

Confidential



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Appendix A: Energy Efficiency Measures and Programs

During the technical site visits, a number of broadly applicable energy conservation measures (ECMs) were identified as being relevant to the Belize economy. The sections below include descriptions of the technologies and systems employed in these measures, and a presentation of how energy savings potential is assessed for each.

While ECMs are not cumulative, as savings from one upgrade can reduce savings potential in another (i.e. upgrading air conditioning to a higher efficiency model will reduce the future potential savings from insulating the building), for the purpose of this report savings are combined to estimate the net efficiency potential within the country. As highlighted in Table A.1 below, electricity consumption can theoretically be reduced by up to 143 GWh per year, from the base case 2013 consumption of 505 GWh per year, a 28% savings, at a net annual capital expense of BZ\$29.5M, or BZ\$0.21 per kWh saved. The combined ECM recommendations have a positive net present value when compared against the national average cost of electricity of BZ\$0.49/kWh.

Table A.1: Net Energy Consumption and ECM Potential

	Base year (2013)		ECM Savings		Upgrade Economics			
	Base case MWh	Electricity BZ\$/Yr (x1,000)	Retrofit MWh Saved	% Savings	Ann. Retrofit Capex in BZ\$ (x1,000)	Electricity + Ann. Capex BZ\$/Yr (x1,000)	Net BZ\$/Yr Savings (x1,000)	Ann. Capex. BZ\$/kWh Saved
GOV1	5,800	2,864	1,702	29%	377	2,400	464	0.22
GOV2	16,288	8,099	1,622	10%	398	7,690	409	0.25
STL	50,211	27,616	22,153	44%	3,956	19,388	8,228	0.18
CO1	78,839	38,671	21,052	27%	4,563	32,908	5,763	0.22
CO2	163,835	79,568	57,509	35%	14,364	66,002	13,566	0.25
RES	145,498	68,251	24,119	17%	5,076	62,013	6,238	0.21
IN1	9,038	4,111	2,901	32%	179	2,971	1,140	0.06
IN2	35,610	13,662	12,407	35%	600	9,503	4,159	0.05
TOTAL	505,119	242,843	143,467	28%	29,514	202,876	39,967	0.21

Source: WSP Analysis

Note: *RES* – all residential; *CO1* and *CO2* – small commercial and large commercial; *GOV1* and *GOV2* correspond to government buildings in the *CO1* and *CO2* categories; *IND1* and *IND2* – small industrial and large industrial; *STR* – street lights

A.1 Overview of Methods

This section presents three of the main methods of analysis we used to generate our sector by sector estimates of potential savings from energy efficiency. Those methods are:

- Energy Conservation Measure Costs & Savings per kWh Reduced

- Determining Max Potential
- Energy Conservation Measure National Costs and Savings.

A.1.1 Energy Conservation Measure Costs & Savings per kWh Reduced

By comparing the prevalence of different types of building construction, lighting profiles, and installed equipment with each sector's known average energy intensity, we developed a "typical" building profile for each sector. These building profiles were used as a base case model to assess the feasibility of twenty four energy conservation measures, as outlined in the following sections. Energy savings were calculated through the use of energy modeling software (eQuest) and engineering best practices. Costs were estimated using local rates for equipment and labor where available, and location-adjusted estimates from engineering cost databases as necessary.

A.1.2 Determining Max Potential

Of the 24 ECMs discussed above, each upgrade is only applicable to a select percent of buildings within each sector. For example, only 10-15% of residential units and 60% of commercial units are air conditioned, while 0% of industrial spaces are air conditioned. As such, retrofit improvements that reduce cooling load could only be applied to the buildings that have existing cooling load. This ratio, known as max technical potential, is a key driver in translating efficiency savings at a building by building basis, to the national level.

Max technical potential was calculated individually for each ECM and each sector, as the applicability of each recommendation is dependent upon unique variables such as building use, building schedule, existing equipment, and existing building conditions. These variables were primarily derived using weighted calculations from census and audit data.

A second control variable was introduced to model different levels of implementation at the national scale. This variable, hereby known as percent penetration, was used as a multiplier to determine what percentage of the total number of buildings that have the technical potential for upgrade will actually be upgraded, and what percentage will remain as is without any renovation. To fully assess the cost benefit analysis of different rates of implementation, the % penetration was modeled as low (20%), moderate (40%), aggressive (60%), and maximum technical potential (100%).

As an example, from an engineering analysis of existing air conditioning units and cost effective upgrades, we determined that upgrading outdated window-AC units to split system inverter AC units could reduce the cooling electricity demand (while producing the same amount of cooling) by 51%. Within the large government sector (for example), cooling accounts for an estimated 13,500 MWh of electricity per year. From census and audit data, it is estimated that approximately 12% of large government buildings have window AC units (technical potential). To determine the impacts of an aggressive replacement program, it can be assumed that 60% of all large government building window AC units will be replaced (% Penetration). Therefore, applying this ECM to the large government sector would save:

$$(13,500\text{MWh base case}) * (51\% \text{ Savings}) * (12\% \text{ technical potential}) * (60\% \text{ penetration}) =$$

3.6% large gov't cooling electricity reduction = 495MWh/year electricity reduction

Using the same methodology, this analysis would then be repeated for the other six remaining sectors to determine the net national savings from this particular ECM.

A.1.3 Energy Conservation Measure National Costs and Savings

Repeating the calculation methods outlined in Section A.1.2, we determine the net savings potential for each sector. ECM savings were sorted into four categories: cooling, refrigeration, plug & process load, and transmission & distribution. Results for each ECM category are summarized in three sections: base case operations, savings, and upgrade economics. All values are calculated using an assumed 100% penetration rate to demonstrate the maximum potential savings. These detailed tables are summarized in a high level summary excluding the details of each ECM in Table A.2 below.

Annualized retrofit capital expense (Ann. Retrofit Capex) is calculated as a function of the net capital costs and ECM upgrade's lifetime at an assumed 6% discount rate.

Net BZ\$ savings per year is calculated as the base case electricity costs plus annualized capital costs minus electricity savings that result from the ECM improvements. Annualized capital expense per kwh saved is calculated as the annualized capital costs divided by the net kwh/year reduced from the ECM upgrade.

A.2 EE Measures

The following sections outline ECMs categorized into five overarching measures addressing savings in: lighting, air conditioning, refrigeration, plug loads and processes, industrial power quality, and fuel.¹

A.2.1 Lighting

Lighting accounts for 20% of national electricity consumption in Belize. Street lighting accounts for over half of the total lighting load, with large commercial and residential sectors accounting for the majority of the remaining lighting load.

Lighting ECMs, as outlined in detail below, have the potential to reduce lighting electric load by 43%, at a capital expense equivalent of \$0.22 per kwh.

¹ We did not consider water saving measures in our analysis. Pumping municipal water to residences and commercial businesses in Belize is not especially energy intensive. Belize Water Services LTD uses about 1200 MWh per year, equivalent to 0.2 percent of national electricity demand. Rain water collection and use by residences for non-potable uses (dish washing etc.) is not expected to dramatically reduce this consumption since large waste water treatment loads and potable water pump loads would still remain.

Table A.2: Lighting Energy Consumption and ECM Potential

	Base case Operations			ECM Savings		Upgrade Economics			
	% of Total Energy	Base case MWh	Electricity \$/Yr (x1,000)	Retrofit MWh Saved	% Savings	Ann. Retrofit Capex in BZ\$ (x1,000)	Electricity + Ann. Capex BZ\$/Yr (x1,000)	Net \$/Yr Savings (x1,000)	Ann. Capex. / kWh Saved
GOV1	4%	232	115	83	36%	30	104	11	0.36
GOV2	6%	945	470	194	21%	62	436	34	0.32
STL	100%	50,211	27,616	22,153	44%	3,956	19,388	8,228	0.18
CO1	2%	1,798	882	875	49%	232	685	197	0.27
CO2	14%	23,597	11,460	10,716	45%	3,209	9,465	1,995	0.30
RES	15%	22,028	10,333	8,260	38%	1,952	8,410	1,923	0.24
IN1	9%	822	374	260	32%	84	340	34	0.32
IN2	1%	514	197	241	47%	57	161	36	0.23
TOTAL	18%	100,147	51,447	42,783	43%	9,583	38,989	12,458	0.22

Source: WSP Analysis

Replace Incandescent Bulbs with Compact Fluorescent Lamps

It is recommended that all incandescent bulbs be replaced with compact fluorescent lamps (CFLs). Incandescent bulbs are one of the least efficient methods of lighting, yet are one of the most prevalent sources of light in Belizean residences. Replacing incandescent bulbs with compact fluorescent lamps (CFLs) can achieve up to 75% reduction in lighting energy without degradation of light quality. The combination of low capital cost per lamp, and ease of installation make this ECM a low hanging fruit with strong potential for widespread implementation.

Applicable sectors	% Savings vs. typical baseline	Annualized Net BZ\$/kWh Saved	Simple Payback Period (Years)	Lifetime (Years)
RES / CO1 / CO2	75%	\$0.24	1.9	5

Replace T12 with T8 Lamps

We recommend that all magnetically ballasted F40T12 lamps be replaced with electronically ballasted F32T8 lamps. Low power T8 lamps and ballasts are a cost effective replacement for the older, and less efficient standard T12 systems used throughout Belize. The typical overhead lighting setup in most commercial buildings and some industrial buildings include 2' x 4' panels of magnetically ballasted F40T12 lamps with 2 lamps per panel. Single lamp strip lighting is also fairly common, again using magnetic ballasts. Three lamp panels are likely also in use but were not observed during the site visits. Some building engineers and maintenance managers have begun to retrofit these systems with F32T8 lamps but these cases were the exception, rather than the rule.

T5 lamps are the most efficient of the fluorescent tube bulbs, but cannot be effectively retrofitted into existing T8 (or other) fixtures without degradation of lighting output and quality. While their capital cost is higher than T8 or low power T8, their reduced electricity demand per lumen output makes them economically competitive with low power T8s for T12 replacement in many situations. However, T5 lamps were seen only once and are not available at conventional hardware supply stores in Belize and would need to be special ordered.

Lighting retrofits influence energy consumption in two ways – reductions in electricity used for lighting, as well as reductions in heat gain in the space. Consequently, electricity savings resulting from reduced use of the air conditioner to remove heat dissipated by lighting have been included in this ECM.

Applicable sectors	% Savings vs. typical baseline	Annualized Net BZ\$/kWh Saved	Simple Payback Period (Years)	Lifetime (Years)
CO1 / CO2	36%	0.36	6.9	15

Replace High Bay Lights with LEDs

We recommend that industrial high bay lighting be replaced with new LED fixtures. Based on field observations 250W and 400W bulb sizes seem to be the most common but 1000W and 1500W bulbs are both available at local hardware stores indicating they are commonly used. Manufacturer recommended replacement wattage for the LED lamps determined the connected load we calculated after the retrofits.

Industrial overhead lighting is performed with high intensity discharge (HID) lamps using either metal halide or high pressure sodium lamps. Metal halide bulbs were the most common lamp type observed in Belize but both types are expected to be common. Many suppliers are now offering high bay replacement fixtures using LED technology. These fixtures typically include an electronic board with LEDs, a heat sink, and a shading device in a single unit, therefore the “bulb” cannot be replaced. However these fixtures have very long (80,000 hour plus) rated lifetimes and consume a fraction of the energy that typical HID lights do.

In addition to reducing annual electricity costs there will be annual cost savings due to avoided maintenance associated with replacing metal halide bulbs which would burn out 8 times during the life of the typical LED high bay lamp. Cooling energy cost savings are not included in this assessment since industrial facilities do not typically condition the spaces where these lights are used.

Applicable sectors	% Savings vs. typical baseline	Annualized Net BZ\$/kWh Saved	Simple Payback Period (Years)	Lifetime (Years)
CO1 / CO2 / IN1 / IN2	65%	0.18	2.9	11

Retrofit Street Lights with LEDs

We recommend that Belize begin replacing high pressure sodium street light fixtures with new LEDs using photocells. Street lighting in Belize is accomplished primarily with HPS lamps with cobra fixtures. Typical street lighting bulb wattages range from 100W to 250W. We were unable to get a complete inventory of street lights in Belize so our estimates are based on typical products and used in other Caribbean and Central American countries, as well as observations we made during site visits.

The LEDs are expected to have a lifetime of 100,000 hours (approximately 23 years) which is 5 times longer than HPS bulbs. So although LED fixtures have a very high upfront capital cost, this is partly offset by annual bulb replacement and energy cost savings. The photocell will switch the lamp on when the sun goes down and turn it off at sunrise. We assume that current lighting schedules follow the sunrise and sunset hour but likely over light the periods at dusk and dawn. Therefore, in addition to wattage savings enabled by more efficient lamps, the photocell is expected to deliver additional savings by reduced operating hours versus the baseline.

Applicable sectors	% Savings vs. typical baseline	Annualized Net BZ\$/kWh Saved	Simple Payback Period (Years)	Lifetime (Years)
STL	40%	0.18 ²	5.2	20

A.2.2 Reducing Cooling Loads & Air Conditioning Upgrades

Air conditioning accounts for 36% of national electricity consumption in Belize. Demand from large commercial facilities account for 53% of air conditioning load, with residential and small commercial accounting for 14% and 29% respectively. Government facilities account for the majority of the remaining demand at 4%, with large and small industrial facilities accounting for less than 1% combined.

Air conditioning and building envelope ECMs, as outlined in detail below, have the potential to reduce cooling electric load by 33%, at a capital expense equivalent of BZ\$0.21 per kWh.

² Note that factoring in the savings in O&M expenses, the annualized cost to save 1 kWh is estimated at BZ\$0.18. This is to account for savings accrued from not replacing multiple HPS bulbs over the 20 year life of the LED, as well as the labor cost of sending repair crews out.

Table A.3: Air Conditioning Energy Consumption and ECM Potential

	Base case Operations			ECM Savings		Upgrade Economics			
	% of Total Energy	Base case MWh	Electricity \$/Yr (x1,000)	Retrofit MWh Saved	% Savings	Ann. Retrofit Capex in BZ\$ (x1,000)	Electricity + Ann. Capex BZ\$/Yr (x1,000)	Net \$/Yr Savings (x1,000)	Ann. Capex. BZ\$/ kWh Saved
GOV1	72%	4,176	2,062	1,619	39%	347	1,609	453	0.21
GOV2	19%	3,060	1,521	1,002	33%	198	1,222	300	0.20
STL	0%	-	-	-	0%	-	-	-	-
CO1	66%	51,843	25,429	20,099	39%	4,306	19,876	5,553	0.21
CO2	59%	96,403	46,819	31,568	33%	6,252	37,740	9,079	0.20
RES	17%	25,147	11,796	5,325	21%	1,225	10,524	1,272	0.23
IN1	8%	707	321	-	0%	-	321	-	-
IN2	1%	468	180	-	0%	-	180	-	-
TOTAL	36%	181,803	88,129	59,613	33%	12,329	71,472	16,657	0.21

Source: WSP Analysis

Replace Louvered Windows with Double Pane Low-e Windows

We recommend that all louvered windows be upgraded to double pane low-e windows if the building utilizes air conditioning. Much of the building stock in Belize was constructed prior to widespread use of air conditioning and appropriately, many of the windows were designed with louvers to allow maximum air flow through buildings. Since the arrival of AC units however, these have been covered with plastic window covers to provide some, albeit minimal, level of sealing. This measure proposes to replace these windows with new double pane low-e glazing. The new windows will not only improve the building seal (prevent warm air from coming in), but they will reduce solar heat gain through the windows. The low-e glazing will effectively reflect some of the incident solar radiation while keeping the building cooler and reducing loads on the air conditioning system.

Double pane windows are available in Belize and are being used for new residential and commercial construction for two reasons, energy efficiency and storm protection.

Applicable sectors	% Savings vs. typical baseline	Annualized Net BZ\$/kWh Saved	Simple Payback Period (Years)	Lifetime (Years)
RES / CO1 / CO2	5%	0.28	7.0	25

Retrofit Existing Windows with SHGC Film

It is recommended that all non-louvered windows be upgraded with the installation of SHGC film in buildings that utilize air conditioning. With the exception of the louvered windows discussed above, the majority of windows in commercial buildings are single pane glass vinyl windows. These typically do not have any reflective glazing at all. The use of

retrofit window films would add a thin layer to the interior of the windows and would reflect some of the incident solar radiation without dramatically lowering lighting levels.

This measure could improve thermal comfort in unconditioned buildings but will only deliver energy cost savings in conditioned spaces. Therefore, this measure is recommended for buildings in Belize where AC is used.

Applicable sectors*	% Savings vs. typical baseline	Annualized Net BZ\$/kWh Saved	Simple Payback Period (Years)	Lifetime (Years)
CO1 / CO2	10%	0.07	1.2	15

Install Roof Insulation

We recommend that all air-conditioned commercial buildings have roof insulated upgraded to R-30 levels. Because many Belizean buildings were originally designed and constructed to be un-conditioned, or passively cooled structures, most are un-insulated or under-insulated. As such, a modest retrofit installation of R-30 insulation in ceiling spaces can reduce heat gain from solar radiation absorbed by roofs during the day. The potential savings of the ECM are based on existing levels of insulation in building roofs (typically either none, or less than R-13), and limitations in building construction (i.e. is there sufficient room between ceiling and roof).

This measure could improve thermal comfort in unconditioned buildings but will only deliver energy cost savings in conditioned spaces. Therefore, this measure is recommended for commercial office buildings in Belize where AC is used.

Applicable sectors*	% Savings vs. typical baseline	Annualized Net BZ\$/kWh Saved	Simple Payback Period (Years)	Lifetime (Years)
CO1 / CO2	5%	0.14	3.2	20

Retrofit Cool-Roofs

It is recommended that the roofs of all air conditioned buildings without roof insulation be painted using cool-roof white paint.

Although rarely seen by occupants, the color choice of residential, commercial, and industrial buildings can have a significant impact on occupant thermal comfort and energy loading while buildings sit in the equatorial sun. When sunlight strikes a roof, a portion is absorbed by the building, while some is reflected back into the atmosphere. This property, known as emissivity, is directly connected to the selected color of a roof, with dark roofs reflecting less sun, and therefore absorbing more heat, and light/white roofs reflecting more light, and therefore absorbing less heat.

Because emissivity is directly related to a material's color, reducing a building's heat gain can be as simple as painting the roof with a light color, or special low-emissivity white paint.

While effective on all building types, cool-roof retrofits achieve the highest savings when installed in buildings without existing roof insulation, as heat absorbed by the roof in these buildings will quickly find its way into conditioned spaces. From preliminary audit data, it is

estimated that approximately 50% of government and commercial buildings, and 20% of residential buildings meet these requirements.

This measure could improve thermal comfort in unconditioned buildings but will only deliver energy cost savings in conditioned spaces. Therefore, this measure is recommended for commercial office buildings in Belize where AC is used.

Applicable sectors*	% Savings vs. typical baseline	Annualized Net BZ\$/kWh Saved	Simple Payback Period (Years)	Lifetime (Years)
RES / CO1 / CO2	5%	0.33	6.3	15

Retrofit Cool-Walls

It is recommended that the exterior walls of all un-finished air conditioned buildings be painted using light colored (high emissivity) paint. While retrofitting cool-roofs offers a higher level of thermal protection per square foot, the combination of Belizean construction and climate make cool-wall retrofits another opportunity to reduce cooling load in conditioned buildings. With many buildings having unfinished and un-insulated concrete exterior walls, they are likely to experience a high level of solar heat gain, particularly on the Southern façade which receives the most prolonged solar exposure. As such, painting unfinished or darker colored buildings with white, beige, yellow, or lighter colors offers the potential to further reduce cooling loads.

While cool-roof white paint would offer the greatest opportunity for lowering solar emissivity, less-“aggressive” color options like beige or yellow could still reduce solar heat gain while better blending with existing architecture colors.

Applicable sectors*	% Savings vs. typical baseline	Annualized Net BZ\$/kWh Saved	Simple Payback Period (Years)	Lifetime (Years)
RES / CO1 / CO2	14%	0.28	5.2	15

Install Window Awnings

We recommend that window awnings be installed over South, East, and West windows that receive direct sunlight in air conditioned buildings. On buildings with minimal shading, and therefore high levels of direct solar exposure, awnings can be installed to reduce incident solar heat gain through windows. While many options exist to balance a building’s shading and passive-lighting needs, building simulations suggest that three foot awnings positioned at 45 degrees over the top of windows on the South, East, and West walls of a building offer the greatest potential for reducing day-time cooling loads, particularly when installed over older windows with higher emissivity and solar heat gain coefficient’s.

Applicable sectors	% Savings vs. typical baseline	Annualized Net BZ\$/kWh Saved	Simple Payback Period (Years)	Lifetime (Years)
RES / CO1 / CO2	6%	\$0.45	8.6	15

Replace Window AC Units with Inverter Split Systems

It is recommended that all window AC units be upgraded to higher efficiency split units with inverters at the end of their useful life. Window AC units are present in approximately 3% of all buildings in Belize, and are one of the least efficient, yet easiest to install air conditioner types. Often, older window units were designed to operate the compressor in a binary, on/off cycle. Newer models utilize inverters with variable frequency drives to allow the compressor motor to cycle at different speeds based on cooling demand, resulting in a lower operating electricity demand.

While AC units with inverters can produce the same cooling load with as little as half the electricity demand of an older unit, the annual electricity savings are not enough to offset the entire cost of replacing existing units with newer systems. If, however, existing systems remain in use until their end of life, the net cost difference between a “traditional” lower efficiency unit and a high efficiency inverter unit is small enough that annual electricity savings will offset the higher capital cost within a reasonable payback period.

Applicable sectors*	% Savings vs. typical baseline	Annualized Net BZ\$/kWh Saved	Simple Payback Period (Years)	Lifetime (Years)
RES / CO1 / CO2	51%	0.25	4.7	15

Replace Split AC Units with Inverters at End of Life

It is recommended that all split AC units be upgraded to higher efficiency split units with inverters at the end of their useful life. Split units are present in approximately 30% of buildings in Belize, the majority of which are assumed to not have inverters installed. Older model air conditioners were designed to operate the compressor in a binary, on/off cycle. Newer high efficiency models utilize inverters with variable frequency drives to allow the compressor motor to cycle at different speeds based on cooling demand, resulting in a lower operating electricity demand.

While AC units with inverters can produce the same cooling load with as little as half the electricity demand of an older unit, the annual electricity savings are not enough to offset the entire cost of replacing existing units with newer systems. If, however, existing systems remain in use until their end of life the net cost difference between a ‘traditional’ lower efficiency unit and a high efficiency inverter unit is small enough that annual electricity savings will offset the higher capital cost within a reasonable payback period.

Applicable sectors*	% Savings vs. typical baseline	Annualized Net BZ\$/kWh Saved	Simple Payback Period (Years)	Lifetime (Years)
RES / CO1 / CO2	25%	0.17	3.2	15

A.2.3 Refrigeration Upgrades

Refrigeration accounts for 15% of national electricity consumption in Belize. Large commercial facilities account for 41% of total refrigeration demand, with residential demanding an additional 45%, and industrial facilities drawing the remaining 13%. Government and small commercial facilities combined demand about 1% of national consumption.

Refrigeration ECMs, as outlined in detail below, have the potential to reduce refrigeration electric load by 38%, at a capital expense equivalent of BZ\$0.25 per kWh.

Table A.4: Refrigeration Energy Consumption and ECM Potential

	Base case Operations			ECM Savings		Upgrade Economics			
	% of Total Energy	Base case MWh	Electricity \$/Yr (x1,000)	Retrofit MWh Saved	% Savings	Ann. Retrofit Capex in BZ\$ (x1,000)	Electricity + Ann. Capex BZ\$/Yr (x1,000)	Net \$/Yr Savings (x1,000)	Ann. Capex. / kWh Saved
GOV1	0%	-	-	-	0%	-	-	-	-
GOV2	5%	854	425	426	50%	137	350	75	0.32
STL	0%	-	-	-	0%	-	-	-	-
CO1	0%	157	77	78	50%	25	64	13	0.32
CO2	19%	30,502	14,814	15,225	50%	4,902	12,322	2,492	0.32
RES	23%	33,255	15,599	10,534	32%	1,898	12,556	3,043	0.18
IN1	23%	2,063	938	278	13%	6	818	121	0.02
IN2	20%	7,290	2,797	1,710	23%	22	2,163	634	0.01
TOTAL	15%	74,121	34,650	28,251	38%	6,991	28,273	6,377	0.25

Source: WSP Analysis

Retail Freezers & Refrigerators with Remote Refrigeration

We recommend that all retail freezers and refrigerators be upgraded with high efficiency units utilizing remote refrigeration. Traditionally, refrigerators and freezers are integrated units with all the components required for operation (compressor, motor, evaporator, etc.) contained in a single container. From preliminary audit analysis, it was observed that these units dominate the commercial sector.

Remote refrigeration units separate the unit's motor and condensing unit from the cooling space, reducing waste heat generated in the cooling area and thereby improving system operating efficiency. Remote refrigeration units also have the added benefits of reduced in-

shop footprint, reduced noise, and reduced ancillary cooling load on the building's air conditioning, when the motor and condenser are moved to an unconditioned area.

Applicable sectors*	% Savings vs. typical baseline	Annualized Net BZ\$/kWh Saved	Simple Payback Period (Years)	Lifetime (Years)
CO1 / CO2	59%	0.30	5.6	15

Upgrade to Higher Efficiency Residential Refrigerators

We recommend that all residential refrigerators be upgraded to Energy Star or other comparable high efficiency units at the end of their useful life. During audits, most refrigerators observed were older, lower efficiency models. With many countries continuously increasing refrigeration efficiency standards, residential refrigerators have dramatically reduced electricity consumption while improving function and size. According to the US Department of Energy, while today's refrigerators are on average 20% larger, they use only 25% of the energy that was required to power models built in 1975. While the capital cost of a new refrigerator cannot be entirely offset by annual electricity savings, if systems remain in use until their end of life, the net cost difference between a lower efficiency unit and a high efficiency unit is low enough to allow for a payback period of only a few years.

Applicable sectors	% Savings vs. typical baseline	Annualized Net BZ\$/kWh Saved	Simple Payback Period (Years)	Lifetime (Years)
RES	32%	0.18	3.4	15

Upgrade to Higher Efficiency Commercial Refrigerators

It is recommended that all commercial refrigerators be upgraded to energy star or other comparable high efficiency units at the end of their useful life. During audits, most commercial refrigerators observed were older, lower efficiency models. With many countries continuously increasing refrigeration efficiency standards, commercial refrigerators have dramatically reduced electricity consumption while improving function and size. As noted above, remote refrigeration offers the benefit of separating the motor and compressor to an unconditioned space, thereby reducing cooling as well as refrigeration loads. Where remote refrigeration is not necessary and/or applicable, high efficiency integrated models should be considered.

Applicable sectors*	% Savings vs. typical baseline	Annualized Net BZ\$/kWh Saved	Simple Payback Period (Years)	Lifetime (Years)
CO1 / CO2	41%	0.36	8.1	20

Retrofit Industrial Compressors to 2 Stage Compression

We recommend that industrial refrigeration units used to achieve sub-zero temperatures upgrade from a single to two stage compression cycle. While specific upgrade opportunities

must be addressed on a case by case basis, from preliminary audit data it is assumed that most industrial refrigeration units that could benefit from two stage compression, do not yet have it installed.

Two stage compression refrigeration systems were originally introduced to the industrial sector as a means to overcome compression ratio limits and equipment fatigue when trying to achieve a lower refrigerant temperature. These systems, which operate two compressors in series, also proved effective at improving the overall efficiency of the system, particularly where lower saturation temperatures are desired. While these systems do present some disadvantages over their single stage counterparts, particularly increased floor space and capital cost, they are typically cost effective upgrades for systems with desired suction temperatures below -25F.

Applicable sectors*	% Savings vs. typical baseline	Annualized Net BZ\$/kWh Saved	Simple Payback Period (Years)	Lifetime (Years)
IN1 / IN2	18%	0.02	0.4	20

Retrofit Liquid Pressure Amplification on Industrial Compressors

We recommend that high capacity industrial compressors with varying load be upgraded to include liquid pressure amplification. A typical refrigeration system is a closed loop system comprised of an evaporator, compressor, condenser, and expansion valve that utilizes changes in the latent heat of a refrigerant as it changes phase from liquid to gas to liquid. The system’s expansion valve, located between the condenser and evaporator, allows the liquid refrigerant to expand, reducing its pressure and temperature to conditions more suitable for the evaporator, and operates most effectively with a constant inlet pressure. To account for this, the compressor is often operated at pressures higher than necessary, thereby providing a constant refrigerant pressure at the expansion valve inlet over a varying range of cooling loads, but consuming more electricity than necessary in the process.

To reduce the necessary compressor operating pressure while maintaining a constant pressure at the expansion valve inlet regardless of the system’s load, a liquid pressure amplification (LPA) pump can be installed. This allows the compressor to operate at the minimum pressure required to meet the load at any given moment, while re-pressurizing the liquid to specified levels just before the expansion valve. Although the additional LPA pump does require some electricity to operate, the net savings from compressor energy are much larger than those added from the additional pump. This ECM is most effective when installed on refrigeration systems with varying load, or that do not operate regularly near maximum capacity.

Applicable sectors	% Savings vs. typical baseline	Annualized Net BZ\$/kWh Saved	Simple Payback Period (Years)	Lifetime (Years)
IN1 / IN2	20%	0.003	0.1	15

Upgrade Industrial Thermosyphon Oil Cooling for Compressors

We recommend that high capacity industrial refrigeration compressors be upgraded with thermosyphon oil cooling. From preliminary audit data, we estimate that approximately 30% of small and large industrial facilities have compressors eligible for this upgrade. The process of refrigerant compression produces a significant amount of waste heat, some of which is transferred to the compressor oil. Traditionally, compressor oil is cooled through liquid injection or indirect water or glycol cooling systems. These systems, which typically have a lower capital cost, require additional energy to operate, either as a result of increased refrigeration demand (liquid injection) or for circulation pumps and cooling equipment (water/glycol cooling). Thermosyphon cooling however directs condensate from the refrigerant through a gravity fed heat exchanger to passively cool the compressor oil without the need for additional pumping or refrigeration capacity.

Applicable sectors*	% Savings vs. typical baseline	Annualized Net BZ\$/kWh Saved	Simple Payback Period (Years)	Lifetime (Years)
IN1 / IN2	27%	0.01	0.2	15

A.2.1 Industrial Plug and Process Load Upgrades

Plug and process loads account for 30% of national electricity consumption in Belize. Approximately 30% of demand comes from commercial, residential, and industrial sectors each, with the remaining 10% demand from government facilities.

Although all sectors have opportunity for reducing plug and process load electricity, the industrial sector was exclusively targeted for ECM improvements in this analysis, as individual industrial plug loads typically demand more power and are used more frequently, and can therefore be upgraded at a more attractive cost to benefit investment ratio. As outlined in detail below, plug and process ECMs have the potential to reduce industrial electric load by 8%, at a capital expense equivalent of \$0.20 per kwh saved.

Table A.5: Plug and Process Energy Consumption and ECM Potential

	Base case Operations			ECM Savings		Upgrade Economics			
	% of Total Energy	Base case MWh	Electricity \$/Yr (x1,000)	Retrofit MWh Saved	% Savings	Ann. Retrofit Capex in BZ\$ (x1,000)	Electricity + Ann. Capex BZ\$/Yr (x1,000)	Net \$/Yr Savings (x1,000)	Ann. Capex. / kWh Saved
IN1	60%	5,447	2,477	427	8%	83	2,366	111	0.19
IN2	77%	27,337	10,488	2,285	8%	457	10,068	420	0.20
TOTAL	30%	32,784	12,965	2,712	8%	539	12,434	531	0.20

Source: WSP Analysis

Upgrade Industrial Chain Drives with Synchronous Belt Drives

It is recommended that all chain drives and V-belts be upgraded to synchronous belt drives. From preliminary audit data it is estimated that this ECM is applicable in approximately 13% of industrial facilities.

Pulleys are used in industrial applications to transfer rotational power from a motor to fans, pumps, and various other industrial equipment. Commonly used V-belts are susceptible to slippage, especially as they age resulting in power loss. Chain drives, while unlikely to slip, lose transfer efficiency through increased operating friction of the chain and sprocket system. Synchronous belt drives use mating grooved sprockets to provide a low-slip connection at variable load ranges with a consistent 98% efficiency. Compared to V-belt or chain drives, synchronous belt drives operate at a higher efficiency and typically exhibit lower operating costs, as they rarely require adjustment, tightening, or lubrication.

Applicable sectors*	% Savings vs. typical baseline	Annualized Net BZ\$/kWh Saved	Simple Payback Period (Years)	Lifetime (Years)
IN1 / IN2	6%	0.01	0.1	15

Upgrade to Industrial Premium Efficiency Motors

It is recommended that all industrial motors be upgraded to premium efficiency motors. From preliminary audit data it is estimated that most industrial motors are viable for upgrade to premium efficiency models.

At 75% load, standard efficiency motors range from 87% to 93% efficiency depending on output horsepower (larger motors have higher efficiency). Conversely, premium efficiency motors of the same size and operating load range from 92% to 96% efficiency. In industrial settings where motors run for a significant portion of the year and account for a significant portion of annual electricity consumption, motor efficiency improvements of a few percent will quickly accumulate kWh savings.

Applicable sectors*	% Savings vs. typical baseline	Annualized Net BZ\$/kWh Saved	Simple Payback Period (Years)	Lifetime (Years)
IN1 / IN2	6%	0.18	4.0	20

Install Variable Frequency Drives (VFDs) on Industrial Motors

We recommend that all industrial motors operated at variable output be retrofitted with VFDs. From preliminary audit data it is estimated that approximately 30% of industrial motors are well suited for the installation of variable frequency drives.

Fixed speed motors are designed to operate at a single speed with a constant output. As such, any deviation from a motor's designed output capacity must be adjusted by pulsing motor operation on and off, or through downstream throttling (specifically with pumps and fans). Conversely, variable frequency drives can be installed on motors to modulate the motor input frequency and voltage thereby allowing the motor to produce only as much power as required for a specific application and load at any given moment. While actual

savings are dependent upon a motor’s specific operating schedule, VFDs can typically have a significant impact on industrial electricity demand.

