Energy Demand Assessment

For Jamaica's Commercial And Residential Sector

MARCH 2020

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Energy Demand Assessment Report

For Jamaica's Commercial And Residential Sector

The University of the West Indies, Institute for Sustainable Development "LGGE Promoting Energy Efficiency & Renewable Energy in Buildings in Jamaica"

With the financial support of the Global Environmental Facility (GEF) and the technical assistance of the United Nations Environment Programme (UNEP)

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March 2020

Notice to Reader

This assessment and subsequent report were completed before the Covid-19 Pandemic, and its impact on Jamaica. All projections, forecasts and recommendations made in this document were developed exclusively from historical data, trends and patterns identified from sources listed in the References section, as well as from the author's own experience in the energy industry.

It is clear that the Covid-19 pandemic impact on Jamaica will negatively affect all economic and related projections in the near future. This report assumes that Jamaica will eventually return to its pre-Covid-19 economic development trajectory.

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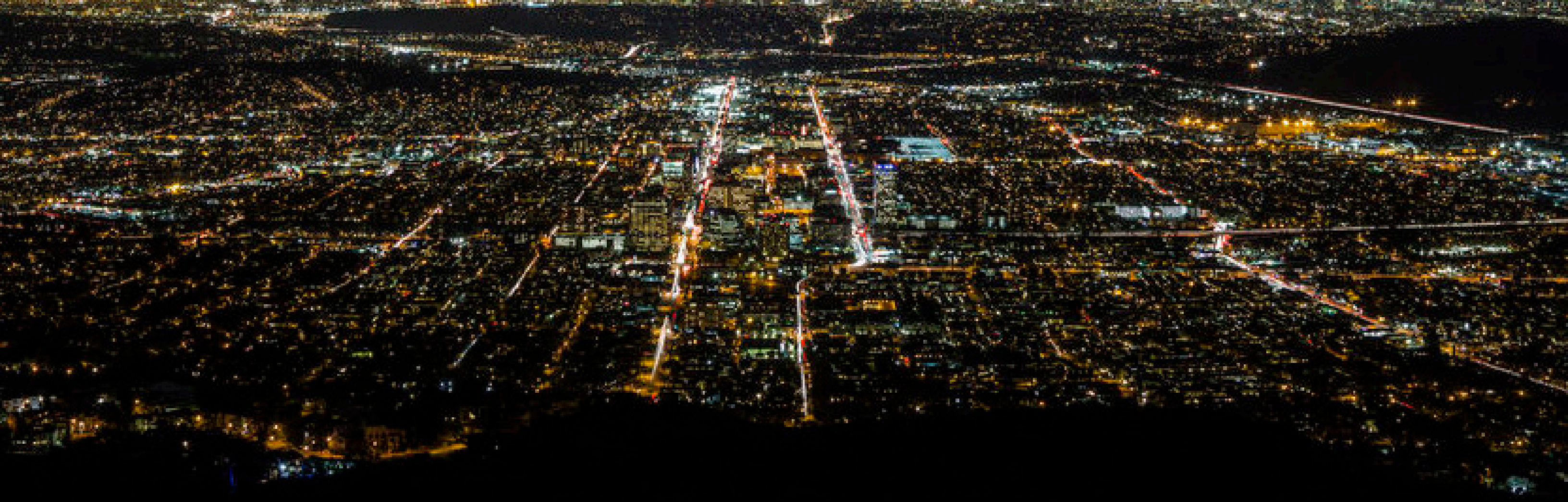
GLOSSARY

A	Amps
AC	Alternating Current
A/C	Air Conditioner
AEE	Association of Energy Engineers
ASHRAE	American Society of Heating, Refrigerating and Air-conditioning Engineers
BBI	Barrels
BTU	British Thermal Unit
CBECS	Commercial Buildings Energy Consumption Survey
CBD	Could not be Determined
CFL	Compact Fluorescent Lamps
CHP	Combined Heat and Power
CO2	Carbon Dioxide
COP	Coefficient of Performance
DBJ	Development Bank of Jamaica
DC	Direct Current
DECs	Display Energy Certificates
DSM	Demand Side Management
EC	Energy Conservation
EE	Energy Efficiency
EER	Energy Efficiency Ratio
EMP	Energy Management Programme
EMR	Energy Management Recommendation
EPA	Environmental Protection Agency
EPC	Energy Performance Certificates
EUI	Electricity Use Intensity
ft.	Unit of length, foot
GDP	Gross Domestic Product
GJ/yr	Giga-Joule per year
HC	Hydrocarbon
HFC	Hydrofluorocarbon
JCA	Jamaica Customs Agency
JPSCo	Jamaica Public Service Company
kJ	kilo-Joule
IEER	Integrated EER
IPP	Independent Power Producer
IRR	Internal Rate of Return (%)
k	Thermal conductivity (W/mK)
KVA	Kilo Volt-Amps
kW	kilo-Watt
kWh	kilo-Watt hour
LCOE	Levelized Cost of Electricity
LED	Light Emitting Diodes
M&V	Measurement & Verification
MJ	Mega-Joule
MWh	Mega-Watt hour
N/A	Not Applicable
NEMA	National Electrical Manufacturers Association
O2	Oxygen
OUR	Office of Utilities Regulation
PF	Power Factor
PV	Photovoltaic
RE	Renewable Energy
ROI	Return on Investment
SET	Sustainable Energy Technologies
SEER	Seasonal EER
SIDS	Small Island Developing States
SME	Small to Medium Enterprises
SWH	Solar Water Heater
THD	Total Harmonic Distortion
V	Volts
VFD	Variable Frequency Drive
VSD	Variable Speed Drive
VRF	Variable Refrigerant Flow
W	Watts
W/m2	Watts per meter squared



"Jamaica's residential and commercial sectors are responsible for approximately 88% of total electricity consumption."

1. Overview

Jamaica, with a population of 2.9 Million as of 2018 (World Bank Group 2019c) has seen consistent growth in its GDP over the past 5 years (2014 – 2018), with an annual average growth of 1.2%; compared to the previous 5 years (2009 – 2013) which had an average annual growth of -0.84% (World Bank Group 2019a). Statistics taken from the Jamaica Public Service Company's (JPSCo) annual reports have also shown that Jamaica experienced an average reduction in its overall demand for electrical energy by 0.7% during the 2009 – 2013 period; with the residential sector accounting for the bulk of this reduction at 1%. In contrast, Jamaica experienced an average increase in demand for electrical energy by 0.9% during the 2014 – 2018 period; with the residential sector again accounting for the bulk of increase at 1.3%.

