**Selecting Government Facilities for EE & EC Retrofits: Methodology**

**1. Review of Existing Audits and JPSCo Information:**

The building selection process, for facilities slated to receive deeper retrofits, started with a consultation with the Auditors, (DNV GL) in determining the basic data which was required to complete a literature review.

Selecting which buildings require deeper energy efficiency involved the review of a subset of the 106 existing audits and energy data on 4,000 JPSCo meters. A further consultation involving personnel from MSET, DNV, IDB and PCJ, determined the use of the following selection criteria:

* High Energy Users: High energy users provide the biggest immediate impact and result in lower administrative costs per kWh saved.
* High Profile: Projects which the community will identify with, and which will show up in local news cycles help provide project momentum and expand in-country knowledge
* Best Investments: In order for the loan to be successful, focusing on projects with high ROI and high kWh saved per capital dollar spent is critical
* Ease of Implementation: Projects that are easy to manage, have eager stakeholders, and are along transit corridors reduce risk.
* Facilities Conditions Index (FCI): Knowing the facility is in good enough condition to handle a retrofit is critical to safe and aesthetically pleasing project success.
* Quality of Life Improvements: Projects where the retrofits will include educational opportunities, emergency response (shelters), thermal comfort, etc.

A review of the existing audits showed variations in both scope of work, quality, depth of analysis, and calculation methodology.

Also capital costs have changed dramatically for some technologies over the past 5 years, this is especially true for solar PV systems and LED lighting. There were also some inconsistencies with some audits and whereas other audits appear slighting more in-depth.It was noted that a specific group of audits were very lighting-centric.

Some of the inconsistencies noted by DNV GL include:

* Lighting savings sometimes seems over-estimated, especially in APS studies
* No clear evaluations of right-sizing HVAC equipment to ensure optimum efficiency, though this may not be feasible.
* The partial year energy use calculations do not always make sense when metered data is also available
* It does not appear peak load & demand response opportunities were evaluated
* Basic building data, like overall square footage, is often lacking

As such, even though the existing library of audits were helpful, the decision was taken to complete new audits which would provide more up to date data.

A summary of the top energy users as per the previously completed audits are given in table 1