Applicable sectors*	% Savings vs. typical baseline	Annualized Net BZ\$/kWh Saved	Simple Payback Period (Years)	Lifetime (Years)
IN1 / IN2	17%	0.30	1.4	10

A.2.2 Industrial Power

Industrial loads account for 9% of national electricity consumption in Belize. Through retrofits to improve industrial end use power quality, the industrial sector can save 23% of baseline electricity consumption at a capital cost equivalent of \$0.01 per kWh.

Table A.6: Industrial Energy Consumption and ECM Potential

	Base case Operations			ECM Savings		Upgrade Economics			
	% of Total Energy	Base case MWh	Electricity \$/Yr (x1,000)	Retrofit MWh Saved	% Savings	Ann. Retrofit Capex in BZ\$ (x1,000)	Electricity + Ann. Capex BZ\$/Yr (x1,000)	Net \$/Yr Savings (x1,000)	Ann. Capex. / kWh Saved
IN1	100%	9,038	4,111	1,937	21%	6	3,236	874	0.00
IN2	100%	35,610	13,662	8,171	23%	65	10,593	3,069	0.01
TOTAL	9%	44,648	17,773	10,107	23%	72	13,829	3,944	0.01

Source: WSP Analysis

Power Factor Correction

We recommend that all industrial facilities correct their power factor by reducing idling motor loads, properly sizing motors to match operating load, and installing capacitors in the facility’s AC circuit. This ECM is applicable to all industrial sites in Belize.

In an alternating current (AC) system, power factor is defined as the ratio of real power supplied to the load divided by the apparent power of the circuit. This dimensionless unit can range from -1 to 1, with 1 representing a 100% efficient system. Industrial applications, where induction motors account for a significant portion of electrical load, commonly experience higher levels of apparent power, and as such, less than optimal power factors. Power factor can be corrected (increased) through several strategies including reducing idling motor loads, properly sizing motors to match their typical operating load, and installing capacitor banks in the facility’s AC circuit. The cost and savings estimate presented here are based on the use of capacitor banks to correct facility power factor. While the industrial equipment may still consume a comparable amount of real power, apparent power consumption will be reduced, thereby reducing the necessary amount of power needed to be generated by the electric utility.

Applicable sectors*	% Savings vs. typical baseline	Annualized Net BZ\$/kWh Saved	Simple Payback Period (Years)	Lifetime (Years)
IN1 / IN2	21%	\$0.003	0.4	20

Industrial Premium Efficiency Transformers

We recommend that all industrial transformers be upgraded to premium efficiency transformers. During audits, all transformers identified were out of date, and optimal for upgrade. It is assumed that all industrial sites are applicable for this ECM. Electrical transformers are used to step down electricity voltage from the grid before supply to end use customers. High voltage customers, such as industrial customers, are often required to supply their own transformers, and as such have the opportunity to upgrade to higher efficiency options, thereby reducing their electrical demand. National Electrical Manufacturers Association (NEMA) certified premium efficiency transformers can provide 30% less losses than standard efficiency models, thereby reducing end use electricity demand and resulting operating costs.

Applicable sectors*	% Savings vs. typical baseline	Annualized Net BZ\$/kWh Saved	Simple Payback Period (Years)	Lifetime (Years)
IN1/IN2	2%	\$0.07	1.7	20

A.3 Baseline Analysis by Sector

To extrapolate individual building audits into estimates at a national scale, buildings were classified into eight different sectors using BEL’s sector categories as a guideline. BEL’s classification structure is based on a combination of customer type, and electricity intensity per square foot of net area.

For simplicity, employees of BEL (EMP), government subsidized residential (SOC), and regular residential (RES) customers were combined into a single residential sector (RES). Similarly, public and private street lights accounts were combined into a single street light sector (STL). To improve data transparency, commercial customers were split into either private (CO1 & CO2) or government (GOV1 & GOV2) commercial sectors based on each building’s primary use and annual electricity consumption. Industrial customers (IN1 & IN2) were defined based on their typical annual electricity consumption.

- RES: All residential accounts
- CO1: Private commercial customers consuming 0-2,500 kwh/month
- CO2: Private commercial customers consuming 2,500-30,000kwh/month
- GOV1: Government customers consuming 0-2,500 kwh/month
- GOV2: Government customers consuming 2,500-30,000 kwh/month
- IN1: Industrial customers consuming 30,000kwh/month – 1.5MWh/month
- IN2: Industrial customers consuming > 1500 MWh/month

- STL: Public & private street light accounts

Because it was logistically impossible to audit every building in Belize, audit data was supplemented with utility records for over 84,000 BEL customers. Sorting customers into the aforementioned seven sectors, the average electricity demand per customer was calculated, as summarized in Table A.7 below.

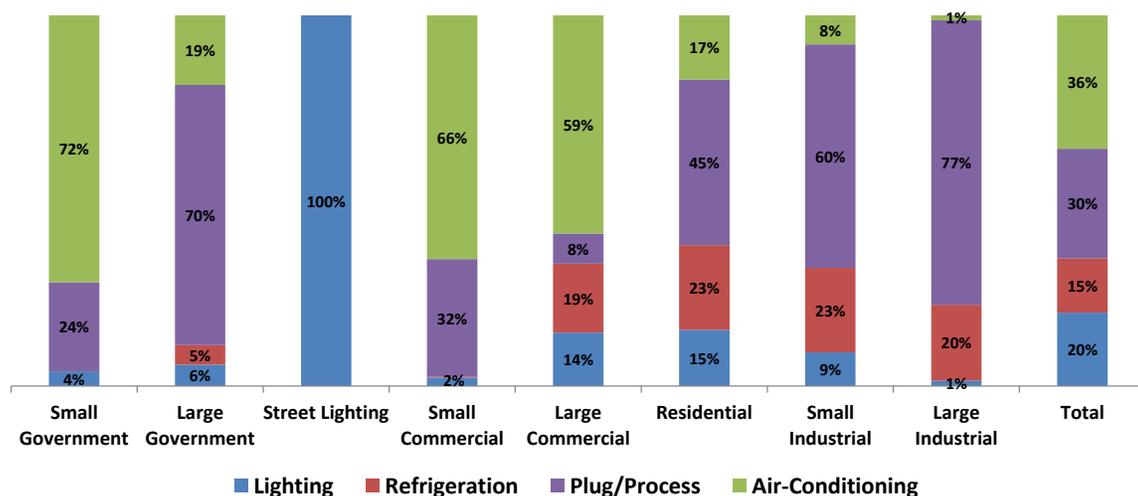
Table A.7: BEL Electricity Consumption Rates per Customer Sector

Sector Name	Sector Code	Average Rate (BZ\$ / kWh)	Annual MWh	# of Customers	kWh/ Avg. Customer
Government (Small Commercial)	GOV1	0.49	5,800	989	5,864
Government (Large Commercial)	GOV2	0.49	16,288	177	92,021
Private Small Commercial	CO1	0.49	78,839	16,709	4,718
Private Large Commercial	CO2	0.48	163,835	1,284	127,598
Street Lighting	STL	0.55	50,211	30	1,673,712
Residential	RES	0.46	145,498	65,227	2,231
Small Industrial	IN1	0.45	9,038	4	2,259,497
Large Industrial	IN2	0.38	35,610	4	8,902,438
Total		0.48	505,119	84,424	5,983

Source: WSP Analysis

Using data collected from the aforementioned audits, a weighted average electrical load profile was calculated for a “typical building” in each sector. As can be seen in Figure A.1 and Table A.8 below, air conditioning is the dominant load in commercial buildings. Industrial buildings are split nearly evenly between refrigeration and plug/process loads, whereas residential buildings split their demand between lighting, refrigeration, and air conditioning fairly evenly. Nationally, air conditioning accounts for approximately 43% of electrical load, with the remaining 57% split between lighting, refrigeration, and plug/process loads.

Figure A.1: Distribution of Electricity End Use by Sector



Source: WSP Analysis

Table A.8 presents the same information as Figure A.1 numerically.

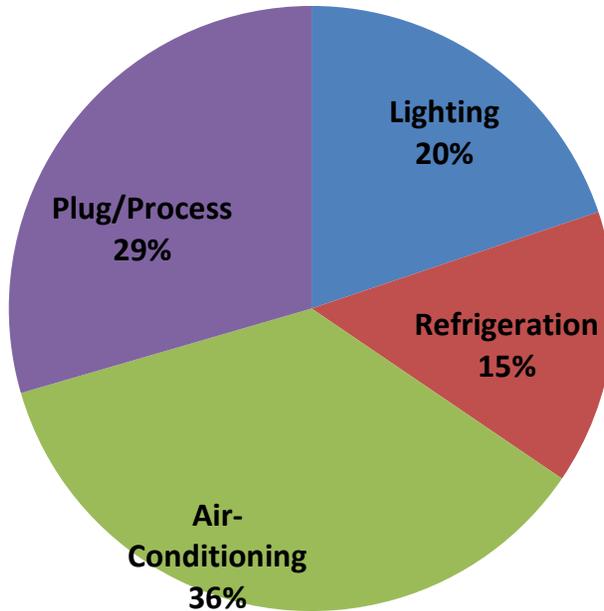
Table A.8: Distribution of Electricity End Use by Sector

	Lighting	Refrigeration	Air-Conditioning	Plug/Process
Government (Small Commercial)	4%	0%	72%	24%
Government (Large Commercial)	6%	5%	19%	70%
Street Lighting	100%	0%	0%	0%
Private Small Commercial	2%	0.2%	66%	32%
Private Large Commercial	14%	19%	59%	8%
Residential	15%	23%	17%	45%
Small Industrial	9%	23%	8%	60%
Large Industrial	1%	20%	1%	77%
Total	20%	15%	36%	30%

Source: WSP Analysis

Figure A.2 provides a breakdown of end uses of electricity at the national level.

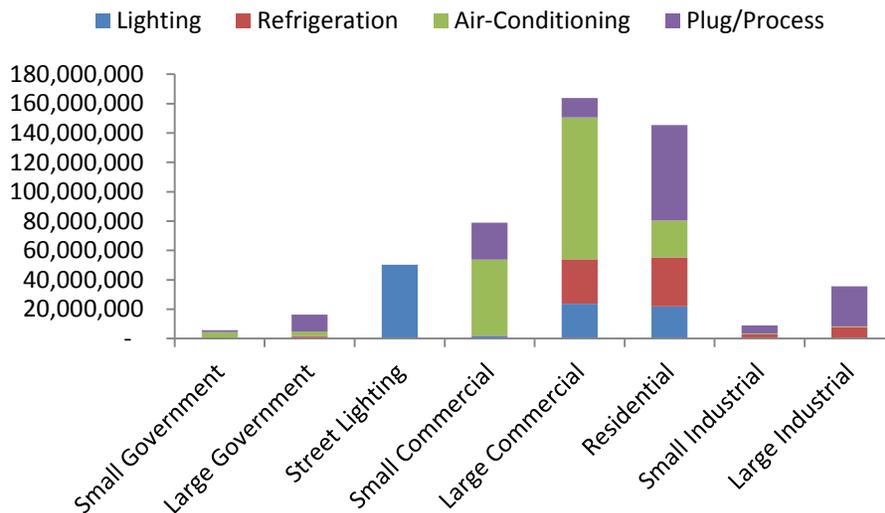
Figure A.2: Distribution of National Electricity End Use



Source: WSP Analysis

Figure A.3 presents a comparison of absolute energy use by sector, as well as the end uses within each sector.

Figure A.3: Electricity End Use by Sector (kWh/yr)



Source: WSP Analysis

As illustrated in Figure A.3 above, private large commercial and residential sectors account for the majority of Belize’s electricity consumption. However, when looking at electricity consumption on a per-customer basis, as highlighted in Table A.7 industrial electricity consumption has by and large the highest energy use intensity, ranging from 2,000,000 – 9,000,000 kWh/year per customer.

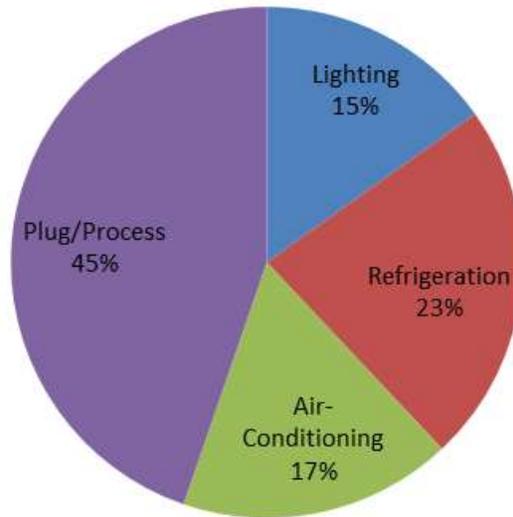
A.3.1 Residential sector

With 65,000 customers and 146,000 MWh of annual electricity consumption, the residential sector accounts for 29% of the national electricity demand. Household consumption varies depending on the size and income level of the household so patterns observed at the sector level may be different from the consumption patterns of many individual residential customers

End uses

As outlined in Figure A.4, for the residential sector, plug and process loads account for 45% of all electricity consumption, with air conditioning, refrigeration, and lighting accounting for 17%, 23%, and 15% respectively.

Figure A.4: Distribution of Residential Electricity End Use



Source: WSP Analysis

From audit data it is estimated that the average residence has an area of between 500-1,500 sf, has either louvered or single pane windows, minimal to no roof insulation, and has zero to one low-efficiency air conditioners. Energy savings potential from each ECM was calculated under four scenarios by varying what percent of upgradable buildings within a sector would implement the recommended ECMs. This factor, known as the penetration rate, was varied between max technical capacity (100%), aggressive penetration (60%), moderate penetration (40%), and low penetration (20%). The net percent savings was calculated as a function of the penetration rate times the percent upgradability (for example,

X% of buildings have louvered windows, and are therefore good candidates for upgrades to double paned windows). Net residential savings at each penetration rate are outlined in Table A.9 below.

Table A.9: Residential Net Percent Savings at Varied Penetration Rates

Penetration Rate	100%	60%	40%	20%
Lighting	38%	23%	15%	8%
Cooling	21%	13%	8%	4%
Refrigeration	32%	19%	13%	6%

Source: WSP Analysis

It should be noted that while the sector will achieve greater net electricity savings with higher penetration rates, because capital costs and savings are both driven by the penetration rates, the net cost per kwh saved will remain the same, as outlined below.

EE measures package

The residential sector is appropriate for nine ECM improvements as outlined in Table A.10 below. Of the recommended ECMs, reducing air infiltration through leaky doors is the most cost effective option at \$0.09/kwh saved, while installing awnings over South, East, and West windows is the least cost effective option at \$0.45/kwh saved.

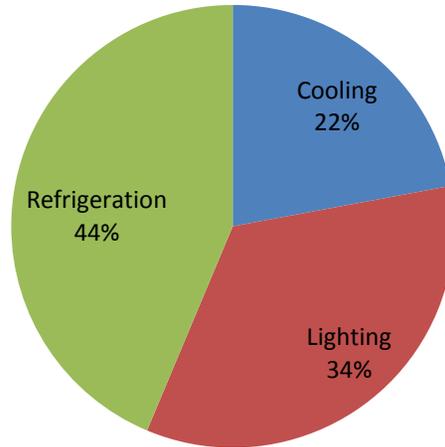
Table A.10: ECM Equivalent Cost per kWh Saved

Residential ECM Measure	(BZ\$/kWh)
Replace louvered windows with new low-e windows	0.28
Reduce Infiltration on Louvered Windows (or leaky doors/windows)	0.09
Paint Concrete Walls w/ Beige or Yellow (Abs. = 0.55)	0.20
Paint Concrete Walls w/ Cool Roof White (Abs. = 0.25)	0.28
Install 3' Awnings @ 45 deg. On S/E/W Windows	0.45
Compact Fluorescent Lamps (CFLs)	0.24
Cool Roof (Painted White Roof) if no insulation present	0.33
Replace Split AC Units with Inverters at EOL	0.17
Net Residential Savings Combined	0.21

Source: WSP Analysis

As highlighted in Figure A.5, reducing refrigeration loads and improving air conditioner efficiency will account for over half the total electricity savings from the recommended ECM bundle.

Figure A.5: Distribution of Potential Residential ECM Savings



Source: WSP Analysis

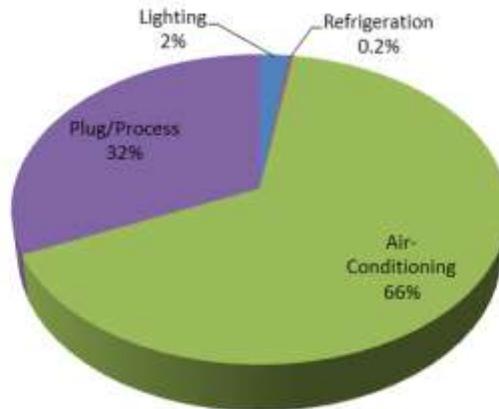
A.3.2 Small Commercial sector

With 16,709 customers and 78,800 MWh of annual electricity consumption, the small commercial sector accounts for 16% of the national electricity demand. Included in this category are small offices, storefronts, restaurants, and other businesses.

End uses

As outlined in Figure A.6, in the average small commercial building air conditioning accounts for 66% of all electricity consumption, with plug and process load accounting for the majority of the remaining loads at 32%. Lighting accounts for only 2% of small commercial electricity consumption.

Figure A.6: Distribution of Small Commercial Electricity End Use



Source: WSP Analysis

Energy savings potential from each ECM was calculated under four scenarios by varying what percent of upgradable buildings within a sector would implement the recommended ECMs. This factor, known as the penetration rate, was varied between max technical capacity (100%), aggressive penetration (60%), moderate penetration (40%), and low penetration (20%). The net percent savings was calculated as a function of the penetration rate times the percent upgradability (for example, X% of buildings have louvered windows, and are therefore good candidates for upgrades to double paned windows). Net residential savings at each penetration rate are outlined in Table A.11 below.

Table A.11: Small Commercial Net % Savings at Varied Penetration Rates

Penetration Rate	100%	60%	40%	20%
Lighting	49%	29%	19%	10%
Cooling	39%	23%	16%	8%
Refrigeration	50%	30%	20%	10%

Source: WSP Analysis

It should be noted that while the sector will achieve greater net electricity savings with higher penetration rates, because capital costs and savings are both driven by the penetration rates, the net cost per kWh saved will remain the same, as outlined below.

EE measures package

The residential sector is appropriate for 15 ECMs as outlined in Table A.12 below.

Table A.12: Small Commercial ECM Equivalent Cost per kWh Saved

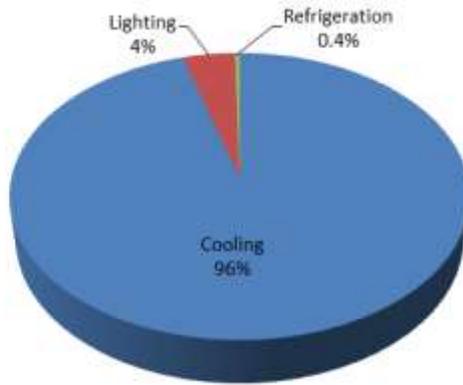
Small Commercial ECMs	(BZ\$/kWh)
Replace louvered windows with new low-e windows	0.28
Reduce Infiltration on Louvered Windows (or leaky doors/windows)	0.09
Paint Concrete Walls w/ Beige or Yellow (Abs. = 0.55)	0.20
Paint Concrete Walls w/ Cool Roof White (Abs. = 0.25)	0.28
Install 3' Awnings @ 45 deg. On S/E/W Windows	0.45
Compact Fluorescent Lamps (CFLs)	0.24
Cool Roof (Painted White Roof) if no insulation present	0.33
Replace Split AC Units with Inverters at EOL	0.17
Replace MH/HPS High Bay Lamps with LED	0.18
Replace T12 with T8 and electronic ballasts	0.36
Retrofit existing windows with low SHGC film	.07
Install Roof Insulation (Blown Cellulose R30)	0.14
Energy Star Certified Commercial Freezers and Refrigerators	0.36
Retail Freezers & Refrigerators with Remote Refrigeration	0.30
Replace Window AC Units with Inverter Split Systems	0.25
Net Commercial ECMs	0.22

Source: WSP Analysis

Of the recommended ECMs, retrofitting existing single pane windows with low SHGC film is the most cost effective option, at a net cost of \$0.07/kWh saved, while installing window awnings has the highest cost at \$0.45/kwh saved. Combined, the recommended ECMs have a net cost of \$0.22/kwh saved.

As highlighted in Figure A.7, reducing cooling loads and improving air conditioner efficiency will account for over 96% of total electricity savings from the recommended ECM bundle.

Figure A.7: Distribution of Small Commercial Potential ECM Savings



Source: WSP Analysis

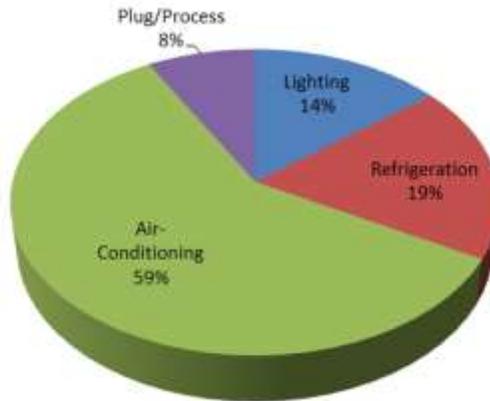
A.3.1 Large Commercial sector

With 1,284 customers and 163,800 MWh of annual electricity consumption, the large commercial sector accounts for 32% of the national electricity demand. This category includes offices, larger retail facilities, hotels, and some light industry.

End uses

As outlined in Figure A.8, in the average large commercial building air conditioning accounts for 59% of all electricity consumption, with refrigeration, lighting, and plug and process loads accounting for 14%, 19%, and 8% respectively.

Figure A.8: Distribution of Large Commercial Electricity End Use



Source: WSP Analysis

Energy savings potential from each ECM was calculated under four scenarios by varying what percent of upgradable buildings within a sector would implement the recommended ECMs. This factor, known as the penetration rate, was varied between max technical capacity (100%), aggressive penetration (60%), moderate penetration (40%), and low penetration (20%). The net percent savings was calculated as a function of the penetration rate times the percent upgradability (for example, X% of buildings have louvered windows,

and are therefore good candidates for upgrades to double paned windows). Net residential savings at each penetration rate are outlined in Table A.13 below.

Table A.13: Large Commercial Net % Savings at Varied Penetration Rates

Penetration Rate	100%	60%	40%	20%
Lighting	45%	27%	18%	9%
Cooling	33%	20%	13%	7%
Refrigeration	50%	30%	20%	10%

Source: WSP Analysis

It should be noted that while the sector will achieve greater net electricity savings with higher penetration rates, because capital costs and savings are both driven by the penetration rates, the net cost per kWh saved will remain the same, as outlined below.

EE measures package

The large commercial sector is appropriate for 15 ECM improvements as outlined in Table A.14 below. Of the recommended ECMs, retrofitting existing single pane windows with low SHGC film is the most cost effective option, at a net cost of \$0.07/kwh saved, while installing window awnings has the highest cost at \$0.45/kwh saved. Combined, the recommended ECMs have a net cost of \$0.25/kWh saved.

Table A.14: ECM Equivalent Cost per kWh Saved

Large Commercial ECMs	(BZ\$/kWh)
Replace louvered windows with new low-e windows	0.28
Reduce Infiltration on Louvered Windows (or leaky doors/windows)	0.09
Paint Concrete Walls w/ Beige or Yellow (Abs. = 0.55)	0.20
Paint Concrete Walls w/ Cool Roof White (Abs. = 0.25)	0.28
Install 3' Awnings @ 45 deg. On S/E/W Windows	0.45
Compact Fluorescent Lamps (CFLs)	0.24
Cool Roof (Painted White Roof) if no insulation present	0.33
Replace Split AC Units with Inverters at EOL	0.17
Replace MH/HPS High Bay Lamps with LED	0.18
Replace T12 with T8 and electronic ballasts	0.36
Retrofit existing windows with low SHGC film	0.07
Install Roof Insulation (Blown Cellulose R30)	0.14
Energy Star Certified Commercial Freezers and Refrigerators	0.36
Retail Freezers & Refrigerators with Remote Refrigeration	0.30
Replace Window AC Units with Inverter Split Systems	0.25

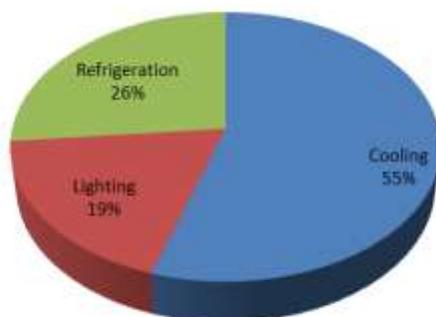
Net Commercial ECMs

0.25

Source: WSP Analysis

As highlighted in Figure A.9 reducing cooling loads and improving air conditioner efficiency will account for 55% of total electricity savings, with additional savings from retrofits to the refrigeration and lighting systems.

Figure A.9: Large Commercial Distribution of Potential ECM Savings



Source: WSP Analysis

A.3.2 Small Government Sector

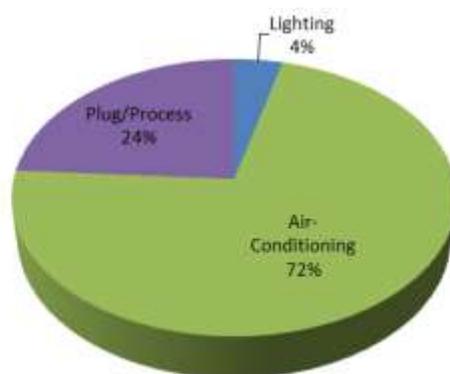
With 989 customers and 5,800 MWh of annual electricity consumption, the small government sector accounts for 1% of the national electricity demand. This category includes government facilities like offices, sports facilities, schools, clinics, army facilities, among others.

End uses

As shown in Figure A.10, in the average small government building air conditioning accounts for 72% of all electricity consumption, with lighting and plug and process loads accounting for 4% and 24% respectively.

Energy savings potential from each ECM was calculated under four scenarios by varying what percent of upgradable buildings within a sector would implement the recommended ECMs. This factor, known as the penetration rate, was varied between max technical capacity (100%), aggressive penetration (60%), moderate penetration (40%), and low penetration (20%). The net percent savings was calculated as a function of the penetration rate times the percent upgradability (for example, X% of buildings have louvered windows, and are therefore good candidates for upgrades to double paned windows). Net residential savings at each penetration rate are outlined in Table A.15 below.

Figure A.10: Distribution of Small Government Electricity End Use



Source: WSP Analysis

Table A.15: Small Government Net % Savings at Varied Penetration Rates

Penetration Rate	100%	60%	40%	20%
Lighting	36%	22%	14%	7%
Cooling	39%	23%	16%	8%
Refrigeration	0%	0%	0%	0%

Source: WSP Analysis

It should be noted that while the sector will achieve greater net electricity savings with higher penetration rates, because capital costs and savings are both driven by the penetration rates, the net cost per kWh saved will remain the same, as outlined below.

EE measures package

The small government sector is appropriate for 15 ECM improvements as outlined in Table A.16 below. Of the recommended ECMs, retrofitting existing single pane windows with low SHGC film is the most cost effective option, at a net cost of \$0.07/kwh saved, while installing window awnings has the highest cost at \$0.45/kwh saved. Combined, the recommended ECMs have a net cost of \$0.22/kwh saved.

Table A.16: ECM Equivalent Cost per kWh Saved

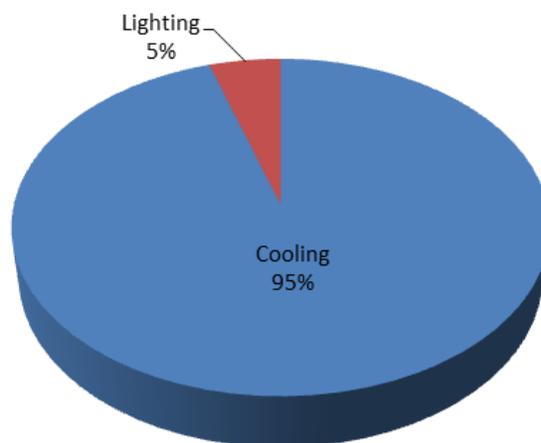
Small Government ECMs	(BZ\$/kWh)
Replace louvered windows with new low-e windows	0.28
Reduce Infiltration on Louvered Windows (or leaky doors/windows)	0.09
Paint Concrete Walls w/ Beige or Yellow (Abs. = 0.55)	0.20
Paint Concrete Walls w/ Cool Roof White (Abs. = 0.25)	0.28
Install 3' Awnings @ 45 deg. On S/E/W Windows	0.45
Compact Fluorescent Lamps (CFLs)	0.24
Cool Roof (Painted White Roof) if no insulation present	0.33

Small Government ECMs	(BZ\$/kWh)
Replace Split AC Units with Inverters at EOL	0.17
Replace MH/HPS High Bay Lamps with LED	0.18
Replace T12 with T8 and electronic ballasts	0.36
Retrofit existing windows with low SHGC film	0.07
Install Roof Insulation (Blown Cellulose R30)	0.14
Energy Star Certified Commercial Freezers and Refrigerators	0.36
Retail Freezers & Refrigerators with Remote Refrigeration	0.30
Replace Window AC Units with Inverter Split Systems	0.25
Net Small Government ECMs	0.22

Source: WSP Analysis

As highlighted in Figure A.11 reducing cooling loads and improving air conditioner efficiency will account for 95% of total electricity savings, with additional savings from retrofits to lighting systems.

Figure A.11: Small Government Distribution of Potential ECM Savings



Source: WSP Analysis

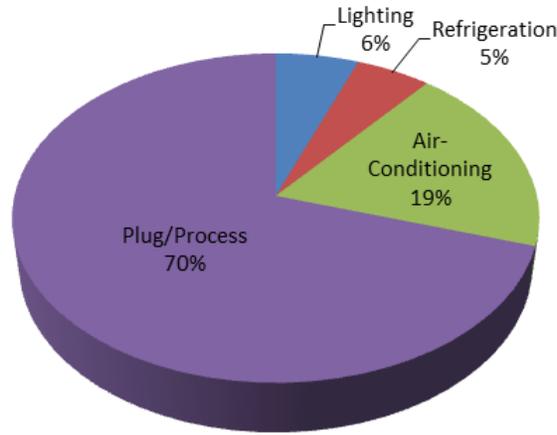
A.3.3 Large Government Sector

With 177 customers and 5,800 MWh of annual electricity consumption, the large government sector accounts for 1% of the national electricity demand. This category includes larger versions of the facilities included in the ‘small government’ category, for example, stadiums, hospitals, government ministry offices, and others.

End uses

As outlined in Figure A.12, in the average large government building plug and process load accounts for 70% of all electricity consumption, with air conditioning, lighting and refrigeration loads accounting for 19%, 6%, and 5% respectively.

Figure A.12: Distribution of Large Government Electricity End Use



Source: WSP Analysis

Energy savings potential from each ECM was calculated under four scenarios by varying what percent of upgradable buildings within a sector would implement the recommended ECMs. This factor, known as the penetration rate, was varied between max technical capacity (100%), aggressive penetration (60%), moderate penetration (40%), and low penetration (20%). The net percent savings was calculated as a function of the penetration rate times the percent upgradability (for example, X% of buildings have louvered windows, and are therefore good candidates for upgrades to double paned windows). Net residential savings at each penetration rate are outlined in Table A.17 below.

Table A.17: Large Government Net % Savings at Varied Penetration Rates

Penetration Rate	100%	60%	40%	20%
Lighting	21%	12%	8%	4%
Cooling	33%	20%	13%	7%
Refrigeration	50%	30%	20%	10%

Source: WSP Analysis

It should be noted that while the sector will achieve greater net electricity savings with higher penetration rates, because capital costs and savings are both driven by the penetration rates, the net cost per kwh saved will remain the same, as outlined below.

EE measures package

The large government sector is appropriate for 15 ECM improvements as outlined in Table A.18 below. Of the recommended ECMs, retrofitting existing single pane windows with low SHGC film is the most cost effective option, at a net cost of \$0.07/kwh saved, while installing window awnings has the highest cost at \$0.45/kwh saved. Combined, the recommended ECMs have a net cost of \$0.25/kwh saved.

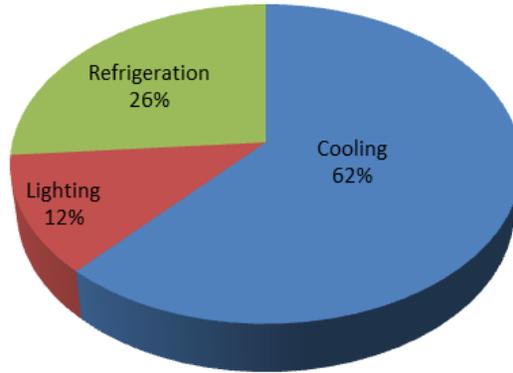
Table A.18: ECM Equivalent Cost per kWh Saved

Large Government ECMs	(BZ\$/kWh)
Replace louvered windows with new low-e windows	0.28
Reduce Infiltration on Louvered Windows (or leaky doors/windows)	0.09
Paint Concrete Walls w/ Beige or Yellow (Abs. = 0.55)	0.20
Paint Concrete Walls w/ Cool Roof White (Abs. = 0.25)	0.28
Install 3' Awnings @ 45 deg. On S/E/W Windows	0.45
Compact Fluorescent Lamps (CFLs)	0.24
Cool Roof (Painted White Roof) if no insulation present	0.33
Replace Split AC Units with Inverters at EOL	0.17
Replace MH/HPS High Bay Lamps with LED	0.18
Replace T12 with T8 and electronic ballasts	0.36
Retrofit existing windows with low SHGC film	0.07
Install Roof Insulation (Blown Cellulose R30)	0.14
Energy Star Certified Commercial Freezers and Refrigerators	0.36
Retail Freezers & Refrigerators with Remote Refrigeration	0.30
Replace Window AC Units with Inverter Split Systems	0.25
Net Large Government ECMs	0.25

Source: WSP Analysis

As highlighted in Figure A.13, reducing cooling loads and improving air conditioner efficiency will account for 62% of total electricity savings. Refrigeration upgrades will account for 26% of potential savings, with lighting accounting for the remaining 12% of savings potential.