The above data serves to confirm a direct relationship between Jamaica's growth and its demand for electrical energy from the utility (JPS); that is, a growing Jamaica demands more electrical energy from the grid[1]. With growth expected to accelerate to an average of

Figure 1.1 GDP Growth vs Energy Demand Growth

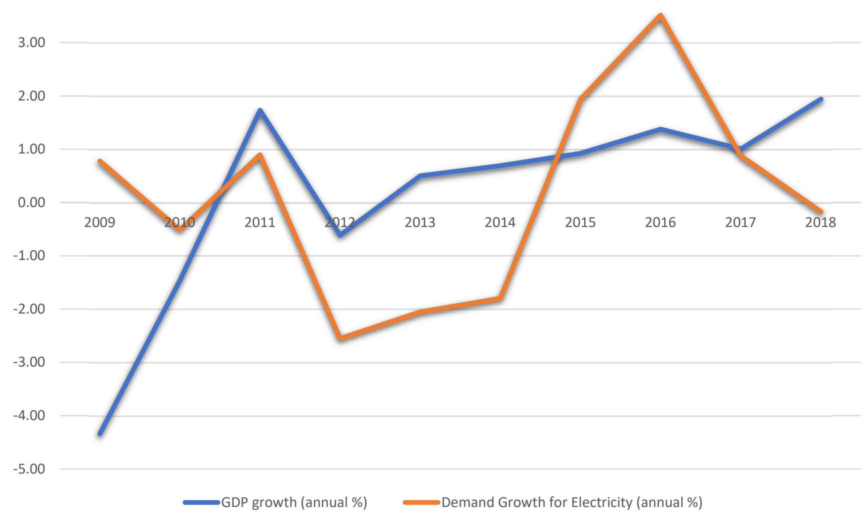


Table 1.1 JPSCo Energy Sales Growth Rate

ENERGY SALES (MWH)	2013	2012	2011	2010	2009	Avg
Residential	-3.8%	-2.7%	-2.4%	0.7%	3.3%	-1.0%
Total Commercial	-1.3%	-2.6%	2.8%	-1.4%	-0.4%	-0.6%
Total	-2.1%	-2.6%	0.9%	-0.5%	0.8%	-0.7%

ENERGY SALES (MWH)	2013	2012	2011	2010	2009	Avg
Residential	-0.5%	-0.8%	6.0%	3.5%	-1.5%	1.3%
Total Commercial	2.4%	1.1%	2.2%	1.3%	-1.4%	0.5%
Total	-0.2%	0.9%	3.5%	1.9%	-1.8%	0.9%

JPSCo Energy Sales (MWH) Growth Rates (JPSCo Ltd. 2014, JPSCo Ltd. 2019)

1. This is in part a measure of the relatively high inefficiencies in transmission, distribution and consumption of electricity; and relatively low economic productivity of energy use in Jamaica.

2% over the medium term (World Bank Group 2019a) and sustained, it is reasonable to expect that demand for electrical energy from the grid will also accelerate. If not managed properly, increased demand for electricity may have implications on our US Dollar reserves and the US exchange rate, security of energy supply, and climate change[2]– on a national level; cost for supply of electricity and business competitiveness on a personal (residential or commercial) level.

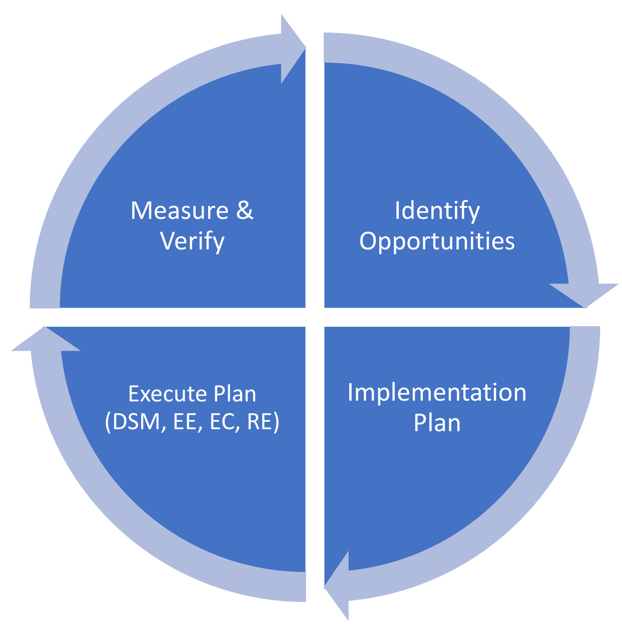
The argument of managing demand for electricity is particularly critical for buildings (residential and commercial), considering that studies carried out between 2006 and 2010 had revealed that public sector energy use represents only approximately 12% of total electricity consumption in Jamaica (Government of Jamaica 2019), which indicates an 88% share for residential and commercial use. Though more current figures could not be sourced, it is reasonable to conclude that an effective and sustainable management plan for residential and commercial electricity demand and use, would result in the most significant economic and environmental benefits for Jamaica. This consultancy is seeking to identify and detail the opportunities to achieve such a management plan, and the appropriate incentive structure for support.

2.0 An Energy Management Plan (EMP)

An effective and sustainable energy management plan (EMP) is one that combines demand side management (DSM), energy efficiency, self-generation using clean alternate fuels such as solar and wind, and Measurement and Verification (M&V) to ensure desired results are being achieved. DSM, as the name suggests, focuses on electricity demand which is represented as Watts (real power) or Volt-Amps (apparent power). In Jamaica, electricity demand is represented as kVA on a JPSCo demand Rate bill. A good DSM program keeps a relatively high load factor (>60%), high power factor (>85%), and shifts demand (and consumption) to off-peak periods where it is practical and advantageous to do so. The result and ultimate goal is a reduced demand cost on the bill. Energy efficiency (EE) focuses on consumption and involves implementing technologies that require less electrical input while giving the same required output. A good EE program, if implemented properly in targeted facilities, will often reduce electricity consumption by at minimum 15 to 25%[3]. After DSM and EE initiatives are implemented, a self-generation solution is designed and tailored to the demand profile of the targeted facility. With very few exceptions, these systems are often solar based – as a result of Jamaica's relatively high solar irradiance[4], ease of implementation and maturity of the technology, modularity and increasingly competitive LCOE[5]. The share of electricity demand that such systems can offset from the grid is dependent on the availability of space and capital, with some facilities opting to generate 100% of their power[6]. M&V lastly, ensures that targets set during the planning and execution of all the above interventions, are being met. Where targets are not being met, it allows for deliberate and objective adjustments and modifications, ensuring optimum returns on investment for the overall energy management programme.

Effective energy management programmes are developed by qualified energy professionals with specific training and experience in energy auditing and energy management in a combination of different type of facilities with different core functions.

Figure 2.1 Energy Management Plan Cycle



2. Assuming continued dependence on imported hydrocarbons. The Jamaican government has articulated a vision for 50% renewables and 50% hydrocarbons mix into the grid by 2030, though current policy targets are set at 30% renewables in the energy mix by 2020.

3. Having completed over 80 energy audits covering residential and commercial facilities, the minimum savings often identified from energy efficiency measures is between 15% to 25%.

4. Jamaica experiences 4.54 – 6.44 kWh/m2/day of solar irradiance. (Greenstream Publishing 2019)

5. The latest study published by the International Renewable Energy Agency says the average solar electricity cost of $0.085/kWh produced by projects commissioned in 2019 is set to fall to $0.048 in 2020, and $0.02-0.08 by 2030. (Bellini 2019)

6. Some large international corporations like Wal-Mart and Apple are seeking to do just that. https://sunbadger.com/7-companies-with-commercial-solar-panel-systems/

The DBJ has loaned over $3 billion Jamaican Dollars to SMEs for EE and RE projects, since 2010.