**TABLE 1: Top Electricity Consumers from Previous Audits: Jamaican Government Facilities**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Energy Use Rank | Occupancy Type | Building Name | Annual Energy Use (kWh) | Total Retrofit Capital Cost (USD) | Total Retrofit Savings (USD) | Payback |
| 1 | Hospital | KPH | 319,779,144 | $423,583 | $201,333 | 2.1 years |
| 2 | Hospital | May Pen Hospital | 30,458,087 | $41,546 | $17,070 | 2.4 years |
| 3 | Campus | JDF Newcastle | 19,023,620 | $43,017 | $20,927 | 2.1 years |
| 4 | Office (Campus) | HEART Trust Ebony Park | 10,481,280 | $67,627 | $68,147 | 1.0 years |
| 5 | Office | Ministry of Agriculture & Fisheries | 6,238,186 | $33,826 | $18,408 | 1.8 years |
| 6 | Campus | JDF Up Park Camp | 5,563,776 | $965,948 | $219,903 | 4.4 years |
| 7 | Office | JCF Greater Portmore Police Station | 5,119,836 | $62,723 | $20,994 | 3.0 years |
| 8 | Office/Community Center | Kindstron & St. Andrew Cooperation | 5,023,352 | $23,995 | $10,120 | 2.4 years |
| 9 | School | Jamaica College | 3,623,868 | $68,098 | $28,078 | 2.4 years |
| 10 | Hospital | Falmouth Hospital | 3,014,688 | $34,188 | $13,044 | 2.6 years |
| 11 | Office | JCF Constant Spring Police Station | 2,925,876 | $10,122 | $4,311 | 2.3 years |
| 12 | Campus | Ministry of Finance & Planning | 2,721,924 | $239,807 | $106,672 | 2.2 years |
| 13 | Office | National Housing Trust | 2,497,056 | $788,641 | $162,705 | 4.8 years |
| 14 | Office | Electoral Office Downtown | 2,472,828 | $39,646 | $17,468 | 2.3 years |
| 15 | Hospital | Chapleton Hospital | 2,437,003 | $24,367 | $10,120 | 2.4 years |
| 16 | Hospital | Linstead Hospital | 2,288,459 | $13,063 | $4,469 | 2.9 years |
| 17 | Office | Ministry of Education Port Antonio | 2,241,562 | $33,655 | $12,985 | 2.6 years |
| 18 | Hospital | Savanna-la-mar Hospital | 1,924,725 | $26,446 | $9,300 | 2.8 years |
| 19 | Office | Urban Development Corporation | 1,824,300 | $439,313 | $78,709 | 5.6 years |
| 20 | Office | PCJ | 1,599,612 | $87,939 | $23,168 | 3.8 years |
| 21 | Office | Central Sorting Office | 1,418,460 | $136,194 | $88,771 | 1.5 years |
| 22 | Office (Campus) | Ministry of Education | 1,245,552 | $671,246 | $124,644 | 5.4 years |
| 23 | Office (Campus) | Development Bank of Jamaica | 1,238,748 | $655,275 | $120,976 | 5.4 years |
| 24 | Airport | Norman Manley International Airport | 1,150,356 | $479,764 | $184,077 | 2.6 years |
| 25 | Office | Vocational Training and Development Institute | 1,128,996 | $73,463 | $23,266 | 3.2 years |
| 26 | Office (Campus) | Office of the Prime Minister | 1,090,860 | $530,272 | $104,810 | 5.1 years |
| 27 | Hotel | Heart Trust Runaway Bay | 1,045,944 | $151,366 | $49,294 | 3.1 years |
| 28 | Office | Ministry of Education (Region 5, Mandeville) | 980,049 | $28,963 | $19,950 | 1.5 years |
| 29 | Office | Ministry of Agriculture | 950,316 | $195,096 | $56,716 | 3.4 years |
| 30 | Office | Civil Aviation Authority | 913,500 | $912,197 | $164,588 | 5.5 years |
|  |  | **Total** | **442,421,963** | **$7,301,382** | **$1,985,027** |  |

It is important to understand the context of the audited buildings as compared to the total municipal energy demands on the island. A further review of the JPSCo billing data was used to overlay the audits-review which was completed by DNV. This is presented in table 2.

**Table 2 Top Electricity Consumers from JPSCo Billing Data: Jamaica Government Facilities**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Rank** | **Customer and Address** | **Annual Consumption (kWh)** | **Annual Cost (USD)** | **Has Audit?** |
| 1 | Ministry of Health: Victoria Jubilee Hospital Kingston C.S.O., Kingston | 6,243,408 kWh | $1,873,022 | Yes |
| 2 | Ministry of Health: Cornwall Regional Hospital Montego Bay #1 P.O., St. James | 4,633,200 kWh | $1,389,960 | No |
| 3 | National Housing Trust: 4 Park BLVD Kingston 5, Kingston | 2,319,912 kWh | $695,974 | Yes |
| 4 | Portland Parish Council: Orange Grove - Hart Hill Windsor Castle P.O., Portland | 2,185,368 kWh | $655,610 | No |
| 5 | Ministry of Health: St Anns Bay Hospital St.Anns Bay P.O., St. Ann | 2,054,232 kWh | $616,270 | No |
| 6 | Ministry of Health: Bustamante Children Hospital Kingston 5, Kingston | 1,718,496 kWh | $515,549 | No |
| 7 | Ministry of Nat Sec & Justice: Twickenham Park Spanish Town #1 P.O., St. Catherine | 1,567,354 kWh | $470,206 | No |
| 8 | Min Of Health: Mandeville Public Hospital Mandeville P.O., Manchester | 1,563,072 kWh | $468,922 | No |
| 9 | Ministry of Health: 21 Slipe Pen Public Health RD Kingston 5, Kingston | 1,489,997 kWh | $446,999 | No |
| 10 | Urban Development Corporation: Kingston Mall Office Centre Kingston C.S.O., Kingston | 1,450,944 kWh | $435,283 | No |
| 11 | Urban Development Corporation: Complant Bldg, Convention Cent Montego Bay #1 P.O., St. James | 1,396,080 kWh | $418,824 | No |
| 12 | Ministry of Health: May Pen Hospital New Denbigh P.O., Clarendon | 1,364,976 kWh | $409,493 | Yes |
| 13 | Urban Development Corporation: 11 Duke BLVD, Port Royal Kingston C.S.O., Kingston | 1,360,800 kWh | $408,240 | No |
| 14 | Central Sorting Office: South Camp RD Kingston 4, Kingston | 1,336,435 kWh | $400,931 | Yes |
| 15 | Heart Trust/NTA: Runaway Bay Runaway Bay P.O., St. Ann | 1,052,611 kWh | $315,783 | Yes |
| 16 | Min Of Transport & Works: Half Way Tree/Oxford RD Kingston 5, Kingston | 897,996 kWh | $269,399 | Yes |
| 17 | Urban Development Corporation: 8 Ocean BLVD BLK 6, Kingston C.S.O., Kingston | 1,003,440 kWh | $301,032 | No |
| 18 | Urban Development Corporation: Caymanas Estate Spanish Town #1 P.O., St. Catherine | 963,130 kWh | $288,939 | No |
| 19 | Ministry of Nat Sec & Justice: King ST, Supreme Court Kingston C.S.O., Kingston | 930,874 kWh | $279,262 | No |
| 20 | Ministry of Health: Burke RD Spanish Town #1 P.O., St. Catherine | 866,232 kWh | $259,870 | No |

