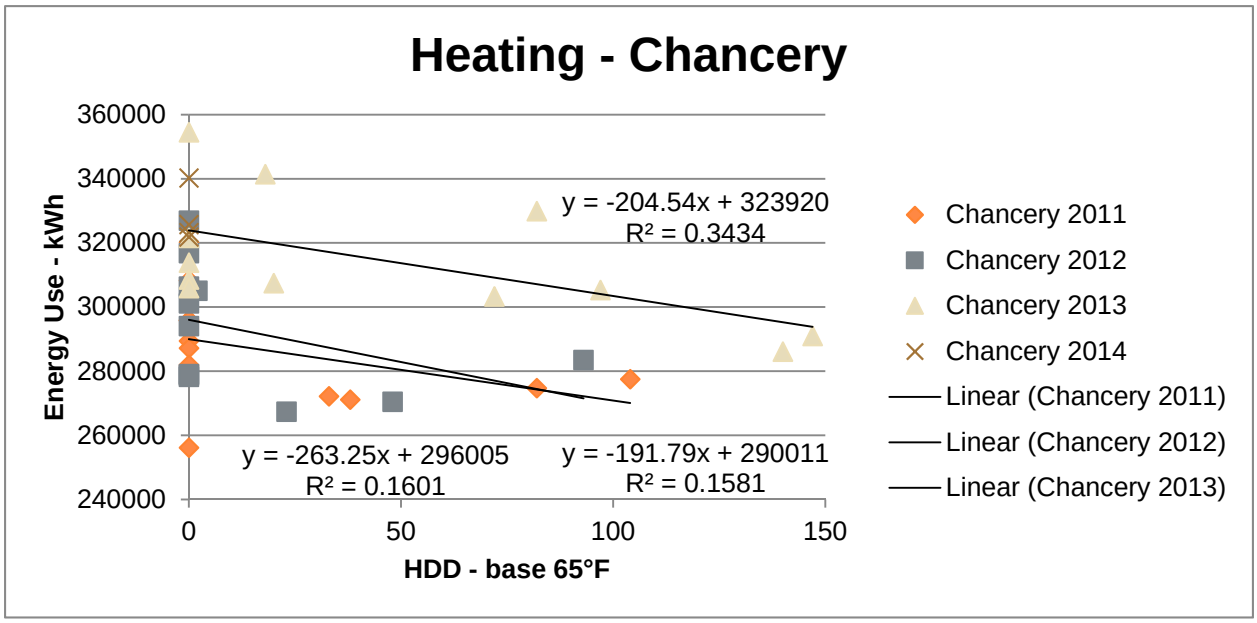
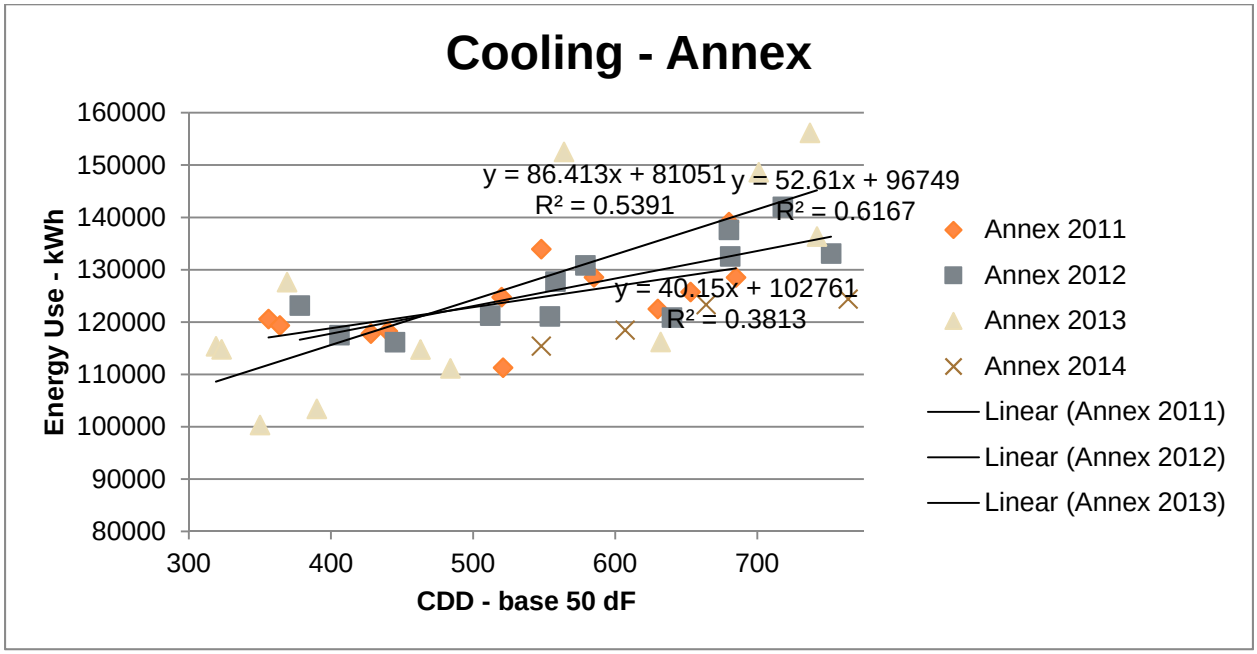




**Figure 8 Energy use as a function of weather - Chancery**



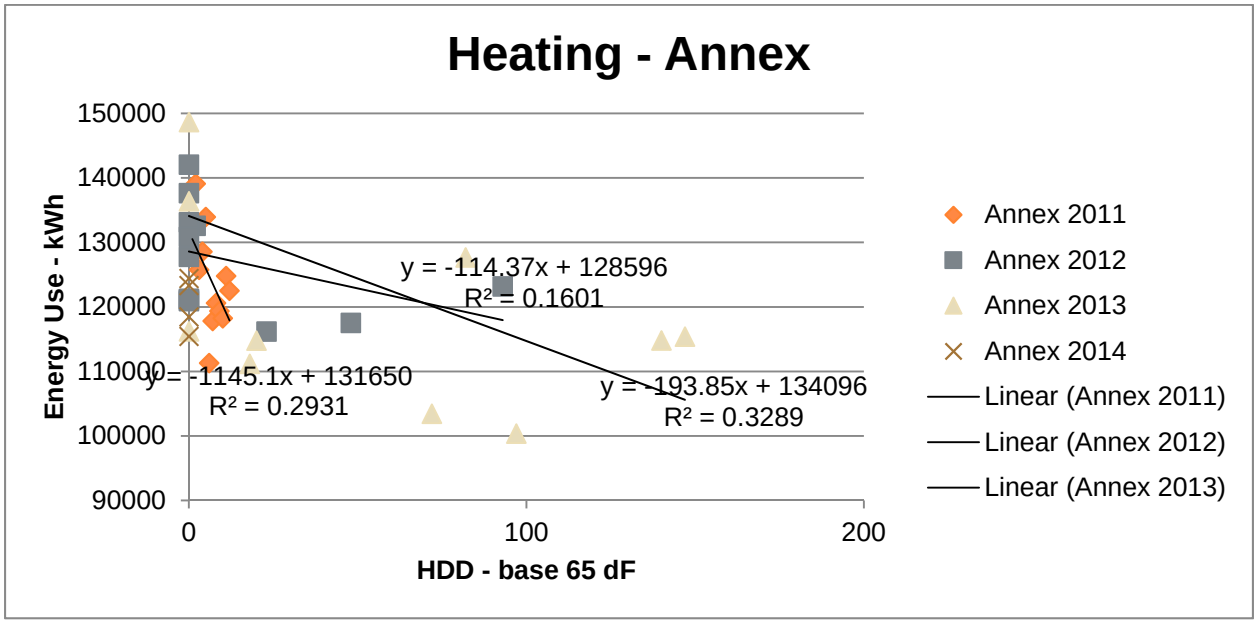




**Figure 9 Energy use as a function of weather - Annex**

Energy use in the Chancery and Annex is very even throughout the year. Figure 11 shows monthly energy use for the Chancery and Annex for 2013. The Annex uses only 25% of the Compound's total energy use and about 40% as much energy as the Chancery.

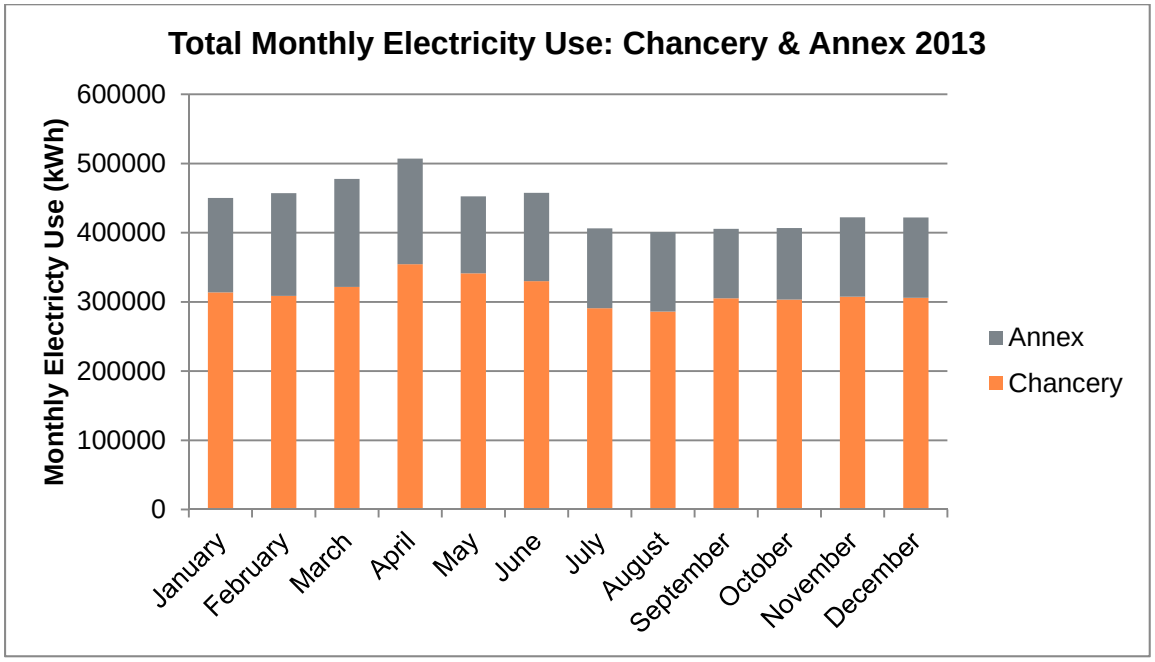



**Figure 10 Total Monthly Electricity Use: Chancery & Annex 2013**

Year over year since 2011, no major changes in energy use are indicated by the data. Figure 11 shows the monthly energy use for the Compound from January 2011 until May 2014. The figure does not indicate any major changes concerning the building's energy use pattern.

Understanding the energy end-use breakdown is a challenge for the facility. There are many things known about the facility and that can be defined. However, classified areas were not included in this audit. The end-use breakdowns shown in Figure 12, Figure 13, and Figure 14 were developed using an equivalent full load hours calculation along with information about the facility's equipment and operations. It shows an expected end-use breakdown for an office building.

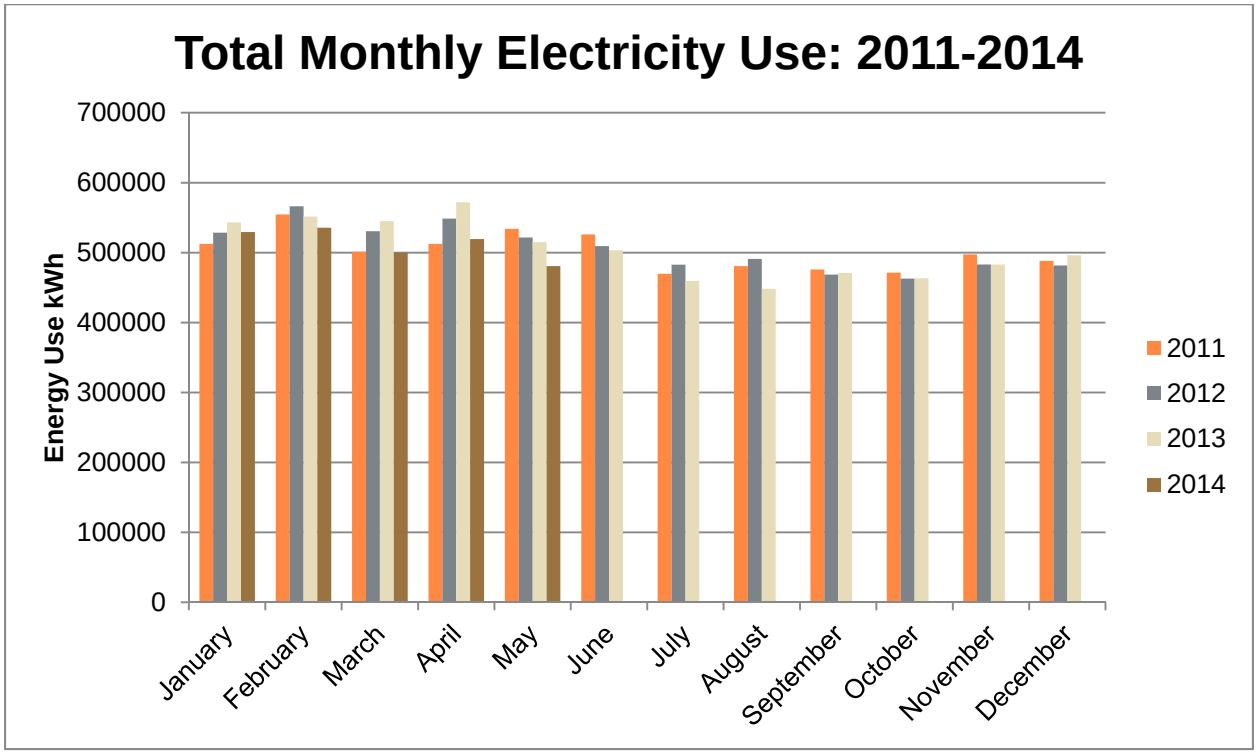



Figure 11 Compound Monthly Electricity Use 2011-2014

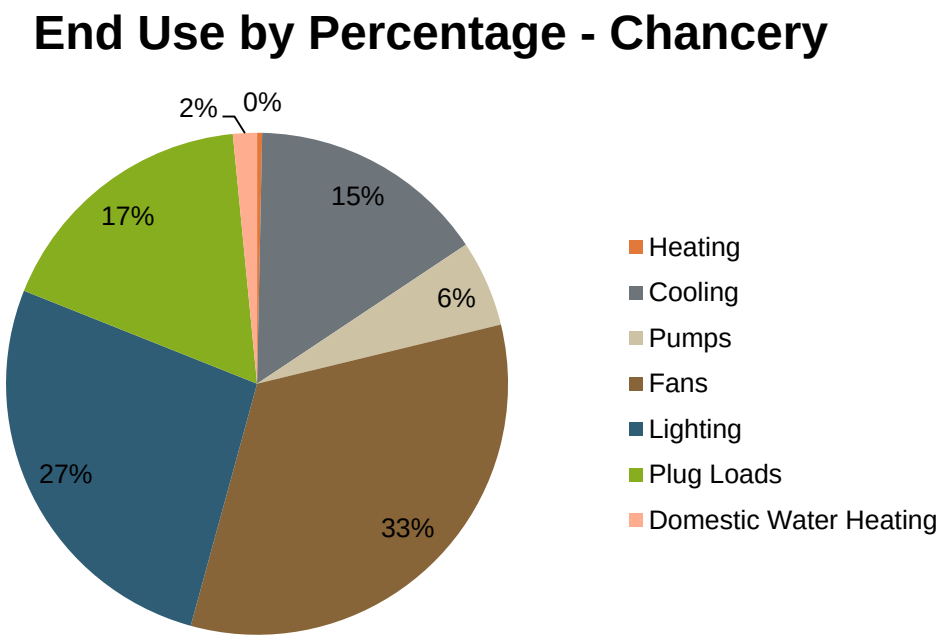



Figure 12 Lima Chancery Energy End Use Breakdown

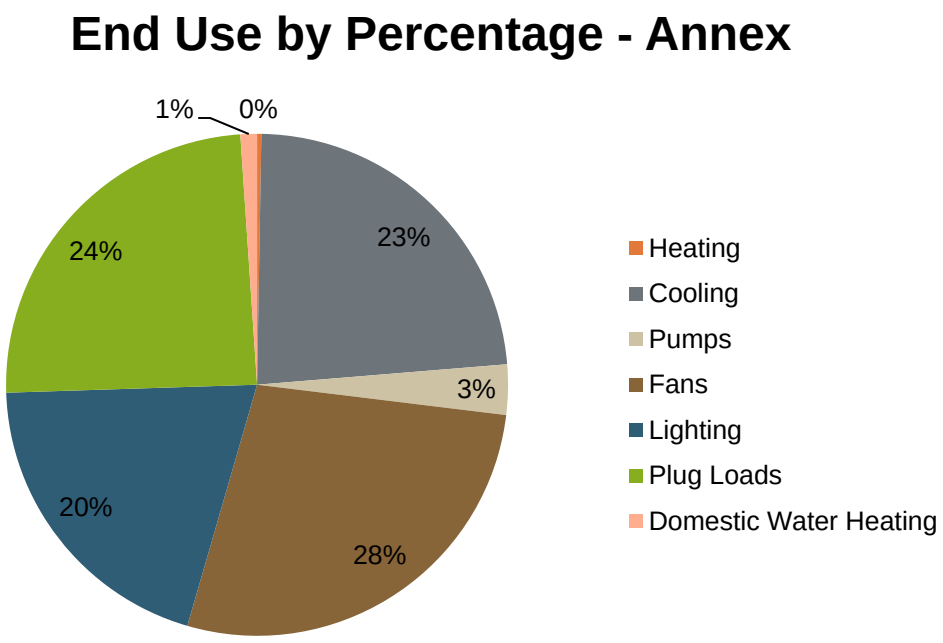



**Figure 13 Lima Annex Energy End Use Breakdown**

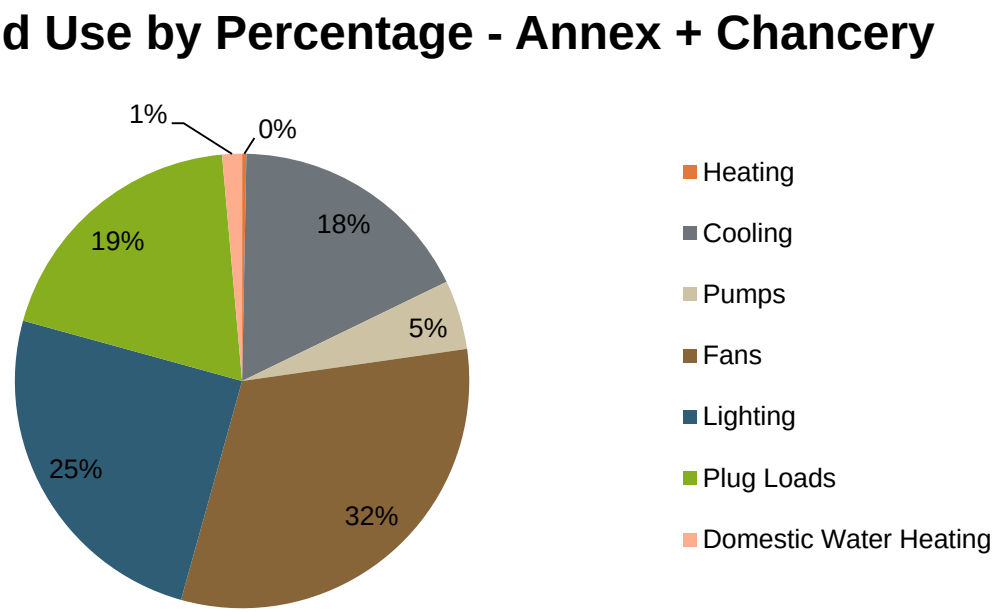
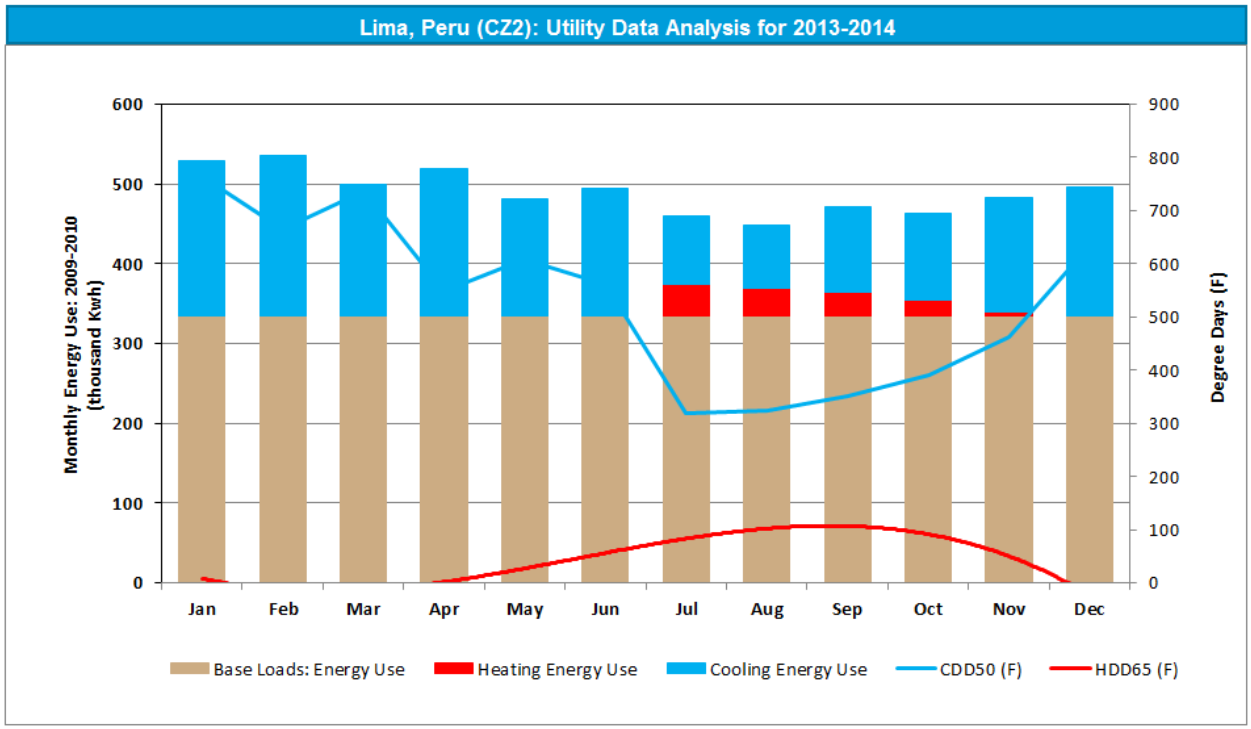



**Figure 14 Lima Chancery and Annex Energy End Use Breakdown**

Figure 16 illustrates the relationship between energy consumption and either Cooling Degree Days (CDD) or Heating Degree Days (HDD). Cooling degree days are a measure of how much (in degrees), and for how long (in days), the outside air temperature was above a certain level. Heating degree days are a measure of how much (in degrees), and for how long (in days), the outside air temperature was below a certain level. They are commonly used in calculations relating to the energy consumption required to heat buildings. Base loads (shown in tan on chart) represent energy use by lights & plug loads.




| | Base Loads | Heating Loads | Cooling Loads |
|---|---|---|---|
| % of total | **68%** | **2%** | **30%** |

**Figure 15 Lima Compound Load Profile Curve**

Figure 16 shows that the Lima Post facilities Heating and Cooling energy consumption match demand as indicated by Degree Days. The Post's HVAC systems are relatively well behaved. This type of comparison, degree days vs. energy consumption with respect to time is useful to quickly identify exceptions to expected performance.