3.0 The Current Scenario

3.1 INTERVENTIONS

Jamaica has made significant strides towards managing energy demand and use in our commercial and residential sectors. In 2011, the Jamaica Energy Security and Efficiency Enhancement Project was approved by the Government of Jamaica (Government of Jamaica 2019). This project, developed and funded by The World Bank, contributed to the following energy demand and use management results by end of 2017:

- Expanded and refurbished energy efficiency testing chambers aided compliance with the country's new energy efficiency standards.
- Through the Development Bank of Jamaica (DBJ) line-of-credit, 55 loans, totaling US$5.38 million, were disbursed for private sector energy efficiency projects.

Under the DBJ line-of-credit, a private sector financing market was created, leading 12 additional lenders to participate by extending financing for energy efficiency and renewable energy of 3.08 billion Jamaican dollars (approximately US$28 million). *(World Bank Group 2019b)*

Table 3.1 DBJ Approved energy loans since 2010

Year End	No. of Loans	Project Cost (J$)	Loan Approved (J$)
Mar-10	5	68,725,000	68,725,000
Mar-11	5	135,089,683	58,326,800
Mar-12	7	506,617,000	174,500,000
Mar-13	75	2,094,871,499	658,026,425
Mar-14	103	1,990,078,067	658,786,124
Mar-15	41	1,073,576,995	595,595,407
Mar-16	26	879,944,034	592,845,695
Mar-17	12	227,485,695	139,015,872
Mar-18	7	405,196,315	196,406,215
Mar-19	10	61,191,348	55,054,000
Mar-20	2	42,077,000	32,933,488
TOTAL	**293**	**$ 7,484,852,636**	**$ 3,230,215,026**

(Galbraith, Brown 2020)

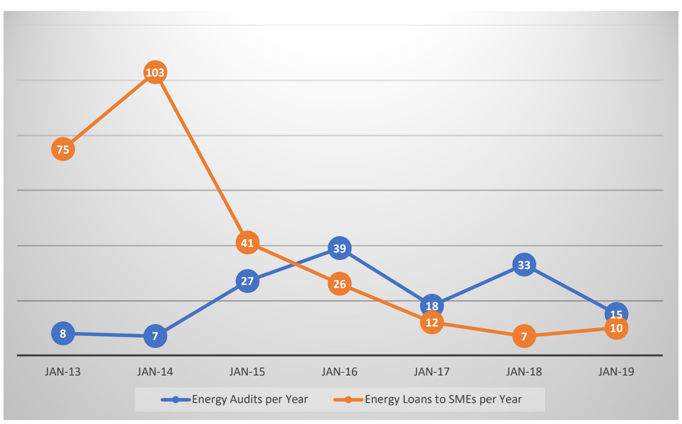
The DBJ indicated that these $3 Billion in loans has benefitted approximately 280 business to assist in reducing and managing their demand and energy consumption levels. The DBJ also gave credit to the PetroCaribe Fund and the Inter-American Development Bank for being able to achieve the above feat. *(McIntosh 2018)*

The antecedence of this DBJ line-of-credit goes back to fiscal year 2008/2009 when DBJ established an energy fund for SMEs. This initiative would eventually give birth to a multilateral funded energy programme to promote and facilitate EE and RE intervention in SMEs (Development Bank of Jamaica 2019). The programme includes grants up to $200,000 for level II energy audits, and up to $100,000 for Level I energy audits. This programme is currently still active, and the energy audits have been made a mandatory requirement for SME's to access their energy line-of-credit.

However, take up of this energy audit grant for SMEs has been relatively low, at an average 26 applications per year since 2013. This pales in comparison to the almost 70,000 SMEs that are registered customers of JPS as of 2018, and is a finding that suggests that most in the commercial and residential sector are aware and concerned about their electricity costs, but only a fraction are prepared to invest in a full EMP.

On the other hand, import data from the Jamaica Customs Agency (JCA) suggests that Jamaicans have had a strong growing demand for solar and wind systems, opting perhaps to bypass the other elements of an EMP as defined in section 2.0 above. A review of the JCA import data shows a fairly consistent growth in the import of DC/AC inverters from 2014 to 2019 by an average 62% per annum – from 29,000 inverters in 2014 to over 250,000 inverters in 2019[7].

Figure 3.1 Number of Energy Audits and Loans to SME's from DBJ per Year

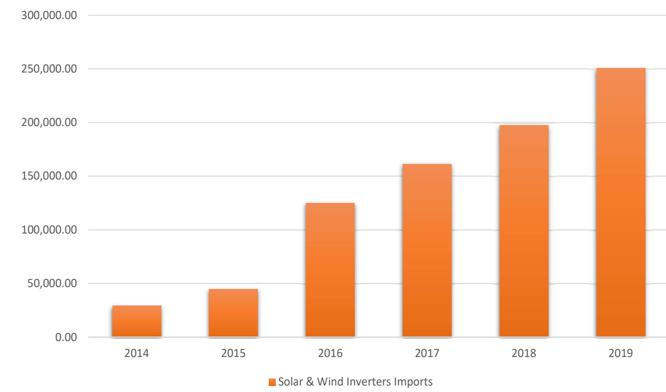


7. All solar and wind systems require an inverter. The assumption is made that each solar and wind system will have 1 – 4 inverters.

8. Residential and commercial EUIs were calculated using energy sales (MWh) and average number of customers from JPSCo 2018 and 2013 annual returns.

9. In fact, with the exception of years 2010 and 2014; JPSCo's annual returns show that their customer numbers have grown consistently from 2009 to 2018.

Figure 3.2 Solar and Wind Inverter Imports



Courtesy of JCA

3.2. THE RESULTS

These interventions, from 2008 to 2019, along with a general increased awareness among commercial and residential energy consumers, has led to some significant measurable results. For instance, a calculation of Jamaica's residential and commercial Electricity Use Intensities (EUI)[8] between the years 2009 to 2018 reveals that Jamaica has achieved a 13% and 9% overall reduction in respective residential and commercial EUIs over the period. The change in EUI for the residential and commercial sector, using JPSCo data; provides a rough measuring stick for gains in efficiency and increased self-generation over the period in question; since both (EE and self-generation) impact consumption from JPSCo but do not impact customer numbers[9]. Consequently, this EUI data suggest that Jamaica has achieved roughly 13% reduction in residential electricity demand and 9% reduction in commercial electricity demand – from the grid for the period 2009 to 2018. With this trend forecasted to 2025, an additional reduction of 14% and 9% in the respective residential and commercial sectors can be expected under a business as usual scenario. This is an average of just 2% and 1.3% reduction per year. Considering that 15% to 25% reduction is the minimum identified for energy efficiency interventions only (over a 1 year period), as indicated above in section 2.0, it is reasonable to conclude that Jamaica is performing significantly below its potential where electricity demand reduction is concerned. Most professionals would agree that this poor performance may be a combination of several variables including a lack of supportive government policies, a lack of competition, weak economic incentives, slow rate of technology adoption and the current fall in oil/fuel prices.