Figure A.13: Large Government Distribution of Potential ECM Savings



Source: WSP Analysis

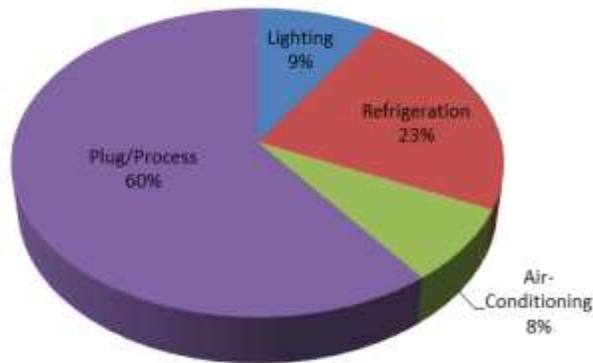
A.3.4 Small Industrial Sector

With 4 customers and 9,000 MWh of annual electricity consumption, the small industrial sector accounts for 2% of the national electricity demand.

End uses

As outlined in Figure A.14, in the average large government building plug and process load accounts for 60% of all electricity consumption, with refrigeration accounting for 23%, and the remaining electricity consumption split between air conditioning and lighting.

Figure A.14: Distribution of Small Industrial Electricity End Use



Source: WSP Analysis

Energy savings potential from each ECM was calculated under four scenarios by varying what percent of upgradable buildings within a sector would implement the recommended ECMs. This factor, known as the penetration rate, was varied between max technical capacity (100%), aggressive penetration (60%), moderate penetration (40%), and low penetration (20%). The net percent savings was calculated as a function of the penetration rate times the percent upgradability (for example, X% of buildings have louvered windows, and are therefore good candidates for upgrades to double paned windows). Net residential savings at each penetration rate are outlined in Table A.19 below.

Table A.19: Small Industrial Net % Savings at Varied Penetration Rates

Penetration Rate	100%	60%	40%	20%
Lighting	32%	19%	13%	6%
Cooling	0%	0%	0%	0%
Refrigeration	13%	8%	5%	3%
Plug & Process	8%	5%	3%	2%
Industrial Power	21%	13%	9%	4%

Source: WSP Analysis

It should be noted that while the sector will achieve greater net electricity savings with higher penetration rates, because capital costs and savings are both driven by the penetration rates, the net cost per kwh saved will remain the same, as outlined below.

EE measures package

The small industrial sector is appropriate for 9 ECM improvements as outlined in Table A.20 below. Of the recommended ECMs, liquid amplification on compressors and power factor correction are the most cost effective options, with a net cost of \$0.003/kwh saved, while variable frequency drives have the highest cost at \$0.30/kwh saved. Combined, the recommended ECMs have a net cost of \$0.06/kwh saved.

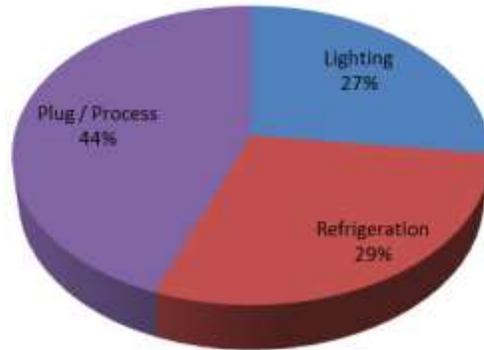
Table A.20: Small Industrial ECM Equivalent Cost per kWh Saved

Small Industrial ECMs	(BZ\$/kWh)
Replace MH/HPS High Bay Lamps with LED	0.18
Thermosyphon Oil Cooling for Screw Compressors	0.01
Chain Drive to Synchronous Belt Drives	0.01
Premium Efficiency Motors	0.18
Variable Frequency Drives	0.30
Power Factor Correction	0.003
Liquid Pressure Amplification on Compressors	0.003
2 Stage Compressor Retrofit	0.02
Premium Efficiency Transformers	0.07
Net Small Industrial ECMs	\$0.06

Source: WSP Analysis

As highlighted in Figure A.14 improving plug and process load efficiency will account for 44% of total electricity savings, with the remaining 56% of savings split between refrigeration and lighting retrofits.

Figure A.15: Small Industrial Distribution of Potential ECM Savings



Source: WSP Analysis

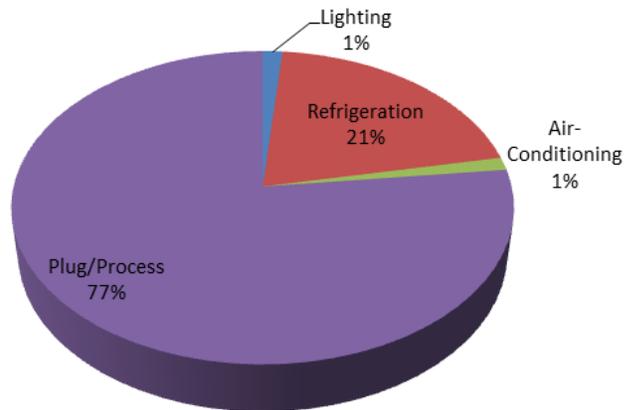
A.3.5 Large Industrial Sector

With 4 customers and 35,600 MWh of annual electricity consumption, the large industrial sector accounts for 7% of the national electricity demand.

End uses

As outlined in Figure A.16, in the large industrial facility plug and process load accounts for 77% of all electricity consumption, with refrigeration accounting for 21%, and the remaining electricity consumption split between air conditioning and lighting.

Figure A.16: Distribution of Large Industrial Electricity End Use



Source: WSP Analysis

Energy savings potential from each ECM was calculated under four scenarios by varying what percent of upgradable buildings within a sector would implement the recommended ECMs. This factor, known as the penetration rate, was varied between max technical capacity (100%), aggressive penetration (60%), moderate penetration (40%), and low penetration (20%). The net percent savings was calculated as a function of the penetration rate times the percent upgradability (for example, X% of buildings have louvered windows,

and are therefore good candidates for upgrades to double paned windows). Net residential savings at each penetration rate are outlined in Table A.21 below.

Table A.21: Large Industrial Net % Savings at Varied Penetration Rates

Penetration Rate	100%	60%	40%	20%
Lighting	47%	28%	19%	9%
Cooling	0%	0%	0%	0%
Refrigeration	23%	14%	9%	5%
Plug & Process	8%	5%	3%	2%
Industrial Power	23%	14%	9%	5%

Source: WSP Analysis

It should be noted that while the sector will achieve greater net electricity savings with higher penetration rates, because capital costs and savings are both driven by the penetration rates, the net cost per kwh saved will remain the same, as outlined below.

EE measures package

The large industrial sector is appropriate for 9 ECM improvements as outlined in Table A.22 below. Of the recommended ECMs, liquid amplification on compressors and power factor correction are the most cost effective options, with a net cost of \$0.003/kwh saved, while variable frequency drives have the highest cost at \$0.30/kwh saved. Combined, the recommended ECMs have a net cost of \$0.05/kwh saved.

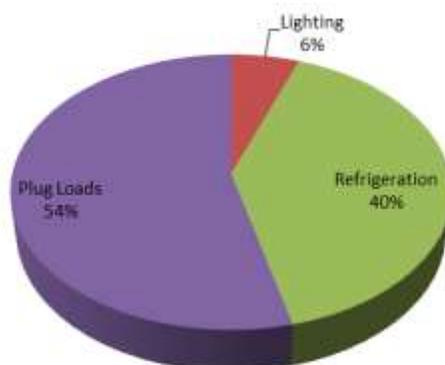
Table A.22: Large Industrial ECM Equivalent Cost per kWh Saved

Large Industrial ECMs	(BZ\$/kWh)
Replace MH/HPS High Bay Lamps with LED	0.18
Thermosyphon Oil Cooling for Screw Compressors	0.01
Chain Drive to Synchronous Belt Drives	0.01
Premium Efficiency Motors	0.18
Variable Frequency Drives	0.30
Power Factor Correction	0.003
Liquid Pressure Amplification on Compressors	0.003
2 Stage Compressor Retrofit	0.02
Premium Efficiency Transformers	0.07
Net Large Industrial ECMs	0.05

Source: WSP Analysis

As highlighted in Figure A.17 improving plug and process load efficiency will account for 54% of total electricity savings, refrigeration upgrades will account for 40% of total electricity savings, and lighting upgrades will account for the remaining 6%.

Figure A.17: Large Industrial Distribution of Potential ECM Savings



Source: WSP Analysis

A.3.6 Street Lighting EE Opportunities

Private and commercial street lighting combined demand 50,200 MWh/year, or 10% of national electricity consumption. High efficiency LED street lights coupled with photo-sensors has an equivalent cost of \$0.28 per kWh saved.

Energy savings potential from each ECM was calculated under four scenarios by varying what percent of upgradable buildings within a sector would implement the recommended ECMs. This factor, known as the penetration rate, was varied between max technical capacity (100%), aggressive penetration (60%), moderate penetration (40%), and low penetration (20%). The net percent savings was calculated as a function of the penetration rate times the percent upgradability (for example, X% of buildings have louvered windows, and are therefore good candidates for upgrades to double paned windows). Net residential savings at each penetration rate are outlined in Table A.23 below.

Table A.23: Street Lighting Net % Savings at Varied Penetration Rates

Penetration Rate	100%	60%	40%	20%
Street Lighting	40%	24%	16%	8%

Source: WSP Analysis

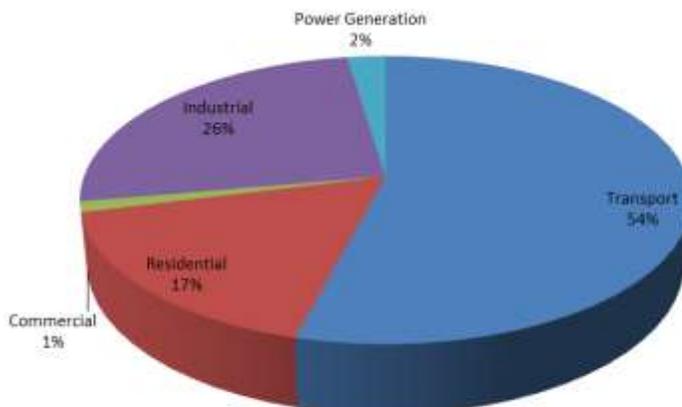
It should be noted that while the sector will achieve greater net electricity savings with higher penetration rates, because capital costs and savings are both driven by the penetration rates, the net cost per kWh saved will remain the same.

A.4 Fuel Consumption

Historical fuel consumption in Belize has been principally limited to the transport, power generation, industrial and residential sectors. Commercial fuel consumption comprises only 1% of overall consumption. We evaluated energy efficiency measures for the industrial,

commercial and residential buildings only, and do not consider the transportation or power generation sectors.

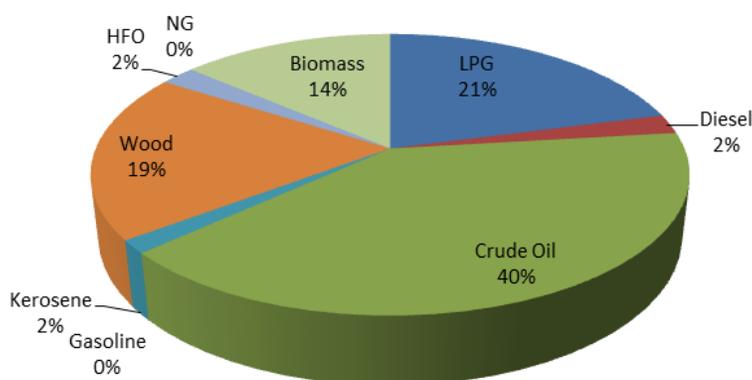
Figure A.18: 2013 Shares of Fuel Energy Use in Belize by Sector



Source: MESTPU Energy Balance and WSP Analysis

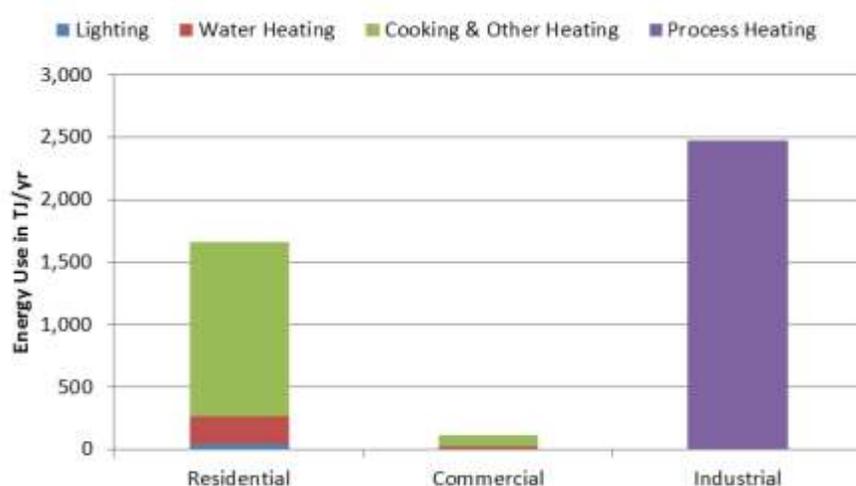
Within these sectors, crude oil is the most commonly used fuel particularly in the industrial sector. LPG is the most commonly used fuel in the residential and commercial sectors for water heating and cooking. Fuel consumption estimates were taken from the Energy Balance produced by the Ministry of Energy, Science, Technology, and Public Utilities. Initial estimates from MESTPU on the balance of fuel use within the industrial sector have been reallocated to 90% crude oil, 5% diesel, and 5% HFO based on observations made during site energy audits. Not unsurprisingly, following the recent discovery and production of domestic crude oil in Belize, most industrial boilers have switched over to crude from diesel or HFO.

Figure A.19: 2013 Fuel Use by Type



Source: MESTPU Energy Balance and WSP Analysis

Outside of transport and power, the typical end uses of fuel in Belize include energy for cooking, domestic hot water production, and industrial process heat as presented in Figure A.20. As such, the energy efficiency measures proposed target these end uses, and primarily target savings for crude oil and LPG. These are discussed below and in Table A.24.

Figure A.20: 2013 Fuel Consumption by End Use and Sector

Source: MESTPU Energy Balance and WSP Analysis

Table A.24: Proposed Fuel Saving Measures

Energy Efficiency Measure	Target Fuel	Target Sector
Commercial SHW (5 kWth)	LPG	Commercial hot water
Replace Ovens and Cooking Equip. with Energy Star Certified units, at EOL	LPG	Commercial cooking and other heating
Replace Ovens and Cooking Equip. with Energy Star Certified units, at EOL	LPG	Residential cooking
Solar Industrial Process Heat	Crude Oil	Industrial process heat
Industrial Heat Pumps to replace Boiler	Crude Oil	Industrial process heat
High Efficiency Industrial Boilers (1000 kW)	Crude Oil	Industrial process heat
Biomass Boiler (1000 kW)	Crude Oil	Industrial process heat
Residential SHW (2.1 kWth)	LPG	Residential hot water
Tankless Gas Water Heater	LPG	Residential hot water
Group of 11 general fuel saving measures for industrial steam production and distribution	Crude Oil	Industrial process heat

Source: WSP Analysis

Commercial Solar Hot Water

Installing solar hot water production systems at commercial buildings, primarily hotels and resorts can displace LPG consumption. This measure will displace up to 95% of the LPG used by conventional gas fired tank water heaters. It would cost the average building BZ\$15,000 to install a 5 kWth system which would be paid off in 5.5 years by savings on LPG purchases.

Target Sector	Target Fuel	Capital Cost (BZD / TJ)	Incremental O&M Costs (BZD / TJ)	Annualized Cost of Savings (BZD / TJ)	Simple Payback Period (yrs)
Commercial	LPG	25,097	1,439	26,537	5.5

Replace Ovens and Cooking Equipment at End-of-Life

This measure proposes to replace all conventional gas fired kitchen and cooking equipment (stoves, fryers, dishwashers, etc.) in the residential and commercial sectors with US EPA Energy Star Certified equipment. This measure should be implemented during the normal course of equipment end of life and replacement, and as such, considers only the incremental cost of Energy Star Certified equipment. New equipment will cost an additional BZ\$50 on average but will deliver 33% energy savings versus conventional equipment, paying off the initial investment in 1.3 years.

Target Sector	Target Fuel	Capital Cost (BZD / TJ)	Incremental O&M Costs (BZD / TJ)	Annualized Cost of Savings (BZD / TJ)	Simple Payback Period (yrs)
Commercial & Residential	LPG	6,139	0	6,139	1.3

Solar Industrial Process Heat

In this measure, industrial hot water and steam would be generated using concentrating solar energy collectors such as parabolic troughs. The capital equipment cost of this measure is very high and the low direct beam radiation potential in Belize makes this measure uneconomical for industry in Belize. The measure would require an investment of 2.8 mm BZD and require 60 years to pay off at current fuel pricing.

Target Sector	Target Fuel	Capital Cost (BZD / TJ)	Incremental O&M Costs (BZD / TJ)	Annualized Cost of Savings (BZD / TJ)	Simple Payback Period (yrs)
Industrial	Crude Oil	160,186	0	160,186	60.0

Industrial Heat Pumps

Heat pumps can be used to upgrade the heat of rejection from industrial refrigeration systems to hot water (rather than rejecting the heat with an air cooled condenser) that could be used for industrial process heat loads. A typical unit would cost BZ\$1 million upfront but would displace 1.5 MWth of boiler capacity. The heat pumps would consume an additional 250 kW of electrical power but would deliver sufficient annual energy cost savings to pay off the capital investment in under a year.

Target Sector	Target Fuel	Capital Cost (BZD / TJ)	Incremental O&M & Energy Costs (BZD / TJ)	Annualized Cost of Savings (BZD / TJ)	Simple Payback Period (yrs)
Industrial	Crude Oil	2,217	7,559	9,830	0.9

High Efficiency Industrial Boilers

The existing inventory of fuel fired boilers in Belize is primarily packaged water tube and fire tube boilers without economizers. New high efficiency condensing boilers running on crude oil would improve the average boiler efficiency from roughly 75% to over 85%. A new 1,000 kWth unit would cost BZ\$220,000 but would be paid off in less than 1.5 years through fuel cost savings.

Target Sector	Target Fuel	Capital Cost (BZD / TJ)	Incremental O&M Costs (BZD / TJ)	Annualized Cost of Savings (BZD / TJ)	Simple Payback Period (yrs)
Industrial	Crude Oil	5,693	653	6,346	1.5

Biomass Boilers

Similarly, high efficiency wood chip or biomass fired boilers could be purchased to displace crude oil boilers and would maximize GHG emission reductions in the sector. A 1000 kWth biomass boiler would require a BZ\$2 million investment but would be paid off in 2.3 years from annual energy cost savings assuming wood chips can be obtained from \$15 per dry ton delivered.

Target Sector	Target Fuel	Capital Cost (BZD / TJ)	Incremental O&M Costs (BZD / TJ)	Annualized Cost of Savings (BZD / TJ)	Simple Payback Period (yrs)
Industrial	Crude Oil	6,522	3,960	10,482	2.30

Residential Solar Hot Water

Solar hot water systems in the residential sector would displace up to 85% of the annual LPG use of a typical gas fired tank water heater. These units would cost consumers BZ\$3,500 and would produce a simple back period of 1.3 years through LPG purchase savings.

Target Sector	Target Fuel	Capital Cost (BZD / TJ)	Incremental O&M Costs (BZD / TJ)	Annualized Cost of Savings (BZD / TJ)	Simple Payback Period (yrs)
Residential	LPG	5,896	338	6,234	1.26

Residential Tankless Gas Water Heaters

Tankless gas water heaters minimize energy use by eliminating storage losses. These new units have an energy factor of 0.95 up from 0.8 for a typical tank water heater. These would cost roughly BZ\$900 and would deliver annual savings of LPG purchases sufficient to produce simple payback period of under 6 years.

Target Sector	Target Fuel	Capital Cost (BZD / TJ)	Incremental O&M Costs (BZD / TJ)	Annualized Cost of Savings (BZD / TJ)	Simple Payback Period (yrs)
Residential or Commercial	LPG	27,974	0	27,974	5.93

Generic Industrial Fuel Saving Measures

In addition to the specific measures identified above, a package of 11 generic fuel saving measures have been included for industrial steam production and distribution. These measures include everything from improving steam line insulation to repairing steam traps and optimizing air to fuel ratios. Generally, these measures are “low or no-cost” measures but have very attractive returns on investment. This generic package of measures would apply to crude oil savings in industrial and commercial boilers and would cost BZ\$368 per TJ of fuel savings and have a payback of 0.12 years on average.

Target Sector	Target Fuel	Capital Cost (BZD / TJ)	Incremental O&M Costs (BZD / TJ)	Annualized Cost of Savings (BZD / TJ)	Simple Payback Period (yrs)
Industrial	Crude Oil	368	0	368	0.12

To estimate the economy wide implementation potential of each measure the following procedure was followed. First, representative system capacities were assumed for each measure, e.g. 1000 kWth heating capacity boiler. Then, an estimate for the total number of units that could be installed in 2013 was made. As an example, to estimate the potential for cooking equipment savings in the residential sector, 2010 census data was used to identify the number of households with stoves and this defined an upper limit for the number of LPG fired cooking units that could be replaced in the sector. In other cases, observations made during site energy audits informed these assumptions. Roughly 20% of the residences surveyed had a domestic water heater and of these about half were LPG fired tank water

heaters. Therefore, there are roughly 7000 LPG fired DHW units that could be replaced by solar water heater or LPG tankless gas units.

Table A.25 shows the result of this process which yields an estimated potential fuel savings of 640 TJ per year at an annualized capital cost of BZ\$4.44 million. Implementing all of these measures at once would result in annual energy cost savings of BZ\$25.4 million to the Belizean economy in the base year.

Table A.25: Summary of Fuel Savings Measures

Fuel Savings Measure	# of Installations or % Penetration	Combined Fuel Savings (TJ)	Annualized Capital Cost (BZ\$/Yr)	Annual Savings (BZ\$/yr)
Commercial SHW (5 kWth)	50% penetration	11.14	158,526	444,473
Commercial tankless water heating	50% penetration	1.86	52,084	
Residential SHW (2.1 kWth)	30% penetration	77.29	722,671	3,459,469
Residential tankless water heating	70% penetration	33.46	936,127	
Efficient residential cooking equipment	100% penetration	189.22	1,158,764	9,080,555
Efficient commercial cooking equipment	100% penetration	32.51	199,577	1,559,560
Solar Industrial Process Heat	0	0	257,647	0
Industrial Heat Pumps to replace Boiler	2 installations	67.19	660,482	2,503,738
High Efficiency Industrial Boilers (1000 kW)	6 installations	20.33	129,007	828,376
Biomass Boiler (1000 kW)	3 installations	9.00	94,341	329,500
Package of 11 Industrial Steam savings Measures	8 installations	197.97	72,842	7,175,798
Total of All Measures		640	4,442,067	25,381,469

Source: WSP and Castalia Analysis

A.5 Energy Efficiency Program Case Studies

As Belize considers a government organized program to increase energy efficiency, it can be helpful to consider the experience of other countries. In this section we present four case studies: one from the United States, two from Thailand, and one from Vietnam. We first present summary tables (Table A.26) with the key characteristics of the programs. Following the summary table, we provide narrative descriptions of the programs and source information for further information.

Table A.26: EE Program Comparison

	Program to promote the Energy Service Industry	Comprehensive DSM Program in the Electricity Sector
Country	United States (State of New York)	Thailand
Objective	Promote energy efficiency projects and support the growth of the energy service industry through payments for energy savings.	Build institutional capability to deliver cost-effective energy services and help the development, manufacturing and adoption of energy efficient equipment.
Time horizon	1998 to 2006	1993 to 1998
Implementing Agencies	<ul style="list-style-type: none"> ▪ New York State Energy Research and Development Authority (NYSERDA) ▪ 150 energy service companies (ESCOs) 	<ul style="list-style-type: none"> ▪ Electricity Generating Authority of Thailand (EGAT) ▪ Manufacturers of electric appliances
Sector(s)	<ul style="list-style-type: none"> ▪ Commercial ▪ Industrial ▪ Public 	<ul style="list-style-type: none"> ▪ Commercial ▪ Industrial ▪ Residential ▪ Public
Barrier(s) addressed	Financing	<ul style="list-style-type: none"> ▪ Awareness ▪ Financing
Measure(s)	Payments for kWh of verified electricity savings	<ul style="list-style-type: none"> ▪ Bulk purchasing of CFL lamps to achieve economies of scale and lower sales price ▪ Voluntary agreements to phase out production of T-12 lamps and to label appliances ▪ Public campaigns to support industry efforts
Outcomes	<ul style="list-style-type: none"> ▪ 1,348 projects applied ▪ 1.0TWh annual savings ▪ 214MW peak load reduction 	<ul style="list-style-type: none"> ▪ 5.8TWh annual savings ▪ Increased market shares of high-efficient light bulbs, refrigerators, and A/C units
Cost (\$US million)	101.5 (until 2003)	60
Funding Source	Public (100%)	<ul style="list-style-type: none"> ▪ Public (79%) ▪ International donors (21%)
Funding instrument	Charge levied on electricity consumers in the state.	Resources from a tariff surcharge and grants and loans from international donors (World Bank, Governments of Australia and Japan).

	Revolving Fund for the Promotion of Energy Efficiency Financing	Program to Promote Energy Efficient Public Lighting
Country	Thailand	Vietnam
Objective	Stimulate the investment appetite of commercial banks in Thailand to engage them in financing energy efficiency projects.	Build technical and policy support for transition to more energy efficient public lighting systems.
Time horizon	2003 to 2013	2005 to 2011
Implementing Agencies	<ul style="list-style-type: none"> ▪ Department of Alternative Energy Development and Efficiency (DEDE) ▪ 11 commercial banks 	<ul style="list-style-type: none"> ▪ United Nations Development Programme (UNDP) ▪ Vietnamese Academy of Science and Technology (VAST)
Sector(s)	<ul style="list-style-type: none"> ▪ Commercial ▪ Industrial 	Public
Barrier(s) addressed	Financing	<ul style="list-style-type: none"> ▪ Awareness ▪ Financing ▪ Policy Framework
Measure(s)	Low interest credit lines to commercial banks which lend to facilities and organizations that implement energy efficiency projects	<ul style="list-style-type: none"> ▪ Development of a regulatory framework for public lighting ▪ Technical support to manufacturers to improve lighting products ▪ Establish National Lighting Testing and Certification Laboratory ▪ Pilot programs to in large cities to showcase efficient lighting solutions
Outcomes	<ul style="list-style-type: none"> ▪ 294 projects (from 2003 to 2012) ▪ 1.2TWh annual savings ▪ 1.5 million barrels annual oil savings ▪ Fund is now independently managed by participating banks 	<ul style="list-style-type: none"> ▪ Increasing market share of efficient lighting ▪ 0.3TWh annual savings
Cost (\$US million)	500 (loans disbursed)	28.6
Funding Source	Public (100%)	<ul style="list-style-type: none"> ▪ Public (60%) ▪ Private (29%) ▪ International donors (11%)
Funding instrument	Revenues from a tax on petroleum.	Grants from local and national governments and international sources (Global Environment Facility).

Sources: See end of section

Program to promote the Energy Service Industry—United States

New York State Energy Research & Development Authority (NYSERDA) launched the “\$mart” Commercial/Industrial Performance Program in 1998 to support the growth of the energy efficiency service industry in New York State.

To encourage the development of energy efficiency and peak demand reduction projects, NYSERDA created a result-based incentive system. All electricity customers paying the System Benefits Charge³ are eligible for program funding. Projects that save at least 50,000kWh per year receive payments based on verified electricity consumption savings. Payments amount to US\$0.105-0.288 per kWh saved over equipment lifetime and are 20 percent higher for small facilities with annual energy consumption below one million kWh. In addition, there is a bonus of US\$300/KW for projects that reduce peak load during the summer. In order to receive these benefits, projects have to be reviewed by an independent third party and need to monitor and verify the savings in the first two years.

The program was successful in mobilizing Energy Service Companies (ESCOs) and incentivizing energy savings and demand load reduction projects. The number of participating ESCOs increased from seven in the first program year to 166 at the end of the program. Furthermore, the estimated energy savings of the 1,348 projects are equal to more than 1TWh annually and peak demand reduction is estimated at 214 MW.⁴

Comprehensive Electricity Demand Side Management Program—Thailand

In the late eighties and early nineties, rapid economic growth in Thailand led to quickly increasing electricity demand. Considering this, the Thai government decided to launch the country’s first demand-side management (DSM) program. Electricity Generation Authority of Thailand (EGAT), the public utility asked to design and implement the program, started the first initiatives in 1993.

The program aimed at fostering public awareness, incentivizing the production of energy efficient appliances and strengthening Thailand’s institutional capacities. EGAT developed a program that included a broad range of energy efficiency. To transform the lighting industry, EGAT negotiated a voluntary agreement with all five manufacturers to switch production from T12 lamps to the more efficient T8 lamps. Building upon the success with this initiative, the program was expanded to refrigeration. EGAT convinced refrigerator manufacturers and importers to test their equipment and participate in a labeling program. Again, the voluntary agreement was supported by a big advertising campaign. The program finally expanded to air-conditioners where EGAT again used a combination of voluntary labeling and awareness campaigns. In addition, EGAT purchased CFLs in bulk and resold them through a distribution network. Besides the aforementioned measures, EGAT launched a pilot ESCO, provided interest free loans for high-efficiency motors, sponsored building energy audits, and funded demonstration projects for efficient street lighting.

³ New York's system benefits charge (SBC) is an electricity surcharge collected by New York State’s six utilities. The funds are used to supports energy efficiency, education and outreach, research and low-income energy assistance.

⁴ Engel, V. 2007. “Commercial and Industrial Performance Program (CIPP) – Market Characterization, market assessment and causality evaluation.” Report for NYSERDA. <http://text.nyscrda.org/BusinessAreas/Energy-Data-and-Prices-Planning-and-Policy/Program-Evaluation/NYES-Evaluation-Contractor-Reports/2007-Reports/Market-Analysis.aspx>

York, D., M. Kushler and P. Witte. 2008. “Commercial/Industrial Standard Offer Exemplary Program: New York Energy \$martSM Commercial/Industrial Performance Program” in *Compendium of Champions: Chronicling Exemplary Energy Efficiency Programs from Across the U.S.* Washington, DC: American Council for an Energy-Efficient Economy <http://www.aceee.org/sites/default/files/publications/researchreports/u081/ci-lighting.pdf>

The program achieved significant changes. T12 lamps were phased out within one year and the market share of the most efficient refrigerators increased from 2% in the mid-1990s to 100% in 2000. The CFL bulk purchase allowed EGAT to sell 0.9 million CFLs at 40% below market price without subsidies. The entire program resulted in energy savings of almost 6TWh per year. Finally, local capacities in energy efficiency were strengthened. The DSM office grew from 40 staff in 1993 to about 177 skilled and trained staff in 2000.⁵

Energy Efficiency Revolving Fund—Thailand

The Government of Thailand created the Energy Efficiency Revolving Fund (EERF) in 2003 as part of its efforts to reduce Thailand's energy intensity by 25 percent between 2005 and 2025. The purpose of the EERF was to overcome barriers within the Thai financial sector and stimulate financing for energy efficiency activities.

The fund was created with capital from a petroleum tax and an initial allocation of US\$50 million. The fund extended credit lines with 0.5 percent interest in the range of US\$2.5 to 10 million to initially six and later 11 commercial banks. The partner banks can use the credit lines to give soft loans with a maximum interest rate of 4 percent. They can only access credit lines in exchange for project proposals with facilities or third parties such as ESCOs.

The fund has created awareness about energy efficiency in the financial sector. Until 2012, the eleven partner banks had financed 294 projects with annual electricity savings of 1.2TWh and a reduction of annual oil demand of 1.5 million barrels. Besides the impact of the financed projects, the fund has also helped create networks of ESCOs and private financiers. ESCOs have developed training materials to empower banks in the financial assessment of energy efficiency projects.⁶

Energy Efficient Public Lighting—Vietnam

Vietnam lacked a regulatory framework to provide incentives for energy efficient public lighting; it also lacked the professional skills to implement such projects. To address these bottlenecks, the United Nations Development Programme (UNDP) together with the Vietnamese Academy of Science and Technology (VAST) designed a project to promote the use of energy efficient equipment in Vietnam's public sector.

⁵ Birner, S. and E. Martinot. "Promoting energy-efficient products: GEF experience and lessons for market transformation in developing countries, *Energy Policy*, 33 (14), 1765-1779

Lefevre T. and G.R.Timilsina. 2000. "Demand Side Management Program in Thailand: A Model for Implementing GHG Mitigating Technologies in Developing Countries." Presentation at the UNFCCC Regional Workshop on Technology Transfer in Cebu. https://unfccc.int/files/meetings/workshops/other_meetings/application/vnd.ms-powerpoint/lefevre.ppt

Singh, J. and C. Mulholland. 2004. "DSM in Thailand: a case study. Energy Sector Management Assistance Programme (ESMAP)." Washington, DC: World Bank. <http://documents.worldbank.org/curated/en/2004/01/5711914/dsm-thailand-case-study>

Wedderburn, S. and K. N. Phumaraphand. 2006. "Thailand: promotion of electrical energy efficiency project (TPEEE), post-implementation impact assessment." Washington, DC: World Bank. <http://documents.worldbank.org/curated/en/2006/01/7090372/thailand-promotion-electrical-energy-efficiency-project-tpeee-post-implementation-impact-assessment>

⁶ APEC. 2005. "Thailand's Energy Efficiency Revolving Fund: A Case Study." Report for the APEC Energy Working Group. <http://www.climate-eval.org/sites/default/files/evaluations/531%20Thailands%20Energy%20Efficiency%20Revolving%20Fund.pdf>

Grüning, C.; C. Menzel, T. Panofen and L. S. Shuford. 2012. "Case Study: The Thai Energy Efficiency Revolving Fund (EERF)" Frankfurt, Germany: Frankfurt School - UNEP Collaborating Centre for Climate & Sustainable Energy Finance. <http://fs-unep-centre.org/publications/case-study-thai-energy-efficiency-revolving-fund-eerf>

To improve the efficiency of public lighting, the program assisted local governments in developing appropriate regulations for the public lighting systems and developed standards for efficient street lighting and efficient lighting in schools. Moreover, it provided technical assistance to local manufacturers and helped establish a national lighting testing and certification laboratory. Finally, it promoted the use of efficient lighting in the public sector through pilot projects in Hanoi, Ho Chi Minh, Hai Phong, Da Nang and Quy Nhon.