In reviewing of the Energy Consumption data in Table 3, which was provided by compiling the JPSCo bills for the Public Sector Facilities-2015, the agencies which showed the highest consumption (after NWC and Street lights) were the Health, Education and Public Agencies combined sectors

**TABLE 3: Summary of Public Sector (and sub-sectors) Electricity Consumption 2015**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sector (2015 Figures)** | **Annual consumption (GWh)** | **Share of annual consumption (%)** | **Average annual consumption (GWh)** | **Annual cost per sector (US$ million)** |
| **National Water Commission** | 174.10 | 44.2% | 14.51 | 44.09 |
| **Street Lighting** | 69.80 | 17.7% | 5.82 | 18.45 |
| **Public Agencies Combined** | 34.07 | 8.7% | 2.84 | 9.65 |
| **Ministry of Health** | 30.59 | 7.8% | 2.55 | 7.41 |
| **Ministry of Education** | 23.73 | 6.0% | 1.98 | 6.64 |
| **Civil Aviation** | 16.90 | 4.3% | 1.41 | 4.46 |
| **Security and Justice** | 19.11 | 4.9% | 1.59 | 5.48 |
| **Irrigation** | 15.01 | 3.8% | 1.25 | 3.92 |
| **Defense** | 10.25 | 2.6% | 0.85 | 2.50 |
| **TOTAL** | **393.56** | **100.0%** | **32.80** | **102.61** |

Based on the selection criteria which included facilities which can be used as shelters, six buildings for the walk-through and subsequent Investment Grade Audits (IGAs) were selected.

**2. Selecting the Sample Six Facilities:**

Hospitals represent 6 of the top ten energy users among GoJ facilities. Due to their high energy use, public-facing nature, and importance to the community in extreme weather events, it was determined that the project should specifically focus on hospitals as one occupancy type. As the single highest energy user, Kingston Public/Victoria Jubilee Hospital was chosen for further diagnosis. In addition Cornwall Regional and Mandeville Public Hospitals were each chosen due to their high energy use and regional significance.

It is important not to focus on a single building type. Schools were selected as a major opportunity. They are extremely high profile within their local communities, and provide an opportunity to educate the future leaders of Jamaica on climate change. They also tend to use a great deal of energy and many have been audited previously, allowing the team an opportunity to leverage the work of previous efforts. Marcus Garvey High School was included based on the emergency shelter criteria as well as the results of a CALATEL/PCJ audit of schools. Many of the schools in the CALATEL audits have since received a number of retrofits and Marcus Garvey was selected as they have not received any interventions, and the relatively high energy consumption. Ebony HEART Trust Academy was chosen as it is an important resource for the community; provide technical education opportunities to the surrounding community. Its proximity to Mandeville also allows for more manageable travel by the contractor during installation.