While Lima is primarily a cooling demand climate, winter months show nominal heating <10,000 kWh during "peak" heating season (Jul-Oct). Cooling demand falls off during heating months but, even in winter, afternoon solar gain develops and cooling uses double the amount of energy, >200,000 kWh when compared to heating. Peak cooling demand (Dec-Jun) uses as much as 4 times more, >400,000-500,000 kWh energy compared to heating.

# ENERGY CONSERVATION MEASURES

The Energy Conservation Measure (ECMs) identified as a result of this audit are presented in detail in Table 15. The ECMs presented are the result of a proven process of energy analysis that aligns with ASHRAE Level 2 Audit guidelines. This process included three distinct activities:

1. Utility data was analyzed to establish baseline energy use and demand, compare the facilities to others, and identify potential areas of energy use reduction.
2. A walk-through of the building was performed over the course of five days in July 2014 to interview operators, verify information provided by OBO and the Post, gather data to support the end-use estimate model, inspect equipment, and investigate potential opportunities to improve the buildings energy performance.
3. A non-dynamic energy model was created to model the energy use of the entire building. This model was calibrated using historic energy use data and weather data. This spreadsheet based model, along with building energy efficiency literature, and other calculations were used to evaluate potential ECMs for cost and energy savings.

Paladino identified 18 energy conservation measures (ECMs) that were explored as part of this study. Of those 18, 16 are being recommended by Paladino. The 16 ECMs are sorted into three categories: Low- and no-cost, medium-cost, and high-cost, according to the following scale:

- No- and low-cost measures = measures that have very little to no first cost associated with it and that post staff may implement easily. In this study, the maximum cost for a measure to be considered “No- and low cost” is $8,000.
- Medium cost measures = measures that require OBO funding and/or permit. In this study, the costs range from $6,000 to $100,000.
- High-cost measures = measures that may require alternative financing such as an Energy Savings Performance Contracts with support from ICASS and OBO. In this study, costs would exceed $100,000.

The recommended measures identified offer a potential energy savings $235,212 and 864 MWh of energy. Low cost measures presented are estimated to save approximately $23,153 with an implementation cost of approximately $27,650. Medium cost measures presented are estimated to save approximately $59,959 with an implementation cost of approximately $140,000. Two high cost measures are recommended. They have an annual savings potential of $29,000 and a combined implementation cost of $2.7 million. An ECM financial summary of these energy conservation measures is shown in Table 14 on the next page.

Measures were not recommended if their financial payback exceeded the useful life of the equipment or if they had a negative net present value. The only exception is the ECM1, Exterior Lighting upgrade, because of the additional physical security considerations associated with that measure.

To sort the ECMs using a different criteria, please refer to the OBO Output Tool provided in companion to this report.

**Table 14 ECM Financial Summary**

| | | Low-and no-cost | Medium-cost | High-cost |
|---|---|---|---|---|
| FINANCIAL (ENERGY ONLY) | Net Annual Savings (US$) | $23,153 | $59,959 | $29,000 |
| | First Costs (US$) | $27,650 | $139,548 | $2,655,800 |
| | Simple Payback (yrs) | 1 | 2 | 92 |
| | Financial Payback (yrs) | 2 | 3 | 41 |
| | Net Present Value (NPV) (US$) | $4,423,445 | $11,360,244 | $2,124,128 |
| ENERGY | Total (MWh/yr) | 185 | 542 | 137 |

## Table 15 Recommended Energy Conservation Measures

| Difficulty | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | $ 2,811,725 | $ 702,385 | $ 80 | $ 872 | $ 274 | $ 107,875 | $ 5,250 | $ 113,125 | 25 | 7 | $ 17,767,248 |
| | | | | | | | FIRST COST | REPLACEMENT (O&M) | | ANNUAL UTILITY SAVINGS | | ANNUAL UTILITY AND O&M COST | | | LCCA | | |
| Low-and no-cost | Medium-cost | High-cost | Strategy Categories | Conservation Measures | Notes | | First Cost ($) *Includes material and labor costs | Cost ($) *Material and Installation cost | Replacement Interval (years) | Electricity Savings (MWh) | GHG Savings (t CO2e) | Electricity Cost Savings ($) | Replacement (O&M) Cost Savings ($) | Total Savings ($) | Simple Payback (Yrs) | Financial Payback (Yrs) | Net Present Value ($) |
| | | Y | Lighting | Exterior lighting upgrade | ECM #1 | Post | $ 2,000,000 | $ - | 40 | 114 | 36 | $ 8,000 | $ (2,000) | $ 6,000 | 333 | 51 | $ (845,839) |
| | Y | | HVAC | Test, Adjust & Balance Flows on Chancery AHUs | ECM #2 | Chancery | $ 39,300 | $ - | 0 | 140 | 45 | $ 16,900 | | $ 16,900 | 2 | 3 | $ 3,211,587 |
| | Y | | HVAC | Retro-commission compound HVAC | ECM #3 | Chancery and Annex | $ 93,600 | $ - | 0 | 400 | 127 | $ 43,040 | | $ 43,040 | 2 | 3 | $ 8,185,581 |
| Y | | | HVAC | Install Timer for DHW Recirc Pump | ECM #4 | Chancery | $ 470 | $ 470 | 10 | 1 | 0 | $ 93 | | $ 93 | 5 | 5 | $ 14,753 |
| | | Y | HVAC | Replace water cooled chillers in Chancery with high-efficiency air cooled chillers | ECM #5 | Chancery | $ 658,800 | $ 700,000 | 30 | 23 | 7 | $ 17,000 | $ 6,000 | $ 23,000 | 29 | 19 | $ 2,966,967 |
| Y | | | HVAC | Implement chilled water temperature setpoint reset in Chancery | ECM #7 | Chancery | $ 720 | $ 10 | 0 | 7 | 2 | $ 694 | | $ 694 | 1 | IMMEDIATE | $ 132,682 |
| Y | | | HVAC | Chancery domestic hot water set point reduction | ECM #9 | Chancery | $ 40 | $ - | 0 | 17 | 8 | $ 1,644 | | $ 1,644 | 0 | IMMEDIATE | $ 316,200 |
| Y | | | HVAC | Reset condenser water supply temperature setpoint in Chancery | ECM #10 | Chancery | $ 675 | $ - | 0 | 10 | 0 | $ 950 | | $ 950 | 1 | IMMEDIATE | $ 182,067 |
| Y | | | HVAC | Implement optimal start/stop in Chancery and Annex | ECM #11 | Chancery and Annex | $ 5,400 | $ - | 0 | 30 | 6 | $ 2,900 | | $ 2,900 | 2 | 2 | $ 552,444 |
| Y | | | Lighting | De-lamp overhead lighting in Annex | ECM #12 | Annex | $ 4,700 | $ - | 0 | 89 | 28 | $ 12,800 | 1100 | $ 13,900 | 0 | IMMEDIATE | $ 2,669,106 |
| Y | | | HVAC | Implement BAS operator override time limits in | ECM #13 | Chancery and Annex | $ 1,850 | $ 701 | 0 | 14 | 5 | $ 1,363 | $ 150 | $ 1,513 | 1 | 2 | $ 289,184 |
| Y | | | HVAC | Implement BAS supply air temperature reset in Chancery | ECM #14 | Annex | $ 1,960 | $ 1,204 | 0 | 10 | 3 | $ 973 | | $ 973 | 2 | 2 | $ 185,168 |
| Y | | | HVAC | Repair Star lobby temperature control in Chancery | ECM #15 | Chancery | $ 3,600 | $ - | 0 | 11 | 4 | $ 1,072 | | $ 1,072 | 3 | 4 | $ 202,533 |
| Y | | | HVAC | Optimize space temperature setpoints in Annex | ECM #16 | Annex | $ 610 | $ - | 0 | 2 | 1 | $ 195 | | $ 195 | 3 | 3 | $ 36,852 |
| Y | | | Plug Loads | Reduce plug loads by eliminating desktop printers | ECM #18 | Chancery and Annex | $ - | $ - | 0 | 3 | 1 | $ 252 | | $ 252 | IMMEDIATE | IMMEDIATE | $ (332,037) |

## ECM-1 Exterior lighting upgrade for physical security

| | | | |
|---|---|---|---|
| **Estimated Savings** | **Energy** | 113,880 | kWh\/yr |
| | **Power** | 0 | kW |
| | **Maint.** | $ (2,000) | /yr |
| | **Cost** | $ 6,000 | /yr |

No on-peak power savings provided.

| | |
|---|---|
| **Cost Opinion** | $ 2,000,000 |

| | | |
|---|---|---|
| **Simple Payback** | 333 | years |

### Base Case

Approximately 44 poles, 20 wall wash lights, bollard lights, and in-wall walkway fixtures provide lighting to the Embassy compound. These fixtures use high intensity discharge lamps - the poles use mogul base 250 W high pressure sodium lamps, the wall washers use 175 W metal halide lamps, and the bollards and walkway lights use smaller lamps. Total exterior lighting power is estimated at 56kW.The current configuration allows for numerous dark spots on the post and insufficient control. In addition, the OBO lighting design standard has been updated at least twice since the lights for the post were installed. Per Dave Shaffer, the current lighting scheme is not able to meet lighting requirements for physical safety therefore this is a required upgrade for FAM compliance, rather than just an energy cost measure. Lights are controlled by a timer and photocell in parallel.

### Proposed Case

Replace existing exterior lighting system with new, LED based system that meets Foreign Affairs Manual requirements. Include zoned DDC control for various compound areas, control overrides from Marine Guard Post, energy metering for new exterior lighting system, and integration with Chancery building automation system. ECM assumes a decrease in lighting power density of 50%.

This measure is **recommended** for implementation because of physical security requirements.

### Energy Savings

Current installed lighting power density is 56 kW. Assumed new lighting power density is 28 kW. Hours of operation per year are 4380 or 12 hours per day.

| | | | |
|---|---|---|---|
| Decrease in lighting power | | 26 | kW |
| Hours/year | | 4,380 | hrs |
| Savings/year | | 113,880 | kWh |
| Energy cost | $ | 0.095 | per kWh |
| Energy cost savings | $ | 10,000 | |

### Maintenance Savings

Current operations use lamps with 25,000 hour lives. They require replacement every 5 years. Current LED lamps are rated at between 40,000 and 50,000 hrs. A labor rate of $15/hr and 0.25 hrs/lamp were assumed. Replacement LED lamps currently cost 5-6 times existing HID lamps.

| | | | | | |
|---|---|---|---|---|---|
| Labor/hr | $ | 15.00 | | $ | 15.00 |
| Current Hours | | 25000 | LED hours | | 45000 |
| Current lamps/yr | | 45 | LED lamps/yr | | 25 |
| Current replacement cost | $ | 15.00 | LED rep cost | $ | 75.00 |
| Annual relamp costs | $ | 1,005 | | $ | 2,048 |
| Maintenance cost savings | $ | (2,000) | | | |

## Cost Opinion

The proposed energy conservation measure is motivated by security considerations, and will also produce energy cost savings. A one-for-one swap of existing lamps with LEDs is possible and would be more cost effective, but would not meet the required lighting levels, zoning or have the required controllability to comply with OBO's current standards. To that end, a total replacement is recommended to address both security and energy efficiency concerns.

| | Low | High |
|---|---|---|
| Cost per SF | 1 | 2 |
| Cost total | 1000000 | 2000000 |

## Measurement and Verification

IPMVP Option A - Partially Measured Retrofit Isolation - record burn time before and after installation of new lighting system, document lighting power before and after installation.

## Additional Considerations

Security - site lighting does not meet standards for illumination level or controllability. There are numerous dark spots on the Post that should be addressed in a whole-Compound, systematic way.

## ECM-2 Test, Adjust & Balance Flows on Chancery AHUs

| | | | |
|---|---|---|---|
| **Estimated Savings** | **Energy** | 140,000 | kWh\/yr |
| | **Power** | 25 | kW |
| | **Maint.** | $ - | /yr |
| | **Cost** | $16,900 | /yr |

| | |
|---|---|
| **Cost Opinion** | $39,300 |

| | | |
|---|---|---|
| **Simple Payback** | 2.33 | years |

### Base Case

In 2011, single zone constant volume, chilled water air handling units were replaced by multizone, constant volume, chilled water air handling units. The replacement was done as part of an environmental security upgrade. The goals of the project were to provide minimum levels of filtration as required by OBO standards and improve building pressurization control. Our field observations and investigation of the control sequences programmed for these units indicate that air flows were not set and the units were not commissioned upon installation.

### Proposed Case

Retain a qualified testing, adjusting, and balancing company to measure and set outside air damper positions, relative return air damper/relief air damper positions, perform a proportional balance on the chilled water distribution system, and document findings in a certified report. Balance to be performed to OBO Standards which reference ASHRAE 62.1 - Ventilation for Acceptable Indoor Air Quality.

This measure is **recommended** for implementation because it has a net present value of $26,891,121 and an immediate financial payback.

### Energy Savings

Energy savings potential for testing and balancing can be estimated at 10% of fan and pump energy use for the chancery. The savings is achieved by reducing air and water flow, which reduces pump and fan energy use.

### Maintenance Savings

No maintenance savings predicted.

### Cost Opinion

Testing, adjusting, and balancing cost is based on the type, size, and complexity of equipment being balanced. For the Chancery, all AHUs should be balanced. Parameters to be balanced - supply air flow, return air flow, relief air flow, outside air flow, and chilled water flow. Note: Additional cost is incurred because of the security requirements of the building and its location.

| Item | QTY | Cost | Unit | Total |
|---|---|---|---|---|
| Travel | 2 | 5000 | each | 10000 |
| AHUs | 13 | 1750 | each | 22750 |
| Contingency | 1 | 0.2 | percent | 6550 |
| Total | | | | $39,300 |

### Measurement and Verification

IPMVP Option A - Partially Measured Retrofit Isolation based on changes in supply air flow rates at each air handler. Prior to testing and balancing record baseline supply air flow rates. After testing and balancing compare new values to previously recorded ones.

### Additional Considerations

Security - it is not clear that building pressurization control is actually working. Based on the behavior of the control devices in the system, there is likely a periodic pressure fluctuation that may cause unintended infiltration.

Occupant Health and Comfort - the capability for outside air minimums exists in the building automation system, but has not been configured. As a result, there is no minimum rate of outside air flow into the building. Balancing outside air dampers effectively and setting flows would improve ventilation throughout the building.

## ECM-3 Retro-commission compound HVAC

| | | | |
|---|---|---|---|
| **Estimated Savings** | **Energy** | 400,000 | kWh\/yr |
| | **Power** | 35 | kW |
| | **Maint.** | $ - | /yr |
| | **Cost** | $43,040 | /yr |

| | |
|---|---|
| **Cost Opinion** | $93,600 |

| | | |
|---|---|---|
| **Simple Payback** | 2.2 | years |

### Base Case
In 2011, single zone constant volume, chilled water air handling units were replaced by multizone, constant volume, chilled water air handling units. The replacement was done as part of an environmental security upgrade. The goals of the project were to provide minimum levels of filtration as required by OBO standards and improve building pressurization control. Our field observations and investigation of the control sequences programmed for these units indicate that air flows were not set and the units were not commissioned upon installation.

### Proposed Case
Retain a qualified commissioning provider to facilitate a retro-commissioning process for the Chancery and Annex. Focus on HVAC systems. Select a team that can implement selected low cost system tune up measures as part of the retro-commissioning investigation phase.

This measure is **recommended** for implementation because it has a net present value of $8,185,581 and a financial payback of 3 years.

### Energy Savings
Energy savings will result from decreased overall air volume. There will be an energy penalty, however, because the air handlers currently have no minimum outside air damper position.

| | | |
|---|---|---|
| 10% HVAC Energy Use | | 400,000 |
| | $ | 40,000 |

### Maintenance Savings
A retro-commissioning process for the Chancery and Annex would improve operations, identify non-functioning equipment, provides a training-by-doing experience for the post personnel who run the building. In our experience, it is not recommend that OBO rely on potential maintenance savings to justify a retro-commissioning process.

## Cost Opinion

Retro-commissioning is a facility wide effort to test and verify mechanical systems operational performance to drive energy efficiency, extend equipment service life and save energy costs. Retro-Cx budgets based on expert level providers. Some costs may be saved if Cx engineers are familiar with the facility.

| Item | QTY | Cost | Unit | Total |
|---|---|---|---|---|
| Travel | 2 | 6000 | each | $ 12,000 |
| Labor | 400 | 165 | each | $ 66,000 |
| Contingency | 1 | 20% | | $ 15,600 |
| Total | | | | $ 93,600 |

## Measurement and Verification

IPMVP Option B -Logging Retrofit Isolation. Set up trend logs prior to implementation of any retro-commissioning measures. Allow at least 90 days of data to be recorded before implementation to ensure a sufficient sample to identify changes resulting from retro-commissioning measures.

## Additional Considerations

Training - a well-executed commissioning process would be guided by a skilled consultant and, in large part, executed by the post. The long term goal being that the post integrate on-going commissioning activities into normal operations.

Cost effectiveness and timing - it would likely be most cost effective to implement this measure along with commissioning of the Annex AHU replacement project that is scheduled for the end of FY14 or early FY15.

## ECM-4 Install Timer for DHW Recirc Pump

| | | | |
|---|---|---|---|
| **Estimated Savings** | **Energy** | 931 | kWh\/yr |
| | **Power** | 0 | kW |
| | **Maint.** | $- | /yr |
| | **Cost** | $93 | /yr |

No on-peak power savings provided.

| | |
|---|---|
| **Cost Opinion** | $470 |

| | | |
|---|---|---|
| **Simple Payback** | 5 | years |

### Base Case

The domestic hot water system for the chancery is set up in a cascade configuration. Water enters a 49°C (120°F) storage tank heated by a pair of heat pumps and an electric heating element. Then water enters a pair of 60-71°C (140-160°F) storage tanks each equipped with a 30 kW electric heater. These are equipped with timers that shut off the heating elements from 6pm to 6am Monday through Saturday and all day on Sunday. Last, water enters the hot water distribution piping. This piping is equipped with a return to maintain hot water temperature and reduce water waste. Recirculation is driven by a 0.187 kW (1/3 hp) centrifugal pump controlled by an aquastat set at 66°C (150°F).