Since the project's inception, local production of energy efficient lighting equipment has increased and public lighting systems have become more energy efficient. For instance, the percentage of efficient school lighting systems increased from one percent in 2006 to 65 percent in 2010. Similarly, 89 percent of public urban lighting systems were energy efficient, up from 69 percent in 2006. Finally, demonstration of energy efficient lighting systems in many big cities led to large scale installment of efficient lights. In 2012, announced the deployment of an energy control networking system that covers 25% of all street lights in Hanoi.⁷

⁷ UNDP. 2011. "Vietnam Energy Efficiency Public Lighting (VEEPL) End of Project Evaluation." New York, NY: United Nations Development Programme. <http://erc.undp.org/evaluationadmin/downloaddocument.html?docid=4927>

Box A.1: PRONASE—The EE Program in Mexico

While EE programs in Mexico have existed since the early 1990s, historically they have been highly decentralized. More recently, the passage of a national sustainable energy law in 2008 consolidated many of these programs under the broad national energy strategy, PRONASE. Between 2009 and 2012, PRONASE initiatives have yielded cumulative energy savings of 43,416GWh. These efforts are funded through a duty on oil production by the state-owned oil company, PEMEX.

The PRONASE strategy is implemented by the National Commission for Efficient Energy Use (CONUEE), a technical arm of the Secretary of Energy. CONUEE sets EE standards, regulations, and policies; disseminates technical publications; provides technical assistance to government agencies; and serves as a clearinghouse of information on financing available for EE investments.

Key components of Mexico's EE program include:

- **EE standards**—Mexico first adopted EE standards in 1995, and has since established standards for 25 product categories
- **Product labeling**—CONUEE implements a mandatory comparative labeling program for select appliances, which allows consumers to easily compare operating efficiency before purchasing. Since 1995, the Energy Savings Trust Fund (FIDE) has operated a sister labeling program, which emphasizes those products deemed to be the most efficient
- **Voluntary certifications**—CONUEE has established a certification program for energy auditors and other industry practitioners, as a means of reducing the information barrier for consumers
- **Dedicated EE financing**—Due to legal restrictions, government entities are generally unable to raise private sector financing for EE projects. However, FIDE has served a critical role by offering a number of lending programs that focus on promoting high efficiency motors and appliances in the private sector.

Sources: Energy Sector Management Assistance Program. 2009. "Innovating Financing Mechanism to Implement Energy Efficiency Projects in Mexico." Formal Report 338/09.
http://www.esmap.org/sites/esmap.org/files/Formal338-09_Mexico-Innovative%20Financial%20Mechanism%20to%20Implement%20Energy%20Efficiency%20Projects.pdf (accessed March 4, 2014).

Asia Pacific Energy Research Centre. 2012. "Compendium of Energy Efficiency Policies of APEC Economies." <http://aperc.ieej.or.jp/publications/reports/compendium.php> (accessed March 4, 2014).

Box A.2: EE Program in Panama

Since the 1980s, energy efficiency has been a high profile topic in Panama, and there have been several governmental entities responsible for promoting EE. Most recently, in 2008 the National Energy Secretariat assumed this role. The Government has adopted a National Energy Plan, which seeks to implement the following:

- Standards for EE equipment
- EE building codes
- Information campaigns and public education
- Public sector EE programs.

Despite having a dedicated government policy addressing these areas, the overall EE programs have met with limited success. For example, the Government has implemented several public sector EE programs (in 1983, 1985, 1990, and 2007); and yet, due to a lack of monitoring and evaluation capacity, each of these programs has failed to meet its objectives. Similarly, efforts to provide public education on EE technologies available in the market have eroded over time due to budget cuts.

The Panamanian example emphasizes that successful EE programs generally demonstrate two key characteristics:

- **Dedicated funding**—The most successful EE programs have a dedicated funding source which is not tied to the general budget
- **Independent oversight**—The most successful EE programs are implemented by an independent governmental entity, which operates within a clearly defined scope.

Source: ECLAC—United Nations. 2010. “Energy efficiency in Latin America and the Caribbean: situation and outlook.” <http://www.eclac.cl/publicaciones/xml/2/39412/lcw280i.pdf> (accessed March 4, 2014).

Appendix B: Renewable Energy Technologies

A.5 elaborates on our assessment of Belize’s renewable energy potential. For each potential power source, we present our assessment of the availability of the resource (in terms of quantity and quality) and the maturity of the technology used to exploit the resource. The information in this appendix serves as an accompaniment to the resource assessment table in the main report, reproduced below as Table B.1.

Table B.1: Technical Screening Summary of RE Technologies

Technology	Resource Availability (0-2)	Tech. Maturity (0-2)	Overall Assessment	In or out?
On-Shore Wind	2	2	Several sites with good wind speeds; mature technology	In
Off-Shore Wind	1	1	Sites with good wind speeds are far offshore; technology still maturing	Out
Distributed PV	1	2	Decent solar resource; relatively mature technology, still experiencing cost declines	In
Utility Scale PV	1	2	Decent solar resource; relatively mature technology, still experiencing cost declines	In
Concentrated Solar Power	1	1	Marginal resource availability; technology in commercial operation, but significant improvements and cost reductions expected.	Out
Waste Incineration	0	2	Mature technology; insufficient waste quantity	Out
Landfill gas	1	2	Small resource, but sufficient for power generation; mature technology	In
Biomass Power	2	2	Good resource availability; proven technology in Belize	In
Small Hydro (1-5MW)	2	2	Good resource availability; proven technology	In
Larger Scale Hydro (5-25MW)	1	2	Several sites still undeveloped; proven technology in Belize	In
Geothermal	0	2	Mature technology, no resource identified	In
Ocean thermal energy conversion	1?	0	Resource quality unstudied; immature technology	Out
Ocean wave	1?	0	Resource quality unstudied; immature technology	Out

B.1 Bagasse and Forestry Residues

Belize has a rich biomass resource base. Two of the country’s industries, sugar and forestry products, have waste streams particularly well-suited for power generation. Sawmill residues (bark,

sawdust, and so on) and sugarcane bagasse could be consumed in cogeneration schemes, similar to the BELCOGEN bagasse generation facility currently in operation.

B.1.1 Availability of the Resource: Quantity and Quality

Based on the best information we could obtain, we estimated quantities of bagasse and wood residues in Belize. Sugarcane bagasse is an excellent biomass energy resource and could be available for industrial process heat and power generation, with excess available for grid export. Insofar as there is expansion in this sector, there will be additional residues available for export power generation capacity. Current sugar cane crushing and bagasse firing capacity in Belize is assumed to process the current sugar cane production acreage. Details on the expansion are needed to develop a reasonable estimate of the capacity potential, but we assumed some growth of the industry in our model.

Availability of woody biomass residues were estimated using 5 years of production statistics for the Belizean forestry sector obtained from the UN FAO Production Stat database. Annual production volumes for sawn wood and industrial round wood were used along with residue factors to estimate the total annual residue potential from the two sources. The analysis assumes that 50% of logging residues and 80% of saw mill residues could be obtainable for energy production. Power generation potential from woody biomass is estimated at 4.3 MW using a plant heat rate of 14,240 kJ/kWh, as summarized in Table B.2.

Table B.2: Availability and Power Generation Potential from Woody Biomass Residues

	Annual Potential
Saw Mill Residues	23,784 dry tons
Logging Residues	29,043 dry tons
Total Residues	52,826 dry tons
Energy Available in Residues	426,843 GJ
Power Potential	4.3 MWe

Source: UN FAO Production Stat and WSP USA Analysis

B.1.2 Maturity of Technology

Biomass combustion technologies, typically defined as a steam boiler and steam turbine are commercialized technologies utilized around the world, including in Belize. Other thermochemical conversion methods like gasification and pyrolysis are newer variants of combustion which generate fuels suitable for use in more advanced prime movers like gas turbines and reciprocating engines. These technologies are far less commercialized and would not be recommended initially in Belize.

B.1.3 Sources

UN FAO Stat Forestry Production and Trade Database.

B.2 Anaerobic Digestion

Anaerobic digestion technology could be utilized in Belize to produce biogas. The biogas could be used for power generation, heat generation, or both, using combined heat and power. The potential to produce biogas exists at industrial food processing facilities that have high organic loading in waste water streams, at dairies, and large animal confinement facilities. In Belize, most of the cities

have combined storm water and sewage treatment plants and this diminishes the potential for anaerobic digestion of municipal waste water. Very little information from individual processing plants could be obtained to make qualified estimates for biogas potential within the industrial sector. However, based on the scale of the Citrus Products of Belize Limited operations, there is likely sufficient biogas generation potential from waste water digestion to make a meaningful contribution to reducing fuel purchases.

Several sources of data have been collected to estimate annual availability of these different resources. They include:

- Agricultural production statistics for 2012 in Belize, showing livestock headcount and live weight
- Agricultural production statistics for 2012 in Belize, showing output of processed food by weight

B.2.1 Availability of the Resource: Quantity and Quality

Quantities of animal waste generated are estimated using 2012 production statistics from the ministry of Agriculture and Fisheries. The data include animal population and slaughter rates by head per year, as well as live weight in pounds. Data from the US EPA are used to estimate methane generation potential for each class of livestock using manure volatile solids production rates and maximum methane generation potential rates specific to each animal type. The estimated power production potential considers that only 10% of manure could be efficiently collected and delivered to anaerobic digesters.

The current and future (2033) power generation potential from this resource is estimated at 1.5MW in 2013 and 4.2MW in 2033. A summary of this estimate is presented in Table B.3.

Table B.3: Power Generation Potential from Animal Manure

Livestock Type	Population (Head/yr)	Live Weight (kg/head)	Max Energy Potential (kW)	Current Potential at 10% Utilization (kW)	Annual Growth in Population	2033 Potential at 10% Utilization (kW)
Cattle	8,157	457.22	646	65	3.89%	138
Hogs and Pigs	25,881	104.33	950	95	7.18%	380
Sheep and Lambs	1,735	38.10	16	2	7.49%	7
Chickens	182,863	1.5	157	16	3.07%	29
Commercial Broilers	8,964,840	2.01	13,205	1,321	5.27%	3,685
Turkeys	7,369	7.79	27	3	-4.60%	1
Goats	9	40.8	0	0		0
Total	9,190,854		15,001	1,500		4,240

Source: Ministry of Agriculture, WSP Analysis

Since this resource is typically available on a firm basis, this would result in expected annual generation rates of 10,512 and 29,714 MWh for the two scenarios.

B.2.2 Maturity of Technology

The conversion of animal manure to biogas via anaerobic digestion process is relatively new but in the US and EU is considered both technically and financially mature and commercialized.

B.2.3 Sources

US EPA National GHG Inventory; Belize Ministry of Agriculture and Fisheries, Agricultural Production Statistics for 2012. March 2013.

B.3 Municipal Solid Waste

The potential for generating electricity from municipal solid waste (MSW) in Belize has been estimated using annual waste generation statistics from a May 2011 study on generation and composition of MSW. The annual waste generation by all municipalities in Belize has been used to estimate the potential for electricity production using conventional MSW combustion plants (Waste to Energy – WTE) and from landfill gas-to-energy (LFGTE) projects. The analysis of LFGTE potential is based on the assumption that current landfills are un-covered and are not suitable for LFGTE. Therefore, the analysis is forward looking only assuming that starting in 2013, all MSW were disposed of using conventional covered landfills with landfill gas capture equipment in place. The estimate shows a long term potential of 49.5 MWe for WTE or 3.4 MWe for LFGTE by the year 2033 using the annual growth rates assumed in the study.

B.3.1 Availability of the Resource: Quantity and Quality

The availability of municipal solid waste has been estimated using the Hydroplan 2011 waste generation and characterization study. This report characterized the waste composition in different regions and analyzed total generation rates in each region. The composition analysis data was used to develop average gross calorific values (GCV) for the MSW. The study characterized a combined area corresponding to a population of 101,300 inhabitants. These data were scaled up to the current population to estimate country wide available waste volumes. The study also estimated future waste generation rates and these growth rate assumptions were incorporated into the figures in Table B.4.

Table B.4: Estimated Potential for MSW to Energy

Year	MSW Availability		MSW Combustion		LFG to Energy	
	Tons/yr	TJ/yr	MWe	MWh/yr	MWe	MWh/yr
2013	197,802	2,629	25.5	189,857	0.0	0
2015	214,970	2,857	27.7	206,336	0.3	2,566
2020	261,117	3,470	33.7	250,628	1.2	8,903
2025	309,198	4,109	39.9	296,779	2.0	15,232
2033	384,309	5,107	49.5	368,873	3.4	25,365

Source: WSP Analysis

Waste-to-Energy

WTE electricity generation potential is estimated using the combined average waste GCV of 13.29 GJ/tonne and a plant net heat rate of 15,000 kJ/kWh, along with the estimated waste generation for

the entire population. This estimate assumes that state-of-the-art emission control systems would be installed on the boilers.

Landfill gas-to-Energy

LFGTE potential is estimated using current and future waste generation rates and assuming that all MSW in Belize would be landfilled in a covered landfill with LFG collection. LFG production estimates have been produced using the US EPA's LandGEM model. The LFG would be burned in a reciprocating engine to produce electricity at 35% electrical efficiency. Additional LFG may be available from existing landfills in Belize, but not enough information was known about current landfill practices and configurations to include this in the estimate. If LFG is available from existing landfill sites, the overall potential of LFG could be higher.

B.3.2 Maturity of Technology

Landfill gas-to-energy facilities rely on mature and proven hardware components like gas fired reciprocating engines. While there continues to be development in optimizing engines for low CV gases like LFG, the technology is considered advanced and is suitable for deployment in markets like Belize.

MSW combustion is also fully commercialized technology but may not be suitable for the Belize market. These plants are often quite large (>50 MW) and rely on sophisticated front end material screening and back-end emission control technologies that require a properly trained skilled labor force. As such, this type of facility may not be suitable for Belize in the near term.

B.3.3 Sources Used

EPA LandGEM Model.

B.4 Small and Conventional Hydro

Hydroelectric power historically has been the most reliable source of low cost electricity in Belize and this is likely to continue to be the case going forward. This section outlines the potential for further resource development in Belize.

B.4.1 Availability of the Resource: Quantity and Quality

In 2006, Poyry produced a report highlighting the potential for further development in the hydro sector Belize with a principal focus on small hydro plants in the range of 1 to 20 MWe of gross generating capacity. The study concluded that there are at least 60 to 70 MW of untapped hydro power potential in Belize available at locations where flow data have been quantified. There are a number of remaining sites that hold potential but either haven't been properly monitored yet, or are likely to face environmental opposition.

Table B.5 presents a summary of the Poyry study's evaluation of hydro generation potential in Belize.

In line with the Poyry Group's study, BEL's 2009 expansion plan (prepared by Siemens) identifies the following three hydro sites for exploitation:

- Chalillo 2 (18MW gross power, 16.6MW net power)
- Vaca 2 (10MW gross power, 9.2MW net power)
- Chalillo 3 Pumped Storage (27MW gross power, 26.5 net power).

Following these assessments, our expansion projections for hydro power in Belize include 65MW of new hydro generation assets. These include hydroelectric plants of similar capacity to the plants already operating in Belize, as well as small plants (1-2MW per plant), and a pump hydro facility.

Table B.5: Hydroelectric Power Development Potential In Belize

Project	Gross Power (MW)	Net Power (MW)	Net Generation (GWh)	Notes
Chalillo II	18.00	16.60	92.00	Poyry, OCT 2006
Vaca Falls	18.00	15.80	69.20	Poyry, OCT 2006
Chalillo III	27.00	26.51	38.70	Pumped storage, and only considered an alternative to Chalillo II.
Macal Riverdownstream of Vaca Falls	8.40	7.56	33.11	
Rio On	2.00	1.80	7.88	
Privassion Rio	1.00	0.90	3.94	
Mopan River Cascade	15.00	13.50	59.13	
Monkey River Bladen Branch				no flow data available
Chiquibul Development				no flow data available
Swasey Branch of Monkey River				no flow data available
South Stann Creek				no flow data available, could be economical
Trio Branch				no flow data available, not studied and environmental issues expected
Sittee River				no flow data available, not studied and environmental issues expected
Balckwater Branch				no flow data available, not studied and environmental issues expected
Sibun Gorge				no flow data available, not studied and environmental issues expected
Hidden Valley Falls				no flow data available, not studied and environmental issues expected
Barton Creek				no flow data available, not studied and environmental issues expected
Total Unrealized Potential - Option 1	62.40	56.16	265.27	Chalillo II is built
Total Unrealized Potential - Option 2	71.40	66.07	211.98	Chalillo III is built instead

Source: Electrowatt-Ekono Jaakko Poyry Group, 2006

B.4.2 Maturity of Technology

Hydropower is a mature technology and has already proven its viability in Belize at scales from 3MW to 27MW. Small hydro (between 1MW to 2MW) is in use around the world and is considered

mature. Over 100GW of pumped hydro capacity are in use around the world and pumped hydro storage is considered mature.

B.4.3 Sources

Electrowatt-Ekono Jaakko Poyry Group. (2006). Belize Hydroelectric Development. Technical Report; Ledezma, J. C., de Lima, O., Villarroel, J., & Suarez, J. (2009). Least Cost Generation Planning Study. Siemens.

B.5 Potential for Intermittent Renewables

Wind and solar power are intermittent renewables that produce electricity only when the resource is available. The estimates of the potential for generating electricity using these resources are derived using long-term average weather data and therefore although their near term production is uncertain, their annual total output and typical daily production curves are relatively certain.

Belize Electricity Limited (BEL) has estimated that the electricity grid in Belize can accommodate a maximum of 10% of the peak load as intermittent generation sources. While this figure is widely cited by utilities in the emerging markets, and even in the USA, it is inherently a conservative value. Germany for instance has over 34 GW of installed solar capacity and on June 6th, 2013 recorded peak output from all of its solar PV facilities totaling 39% of the grid peak demand (SMA Solar Technology AG). Clearly, BEL and GoB must plan for, and implement, upgrades to the national grid over time to realize multiple co-benefits including improved reliability, reduced technical losses, and ability to absorb growing amounts of variable output from RE sources. For purposes of this analysis, WSP has estimated the installed capacity of wind and solar that could be deployed to achieve 10%, 15%, and 20% penetration of variable output RE on the grid.

This analysis first uses actual hourly system peak demand on the grid from BEL's 2012 dispatch dataset. Next, we aggregated modeled hourly production curves for wind and solar plants (as discussed above) to determine the number of total MW of each technology that could be installed without exceeding the system wide maximum penetration rates (10%, 15%, and 20%). The analysis compares the output of intermittent renewables with the peak power required by the grid for each hour of the year and increases the installed capacity until the threshold is exceeded during any hour. The annual peak system demands in this model are assumed to be 87 MW and 195 MW for 2013 and 2033 respectively.

Although this analysis does not account for energy efficiency improvements, it is inherently conservative because the same solar and wind hourly output assumptions are stacked on top of one another (representing additional generating plants), but in reality two wind turbines, and indeed two wind farms, in different locations will have different peak output values and times of occurrence which act to flatten out the peaks and valleys in these annual production curves. In this respect, the analysis underestimates the amount of each technology that can be deployed.

Table B.6 shows the maximum capacity in MW of each technology that could be deployed before exceeding the various thresholds considered at current and future demands. The analysis concludes that at 10% intermittent penetration, the grid could support 23.8 MW of wind or 28.1 MW of solar by installed capacity in the year 2033.

Table B.6: Results of Maximum Grid Penetration (MW) for Intermittent Renewables

	2013 Potential	2033 Potential
Only Wind Power		
10% Penetration	11.2	23.8
15% Penetration	16.8	35.7
20% Penetration	22.5	47.6
Only Solar Power		
10% Penetration	13.3	28.1
15% Penetration	19.9	42.2
20% Penetration	26.6	56.3

Source: WSP Analysis

Using the installed capacity values above and the expected capacity factors for each technology, the annual total renewable energy generation potential was investigated for a number of scenarios considering different mixes of capacity by technology. The optimum scenario was found at 80% installed wind and 20% installed solar, by capacity, as this scenario maximizes total electricity production while also keeping peak intermittent output below 20% of system demand at any time.

Table B.7: Annual RE Generation from Intermittent Sources Scenario Comparison

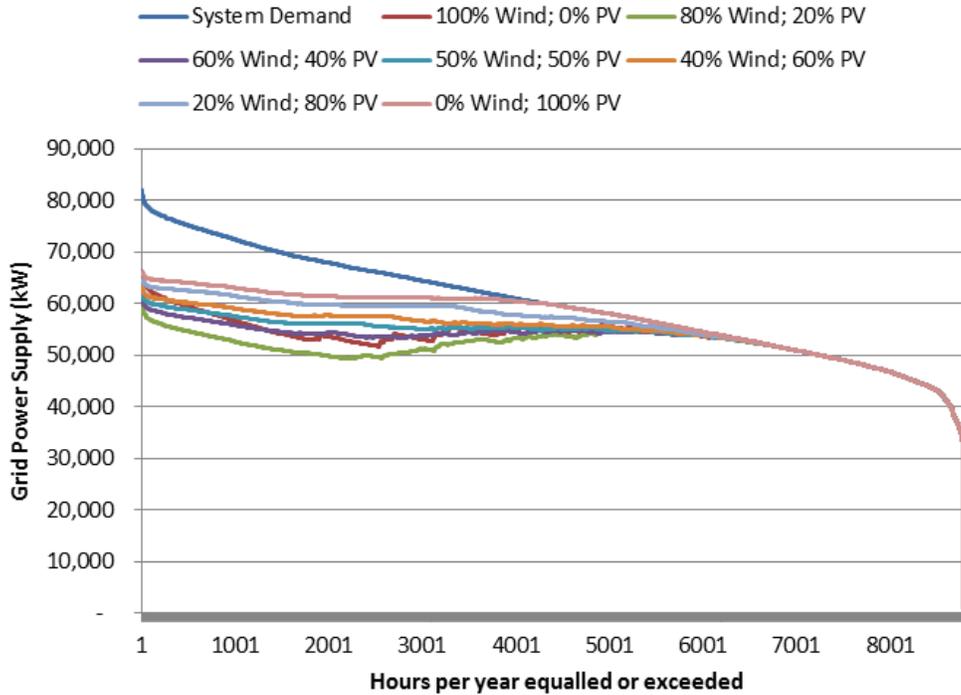
Scenario	Installed PV Capacity (MW)	Installed Wind Capacity (MW)	Total RE Generation (GWh/yr)
100% Wind; 0% Solar	0.0	16.7	58.3
80% Wind; 20% Solar	4.8	19.2	73.7
60% Wind; 40% Solar	9.2	13.9	61.2
50% Wind; 50% Solar	11.1	11.1	54.3
40% Wind; 60% Solar	12.9	8.6	47.8
20% Wind; 80% Solar	16.1	4.0	36.2
0% Wind; 100% Solar	18.8	0.0	26.0

Source: WSP Analysis

Another important feature of intermittent renewables is their ability to flatten out the overall grid system demand profile. Figure B.1 shows net system duration curves for the grid without renewables, and with the inclusion of renewable energy produced by these scenarios. The top blue line shows the system duration curve absent renewables with a peak load of 82 MW and a base load of roughly 40 MW. The hourly generation from the RE scenarios (Table B.7) have been subtracted from the baseline duration curve and the resulting curves show the net demand from conventional

(hydro, fossil, bagasse) sources after the inclusion of renewables. The figure shows that the scenarios with high installed capacities (100%, 80% and 60%) have the greatest ability to flatten out the annual duration curve. The implication of this is that BEL can effectively displace some peaking capacity with intermittent renewables.

Figure B.1: Net Duration Curve for Various RE Mixes (2012)



Source: WSP Analysis

B.5.1 Sources

Homer Energy Software; BEL Annual Report 2012.

B.6 Wind

Though the wind resource in Belize is poor throughout most inland locations, several inland locations offer moderate to good resource. Off-shore locations of the northeast coastline offer fairly widespread moderate to good wind resource. Wind power generation potential has been assessed in this section for three scenarios as shown below and the results indicate that wind power can be an important part of a renewable energy growth strategy for Belize. The “gross power potential” refers to the total MW of installed capacity that could be achieved if all good wind resource areas were exploited without any consideration for demand, economics, and turbine layout. This represents the maximum technical potential *if* all available resource were utilized. The “long term potential” on the other hand incorporates more realistic assumptions about the size of wind farms, limitations on available space, and the demand for energy as context for generation potential in 2033. This is intended to represent a realistic resource potential. These scenarios are summarized in Table B.8.

Table B.8: Technically Feasible Wind Energy Potential in Belize

Wind Resource Type	Average Capacity Factor	Gross Potential (MW)	Long Term Potential (MW)	Long Term Generation Potential (MWh/yr)
1-10 kW DG	21.8%	Not assessed	1	1,910
Off-Shore Utility	32%	Combined total of 3,715MW	300	909,288
On-Shore Utility	27%		150	353,466

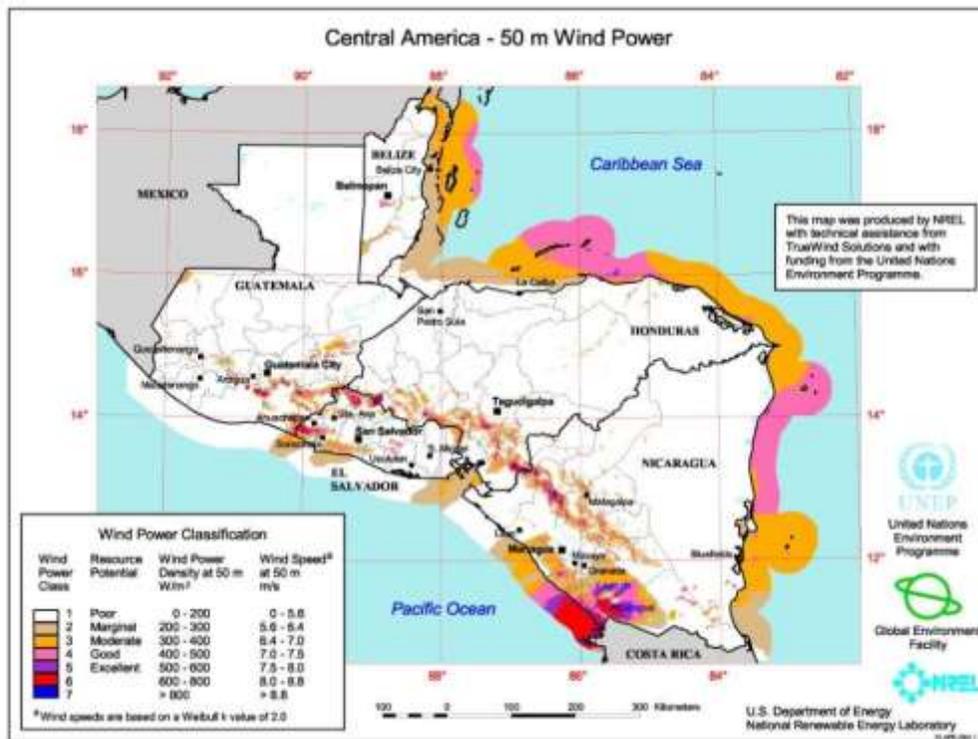
Source: WSP Analysis

B.6.1 Availability of the Resource: Quantity and Quality

Detailed wind resource data files of the type needed for wind power assessments are not publicly available for the country of Belize. Wind power development companies very likely have collected wind speed and direction data for certain locations but have not released these data sets into the public domain.

Figure B.2 shows a wind resource map for Central America produced by the National Renewable Energy Laboratory as part of the Central American Wind Resource Mapping Activity.

Figure B.2: Central America Wind Resource Map



Source: National Renewable Energy Laboratory, Central American Wind Resource Mapping Activity

This map presents annual average wind speeds color coded by wind power class for the region. In Belize, there is very poor overall wind power potential as most of the inland areas have been assessed as having wind speeds averaging below 5.6 m/s. However, there is at least one region south of Belmopan in the mountains of Bald Hills where a good wind resource exists. This region is characterized by high elevations (500 to 900 meters above sea-level) and wind speeds averaging 7.0 to 7.5 m/s at a 50 meter height. Perhaps the best wind resource in Belize outside of this very localized Bald Hills area is available off-shore. Moderate to good wind speeds are available off the coast east and north of Belize City and beyond the cayes. Moderate wind speeds begin at an approximate distance of 12 miles off shore, and good wind speeds are not available until approximately 50 miles off-shore. Further north of Belize City, the moderate wind speed class is available closer to shore near Chetumal, Mexico.

Gross Resource Potential

The NREL study also identified gross wind resource potentials for the countries studied. NREL’s estimate assumes that turbines will be placed at a density of 5 MW per km² and that all of the Class 3+ areas would be exploited. If all of these areas were to be utilized for wind power production a gross potential of 3.7 GW could be realized. The gross resource potential is not intended to represent a realistic economically achievable potential, but rather to set a context for the maximum technically feasible potential.

Table B.9: Gross Installed Power Assessment for Wind in Belize

Wind Power Class	Wind Speed (m/s)	Gross Area (km ²)	Gross Installed Power (MWe)
3	6.4 – 7.0	497	2,485
4	7.0 – 7.5	234	1,170
5	7.5 – 8.0	6	60
Total		737	3,715

Source: National Renewable Energy Laboratory, Central American Wind Resource Mapping Activity

Long Term Realistic Potential

The long term realistic potential for wind power in Belize has been developed for three scenarios which may be technically and financially attractive. These represent more typical installation sizes and therefore set a context for a realistic long term (2033) implementation potential, though detailed financial analysis has not been conducted specifically on these scenarios to determine their feasibility.

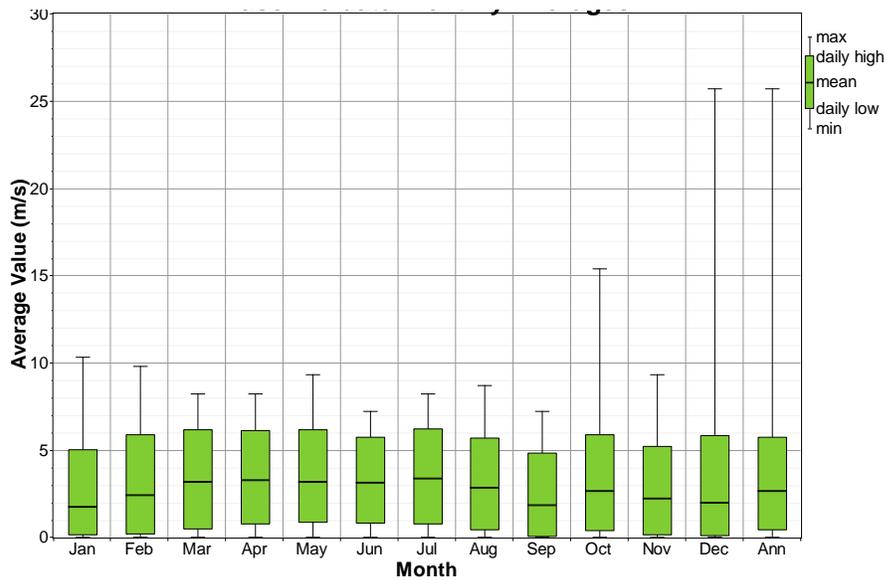
- Utility scale off-shore wind farms located north east of Belize City to exploit Class 4 wind speeds. Power produced from this location could be transmitted via underwater power cables to the islands of Caye Caulker and Ambergris Caye displacing on-site diesel generation and power fed from the mainland. A 30 km by 2 km rectangle (60 km²) east of Ambergris Caye could host a 300 MW wind farm that might achieve an average annual capacity factor of about 32%

- Utility scale on shore wind farm located in the mountains south of Belmopan. This region is ideally situated close to the Belmopan and San Ignacio load centers. While the Baldy Hills may offer Class 4 winds, Class 3 are conservatively assumed with an associated annual average capacity factor of about 27%. An area of approximately 40 km² would be sufficient to construct a 150 MW wind farm
- Small scale wind turbines (1-10 kW) built in a distributed fashion for off-grid and or supplemental power generation of commercial users. These turbines would be geared to take advantage of very low wind speeds and would operate only at small scales.

Small Scale Distributed Generation

Small scale wind turbines are not necessarily limited to the class 3+ regions that large utility scale turbines are since they can be geared to utilize low wind speeds and may have good economics in off-grid or niche applications. For this scenario, hourly power production is modeled using long term average wind speed data from the Belize City airport. These measured data are shown below in Figure B.3 in a box and whisker plot where the median wind speed for each month is shown as a horizontal dash, the box represents mean daily high and low values, the whiskers represent monthly max and min values. The figure shows that March is typically the windiest month and that the annual average wind speed for the airport at 10 meters above ground is 2.68 m/s with a typical daily low to high range of 2.68 to 5.72 m/s.