The Ministries of Health and Education combined account for 14% of total GoJ electricity usage, and are a critical components of the regional energy strategy. The six buildings chosen for Investment Grade Audits represent 25% of the electricity consumed by the Health and Education Ministries. Hospitals represent 6 of the top ten energy users among GoJ facilities and due to their high energy use, public-facing nature, and importance to the community in extreme weather events. Schools were selected as a second major opportunity for receiving retrofits given their electricity consumption, their high profile within their local communities and natural platform to educate the future leaders of Jamaica on climate change. Importantly all these facilities had been audited previously, allowing a better understanding of the condition of the buildings in advance.

A similar process was used to select additional 24 HEPA facilities to be considered for financing with this Project in that an understanding of the buildings was based on previous audits (including the CALATEL) and JPSCo billing data. Projections were calculated by using kilowatt hour consumption in each building and relating this to the main factors that drive their energy use and estimating the capital investment required, given a limited Project budget. For example, 7 additional hospital selected were analyzed based on their kWhs per bed energy consumption and for schools, the average annual KWh use per student was estimated. Approximately 10 public administrative facilities were selected based on the most recent audits already performed and for the single LED lighting intervention across the 50 public sector facilities, an existing lighting audit and comparable-estimate was used whose technical specifications were completed but not procured during the previous IDB loan (JA-L1025).

**3. Detailed Diagnostic Audit: Investment Grade Audits (IGAs)**

For detailed energy audits, more detailed data and information were required. Measurements and a data inventory were conducted over two to three days and different energy systems (pump, fan, compressed air, steam, process heating, etc.) were assessed in detail. The results of these audits are more comprehensive and useful since they gave a more accurate picture of the energy performance of the plant and more specific recommendation for improvements.

**The Energy Use Profile**

Different options were deployed determine the Energy profiles. These included:

* Load Inventory
* Measurement of energy use
* Benchmarking and comparative energy performance analysis

**Load Inventory**

An inventory of the uses of electricity was completed to help develop a baseline that would allow the team to focus the required energy management efforts upon the areas of greatest opportunity.

Thus discussions with the Facilities’ Managers and the preparation of the inventory list of all loads in the facilities, would answer two important questions:

* Where is the electricity used?
* How much and how fast is electricity used in each category?

The building electrical use profile was divided into different end-use categories such as those shown on the pie chart below for KPH/VJH.



The IGAs also indicated that more accuracy could be garnered by adding sub-metering systems throughout the facility

**Measurement-Sub Meters and Data Loggers**

Recommendations were made in the IGAs for each facility to also consider sub-metering.

In its simplest form, sub-metering involves installing separate meters downstream of the primary billing meter. These meters monitor specific points in the system. In campus settings, for example, sub-meters might be set up on a building-by-building basis to allocate energy costs among departments

The IGAs pointed out that there are multiple buildings at some of the facility locations and that they are used on inconsistent schedules and with dissimilar equipment. As such the installation of sub meters would allow the facility managers to track the energy use of the individual activities more closely.

Even though the IGAs did not incorporate the use of sub meters, they did utilize data logging. Data logging helps to identify opportunities to save energy as well as any performance issues with supply and equipment. The information can also help to verify information collected in the load inventory.

**Benchmarking and comparative energy performance analysis**

Energy use benchmarking is defined as the process that compares the energy use of a building with other similar structures. It is a critical evaluation for organizations with a large building portfolio to identify building performance and the factors that drive their energy use.

Load profiles referenced in the IGAs identify Typical Electric End-Use Breakdown. The end-use energy factors are based on the California Commercial End-Use Survey (CEUS) with adjustment based on engineering judgment from site observations.