Figure 3.3 Residential EUI with 5 year forecast for Jamaica

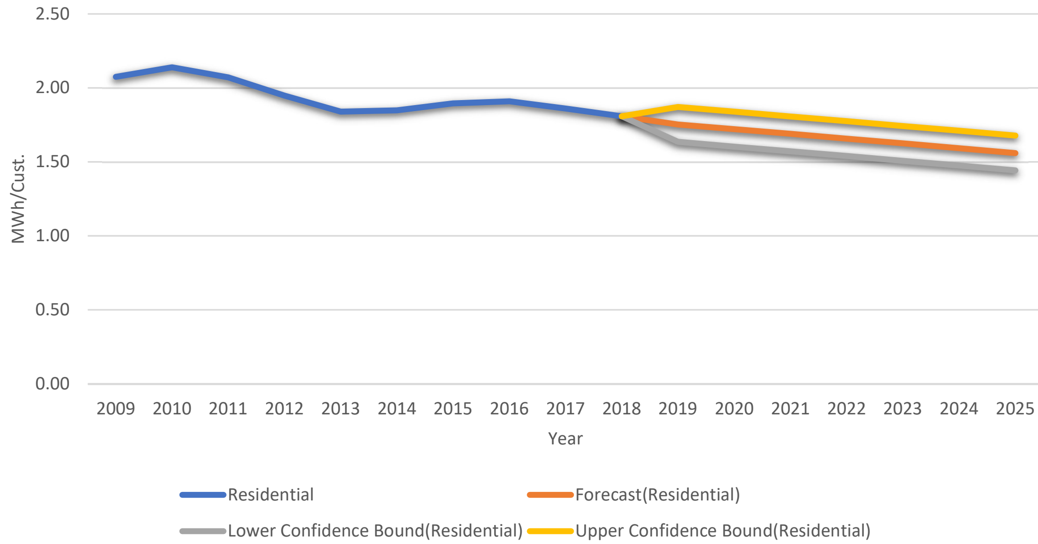
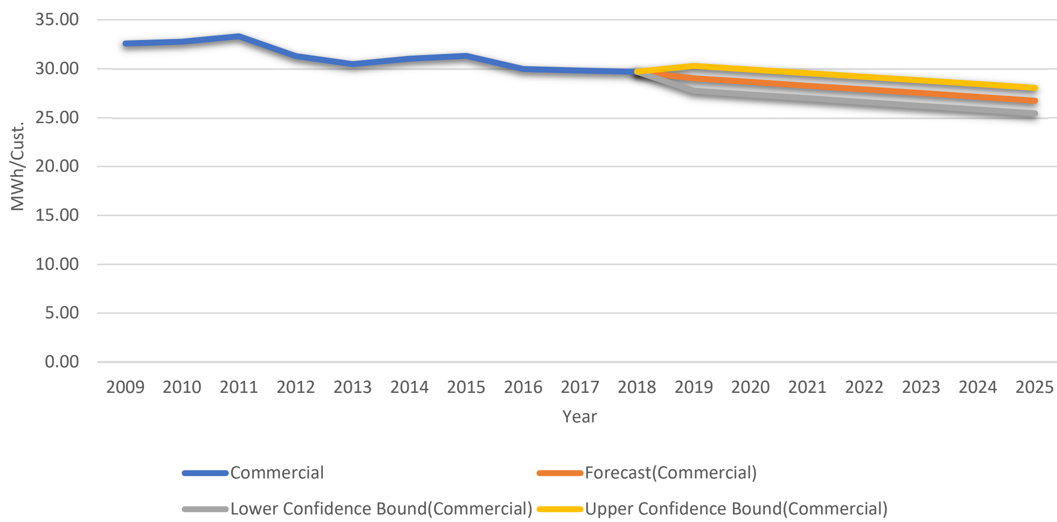


Figure 3.4 Commercial EUI with 5 years forecast for Jamaica



4.0 The Proposed Scenario

We must take into consideration that not all facilities/energy users (residential and commercial) will adapt measures to improve their EUI or energy performance for the following main reasons:

1. They are already performing well with respect to their energy use (relative to comparable EUI benchmarks)

2. They have prioritized energy performance of their facility below other areas they consider more critical

3. They have difficulty accessing the required capital to implement energy management recommendations (EMRs), OR in relation to the above; they believe the available capital is better spent elsewhere

With this in mind, and considering that the minimum savings often identified from energy efficiency measures is 15 to 25% as indicated in section 2.0 (EMP) above; This suggests that an average EUI (or total energy demand from the grid) of 10% (averaged) is achievable – across our residential and commercial sectors. To achieve an EUI or energy demand reduction of 10% or more in Jamaica's commercial and residential sectors, an effective EMP is needed with sufficient incentive to allow for national adoption. This must start with an energy audit completed by a certified energy manager or auditor (CEM/A) by the association of energy engineers (AEE); or a similar qualified and accredited energy professional. A properly done energy audit covers all critical areas known to drive demand and energy consumption and costs. It provides recommendations specific to each of these areas, all of which culminate to form an EMP for the entity in question.

4.1 Critical Areas for Demand and Energy Management

Having completed over 80 energy audits ranging from level 1 to level 3, from residential to commercial; the following areas have been identified as primary or critical areas for demand and energy management. These areas are also validated by most well-known and accepted energy auditing texts such as "Handbook of Energy Engineering. 6th edn", "Certified Energy Managers Handbook "and "Guide to Energy Management. 5th edn". Along with each area identified are energy management recommendation (EMR) that have proven to be mature, proven and practical.

4.1.1 Electric Bills/Billing Schedule

This is the first place an audit starts. Potential billing discrepancies and incorrect billing schedules are not as unique as one might think. While correction in billing discrepancies does not affect actual demand and/or energy consumption, it will affect demand and/or energy charges paid – which is one of the main objectives of an effective EMP. Consequently, the following energy management recommendations (EMRs) are common in this area:

- **Ensure appropriate billing Rate Schedule is being used.** Applicable only to commercial facilities. A commercial facility may find themselves paying as much as 12% more on their electricity charges if they are being billed through a billing rate schedule[10] that is not applicable or suited to their demand and load factor. This is a common misunderstanding among small commercial facilities that opt to stay on or install a residential billing rate schedule, with the belief that commercial billing rate schedules will cost them more.

4.1.2 Electrical Supply/Distribution

This area essentially represents the quality of power supply, distribution and the effective/efficient use of said power being received. Data here is collected mostly through logging apparatus, and requires an electrical background to adequately assess, analyze and interpret the data. The usual recommended EMRs in this area includes:

- **Correct grounding issues.** Grounding issues are more of a safety concern than they are an energy concern. Proper grounding is essential in protecting electrical equipment from overloads and allows for the efficient travel of electricity to its intended point of use. It is also essential in stabilizing voltage levels (important for sensitive electronics) and is a fundamental basis for most renewable energy generators.