Figure B.3: Wind Speed Data for Belize City Airport

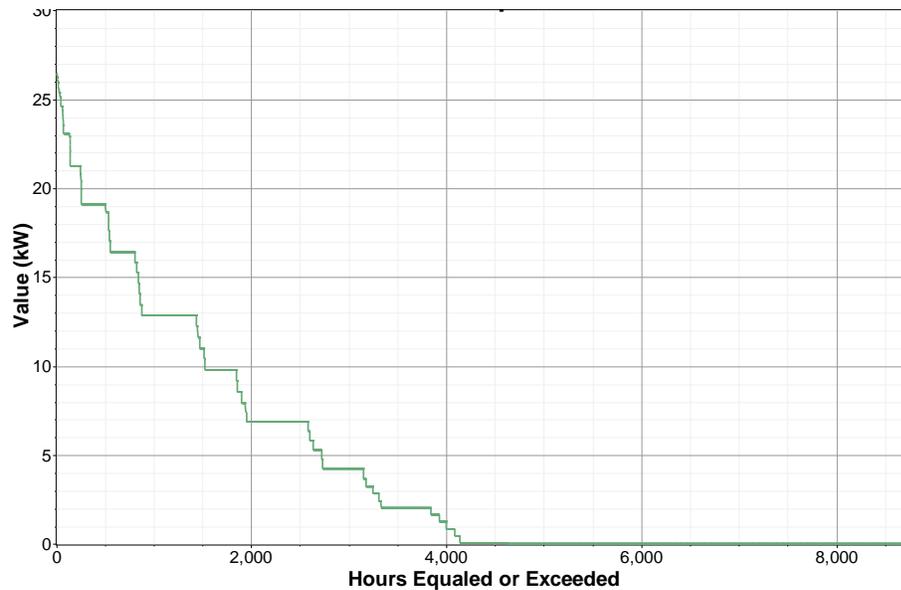


Source: HOMER Energy Software; Belize City Airport Weather Data File

Annual electricity generation from a small scale distributed system is estimated using the HOMER Energy Software tool and Belize City Airport wind speed data. An Energie PGE 25 kW turbine was selected for analysis because its power curve was better suited for low wind speeds and this is assumed to be representative of the small scale turbine class. HOMER predicts an annual generation of 37,700 kWh per year, or a capacity factor of 17.2%. A duration curve for the unit is shown below in Figure B.4 which shows the unit's power output by number of hours per year, for example, the unit produces more than 7 kW for at least 2000 hours per year, and more than 13 kW

for at least 1000 hours per year. This class of turbine is expected to have a capital cost of \$US 6,000 per kW installed, and an O&M expense of \$US44/kW-yr.

Figure B.4: 25 kW Wind Turbine Duration Curve



Source: HOMER Energy Software; Belize City Airport Weather Data File

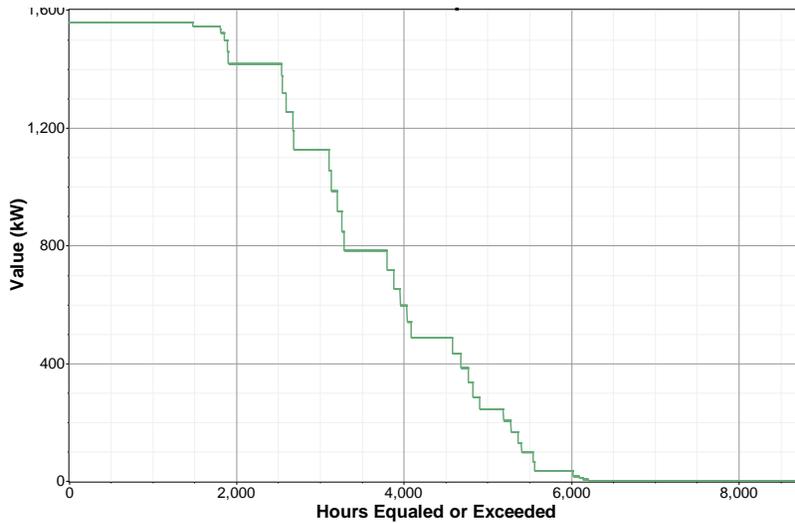
On-Shore Utility Scale Wind Power Generation

Since detailed hourly average wind speed data are not available for locations other than Belize City, including the good wind resource of the Baldy Hills, it is more difficult to predict annual electricity production for this scenario. To make an estimate of annual generation, the Belize City wind speeds were scaled-up using the ratio of the known wind speed in this region (from Figure B.2) to the mean wind speed at the airport. In this way, the same wind speed profile is assumed but the order of magnitude of the wind speeds are increased by a ratio of these two values.

A 1.65 MW Vestas V82 machine with a hub height of 59 meters was selected for analysis of this scenario, and a mean wind speed of 7.25 m/s (at 50 meters) for the moderate wind power class was used. HOMER was used to simulate hourly power generation for the unit. The total annual hourly power generation for the 1.65 MW turbine is estimated at 5.77million kWh per year and is equivalent to a capacity factor of 39.9%. Refer to Figure B.5 for a duration curve of this unit. The on-shore utility scale unit has a much greater tower height and is able to take advantage of higher wind speeds closer to the design conditions. This is show by a more flat output for 2000 + hours, and much higher capacity factor at half the rated output.

A minimum capital cost for this scale of project is around 2,225 US\$ per installed kW, and an O&M cost of US\$ 40/kW-yr is expected. However, this site does not appear to have road access and the associated transport of turbine blades, installation of machines and interconnection may be impractical or impossible. As such this capital cost may be optimistic.

Figure B.5: Output Duration Curve for a Typical On-Shore Wind Turbine in Belize

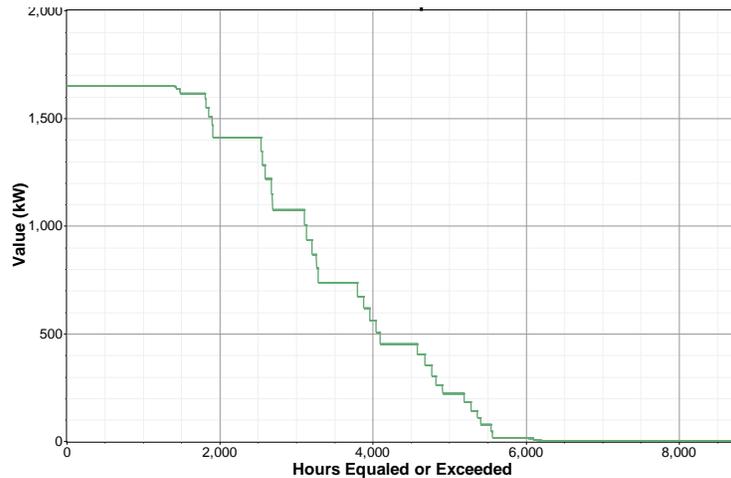


Source: WSP Analysis using HOMER Energy Software

Off-Shore Utility Scale Wind Power Generation

Since detailed hourly average wind speed data are not available for locations other than Belize City, including the off-shore regions north east of the cays, it is difficult to predict annual electricity production for this scenario. To make an estimate of annual generation, the Belize City wind speeds were scaled-up using the mean wind speed ratios. In this scenario, a 1.65 MW Vestas V82 machine with an 80 meter hub height was selected for analysis. HOMER was used to simulate hourly power generation for the unit. The total annual hourly power generation for the 1.65 MW machine is estimated at 5.8 million kWh per year and is equivalent to a capacity factor of 40.2%. Refer to Figure B.6 for a duration curve of this unit. The same general behavior is exhibited in this curve as for the utility on-shore unit. The higher capacity factor is again reflected by a flatter output above 2000 hours and showing at least some availability up to 6000 hours annually.

Figure B.6: Duration Curve for Off-Shore Wind Turbine



Source: WSP Analysis using HOMER Energy Software

A minimum capital cost for this scale of project is around 6,230 US\$ per installed kW, and an O&M cost of US\$ 40/kW-yr is expected.

Wind with Pumped Hydro Storage

Belize's wind energy potential exceeds the ability of the grid to absorb intermittent generation (see B.5 and B.6.1). In order to take greater advantage of this low-cost resource, Belize has the potential to develop a pumped hydro storage facility.

The Chalillo 3 hydro site was identified in the 2009 BEL expansion plan (and also by Poyry) as a potential pumped hydro storage site. A pumped hydro facility at Chalillo 3 could be coupled with an intermittent generation source (such as wind or solar) to allow greater penetration of low-cost intermittent technology. Chalillo 3 could have a nominal capacity of 27MW and an net capacity of 26.5MW.

According to an energy storage model Castalia developed for IDB during a separate assignment, 7MW of pumped hydro storage could backup 100MW of wind capacity with a generation profile similar to Belize's. The model also considered Belize's load profile and the generation characteristics of Belize's current generation assets. Because the 100MW of wind backed up by hydro storage would not count towards the overall penetration of renewables on the grid, additional intermittent generation beyond the 100MW of wind could still be developed.

Using wind coupled with pumped hydro storage allows the grid to accommodate a higher penetration of wind energy. The levelized cost of wind power with pumped hydro storage is based on two components: (i) the levelized cost of the wind power, and (ii) the cost of storage spread over the total system benefit of storage. We assume a levelized cost of generation for wind of US\$0.13 per kWh.

To derive the cost of wind with storage we:

- Use an optimization model to size the pumped hydro storage facility at 7MW with four hours of storage; this is optimized to the estimated size of the wind resource and with a projected demand and generation profile for Belize in
- Estimate the capital cost of storage for the 7MW pumped hydro system—we estimate a figure of approximately US\$4,000 per kW at the Chalillo 3 site,⁸ for a total cost of US\$28 million
- Amortize the capital cost at a 10 percent discount rate over the 40 year life of the project to calculate the cost per day; to this we add a daily operations and maintenance cost for a total of approximately US\$10,000
- Calculate the MWh of additional wind generation allowed on the system due to the presence of the pumped hydro facility hour. This is equal to the difference between 20 percent of peak load during a given hour and actual wind generation in that hour. We sum the differences between the two figures for 24 hours and get 235MWh (this does not mean that all of this generation goes into the storage facility; it only means that because of the storage, intermittent generation is allowed to be above 20 percent of peak demand)

⁸ The 2009 BEL Expansion Plan estimates US\$1,450 per kW to construct the Chalillo 3 project at a size of 26MW. We have increased this to be closer to the cost estimates we have for other hydropower facilities.

- Divide the daily cost of the pumped hydro facility (US\$10,000) by the 235MWh of daily wind generation allowed due to storage. This calculates the cost of having the additional low-cost wind generation on the system.
- Calculate the final levelized cost as the cost of wind energy generation, plus the cost of having the storage to accommodate such a high amount of wind generation.

B.6.2 Maturity of Technology

All of the wind energy systems and technologies discussed above are widely available and have been proven at commercial scales. Small and large wind energy systems would be suitable for use in Belize but training and development of technicians and operators would be required to develop a domestic market.

B.6.3 Sources

Central America Wind Energy Resource Mapping Activity. NREL; Homer Energy Software ; Department of Energy Cost Estimates; EnergyPlus EPW weather file for BZMZ

B.7 Solar Power

This section assesses the technical potential of generating electricity using solar energy. The assessment considers large scale conventional PV power generation and concentrated solar power generation. Solar thermal energy is considered for the hotel sector, as a source of domestic hot water for guest showers.

We assessed solar photovoltaics at several different scales in Belize including commercial, residential and utility. Solar PV systems are not yet at grid parity in Belize, but cost reductions in PV modules have historically been so rapid that these systems are expected to be cost competitive within a few years' time. As an example, GTM Research predicts that PV module pricing will drop to \$US 0.5 per Watt by 2017 from a current average of \$US 1.10 per Watt. Applying these cost reductions to the full installed cost of utility scale systems in Belize would mean that the LCOE could drop to BZ\$0.26 per kWh by 2017.

B.7.1 Availability of the Resource: Quantity and Quality

Incident solar radiation data is well characterized by NREL for the country of Belize. Hourly resource data is available from an EnergyPlus EPW weather file for Belize City Airport. For detailed hourly simulations, this site is assumed to be representative of the country.

Gross Solar Energy Potential

Gross technically feasible potential to generate electricity from solar energy has been evaluated using the incident global horizontal radiation (PV potential) and direct normal radiation (CSP potential). Figure B.7 below presents the relative availability of solar energy suitable for PV electricity generation showing annual total radiation in kWh/m² per day. Likewise, CSP resource potential is displayed in Figure B.8 which shows direct normal radiation in kWh/m² per day.

Figure B.7: Global Horizontal Radiation Potential (kWh/m²-day)



Source: National Renewable Energy Laboratory

To estimate the total technical potential for each technology, the resource potential is broken out by class and multiplied by the approximate land area of each resource region. The total “theoretical potential” represents the situation where every square meter of area is covered by PV panels. The “practical technical” potential considers deploying PV on 2% of arable land, which is estimated as 0.06% of total land area or 1,300 hectares. The capacity factor assumptions used in the analysis will be discussed in subsequent sections. This analysis projects a total practical potential of 1.7 GW of PV as presented in Table B.10.

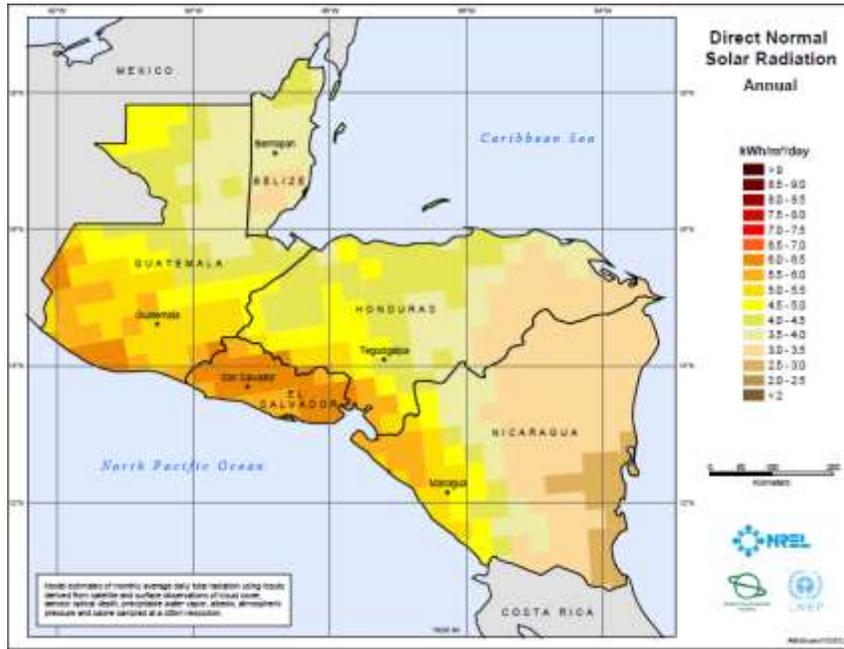
Table B.10: Gross Potential for Solar PV Electricity Generation

		Theoretical Technical Potential		Practical Technical Potential	
Global Horizontal Radiation (kWh/m ² /day)	Fraction of Area	Generation (TWh/yr)	Installed Capacity (MWp)	Practical Technical Potential (GWh)	Practical Installed Capacity (MWp)
5.0 to 5.5	15%	643	442,033	366	252
4.5 to 5.0	85%	3,463	2,505,404	1,974	1,428
Total		4,106	2,947,436	2,340	1,680

Source: National Renewable Energy Laboratory

The potential for CSP is estimated in the same manner using the resource availability data shown in Figure B.8. Annual average direct normal radiation in Belize is estimated at 3.75 kWh/m²-day and the best resource is available in the north of the country.

Figure B.8: Direct Normal Solar Radiation Potential (kWh/m²-day)



Source: National Renewable Energy Laboratory

The total theoretical and practical potential for CSP power generation is estimated using similar assumption described above for PV power generation. However, CSP is assumed to be used only on 0.5% of arable land or a total of 330 hectares. Using this approach yields a total practical implementation potential of 428 MW of capacity generating a total of 571,000 MWh annually.

Table B.11: Gross Potential for CSP in Belize

		Theoretical Technical Potential		Practical Technical Potential	
Direct Normal Radiation (kWh/m ² /day)	Fraction of Area	Generation (TWh/yr)	Installed Capacity (MW _p)	Practical Technical Potential (GWh)	Practical Installed Capacity (MW _p)
4.0 to 4.5	15%	681	450	97	64
3.5 to 4.0	70%	2,803	2,101	399	299
3.0 to 3.5	15%	520	450	74	64
Total		4,004	3,001	571	428

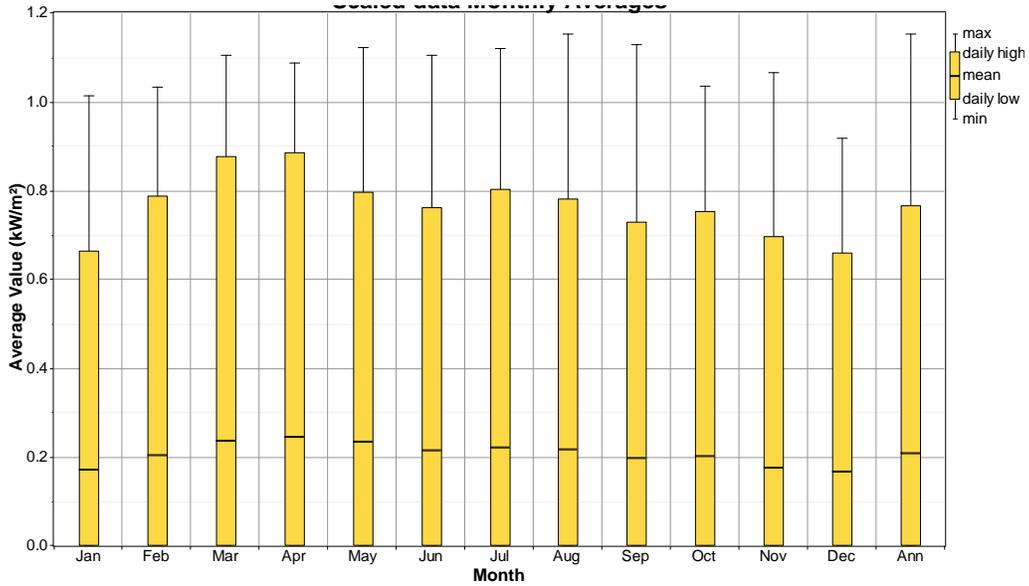
Source: WSP Analysis

Solar PV Implementation Potential

To estimate the practical implementation of solar PV in Belize, a HOMER energy model was constructed to estimate the electricity production of a typical Residential, Commercial and utility scale installation. Each of these scenarios is assumed to use the same type of panel with a fixed axis

(no-tracking) tilted at the latitude and facing south. Long term average hourly global horizontal solar radiation data was imported into home for Belize City, and this is summarized in Figure B.9 using a box and whisker plot. Moisture in the atmosphere, along with other factors, limits the incident radiation during the summer months despite higher extraterrestrial solar radiation during this period. Annual average incident radiation for the site is 0.21 kW/m², equivalent to 4.98 kWh/m²-day.

Figure B.9: Summary of Hourly Global Horizontal Radiation for Belize City



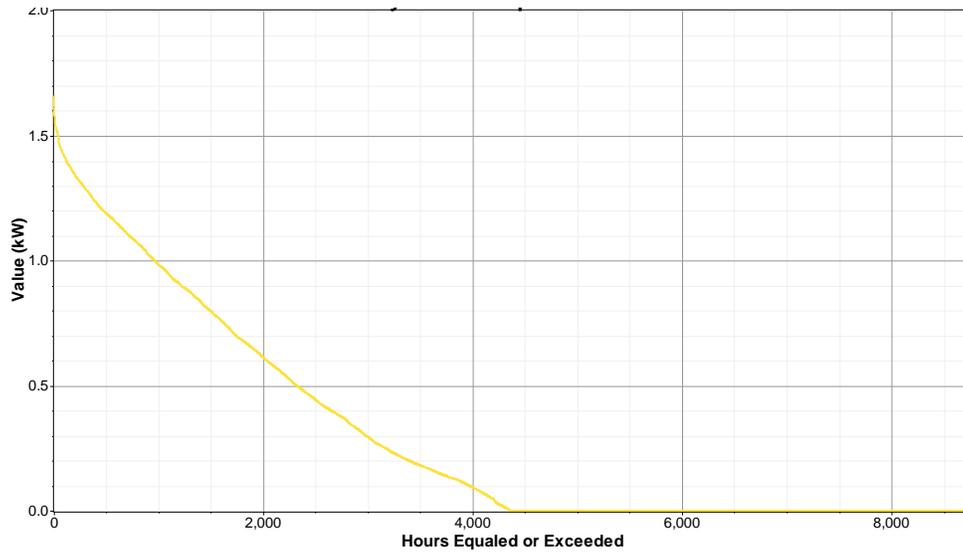
Source: HOMER Energy Software with Belize City Airport Weather File

Assumptions used to model PV output include the following:

- Panel efficiency of 14.9% at standard test conditions
- Temperature coefficient of power -0.46 % per °C of ambient temp.
- 17.33 degree slope

A duration curve for the small scale distributed generation (residential) scenario is presented in Figure B.10 showing PV output versus the number of hours per year exceeded. The curve reveals that the peak output of the system would be around 1.6 kW and that it would produce electricity for 4000 plus hour per year. It shows that the system would produce at least 1.0 kW for 1000 hours per year. The net result translates into a 15.8% capacity factor (1,381 kWh/kWp) and this is used for each PV scenario investigated. This estimate agrees well with an existing project at the University of Belize which has an installed capacity of 480 kWp DC and generates approximately 680 MWh annually which equates to a capacity factor of 16.2%.

Figure B.10: Duration Curve for 1.92 kWp dc PV array



Source: WSP Analysis using HOMER Energy Software

Using the predicted performance of solar PV systems and applying typical installation sizes by different applications of the technology, annual electricity generation rates are presented in Table B.12 for typical installations.

Table B.12: Potential for Residential, Commercial and Utility Scale Installations

Scenario	Rated DC Capacity (kWp)	Capacity Factor	Annual Generation (MWh/yr)
Residential	1.92	15.8%	2.654
Commercial	60	15.8%	82.87
Utility	2,000	15.8%	2,762

Source: WSP Analysis

Solar CSP Implementation Potential

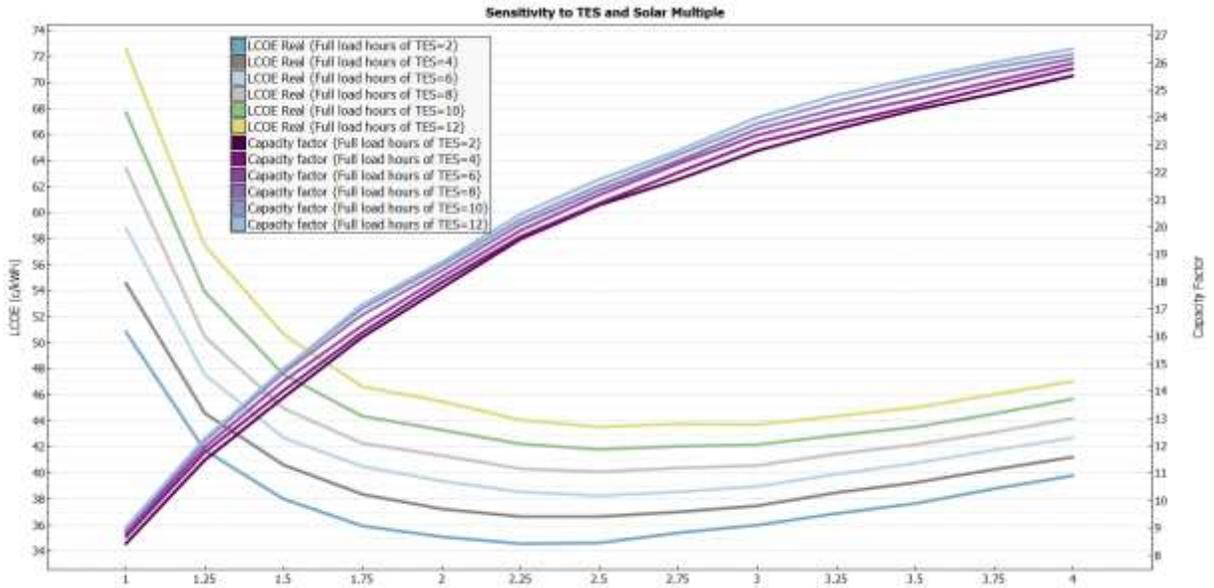
The potential for CSP in Belize is not sufficient for a financially viable project. Relative to the Southwestern US, where CSP plants are being built commercially, Belize receives roughly 60% of the direct beam radiation the US does despite its southern latitude. Also, as Figure B.8 shows, Belize has a CSP poor resource even when compared with its Central American neighbors El Salvador and southern Guatemala where direct beam radiation is about 50% higher. To simulate the annual electricity production potential for this resource an hourly simulation was performed using Belize City direct normal radiation data and using the NREL System Advisor Model (SAM).

Thermal energy storage, usually facilitated using molten salts, is required to make CSP economical but the right amount of storage is typically determined by optimizing the plant’s economics when considering peak power purchase rates along with other factors. The SAM model was used to

model various levels of thermal energy storage and different solar multiples. The solar multiple is a ratio of the collector field's heat output to the heat input of the steam cycle at design conditions. A larger solar multiple therefore implies a higher capacity factor but also a greater amount of energy to storage.

Figure B.11 shows the results of this sensitivity analysis where the levelized cost of electricity (left y-axis) and capacity factor (right y-axis) are plotted as a function of both the full load equivalent number of hours of storage and the solar multiple. It shows that LCOE is minimized with 2 hours of TES at a solar multiple of 2.25. This scenario would produce a capacity factor of 19.5%. Since peak power purchase rates are not available from BEL, this model does not correctly reward the CSP plant for storing thermal energy and delivering power during peak periods. If this were the case, the optimum TES amount would likely be higher than 2 hours. Regardless, the capacity factor for this technology is projected to range from 19.5% to 21.5% using this analysis.

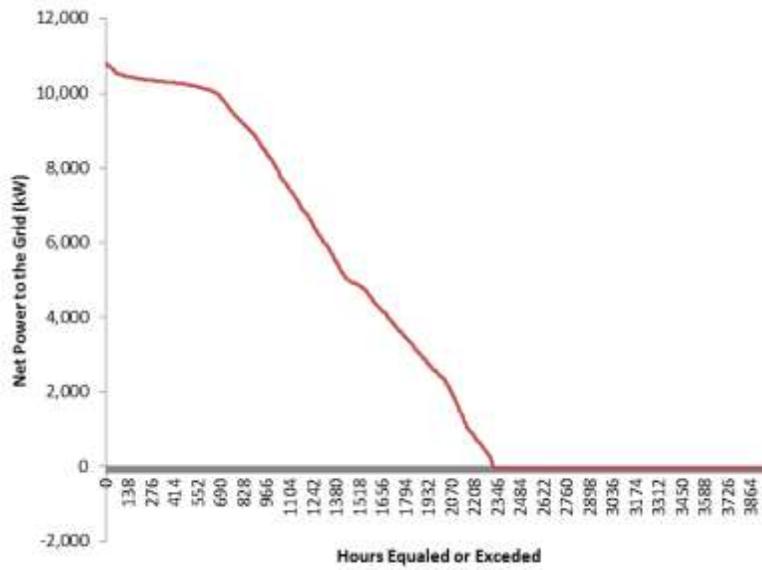
Figure B.11: LCOE for CSP Plants as a function of Solar Multiple and TES hours



Source: WSP Analysis

Figure B.12 shows an annual output duration curve for a generic 25 MW CSP plant with 2 hours of TES, representing a 19.5% capacity factor. The duration curve shows that the plant can basically provide 25 MW of firm power for roughly 1000 hours per year (during peak periods), but that output is less reliable for the balance of the year.

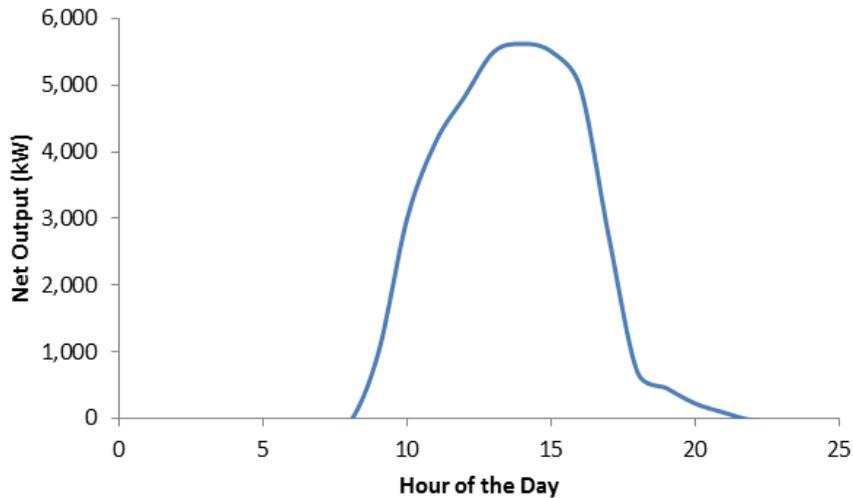
Figure B.12: Duration curve for Parabolic Trough CSP (11 MW)



Source: WSP Analysis

A typical daily power output curve is shown in Figure B.13 for the same 10 MW net CSP Plant. Average peak production of 5.6 MW occurs at 2 PM, but can range from as low as 4.5 MW in November to as high as 7 MW in April.

Figure B.13: Typical Daily Power Curve for 25 MW CSP plant



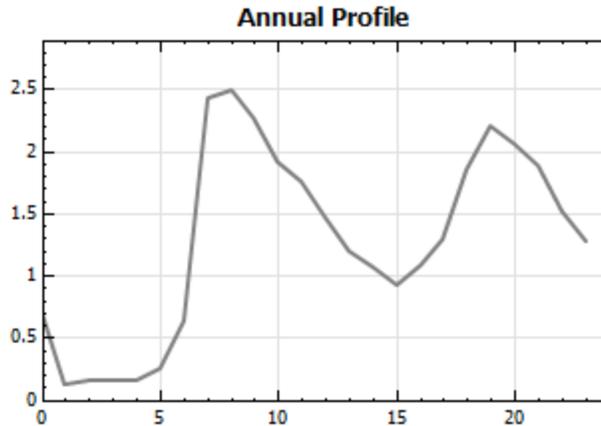
Source: WSP Analysis

Solar Hot Water Production Potential

Solar water heater energy production potential has been assessed for two scenarios, both for a typical residential unit size and a commercial user such as a hotel. In both cases, the system is assumed to utilize evacuated tube collectors supplying hot water at 113 F. A typical daily load curve

(hourly fraction of total daily demand) for a US residential building was developed using a demand of 12.2 gallons per person per day. Total daily hot water demand was estimated for a hotel with 24 rooms serving approximately 12,000 person-days per year. Figure B.14 shows the annual average daily load profile with the hour of the day on the X-axis and the hot water demand in kWth on the Y-axis.

Figure B.14: Typical daily hot water profile used in SHW analysis



Source: WSP Analysis

Using the same techniques described for the CSP analysis, the optimum number of solar collector panels was determined by maximizing the capacity factor and minimizing overall cost per kWh saved. For the prototypical hotel, an optimum system size of 4.8 kW thermal, with an area of 8 square meters was determined. A similar exercise was performed for a typical residential unit. Residential HW demand was estimated at 44 gal/day and it would be served by a 1.4 kWth system.

Annual production details are shown in Table B.13. The hot water demand is shown in gallons per day of hot water on average. The optimum system size is presented in kWth, and the total annual hot water production for the systems is shown in kWh. The optimum commercial system supplies 64% of the hot water needed, with a capacity factor of 16.9%. The optimum residential system displaces 94% of the conventional fuel and has a 10% capacity factor overall.

Table B.13: Solar Hot Water Potential

Scenario	Typical Size (kWth)	Hot water Demand (gal/day)	Annual SHW Supply (kWh)	Solar Fraction of DHW	SHW Capacity Factor
Residential	1.4	44.2	1,225	94%	9.9%
Commercial	4.8	377	7,093	64%	16.9%

Source: WSP Analysis

B.7.2 Maturity of Technology

Solar PV and solar water heaters are mature, commercially available technologies that can be purchased, financed and installed in Belize. There are a number of local firms specializing in small scale PV and SHW system design and installation.

Large utility scale PV systems have not yet been constructed. The University of Belize likely has the largest PV system in the country which is rated at 480 kW_p DC output. The development, design and construction of a true utility scale system would probably be carried out by IPPs and developers not based in Belize.

CSP technologies are quickly becoming commercialized but most of the currently operating facilities were built as commercial demonstration projects having varying degrees of success. Due to this fact and the overall low resource availability in Belize, CSP technologies are not recommended for Belize.

B.7.3 Sources

HOMER Energy Software; National Renewable Energy Laboratory Solar Energy Resource Maps

B.8 Technologies Not Suitable for Belize in 2014

A number of renewable energy technologies are not suitable for Belize at this time. The following technologies have been excluded from the analysis:

- **Biofuel for electricity generation**—Belize does have land resources that could be used to grow biofuel crops; however, using biofuels for power generation would not be economically efficient for two reasons:
 - The biofuels produced in Belize would be valued at the world price of biofuels; our analysis indicates that using global biofuel prices (US Gulf Coast price for biodiesel and Brazilian export price for ethanol) the cost of power generation with biofuels in Belize would increase significantly
 - Given the objective of lowering power prices in Belize, using available land for directly combustible crops is more efficient⁹
- **Geothermal**—Little information on Belize’s geothermal energy potential was available and it is thought to be very low. Resource assessments which have been conducted in Central America have excluded Belize from their scopes, also indicating low potential.
- **Ocean Thermal Energy Conversion**—The waters off-shore in Belize are relatively shallow and consequently don’t generate the large temperature gradients needed between the surface and ocean floor needed for this technology to operate; in addition this technology is still at a demonstration phase, and is not in use commercially
- **Ocean Wave Energy Conversion**—Wind speeds, and consequently wave heights off-shore of Belize are too low to serve as a suitable resource for this technology; the technology is also immature and still in a demonstration phase
- **Tidal Energy** – no restricted inlets exist on the Belizean coast where tidal fluxes can be harnessed for energy generation; this technology is also in a demonstration phase.

⁹ Campbell, et al. “Greater Transportation Energy and GHG Offsets from Bioelectricity Than Ethanol.” *Science*. Accessed online at: <http://www.sciencemag.org/content/324/5930/1055.abstract>

Appendix C: Audit Process and Reports

Site energy use surveys were conducted for representative buildings in Belize covering each primary sector of the economy except power generation facilities. The site surveys consisted of a walk through level energy audit with the goal of collecting utility information (fuel and electricity invoices), characterizing the overall annual energy use of the site, and developing end use energy breakouts as discussed in the main body of this report. Auditors noted the types of installed energy using equipment and inquired with building managers about the energy use patterns and schedules of operation. These data were then used to develop estimates of annual energy use by category (lighting, plug and process loads, air-conditioning and refrigeration).

C.1 Site Audit Procedures

WSP developed audit protocol documents that were used by Young's Engineering for residential, commercial and government buildings. These protocol documents are presented below. WSP conducted all of the industrial site audits and due to the unique nature of each industrial facility a prescriptive audit protocol was not prepared.