### Proposed Case

Install a timer and relay to shut off the recirculation pump on the same schedule as the water heaters. This will reduce thermal losses during the time periods when the pump is turned off and reduce operating hours of the pump motor.

This measure is **recommended** for implementation because it has a net present value of $14,753 and a financial payback of 5 years.

### Energy Savings

Energy savings will result from decrease pump operation. There will be decreased system loss, too. These results of these calculations are below.

| | | | |
|---|---|---|---|
| Motor Size | 0.33 | hp | |
| Load Factor | 0.75 | | estimate |
| Motor Power | 187 | W | |

Current Annual Pump Energy Use

| | | |
|---|---|---|
| Est. Time On* | 6864 | Hrs |
| Energy Use | 1280 | kWh |

* 6pm plus 6am M-Sa, all day Su, plus half of the remaining time

Pump Energy Use with Timer

| | | |
|---|---|---|
| Est Time On* | 1872 | Hrs |
| Energy Use | 349 | kWh |

* Half of the time 6am to 6pm M-Sa

Pump Energy Use Savings 931 kWh

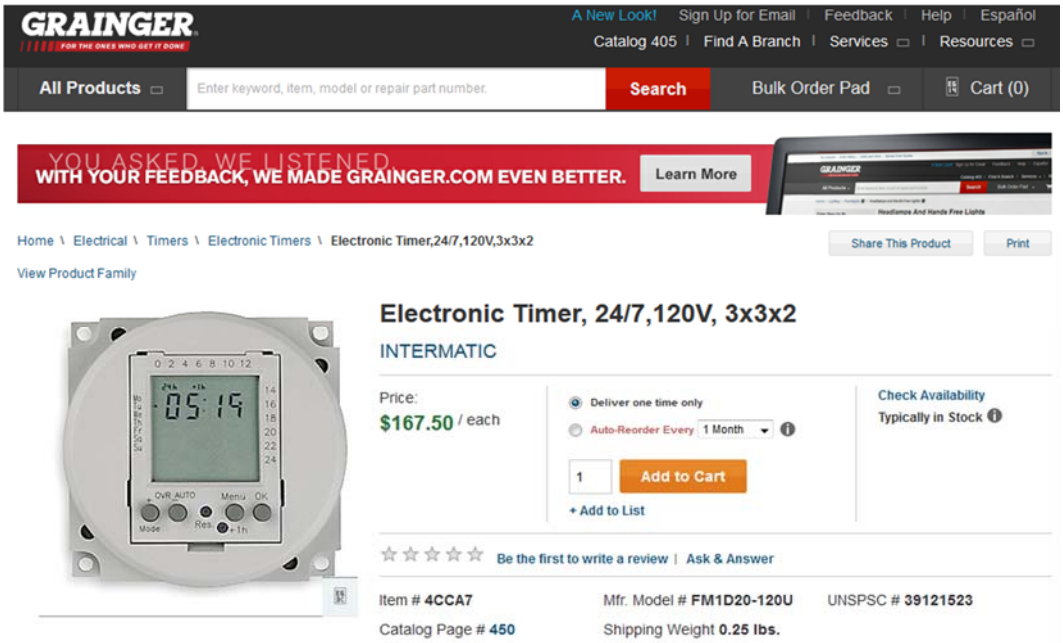
### Maintenance Savings

This measure will not change the life of the pump or water heaters. Annual inspection of the timer should be added to the preventive maintenance plan. This could be included in the preventive maintenance checklist of the circulating pump with little or no impact on maintenance costs.

### Cost Opinion

Installation of the timer and relay can be accomplished in-house. An in-house electrician rate of $40/hr is assumed. Parts are quoted from Grainger.

| Item | QTY | Cost | Unit | Total |
|---|---|---|---|---|
| Timer | 1 | 200 | each | 200 |
| Wiring & Conduit | 20 | 1400 | mlf | 28 |
| Labor | 4 | 40 | hours | 160 |
| Contingency | 1 | 0.2 | | 78 |
| Total | | | | 470 |




### Measurement and Verification

IPMVP Option A - Partially Measured Retrofit Isolation - install temporary inductive

### Additional Considerations

http://www.grainger.com/ec/pdf/Intermatic-FMDSeries%20Instructions.pdf

### References

http://www.aceee.org/files/proceedings/2010/data/papers/2220.pdf

## ECM-5 Replace water cooled chillers in Chancery with high-efficiency air cooled chillers

| | | | | | | |
|---|---|---|---|---|---|---|
| **Estimated Savings** | **Energy** | 23,000 | kWh\/yr | **Water** | 6,789 | m3/yr |
| | **Power** | 0 | kW | No change in peak power. | | |
| | **Maint.** | $6,000 | /yr | | | |
| | **Cost** | $17,000 | /yr | | | |

| | | |
|---|---|---|
| **Cost Opinion** | $658,800 | |

| | | |
|---|---|---|
| **Simple Payback** | 29 | years |

### Base Case

The Chancery is served by a pair of Trane CenTraVac water cooled chillers. These chillers were installed when the building was constructed and have about ten years left in their useful life. The chillers are identical 250 ton machines with a full load efficiency rating of 0.62 kW/ton. The cooling towers are a Peruvian make and appear to be approximately five years old. Standard practice would suggest these have approximately ten years left in their useful life, but, based on the hardness of the water the towers may have only six to eight years before they must be replaced.

### Proposed Case

Replace the existing chillers with high efficiency air cooled chillers. Run electrical service to support new chillers from mechanical room to roof. Repurpose condenser water piping to roof as a chilled water supply. Provide temporary chilled water during installation.

This measure is **recommended** for implementation because it has a net present value of $2,969,967 and a financial payback of 19 years.

### Energy Savings

While there is an increase in COP or EER by switching from a water-cooled to an air-cooled system. The elimination of cooling towers, four hydronic pumps, and two large fans results in a net energy savings. In addition, this measure will eliminate cooling tower water use.

| | | |
|---|---|---|
| Current chilled water plant energy use: | 778,000 | kWh |
| Proposed chilled water plant energy use: | 755,000 | kWh |
| Savings: | 23,000 | |

### Water Savings

Cooling tower water use is one of the Post's top three water users.

| | | |
|---|---|---|
| Cooling tower water use: | 1.55 | m3/hr |
| Time: | 4380 | hours/yr |
| Water use: | 6789 | m3/yr |
| Water cost savings: | $ 8,900 | |

Calculated assuming an average wet bulb temperature of 18.3°C.

Estimated using SPX's cooling tower Water Usage calculator

http://spxcooling.com/green/leed/water-usage-calculator/

### Maintenance Savings

Cooling tower maintenance can be substantially reduced. In addition, R-123 can be eliminated from the compound. R-123 is approximately twice the price of R-134a.

| | | | |
|---|---|---|---|
| 1st refrigerant charge cost savings | $ | 3,000 | (one-time) |
| Cooling tower annual maintenance | $ | 2,000 | |
| Chiller maintenance savings | $ | 4,000 | |
| Total Annual Maint. Savings | $ | 6,000 | |

### Cost Opinion

Professional mechanical design/build contractor or MEP plan & spec consultants required for successful implementation.

| Item | QTY | Cost | Unit | Total |
|---|---|---|---|---|
| Air Cooled Chiller | 2 | 174500 | each | 349000 |
| Electrical Upgrade | 1 | 50000 | each | 50000 |
| Demo | 1 | 50000 | hours | 50000 |
| Install | 1 | 100000 | total | 100000 |
| Contingency | 0.2 | | | 109800 |
| Total | | | | $658800 |

### Measurement and Verification

IPMVP Option C – Whole Facility bill analysis. Compare whole building energy performance for the Chancery before and after the retrofit to determine savings. The retrofit impacts numerous pieces of equipment and the exact performance of the equipment is highly weather dependent.

### Additional Considerations

1. OBO Policy – air cooled chillers reflect the current approach being adopted by OBO.
2. Resiliency – air cooled chillers are less sensitive to water quality and supply than water cooled chillers. In addition, there are fewer failure points, an easier to operate system, and less risk for legionella compared to the existing system.
3. This measure is recommended for further analysis.

#### References

http://spxcooling.com/green/leed/water-usage-calculator/

RS Means Mechanical 2014

RS Means Facilities 2013

## ECM-6 Install variable speed drive for cooling tower fans

| | | | |
|---|---|---|---|
| **Estimated Savings** | **Energy** | 2,300 | kWh\/yr |
| | **Power** | 0 | kW |
| | **Maint.** | $(100) | /yr |
| | **Cost** | $119 | /yr |

No change in peak power.

| | | |
|---|---|---|
| **Cost Opinion** | $ | 8,150 |

| | | |
|---|---|---|
| **Simple Payback** | 69 | years |

### Base Case
Existing two cooling towers fans are either on or off. It is not possible to vary fan speeds to match actual demand and variable chiller load conditions.

### Proposed Case
VFD control of fans will allow proportional response to demand thus matching loads and reduce current inrush by eliminating across the line starts.

This measure is **not recommended** for implementation because it has a negative net present value.

### Energy Savings
Variable speed control of fans will save power incrementally compared to on-off sequence.

Using Alliant Energy's VFD Calculator

| | | |
|---|---|---|
| 7.5hp fan | 2,300 | kWh |

### Maintenance Savings
This measure will not significantly extend life of existing pumps and fans but will eliminate contactor and relay replacement cycles.

| | | | |
|---|---|---|---|
| Maintenance cost savings | $ | (100) | (1 contactor or capacitor per year parts and labor) |

### Cost Opinion
Journey level task for electrician and Expert level task DDC technician for controls programming. VFD cost are approx. $300/hp installed

| Item | QTY | Cost | Unit | Total |
|---|---|---|---|---|
| VFD | 2 | 2250 | each | 4500 |
| Relay | 2 | 125 | each | 250 |
| Electrician Labor | 16 | 125 | hours | 2000 |
| Controls Technician | 4 | 225 | hours | 900 |
| Total | | | | $ 8,150 |

### Measurement and Verification
IPMVP Option A - Partially Measured Retrofit Isolation. Trend cooling tower run time using the building management system prior to installation of the retrofit. Trend VFD energy use after installation. Use a 90 day interval for prior and post retrofit. Compare total energy use during each period.

### References
Typical VFD materials only pricing from Grainger

Alliant VFD Energy Savings Calculator

## ECM-7 Implement chilled water temperature setpoint reset in Chancery

| | | | |
|---|---|---|---|
| **Estimated Savings** | **Energy** | 7,300 | kWh\/yr |
| | **Power** | 0 | kW |
| | **Maint.** | $- | /yr |
| | **Cost** | $694 | /yr |

No change in peak power.

| | |
|---|---|
| **Cost Opinion** | $720 |

| | | |
|---|---|---|
| **Simple Payback** | 1 | years |

### Base Case
The chilled water system in the Chancery operates based on a constant chilled water supply temperature setpoint of 7°C. This means that even in low load conditions, when the difference between return and supply temperatures is much lower than design conditions.

### Proposed Case
Implement a chilled water supply temperature reset scheme to increase the chilled water temperature set point in times of low load. The reset should be based on chilled water control valve position. The BMS should poll the position of the valves and maintain the position of the most open chilled water valve at 90%. The minimum temperature setpoint should be 7°C and the maximum should be 10°C.

This measure is **recommended** for implementation because it has a net present value of $132,682 and an immediate financial payback.

### Energy Savings
Studies indicate a 0.5 to 1.5% decrease in HVAC energy savings. A savings factor of 1% was applied to HVAC energy use.

| | | |
|---|---|---|
| Current SCHWP Energy Use | 49,012 | kWh |
| Proposed SCHWP Energy Use | 41,660 | kWh |
| Estimated Energy Savings | 7,300 | kWh |

### Maintenance Savings
No expected maintenance savings.

### Cost Opinion
Controls program modifications require an Expert level DDC technician for controls programming.

| | Item | QTY | Cost | Unit | Total |
|---|---|---|---|---|---|
| Program CHWST Reset | BAS | 4 | 120 | hours | 480 |
| | Test | 2 | 120 | hours | 240 |
| | Total | | | | $ 720 |

### Measurement and Verification
IPMVP Option A - Partially Measured Retrofit Isolation. Create at least a 90 day baseline of the VFD command for the secondary chilled water pumps. Compare this baseline to a 90 day trend of the same value after implementation of the ECM.

### References
http://buildingretuning.pnnl.gov/documents/pnnl_21569.pdf

## ECM-8 Implement chilled water differential pressure setpoint reset in Annex

| | | | |
|---|---|---|---|
| **Estimated Savings** | **Energy** | 344 | kWh\/yr |
| | **Power** | 0 | kW |
| | **Maint.** | $- | /yr |
| | **Cost** | $33 | /yr |

No change in peak power.

| | |
|---|---|
| **Cost Opinion** | $7,625 |

| | | |
|---|---|---|
| **Simple Payback** | 224 | years |

### Base Case
Annex AHUs maintain the supply air temperature at 16°C (61°F) by modulating 3-way valves at chilled water coils. VFDs control fan speeds to maintain 1.0" wc duct pressure. Chilled water pumps run at constant speed in occupied mode, off in unoccupied mode.

### Proposed Case
Implement a chilled water differential pressure setpoint reset. This sequence would check all the valves' position served by the loop to reset the differential pressure and is recommended by the ASHRAE Handbook – Application (ASHRAE, 2011). It is recommended that every 5 minutes the chilled-water valves' position should be checked or polled. If more than one valve has been saturated at 100%, increase the differential pressure set point by a fixed value (e.g., 5% of the design value). Otherwise, if any of the valves is less than half-open, decrease the differential pressure set point by the same amount.

This measure is not recommended for implementation because it has a negative net present value.

### Energy Savings
Energy savings will result from nominal reduction in pump kW

| | | | | |
|---|---|---|---|---|
| Annual Operating Hours | | 2,087 | | |
| Potential Energy Savings | | 0.165 | 1.5% of pump kW | (11kW) |
| Annual kWh | | 344.35 | | |
| Annual kWh value | $ | 33 | USD | |

### Maintenance Savings
There are no maintenance savings or additional costs expected for this measure. This measure will not change the life of the pump.

## Cost Opinion

Expert task level: Pipe differential pressure transmitters, low voltage wiring to nearest DDC system field I/O controller and programming of BAS software re-set logic.

| Item | QTY | Cost | Unit | Total |
|---|---|---|---|---|
| Differential Pressure Transmitter | 2 | $300 | each | $600 |
| VFDs for pumps | 2 | $1,750 | each | $3,500 |
| Piping | 5 | $125 | Hrs. | $625 |
| Wiring | 20 | $100 | each DPx | $2,000 |
| Software | 4 | $225 | each DPx | $900 |
| Total | | | | $7,625 |

## Measurement and Verification

IPMVP Option A – Partially Measured Retrofit Isolation. Calculate a baseline energy profile for the chilled water pumps before implementation. After implementation set up a trend of VFD energy use. Compare the two energy profiles to determine savings.

## ECM-9 Chancery domestic hot water set point reduction

| | | | |
|---|---|---|---|
| **Estimated Savings** | **Energy** | 17,300 | kWh\/yr |
| | **Power** | 0 | kW |
| | **Maint.** | $- | /yr |
| | **Cost** | $1,644 | /yr |

No change in peak power.

| | |
|---|---|
| **Cost Opinion** | $ 40 |

| | |
|---|---|
| **Simple Payback** | Immediate |

### Base Case

The domestic hot water system for the chancery is set up in a cascade configuration. Water enters a 49°C (120°F) storage tank heated by a pair of heat pumps and an electric heating element. Then water enters a pair of 60-71°C (140-160°F) storage tanks each equipped with a 30 kW electric heater. These are equipped with timers that shut off the heating elements at from 6pm to 6am Monday through Saturday and all day on Sunday. Last, water enters the hot water distribution piping. This piping is equipped with a return to maintain hot water temperature and reduce water waste. Recirculation is driven by a 0.187 kW (1/3 hp) centrifugal pump controlled by an aquastat set at 66°C (150°F).

### Proposed Case

Reduce the domestic hot water tank on temperature setpoint to 60°C (140°F) and off temperature setpoint to 49°C (120°F). Reduce the aquastat temperature set point to 52°C (125°F).

This measure is **recommended** for implementation because it has a net present value of $316,200 and an immediate financial payback.

### Energy Savings

Energy savings will result from supply lower temperature water to satisfy domestic use demands.

| | | |
|---|---|---|
| Current est. DHW energy use: | 86,763 | kWh |
| Proposed est. DHW energy use: | 69,410 | kWh |
| Estimated energy savings: | 17,300 | kWh |

### Maintenance Savings

This measure will not change the life of the pump or water heaters or maintenance costs.

### Cost Opinion

This measure should be implemented by the Post. All that is required is manual adjustment of three thermostats located in the Chancery water pump room. A conservative estimate of one hour at $40/hour is used.

| Item | QTY | Cost | Unit | Total |
|---|---|---|---|---|
| Post Labor | 1 | 40 | hours | 40 |
| Total | | | | 40 |

**Measurement and Verification**

IPMVP Option A - Partially Measured Retrofit Isolation - monitor burn time of electric heating elements for a 90 day period before and after the measure is implemented.

## ECM-10 Reset condenser water supply temperature setpoint in Chancery

| | | | |
|---|---|---|---|
| **Estimated Savings** | **Energy** | 10,000 | kWh\/yr |
| | **Power** | 0 | kW |
| | **Maint.** | $- | /yr |
| | **Cost** | $950 | /yr |

No change in peak power.

| | |
|---|---|
| **Cost Opinion** | $ 675 |

| | |
|---|---|
| **Simple Payback** | 1 year |

### Base Case
Chancery condenser water loop temperature set point is constant and sequence is not taking advantage of BAS reset capability.

### Proposed Case
Condenser water reset saves energy by decreasing condenser loop supply temperature set-point. Chiller COP (coefficient of performance) increases after the measure is applied. However, the condenser loop will balance out system level savings because the cooling tower fan runs longer to reject the same amount of heat.

This measure is **recommended** for implementation because it has a net present value of $182,067 and an immediate financial payback.

### Energy Savings
Reset the constant condensing loop supply temperature from constant 26.7°C (80°F) to a dynamic range of 21-26.7°C (70-80°F) based on the outdoor-air wet-bulb temperature (WBT). When the outdoor-air wet-bulb temperature is below15.5°C, reset the condensing loop set point to 21°C (70°F). When the outdoor-air wet-bulb temperature is above 21°C, reset to 26.7°C (80°F); when the outdoor-air wet-bulb temperature is in between, reset the condensing supply temperature to 10°C higher than the outdoor-air wet-bulb temperature.

Chancery HVAC: 2,134 MWh/yr. 0.5% HVAC energy use 10,000 kWh
$ 950

### Maintenance Savings
There are no maintenance savings or additional costs expected for this measure.

### Cost Opinion
Task Level: EXPERT - requires BAS programming of re-set schedule

| | Item | QTY | Cost | Unit | Total |
|---|---|---|---|---|---|
| BAS | Labor | 3 | 225 | hours | $675 |
| | | | Total | | $675 |

**Measurement and Verification**
IPMVP Option A - Log condenser water temperatures

## ECM-11 Implement optimal start/stop in Chancery and Annex

| | | | |
|---|---|---|---|
| **Estimated Savings** | **Energy** | 30,000 | kWh\/yr |
| | **Power** | 0 | kW |
| | **Maint.** | $- | /yr |
| | **Cost** | $2,900 | /yr |

No change in peak power.

| | |
|---|---|
| **Cost Opinion** | $5,400 |

| | | |
|---|---|---|
| **Simple Payback** | 1.9 | years |

### Base Case
HVAC systems run from 2:30am-6pm Mondays and 6am-6pm Tuesday-Thursday for temperature control and fans run 24/7 to maintain pressure (security) control.

### Proposed Case
Re-program existing BAS systems to use optimal start/stop strategies.

This measure is **recommended** for implementation because it has a net present value of $360,084 and a financial payback of 3 years.

### Energy Savings
Start/Stop optimization sequences can save between 2%-15% of HVAC systems energy use. Maximum savings are realized in heating climates.

| | | | |
|---|---|---|---|
| 3% energy use or | 30,000 | kWh | savings based on 1000000 kWh/yr. for combined cooling systems for Annex and Chancery |
| | $ 2,900 | | |

### Maintenance Savings
There are no maintenance savings or additional costs expected for this measure.

### Cost Opinion
Task skill level: EXPERT - BAS system programming modifications required.

| | Item | QTY | Cost | Unit | Total |
|---|---|---|---|---|---|
| DDC | Labor | 24 | 225 | hours | 5400 |
| | Total | | | | $5,400 |

### Measurement and Verification
IPMVP Option A - Set up trend logs to track system start/stop times

## ECM-12 De-lamp overhead lighting in Annex

| | | | |
|---|---|---|---|
| **Estimated Savings** | **Energy** | 89,300 | kWh\/yr |
| | **Power** | 23 | kW |
| | **Maint.** | $1,100 | /yr |
| | **Cost** | $12,800 | /yr |

| | |
|---|---|
| **Cost Opinion** | $4,700 |

| | | |
|---|---|---|
| **Simple Payback** | 0.4 | years |

### Base Case

The Annex office area lighting levels at task surfaces were measured between 70 and 80 foot candles. This is almost twice the level recommended when compared to ASHRAE / IESNA standard practice.