- **Correct voltage imbalance.** This EMR is more directed to three phase supplies in which all three voltages should be no more than 5% within range of each other[11]. Voltage balance across phases is important in ensuring that three phase motors run at their designed efficiency. This EMR also covers issues of over-voltage or under-voltage, greater than 10%, which can also serve to reduce motor life and cause current surges which causes additional power usage. A line/power conditioner can be used to correct these issues in many cases. Correcting these issues can save in this area, up to 5% in energy consumption and extend equipment and motor life.

- **Improve power factor.** Facilities that are billed on a demand rate billing schedule are penalized by JPSCo for having a poor power factor. Power factor is a function of the reactive power generated by induction based loads, typically machinery with induction motors and magnetic ballasts. The higher the reactive power, the poorer the power factor. Assuming harmonics are within acceptable limits, power factor is usually corrected/improved through the application of capacitor banks at the main meter or at the source of high reactive power draw. Power factor correction is often a very cost-effective way to reduce demand charges at a facility. It is an option that should be explored however, after other EMR options are explored. The reason for this is that other EMR options may result in the change of equipment/technologies that may be a source of the low power factor being experienced by the facility. Consequently, the other EMRs listed in this report - particularly any EMR which results in the change, removal or modification of any motor, pump, magnetic ballasts and any other inductive loads; may give an additional benefit of improved power factor.

- **Reduce Total Harmonic Distortion (THD) to acceptable levels.** The facility management should ensure that THD is within acceptable levels (no greater than 5%) before any capacitor bank (power factor correction) is implemented.

10. JPSCo offers several billing rate schedule options to commercial and industrial customers, with each designed for the demand and service voltage expected. The larger the demand and service voltage, the lower the per unit charges for demand and energy consumption. (JPSCo Ltd. 2018)

11. Some three phase supplies (3ph), such as the 3ph delta configuration (also known as an Edison configuration), has what's regarded as a "high leg". The high leg voltage is 0.864 the value of the phase voltage.

THD checks may fall outside the scope of some energy audits; but the facility management can request that the auditing team carry out such checks. High THDs are known to increase the current in electrical systems and can be damaging to electrical equipment. THD can be addressed using harmonic filters.

4.1.3 Building Envelope and Insulation

The building envelope represents any structure that separates a conditioned space[12] from the outside. Insulation can be considered a sub-category of building envelope in some instances, but it is more accurately defined as any material (or combination thereof) designed to inhibit/resist heat transfer. The recommended EMRs in this area usually includes:

- **Use airtight sealed glass windows in air-conditioned spaces.** This is to prevent conditioned air loss by convection through openings in poor window seals, as well as convectional heat gain by the ingress of air through said openings. Both scenarios result in additional energy (kWh) consumption and possible increased demand (kVA) that must be offset by the air conditioning or cooling unit/s. This EMR can reduce air condition wastage by up to 10%.

- **Use skirting/strips to reduce air gaps (beneath and between doors).** For the same concerns listed above. This EMR can reduce air conditioning wastage by up to 5%.

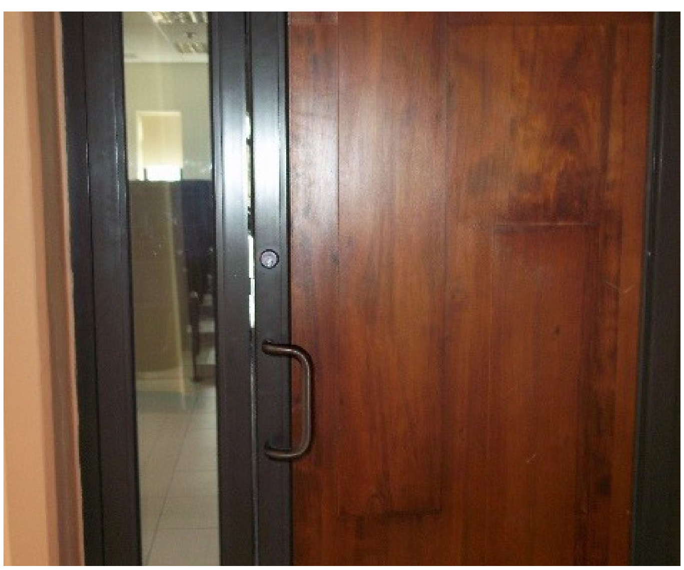
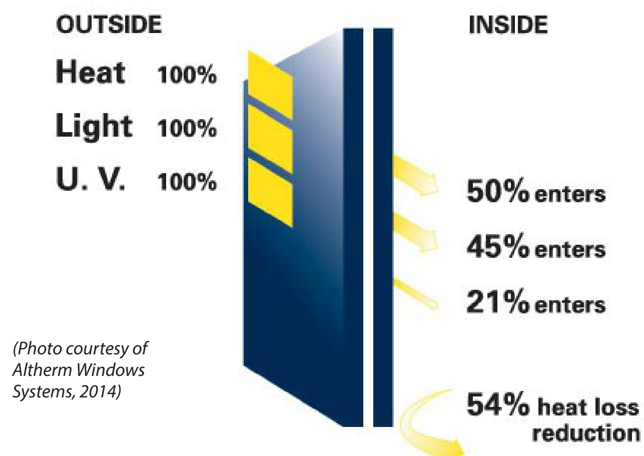


Figure 4.1 *Example of air gap between door and mull post*

- **Tint Windows or use windows with low heat gain.** Solar fenestration[13] is a common, but often unnoticed or unappreciated form of solar radiation heat gain into a space. Tables and charts have been made available by recognized energy-based institutions such as CIBSE (Chartered Institute of Building Services Engineers) to make determination of such heat gains relatively simple. This EMR can reduce cooling/air conditioning needs by up to 10%.

Figure 4.2 *Potential heat reduction from tinted low heat gain windows*



- **Improve Roofing Insulation.** A facility's roof can often be a facility's largest (building envelope based) source of heat gain in countries with tropical climates. This is because the roof often times has the greatest surface area, compared to other building envelope areas, and is a surface which encounters direct solar radiation. This EMR may simply be a reflective roof coating, or a combination of roof coating and heat conduction resistive based insulation (air gaps, special foams, etc). This EMR, depending on its scope of application, can save up to 40% in cooling/air conditioning.

Figure 4.3 *Example of coated roof in Kingston, Jamaica*

12. Any space that is being cooled, heated, lit or has its ambient conditioned being forcefully changed through energy consumption.
13. Reflection of the sun off an object adjacent to a window, into a space.