C.1.1 Commercial & Government Buildings Audit Protocol

We have reproduced below the audit protocol for commercial and government buildings.

Audit Procedure and General Recommendations:

1. Auditors should collect/request energy consumption billing data including monthly electricity purchase invoices, monthly fuel purchase invoices / delivery records
2. Auditors should sit down with building managers to discuss the operation of the building. Determine the building occupancy schedule and hours operation by season or time of year if applicable, determine number of building occupants.
3. Determine if HVAC systems have automated controls and determine their occupied and unoccupied cooling set-points etc. (degrees Fahrenheit, % relative humidity etc.)
4. Inquire about the types of HVAC systems in the building (refer to the HVAC system types provided in the guideline), produce a list of equipment and identify to which areas of the building each unit provides space cooling/outside ventilation air.
5. Inquire with building managers/owners whether as-built construction drawings exist. Make copies (digital preferably) of the mechanical and electrical equipment schedules if available.
6. Conduct a building walk through:
 - a. Take general photographs of the building and site, capturing lighting systems, major HVAC equipment, small AC units, windows, typical office/room spaces, ceiling fans etc.
 - b. Make note of the types of lighting used on the exterior and interior of the building, identify all bulb types and wattages/ballast types and wattages for area lighting and for task lighting. Obtain a rough building total lighting bulb and ballast count. If electrical equipment schedules exist, obtain lighting information from this source. Note whether occupancy sensors, daylight sensors or exclusive use of day lighting would be appropriate for each space in the building.

Confidential

- c. Inspect HVAC equipment, making note of the unit cooling capacity, COP/EER, supply air CFM, outside ventilation air CFM, fan HP etc. for all units identified.
- d. Make note of condition/age and types of motors (anything larger than ½ hp). Note whether VFDs exist on large motors, note the motor minimum efficiency, and RPM
- e. Interview employees at random to solicit energy saving ideas, inquire about general thermal comfort in the space, determine whether space temps match the programmed set points
- f. Make note of the roofing construction materials and color, make note of the wall construction material and color
- g. Determine if windows have tinting/glazing. Note whether windows are open or closed during the day
- h. If building has domestic or service hot water production, inspect this equipment making note of its electric or fuel input (kW, kBh), storage volume (gallons) and energy factor if labeled. Determine rough age of equipment. Note the temperature at which hot water is supplied to showers/wash basins/kitchens/laundries.
- i. Inspect kitchens and food storage and preparation areas. Determine the typical number of meals produced each day. Make a list of appliances and their type/size. If dishwashers are present, note whether booster heaters are electric or fuel-fired and the heater rating (kW or kBh). Make note of large walk-in refrigerators and freezers and identify their cooling capacity, size and condenser arrangement. Are there opportunities for condenser heat recovery?
- j. Inspect laundry areas. Note types/sizes of washing machines and dryers. If laundry dryers are present, note whether they are electric heat or fuel-fired heat.
- k. Inspect building exhaust and supply air fans, note typical fan type, CFM and motor HP. Note physical distance separating exhaust fan outlets from makeup air intakes.

C.1.2 Residential Buildings Audit Protocol

The residential building audit protocol is reproduced below:

- 1. Interview head of household about general practices regarding ventilation, cooling, occupancy schedules, cooking habits etc.
- 2. Obtain photographs of building exterior and roofing construction materials, windows, lights, natural shading by trees, etc.
- 3. Bring a bucket of known volume (gallons) and take measurements of the shower and faucets to determine gallon per minute flow rates
- 4. Walk through the unit and complete the table below

Auditors were asked to record their observations during the residential audits using the following format (shown in Table C.1)

Table C.1: Format for Recording Audit Observations

Item	Observation [instructions]
Energy Use	[ask resident for a copy of a BEL invoice, and record the customer at the top of this page. Also inquire about butane and other fuel use, record typical monthly electricity and butane purchases here]
Occupants	[List number of occupants, ages, typical daily schedules for occupancy and cooking]
Building Shell	[wall, doors and roofing construction materials, color, photograph building exterior, use of exterior shads etc.]
No. Floors	[list floors above and below grade]
Windows	[provide # of windows and approximate area, photograph typical window]
Lighting systems	[record typical bulb & ballast types, number and wattage, photograph typical lightis]
Domestic Hot Water	[list type, capacity of water heater, list devices, capacity of devices using HW sincluding shower gpm flowrates, take photographs]
Appliances	[provide general descriptions of refrigerators, dishwashers, clothes water/dryer, and stoves/ovens, list size capacity and volume information, list energy source and efficiency ratings if provided]
Cooling Equipment	[list type of air conditioner present, capacity, and COP/EER as labeled]
Fans	[list number and types of ceiling and space fans in unit]
Plug Load	[identify types of equipment plugged in, e.g. small appliances, computers etc.]
Other Notes	

C.2 Site Selection for Audits

Working together with the Ministry of Energy, Science, Technology and Public Utilities, the Young’s Engineering and WSP USA teams selected a total of 28 buildings in which to conduct walk through energy assessments. These buildings comprised a mix of different buildings from the main sectors in the Belizean economy. Table C.2 presents all the facilities audited.

Table C.2: Facility Assessments

Building type	# of Buildings	Business name or Location
Industrial & Manufacturing	6	Citrus Products of Belize, Ltd #1 Citrus Products of Belize, Ltd #2 Travellers Rum Bottling Plant Travellers Rum Distillery Running W Meats Quality Poultry Products, Ltd
Hotels	4	The Villa at Banyan Bay El Rey Hotel Caves Branch Lodge San Ignacio Hotel

Confidential

Building type	# of Buildings	Business name or Location
Offices	2	Young's Law Firm Bowen & Bowen
Restaurant	1	Celebrity Restaurant
Retail	1	Publics Market
Government	4	Ministry of ESTPU Western Regional Hospital Customs & Excise Department Holy Redeemer Lower School
Residential	10	5678 Vasquez Avenue, Belize City 19.75 Miles P. Goldson Hwy Coral Street, San Igancio Town 1031 Coral Street, San Ignacio Town 32 Santa Barbra Street, Belize City 6 Flowers Street, Belmopan City 14 Barrier Reef Drive, San Pedro Town 44 Edge Water, Sandhill Village, Belize 8 Kumquat St. Cohoon Walk, Belmopan City 8 Airport Camp Road, Ladyville, Belize
Total	28	

Source: Youngs Engineering & WSP

Commercial, industrial and government facilities were selected for analysis somewhat at random by MESTPU staff. Building managers and owners were invited by written letter to participate in this energy survey and the willing participants were selected until the target number of facilities in each category was obtained.

Residential unit owners were also invited to participate in the survey; however, in this case only one residence from each 10th percentile group was selected. BEL annual energy use data for residential units was analyzed ranked by total annual electricity consumption (kWh/yr-residence) so that different residential customers could be selected from each group. Table C.3 shows the breakdown of total annual electricity in each percentile grouping.

Table C.3: Residential Sector Annual Electricity Use by Percentile Rank

Percentile Rank	Annual Energy Usage (kWh/yr)
10 th Percentile	114
20 th Percentile	303
30 th Percentile	456
40 th Percentile	596
50 th Percentile	741
60 th Percentile	913
70 th Percentile	1,148
80 th Percentile	1,534
90 th Percentile	2,542

Source: MESTPU, BEL, Young’s Engineering, WSP

C.3 Industrial Facility Assessments

This section presents the facility audit reports as prepared by Young’s Engineering and WSP. Each section includes the general building characteristics, descriptions of energy using equipment, recommended energy efficiency measures, and pictures of the facility.

C.3.1 Citrus Products of Belize (3 facilities)

Date completed – 08/02/2013

Completed By – M. Huisenga, D. Sobrinski, C. Young, R. Allen

Primary Site Activities

Citrus processing and product storage

Plant Overview

The purview of this report is three plants, CCB plant, BFB plant and feed mill. Two citrus processing plants and one plant that processes spent peels into animal feed.

Production schedule is October through June, and they operate 24/7 during November through May. 2 crops harvested annually. At least 3 months of downtime are used for improvement projects

Total processing:

- 4 mm boxes of orange at BFB
- 1 mm boxes of orange at CPBL
- 900,000 boxes of grapefruit at CPBL

Production of wastewater is 100 mm gallons annually from both sites, 9 holding ponds, 1 filter pond
90% of product sold as frozen concentrate

Plant Manager Jerry Williams manages operations at 5 separate processing plants.

Process Description

1. Material receiving – fruits arrive by truck, check for quality and brix, metered and dumped

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2. Unloading – fruits are unloaded into chain driven bucket dumps, visually screened, using at least 13 x 3.5 hp of chain driven equipment
3. Conveying to storage bins
4. By product 135 deg F water from evaporation is used to wash the fruits
5. Second round of screening, automatic by size
6. Oil extraction from the peel, water and oil emulsion. Equipment supplied by Brown Equipment
7. Fruit sizer on 7.5 hp, 88.5% efficient motor on belt drive
8. Pneumatic driven press extraction and cutting machines extract juice
9. Peel is separated
10. Finisher separates the pump
11. Juice tanks store product prior to pasteurization and evaporation
12. Pasteurizer processes 60 gal/minutes supplied with hot water. Process equipment is entirely un-insulated.
13. Stabilizer uses chilled glycol cooled plate and frame HX, all lines are un insulated
14. Evaporation to remove water and concentrate the juice, 2 x 30,000 lb/hr evaporation rate. 7 stage evap with 11 brix inlet and finishing at 66. Candidate for VFD and high efficiency motors on the pumps. Flash cooling follows.
15. 2 homogenizers to break down heavy particles
16. Product cooling to 35 deg F, insulated tanks store product and 1 deg F per day needs to be removed
17. Refrigerated product blending and cooling

There was also a pineapple hammermill and press which is used seasonally, with 2 x 30 hp and 2 x 15 hp motors

Refrigeration systems

- Total of 500 tons of cooling capacity, 400 tons active, 100 tons redundant. Three recip and two screws. Another 600 tons at the other plant.
- Each screw compressor is 200 hp at 1.5 kW per ton = 100 tons of cooling capacity
- Each reciprocating compressor is 200 hp at 1.06 kW per ton = 150 tons of cooling
- Refrigerant lines could use improved insulation on flanges and joints
- Long line runs would ideally be shortened
- All units are single stage
- Approximately half othe load is refrigerated storage at 35 deg F, and the other half are frozen product storage where product is kept at 10 deg F for up to 4-5 months

Compressed Air Systems

1. 80 kW screw air compressor, Ingersoll rand. Unit sounds leaky. 140 psi in the 300 gal tank
2. Pressure at air users:
 - a. Extraction machines: 80 PSI
 - b. Finisher: 125 PSI
 - c. Concentrator line: 125 PSI

Process Heating Equipment

1. Heating loads are primarily for clean-in-place system (steam), pasteurization (hot water) and evaporation (steam)
2. 1 x 16.74 mmBtu/hr cleaver brooks crude oil fired packaged boiler
3. 1 x 20 mmBtu/hr cleaver brooks crude oil fired packaged boiler
4. 2 x. 1000 kW Diesel / oil fired combustion turbine with 7000 lb/hr steam heat recovery. Unit was un-operational during the site visit.
5. Poor insulation on main steam headers, missing insulation on elbows and flanges

Backup Power

6. Caterpillar backup generators

Air conditioning

Limited to offices and control rooms, but at least 90 units on-site, a mix of split systems, window units, and central forced air. All units assume dot run during office hours and production schedule.

Lighting Types

- Primarily metal halide lighting
- Some LED high bay lights being piloted
- T12 lighting in offices and other spaces

Energy Use and Costs

- Crude oil consumption of 1.36 million gallons per year at \$2.55 per gallon = 3.5 million USD per year
- Electricity consumption of 11,231 MWh per year at 0.454\$/kWh = 2.55 million USD per year in electricity costs
- Normalized fuel consumption of 0.365 gallons per box of fruit processed
- Normalized electricity consumption of 1.97 kWh per box of fruit processed

	CCB (kWh)	BFB (kWh)	Feed mill (kWh)	Total Operations (kWh)	Cost (USD)
Oct	309,144	119,610	8,200	436,954	99,188
Nov	476,244	188,326	184,400	848,970	192,716
Dec	526,979	322,850	135,000	984,829	223,556
Jan	444,173	557,531	312,600	1,314,303	298,347
Feb	552,271	619,823	326,800	1,498,894	340,249
Mar	470,209	514,956	242,800	1,227,965	278,748
Apr	508,331	591,080	314,600	1,414,011	320,980
May	418,649	706,219	201,000	1,325,868	300,972
Jun	360,972	343,680	39,200	743,852	168,854
Jul	296,472	149,453	8,400	454,325	103,132
Aug	353,956	135,468	9,600	499,024	113,278
Sep	340,338	134,421	7,600	482,359	109,495
Year Total	5,057,737	4,383,415	1,790,200	11,231,351	2,549,517

Estimated Breakdown of Electricity by End Uses

Lighting	Refrigeration	Air-Conditioning	Plugs/Process
2%	30%	2%	66%

Energy Conservation Measures (ECM)

- Steam and refrigerant line insulation improvement
- Air compressor leaks, pressure setting reduced, line length reduction
- Investigate 2 stage ammonia compressors for freezers and coolers
- Improve cooler room insulation
- VFD and high eff motors on evaporation pumps
- Capacitor banks for power factor correct, reported at ~0.75 for the plant
- Insulation on pasteurization equipment ~ \$15000
- Upgrade metal halide and T12 lighting
- Retrofit chain drives to synchronous belts or cogged v belts on conveying equipment
- Anaerobic digestion of waste water to recover methane
- Soft start on large motors

Site Visit Photos







C.3.2 Travellers Distillery, Belmopan

Date completed – 7/31/2013

Completed By - Huisenga

General Building Characteristic

- Primary Use –production of rum, tank storage
- Age – approximately 30 years old
- 1 building, 6500 sf, concrete blocks and corrugated metal roof
- Energy Types
 - BEL Electricity (Customer number 19754)
 - Crude oil fired boilers
- General Operation Schedule
 - Production
 - Bottling takes place from 8:30 am to 4:00 pm M-F
 - Offices open 7:30 to 5
 - Boiler is used 2 weeks per month, assume 5 hrs per day
 - Cool room and ref/freezer room are cooled 24/7

Building Envelopee

- Construction type –
 - Wall
 - corrugated aluminum and concrete block
 - no insulation
 - Roof
 - Corrugated aluminum
 - No insulation
- Day lighting on roof
 - Yellow corrugated fiberglass
- Windows
 - % of wall Area = 0%
- Shading
 - N/A

Controls

- Type of controls
 - Lighting – Manual
 - AC = Manual, running in cooler rooms and product testing lab 24/7
 - Plug/Process Loads – Manual
- Control Schedules
 - Lighting – on in offices when building occupied
 - Plug/Process Loads – when plant is operating

Utility Rates and Energy Performance

- BEL Customer # = 19754
- 2013 average rate of \$0.250 / kWh
- Annual equivalent consumption – 239,496 kWh
- Electricity use intensity – 9.82 kWh/sf-yr

Row Labels	Sum of Usage (kWh)	Sum of Charges (BZD)	Average of BZD/kWh
January	19,691	8,338	0.440
February	19,403	9,758	0.507
March	19,497	9,811	0.507
April	19,396	9,771	0.508
May	22,390	11,242	0.508
June	21,331		
July	17,998	10,175	0.477
Total	139,706	59,094	0.499

Lighting Types

- High bay lighting
 - 2 x 250W HPS
- Overhead lighting in warehouse spaces
 - 8 x 2 x 40W T12
- Lab
 - 4 x 4 x 40W T12
- Conf room
 - 3 x 2 x 40W T12
- Corner office/label room
 - 3 x 2 x 40W T12
- Main office suite (5 offices)
 - 12 x 2 x 40W T12
- Cashier's office (2 offices)
 - 4 x 120W CFL clusters
- Bottling
 - 8 CFL straight bulbs, assume 46 W each
- Gift shop
 - 18 x 100W CFL
 - LED display lighting, assume 100W total
 - 12 x 1 x 40W T12 strip lights
 - 10 x 24W halogen accents
- Blending lab
 - 1 x 4 x 40W T12
 - 2 x 2 x 40W T12

- Fermenting room
 - 2 x 2 x 40W T12
- Water treatment
 - 3 x 1 x 40W T12 strip
- Warehouse
 - 40W bulb, off
- Aging building
 - 2 x 250 metal halides, off

Air Conditioning

- 4 centralized, ducted AC systems serving:
 - Bottling room, on only during operating hours, set point 78F
 - Label storage office, on 24/7
 - Cool room for wine conditioning, on 24/7
 - Museum and gift shop
- QA lab
 - 24,000 Btu/hr cooling capacity, 2490W input, on 24/7
- Main office, partly served by central systems
 - 2 split systems, assume 9000 Btu/hr, EER =10
- Cashiers office
 - 2 x 18,000 Btu, 10 EER
- Bottling
 - RHEEM AC unit, 7.5 tons, assume 10 EER
- Gift shop
 - RHEEM AC unit, 7.5 tons, assume 10 EER
- Blending
 - Split AC, 5100W cooling, 1890W input
- Fermenting room
 - Split FCU
- Receiving
 - Small split, assume 2500W cooling, EER =10
- Water quality
 - 18,000 Btu split AC, 1800W input
- Warehouse office
 - Small split, assume 12,000 Btu, EER =10

Plug & Process Loads

- 10 Computers
- Gas chromatograph
- 2 TVs
- Small refrigerator

- Microwave
- 1/3 hp air compressor, assume 100 hrs per yr
- 1.5 hp water pump, assume 1000 run hrs per yr
- Air Compressor
 - 45.3 kW input, assume it runs for 800 hrs per yr
- Boiler, 330 KBH, assume 100 hrs per yr

Domestic Hot Water

- None

Energy Conservation Measures (ECM)

- Upgrade split system AC units
- T12 to T8

C.3.3 Travellers Bottling Plant

Date completed – 7/30/2013

Completed By - Huisenga

General Building Characteristic

- Primary Use – Distribution warehouse, bottling of product, storage and QA/QC of product and supplies
- Age – approximately 50 years old
- 3 buildings with areas of 15,000, 2700, and 6700 square feet each
- Energy Types
 - BEL Electricity (Customer number 19754)
 - Butane fired steam boiler, Western Gas Co. LTD
- General Operation Schedule
 - Main floor is open 7:30 am to 5 pm Mon-Fri; closed on weekends
 - Bottling takes place from 8:30 am to 4:00 pm M-F
 - Offices open 7:30 to 5
 - Boiler is used 2 weeks per month, assume 5 hrs per day
 - Cool room and ref/freezer room are cooled 24/7

Building Envelope

- Construction type –
 - Wall
 - corrugated aluminum and concrete block
 - no insulation
 - Roof
 - Corrugated aluminum
 - No insulation
- Day lighting on roof

- Yellow corrugated fiberglass
- Windows
 - % of wall Area = 0%
- Shading
 - N/A

Controls

- Type of controls
 - Lighting – Manual
 - AC = Manual, running in cooler rooms and product testing lab 24/7
 - Plug/Process Loads – Manual
- Control Schedules
 - Lighting – on in offices when building occupied
 - Plug/Process Loads – when plant is operating

Utility Rates and Energy Performance

- BEL Customer # = 19754
- 2013 average rate of \$0.250 / kWh
- Annual equivalent consumption – 239,496 kWh
- Electricity use intensity – 9.82 kWh/sf-yr

Row Labels	Sum of Usage (kWh)	Sum of Charges (BZD)	Average of BZD/kWh
January	19,691	8,338	0.440
February	19,403	9,758	0.507
March	19,497	9,811	0.507
April	19,396	9,771	0.508
May	22,390	11,242	0.508
June	21,331		
July	17,998	10,175	0.477
Total	139,706	59,094	0.499

Lighting Types

- High bay lighting
 - 2 x 250W HPS
- Overhead lighting in warehouse spaces
 - 8 x 2 x 40W T12
- Lab
 - 4 x 4 x 40W T12
- Conf room
 - 3 x 2 x 40W T12
- Corner office/label room

Confidential

- 3 x 2 x 40W T12
- Main office suite (5 offices)
 - 12 x 2 x 40W T12
- Cashier's office (2 offices)
 - 4 x 120W CFL clusters
- Bottling
 - 8 CFL straight bulbs, assume 46 W each
- Gift shop
 - 18 x 100W CFL
 - LED display lighting, assume 100W total
 - 12 x 1 x 40W T12 strip lights
 - 10 x 24W halogen accents
- Blending lab
 - 1 x 4 x 40W T12
 - 2 x 2 x 40W T12
- Fermenting room
 - 2 x 2 x 40W T12
- Water treatment
 - 3 x 1 x 40W T12 strip
- Warehouse
 - 40W bulb, off
- Aging building
 - 2 x 250 metal halides, off

Air Conditioning

- 4 centralized, ducted AC systems serving: (assume 5ton 10 EER system split evenly)
 - Bottling room, on only during operating hours, set point 78F (assume main building hours)
 - Label storage office, on 24/7
 - Cool room for wine conditioning, on 24/7
 - Museum and gift shop (assume main building hours)
- QA lab
 - 24,000 Btu/hr cooling capacity, 2490W input, on 24/7
- Main office, partly served by central systems
 - 2 split systems, assume 9000 Btu/hr, EER =10
- Cashiers office
 - 2 x 18,000 Btu, 10 EER
- Bottling
 - RHEEM AC unit, 7.5 tons, assume 10 EER
- Gift shop
 - RHEEM AC unit, 7.5 tons, assume 10 EER

- Blending
 - Split AC, 5100W cooling, 1890W input
- Fermenting room
 - Split FCU (assume 2ton 10 EER unit)
- Receiving
 - Small split, assume 2500W cooling, EER =10
- Water quality
 - 18,000 Btu split AC, 1800W input
- Warehouse office
 - Small split, assume 12,000 Btu, EER =10

Plug & Process Loads

- 10 Computers
- Gas chromatograph
- 2 TVs
- Small refrigerator
- Microwave
- 1/3 hp air compressor, assume 100 hrs per yr
- 1.5 hp water pump, assume 1000 run hrs per yr
- Air Compressor
 - 45.3 kW input, assume it runs for 800 hrs per yr
- Boiler, 330 KBH, assume 100 hrs per yr

Domestic Hot Water

- None

Energy Conservation Measures (ECM)

- Upgrade split system AC units
- T12 to T8

C.3.4 Running W Meats

Date completed – 8/23/2013

Completed By – L.Young, R.Allen (Young's Engineering)

General Building Characteristics

- Primary Use – Meat Processing Plant
- Age – The Core building is 27 years old. Major addition 13 yrs ago and last addition 9 years ago.
- # of floors - 2
- Total Building Area approx. 16,200 ft²:

Confidential

- Processing plant 13,625 ft² occupies is entire ground floor
- Office building 1135 ft² on top processing plant
- Lunch/Training 1440 ft² on top processing plant
- Processing plant core is approx. 85' x 113' rectangular structure with approx. 700 ft² of annexes
 - Office is 42' x 27' rectangular structure
 - Lunch and Training is 60' x 24'
- Energy Types
 - BEL Electricity (Customer number 00026928)
 - Butane for hot water and smoking meats
- General Operation Schedule
 - Occupied – Mon-Thu – 8am-5pm
 - Friday 8am – 4:30pm
 - Saturday Store only 8am to 1pm
 - Unoccupied all other hours except for security

Building Envelope

- Construction type –
 - Wall
 - concrete
 - Insulation in Freezers and Coolers
 - Roof
 - Concrete deck grey– no reflective coating
 - Insulation in Freezers and Coolers
- Windows
 - No windows in Processing plant.
 - Windows in Office and Lunch/Training rooms approx. 12% of wall Area
 - Single pane, lightly tinted
- Shading
 - Window shading is used. Manually controlled by occupants

Controls

- Type of controls
 - Lighting – Manual
 - AC = Manual
 - Plug/Process Loads - Manual
- Control Schedules
 - Lighting – on only when occupied
 - AC – on only when occupied

Confidential

- Plug/Process Loads - on only when occupied
- Freezers and Coolers on 24x7

Utility Rates and Energy Performance

- Butane consumption of 44 gals per week or BZD 218/week
- BEL Customer # = 00026928
- 2013 average rate of BZ\$0.46/kWh up to Jan 2013; BZ\$55/ kWh thereafter
- Annual equivalent consumption – 499,091 kWh
- 18.43 kWh/sf-yr

Row Labels	Sum of Usage (kWh)	Sum of Charges No GST (BZD)	Average of BZD/kWh
July 2012	49450	20180	0.41
Aug	46622	19048	0.41
Sep	45558	18628	0.41
Oct	43066	17626	0.41
Nov	42420	17368	0.41
Dec	41774	17110	0.41
Jan 2013	38946	15978	0.41
Feb	36845	17942	0.49
Mar	36037	17562	0.49
Apr	39754	19310	0.49
May	44602	21589	0.48
Jun	11393	5808	0.51
July	22624	11258	0.50
Grand Total	499091	11262	0.45

Lighting Types

- Offices
 - T12/6-2x40 W Fluorescents
- Lunch/Training
 - Overhead T-12/6-1x20 W fluorescents
- Processing Plant
 - Overhead T-12/11-2x40 W fluorescents, a few CFL

Air Conditioning

- Conditioned areas in office ~95%
- All air conditioners have an EER of 10
- One 24k btu, one 36k btu, one 60k btu

Plug & Process Loads

- Office/Dining area/kitchen
 - 4 ceiling fans

- 1 Microwave
- Computers and Printers
- 2 small refrigerators
- 1 flat panel TV

- Refrigeration Equipment
 - Six freezers (R-404A Refrigerant) – only 4 in operation
 - 3 phase, 220V
 - Current Draw: 31.5 amps
 - Defrost heater: 35 amps

- Cooler Equipment
 - Seven walk-in coolers
 - Cooler No.1
 - 3 phase, 208 / 230 V
 - Current: 50 amps/17.9 kW
 - R-12 refrigerant
 - Cooler No. 2
 - 3 phase 208 / 230 V
 - Current: 21.4 amps
 - R-22 Refrigerant
 - Other 5 Coolers:
 - 3 Phase, 208/230 V
 - Current: 22.3 amps
 - R-22 Refrigerant

 - Pumps
 - One 1.5 HP pump
 - One 1.0 HP Pump

Domestic Hot Water

- 2 butane boilers, capacity unknown

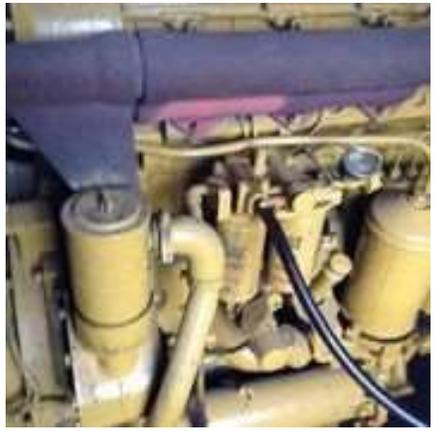
Energy Conservation Measures (ECM)

- Note: Plant replacing 40 Watt fluorescent (T-12) to the 4-ft 16.8 Watt L.E.D. lights (assuming about 5% L.E.D. of the total lighting)
- Replace lights with LED
- T12 to T8
- New refrigerators and freezers
- Higher efficiency split systems

- Shade out door condensing units
- Double pane & low -e window

Site Visit Photos





C.3.5 Quality Poultry Products

Date completed – 08/01/2013

Completed By – M. Huisenga, D. Sobrinski

Site Contacts

Raymond Barkman	General Manager
Daniel Koop	Engineering & Accounting Consultant
Herman Thiessen	Maintenance & Renovation Manager
Salbino Pimental	Boiler & Rendering Plant Operator
Abner Sosa	Refrigeration Technician

Primary Site Activities

Slaughtering, processing, and packaging chickens and turkeys for retail sale, product storage

Plant Overview

Confidential

- The site operations include live bird receiving, processing, refrigerated and frozen product storage
- Production schedule is year around, processing 100,000 live birds per week at 4 lb/bird for a total annual output of 26.5 million lbs of poultry
- Process consists of stunning, scalding, chilling, processing, processing renderings, packaging of product, bagging of animal fee by products
- Electricity is supplied by Farmers Light and Power from crude oil fired reciprocating engines next door
- QPP sub-meters electricity at the rendering plant, the processing plant, and separately on the refrigerant compressors
- Waste water is settled, aerated and discharged
- Operating schedule is 7 am to 5 pm 4 to 5 days per week, sanitation takes place from 6-8 pm
- 350 kW peak load at the plant

Refrigeration systems

- Total of 500 tons of cooling capacity, 400 tons active, 100 tons redundant. Three recip and two screws. Another 600 tons at the other plant.
- Each screw compressor is 200 hp at 1.5 kW per ton = 100 tons of cooling capacity
- Each reciprocating compressor is 200 hp at 1.06 kW per ton = 150 tons of cooling
- Refrigerant lines could use improved insulation on flanges and joints
- Long line runs would ideally be shortened
- All units are single stage
- Approximately half othe load is refrigerated storage at 35 deg F, and the other half are frozen product storage where product is kept at 10 deg F for up to 4-5 months

Compressed Air Systems

3. 15 hp reciprocating compressor at 140 psig, and 80 gallon received. Unit is located opposite side of the plant from the compressed air loads

Process Heating Equipment

7. Heating loads are primarily for scalding, both units are Cleaver Brooks water tube packaged boilers running on crude oil
8. 1 x 100 ton/hr at 70 psig, 200 deg C
9. 1 x 150 ton/hr at 70 psig

Backup Power

None

Air conditioning

Limited to offices

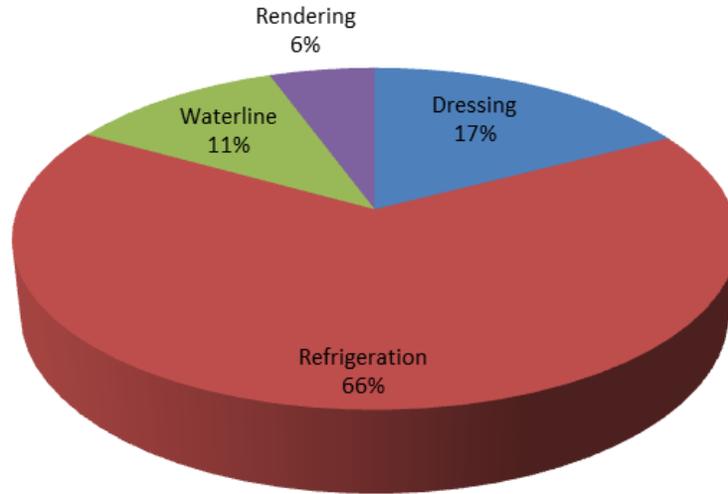
Lighting Types

- T12 lighting in offices and other spaces

Energy Use and Costs

- Crude oil consumption of 1.36 million gallons per year at \$2.55 per gallon = 3.5 million USD per year
- Total Electricity consumption of 4,469 MWh per year at 0.365 \$USD/kWh = 1.63 million USD per year in electricity costs
- Normalized fuel consumption of 662 Btu/lb of product
- Normalized electricity consumption of 0.17 kWh/lb of product

The chart below shows the breakdown of electricity use as it is metered in the plant. Refrigeration is the largest load and consists of ice production machines and freezer room compressors



The electricity consumption is broken out by these end uses as estimated below:

Estimated Breakdown of Electricity by End Uses

Lighting	Refrigeration	Air-Conditioning	Plugs/Process
1%	66%	1%	32%

Boiler Fuel Crude Oil Consumption and Costs

Date	Gallons	Dollars [BZD]
Jan 12	8,311	\$ 37,467.44
Feb 12	8,222	\$ 38,552.44
Mar 12	7,512	\$ 37,324.95
Apr 12	5,468	\$ 26,809.02
May 12	6,297	\$ 33,033.27
Jun 12	7,080	\$ 32,826.77
Jul 12	5,201	\$ 22,809.77

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Aug 12	7,000	\$ 30,699.55
Sep 12	6,234	\$ 30,060.04
Oct 12	7,919	\$ 38,870.73
Nov 12	6,321	\$ 30,372.78
Dec 12	6,700	\$ 32,193.90
Jan 13	8,762	\$ 42,372.86
Feb 13	7,498	\$ 37,805.22
Mar 13	7,074	\$ 36,514.64
Apr 13	5,122	\$ 25,639.55
May 13	8,601	\$ 41,048.27
Jun 13	7,750	\$ 36,986.88
Total	127,072	611,388

Electricity used in Poultry Processing

Date	Dressing Plant		Refrigeration - 480 Volts	
	kwh	Dollars [BZD}	kwh	Dollars [BZD}
Jan 12	41440	\$ 30,251.20	175200	\$ 127,896.00
Feb 12	38480	\$ 28,090.40	161280	\$ 117,734.40
Mar 12	40320	\$ 29,433.60	153480	\$ 112,040.40
Apr 12	43600	\$ 31,828.00	156480	\$ 114,230.40
May 12	49600	\$ 36,208.00	191640	\$ 139,897.20
Jun 12	38880	\$ 28,382.40	154200	\$ 112,566.00
Jul 12	44240	\$ 32,295.20	175080	\$ 127,808.40
Aug 12	46960	\$ 34,280.80	169800	\$ 123,954.00
Sep 12	40080	\$ 29,258.40	151680	\$ 110,726.40
Oct 12	44640	\$ 32,587.20	201600	\$ 147,168.00
Nov 12	36400	\$ 26,572.00	149160	\$ 108,886.80
Dec 12	38000	\$ 27,740.00	152400	\$ 111,252.00
Jan 13	41440	\$ 30,251.20	174480	\$ 127,370.40
Feb 13	36240	\$ 26,455.20	146280	\$ 106,784.40
Mar 13	41120	\$ 30,017.60	145680	\$ 106,346.40
Apr 13	52880	\$ 38,602.40	167280	\$ 122,114.40
May 13	50080	\$ 36,558.40	152160	\$ 111,076.80
Jun 13	51040	\$ 37,259.20	161280	\$ 117,734.40

Electricity used for other areas of the business

Date	Waterline		Rendering Plant	
	kwh	Dollars [BZD}	kwh	Dollars [BZD}
Jan 12	26098	\$ 19,051.54	16794	\$ 12,259.62
Feb 12	23615	\$ 17,238.95	15729	\$ 11,482.17
Mar 12	26252	\$ 19,163.96	14201	\$ 10,366.73
Apr 12	29630	\$ 21,629.90	12517	\$ 9,137.41
May 12	35857	\$ 26,175.61	15197	\$ 11,093.81
Jun 12	23049	\$ 16,825.77	11783	\$ 8,601.59
Jul 12	29180	\$ 21,301.40	14622	\$ 10,674.06

Confidential

Aug 12	23379	\$ 17,066.67	13161	\$ 9,607.53
Sep 12	22680	\$ 16,556.40	11366	\$ 8,297.18
Oct 12	27106	\$ 19,787.38	15783	\$ 11,521.59
Nov 12	26548	\$ 19,380.04	13714	\$ 10,011.22
Dec 12	29973	\$ 21,880.29	12947	\$ 9,451.31
Jan 13	28324	\$ 20,676.52	15591	\$ 11,381.43
Feb 13	23618	\$ 17,241.14	12517	\$ 9,137.41
Mar 13	27846	\$ 20,327.58	13274	\$ 9,690.02
Apr 13	34294	\$ 25,034.62	14329	\$ 10,460.17
May 13	38336	\$ 27,985.28	12686	\$ 9,260.78
Jun 13	30424	\$ 22,209.52	12324	\$ 8,996.52

Energy Conservation Measures (ECM)

- Steam and refrigerant line insulation improvement
- Air compressor leaks, pressure setting reduced, line length reduction
- Investigate 2 stage ammonia compressors for freezers and coolers
- Replace cooling towers with new units with VFDs
- Capacitor banks for power factor correction
- VFD on evaporator fans
- Replace T12 with T8 lighting
- Retrofit chain drives to synchronous belts or cogged v belts on conveying equipment
- Anaerobic digestion of waste water to recover methane
- Soft start on large motors
- Discussion of biomass CHP project with local sawmills

Site Visit Photos





C.4 Hotel Assessments

This section presents the four hotels we audited. Each section includes the general building characteristics, descriptions of energy using equipment, recommended energy efficiency measures, and pictures of the facility.