**Proposed Case**

Remove approximately 700 overhead lamps in the open office areas.

This measure is **recommended** for implementation because it has a net present value of $2,669,106 and an immediate financial payback.

**Energy Savings**

Fewer lamps mean less energy use. The estimated savings is based on removing 700 32W T8 tubes from the overhead lighting system.

| | | |
|---|---|---|
| Current est. lighting energy | 357,462 | kWh |
| Proposed est. lighting energy | 290,427 | kWh |
| Estimated lighting energy savings | 67,000 | kWh |
| Estimated cooling energy savings | 22,333 | kWh |

**Maintenance Savings**

Removing extra luminaries reducing the cost to re-lamp the lighting system. Ten minutes per lamp at a rate of $40 per hour, assuming each lamp lasts four years.

| | |
|---|---|
| Maintenance cost savings | $1,100 |

**Cost Opinion**

De-lamping can be conducted in house. The cost is assumed at 10 minutes per lamp at $40/hour.

| | |
|---|---|
| Implementation cost | $4,700 |

**Measurement and Verification**

IPMVP Option A - Measure light levels after de-lamping, compare with base load kWh.

## ECM-13 Implement BAS operator override time limits in Chancery and Annex

| | | | |
|---|---|---|---|
| **Estimated Savings** | **Energy** | 14,347 | kWh\/yr |
| | **Power** | 0 | kW |
| | **Maint.** | $150 | /yr |
| | **Cost** | $1,510 | /yr |

No change in peak power.

| | |
|---|---|
| **Cost Opinion** | $1,850 |

| | | |
|---|---|---|
| **Simple Payback** | 1.2 | years |

### Base Case

Both DDC systems (Chancery is Honeywell and Annex is Johnson) allow building operator to leave commands in "Hand" (operator override mode). This creates opportunity for accidental modification of scheduled operation and potential for unlimited run time of overridden zones.

### Proposed Case

Define positive operator override time limits in BAS

This measure is **recommended** for implementation because it has a net present value of $289,184 and a financial payback of 2 years.

### Energy Savings

Prevent users from leaving equipment ON in hand mode

Assume 2 ton load left on cumulatively for 1 year

| | Value | Unit |
|---|---|---|
| Run time | 2,040 | Hrs. |
| BTUs | 24,000 | Hr. |
| Watts | 7,033 | Hr. |
| Kwh | 14,347 | Annual |
| | $1,360 | |

### Maintenance Savings

This measure potentially extends service life of equipment by assuring all zones follow schedules thereby reducing equipment run times.

Maintenance cost savings $ 150

### Cost Opinion

EXPERT task: Modification of DDC systems software should be done by qualified DDC controls specialist.

| | | | | |
|---|---|---|---|---|
| BAS Labor | 10 | $200 | hours | $2,000 |
| Total | | | | $ 1,850 |

### Measurement and Verification

IPMVP Option A - Update DDC O&M to define operator override limits and commission these limits annually via the preventative maintenance plan.

## ECM-14 Implement BAS supply air temperature reset in Chancery

| | | | |
|---|---|---|---|
| **Estimated Savings** | **Energy** | 10,240 | kWh\/yr |
| | **Power** | 0 | kW |
| | **Maint.** | $- | /yr |
| | **Cost** | $973 | /yr |

No change in peak power.

| | |
|---|---|
| **Cost Opinion** | $1,960 |

| | | |
|---|---|---|
| **Simple Payback** | 2 | years |

### Base Case
Supply-air temperature reset: Chancery AHUs use constant supply-air temperature set point of 12 °C (53.6 °F) (SAT-SP). When supply fan(s) system is operational, the SAT-SP value should be automatically adjusting to match load.

### Proposed Case
Occupied Mode: Re-set Logic: SP (between T-min to T-max) 0 cooling demand increase SP 0.1 °C (up to T-max), when cooling request is signaled (zone set points cannot be maintained even when modulating its VAV damper to 100% open). As more zones call for cooling SP is reduced by 0.1 °C (down to T-min)

This measure is **recommended** for implementation because it has a net present value of $185,168 and a financial payback of 2 years.

### Energy Savings
Fractional reduction on primary chilled water system

| | | | |
|---|---|---|---|
| 2% energy use or | | 10,240 | Chancery cooling input 512000 kWh/yr. |
| | $ | 1,024 | |

### Maintenance Savings
There are no maintenance savings or additional costs expected for this measure.

### Cost Opinion
EXPERT task: Modification of DDC systems software and testing should be done by qualified DDC controls specialist.

| | Item | QTY | Cost | Unit | Total |
|---|---|---|---|---|---|
| DDC | Software. | 8 | $225 | each | $1,800 |
| Post | Labor | 4 | $40 | hours | $160 |
| | Total | | | | $1,960 |

### Measurement and Verification
IPMVP Option A - Establish DDC system trend logs to track and verify performance.

## ECM-15 Repair Star lobby temperature control in Chancery

| | | | |
|---|---|---|---|
| **Estimated Savings** | **Energy** | 11,280 | kWh\/yr |
| | **Power** | 0 | kW |
| | **Maint.** | $- | /yr |
| | **Cost** | $1,072 | /yr |

No change in peak power.

| | |
|---|---|
| **Cost Opinion** | $3,600 |

| | | |
|---|---|---|
| **Simple Payback** | 3.36 | years |

### Base Case
Post HVAC staff report that Star Lobby temperature controller has failed and it was replaced with a local thermostat and return air duct sensor. Unit now operates 24/7 with cooling set point of approx. 18 °C (65 °F).

### Proposed Case
Repair or replace failed DDC controller, restore scheduled set back / set up. Adjust cooling set point to 23 °C (73 °F). Optional: leave "temporary" stat in place but adjust local set point to match Post standard.

This measure is **recommended** for implementation because it has a net present value of $202,533 and a financial payback of 4 years.

### Energy Savings
Energy savings will result from scheduled set back / set up and raised occupied mode cooling set point.

Current Energy Use for **AC 2-1**

| | | |
|---|---|---|
| kWh based on cooling set point of 18c | | |
| serving approx. 2000 cu. Meters 24/7 | 3,120 | Scheduled Hrs. |
| Load is about 20,000 btu/h @ 10 seer | 5,640 | Excess Hrs. |
| 8760 hours x 2000 w/hr. = 175,300 kWh | 11,280 | Excess kWh |

| | | |
|---|---|---|
| Energy avoided | 11,280 | kWh |
| | $ 1,072 | USD |

### Maintenance Savings
This measure will not change expected service life of cooling coil but may nominally extend fan life by now shutting unit off per schedule (approx. 60% reduction in run time).

### Cost Opinion
Replacement of DDC controller (if reported diagnosis is correct) may require controls contractor site visit.

| Item | QTY | Cost | Unit | Total | |
|---|---|---|---|---|---|
| DDC Controller | 1 | $1,800 | each | $1,800 | |
| DDC Labor | 8 | $225 | hours | $1,800 | |
| Total | | | | $3,600 | USD |

### Measurement and Verification
IPMVP Option A - verify AC2-1 performance by setting up permanent trend log in Post DDC system.

## ECM-16 Optimize space temperature setpoints in Annex

| | | | |
|---|---|---|---|
| **Estimated Savings** | **Energy** | 2,050 | kWh\/yr |
| | **Power** | 0 | kW |
| | **Maint.** | $- | /yr |
| | **Cost** | $195 | /yr |

No change in peak power.

| | |
|---|---|
| **Cost Opinion** | $610 |

| | | |
|---|---|---|
| **Simple Payback** | 3.13 | years |

### Base Case

Space temperature cooling set points currently range from 18-24 °C (64.4 - 75.2 °F). Terminal units serving open office areas have up to a 4.5 °C variance in target temperatures. Perimeter offices are served by individual terminal units with independent thermostats but most office doors were observed to be open during work hours. Effectively interior and perimeter areas are one contiguous climate control zone.

### Proposed Case

Adjust all cooling set points to a common value to prevent terminal units from "fighting". Recommended cooling set point of 23.0 - 23.3c °C (73.4 - 73.94 °F)

This measure is **recommended** for implementation because it has a net present value of $36,852 and a financial payback of 3 years.

### Energy Savings

Energy savings will result from even temperatures equalizing terminal units demand. DOE reports 2%-4% energy savings for every 1 °C target cooling set point is raised. Estimate based on raising all cooling set points 1 °C.[15]

| | | | | |
|---|---|---|---|---|
| 1% of energy use or | | 2,050 | kWh | VAV terminal units cooling input |
| | $ | 205 | USD | based on 205,000 KWh/yr. |

### Maintenance Savings

This measure will potentially extend service life of VAV terminal unit damper actuators by reducing competitive cycling. Labor savings reduction estimate based eliminating on one temperature adjust service request per zone per year measure.

### Cost Opinion

Adjustment of cooling set points (by local Post staff) and set up of trend logs (may require BAS service programming) for ongoing verification can be accomplished in about 4-6 hours (travel, if required is excluded).

| | Item | QTY | Cost | Unit | Total |
|---|---|---|---|---|---|
| BAS | Software. | 2 | 225 | hours | 450 |
| *Post | Labor | 4 | 40 | hours | 160 |
| | Total | 0 | 0 | | $ 610 |

*Assuming post staff can perform in house at $40/hr

### Measurement and Verification

IPMVP Option A - establish trend logs to verify persistence

[15] http://energy.gov/energysaver/articles/thermostats

## ECM-17 Install solar photovoltaic system

| | | | | |
|---|---|---|---|---|
| **Estimated Savings** | **Energy** | 438,438 | kWh\/yr | |
| | **Power** | 308 | kW | No change in peak power. |
| | **Maint.** | $(3,200) | /yr | |
| | **Cost** | $41,652 | /yr | |

| | |
|---|---|
| **Cost Opinion** | $2,000,000 |

| | | |
|---|---|---|
| **Simple Payback** | 48.02 | years |

### Base Case
No renewable energy is generated on site.

### Proposed Case
Install a 400 kW, grid tied photovoltaic system with no storage on Post. See Appendix D for a full description.

This measure is **not recommended** for implementation because it has a simple payback that significantly exceeds the life of the system.

### Energy Savings
The PV array will produce energy during daylight hours. A full calculation is provided in Appendix D.

| | | | |
|---|---|---|---|
| AC Capacity | | 308 | kW |
| Production Hours per year | $ | 1,424 | hrs |
| Energy produced | | 438,438 | kWh/yr |

### Maintenance Savings
FAC will have to maintain the new system. Maintenance costs are estimated at $8/kW/yr

| | | | |
|---|---|---|---|
| Maintenance cost savings | $ | (3,200) | USD |

### Cost Opinion
A rough order of magnitude estimate is $2,000,000 for the system at $5/W peak installed.

#### Measurement and Verification
IPMVP Option A - isolate the measure with meters downstream of the panels. Include temperature sensors and a solar pyrometer to verify that energy production meets the performance expectation of the system.

## ECM-18 Reduce plug loads by eliminating desktop printers

| | | | |
|---|---|---|---|
| **Estimated Savings** | **Energy** | 2,654 | kWh\/yr |
| | **Power** | 0 | kW |
| | **Maint.** | $- | /yr |
| | **Cost** | $252 | /yr |

No change in peak power.

| | |
|---|---|
| **Cost Opinion** | $0 |

| | |
|---|---|
| **Simple Payback** | Immediate |

**Base Case**
Currently there are multiple desktop printers in each building that consume power in standby mode in addition to network printers located in communal areas. Beth Kempton, OBO met with the Information Systems Officer (ISO), Chris Corlett, and the Computer Management Specialist (CMS), Alfredo Barboza. The ISO noted that the embassy has many personal USB printers. The ITC has already implemented a policy that when a personal printer is retired, they do not replace the printer for personal use. The IS office ensures enough network printers are available, but generally speaking there are numerous network printers around the Chancery and Annex.

Printers are assumed to be laser printers.

Total printer counts by building
Annex = 41 network and 27 desktop
Chancery = 37 network and 16 desktop

**Proposed Case**: Eliminate desktop printers and consolidate to existing network printers

This measure is **recommended** for implementation because it has a net present value of $48,496 and an immediate financial payback.

**Energy Savings: Remove all desktop printers**

| | Energy Use (kWh/yr) | Annex - Change in energy consumption | Chancery - Change in energy consumption | |
|---|---|---|---|---|
| Laser Small Desktop | 330 | (8,910) | (5,280) | Assumes all desktops are removed |
| Laser Large Office | 1,479 | 6,064 | 5,472 | Assumes removing desktops increases power consumption of network printers by a nominal 10% to account for increased print activity |
| | | (2,654) | Annual | |
| | | -$252.11 | USD | |

**Maintenance Savings**
This measure reduces the amount of IT hardware in the building and potentially increases the maintenance required for the network printers. Therefore it is assumed that there are no net maintenance cost savings as a result of this ECM.

**Cost Opinion**
Implementation of this option will require time from the ITC but is expected to not incur a cost to remove the printers.

**Measurement and Verification**
IPMVP Option C - Reducing plug loads will be seen through an overall reduction of energy consumption, it is not possible to isolate this ECM given the currently available electricity metering at the buildings.

**Additional Considerations**

Occupant Health and Comfort - Building occupants will require notification of the ECM. Referencing the ITC policy and revising it to prohibit desktop printers is recommended. Consider if mobility to access printers is an issue for building occupants

Estimated energy savings are conservative as the printer counts may not reflect all spaces in the building. The 2nd floor of the Chancery was not audited since it was mostly VISA status customer service. Paladino were unable to access the 4th and 5th floor areas that were Classified.

Waste Management - The printers removed represent e-waste that should be disposed of in a responsible manner by recycling where available or through donation to in country charities or NGOs linked with the Embassy's mission.

**References**

**DOE** Printer energy consumption values

## WATER USE ANALYSIS

The Post receives potable water from Sedapal and non-potable water from Lima. The non-potable water meter was not functioning during the site visit. Water provided by Sedapal is metered. The monthly meter data for 2013 is shown in Figure 17 Lima Annex & Chancery Monthly Water Use. There is no discernible trend to explain water use patterns. The largest user of water is the restrooms, the second is cooking. End use allocations are estimated in Table 16.

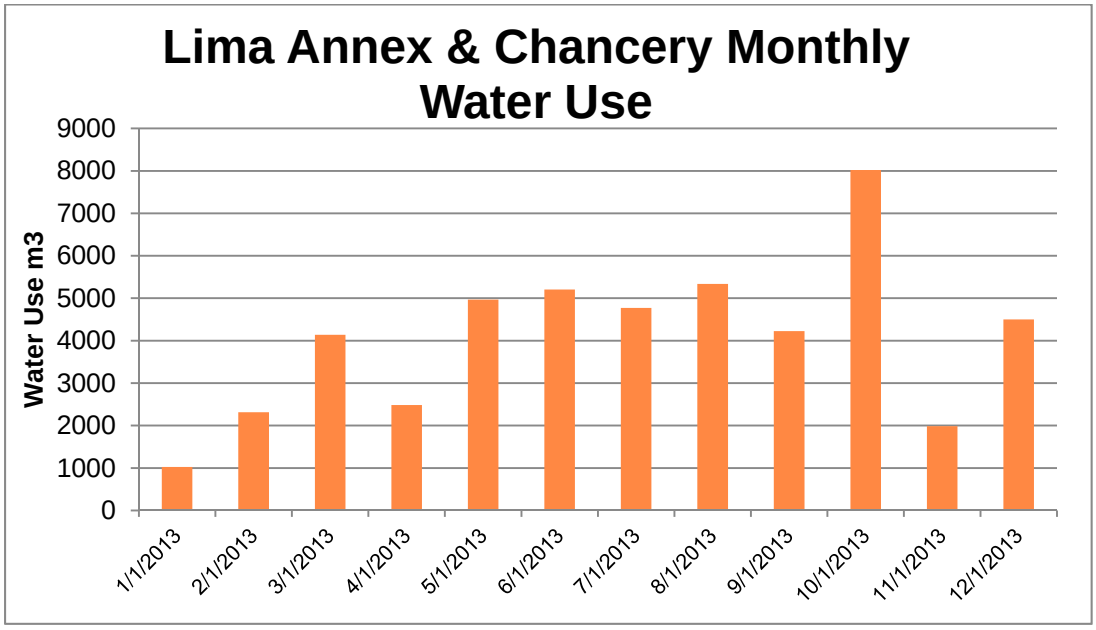



**Figure 16 Lima Annex & Chancery Monthly Water Use**

The quantity of water used for irrigation is not known. During the site visit, the meter was observed to be inoperative. In addition, no long term trend is kept of the meter and the meter read logs are do not have consistently reliable data.

**Table 16 Estimated End Use Breakdown for the Lima Post**

| End Use | Primary Water Source | Water Use $m^3$ |
|---|---|---|
| Cooking | Sedapal | 8000 |
| Cleaning | Sedapal | 6000 |
| Bathrooms | Sedapal | 22000 |
| Drinking | Sedapal | 4000 |
| Irrigation | Non Potable | Unknown |
| Cooling Tower | Sedapal | 8000 |

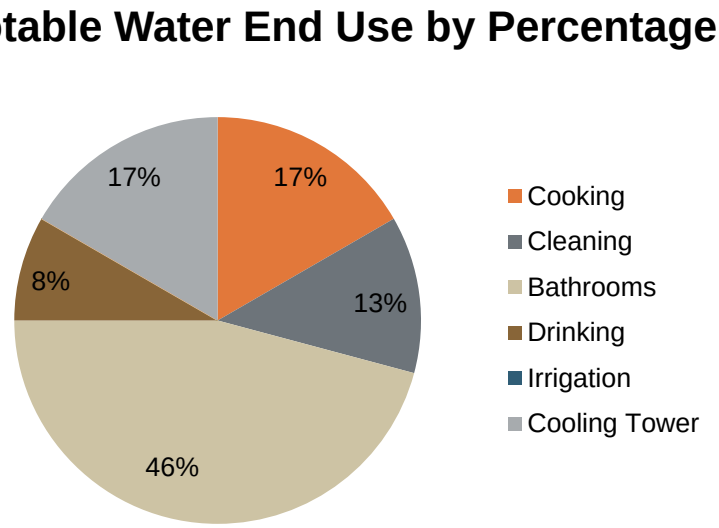



**Figure 17 Potable Water End Use by Percentage**

The potable water end use breakdown shown in Percentage indicates that the biggest water use reduction opportunity is in the bathrooms. This was confirmed by an inventory of water fixtures conducted in parallel to the energy audit.

# WATER CONSERVATION MEASURES

The process for identifying and evaluating water conservation measures follows a very similar approach to energy conservation measure identification. The pre-rinse spray valve replacement (ECM19) has an impressive savings potential at a very low cost and should be implemented as soon as possible. A high-level cost savings breakdown is provided in Table 17.

**Table 17 WCM financial summary**

| | | Low-and no-cost | Medium-cost | High-cost |
|---|---|---|---|---|
| FINANCIAL (WATER ONLY) | Net Annual Savings (US$) | $32,155 | $0 | $0 |
| | First Costs (US$) | $15,235 | $75,000 | $0 |
| | Simple Payback (yrs) | IMMEDIATE | n/a | 0 |
| | Financial Payback (yrs) | IMMEDIATE | 51 | - |
| | Net Present Value (NPV) (US$) | $15,636,942 | $75,000,000 | $0 |
| WATER | Total Savings (m3/yr) | 6,563 | 7,378 | 0 |

Low cost measures can provide annual savings of more than $30,000 with a water use reduction of more than 6,500 kL. Medium cost measures can provide a significant reduction in irrigation water use, however, no cost savings are anticipated as the city does not charge for using canal water. No high cost measures were identified.

Figure 19 Projected water cost as a result of implementing WCMs shows the changes in annual cost as a resulting the recommended WCMs. Water conservation measures are discussed individually, below, and listed in Table 18 Recommended Water Conservation Measures. All water conservation measures identified are recommended for implementation.