- **Improve wall insulation.** In the Caribbean, ambient temperatures typically rise as high as 33 deg C (Bateman 2020). An air-conditioned space, typically at 23 deg C gives a relatively small temperature delta between ambient and inside temperatures at just 10 deg C maximum. Heat conduction (type of heat transfer through solids such as walls) is directly proportional to this temperature delta where the bigger the delta, the greater the flow. For this reason, typical Caribbean wall construction – concrete walls (4" – 6" thick), Structurally Insulated Paneling systems (SIPs) and even wood have provided sufficient resistance to conductive heat transfer for air-conditioned rooms. On the other hand, cold and refrigerated rooms have internal temperatures ranging from -20 deg C to 4 deg C – a temperature delta of 29 deg C to 53 deg C. Materials specifically engineered to have high resistivity (R-value) to conductive heat transfer are required under these circumstances. Consequently, cold rooms should use engineered sandwich panels for walls and doors – such as polyurethane insulation core (PUR) or polyisocyanurate (PIR) which are the latest most efficient materials currently available on the market. Those facilities that employ walk in cold/cool rooms and that have refrigeration as a core part of their business, will find this area to be a particularly critical area in controlling electricity costs. Use of antiquated or inappropriate wall and door panels, as is often seen in many facilities, can result in significant cooling/refrigeration demands. Depending on the type of walls being replaced for a full cold room, this EMR can lead to a reduction in cooling energy from 6% - 20% (InspiraFarms 2019).

- **Insulate steam lines and chilled water lines.** Both offer benefits in regard to energy and safety. For steam lines, the loss of heat along the line is tantamount to the loss of fuel (being used in the boiler). Additionally, an uninsulated line can reach up to temperatures of 1000C and over. This is a hazard with respect to ignition, but more importantly to humans that may come in contact. For chiller lines, heat gain to the lines will result in additional load on the chiller's compressor, resulting in additional energy consumption. Additionally, uninsulated chiller lines will result in significant condensation as a result of their relatively cooler surface to the ambient environment. This in turn will lead to wet floors below such pipes, which can become a falling hazard. There is no set determination of savings for insulating both pipes, as it would depend on the amount of pipe in need of insulation.

Figure 4.4 *Example of some insulated chilled lines*

4.1.4 Lighting

This refers simply to the types of lights (lighting technology) being used and their hours of use. This area is often considered a low hanging fruit as it is one of the easiest areas to change and attend to. Recommended EMRs in this area tend to include:

- **Switching to more efficient lighting technology.** Most facilities tend to pay not much attention to upgrading their lighting, and consequently they often end up with old and obsolete technologies that only add to their electricity bill. Several new and more efficient lighting technologies have been developed over the past couple decades such as LEDs (Light Emitting Diodes) which make better substitutes to fluorescents. Up to 60% can be saved in lighting, depending on the scope of application and the type of lights being replaced under this EMR.

- **Occupancy sensors/switches.** These eliminate the human factor in lighting control and hence often work in reducing the hours of usage. This of course, results in savings on energy consumption. Sensors such as these have been known to save up to 10% in lighting. Passive Infrared (PIR) sensors are often the preferred technology to be applied in this case.

- **De-lamping.** An audit may reveal that a particular area is over lit. This is determined by comparing the measured lighting levels (lux) against set lighting level standards for certain types of activities or functions. This EMR is intended to reduce both demand (kVA) and energy usage (kWh) along with maintenance costs.

4.1.5. Refrigeration and Air Conditioning

Here is considered one of the most critical areas in developing an effective EMP, as it is often responsible for the largest share of demand and energy consumption in facilities located in tropical climates. This share of demand and energy consumption often ranges from 60% to 80%, depending on the type of operations at the facility. For this reason, it is imperative that primary importance be placed on ensuring that this area is as efficient as is practical and possible. Typical recommended EMRs for this area may include:

- **Change of Refrigerant.** An easy EMR to implement, but with caution as some new refrigerants, particularly hydrocarbon (HC) refrigerants, are known to be flammable and may pose a hazard under circumstances where a spark or source of ignition is very likely. Alternatively, HC refrigerants are known to reduce energy consumption on compressors[14] by as much as 20%.

Figure 4.5 *Refrigerant in an AC unit being changed*

- **Upgrade Units to Higher EER units.** The energy efficiency ratio (EER) is a metric that represents the efficiency of refrigeration and/or air conditioning units[15]. There are permeations of EER in the form of Seasonal Energy Efficiency Ratio (EER) and Integrated Energy Efficiency Ratio (IEER), which allows for other factors to be incorporated into the calculation of a unit's efficiency. There are set EER standards for different types of refrigeration and air conditioning setups. These can be found in most energy guides/standards such as "energy star", ANSI/AHRI standards and ASHRAE standards. Changing older refrigeration and air conditioning units to newer and more efficient units (with higher EERs) often results in saving of up to 35% in this area, on energy consumption.

- **Utilize occupancy sensors/switches.** Similar to lighting, these sensors can help to save by eliminating the human factor. Most ideal for conditioned offices or other conditioned spaces (with stand-alone/isolated cooling units) that are only occupied for a fraction of the day. These can save up to 20% an air conditioning energy use. Again, PIR sensors are the preferred occupancy sensor technology for such cases.

- **Utilize chiller units where applicable.** This EMR is directed towards large facilities that require industrial sized air conditioning units to cool large open spaces (BPOs, conference halls) as a single zone, or facilities that require large evaporator piping runs. Above a certain cooling capacity, water cooled condensers (i.e chiller units) are known to be more feasible and efficient than air cooled condensers. This is because water has a specific heat capacity approximately four times greater than that of air, and consequently will offer more cooling per square meter surface than air would. It must be above a certain capacity[16] however as the facility would have to offset addition recurring cost of water supply and treatment, and pump maintenance. Chiller units however, when implemented under the right circumstances, have been shown to save up to 20% on costs associated with air conditioning.

- **Utilize Variable Refrigerant Flow (VRF) units where applicable.** A type of air conditioning setup that has gained popularity in the last decade is the Variable Refrigerant Flow or Variable Refrigerant Volume (VRF/VRV) air conditioning system. VRF systems operate by using a central condensing unit to supply several evaporating units throughout a building – by varying the refrigerant flow through a "common" refrigeration piping system to each evaporating unit. This allows for independent control of temperature levels in the different spaces being conditioned. VRF systems have also integrated inverter or variable frequency drive technology into their com-

14. The compressor in a refrigeration or air conditioning system is the primary source of energy consumption. Fans are other items that use energy, but comparatively very little.
15. EER is American based. Europe tends to use Coefficient of Performance (COP) which essentially is EER divided by 3.42.
16. The minimum advised threshold is 10 Tons of cooling, or 120,000 BTU/hr

Figure 4.6 *Chiller system at University of West Indies, Mona Campus*

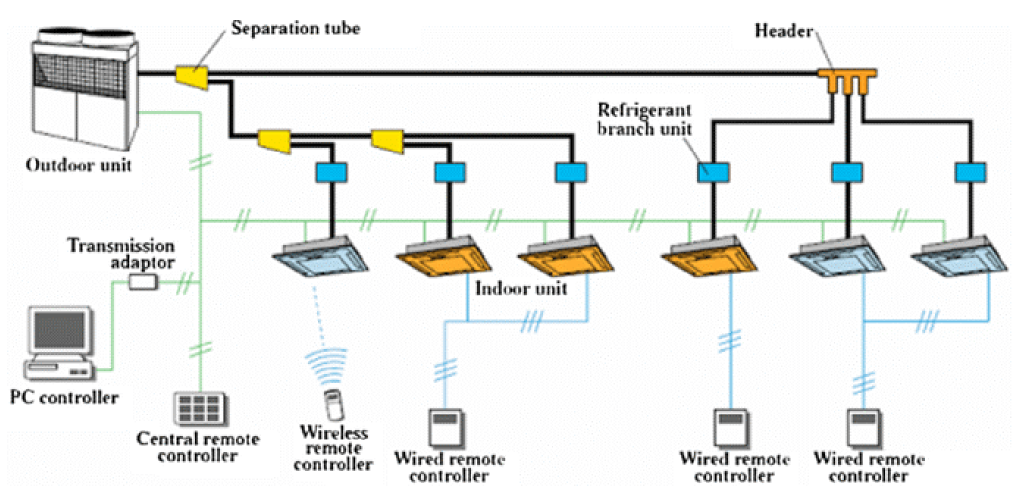
pressors, which allows for maximized efficiency at partial loads – resulting in achievable IEERs of 20 and up. This allows VRF systems to achieve air conditioning consumption savings up to 40% when used to replace a setup of multiple standard split units or standard central units.