C.4.1 San Ignacio Hotel Resort

Date completed – 7/31/2013

Completed By - Huisenga

General Building Characteristic

- Primary Use – Guest hotel (24 rooms) and conference center, annual occupancy of 11,200 person- days, commercial kitchen
- Building Age – approximately 45 years old
- Total building area of 18,7900 sf, 8000 sf for rooms, 8000 sf as conf hall space
- Building areas as follows:

RoomName	Room Size SqFt	EventType	Space	MaximumCapacity
Parking SW	3540	Parking	160	22
Parking SE	2280	Parking	160	14
Parking East	7080	Parking	160	44
Bedran Hall	3453	Theatre	9.5	363
Caracol Room	1277	Theatre	9.5	134
Swimming Pool	810	Swimming	50	16
Pool Deck	246	Cocktail	15	16
Dining Room	1500	Dining	12	125
Bedran Hall	4560	Trade Show 8 x 10	160	29
Bedran Hall	3453	Banquet	12	288
Parking North	2320	Parking	160	14
Rooms	8000			
Total Building	18790			

- Energy Types
 - BEL Electricity (Customer number 12937)
 - Butane fired steam boiler, Western Gas Co. LTD
- General Operation Schedule
 - Reception open 24/7
 - Offices open 7:30 to 5, M-Sun
 - Bedran Hall – events only, assume 5 per year and 8 hours per event
 - Caracol Room – events only, assume 30 per year and 8 hours per event
 - Kitchen – open daily from 6 am to 10 pm
 - Assume rooms occupied for 4 hours per day

Building Envelope

- Construction type –
 - Wall
 - Concrete block, plaster
 - no insulation
 - Roof
 - Corrugated aluminum
 - No insulation
- Windows
 - % of wall Area = 15%
- Shading
 - Some

Controls

- Type of controls
 - Lighting – Manual
 - AC = Manual, turned off by housekeeping staff in the day time, conf center manually turned on 1 hour before events
 - Plug/Process Loads – Manual
- Control Schedules
 - Lighting – on during regular business hours in the office, kitchen etc.
 - Plug/Process Loads – on during regular business hours in the office, kitchen etc.

Utility Rates and Energy Performance

- BEL Customer # = 12937
- 2013 average rate of \$0.245 / kWh
- Annual equivalent consumption – 283,892 kWh, peak load 2.4 kW
- Electricity use intensity – 15.1 kWh/sf-yr
- Butane consumption - 1,655 MMBtu/yr
- Total energy utilization 140.16 kBtu/sf-yr

Row Labels	Sum of Usage (kWh)	Sum of Charges (BZD)	Average of BZD/kWh
January	21937	9996	0.456
February	18624	9351	0.502
March	21937	10935	0.498
April	23917	11866	0.496
May	24159	11980	0.496
Grand Total	110574	54128	0.490

Lighting Types

- Rooms (24 total)

Confidential

- 3 x 23W halogen
- 1 x 13W CFL
- 2 x 15W incandescent candelabras
- Lobby
 - 13W Halogens
 - 25W CFL
 - Assume 1 W/SF but only on for 5 hours per day (assume 1500sf)
- Exterior
 - CFL bulbs, 26 W, assume 10 bulbs
- Admin office
 - F32T8 lighting, assume 0.75 W/SF, 1250 SF
- Caracol room and bedran hall (4500 SF total) , assume 0.5 W/SF with 26 W CFL
- Bar
 - F40T12 40W, maybe 8 total
- Kitchen
 - F40T12 40W, maybe 10 total
- Miscellaneous
 - 6 x 250 HPS outdoor lights, 2000 hrs per yr
- Dining area
 - Assume CFL, 0.5 W/SF, on during evenings only

Air Conditioning

- 12 rooms with window AC units, 12,000 Btu/hr, EER=9
- 12 rooms with split AC Units, 18,000 Btu/hr, EER=10
- Bar
 - 2 x 60,000 Btu/hr, EER=10
- Bedran Hall
 - 2 x 20 ton RTUs
- Caracol Room
 - 20 ton RTU

Plug & Process Loads

- Laundry
 - 2 x 35 lb washer and 2 dryers (1 butane, 1 electric)
- Kitchen
 - Ice maker,
 - 3 door upright refrigerator
 - Walk in cooler with window AC unit, assume 18,000 Btu, EER=9 (24/7)
 - 3 door upright freezer
 - 2 x Butane ovens, 10 burners
 - Flat top
 - Two fryers

- 3 prep top coolers

Domestic Hot Water

- Laundry and rooms
 - 50 gal tank, 4.7 kW electric input 74% minimum efficiency 85% max eff
 - 90 gal tank, butane fired 200 KBH
 - Calculate hot water use for laundry based on 11,200 guests annually
- Kitchen
 - 30 gal tank, 4.7 kW electric input, assume 150 gal per day

Energy Conservation Measures (ECM)

- Upgrade split system AC units
- T12 to T8
- Solar HW

C.4.2 Banyan Bay

Date of Audit: August 15, 2013

Completed By: Young's Engineering Consultancy Limited

Lobby and Main offices

General Building Characteristic

- Primary Use – Office / Check-in / Lobby
- No. of Floors – 2
- Total Building Area – 1,861 sq. ft.

Energy types – BEL Electricity; No fuels used.

General Operation Schedule

- Front desk occupied daily 6:30am to 9pm
- Administration Office occupied Monday –Friday 8am – 5pm, Saturdays 8am – 12 noon
Unoccupied all other hours

Occupancy Schedule

- January to December 2012 at 58%
- January to July 2013 at 55%

Building Envelope

- Construction Type

Walls

- Plastered Concrete Masonry (no insulation)

Roof

- Concrete with Mexican clay shingle tile red
- Unknown if insulation exist

Windows

- Single pane, clear glass with window shade

Shading

- Window shading is used. Manually controlled by occupants

Controls

- Types of control
 - Lighting – Manual
 - Ac – Manual
 - Plug / Process Loads – Manual
- Control Schedules
 - Lighting – on only when occupied
 - AC Lighting – On only when occupied
 - Plug / Process Loads – on only when occupied

Lighting Types

- 38 – Recessed light fixtures using spiral CFL (13W)
- 9 - Recessed light fixtures using 50 watts bulbs
- 14- Recessed Lights (20W / 2700k)

Air Conditioning

- Conditioned Area 95%
 - One 5 ton central ducted, Assume EER of 10
 - One 3 ton split unit, EER 10, R-22 Refrigerant

Plug and Process Loads

- Six ceiling fans
- Office computers and printers

Domestic Hot Water

- None

Energy Conservation Measures (ECM)

- High Efficiency AC units



Guest Villas, Laundry, Kitchen and Pool House

Date of Audit: August 15, 2013

Completed By: Young's Engineering Consultancy Limited

PRIMARY USE – Guest Villas

- Primary Use – Guest Villas
- Age -
- No. of Floors – 2
- Total Building Area – 1,920 ft²
- 20'x48' rectangular structure

Energy types – BEL Electricity; Water heating system.

General Operation Schedule

- Varies; determined by guest

Building Envelope

- Construction Type

Walls

- Plastered concrete masonry
- no insulation

Roof

- Cement roof with clay tiles

Windows

- Single pane, clear glass window
- Windows Area ~0.7% of Exterior Walls Area

Shading

- Window shading is used. Manually controlled by occupants

Controls

- Types of control
 - Lighting – Manual
 - Ac – Manual
 - Plug / Process Loads – Manual
- Control Schedules
 - Lighting – on only when occupied
 - AC Lighting – On only when occupied
 - Plug / Process Loads – on only when occupied
 - Refrigerator – remains on with or without occupant(s)

Utility Rates and Energy Performance

- Butane Consumption
- BEL Customer #

- 2013 average rate of /kwh

Lighting Types

- Dining Area
 - Pendant light with 4/13 watt CFL
 - No task lighting
 - Ceiling fan
- Kitchen
 - Ceiling light with 4/13 watt CFL
 - One 13watts range hood
- Bathroom
 - Wall Lights (4 incandescent)
 - Ceiling Light (1 incandescent)
- Bedroom #1
 - Ceiling fan with light
 - Two bed night light
- Utility Room
 - Ceiling light – 2 incandescent bulbs
- Master Bedroom
 - Two bed head incandescent (40W)
 - Ceiling fan with one 13 watt CFL
- Master Bathroom
 - Six 60W incandescent wall lights
 - One 40watt ceiling wall lights
 - One 40watt ceiling light
- Verandah / Porch
 - One 13watts CFL

Air Conditioning

- Conditioned Area 95%
 - One 3 ton central, Assume EER of 10

Plug and Process Loads

- One microwave
- One Toaster
- Range hood with light and fan
- One blender
- One coffee maker
- Two conventional TV

- One electric oven protected by 2x40A breaker



PRIMARY USE – Laundry House

- No. of Floors – 1
- Total Area - ~675 sq ft
- Energy Type – Electric ; Butane for dryers
- Roof – zinc
- Lighting Types
 - Two 2x40W (T-12)
 - Two 1x40W (T-12)
 - One 1x40W (T-12) exterior light

Plug and Process Load

- Two standard capacity washer at 110V
- One commercial washer
- One standard dryer at 5600W

- Two gas dryers



PRIMARY USE - Pool Room

- Two 2x20W (T-12)
- Two pumps at 2.5HP each rated at 1.88kw
- Three 3W CFL



PRIMARY USE - Kitchen / Restaurant / Outdoor Balcony

- One cold table, refrigerated, unable to get specs.
- One warm table, gas operated
- Two gas Ovens
- One gas grill
- One electric fryer
- One electric waffle maker
- One microwave
- Two double door cooler using 1/2HP Motor
- One blender
- One ½ HP Refrigerator
- One standing freezer @ 15A / 120V
- One chest freezer 176Watts
- One coffee maker
- One cooler

Lighting Types

- Overhead – Four 2x40W (T-12)
Two 1x40W (T-12)
- Two exhaust fans at 150Watts each
- Eight wall light (CFL @ 13 watts)
- Two recessed light @ 20 watts each
- Two ceiling fans
- Thirty Three 13Watts CFL
- **One Shop**
- Two 13W CFL

- Nine 2x40 (T-12)
- **Conference Room**
- Total Room Area – 1600 sq. ft.

Building Envelope

- **Construction Type**

Wall

- Wooden

Roof

- Roof
- Unknown if insulation present

Controls

- Lighting and AC manual

Lighting Type

- Twenty 1x40W (T-12) internal
- Nine 1x20 W (T-12) external
- Three ceiling fan

Air Conditioning

- Conditioned Area 95%
- Two 5 ton central, Assume EER 10
- One 12K BTU Split Unit @ 1150 W

Fence

- Six 15W CFL

Energy Conservation Measures (ECM)

- CFL in bathrooms, utility room
- CFL in bed room to replace incandescent
- T12 – T8
- New kitchen , restaurant equipment
- Higher efficiency AC units (central and split units)
- Turn off refrigerator in unoccupied rooms

C.4.3 Cave Branch – Main Building

Date of Audit: August 16, 2013

Completed By: Young's Engineering Consultancy Limited

General Building Characteristic

- Primary Use – Check In, Main Office, Bar, Gift Shop, Kitchen
- Age -
- No. of Floors – 1
- Total Building Area –

Energy types

- Generated Powered

General Operation Schedule

- Occupied – Everyday 7am to 5pm

Building Envelope

- Construction Type
 - Wall - timber
 - Roof – metal decking on timber sheeting
 - Windows
 - Wooden with Glass Panels
 - Fixed Screen

Controls

- Type of Controls
 - Lighting – Manual
 - AC – Manual
 - Plug / Process Loads – Manual

Control Schedules

- Lighting - is on only when occupied
- AC – is on only when occupied

Utility rates and energy performance

- None; powered by generator from 7am to 10pm
- Battery Powered 10pm to 7am
- Capacity 25 kilowatts
- During downtime generator runs 7am to 10 am. Start up again at 3pm to 10 pm

Lighting Types

- Solar Lights in Walk way
- Exterior lights 13 Watts CFL
- Ceiling Fan

Cabanas

Age -

No. of floors – 1

Total cabana area – 2,020 sq. ft.

Cabana Envelope

- Construction Type

Wall

- Exterior wooden
- Interior sheet rock with 10mm insulation

Roof

- thatch roof

Windows

- Fixed Glass
- Fixed Wooden Louvers
- Fixed Screen
- Windows Area ~38% of exterior wall area

Controls

- Type of Controls
 - Lighting – Manual
 - AC – None
 - Plug / Process Loads – Manual

Control Schedules

- Lighting - is on only when occupied
- Plug /Process Loads – is on only when occupied

Lighting Types

- One 13 Watts CFL
- Two night lights at 13Watts each
- Exterior lights are Two 13Watts CFL
- Bathroom
 - 2 wall lights
 - One ceiling fan with light
- Laundry Area – Use Daily

- Lighting Type – Two 1x40Watts (T-12), One ceiling fan
- One washer Rated at F.L.A 16 Amps, Max Load 65 lbs
- One Butane Dryer
- Two standard washer
- Two standard dryer

PRIMARY USE - Generator Rooms

- Three 13Watts CFL
- Four extractor fans (unable to see specs.)

PRIMARY USE - Kitchen

Lighting Type

- One 2 x40W (T-12)
- Four 2 x40W (T-12)

Air Conditioning

- One 24k BTU @3380Watts EER 7.1

Plug and Process

- Computer
- Display cooler @ 12.9 A./114 volts
- Deep freezer
- Vegetable cooler @ 5.9A /110volts
- Dough mixer, 3/4HP
- Standing fan
- Two extractor fans
- One Butane tank- less water heater

Preparation Room

- Lighting Type
- Overhead 40 Watts (T-12)
- Wall fan

PRIMARY USE - Bar /Gift Shop/Bathroom –

Lighting Type

- Recessed 13 Watts CFL
- Insect repelled light
- LED Net Light (On from 7am – 10pm)
- Two 2x40Watts (T-12)
- Nine wall lights

- Fan Type – Ceiling and extractor fan

Pump room

- Two 15 watts CFL
- One 12k BTU window unit
- One 3 HP pump
- Two 2 HP pump

Filtration System

- One ½ HP pump

Energy Conservation Measures (ECM)

- T12 to T8 conversion
- Higher Efficiency split system
- New refrigerator and freezer



Confidential









C.4.4 El Rey Motel

Date completed – 8/01/13

Completed By - Huisenga

General Building Characteristic

- Primary Use - Hotel

- Age – 25 years old
- # of floors - 2
- Total Building Area – 5200 ft²: 2600 ft² per floor:
- 39' * 67' rectangular structure
- Energy Types
 - All electric
 - Butane DHW
- General Operation Schedule
 - Typical hotel hours

Building Envelope

- Construction type –
 - Wall
 - Concrete blocks, painted white
 - no insulation
 - Roof
 - Concrete deck – no reflective coating
 - No insulation
- Windows
 - % of wall Area = 15%
 - Single pane, louvered, with thin plastic covering
 - No Low-e Coating
- Shading
 - Drapes on windows controlled by occupants

Controls

- Type of controls
 - Lighting – Manual
 - AC = Manual
 - Plug/Process Loads - Manual
- Control Schedules
 - Lighting – on only when occupied
 - AC – on only when occupied
 - Plug/Process Loads - on only when occupied

Utility Rates and Energy Performance

- BEL Customer # =9929282
- Annual equivalent consumption of 20,830 kWh/yr, 4 kWh/sf-yr, or 12 kWh/room-day
- Butane use of 24.84 MMBtu,
- Total EUI of 18.5 kBtu/sf-yr

Row Labels	Sum of Usage (kWh)	Sum of Elec Charges (BZD)	Average of BZD/kWh	Occupied Room-days	kWh/Room -days
January	1399	626	0.411	136	10.29
February	1360	678	0.507	110	12.36
March	1283	644	0.473	109	11.77
April	1809	913	0.525	104	17.39
May	2004	1015	0.664	200	10.02
Grand Total	7855	3875	0.524	186	11.92

Lighting Types

- T12 40W primarily, assume 0.3 W/SF throughout the building
- Assume CFLs at 0.04 W/SF, 13W bulbs
- Assume 46% of installed lights on 5 hours per day

Air Conditioning

- 4 rooms with AC units, assume
 - 12,000 Btu/hr, EER = 8.5
 - Assume running 4 hrs per day if occupied (46%)
- Assume 7 fans, 35W per fan, running 5 hour per day at occupancy rates (46%)
- Per Discussion with Mike – Set all AC/Fans to overnight on = 12 hrs/d

Plug & Process Loads

- Office computers and printers, assume 4 PCs in entire building
- Refrigerator – 574 kWh/yr
- Tank water heater, 4772 kWh/yr
- Fans, 35 W
- Microwave
- Stove, 6 burner = 13 MMBtu/yr
- 6 TVs, 2 hrs per day at 46% occupancy
- Washer
- Butane clothes dryer, 11 MMBtu/yr

Energy Conservation Measures (ECM)

- T12 to T8 conversion
- Higher efficiency split systems
- Double pane & low –e window
- Insulate roof and walls
- Cool roof

C.5 Office, Restaurant, and Retail Facility Assessments

This section presents the office, restaurant and retail facilities we audited. Each section includes the general building characteristics, descriptions of energy using equipment, recommended energy efficiency measures, and pictures of the facility.

C.5.1 Young's Law Firm

Date completed – 7/30/13

Completed By - Sobrinski

General Building Characteristic

- Primary Use - Office
- Age – 15 years old
- # of floors - 2
- Total Building Area – 6,000 ft²: 3,000 ft² per floor:
- 30' * 100' rectangular structure
- Energy Types
 - All electric
 - No fuels used
- General Operation Schedule
 - Occupied - M-F – 7am-6pm
 - Unoccupied all other hours

Building Envelope

- Construction type –
 - Wall
 - concrete
 - no insulation
 - Roof
 - Concrete deck – no reflective coating
 - R13 batt insulation above ceiling tiles on top floor
- Windows
 - % of wall Area = 15%
 - Single pane
 - No Low-e Coating
- Shading
 - Window shading is used. Manually controlled by occupants

Controls

- Type of controls
 - Lighting – Manual
 - AC = Manual
 - Plug/Process Loads - Manual
- Control Schedules

Confidential

- Lighting – on only when occupied
- AC = Lighting – on only when occupied
- Plug/Process Loads - on only when occupied

Utility Rates and Energy Performance

- BEL Customer # = 89879
 - Four BEL account #s
 - 41815
 - 54046
 - 41821
 - 41904
 - Rate for one month was \$0.28 / kWh

Lighting Types

- Overhead T12 / 40W fluorescent
- Limited other lighting – a few CFLs and Incandescent exterior lighting for security
- Lighting Density is about 0.8 watts per ft². Low lighting level however since it is not efficient lighting
- No task lighting at desks

Air Conditioning

- Conditioned Building Area = 90%
- Common area served by ducted rooftop units.
 - Duct work is not insulated and sits above the roof insulation. Thus the ductwork has high losses as the plenum is very hot.
 - Main system is not in great working order. Could not access efficiency
 - System was initially designed to serve the entire building but the perimeter offices now use dedicated split systems
- 12 dedicated Office splits systems
 - Sizing about 120 ft² per ton
 - 10 SEER ratings

Plug & Process Loads

- Office computers and printers
- 1 refrigerator
- 1 Dell server –(200ft² room hoses the server) 24/7 cooling from 1.5 ton split system

Domestic Hot Water

- None (note this is common for Belize offices)

Energy Conservation Measures (ECM)

- T12 to T8 conversion

- Higher efficiency split systems
- Insulated ducting and/or place ducting in conditioned area
- Shade out door units
- Double pane & low –e window

C.5.2 Celebrity Restaurant

Date completed – 7/29/2013

Completed By - Huisenga

General Building Characteristic

- Primary Use - Restaurant
- Age – approximately 10 years old
- # of floors - 2
- Total Building Area – 5,600 ft²: 2,800 ft² per floor. Restaurant occupies only the bottom floor, split up roughly 2,350 sf for dining area and bar, 450 for kitchen.
- 79' * 35' rectangular structure
- Energy Types
 - BEL Electricity (Customer number 123362)
 - Butane for cooking equipment
- General Operation Schedule
 - Occupied - M-Sun – 11am-10pm
 - Unoccupied all other hours

Building Envelope

- Construction type –
 - Wall
 - concrete
 - probably no insulation
 - Roof
 - Concrete deck grey– no reflective coating
 - Unknown if insulation present, assume R-13 batt
- Windows
 - % of wall Area = 15%
 - Single pane, new
 - No Low-e Coating
- Shading
 - Window shading is used. Manually controlled by occupants

Controls

- Type of controls
 - Lighting – Manual
 - AC = Manual

- Plug/Process Loads - Manual
- Control Schedules
 - Lighting – on only when occupied
 - AC – on only when occupied
 - Plug/Process Loads - on only when occupied

Utility Rates and Energy Performance

- Butane consumption of BZD 1000/month; 255 MMBtu/yr
- BEL Customer # = 123362
- 2013 average rate of \$0.257 / kWh
- Annual equivalent consumption – 51,821 kWh
- 18.43 kWh/sf-yr

Row Labels	Sum of Usage (kWh)	Sum of Charges (BZD)	Average of BZD/kWh
January	3976	1838	0.458
February	3810	2051	0.529
March	3793	2044	0.532
April	4504	2404	0.526
May	5509	2925	0.527
Grand Total	21592	11262	0.514

Lighting Types

- Dining area
 - Halogen exterior accent lighting
 - Incandescent candelabra mood lighting, 23 bulbs in main dining area (23 x 40W), density of 0.3 W/sf
- Kitchen
 - 6 x 2 x 40W T12
 - 2 HPS bulbs in fume hood

Air Conditioning

- Conditioned area in restaurant = 84%
- Two large split systems, 4 tons each, assume EER of 10

Plug & Process Loads

- Dining area
 - 2 flat panel TVs, 48 inches
 - 5 ceiling fans
- Kitchen
 - 4 closed case freezers, upright
 - 1 three door refrigerator, upright

- 1 single door refrigerator, upright
- 2 extractor fans
- 1 ceiling fan
- 2 microwaves
- Cooking Equipment
 - 2 – 6 burner stove/ovens
 - 2 fryers
 - 1 griddle

Domestic Hot Water

- None

Energy Conservation Measures (ECM)

- CFL candelabras in dining area
- Replace halogens with LED
- T12 to T8
- New refrigerators and freezers
- Higher efficiency split systems
- Shade out door condensing units
- Double pane & low –e window



C.5.3 Publics Market

Date completed – 7/29/2013

Completed By - Huisenga

General Building Characteristic

- Primary Use – retail supermarket
- Age – approximately 20 years old
- # of floors - 1
- Total Building Area – 12,500 ft²
- 100' * 125' rectangular structure
- Energy Types
 - BEL Electricity (Customer number 19754)
 - Butane for bakery oven only
- General Operation Schedule
 - Main floor is open 7:30 am to 9:30 pm Mon-Sat; 7:30 am to 2:30 pm Sun
 - Office is open 9 am to 5 pm Mon-Fri
 - Cool room and ref/freezer room are cooled 24/7
 - Bakery open 9:00 am to 4:30 pm

Building Envelope

- Construction type –
 - Wall
 - corrugated aluminum
 - no insulation
 - Roof
 - Corrugated aluminum
 - No insulation
- Day lighting on roof
 - Yellow corrugated fiberglass, 20 panels with 2.5' x 8' area
- Windows
 - % of wall Area = 0%
- Shading
 - N/A

Controls

- Type of controls
 - Lighting – Manual, metal halides turned on at 6:30 pm
 - AC = Manual, running in cooler rooms 24/7
 - Plug/Process Loads – Manual
- Control Schedules
 - Lighting – on only when occupied
 - AC – 24/7

- Plug/Process Loads – on only when occupied

Utility Rates and Energy Performance

- BEL Customer # = 19754
- 2013 average rate of \$0.247 / kWh
- Annual equivalent consumption – 240,905 kWh
- Electricity use intensity – 19.3 kWh/sf-yr

Row Labels	Sum of Usage (kWh)	Sum of Charges (BZD)	Average of BZD/kWh
January	19691	8338	0.440
February	19403	9758	0.507
March	19497	9811	0.507
April	19396	9771	0.508
May	22390	11242	0.508
Grand Total	100377	48920	0.494

Lighting Types

- Overhead Lighting
 - 34 x 400W metal halide
 - 22 x 120W CFL clusters
 - 7 x 2 x 40W T12
 - 2 x 3 x 32W T8
 - 2 x 4 x 40W T12 in offices
 - 7 x 3 x 23W halogen
 - 2 x 2 x 23W halogen
 - 4 x 13W CFL

Air Conditioning

- Conditioned area in refrigerator/freezer room ~450 sf, approximately 350 sf in cool dry storage and offices = 6.4% of total building is conditioned
- Refrigerator/freezer room
 - 3 split AC units, each with 22,000 Btu/hr, 2010W, 18 SEER
- Cool room
 - 1 split AC unit, assume 12,000 Btu/hr, EER 10
- Office
 - 1 split AC unit, assume 12,000 Btu/hr, EER 10
- 4 small ceiling fans in produce section

Plug & Process Loads

- Refrigerators
 - 3 open chest freezers, old
 - 5 chest freezers, with top

- Large glass door display upright refrigerators, 15 doors wide, old
- Bakery refrigerator, 765W
- Cooking Equipment
 - Bakery oven 200 MBH burner, ½ hp motor

Domestic Hot Water

- None

Energy Conservation Measures (ECM)

- Improve insulation in refrigerator / freezer rooms
- Replace old refrigerators and freezers
- Replace metal halides with LED high bays
- T12 to T8
- Power factor correction (publics just implemented this)

C.5.4 Bowen & Bowen

Date of Audit: August 22, 2013

Completed By: Rene Allen, Young's Engineering Consultancy Limited

General Building Characteristic

- Primary Use – Office
- Age - > 15 years
- No. of Floors – 2 buildings, 2 floors each
- Total Building Area #1 – 10,491.6 ft² : 5245.8 ft²
56'-11" x 92'-2" rectangular structure
- Total Building Area #2: 5,746 ft²
- Energy types – All Electric, No fuel used

General Operation Schedule

- Occupied Monday to Friday 7am -5pm
- After hours cleaning 3hours/day
- Hours open Monday to Friday 9 hours Average 45/week
- Hours closed 15 hours
- Peak # of occupants when open – 80

Building Envelope

- Construction Type

Wall

- Plastered concrete masonry
- No insulation

Roof

- Concrete deck with zinc/metal
- 50% insulation present R-19
- Non reflective paint

Window

- Louvers with gasket with low-e coating
- Size 53”h x 90”w
- Window shading is used – manually controlled by occupants
- Windows remain closed during the day

Controls

- Type of Control
 - Lighting – Manual / photo
 - AC – Manual
 - Plug / Process Loads – Manual
 - Control Schedules – Lighting on only when occupied.
 - AC – on only when occupied
 - Plug / Process Loads – on only when occupied

Lighting Types

- Overhead T12 / 4 x40 and 4 x 20 fluorescent
- Exterior – 70 watts high pressure sodium
- No task lighting at desk

Air Conditioning

- Conditioned building area = 90%
- Common area served by ducted roof top units
- Other offices uses dedicated split system
- Duct work is not insulated and sits above the ceiling
- Note: Some duct work has 7’-0” height between ceiling and roof and taper down to 2’-0”. (If air is natural insulation hen may need to consider as efficient)
- Main system in good working condition
- 10 S.E.E.R. ratings

Note: three – 7 1/2 ton ducted split units, Two 18k Btu split unit, one 18k BTU serves upper floor of one building

Two 5-ton ducted split units, two 3-ton serves lower flat of building

Two 10-ton package, one 7.5 ton package one 3-ton package, One 24k BTU mini split as back-up for stationary room serves upper flat of second building.

One 3 ton split unit ducted type serves lower flat of second building.

Plugs and Process Loads

- Office computers and printers
- Beverage cooler rated at 5A at 120V
- Microwaves
- Coffee maker
- Water coolers
- One plotter – 2A/120V
- Photocopier

Utility Rates and Energy Performance

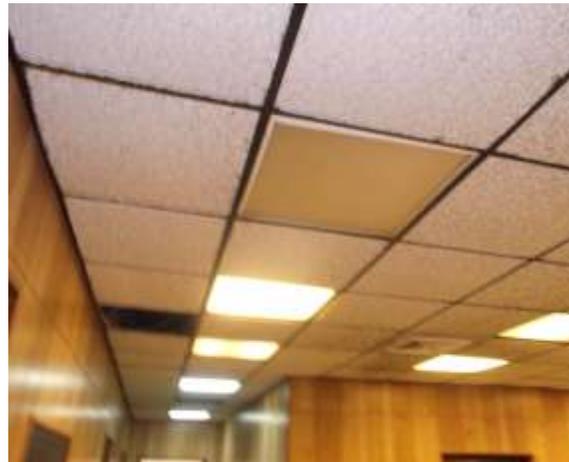
Electrical Consumption per Day (kWh)

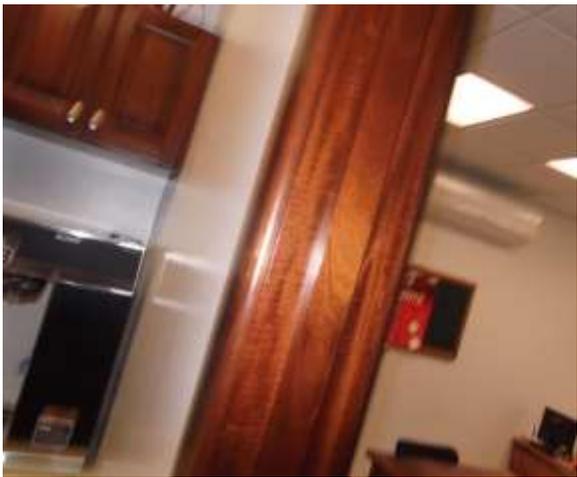
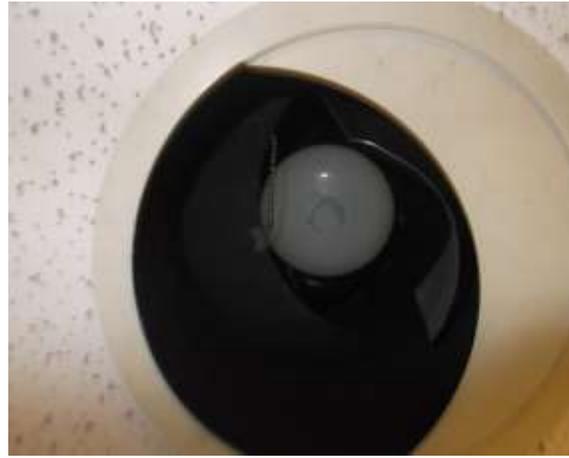
2013	2012
May - 1400	December – 1174
April – 1169	November- 1342
March – 1284	October – 1371
February – 1234	September –
January - 1236	August - 1446
	July - 1417

Domestic Hot Water – None

Energy Conservation Measures (ECM)

- T12 to T8 conversion
- Higher efficiency Split System
- Insulate Ducting
- Shade out door units
- Double pane and Low-e window





C.6 Government Facility Assessments

This section presents the audits of government facilities conducted by WSP and Young's Engineering. Each section includes the general building characteristics, descriptions of energy using equipment, recommended energy efficiency measures, and pictures of the facility.