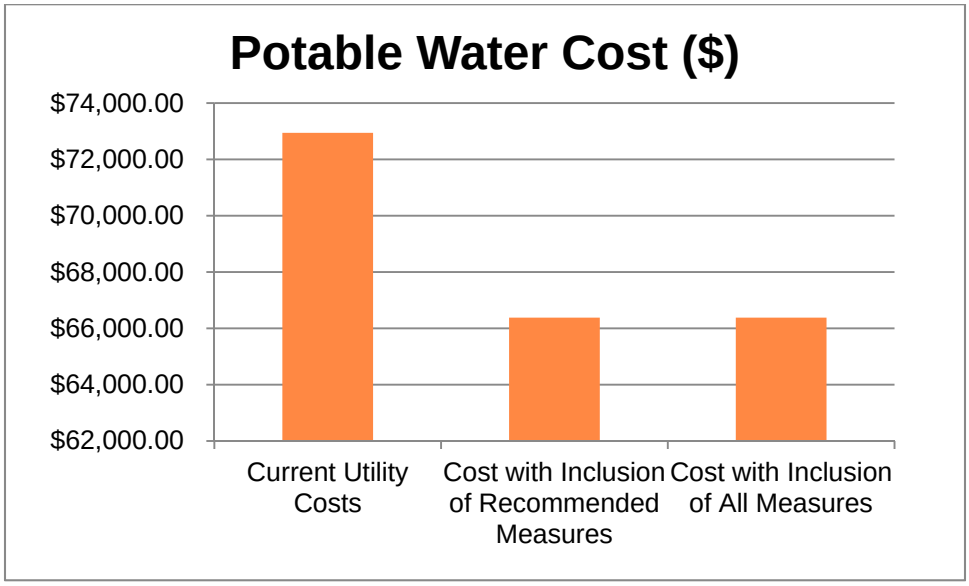



**Figure 18 Projected water cost as a result of implementing WCMs**

## Table 18 Recommended Water Conservation Measures

| Difficulty | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | $ 90,235 | $ 90,235 | $ 112 | $ 205 | $ - | $ 13,941 | $ 65 | $ 25,593 | $ - | $ 6,563 | $ - | $ 32,155 | 3 | 1 | $ 12,166,646 |
| | | | | | | | FIRST COST | REPLACEMENT (O&M) | | ANNUAL UTILITY SAVINGS | | | | ANNUAL UTILITY AND O&M COST SAVINGS | | | | | LCCA | | |
| Low-and no-cost | Medium-cost | High-cost | Strategy Categories | Conservation Measures | Notes | | First Cost ($) *Includes material and labor costs | Cost ($) *Material and Installation cost | Replacement Interval (years) | Electricity Savings (MWh) | Natural Gas/Other Savings (MWh) | Portable Water Savings (kL) | GHG Savings (t CO2e) | Electricity Cost Savings ($) | Natural Gas/Other Cost Savings ($) | Potable Water Cost Savings ($) | Replacement (O&M) Cost Savings ($) | Total Savings ($) | Simple Payback (Yrs) | Financial Payback (Yrs) | Net Present Value ($) |
| Y | | | Water | Replace lavatory faucets in Annex | ECM #19 | Annex | $ 4,095 | $ 4,095 | 40 | 4 | | 150 | 1 | $ 536 | | $ 150 | | $ 686 | 6 | 6 | $ 6,012,110 |
| Y | | | Water | Replace water closets in Chancery | ECM #20 | Chancery | $ 3,780 | $ 3,780 | 40 | | | 1630 | | | | $ 1,630 | | $ 1,630 | 2 | 3 | $ 48,496 |
| Y | | | Water | Replace pre-rinse spray valve in cafeteria | ECM #21 | Chancery | $ 160 | $ 160 | 5 | 202 | | 4,470 | 64 | $ 25,056 | | $ 4,470 | | $ 29,526 | 0 | IMMEDIATE | $ 123,042 |
| Y | | | Water | Upgrade remaining urinals in Annex and Chancery to waterless | ECM #22 | Chancery and Annex | $ 7,200 | $ 7,200 | 12 | | | 313 | | | | $ 313 | | $ 313 | 23 | 32 | $ 305,262 |
| | Y | | Water | Reduce irrigation water use | ECM #23 | Post | $ 75,000 | $ 75,000 | 15 | | | 7378 | | | | | | | | 51 | $ 5,677,737 |

## ECM-19 Replace lavatory faucets in Annex

| | | | |
|---|---|---|---|
| **Estimated Savings** | **Energy** | 3,561 | kWh\/yr |
| | **Water** | 150 | m3/yr |
| | **Maint.** | $- | /yr |
| | **Cost** | $536 | /yr |

| | |
|---|---|
| **Cost Opinion** | $4,095 |

| | | |
|---|---|---|
| **Simple Payback** | 7.64 | years |

### Base Case
The core restrooms in the Annex contain inefficient lavatory fixtures (7.6 lpm/2.0 gpm).

### Proposed Case
Replace all Annex lavatory faucets with efficient .375 lpc (0.1 gpc) metered faucets.

This measure is **recommended** for implementation because it has a net present value of $123,042 and a financial payback of 6 years.

### Water and Energy Savings
Installing aerators that use 0.375 lpc (0.1 gpc), similar to those found in the Chancery, will result in reduced water and electricity consumption. Assuming each occupant will use the restroom three times per day and wash their hands for 12 seconds each time, the reduction in domestic hot water can be calculated given the number of occupants. Energy savings in kWh can be calculated by the following equation: Thermal Energy Savings = (Domestic Hot Water Savings in cubic meters x Degree C Rise x Thermal Energy Factor) / (Domestic Water Heating Efficiency)

Assuming a 33°C rise in water temperature and a hot water system efficiency of 90%:
Energy savings is equal to 75 $m^3$ x 33 °C x 1.439 [kw/°C*$m^3$] / 0.9 or 3,561 kWh.

| | | |
|---|---|---|
| Current lavatory water use: | 203 | $m^3$ |
| Proposed lavatory water use: | 51 | $m^3$ |
| Estimated water savings: | 150 | $m^3$ |
| Estimate hot water savings: | 75 | $m^3$ |
| Estimated energy savings: | 3,561 | kWh |

### Maintenance Savings
There is no expected maintenance savings.

| | | | |
|---|---|---|---|
| Maintenance cost savings | $ | - | USD |

## Cost Opinion

Installation of the new faucets can be performed by Post.

| | Item | QTY | Cost | Unit | Total |
|---|---|---|---|---|---|
| | Faucets | 9 | 375 | each | 3375 |
| *Post | Labor | 18 | 40 | hours | 720 |
| | Total | | | | $ 4,095 |

*Assuming Post staff can perform in-house at $40/hr

## Additional Considerations

U.S. shipping not included in cost. Verify that metered faucets are available locally. If not available allow $500 for shipping.

## ECM-20 Replace water closets in Chancery

| | | | |
|---|---|---|---|
| **Estimated Savings** | **Energy** | 0 | kWh\/yr |
| | **Water** | 1,630 | m3/yr |
| | **Maint.** | $- | /yr |
| | **Cost** | $2,152 | /yr |

| | |
|---|---|
| **Cost Opinion** | $ 3,780 |

| | | |
|---|---|---|
| **Simple Payback** | 1.76 | years |

### Base Case
The core restrooms in the Chancery contain inefficient water closets (13.2 lpf / 3.5 gpf).

### Proposed Case
Replace all Chancery water closet diaphragms with efficient diaphragms (6 lpf / 1.6 gpf).

This measure is **recommended** for implementation because it has a net present value of $305,262 and a financial payback of 3 years.

### Water Savings
Installing diaphragms that use 6 lpf, similar to those found in the Annex, will result in reduced water consumption. Assuming each occupant will use the restroom three times per day, the reduction in domestic water use can be calculated given the number of occupants.

| | | |
|---|---|---|
| Current water use: | 3,010 | $m^3$ |
| Proposed water use: | 1,376 | $m^3$ |
| Estimated water savings: | 1,630 | $m^3$ |

### Maintenance Savings
There is no expected maintenance savings.

Maintenance cost savings $ -

### Cost Opinion
Installation of the new water closets can be performed by Post.

| Item | QTY | Cost | Unit | Total |
|---|---|---|---|---|
| Diaphragm Kit | 42 | 50 | each | 2100 |
| *Post Labor | 42 | 40 | hours | 1680 |
| Total | | | | $ 3,780 |

* Assuming post staff can perform in-house at $40/hr

### Measurement and Verification
n/a

### Additional Considerations
U.S. shipping not included in cost. Verify that 6 lpf diaphragms are available locally.

## ECM-21 Replace pre-rinse spray valve in cafeteria

| | | | |
|---|---|---|---|
| **Estimated Savings** | **Energy** | 201,642 | kWh\/yr |
| | **Water** | 4,470 | m3/yr |
| | **Maint.** | $- | /yr |
| | **Cost** | $25,056 | /yr |

| | |
|---|---|
| **Cost Opinion** | $160 |

| | |
|---|---|
| **Simple Payback** | Immediate |

### Base Case
The pre-rinse spray valve is inefficient. Flow was measured in excess of 23 liters per minute (6 gpm).

### Proposed Case
Replace pre-rinse spray valve with efficient 3.6 liters per minute (0.95 gpm) model.

This measure is **recommended** for implementation because it has a net present value of $5,677,737 and an immediate financial payback.

### Energy Savings
Installing a new pre-rinse spray valve will result in reduced water and electricity consumption. Assuming the pre-rinse spray valve is used 300 times per day for 3 seconds each time, the water and energy savings can be estimated as follows:

Thermal Energy Savings = (DHW Liters saved x °C Rise x Thermal Energy Factor) / (Domestic Water Heating Efficiency)
Assumptions: a 24°C degree change in water and a hot water system efficiency of 70%:

| | | |
|---|---|---|
| Current water use: | 5,314 | $m^3$ |
| Proposed water use: | 841 | $m^3$ |
| Estimated water savings: | 4,470 | $m^3$ |
| Estimated hot water savings: | 2,684 | $m^3$ |
| Estimated energy savings: | 201,642 | kWh |

### Maintenance Savings
There is no expected maintenance savings.

### Cost Opinion
Installation of the new pre-rinse spray valve can be performed by Post.

| Item | QTY | Cost | Unit | Total |
|---|---|---|---|---|
| Pre-rinse spray valve | 1 | 120 | each | 120 |
| *Post Labor | 1 | 40 | hours | 40 |
| Total | | | | $ 160 |

*Assuming post staff can perform in-house at $40/hr

### Additional Considerations

U.S. shipping is estimated in the cost. The basis is fromhttp://bricor.com/products/pre-rinse-sprayer/ with a $40 allowance for shipping.

## ECM-22 Upgrade remaining urinals in Annex and Chancery to waterless

| | | | |
|---|---|---|---|
| **Estimated Savings** | **Energy** | 0 | kWh\/yr |
| | **Water** | 313 | m3/yr |
| | **Maint.** | $- | /yr |
| | **Cost** | $413 | /yr |

| | |
|---|---|
| **Cost Opinion** | $7,200 |

| | | |
|---|---|---|
| **Simple Payback** | 17.45 | years |

### Base Case
The core restrooms in the Annex and on the 4th and 5th floors of the Chancery contain 3.8 lpf (1.0 gpf) urinals.

### Proposed Case
Replace all conventional urinals with waterless urinals.

This measure is **recommended** for implementation because it has a net present value of $20,025 and a financial payback of 32 years.

### Energy Savings
Installing waterless urinals, similar to those already installed on basement through third floor of the Chancery, will result in reduced water consumption. Assuming each male occupant will use the urinal two times per day, the reduction in domestic water use can be calculated given the number of male occupants.

| | | |
|---|---|---|
| Current water use: | 313 | $m^3$ |
| Proposed water use: | 0 | $m^3$ |
| Estimated water savings: | 313 | $m^3$ |

### Maintenance Savings
There is no expected maintenance savings.

### Cost Opinion
Installation of the new waterless urinals can be performed by Post.

| | Item | QTY | Cost | Unit | Total |
|---|---|---|---|---|---|
| | Urinal | 10 | 600 | each | 6000 |
| *Post | Labor | 30 | 40 | hours | 1200 |
| | Total | | | | $ 7,200 |

*Assuming post staff can perform in-house at $40/hr

### Measurement and Verification
n/a

### Additional Considerations
U.S. shipping not included in cost. Verify that waterless urinals are available locally.

## ECM-23 Reduce irrigation water use

| | | | |
|---|---|---|---|
| **Estimated Savings** | **Energy** | 2,915 | kWh\/yr |
| | **Water** | 7,378 | m3/yr |
| | **Maint.** | 0 | /yr |
| | **Cost** | $277 | /yr |

| | |
|---|---|
| **Cost Opinion** | $75,000 |

| | |
|---|---|
| **Simple Payback** | n/a |

### Base Case

Lima, Peru is in the coastal climate region of Peru, an almost rainless area classified according to the Köppen Climate system as a mild desert climate. Conventional ornamental plantings such as turf grass require extensive irrigation in order to survive. Currently the facility contains approximately 22,600 sq. meters planted about 90% Panicum maximum grass and 10% unknown flowers/shrubs. The turf grass is irrigated by sprinklers that are controlled by an irrigation timer. The flowers and shrubs are hand-watered as needed. Paladino estimates the monthly watering requirements in the following table.

### Proposed Case

There are several methods of reducing irrigation needs while maintaining attractive plantings. These methods, in increasing order of difficulty and expense are; installing smart irrigation controls with weather based irrigation controls, installing more efficient means of irrigation delivery, such as drip irrigation in place of sprinklers, and finally utilizing native or extremely drought tolerant plantings in place of traditional ornamental plantings. Paladino recommends installing irrigation controls for the turf areas that utilize soil moisture sensors rather than timers to trigger irrigation. In addition, for the planted areas with flowers and shrubs, Paladino recommends installing drip irrigation systems that are controlled with an irrigation controller that also utilizes soil moisture sensors. The estimated monthly Irrigation requirements are shown in the below table.

This measure is recommended for further study to determine a detailed cost figure.

### Water Savings

The monthly water savings are shown in the table below. It should be noted that the maximum savings are during the summer, when irrigation is most needed for local food production. The annual water savings are estimated to be in excess of 7,000,000 liters per year. This is a reduction in water use for irrigation by approximately 21%. Savings are not shown as an absolute value in the WCM summary table due to inoperable metering. Please note that although the water supplied for irrigation is free to Post, a reduction in the amount of water used for irrigation increases the water available to the rest of the city and the community. This water conservation measure does not have a payback but has been suggested for eco-diplomacy reasons.

| Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Lima, Peru Monthly Irrigation Requirements (m3/month)** | | | | | | | | | | | |
| 3,208 | 3,208 | 3,145 | 3,082 | 3,019 | 2,516 | 2,202 | 2,202 | 2,516 | 2,516 | 2,831 | 3,145 |
| **Lima, Peru Monthly Irrigation Requirements after Retrofit (m3/month)** | | | | | | | | | | | |
| 2,504 | 2,504 | 2,455 | 2,405 | 2,356 | 1,964 | 1,718 | 1,718 | 1,964 | 1,964 | 2,209 | 2,455 |
| **Lima, Peru Monthly Irrigation Savings (m3/month)** | | | | | | | | | | | |
| 705 | 705 | 691 | 677 | 663 | 553 | 484 | 484 | 553 | 553 | 622 | 691 |

Total Savings 7,378 kL

## Maintenance Savings

The proposed system will require the periodic replacement of soil moisture sensors, which can increase maintenance costs over a single or group of irrigation timers. In addition, drip irrigations systems require proper water filtration prior to entering the drip irrigation system. This may require additional water filtration systems, which must be maintained with new filters at appropriate intervals. Labor savings should be realized due the elimination of most of the hand watering of the flowers and shrubs.

## Cost Opinion

In order to obtain a cost for this water savings measure, it is advised to obtain bids for several different design-build irrigation companies. Costs for these services vary widely by geographic location and the actual product being specified. It is advised to hire a landscape architect knowledgeable in irrigation systems to establish a performance specification so that all bids are for a design that will achieve the same water savings.

## Measurement and Verification

IPMVP Method B - Use irrigation water meter to create irrigation baseline. Create performance case using the same meter after the retrofit.

## Additional Considerations

Energy saving potential is estimated to be nominal but will be value of water saved as compared to distribution pump power use. Percentages will track proportionally i.e. a 20% reduction in water use means a 20% reduction in pumping power use. Due to the irrigation system no longer being on a timer system, the operation of the irrigation system will be harder to predict. This could cause issues, such as when there is an event on the turf lawn, the sprinklers could start if the soil moisture sensors initiate the watering sequence. In order to mitigate this, an irrigation controller that utilizes both soil moisture sensors and a timer or shut out control should be specified. It is important to hire a professional irrigation design-build company with experience in installing drip irrigation systems as well as sophisticated irrigation controls in order to achieve the calculated water savings while maximizing the functionality of the landscape.

# APPENDIX A

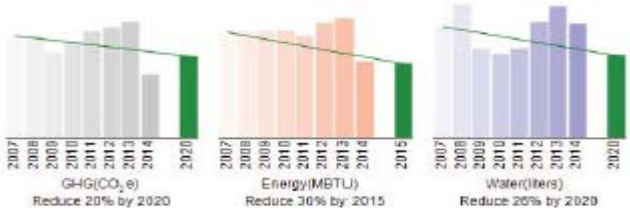
Not used.

# APPENDIX B: TREES REPORT CARD

Printed 08 October 2014

## Building Sustainability Report Card
## Fiscal Year 2014

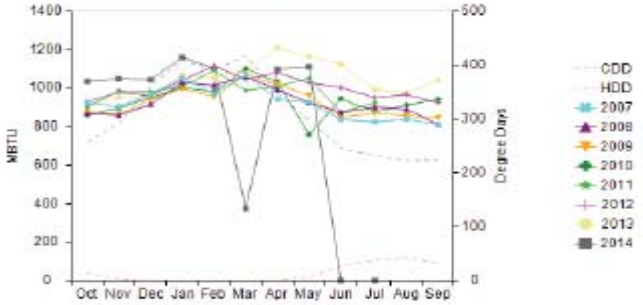
**Office Building Progress Toward Targets**



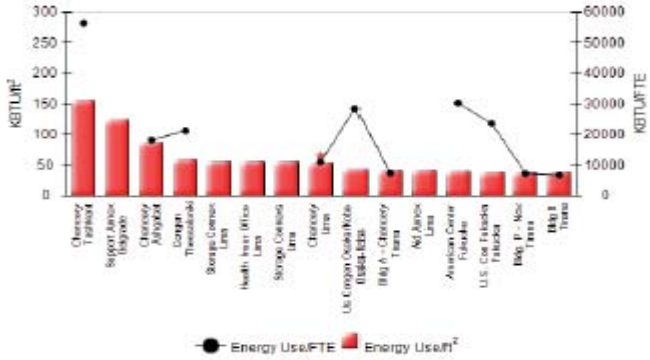

| | |
|---|---|
| **Bureau:** | WHA |
| **Country:** | PERU |
| **City:** | LIMA |
| **Building Name:** | CHANCERY |
| **RPUID:** | 31360112001 |
| **Real Property Use:** | OFFOBC - Chancery Office Building |
| **Agency:** | OTHER |
| **Address 1:** | |
| **Address 2:** | AV. LA ENCALADA, 17TH BLOCK |
| **Address 3:** | |

| | |
|---|---|
| **Normalizing Factors:** | |
| Climate Region: | 3 |
| Heating Degree Days: | 165 |
| Cooling Degree Days: | 3,699 |
| Building Floor Area: | 13,600 $m^2$ (146,385 $ft^2$) |
| Full-Time Employees (FTE): | 721 |
| **Greenhouse Gas (GHG) Emissions:** | |
| Building Electricity GHG: | 373,350 Kg/$CO_2$e |
| Building On-Site Power GHG: | |
| Building Fugitive Emissions: | [Future Reporting] |
| **Electricity (Scope 2):** | |
| Electrical Emissions Factor: | 149 |
| Building Total Electrical **Cost**: | $189,653 |
| Building Electrical Cost: | $14/$m^2$ ($150/$ft^2$) |
| Building Electrical Cost/FTE: | 263 |
| Building Total Electrical **Use**: | 2,334,799 kWh |
| Building Electrical Use: | 172 kWh/$m^2$ (16 kWh/$ft^2$) |
| Building Electrical Use/FTE: | 3,238 kWh |
| **On-Site Power Generation (Scope 1):** | |
| **Diesel:** | Not applicable |
| **Natural Gas:** | Not applicable |
| **Water:** | |
| Building Total Water **Cost**: | 28,555 |
| Building Water Cost/$m^2$: | $2 |
| Building Water Cost/FTE: | $40 |
| Building Total Water **Use**: | 16,450,979,098 liters |
| Building Water Use/$m^2$: | 1,209,666 liters |
| Building Water Use/FTE: | 22,807,813 liters |