**4. Technologies Selected and Measures for all buildings for deep energy retrofits:**

The investment grade audits for the sample 6 buildings had provided sufficiently detailed information to the determine the type of EE and RE technologies (see Table 4) suited to each building along with the capital investment required and the simple payback. From this analysis it was clear that LED lighting provided the fastest payback with an average of 1 year return value; HVAC second at 3 years average and building envelope measures the third with a 5-year payback average. So when packaged together to form a “deep” or comprehensive retrofit, a high rate of return on investment of 5.7 years was possible for the 23 facilities considered for the Project.

The EE and RE technologies and measures for the 23 buildings were selected after comparing them international best practice and norms for energy savings in education facilities. For heating, ventilation and air conditioning (HVAC) technologies recommended by the audits are in keeping with other types of retrofits which have provided comparable electricity reductions in previous energy efficiency programs. Other mechanical technologies selected include variable frequency drive (VFD) installation on kitchen fans, on chiller pumps, compressed air leakage and centralized chiller controls. Solar systems selected have been sized for load-matching, and as such the projected amount of electricity generated by the systems use the average amount required for tropical climates, annually. The building envelope technologies selected for use in the 23 buildings include simple and effective measures such as air seals on doors and windows, automatic door closers, replacing split systems with high efficiency, inverter-driven units. Finally, lighting interventions from the audit are in keeping with other types of retrofits which have provided comparable electricity reductions in previous energy efficiency programs and include fluorescent to LED fixture retrofit; occupancy sensor for interior lights and solar tubes.

**Table 4: Energy Efficient and Conservation Technologies and Measures Identified in the 6 Audits: Savings and Payback**



**Education Facilities**

The results of the audits, the JPSCo data and the CALATEL/PCJ reports were used to select the seven (7) additional educational facilities.

In addition, further consultations with PCJ, provided the names of facilities which should be included, based on their internal reviews and recommendations.

Based on the selection criteria outlined above, the schools were also selected based on:

* High Energy Users: High energy users provide the biggest immediate impact and result in lower administrative costs per kWh saved.
* High Profile: Projects which the community will identify with, and which will show up in local news cycles help provide project momentum and expand in-country knowledge
* Quality of Life Improvements: Projects where the retrofits will include educational opportunities, emergency response (shelters), thermal comfort, etc.

Benchmarking

To allow an understandable comparison between the values from different countries, studies suggest that examining final energy consumption, (the value that comes on monthly energy bills) should be used as the unit for benchmark for schools. This recommendation is proposed by studies completed by University of Coimbra and ADAI in Portugal and the Department of Energy in Italy.

As such, instead of relying only on the kWhrs/student ratio, a more representative benchmark would analyze the electricity consumption of individual categories such as lighting, HVAC systems and electrical equipment, per student.

Projection

In the interim, the electricity consumption per student can be used to project the anticipated electricity consumption reduction in schools.

The additional selected seven (7) schools in the EMEP programme currently use an average of 99 kWhrs per student, annually. The selected EEMS and RE solutions will reduce this to approximately 22 kWhrs per student annually, which will significantly improve the Facilities’ energy efficiencies

**Public Agencies Combined Facilities and Lighting Retrofits**

The buildings in the Public Agencies combined sector, were selected based on Audits, completed by the Energy Efficiency Conservation Technical Assistance report of 2011. These buildings also meet the following criteria:

* High Profile: Projects which the community will identify with, and which will show up in local news cycles help provide project momentum and expand in-country knowledge
* Best Investments: In order for the loan to be successful, focusing on projects with high ROI and high kWh saved per capital dollar spent is critical
* Ease of Implementation: Projects that are easy to manage, have eager stakeholders, and are along transit corridors reduce risk.

Finally, the lighting selections were made based on a lighting audits and comparables-estimate, which was completed during the previous IDB loan.

The technical specifications for that lighting contract were previously given the IDB’s non-objection. As noted by DNV however, capital costs have changed dramatically for some technologies over the past 5 years, this is especially true for solar PV systems and LED lighting. As such a technical/financial review will have to be completed re the lighting component.