C.6.1 Holy Redeemer Primary School

Date of Audit: October 18, 2013

Completed By: Young's Engineering Consultancy Limited (R. Allen)

General Building Characteristic

- Primary Use – School
- Age – 37 years (Built in 1976)
- No. of Floors – 2

- Total Building Area – 10,000 Sq. ft.
- Rectangular Structure

Energy types

- All Electric
- No fuels Used

General Operation Schedule

- Occupied – Monday – Friday Everyday 7am to 6pm
- Unoccupied All Other hours
- Average Weeks / Year – 38
- Average Number of Occupants During Occupied Period
- Staff No. 44
- Average of 33 students in a classroom / 25'x25 room area, Plus 1 (one) teacher

Building Envelope

- Construction Type
 - Wall – concrete stucco on wood framing and hard decking, insulated
 - Roof – unpainted galvanized metal on timber framing
 - Windows
 - % of wall area = 45%
 - Wooden louvers
 - Open all day
 - Only computer room windows remain close

Controls

- Type of Controls
 - Lighting – Manual
 - AC – Manual (computer room only)
 - Plug / Process Loads – Manual

Control Schedules

- Lighting - is on all day
- AC and Lighting – on all day
- Plug / Process Loads – On only when occupied

Utility rates

BEL Invoices - 12042305, 11868852, 11868846, 11868740, 11868727

Lighting Types

- Overhead T12 / 40 Watts fluorescent (6-1x40w)

- Limited other lighting – 3 mercury vapor for security
- Lighting density is about 0.4 Watts per ft²
- No task lighting at desks

Air Conditioning

- Only in computer room, approximately 576 sq. ft
- Two 24k BTU Split System, Assume EER of 10

Plug and Process Loads

- Computer Room – Two photocopiers, 34 computers
- Classrooms
 - Each with 4 ceiling fans
 - One water cooler each at 5.8 amps
 - Microwave
 - Standing fans

Domestic Hot Water

- None

Energy Conservation Measures (ECM)

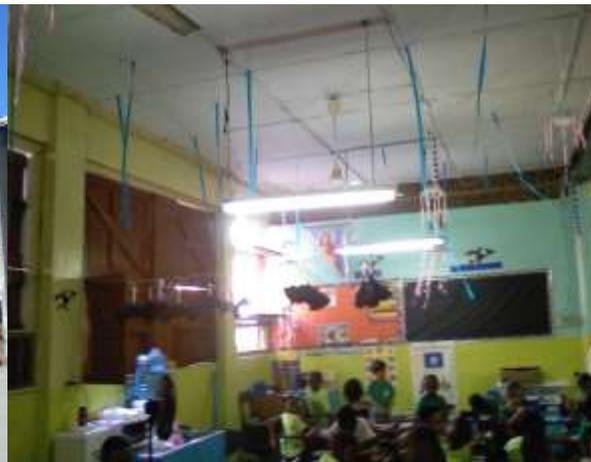
- T12 to T8 conversion
- Higher Efficiency split system

Note:

Technical information is for 1 class room. This division of the school has fourteen (14) classrooms.



Overview



Typical Classroom



Typical Lighting Fixtures



Roof Framing and Sheeting



Extraction Fan



Assembly Area

C.6.2 Ministry of Energy, Science, Technology, and Public Utilities

Date completed – 7/31/13

Completed By - Huisenga

General Building Characteristic

- Primary Use - Office
- Age – 25 years old
- # of floors - 2
- Total Building Area – 6,500 ft²: 3,250 ft² per floor:
- 35' * 187.5' rectangular structure
- Energy Types
 - All electric
 - No fuels used
- General Operation Schedule
 - Occupied - M-F – 7am-6pm

- Unoccupied all other hours

Building Envelope

- Construction type –
 - Wall
 - Concrete blocks
 - no insulation
 - Roof
 - Concrete deck – no reflective coating
 - No insulation
- Windows
 - % of wall Area = 25%
 - Single pane, louvered, with thin plastic covering
 - No Low-e Coating
- Shading
 - Window fixed awnings are used on west side.
 - Drapes on windows controlled by occupants

Controls

- Type of controls
 - Lighting – Manual
 - AC = Manual
 - Plug/Process Loads - Manual
- Control Schedules
 - Lighting – on only when occupied
 - AC – on only when occupied
 - Plug/Process Loads - on only when occupied

Utility Rates and Energy Performance

- Account # 47817

Lighting Types

- Overhead T12 / 40W fluorescent strip lighting
- Lighting Density is 0.6 to 0.7 W/sf. Low lighting level however and many lights turned off while occupied. Assume 50% lighting is on
- Minimal task lighting at desks or other lights

Air Conditioning

- Conditioned Building Area = 80%
- Offices each have mini split AC units, main corridors are exposed to ambient but cooled by the offices.
- Assume 20 offices per floor each with dedicated splits systems
 - 18,000 Btu/hr, EER = 8.5

- Assume 90% running during op hours

Plug & Process Loads

- Office computers and printers, assume 50 PCs in entire building

Domestic Hot Water

- None (note this is common for Belize offices)

Energy Conservation Measures (ECM)

- T12 to T8 conversion
- Higher efficiency split systems
- Double pane & low –e window
- Insulate roof and walls
- Cool roof

C.6.3 Western Regional Hospital

Date completed – 8/1/13

Completed By - Huisenga

General Building Characteristic

- Primary Use – ER and clinic
- Age – 25 years old
- # of floors - 1
- Total Building Area – 39,000 sf
- Energy Types
 - All electric
 - No fuels used
- General Operation Schedule
 - Offices: 7 am – 5 pm
 - ER: 24/7
 - Clinic: 7 am to 5 pm
- 48 patient beds

Building Envelope

- Construction type –
 - Wall
 - Concrete blocks
 - no insulation
 - Roof
 - Concrete deck – no reflective coating
 - No insulation
- Windows
 - % of wall Area = 20%

- Single pane, louvered, with thin plastic covering
- No Low-e Coating
- Shading
 - Window fixed awnings are used on west side.
 - Drapes on windows controlled by occupants

Controls

- Type of controls
 - Lighting – Manual
 - AC = Manual
 - Plug/Process Loads - Manual
- Control Schedules
 - Lighting – on only when occupied
 - AC – on only when occupied
 - Plug/Process Loads - on only when occupied

Utility Rates and Energy Performance

- BEL Account # = 12442

Lighting Types

- Overhead T12 / 40W fluorescent strip lighting
- Lighting Density is 0.6 to 0.7 W/sf.
- Assume 50% lighting is on
- Minimal task lighting at desks or other lights

Air Conditioning

- 3 large ducted central AC systems serving ER and surgery, assume running 12 hours per day
 - 59,800 Btu/hr, SEER = 15.5
 - 59,000 Btu/hr, SEER = 13
 - 59,000 Btu/hr, SEER = 13
- Assume 20 x 12,000 Btu/hr; EER=9 split and window ACs throughout the building running during office hours

Plug & Process Loads

- Office computers and printers, assume 50 PCs in entire building

Domestic Hot Water

- None

Energy Conservation Measures (ECM)

- T12 to T8 conversion
- Higher efficiency split systems
- Double pane & low -e window

- Insulate roof and walls
- Cool roof

C.6.4 Customs and Excise Department

Date of Audit: August 13, 2013

Completed By: Young's Engineering Consultancy Limited

General Building Characteristic

- Primary Use – Office
- No. of Floors – 2
- Total Building Area – Rectangular with inside open area
- Energy types – All Electric, No fuel used

Building Envelope

- Construction Type

Wall

- Plastered concrete masonry (no insulation)
- Glass blocks

Roof

- Concrete roof – No reflective loathing

Window

- Glass louvers, slightly tinted

Control

- Type of Control
 - Lighting – Manual
 - AC – Manual
 - Plug / Process Loads – Manual
 - Control Schedules – Lighting only when occupied.
 - AC – on only when occupied

Note: AC in server room stays on

- Plug / Process Loads – on only when occupied

Utility Rates and Energy Performance

- Ministry of Energy

Lighting Types

- Room No. 1 – Two 2x40 watts T-12

- Security Office
 - Two 2x40 (T-12)
 - One Inverter type 18k BTU AC
 - One small refrigerator
 - One water cooler 5.5A

Broker Office

- Two 2x40W (T-12)

Private Warehouse

- One inverter AC unit 18k BTU
- Two 2x40 (T-12)

Cashier Room

- Three 4x40W Troffer (T-12 bulbs)
- One inverter AC Unit 24k BTU
- One regular AC Unit 18k BTU
- Two ceiling fans (not working)

BAHA

- Two 2x40 (T-12 bulbs)
- One 18k regular AC unit
- One water cooler (5.8 A)

Kitchen / Junk Room

- Two 2x40W Troffers (T-12)

Queen Bounded Warehouse Office

- One 12k window AC Unit (regular)
- Four 4x40w troffer
- 2'x2' ceiling tile with no insulation
- One bottle cooler 5.5A

Modernization Section

- Two 2x40 (T-12)
- One 12k BTU regular AC
- Two 12k BTU AC unit

Kitchenette

- One refrigerator

- One microwave
- One water cooler
- Eleven 2x40W T-12

Server Room

- Two 18k BTU Inverter Unit

Modernization Office Upper Flat

- Six 2x40W (T-12)
- One AC unit

Deputy Comptroller Office

- Four 2x40W (T-12)
- One 24k BTU window AC unit – EER 8.5
- One small refrigerator
- One microwave

Examination Room #1

- Two 2x40W (T-12)
- One AC unit

Examination Room #2

- One 24k BTU
- Four 2x40W (T-12)

Shipping Section

- One water cooler
- Four 2x40 (T-12)
- One 12k BTU (14.5kw)

Administration Officer

- Four 2x40W Troffer (T-12 bulbs)
- One window AC unit
- One small refrigerator

Accounts Section

- Six 2x40 (T-12)
- Two AC Units
 - 1- Inverter type 12K BTU
 - 1- Regular 12k BTU

- One small refrigerator
- One microwave
- One water cooler

Accounts Section (Reconciliation)

- Two 2 x 40 (T-12 bulbs)
- One window AC unit
- One bottle cooler

Excise Department / Office

- Three 2 x40 (T-12 bulbs)
- One regular 12k BTU AC unit
- One small refrigerator
- One microwave
- One bottle cooler

Assistant Comptroller

- Four 2x40W T-12
- One 14k BTU AC Unit
- One refrigerator
- One microwave

Enforcement

- One ceiling mount AC unit (Regular)
- Eight 2 x40W (T-12 bulbs)
- One bottle cooler
- One small refrigerator
- One microwave

Post Clearance Audit #1

- One 24k BTU AC unit (regular)
- Two 2 x40W (T-12 bulbs)

Post Clearance Audit #2

- One 36k BTU Universal AC (regular)
- One 24k BTU (regular)
- Nine 2x40W (T-12)
- One Microwave
- One water cooler

- One refrigerator
- Two 4x40W Troffer (T-12)
- Three 2 x40W Troffer (T-12)

Conference Room

- Six 2 x40W)T-12)
- One 18k BTU AC Unit (Regular)

Risk Management Unit

- Six 2x40 Troffer (T-12)
- One microwave
- One refrigerator
- One water cooler
- One 18k BTU AC Unit (Regular)

Domestic Hot Water – None

Energy Conservation Measures (ECM)

- T12 to T8 conversion
- Higher efficiency split system for regular AC units
- Insulate ceiling on upper flat
- *Note:* New Reverse Osmosis System installed and was in operation about 3 to 4 weeks.



	<ul style="list-style-type: none">- Cooks Daily – Breakfast/lunch/supper
Building Shell	<p>[wall, doors and roofing construction materials, color, photograph building exterior, use of exterior shads etc.]</p> <ul style="list-style-type: none">- Walls – plastered masonry- Doors – Mostly wooden, 1 wood with decorated glass (green)- Roof: ~2/3 of reinforced concrete and ~ 1/3 of cement-plastered foam  <p>A photograph showing the exterior of a two-story building with teal-colored walls. The building features a balcony on the second floor with a white railing. There are some signs and awnings on the ground floor.</p>
Area and no. of floors	<p>[list building area in square footage, list floors above and below grade]</p> <ul style="list-style-type: none">- 54 feet x 42 feet- No. of floors – 2- All above grade
Windows	<p>[provide # of windows and approximate area, photograph typical window]</p> <ul style="list-style-type: none">- eleven single pane 30”wx50”h (clear)- four 24”wx26”h  <p>A close-up photograph of a white-framed window with multiple panes, set against a teal wall. The window has a classic design with a central pane and smaller panes around it.</p>

Confidential

<p>Lighting systems</p>	<p>[Record typical bulb & ballast types, number and wattage, photograph typical lights]</p> <ul style="list-style-type: none"> - 1 – 2x40 Watts (T-12) - 2- 1x20 Watts (T-12) - 1 –pendant light with 5 CFL 13Watts each - 4 – pendant lights with 4 CFL 13 Watts each - 1 pendant light with 3 CFL 13Watts each - 2 pendant lights with 1 CFL 13 Watts each - 1 13 Watt CFL Exterior light 
<p>Domestic Hot Water</p>	<p>[list type, capacity of water heater, list devices, capacity of devices using HW sincluding shower gpm flowrates, take photographs]</p> <ul style="list-style-type: none"> - 16 gallons electrical water heater (entire house)
<p>Appliances</p>	<p>[provide general descriptions of refrigerators, dishwashers, clothes water/dryer, and stoves/ovens, list size capacity and volume information, list energy source and efficiency ratings if provided]</p> <ul style="list-style-type: none"> - Dryer – Butane - Washer – std capacity - Refrigerator – “Gallery”, double door 11 years old (Frigidaire brand)
<p>Cooling Equipment</p>	<p>[list type of air conditioner present, capacity, and COP/EER as labeled, list the % of building area that is conditioned]</p> <ul style="list-style-type: none"> - Air conditioner but not reflected in owner’s bill – 18 k btu. All four rooms are air-conditioned all conventional units.
<p>Fans</p>	<p>[List number and types of ceiling and space fans in unit]</p> <ul style="list-style-type: none"> - 3 standing fans - 4 ceiling fans with light incandescent
<p>Plug Load</p>	<p>[identify types of equipment plugged in, e.g. small appliances, computers etc.]</p> <ul style="list-style-type: none"> - 1 blender - 1 iron

	<ul style="list-style-type: none">- 1 toaster- 1 Bottle cooler- 1 microwave- 1 desktop computer
Other Notes	<ul style="list-style-type: none">- Adjacent building is about 4 to 5 feet away from exterior wall- 1961 Timber Hurricane Haiti destroyed construction; 1962 reconstruction, timber- 2004 started concrete <div data-bbox="548 741 1240 1262" data-label="Image"></div>

C.7.2 19 ¾ Miles Northern Highway, Belize City

Building Address 19 ¾ Miles Northern Highway

BEL Customer Number: Meter #0083226031 Cust#00040761

Date of Visit: 07 September 2013

Written By: C. Young

Residential Unit Type: single or multi-family

Observations:

Confidential

Item	Observation
Energy Use	<p>[Ask resident for a copy of a BEL invoice, and record the customer at the top of this page. Also inquire about butane and other fuel use, record typical monthly electricity and butane purchases here]</p> <ul style="list-style-type: none"> - Typical bill BZ\$22.00 / month - Butane: \$53 tank approx. every 6 months
Occupants	<p>[List number of occupants, ages, typical daily schedules for occupancy and cooking]</p> <ul style="list-style-type: none"> - One (1) occupant, 80 years old - Cooks only one time per week
Building Shell	<p>[wall, doors and roofing construction materials, color, photograph building exterior, use of exterior shads etc.]</p> <ul style="list-style-type: none"> - Timber walls, timber floor, timber and metal roof, wooden louvers <div style="text-align: center;">  </div>
Area and no. of floors	<p>[list building area in square footage, list floors above and below grade]</p> <ul style="list-style-type: none"> - 2 floors but ground floor is not in use. - Approximately 600 square feet
Windows	<p>[provide # of windows and approximate area, photograph typical window]</p> <ul style="list-style-type: none"> - Wooden louvers – 9 total - Roughly 90 sq. ft.

	
<p>Lighting systems</p>	<p>[Record typical bulb & ballast types, number and wattage, photograph typical lights]</p> <ul style="list-style-type: none">- Single 1x20 fluorescent in living room- Compact Fluorescents in other rooms  

Domestic Hot Water	[list type, capacity of water heater, list devices, capacity of devices using HW including shower gpm flowrates, take photographs] - None.
Appliances	[provide general descriptions of refrigerators, dishwashers, clothes water/dryer, and stoves/ovens, list size capacity and volume information, list energy source and efficiency ratings if provided] - Haier refrigerator – approx 20 years old - 4-burner LPG Stove with oven – greater than 10 years old - Samsung WT55HO washing machine – greater than 10 years old   
Cooling Equipment	[list type of air conditioner present, capacity, and COP/EER as labeled, list the % of building area that is conditioned] - None.

<p>Fans</p>	<p>[List number and types of ceiling and space fans in unit]</p> <ul style="list-style-type: none">- 1 upright pedestal fan 
<p>Plug Load</p>	<p>[Identify types of equipment plugged in, e.g. small appliances, computers etc.]</p> <ul style="list-style-type: none">- 1 double – cassette music player- 1 19" television 
<p>Other Notes</p>	

C.7.3 44 Edge Water, Sand Hill Village

Building Address 44 Edge Water, Sand Hill Village

BEL Customer Number: 00042844

Date of Visit: 22-Sep-13

Written By: E Bennett (Young's Engineering)

Residential Unit Type: single or multi-family

Observations:

Item	Observation
Energy Use	<p>[Ask resident for a copy of a BEL invoice, and record the customer at the top of this page. Also inquire about butane and other fuel use, record typical monthly electricity and butane purchases here]</p> <ul style="list-style-type: none"> • ~300 kWh per month
Occupants	<p>[List number of occupants, ages, typical daily schedules for occupancy and cooking]</p> <ul style="list-style-type: none"> • 3 persons <ul style="list-style-type: none"> ○ One < 10 yrs ○ One < 25 yrs ○ One <50 yrs
Building Shell	<p>[wall, doors and roofing construction materials, color, photograph building exterior, use of exterior shads etc.]</p> <ul style="list-style-type: none"> • Walls: plastered masonry / no insulation • Roof: metal decking on timber frame, no insulation <div style="text-align: center;">  </div>
Area and no. of floors	<p>[list building area in square footage, list floors above and below grade]</p>

	<ul style="list-style-type: none"> • Single Story ~ 650 sq. ft.
<p>Windows</p>	<p>[provide # of windows and approximate area, photograph typical window]</p> <ul style="list-style-type: none"> • Five dbl 30" x 48" glass louvers • Six single 30"x 48" glass louvers 
<p>Lighting systems</p>	<p>[Record typical bulb & ballast types, number and wattage, photograph typical lightis]</p> <ul style="list-style-type: none"> • 9-W compact flourescent • 1x20W flourescent  
<p>Domestic Hot Water</p>	<p>[list type, capacity of water heater, list devices, capacity of devices using HW sincluding shower gpm flowrates, take photographs]</p> <ul style="list-style-type: none"> • None
<p>Appliances</p>	<p>[provide general descriptions of refrigerators, dishwashers, clothes water/dryer, and stoves/ovens, list size capacity and volume information, list energy source and efficiency ratings if provided]</p>

	<ul style="list-style-type: none">• One standard size reffridgerator• One microwave owen• One 360 W rice cooker• One blender• One toaster 
Cooling Equipment	<p>[list type of air conditioner present, capacity, and COP/EER as labeled, list the % of building area that is conditioned]</p> <ul style="list-style-type: none">• One 8,000 BTU split unit 
Fans	<p>[List number and types of ceiling and space fans in unit]</p> <ul style="list-style-type: none">• Two ceiling fan/light combinations

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	<p>purchases here]</p> <ul style="list-style-type: none"> - Only butane fuel use, and refill average 1/2 tank, 50 lb every three months
Occupants	<p>[List number of occupants, ages, typical daily schedules for occupancy and cooking]</p> <p>Cook: Every other day</p> <p>No. of Occupants: 2 , Ages 66 yrs and 24 yrs</p> <p>Schedule:</p> <ul style="list-style-type: none"> - Personal/Business Errand in the morning - Home in the afternoon / evening
Building Shell	<p>[wall, doors and roofing construction materials, color, photograph building exterior, use of exterior shads etc.]</p> <ul style="list-style-type: none"> - Walls – wooden - Roofing – Zinc - Doors – wooden - Color - Green
Area and no. of floors	<p>[list building area in square footage, list floors above and below grade]</p> <p>Area: Approximately 459 square ft (18' x 25.5')</p> <p>Upper flat</p>
Windows	<p>[provide # of windows and approximate area, photograph typical window]</p> <ul style="list-style-type: none"> - Two double – 48h x 58w - Four single – 48h x 30w - One kitchen – 29wx29.5h - One bathroom - Total Area ~90 sq. ft. <div style="text-align: center;">  </div>
Lighting	<p>[Record typical bulb & ballast types, number and wattage, photograph typical lighting]</p>

<p>systems</p>	<p>Lights: four incandescent 60 w each</p> 
<p>Domestic Hot Water</p>	<p>[list type, capacity of water heater, list devices, capacity of devices using HW sincluding shower gpm flowrates, take photographs]</p> <p>None.</p>
<p>Appliances</p>	<p>[provide general descriptions of refrigerators, dishwashers, clothes water/dryer, and stoves/ovens, list size capacity and volume information, list energy source and efficiency ratings if provided]</p> <ul style="list-style-type: none"> - One refrigerator (378kwh/hr) - One washing machine (used once/year) - One micorwave rated at 0.95kw - Blender – not in use - Coffee maker – not in use - Toaster – not in use
<p>Cooling Equipment</p>	<p>[list type of air conditioner present, capacity, and COP/EER as labeled, list the % of building area that is conditioned]</p> <p>None.</p>
<p>Fans</p>	<p>[List number and types of ceiling and space fans in unit]</p> <ul style="list-style-type: none"> - One Standing fan
<p>Plug Load</p>	<p>[identify types of equipment plugged in, e.g. small appliances, computers etc.]</p> <ul style="list-style-type: none"> - Blender - One television - One radio / CD combination
<p>Other Notes</p>	<ul style="list-style-type: none"> - Water Flow Rate: 1:12 / 1 Gallon - Occupant also has 5 one room apartments one utility bill so amopunt will reflect hers and the tenant consumption.

Area and no. of floors	[list building area in square footage, list floors above and below grade] <ul style="list-style-type: none">- Area – 50' x 24' = 1200ft²- Upper flat Only
Windows	[provide # of windows and approximate area, photograph typical window] <p>Window count</p> <ul style="list-style-type: none">- Total 13 (includes a combination of double, single and bathroom)- All wooden louvers- Roughly 138 ft² total 
Lighting systems	[Record typical bulb & ballast types, number and wattage, photograph typical lights] <p>Lighting Types</p> <ul style="list-style-type: none">- Ten 1x20Watts Fluorescent (T-12 tubes)- Two 13 watts CFL

	
<p>Domestic Hot Water</p>	<p>[list type, capacity of water heater, list devices, capacity of devices using HW including shower gpm flowrates, take photographs]</p> <p>None.</p>
<p>Appliances</p>	<p>[provide general descriptions of refrigerators, dishwashers, clothes water/dryer, and stoves/ovens, list size capacity and volume information, list energy source and efficiency ratings if provided]</p> <ul style="list-style-type: none"> - One refrigerator (4.5 amps) refrigerant 134 A - One microwave - One small electric oven, counter top - One standard capacity washer - One water pump
<p>Cooling Equipment</p>	<p>[list type of air conditioner present, capacity, and COP/EER as labeled, list the % of building area that is conditioned]</p> <p>None.</p>
<p>Fans</p>	<p>[List number and types of ceiling and space fans in unit]</p> <ul style="list-style-type: none"> - Five standing fans - Five ceiling fans (four without light) and (one with 4-60watts incandescent bulbs)
<p>Plug Load</p>	<p>[identify types of equipment plugged in, e.g. small appliances, computers etc.]</p> <ul style="list-style-type: none"> - One blender - One Television - One Radio
<p>Other Notes</p>	<ul style="list-style-type: none"> - Butane average at 3-1/2 months / 100 lb cylinder - Construction started 1979 and upon completion entire structure was timber - Occupant began to change to concrete after wood lice infestation - Occupant uses rain water for washing 95% of the time - 20% for bathing hence the water pump

	- Water pump about 30 years old.
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C.7.6 #6 Flowers St, Belmopan City

Building Address #6 Flowers St, Belmopan City

BEL Customer Number: 09925036 Jackie Joseph

Date of Visit: September 17, 2013

Written By: Emory K Bennett, YEC Ltd.

Residential Unit Type: single or multi-family

Observations:

Item	Observation
Energy Use	<p>[Ask resident for a copy of a BEL invoice, and record the customer at the top of this page. Also inquire about butane and other fuel use, record typical monthly electricity and butane purchases here]</p> <ul style="list-style-type: none"> - 3 butane refills per year 100lb and 50lb tanks - Typical monthly bill approximately \$145 - \$175 per month
Occupants	<p>[List number of occupants, ages, typical daily schedules for occupancy and cooking]</p> <ul style="list-style-type: none"> - 2 persons occupant: 1 person < 45 years old, 1 person <15 years old
Building Shell	<p>[wall, doors and roofing construction materials, color, photograph building exterior, use of exterior shads etc.]</p> <ul style="list-style-type: none"> - Roof – metal on timber frame - Walls – plastered masonry <div style="text-align: center;">  </div>

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Area and no. of floors	[list building area in square footage, list floors above and below grade] <ul style="list-style-type: none">- Ground Floor – 23 ft x 32 ft- Top Floor – 19 feet x 32ft x 2 ft
Windows	[provide # of windows and approximate area, photograph typical window] French Glass Windows <ul style="list-style-type: none">• 10 – dbl. 30” x 60”• 3 – sgl. 30” x 60”• 2 – 24” x 24” 
Lighting systems	[Record typical bulb & ballast types, number and wattage, photograph typical lightis] <ul style="list-style-type: none">- Compact flourescent bulbs 
Domestic Hot Water	[list type, capacity of water heater, list devices, capacity of devices using HW sincluding shower gpm flowrates, take photographs] <ul style="list-style-type: none">- Butane Hot water heater

Appliances	<p>[provide general descriptions of refrigerators, dishwashers, clothes water/dryer, and stoves/ovens, list size capacity and volume information, list energy source and efficiency ratings if provided]</p> <ul style="list-style-type: none">- 1 refrigerator- 1 microwave- 1 rotisserie oven- 1 blender- 1 crock pot- 1 rice cooker- 1 washing machine- 1 clothes dryer    
Cooling Equipment	<p>[list type of air conditioner present, capacity, and COP/EER as labeled, list the % of building area that is conditioned]</p> <ul style="list-style-type: none">- 1 split AC unit (AC 900 DTU)- 2 ceiling fans

Shell	[exterior shads etc.] <ul style="list-style-type: none">• 2-stories• Walls – wood• Floor – wood• Roof – metal sheeting on wood framing 
Area and no. of floors	[list building area in square footage, list floors above and below grade] <ul style="list-style-type: none">• Downstairs: 324 square feet• Upstairs: 324 square feet
Windows	[provide # of windows and approximate area, photograph typical window] <ul style="list-style-type: none">• Six 30"x60" sliding glass windows upstairs• Four 30"x60" wood louvers downstairs 
Lighting systems	[Record typical bulb & ballast types, number and wattage, photograph typical lightis] <ul style="list-style-type: none">• Four 1x20W fluorescent fixtures

	
Domestic Hot Water	<p>[list type, capacity of water heater, list devices, capacity of devices using HW sincluding shower gpm flowrates, take photographs]</p> <ul style="list-style-type: none">• None
Appliances	<p>[provide general descriptions of refrigerators, dishwashers, clothes water/dryer, and stoves/ovens, list size capacity and volume information, list energy source and efficiency ratings if provided]</p> <ul style="list-style-type: none">• Whirlpool washing machine – 4 years old• GE small refridgerator (3.6A, 120V)• Osterizer Blender (390W)• Chopper (135W)• Juicer (400W)• Toaster (800W)   

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Building Shell	<p>[wall, doors and roofing construction materials, color, photograph building exterior, use of exterior shades etc.]</p> <ul style="list-style-type: none">• Single Story• Walls – plastered concrete masonry – no insulation• Floor – tiled concrete• Roof – metal sheeting on wood framing – no insulation 
Area and no. of floors	<p>[list building area in square footage, list floors above and below grade]</p> <ul style="list-style-type: none">• Main Residence 984 square feet• Washroom / Storage Area 510 square feet
Windows	<p>[provide # of windows and approximate area, photograph typical window]</p> <ul style="list-style-type: none">• Three Double 30”x48” glass louvers• Two Single 30”x48” glass louvers• One Double 30”x24” glass louvers• Three Single 24”x24” glass louvers (one is in Washroom)• Two 36”x48” fixed plexiglass in washroom
Lighting systems	<p>[Record typical bulb & ballast types, number and wattage, photograph typical lightis]</p> <ul style="list-style-type: none">• Twelve 11 W compact fluorescent fixtures• One 1x40W Fluorescent fixture 

<p>Domestic Hot Water</p>	<p>[list type, capacity of water heater, list devices, capacity of devices using HW including shower gpm flowrates, take photographs]</p> <ul style="list-style-type: none">• Two 3,850 W 35A 127V point of source shower heaters 
<p>Appliances</p>	<p>[provide general descriptions of refrigerators, dishwashers, clothes water/dryer, and stoves/ovens, list size capacity and volume information, list energy source and efficiency ratings if provided]</p> <ul style="list-style-type: none">• One Mabe refrigerator (378 kWh)• One 1.35 kW Daewoo microwave oven (~1 yr old)• One 900 W Oster rotisserie roaster (~2 yrs old)• One 390 W Osterizaer Blender (> 5 yrs old)• One 700 W rice cooker• One 4-burner Frigidaire electric stove w/ burner (new, not yet used) (model not indicated, but see attached “typical specification” for two models of 30” Frigidaire electric upright stove/ovens)• 28-Amp 120V Whirlpool dryer• 11.5-Amp 120V Admiral Washer (model AAV8000AWW)• One Whirlpool Refridgerator• One 85 W Brother sewing machine  <p>Electric Stove</p>  <p>LPG Stove</p>

	 <p>Washer & Dryer</p>  <p>Refrigerator</p>  <p>Microwave</p>  <p>Rotisserie</p>
Cooling Equipment	[list type of air conditioner present, capacity, and COP/EER as labeled, list the % of building area that is conditioned] <ul style="list-style-type: none">• None
Fans	[List number and types of ceiling and space fans in unit] <ul style="list-style-type: none">• Two Ceiling Fans c/w lights• One standing fan

	
Plug Load	<p>[identify types of equipment plugged in, e.g. small appliances, computers etc.]</p> <ul style="list-style-type: none">• One 1200W iron• One 5A-AK 340 Panasonic Stereo• One Panasonic combination VHS/DVD player (energy star designation)• One JWin DVD player• One 210 kW/h (180 W) Samsung flatscreen TV• One 75 W 18" Samsung CRT TV (9 yrs old)   

	
Area and no. of floors	[list building area in square footage, list floors above and below grade] - Single Story, ~600 sq. ft.
Windows	[provide # of windows and approximate area, photograph typical window] - Sliding glass 
Lighting systems	[Record typical bulb & ballast types, number and wattage, photograph typical lights] - Typical: 20W Flourescent lights

	
Domestic Hot Water	<p>[list type, capacity of water heater, list devices, capacity of devices using HW sincluding shower gpm flowrates, take photographs]</p> <ul style="list-style-type: none">- 20-gal LPG heater 
Appliances	<p>[provide general descriptions of refrigerators, dishwashers, clothes water/dryer, and stoves/ovens, list size capacity and volume information, list energy source and efficiency ratings if provided]</p> <ul style="list-style-type: none">- Microwave- Refrigerator- Washer- LPG Stove
Cooling Equipment	<p>[list type of air conditioner present, capacity, and COP/EER as labeled, list the % of building area that is conditioned]</p> <ul style="list-style-type: none">- No Air condition

	<ul style="list-style-type: none"> - 6 ceiling fans
Fans	<p>[List number and types of ceiling and space fans in unit]</p> <ul style="list-style-type: none"> - 6 ceiling fans <div style="text-align: center;">  </div>
Plug Load	<p>[identify types of equipment plugged in, e.g. small appliances, computers etc.]</p> <ul style="list-style-type: none"> - 2 laptops - 1 DVD player - 1 42" flat screen television - 1 wii game console - 1 blender - 1 hand mixer - 1 food processor - 1 blow dryer - 1 curling iron - 1 clothes iron
Other Notes	

C.7.10 #8 Airport Camp Road, Ladyville Village, Belize

BEL Customer Number: 00084278

Date of Visit: October 24th 2013

Written By: Carlton N. Young, YEC Ltd.

Residential Unit Type: single or multi-family

Observations:

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Item	Observation
Energy Use	<p>[Ask resident for a copy of a BEL invoice, and record the customer at the top of this page. Also inquire about butane and other fuel use, record typical monthly electricity and butane purchases here]</p> <ul style="list-style-type: none"> - Electricity Usage: avg. 186 kWh per month - Butane Tank approx... 50 gal lasts about 6 months
Occupants	<p>[List number of occupants, ages, typical daily schedules for occupancy and cooking]</p> <ul style="list-style-type: none"> - 3 occupants – 22 years, 42 years, and 80 years old - Cook once per week
Building Shell	<p>[wall, doors and roofing construction materials, color, photograph building exterior, use of exterior shades etc.]</p> <ul style="list-style-type: none"> - 6-Inch concrete masonry walls - Roof of metal sheeting on timber framing - Hardboard ceiling, no insulation <div data-bbox="583 890 1203 1352" style="text-align: center;"> </div>
Area and no. of floors	<p>[list building area in square footage, list floors above and below grade]</p> <ul style="list-style-type: none"> - 1 floor = 600 square feet
Windows	<p>[provide # of windows and approximate area, photograph typical window]</p> <ul style="list-style-type: none"> - 11 24" x 48" aluminum louver windows - 1 24" x 24" aluminum louver window

	
Lighting systems	[Record typical bulb & ballast types, number and wattage, photograph typical lightis] - 20-Watt flourescent bulbs typically
Domestic Hot Water	[list type, capacity of water heater, list devices, capacity of devices using HW sincluding shower gpm flowrates, take photographs] - No water heater
Appliances	[provide general descriptions of refrigerators, dishwashers, clothes water/dryer, and stoves/ovens, list size capacity and volume information, list energy source and efficiency ratings if provided] - 1 small MABE Reffrigerator – 5 years old - 1 whirlpool Microwave - 1 pop up toaster - 1 Whirlpool washing machine – 5 years old  

	
Cooling Equipment	[list type of air conditioner present, capacity, and COP/EER as labeled, list the % of building area that is conditioned] - No Air Conditioning
Fans	[List number and types of ceiling and space fans in unit] - No ceiling fans. - Only standing fans (see photo). 
Plug Load	[identify types of equipment plugged in, e.g. small appliances, computers etc.] - 1 18" Television (RCA Flatscreen) - 1 Sony DVD boombox
Other Notes	



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