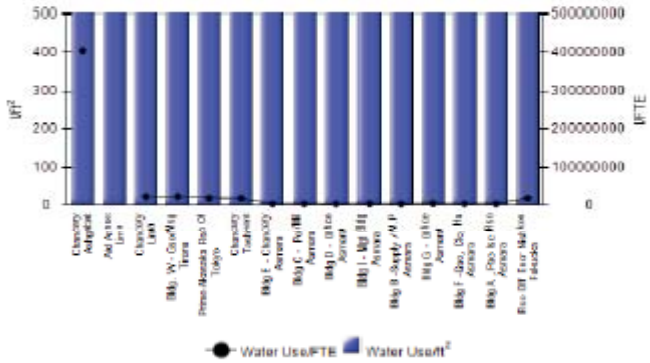
**Energy Use and HDD/CDD**




**Climate Region 3**
**Ranking of Buildings**



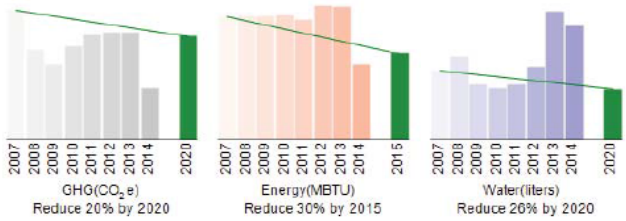

**Climate Region 3**
**Ranking of Buildings**



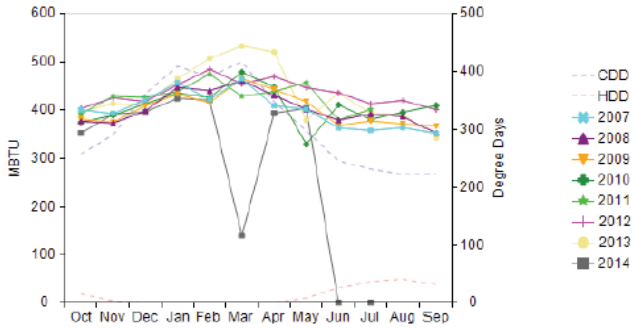
Printed 08 October 2014

# Building Sustainability Report Card
# Fiscal Year 2014

**Office Building Progress Toward Targets**




**Energy Use and HDD/CDD**




| | |
|---|---|
| **Bureau:** | WHA |
| **Country:** | PERU |
| **City:** | LIMA |
| **Building Name:** | AID ANNEX |
| **RPUID:** | 31360112002 |
| **Real Property Use:** | OFFOBX - Annex Office Building |
| **Agency:** | OTHER |
| **Address 1:** | |
| **Address 2:** | AV. LA ENCALADA, 17TH BLOCK |
| **Address 3:** | |

| | |
|---|---|
| **Normalizing Factors:** | |
| Climate Region: | 3 |
| Heating Degree Days: | 165 |
| Cooling Degree Days: | 3,699 |
| Building Floor Area: | 6,603 m2 (71,077 ft2) |
| Full-Time Employees (FTE): | 0 |

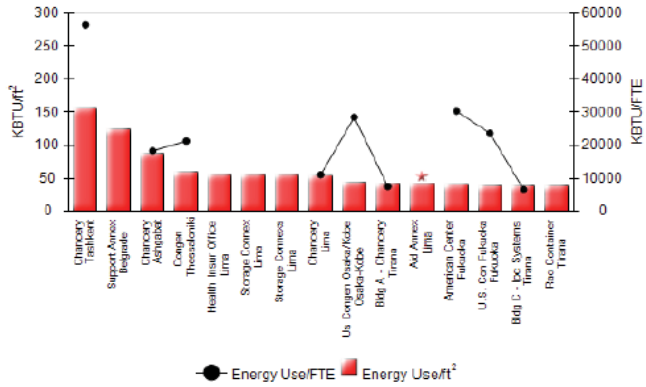
| | |
|---|---|
| **Greenhouse Gas (GHG) Emissions:** | |
| Building Electricity GHG: | 143,095 Kg/$CO_{2e}$ |
| Building On-Site Power GHG: | |
| Building Fugitive Emissions: | [Future Reporting] |

| | |
|---|---|
| **Electricity (Scope 2):** | |
| Electrical Emissions Factor: | 149 |
| Building Total Electrical **Cost**: | $69,998 |
| Building Electrical Cost: | $11/m2 ($114/ft2) |
| Building Electrical Cost/FTE: | 0 |
| Building Total Electrical **Use**: | 861,440 kWh |
| Building Electrical Use: | 130 kWh/m2 (12 kWh/ft2) |
| Building Electrical Use/FTE: | 0 kWh |

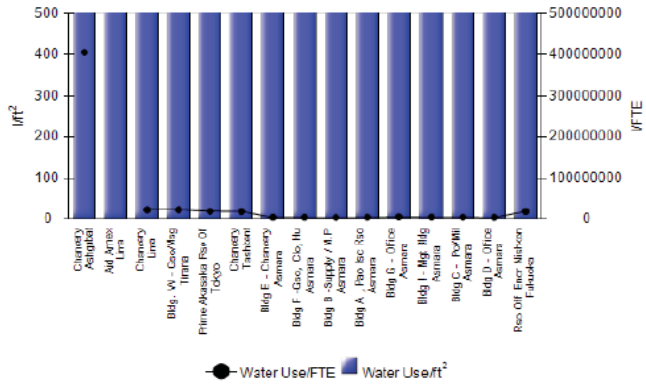
| | |
|---|---|
| **On-Site Power Generation (Scope 1):** | |
| **Diesel:** | Not applicable |
| **Natural Gas:** | Not applicable |

| | |
|---|---|
| **Water:** | |
| Building Total Water **Cost**: | 19,354 |
| Building Water Cost/m2: | $3 |
| Building Water Cost/FTE: | $0 |
| Building Total Water **Use**: | 11,146,288,182 liters |
| Building Water Use/m2: | 1,687,998 liters |
| Building Water Use/FTE: | 0 liters |

**Climate Region 3**
**Ranking of Buildings**




**Climate Region 3**
**Ranking of Buildings**



# APPENDIX C: GENERAL BUILDING DATA FROM OUTPUT TOOL

| Building Name and Post | Lima Chancery | Lima Annex |
|---|---|---|
| Address | Avenida La Encalada, cdra. 17, Monterrico, Surco, Lima, Peru | |
| Audit Date | 7/16-22/2014 | 7/16-22/2014 |
| Building Type | Office | Office |
| Building Use Summary | COM, DAO, Consular Services, Political Office, Admin, Cafeteria, FAC, Mail, MSG | USAID, FAC, DEA |
| Year of Construction | 1996 | 2002 |
| Date of Last Major Renovation | n/a | n/a |
| Gross Floor Area (m2) | 13,600 | 6,603 |
| Conditioned Area (m2) | 13,600 | 6,603 |
| Number of Floors | 6 | 3 |
| Design Occupancy (FTE) based on federal efficiency standards | 681 | 331 |
| Actual Occupancy (as of July 2014) | 437 | 172 |
| Typical Building Schedule Summary | 7am-6pm M-F | |
| Interval Data Available (Y/N) | Interval data for the compound is available from the utility. Post has provided audit team with a copy of year ending June 2014. | |
| Submeter Description | Meters installed, data not being logged and archived. | Meters installed, data not being logged and archived. |
| General Lighting Description | Overhead 32W, 4ft T8s and 28 WCFL downlights | Overhead 32W, 4ft T8s and 28 WCFL downlights |
| Plumbing Fixtures Description | 3.5 GPF WCs, 1.0 GPF URNs, 2.2 GPM LAVs | 3.5 GPF WCs, 0 GPF URNs, 0.5 GPM LAVs |
| Power Service and Distribution Description | 10kV primary service, owned substation, 100% diesel backup, 480V 50Hz distribution, submeters installed | |
| Mechanical System Description | Constant volume multizone, modular chilled water air handlers, water cooled chillers | VAV chilled water air handlers, electric reheat, air cooled chillers |
| Controls and Building Automation Description | Tridium Niagara circa 2011 | Johnson Metasys circa 2002 |
| Water Supply Description | Potable: Municipal 5-10psi, Irrigation: Municipal, intermittent | |
| Wastewater Treatment Description | None | |
| Fire Suppression Systems Description | 100% Sprinklered | |
| Vertical and Horizontal Transportation Systems Description | 3 Passenger, 1 Freight Elevator | 1 Passenger Elevator |
| Notes | | |

# APPENDIX D: PHOTOVOLTAIC FEASIBILITY GUIDANCE

Peru is an excellent place for photovoltaic development. The country is in the midst of implementing a $200 million program called, "The National Photovoltaic Household Electrification Program." Through this program, Peru is working to install more than 12,500 solar photovoltaic systems in rural areas.[16]

Lima, however, is not a great place for renewable investment. The electricity profile for Lima is relatively low-carbon. Much of the city's electricity is from hydro-electric sources. The rest is from new natural gas plants. According to the International Energy Agency, Peru's electricity industry emits 44% less CO2 than the average in the United States. Another consequence of the hydro and natural gas mix is that electricity is relatively inexpensive - on average only $0.095/kWh under the Post's tariff.

To understand the sizing parameters, we looked to the electric demand curves for the Post. The minimum daytime electricity demand for the post is 434 kW. This occurs during daylight hours on the weekend. Net metering is not currently available from the utility and energy storage further increases system cost and is not recommended by OBO for a Post with stable, inexpensive electricity service. As a result, the recommended maximum nominal output of any renewable system at the Lima Post should not exceed 400 kW. If the utility made net metering available, then the system size could be increased.

Prior to investigating locations for a potential system, a cost-benefit analysis was conducted. The output is shown in Table 20. A 400 kW system priced at $5/watt installed does not pay back over a 30 year term. ***Therefore, it is not recommended that the Post pursue a photovoltaic installation.***

There are many suitable locations to install a 400 kW PV system. Four areas have been identified in Table 19. In two areas, modules would be located on the roofs of existing building. In the other two areas, modules would be located on parking canopy structures. A layout of the compound with these locations is shown in Figure 20. Additionally, a schematic layout identifying the main components of a possible PV system is shown in Figure 22. The schematic is based on a micro-inverter design with a grid tie.

**Table 19 Potential PV Locations**

| Area | Approximate Size |
|---|---|
| Annex Roof | 7,200 SF |
| Motor Pool Parking Canopies | 4,900 SF |
| Shops Roof | 2,700 SF |
| US Parking Canopy | 12,500 SF |
| Total | 27,300 SF |

[16] http://cleantechnica.com/2013/07/15/peru-solar-power-program-to-give-electricity-to-2-million-of-poorest-peruvians/

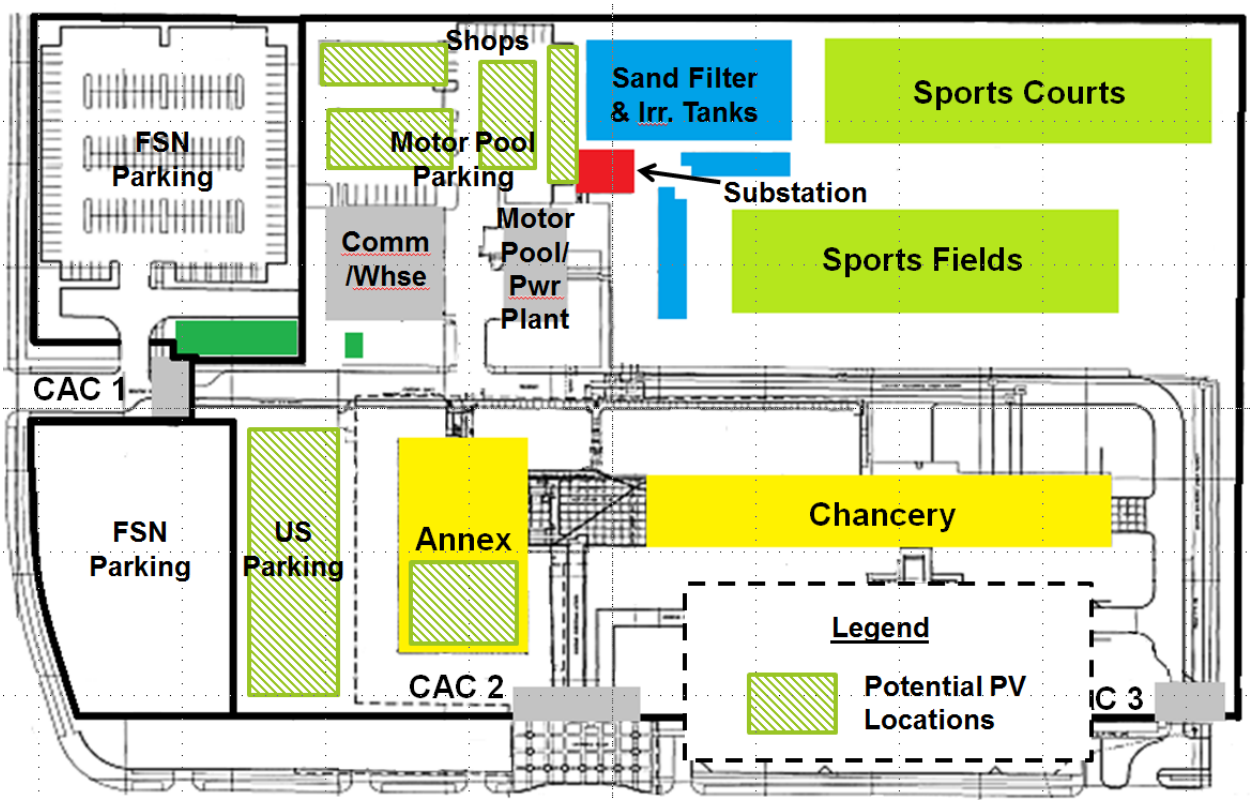



Figure 19 Lima Compound layout showing potential PV locations

Figure 20 Lima Compound aerial image from Google Earth showing potential PV locations

**Table 20 PV Feasibility Assessment Output**

| | Lima | Peru |
|---|---|---|
| **Results** | | |
| Total Avoided Costs | | **$ 943,818** |
| Payback Year | | **#N/A** |
| **Utility Data** | | |
| Current Utility Rate | $ 0.09 | /kWh |
| Inflation Rate | 0.54% | |
| **PV Parameters** | | |
| Insolation | 3.9 | Hours |
| PV Size | 400 | kW |
| Installation Cost | $ 5.00 | /W |
| PV Degradation | 0.10% | |
| System Efficiency | 77% | |
| Life Expectancy | 30 | Years |
| O&M Cost | $ 8.00 | /kW per Year |
| O&M Escalation | 2% | |
| **Calculated Parameters** | | |
| AC Capacity | 308 | kW |
| Production Hours per Year | 1423.5 | Hours |
| Total Installed Cost (Unloaded) | $ 2,000,000 | |
| Total Installed Cost (Loaded) | $ 2,450,000 | |
| First Year O&M | $ 3,200 | |

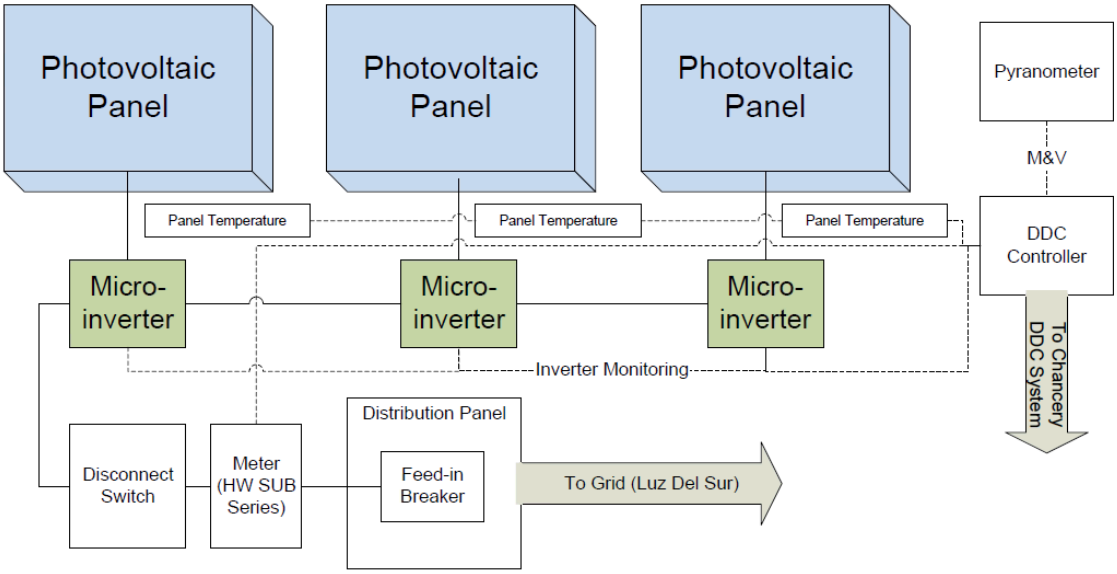



**Figure 21 PV System Schematic**

# APPENDIX E: WIND FEASIBILITY GUIDANCE

Based on a cursory evaluation of site conditions – energy cost and available wind – it is not feasible to construct wind turbines on site.

## Wind Power Feasibility Tool

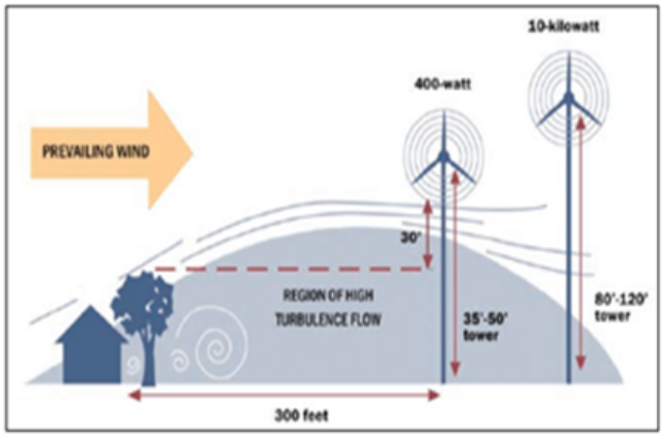
*The following are guidelines for assessing feasibility of on-site wind power during early design phases.*

Spreadsheet by OBO/PDCS/DE/CSE, 2012

**Note: this is NOT intended to be a design tool.**

| Parameter | | | Feasibility Review of Parameter | Notes |
|---|---|---|---|---|
| Average annual wind speed | 5 | m/s | Wind speed might be too low. | The annual wind speed should be above 5.5 m/s annually. Rotor cut-in speeds are typically 4-5 m/s. |
| Electric utility rate | 0.095 | /kWh | Electricity costs may be too low to provide a good payback. | The electric rate should be above $0.15/kWh. |
| Area around turbine site | 20 | m radius | There may be insufficient space to accommodate a turbine. | Each turbine requires a minimum clear circular zone of approximately 30 meters in radius, depending on the tower height. |
| Obstacles within 90m? | 5 | (number) | Confirm that the location can accommodate a wind turbine. | The turbine hub should be located 10 m above any obstacle within 90 m. The turbine should be located in a high location, not in a depression. Ideally the turbine should located in on the windward side of a hill or gradient. |

| Results |
|---|
| **One or more criteria indicate that wind power might not be appropriate for the site; review parameters.** |



# APPENDIX F: SUMMARY OF RECOMMENDATIONS

## Field Observed Deficiencies (FOD)

**FOD1** - In the Chancery, GX-B-10 is missing a service disconnect within sight of the equipment. The closest point to turn off unit is at the breaker in an electrical room that requires moving through three locked set of doors. The deficiency can be resolved by installing a lockable disconnect on the wall adjacent to the fan in the water cistern anteroom.

**FOD2** - In the Chancery, the room housing the chilled water plant does not meet ASHRAE Standard 15 requirements. The most recent iteration of the Standard, ASHRAE 15-2013 provides for exhaust and refrigerant gas detection in mechanical rooms.

**FOD3** – In the Chancery, there is a smoke control sequence defined in the building automation system programming. Based on a cursory investigation, this sequence is missing an enable point.

**FOD4** - The damper position control loops for AHU-3-1 and AHU-3-2 in the Chancery were tuned to be too fast. The cycle time was observed as 0.02 seconds. Normally this value is at least 1 minute and generally more than 2 minutes. The result is premature failure of damper actuators. Three were replaced by the post in coordination with Paladino during the audit site visit. In a failure condition, the outside air damper is closed, the return air damper is open, and the relief air damper is closed. This could create a neutral pressure condition on a portion of the floor and makes the purge mode inoperative.

**FOD5** – Repair airflow monitoring stations installed in VAV AHUs in Annex. During contractor's site visit all sensors were reporting as unreliable in the building management system.

**FOD6**- Outside air ventilation minimum air flows have NOT been established in the Chancery or Annex. Minimum OSA flow is a requirement in order to maintain healthy indoor air quality and to meet ASHRAE 62.1 ventilation standards. The HVAC systems' outside air dampers now modulate from 0%-100% to maintain differential pressure set points ranges from 5.0pa to 9.0pa. It is recommended that the HVAC system be balanced by a certified Test, Adjust and Balancing (TAB) contractor and minimum OSA damper positions be defined and made operational during scheduled work hours. Please refer to Appendix G: Ventilation Study in the supplemental LEED EB:O&M Gap Assessment Report (August 2014) which demonstrates that HVAC systems as currently installed are able to meet minimum ventilation code requirements.

**FOD7** – Annex AHU-1L1 VFD is set in "Hand" mode by operator. Supply and Return fans for this unit had respective VFDs set 45 Hz (75% of fan speed), effectively turning this unit into a constant volume system. When the AHU stays In the override mode VAV zones it serves may not get sufficient air flow to maintain temperatures and indoor air quality. Note: With VFDs limited to 75% fan speed, the Johnson Controls BAS was demanding 100% fan speed to meet duct static pressure target (1.0" wc). It is recommended that this unit be re-commissioned to verify performance of associated BAS controller and field devices and then returned to auto operation.