- **Ensure condensers are clean and unobstructed.** For air cooled condensers, free and unobstructed circulation or air is critical to allow for adequate cooling. Otherwise, the condenser runs above its designed temperature which will serve to negatively affect its EER and add additional load on the compressor – using more energy and shortening compressor life. A blocked or obstructed condenser can result in a 10% increase in energy consumption of the unit, plus reduced life.

- **Utilization of Thermal Energy Storage (TES).** This EMR is only effective when used under a Time of Use (ToU) billing schedule/tariff. ToU billing schedules are designed to bill a facility at different rates during different time periods. These time periods are often divided into three distinct periods which include On-Peak, Off-Peak and Partial-Peak. On-Peak refers to hours, observed by the utility, to be the hours of highest demand and energy consumption; typically no more than 4 hours in a 24 hour period for small island developing states (SIDS). The highest rate, for demand and energy, is charged during these hours. Off-Peak refers to hours, observed by the utility, to be the hours of lowest demand and energy consumption; typically from late at night to early morning when most of the population should be asleep. This is typically no more than 8 hours in a 24 hour period for SIDS, and the lowest demand and energy rates are charged during this time. Partial-Peak, are the hours in-between On- Peak and Off-Peak, typically during the day (for SIDS) when demand and energy consumption is on average midway between peak and base. A demand and energy rate between On-Peak and Off-Peak is charged during this time. TES seeks to achieve savings through this billing structure by shifting, as much as possible, refrigeration and air conditioning loads away from on-peak hours to off-peak hours. The idea, in most instances, is that the refrigeration/cooling units will run at full capacity during off-peak hours. All this cooling energy will be stored in a sensible form (chilled water) or latent form (ice). During on-peak hours, the refrigeration/cooling units are either completely shut down, or allowed to run at a much lesser capacity while the majority or all of the cooling comes from storage. If

Figure 4.7 Typical VRF Setup

(Alahmer, Ali & Alsaqoor, Sameh 2017)



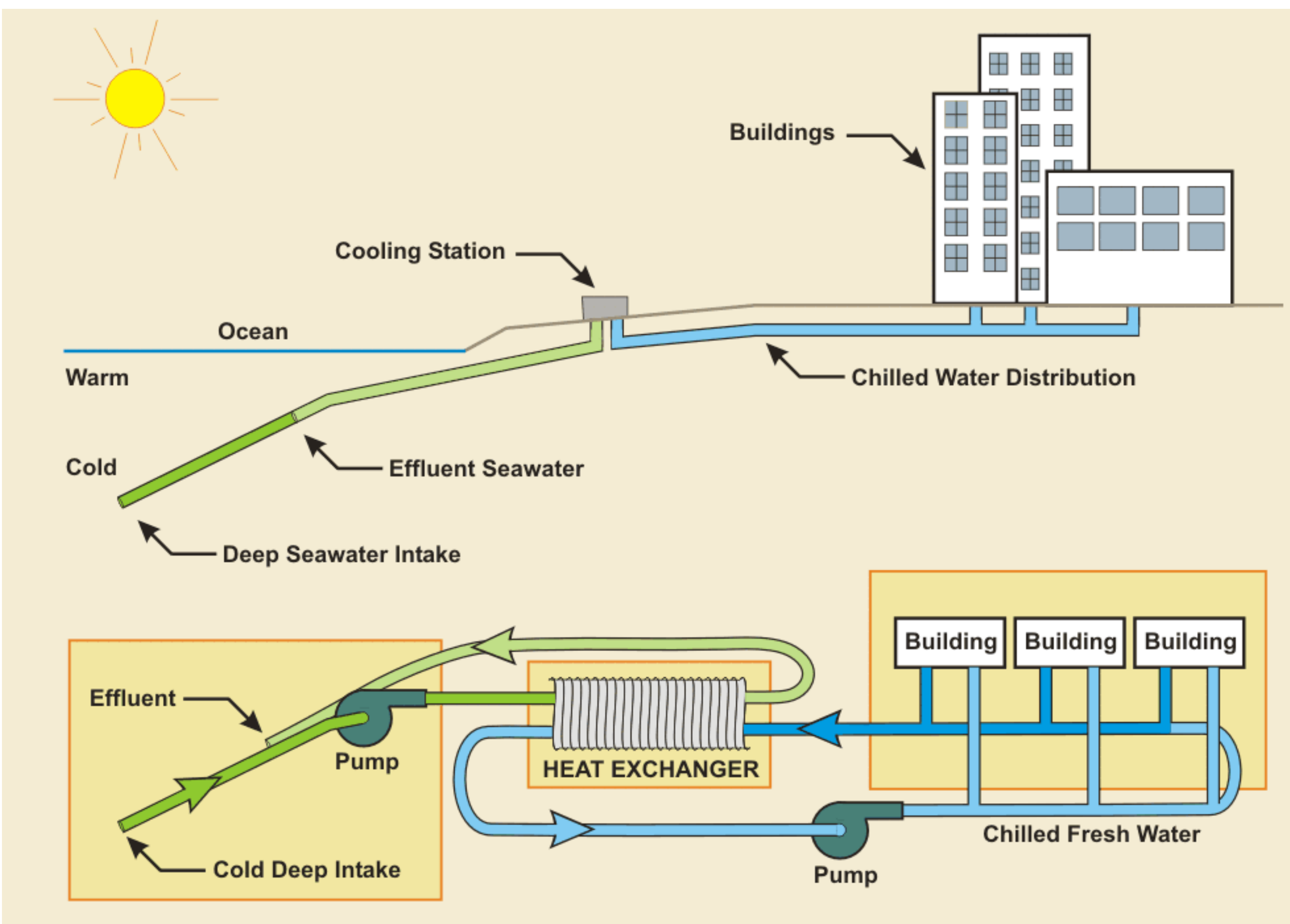
implemented correctly, a facility can save up to 55% on refrigeration and cooling. This EMR however, requires significant infrastructure and capital and hence is usually only recommended for new facilities that are about to be constructed; or facilities that are going through a major restructuring/rehabilitation.