## Operations and Maintenance Recommendations (OMR)

**OMR1** – Provide focused DDC system training for operators. The operators are able to manipulate some set points and schedules and read information from the head-end. Based on the ongoing preventive maintenance needs of the DDC systems and the potential for unlocking further improved operational and energy performance, both the Post and the staff would benefit from

additional, hands-on DDC system training including basic programming of DDC systems. This recommendation applies to the Chancery and Annex buildings.

**OMR2** – The major project close-out process has significant room for improvement. Based on our site observations and available documentation, commissioning, testing and balancing, and contractor training had not been performed for the Environmental Security Upgrade. To improve the process, we recommend that the following activities are always included in major HVAC equipment replacement projects in the Chancery and Annex buildings:

- Independent commissioning
- Contractor provided training for Post facilities management office staff
- Certified testing, adjusting, and balancing

**OMR3** – Improve alarm lists. It is recommended that the following alarms be added to the building management system in the Chancery and Annex:

- Alarm if damper actuator command does not match position feedback after a delay.
- Alarm if fan command does not match fan status proof after a delay.
- Alarm if pressure limits out of range (+/- 20% of set point) after a 3 minute delay)
- Alarm if VFD enable does not correspond with current reference output from VFD
- Alarm if VFD faults are reported to the control system. This should be a general VFD fault alarm for each drive.
- Set up alarm conditions for air temperature points based on an out of range condition.
    - Space temp +/- 1°C (5 minute delay)
    - DAT set-points +/-1°C (5 minute delay)

**OMR4** – Compound – label all metering equipment. Some was labeled, but not consistently. This was not tracked systematically during the meter assessment.

**OMR5** – Maintain trend logs for key points in the Chancery and Annex. A list of recommended points is provided at the end of this Appendix under the heading “OMR5 – Recommended Trend Logs.”

**OMR6** – Initial reading data received from the Post for electric and water sub meters included data that was not correct. Approximately 20% of the entries included various issues including transposed digits, added or removed order of magnitude, or out of sequence numbers. To correct these issues in the future and create an archive of data to reference, it is recommended that the Post implements automated meter reading using the DDC system and includes quality control step in the meter reporting process.

**OMR7** –Define and program a global view for the DDC systems in the Chancery and Annex buildings. This view would summarize the status of major equipment and provide operators a dynamic graphic to quickly understand the building’s operational status.

## Meter Assessment Recommendations

**MAR1** – Trend and archive data from all of the meters on the Compound for at least 3 years on intervals of at least 15 minutes.

### ELECTRICITY

**MAR2** – Add a meter, E17, on the feed to the PBX in the Chancery. The recommended specification is shown in Table 10.

**MAR3** – Add a meter, E18, on the feed to the JUCR in the Chancery. The recommended specification is shown in Table 10.

**MAR4 -** Add a meter on the feed to each chiller (CH-1, CH-2, RM-1, and RM-2). Recommended specifications are shown inTable 11.
Table 11.

**MAR5** – Integrate to the GE power quality meters installed in the switchgear in the Chancery instead of the Honeywell meters. Abandon the duplicate Honeywell meters.

## WATER

**MAR6** – Repair F-12, the flow meter monitoring irrigation in the irrigation water pumping pit.

**MAR7** – Add a domestic hot water meter downstream of F-1 to measure total Chancery hot water production

**MAR8 –** Add a meter for raw irrigation water to monitor the evaporation losses of the slow sand filter.

### BACKUP POWER

**MAR9** – Generator meters – add electric meters downstream of each generator. These should be the same specification as the Honeywell Sub460 meters.

**MAR10** – Diesel meters for generator – add diesel meters upstream of each generator in the Power Plant.

## FOD6 – ASHRAE 62.1-2007 Ventilation Study Results Summary

Paladino and Company conducted a ventilation study at the Chancery and US AID Annex Buildings to document compliance with LEED EB O&M Indoor Environmental Quality Prerequisite 1, Minimum IAQ Performance (IEQp1). This is a summary of the findings of that study. The full report is presented under separate cover as Appendix G to the LEED: EBOM Assessment prepared for the facility. IEQp1 requires that buildings are provided a minimum amount of outdoor air in order to maintain good indoor air quality and keep occupants both healthy and comfortable. Minimum outside airflow measurements and calculations were conducted in accordance with the ventilation rate procedure of ASHRAE Standard 62.1-2007 Ventilation for Acceptable Indoor Air Quality. Measurements were completed during normal operating hours under minimum outside air conditions on July 16-18 and July 21-22, 2014. Based on data collection, onsite testing, and ventilation rate procedure calculations, the project building does not currently meet the requirements of LEED EB O&M IEQp1 Minimum IAQ Performance.

- Due to the security factors that exist at the building, building pressurization is considered a high level priority. During testing, several outdoor air dampers were completely closed. Closed outdoor air dampers were the result of one or more of the following:
    - Low carbon dioxide (CO2) levels in the return air duct that satisfied the ventilation sequence
    - Pressurization holding priority to ventilation within the control sequence
    - Malfunctioning outdoor air damper actuators, which were later replaced by Alex Duenas.
- Air handling units (AHUs) do not currently have a minimum outside air damper positioning for occupied hours.
- Due to the factors listed above, Post does not meet ASHRAE Standard 62.1-2007 outdoor air requirement or Mechanical Ventilation—Case 1 for LEED EB O&M IEQp1 Minimum IAQ Performance.

In order to meet the requirements of LEED EB O&M IEQp1 Minimum IAQ Performance, Paladino recommends that Post building engineering staff hire a certified testing, adjusting, and balancing (TAB) company to meet the ventilation requirements of ASHRAE 62.1-2007 and the embassy's pressurization requirements. Temporary adjustments were made to determine whether each individual AHU was capable of delivering the required quantity of outside air to the zone(s) that it serves, but testing, adjusting, and balancing of the post's mechanical systems is required for any permanent changes necessary to meet the ventilation requirements of ASHRAE 62.1-2007 and the embassy's pressurization requirements. This includes increasing the outdoor air flow in the air handling units during occupied hours to the minimum values indicated in the "Required Outdoor Air Intake Flow to Meet IEQp1" columns in Tables 1 and 2 below.

**Table 21 Summary of Outside Air Requirements and Onsite Measurements for Chancery**

| System Name and Number | Required Outdoor Air Intake Flow to Meet IEQp1 (l/s, cfm) | Measured OA Intake Flow (l/s, cfm) | OA Damper Positioning during Measurement (occupied, unoccupied damper) | Date of Measurement | Zone Complies with IEQp1 |
|---|---|---|---|---|---|
| AHU B1 | 439, 930 | 1037, 2195 | 10%, 10% | July 17, 2014 | Yes |
| AHU B2 | 455, 964 | 731, 1550 | 50%, 50% | July 17, 2014 | Yes |
| KIT-MUA | N/A | 512, 1086 | -- | July 22, 2014 | Yes |
| AHU 1-1 | 839, 1778 | 1525, 3231 | 30%, 0% | July 21, 2014 | Yes |
| AHU 1-2 | 510, 1081 | 1095, 2319 | 40%, 0% | July 21, 2014 | Yes |
| AHU 2-1 | 543, 1151 | 724, 1533 | 15%,15% | July 18, 2014 | Yes |
| AHU 2-2 | 364, 771 | 427, 905 | 0%, 48% | July 18, 2014 | Yes |
| AHU 3-1 | 670, 1420 | 403, 854 | 0%, 100% | July 18, 2014 | No |
| AHU 3-2 | 481, 1019 | 687, 1457 | 35%, 35% | July 18, 2014 | Yes |
| AHU 4-1 | 824, 1746 | 1013, 2147 | 33%,33% | July 18, 2014 | Yes |
| AHU 4-2 | 726, 1538 | 1097, 2326 | 100%, 30% | July 18, 2014 | Yes |
| AHU 5-1 | 315, 667 | 676, 1432 | 25%, 25% | July 18, 2014 | Yes |
| AHU 5-2 | 550, 1165 | 901, 1909 | 25%, 50% | July 18, 2014 | Yes |

**Table 22 Summary of Outside Air Requirements and Onsite Measurements for USAID Annex**

| System Name and Number | Required Outdoor Air Intake Flow to Meet IEQp1 (l/s, cfm) | Measured OA Intake Flow (l/s, cfm) | OA Damper Positioning during Measurement | Date of Measurement | Zone Complies with IEQp1[17] |
|---|---|---|---|---|---|
| AHU 1L1 | 848, 1797 | 1109, 2349 | 40% | July 22, 2014 | Yes |
| AHU 2L2 | 1493, 3163 | 1163, 2464 | 25% | July 22, 2014 | No |
| AHU 4LO | 1038, 2200 | 1365, 2892 | 50% | July 22, 2014 | Yes |
| AHU 6LI | 184, 390 | 334, 707 | 75% | July 22, 2014 | Yes |

[17] Since there is currently no minimum outside air quantity for each unit during occupied hours, this column indicates whether the zone will comply with IEQp1 if the measured value is set as the minimum outside air quantity for each unit.

## OMR5 – Recommended Trend Logs

**HEAT PUMP**

| Point Type | Point Name / Description | Source | Value | Sample Interval Minutes |
|---|---|---|---|---|
| AI | Outside Air Temperature | Analog Sensor | Degree C | 10 |
| AI | Room Temperature | Analog Sensor | Degree C | 10 |
| AI | Discharge Air Temperature | Analog Sensor | Degree C | 10 |
| AI | Return Air Temperature | Analog Sensor | Degree C | 10 |
| AI | Mixed Air Temperature | Analog Sensor | Degree C | 10 |
| DO | Fan Command | Digital Command | On/Off | 10 |
| DO | Compressor Command | Digital Command | On/Off | 10 |
| DO | Reversing Valve Command | Digital Command | On/Off | 10 |
| DO | Auxiliary Heat | Digital Command | On/Off | 10 |
| DI | Fan Status Proof | Current or DP Switch | On/Off | 10 |
| AI | Fan Status Proof | Current Transducer | Amps | 10 |
| AI | Compressor Status Proof | Current Switch | On/Off | 10 |
| AI | Compressor Status Proof | Current Transducer | Amps | 10 |
| DI | Dirty Filter | Differential Pressure Switch | On/Off | 10 |
| | **System Modes** | | | |
| | Operating Heating Set point | Schedule | Degree C | 10 |
| | Operating Cooling Set point | Schedule | Degree C | 10 |
| | Occupied | Schedule | Mode | 10 |
| | Unoccupied | Schedule | Mode | 10 |
| DI | Setback Override | Local or Global field input | Mode | 10 |
| | Morning warm-up | Schedule | Mode | 10 |
| | Holiday | Schedule | Mode | 10 |
| | **General** | | | |
| | Day/Date/Time | System | Day/Date/Time | 10 |
| | **Cumulative run times** | **System Runtime Logs** | **Total ON time per point** | |
| DO | Compressor | Software | Mins./Hrs./Days/Mos./Yrs. | |
| DO | Fan | Software | Mins./Hrs./Days/Mos./Yrs. | |
| DO | Reversing Valve | Software | Mins./Hrs./Days/Mos./Yrs. | |
| DO | Auxiliary Heat | Software | Mins./Hrs./Days/Mos./Yrs. | |

**CHILLER**

| Point Type | Point Name / Description | Source | Value | Sample Interval Minutes |
|---|---|---|---|---|
| AI | Outside Air Temperature | Analog Sensor | Degree C | 10 |
| AI | Entering Water | Analog Sensor | Degree C | 10 |
| AI | Leaving Water | Analog Sensor | Degree C | 10 |
| AO | Bypass valve command | Analog actuator | 0-100% | 10 |
| AI | Bypass valve position | Analog actuator feedback | 0-100% | 10 |
| DO | Chiller enable/run | Digital Command | On/Off | 10 |
| | **System Modes** | | | |
| | Operating Max Set point | Schedule | Degree C | 10 |
| | Operating Min Set point | Schedule | Degree C | 10 |
| | Occupied | Schedule | Mode | 10 |
| | Unoccupied | Schedule | Mode | 10 |
| DI | Setback Override | Local or Global field input | Mode | 10 |
| | Morning warm-up | Schedule | Mode | 10 |
| | Holiday | Schedule | Mode | 10 |
| | **General** | | | |
| | Day/Date/Time | System | Day/Date/Time | 10 |
| | **Cumulative run times** | **System Runtime Logs** | **Total ON time per point** | |
| DO | Chiller enable | Software | Mins./Hrs./Days/Mos./Yrs. | |
| DO | Compressor(s) (If monitored) | Software | Mins./Hrs./Days/Mos./Yrs. | |

**COOLING TOWER**

| Point Type | Point Name / Description | Source | Value | Sample Interval Minutes |
|---|---|---|---|---|
| AI | Outside Air Temperature | Analog Sensor | Degree C | 10 |
| AI | CT Entering Water | Analog Sensor | Degree C | 10 |
| AI | CT Leaving Water | Analog Sensor | Degree C | 10 |
| AO | Bypass valve command | Analog actuator | 0-100% | 10 |
| AI | Bypass valve position | Analog actuator feedback | 0-100% | 10 |
| DO | CT Fan enable/run | Digital Command | On/Off | 10 |
| DO | Spray Pump | Digital Command | On/Off | 10 |
| AO | VFD for fan | Analog Command | % speed | 10 |
| DO | Primary Pump(s) | Digital Command | On/Off | 10 |
| DO | Secondary Pump(s) | Digital Command | On/Off | 10 |
| DI | Pump(s) Status Proof | Current or DP Switch | On/Off | 10 |
| AI | Pump(s) Status Proof | Current Transducer | Amps | 10 |
| AI | VFD signal to fan | VFD output | Hz or %speed or Amps | 10 |
| | **System Modes** | | | |
| | Operating Max Set point | Schedule | Degree C | 10 |
| | Operating Min Set point | Schedule | Degree C | 10 |
| | Occupied | Schedule | Mode | 10 |
| | Unoccupied | Schedule | Mode | 10 |
| DI | Setback Override | Local or Global field input | Mode | 10 |
| | Morning warm-up | Schedule | Mode | 10 |
| | Holiday | Schedule | Mode | 10 |
| | **General** | | | |
| | Day/Date/Time | System | Day/Date/Time | 10 |
| | **Cumulative run times** | **System Runtime Logs** | **Total ON time per point** | |
| DO | CT Fan | Software | Mins./Hrs./Days/Mos./Yrs. | |
| DO | Spray Pump | Software | Mins./Hrs./Days/Mos./Yrs. | |

**VAV BOX**

| Point Type | Point Name / Description | Source | Value | Sample Interval Minutes |
|---|---|---|---|---|
| AI | Outside Air Temperature | Analog Sensor | Degree C | 10 |
| AI | Room Temperature | Analog Sensor | Degree C | 10 |
| AI | Primary Airflow | Analog Sensor | L/s | 10 |
| AI | Entering Air Temperature | Analog Sensor | Degree C | 10 |
| AI | Leaving Air Temperature | Analog Sensor | Degree C | 10 |
| DO | Fan Command | Digital Command | On/Off | 10 |
| DO | Damper | 3pt. Floating actuator | %open | 10 |
| AO | Damper | Analog actuator | 0-100% signal | |
| DO | Auxiliary Heat Elec. | Digital Command | On/Off | 10 |
| AO/DO | Auxiliary Heat Hydronic | Analog Signal/Digital Command | %/Volts/mA | 10 |
| DI | Fan Status Proof | Current or DP Switch | On/Off | 10 |
| AI | Fan Status Proof | Current Transducer | Amps | 10 |
| DI | Dirty Filter | Differential Pressure Switch | On/Off | 10 |
| | **System Modes** | | | |
| | Operating Heating Set point | Schedule | Degree C | 10 |
| | Operating Cooling Set point | Schedule | Degree C | 10 |
| | Operating Max Primary Airflow Set point | Schedule | L/s | 10 |
| | Operating Min Primary Airlfow Set point | Schedule | L/s | 10 |
| | Occupied | Schedule | Mode | 10 |
| | Unoccupied | Schedule | Mode | 10 |
| DI | Setback Override | Local or Global field input | Mode | 10 |
| | Morning warm-up | Schedule | Mode | 10 |
| | Holiday | Schedule | Mode | 10 |
| | **General** | | | |
| | Day/Date/Time | System | Day/Date/Time | 10 |
| | **Cumulative run times** | **System Runtime Logs** | **Total ON time per point** | |
| DO | Fan | Software | Mins./Hrs./Days/Mos./Yrs. | |
| DO | Auxiliary Heat | Software | Mins./Hrs./Days/Mos./Yrs. | |
| | Mode: Heat/Cool | Software | Mins./Hrs./Days/Mos./Yrs. | |
| | Mode: Occ/Unocc | Schedule | | |

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**EXHAUST FAN**

| Point Type | Point Name / Description | Source | Value | Minimum Sample Interval Minutes |
|---|---|---|---|---|
| AI | Outside Air Temperature | Analog Sensor | Degree C | 10 |
| AI | Room Temperature | Analog Sensor | Degree C | 10 |
| DO | Fan Command | Digital Command | On/Off | 10 |
| DI | Fan Status Proof | Current or DP Switch | On/Off | 10 |
| AI | Fan Status Proof | Current Transducer | Amps | 10 |
| | **System Modes** | | | |
| | Operating Heating Set point | Schedule | Degree C | 10 |
| | Operating Cooling Set point | Schedule | Degree C | 10 |
| | Occupied | Schedule | Mode | 10 |
| | Unoccupied | Schedule | Mode | 10 |
| | Holiday | Schedule | Mode | 10 |
| | **General** | | | |
| | Day/Date/Time | System | Day/Date/Time | 10 |
| | **Cumulative run times** | **System Runtime Logs** | **Total ON time per point** | |
| DO | Fan | Software | Mins./Hrs./Days/Mos./Yrs. | |

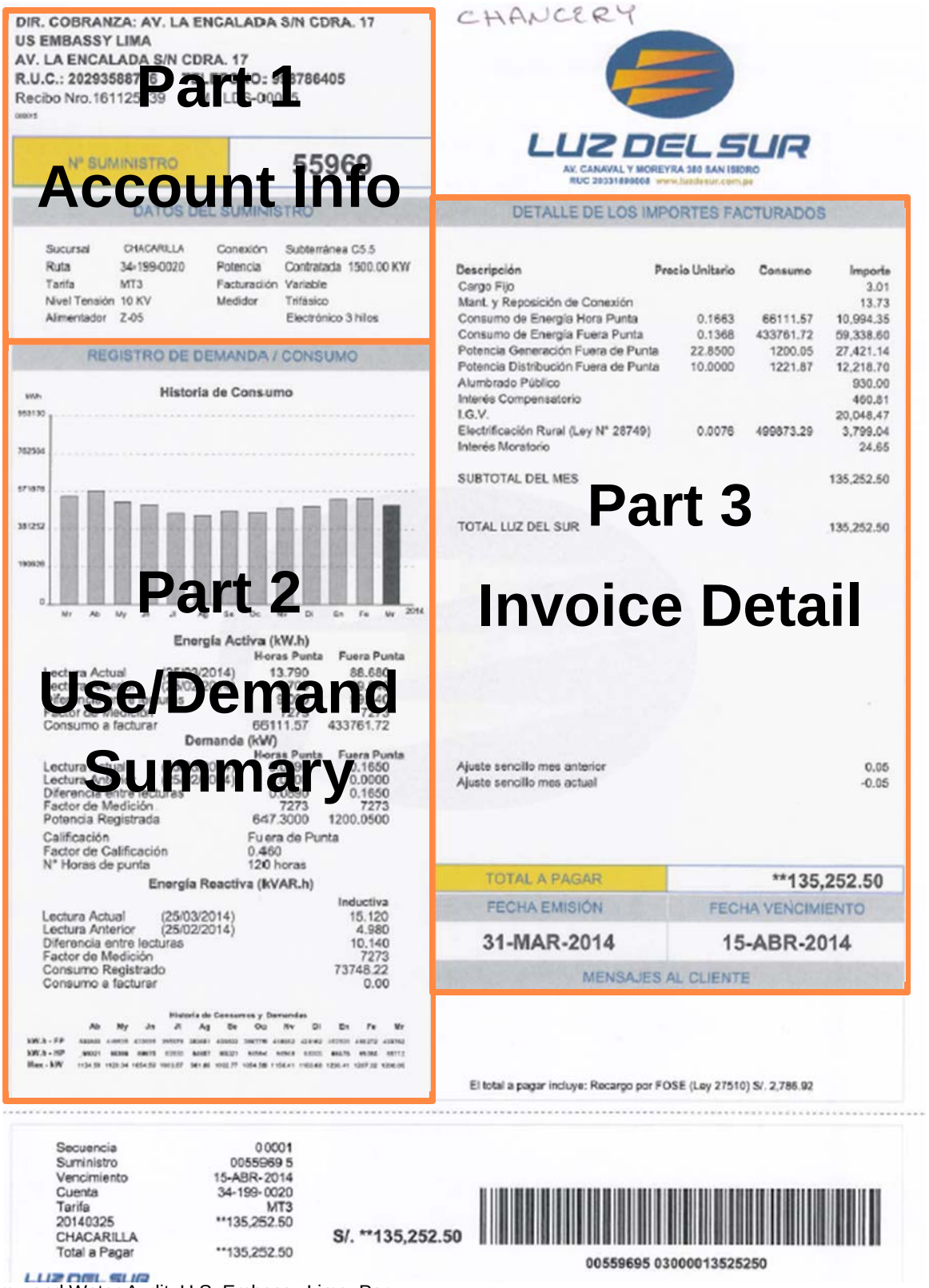
**AHU-CV**

| Point Type | Point Name / Description | Source | Value | Minimum Sample Interval Minutes |
|---|---|---|---|---|
| AI | Outside Air Temperature | Analog Sensor | Degree C | 10 |
| AI | Room Temperature | Analog Sensor | Degree C | 10 |
| AI | Discharge Air Temperature | Analog Sensor | Degree C | 10 |
| AI | Return Air Temperature | Analog Sensor | Degree C | 10 |
| AI | Mixed Air Temperature | Analog Sensor | Degree C | 10 |
| DO | Fan Command | Digital Command | On/Off | 10 |
| DI | Fan Status Proof - OR- | Current Switch | On/Off | |
| AI | Fan Status / Power | Current Transducer | Amps | 10 |
| DI | Dirty Filter | Differential Pressure Switch | On/Off | 10 |
| | **Packaged Units** | | | |
| DO | Cooling Compressor(s) | Digital Command | On/Off | 10 |
| DO | Heating Gas/Electric | Digital Command | On/Off | 10 |
| | **Hydronic Systems** | | | |
| AO | Cooling Valve Command | Analog Signal | 0-10vdc, 4-20ma | 10 |
| AO | Heating Valve Command | Analog Signal | 0-10vdc, 4-20ma | 10 |
| | **Economizers** | | | |
| AO | Outside Air Damper | Analog Signal | 0-10vdc, 4-20ma | |
| AO | Return Air Damper | Analog Signal | 0-10vdc, 4-20ma | |
| AO | Mixed Air Damper | Analog Signal | 0-10vdc, 4-20ma | |
| | **System Modes** | | | |
| | Operating Heating Set point | Schedule | Degree C | 10 |
| | Operating Cooling Set point | Schedule | Degree C | 10 |
| | Occupied | Schedule | Mode | 10 |
| | Unoccupied | Schedule | Mode | 10 |
| DI | Setback Override | Local or Global field input | Mode | 10 |
| | Morning warm-up | Schedule | Mode | 10 |
| | Holiday | Schedule | Mode | 10 |
| | **General** | | | |
| | Day/Date/Time | System | Day/Date/Time | 10 |
| | **Cumulative run times** | **System Runtime Logs** | **Total ON time per point** | |
| DO | FAN | Software | Mins./Hrs./Days/Mos./Yrs. | |

| | | | |
|---|---|---|---|
| DO | COOL | Software | Mins./Hrs./Days/Mos./Yrs. |
| DO | HEAT | Software | Mins./Hrs./Days/Mos./Yrs. |
| DO | ECONO | Software | Mins./Hrs./Days/Mos./Yrs. |

# APPENDIX G: TRANSLATED UTILITY BILLS

## ELECTRIC BILL



# Part 1 Account Info

Address

DIR. COBRANZA: AV. LA ENCALADA S/N CDRA. 17
US EMBASSY LIMA
AV. LA ENCALADA S/N CDRA. 17
R.U.C.: 20293588776 TELEFONO: 998786405
Recibo Nro.161125639 M - LDS-00015
000015

Account Number

Nº SUMINISTRO 55969

Account Information

DATOS DEL SUMINISTRO

| | | | | | |
|---|---|---|---|---|---|
| Branch | Sucursal | CHACARILLA | Conexión | Subterránea C5.5 | Connection |
| Route | Ruta | 34-199-0020 | Potencia | Contratada 1500.00 KW | Power |
| Tariff | Tarifa | MT3 | Facturación | Variable | Billing |
| Voltage Level | Nivel Tensión | 10 KV | Medidor | Trifásico | Meter |
| Feeder | Alimentador | Z-05 | | Electrónico 3 hilos | 3-phase, 3-wire, electronic |

# Part 2 Use/Demand Summary

## REGISTRO DE DEMANDA / CONSUMO

### Historia de Consumo

Use History

On Peak | Off Peak

Active Energy

### Energía Activa (kW.h)

| | | | Horas Punta | Fuera Punta |
|---|---|---|---|---|
| Current reading | Lectura Actual | (25/03/2014) | 13.790 | 88.680 |
| Previous reading | Lectura Anterior | (25/02/2014) | 4.700 | 29.040 |
| Diff. in readings | Diferencia entre lecturas | | 9.090 | 59.640 |
| Measurement factor | Factor de Medición | | 7273 | 7273 |
| Billed consumption | Consumo a facturar | | 66111.57 | 433761.72 |

Demand

### Demanda (kW)

| | | | Horas Punta | Fuera Punta |
|---|---|---|---|---|
| Current reading | Lectura Actual | (25/03/2014) | 0.0890 | 0.1650 |
| Previous reading | Lectura Anterior | (25/02/2014) | 0.0000 | 0.0000 |
| Diff. in readings | Diferencia entre lecturas | | 0.0890 | 0.1650 |
| Measurement factor | Factor de Medición | | 7273 | 7273 |
| Billed power | Potencia Registrada | | 647.3000 | 1200.0500 |
| Rating | Calificación | | Fuera de Punta | |
| Rating factor | Factor de Calificación | | 0.460 | |
| Peak hours | N° Horas de punta | | 120 horas | |

Reactive Energy

### Energía Reactiva (kVAR.h)

| | | | Inductiva |
|---|---|---|---|
| Current reading | Lectura Actual | (25/03/2014) | 15.120 |
| Previous reading | Lectura Anterior | (25/02/2014) | 4.980 |
| Diff. in readings | Diferencia entre lecturas | | 10.140 |
| Measurement factor | Factor de Medición | | 7273 |
| Measured power | Consumo Registrado | | 73748.22 |
| Billed consumption | Consumo a facturar | | 0.00 |

### Historia de Consumos y Demandas

| | Ab | My | Jn | Jl | Ag | Se | Oc | Nv | Di | En | Fe | Mr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| kW.h - FP | 502855 | 446635 | 433689 | 395578 | 383651 | 405833 | 398779 | 418052 | 428162 | 462926 | 466272 | 433762 |
| kW.h - HP | 69021 | 68366 | 69675 | 63930 | 64657 | 65021 | 64584 | 64948 | 68003 | 66475 | 69384 | 66112 |
| Max - kW | 1134.59 | 1120.04 | 1054.59 | 1003.67 | 981.86 | 1032.77 | 1054.59 | 1156.41 | 1163.68 | 1236.41 | 1207.32 | 1200.05 |

# Part 3 Use/Demand Summary

DETALLE DE LOS IMPORTES FACTURADOS

| | Descripción | Unit Price<br>Precio Unitario | Use<br>Consumo | Cost<br>Importe |
|---|---|---|---|---|
| Fixed charge | Cargo Fijo | | | 3.01 |
| Connection charge | Mant. y Reposición de Conexión | | | 13.73 |
| Energy use on peak | Consumo de Energía Hora Punta | 0.1663 | 66111.57 | 10,994.35 |
| Energy use off peak | Consumo de Energía Fuera Punta | 0.1368 | 433761.72 | 59,338.60 |
| Power generation off peak | Potencia Generación Fuera de Punta | 22.8500 | 1200.05 | 27,421.14 |
| Power distribution off peak | Potencia Distribución Fuera de Punta | 10.0000 | 1221.87 | 12,218.70 |
| Public lighting | Alumbrado Público | | | 930.00 |
| Interest | Interés Compensatorio | | | 460.81 |
| Tax | I.G.V. | | | 20,048.47 |
| Rural Electrification Fee | Electrificación Rural (Ley N° 28749) | 0.0076 | 499873.29 | 3,799.04 |
| Interest | Interés Moratorio | | | 24.65 |
| This month's subtotal | SUBTOTAL DEL MES | | | 135,252.50 |
| Total due to LDS | TOTAL LUZ DEL SUR | | | 135,252.50 |
| Simple adjustment last month | Ajuste sencillo mes anterior | | | 0.05 |
| Simple adjustment this month | Ajuste sencillo mes actual | | | -0.05 |

Total due

| TOTAL A PAGAR | **135,252.50 |
|---|---|
| FECHA EMISIÓN | FECHA VENCIMIENTO |
| 31-MAR-2014 | 15-ABR-2014 |

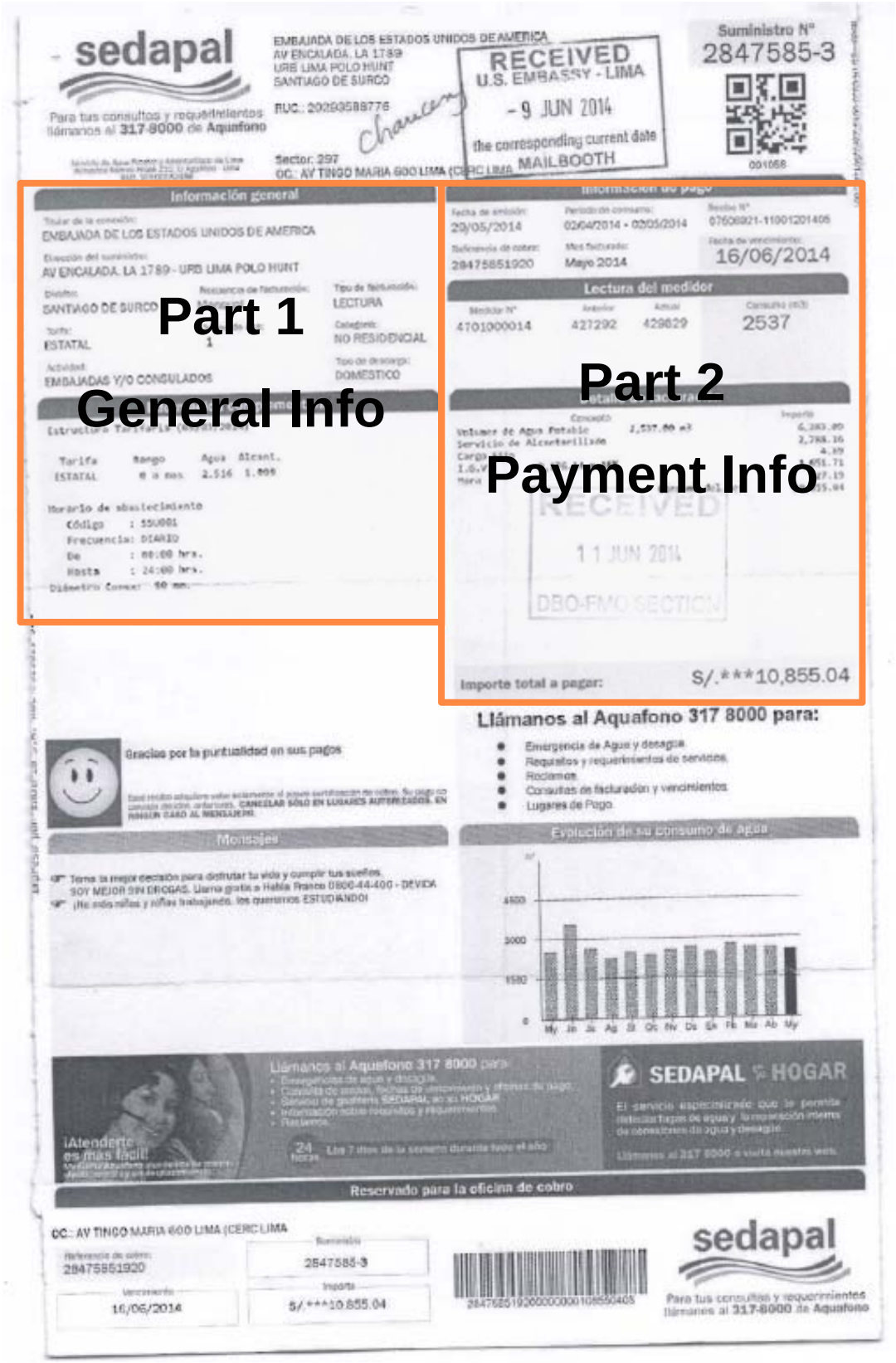
Invoice date

Due date

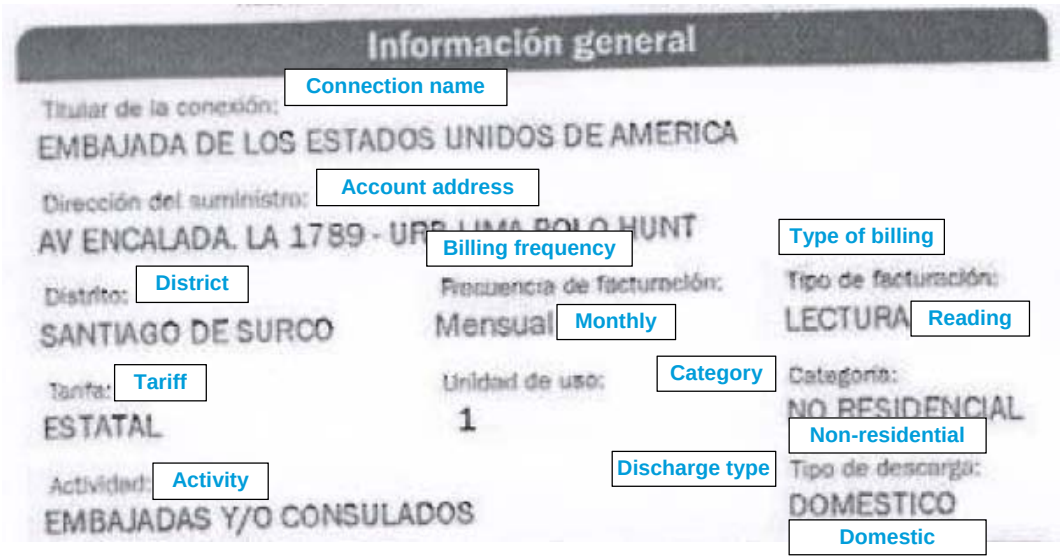
MENSAJES AL CLIENTE

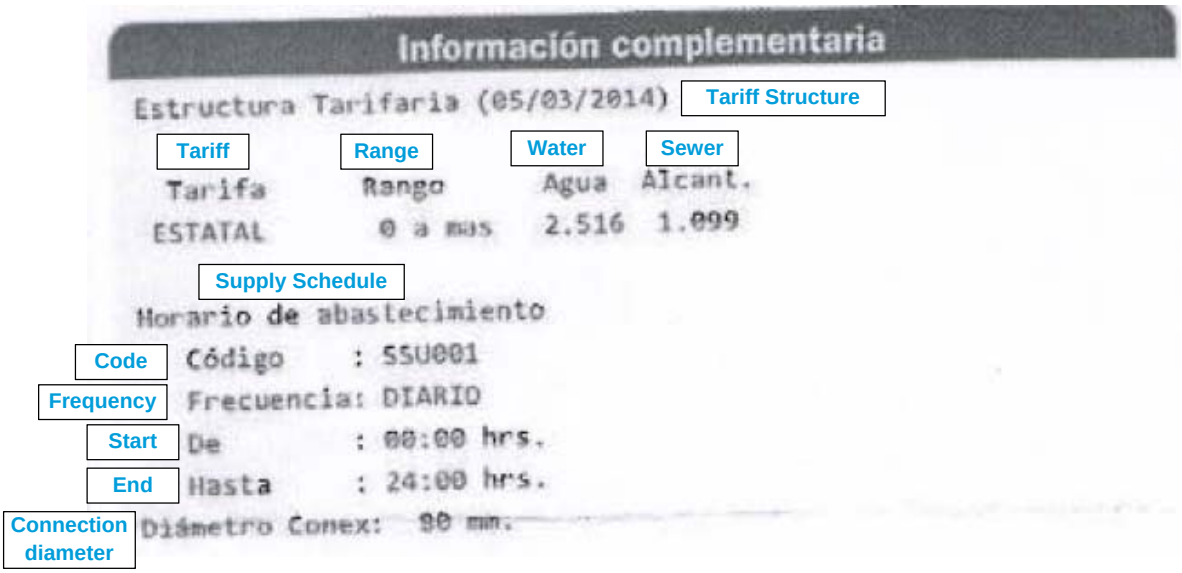
Messages to the client

## WATER BILL


sedapal
EMBAJADA DE LOS ESTADOS UNIDOS DE AMERICA
AV ENCALADA, LA 1789
URB LIMA POLO HUNT
SANTIAGO DE SURCO
RECEIVED
U.S. EMBASSY - LIMA
- 9 JUN 2014
the corresponding current date
MAILBOOTH
Suministro N°
2847585-3
Información general
EMBAJADA DE LOS ESTADOS UNIDOS DE AMERICA
AV ENCALADA, LA 1789 - URB LIMA POLO HUNT
SANTIAGO DE SURCO
LECTURA
ESTATAL
NO RESIDENCIAL
EMBAJADAS Y/O CONSULADOS
DOMESTICO
Part 1
General Info
Información de pago
29/05/2014
02/04/2014 - 02/05/2014
07608921-11001201406
28475851920
Mayo 2014
16/06/2014
Lectura del medidor
4701000014
427292
429829
2537
Part 2
Payment Info
RECEIVED
11 JUN 2014
DBO-FMO SECTION
Importe total a pagar:
S/.***10,855.04
Llámanos al Aquafono 317 8000 para:
Emergencia de Agua y desagüe
Requisitos y requerimientos de servicios
Reclamos
Consultas de facturación y vencimientos
Lugares de Pago
Gracias por la puntualidad en sus pagos
Mensajes
Evolución de su consumo de agua
SEDAPAL HOGAR
¡Atenderte es más fácil!
Reservado para la oficina de cobro
CC.: AV TINGO MARIA 600 LIMA (CERC LIMA
28475851920
2847585-3
16/06/2014
S/.***10,855.04
sedapal
Para tus consultas y requerimientos llámanos al 317-8000 de Aquafono

# Part 1 General Info



# Part 2 Billing Info

Payment Information

## Información de pago

| Issue Date | Billing Period | Invoice # |
|---|---|---|
| Fecha de emisión: 29/05/2014 | Período de consumo: 02/04/2014 - 02/05/2014 | Recibo N° 07506921-11001201405 |
| Collection Reference: Referencia de cobro: 28475851920 | Billing Month: Mes facturado: Mayo 2014 | Due Date: Fecha de vencimiento: 16/06/2014 |

Meter Reading

## Lectura del medidor

| Meter Number | Previous | Current | Consumption |
|---|---|---|---|
| Medidor N° 4701000014 | Anterior 427292 | Actual 429829 | Consumo (m3) 2537 |

Billing Detail

## Detalle de facturación

| Concepto | | Importe |
|---|---|---|
| Volumen de Agua Potable (Water volume) | 2,537.00 m3 | 6,383.09 |
| Servicio de Alcantarillado (Sewage service) | | 2,788.16 |
| Cargo Fijo (Fixed fee) | | 4.89 |
| I.G.V. (Tax) | 9,176.14 x 18% | 1,651.71 |
| Mora | | 27.19 |
| | Consumo del mes | 10,855.84 |

RECEIVED
11 JUN 2014
DBO-FMO SECTION

Total to pay

**Importe total a pagar:** S/.***10,855.04

# APPENDIX H: GLOSSARY OF ACRONYMS

| | |
|---|---|
| AHU | Air-Handling Unit |
| ASHRAE | American Society of Heating, Refrigerating and Air-Conditioning Engineers |
| BAS | Building Automation System |
| Btu | British Thermal Unit |
| CDD | Cooling Degree Day |
| DE | Design and Engineering |
| DHW | Domestic Hot Water |
| DOE | Department of Energy |
| EE | Energy Efficiency |
| EER | Energy Efficiency Ratio |
| ECM | Energy Conservation Measure |
| EFCOG | Energy Facility Contractors Group |
| EO | Executive Order |
| ESPC | Energy Savings Performance Contract |
| FOD | Field Observed Deficiency |
| GPF | Gallons per Flush |
| GPM | Gallons per Minute |
| HDD | Heating Degree Day |
| HVAC | Heating, Ventilation and Air-Conditioning |
| IFMA | International Facilities Management Association |
| IMI | International Maintenance Institute |
| IPLV | Integrated Part Load Value |
| kW | 1 thousand Watts |
| kWh | 1 thousand Watt Hours |
| MAR | Meter Assessment Recommendation |
| MMBtu | 1 million British Thermal Units |
| NPLV | Nominal Part Load Value |
| O&M | Operations and Maintenance |
| OA | Outdoor Air |
| OBO | Overseas Building Operations |
| OMR | Operations and Maintenance Recommendation |
| PDCS | Program Development, Coordination and Support |
| ppm | Parts Per Million |
| RE | Renewable Energy |
| REM | Renewable Energy Measure |
| RH | Relative Humidity |
| VAV | Variable Air Volume |
| WCM | Water Conservation Measure |