- **Utilization of Sea Water Air Conditioning (SWAC).** Makai Ocean Engineering, leaders in SWAC design and implementation, defines SWAC as an alternate-energy system that uses the cold water from the deep ocean to cool buildings. This cold water is usually around 7-8oC and can be found at a depth of approximately 700m. SWAC[17] systems eliminate the need for chillers, and so they require only around 10% to 20% of the energy required for the same cooling. They can be used to cool a single large building, or several buildings on a cooling ring.

In a 2014 pre-feasibility study done by Makai Ocean Engineering that looked at the possibility of Montego Bay benefiting from a SWAC system (Makai Ocean Engineering 2015). The report found at the time that SWAC was economically viable and competitive against conventional air conditioning at several large cooling sites selected, though it indicated that more detailed data was needed. This is significant considering the economic viability of a SWAC system is so site specific. The main factors influencing the economic viability of a specific location include:

- **The distance offshore to cold water:** shorter pipelines are more economical than long pipelines.
- **The size of the air conditioning load:** there is an economy of scale associated with SWAC – systems less than 1000 tons are more difficult to justify economically,

Figure 4.8 Typical Schematic of SWAC Systems
(Makai Ocean Engineering 2004)



17. *Many experts also regard SWAC as a subset of Ocean Thermal Energy Conversion Technology (OTEC). OTEC is generally associated with generating electricity by harnessing the temperature differences (thermal gradients) between ocean surface waters and deep ocean waters. More can be read on this in section 4.1.9 "Self/Distributed Generation" below.*

- **The percent utilization of the air conditioning system:** The higher the utilization throughout the year, the higher the direct benefits.
- **The local cost of electricity:** A high cost of electricity makes conventional AC more costly and SWAC, in comparison, more attractive. Any cost analysis should include current and future costs of electricity.
- **The complexity of the distribution system on shore:** SWAC works best with a district cooling arrangement, where many buildings are cooled taking *(Makai Ocean Engineering 2015)*

- **Use screw or scroll compressors**. Most industrial sized compressors found in facilities across Jamaica and other SIDS are the conventional reciprocating compressor. Screw or scroll compressors offer advantages of requiring significantly less maintenance (because of less moving parts[18]) and are more efficient (offering higher EERs). Replacing a reciprocating compressor with a scroll compressor (for equivalent output) can reduce energy consumption up to 22% and demand by up to 10%.
- **Use variable air volume (VAV) where applicable.** Large air conditioning systems with ducts tend to control the temperature in spaces by either varying the temperature from source or varying the volume of air being pushed into the space. The older ventilation and air conditioning (VAC) systems tend to use the former method to achieve this temperature control. The latter method, VAVs, are known to allow for significant reduction in energy use – by virtue of the fan affinity laws[19]. The implementation of this EMR is known to reduce power consumption of VAC fans by up to 33%.
- **Encourage natural ventilation.** This is another EMR that is most ideal for new facilities that are about to be built, or facilities that are undergoing major restructure or rehabilitation works. It is also often only recommended for facilities located in non-built up or non-urban areas. Natural ventilation, through the use of wind catchers/towers, additional vents, strategic placement of windows, etc; not only serve to save energy, they also reduce the risk of allergies and other contaminated air induced illnesses.

4.1.6. Motors and Drives

For manufacturing and/or processed based facilities, this is often another large and significant area that can account for up to 50% of demand and energy consumption. Many manufacturing and processing facilities across Jamaica pay very little attention to their motors and drives, and consequently are paying unnecessary hefty demand and energy related costs. The EMRs often recommended for this area are:

- **Upgrade old motors to high efficiency motors.** Most manufacturing and/or processing facilities in Jamaica with a large contingent of motors tend to rewind old motors instead of replacing them with new high efficiency motors. In fact, many motors can be found in some facilities, in Jamaica, that are decades old and have been rewound multiple times. The clients often go this route as they see it as the cheapest option versus having to buy a brand new motor. At current energy costs in Jamaica however, the economics serve to prove otherwise. Motors, for various reasons, lose anywhere from 2% to 5% efficiency at each rewinding. This means that same motor will end up using 2% - 5% more energy to do the same amount of work, once put back into operation. Additionally, motors over 20 years old have nowhere near the efficiency of current high efficiency motors such as NEMA Premium Motors. If a motor completely fails after its average useful life of 20 years, the client should take this opportunity to replace it with a high efficiency motor. High efficiency motors, at current energy costs, pay for themselves in just 2 years (with high frequency of use) with the energy saved when compared to an equivalent sized older motor.
- **Use Variable Speed Drives/Variable Frequency Drives (VSDs/VFDs).** VSDs are designed specifically for DC motors while VFDs are designed specifically for AC motors; but both are designed for the same objective. VSD/VFDs varies the speed of a motor with respect to the motor's load. This EMR is ideal for motors with very high (> 60%) utilization factors with varying loads such as chill water pumps, air conditioning duct fans and some processing pumps. The higher the utilization factor and variability of load, the more feasible and impactful this EMR will be. Depending on utilization, this EMR can reduce a motors

18. Scroll compressors have 70% less moving parts than an equivalent sized reciprocating compressor
19. The fan affinity laws prove that for every unit of drop in fan speed (i.e. air being pushed into a space) there is an equivalent cube drop in energy consumption from that fan.

energy use by up to 60% based on the same fan affinity laws referred to above. Again, this EMR is not suitable for constant/static loaded motors.

- **Improve motor power factor.** A poor overall power factor (PF) of a facility may be as a result of one or several motors. If pinpointed to a motor or group of motors, it is usually more effective to implement power factor correction at source as opposed to the main meter. This is assuming that the motors are truly the only culprit for the facility's poor power factor. This also lessons the risk of over correcting.

Figure 4.9
Example of a PF Capacitor Bank on a motor load

4.1.7. Boiler and Steam System

Some facilities utilize steam for either power generation or for processing. The latter is found to be most common in facilities here in Jamaica. For these facilities, fuel cost is a major cost component, and hence it is important that their boiler system be at peak efficiency. Consequently, the EMRs often associated with this area includes:

- **Change to a new boiler.** Boilers become less efficient over time as a result of loss of heat transfer surface from soot and calcium build up, degradation of insulation and boiler components/material, and deterioration of burners. Additionally, modern boilers are a lot more efficient than those manufactured and installed as recent as ten years ago, and have the additional capability to utilize two fuels (dual fuel boilers)[20]. Many facilities are known to have boilers over 40 years old. The average life of a boiler is 25 – 30 years. Afterwards, the maintenance becomes more costly as the boiler becomes more unreliable. This EMR, depending on frequency of boiler use, can save on fuel cost by up to 20%.

- **Reduce excess air to combustion.** It must be noted that excess air is required to ensure complete combustion and to reduce the occurrence of soot formation on the fire side of the boiler. Care must be taken in the determination of the amount of excess air, particularly the percentage of Oxygen (O_2), as this can result in loss of useful heat through the stack and consequently a lowered efficiency. Generally, 3% – 4% of O_2 is sufficient and this must be verified through a flue gas analysis.

- **Repair steam leaks.** Leaking steam is tantamount to wasting fuel. Additionally, leaking steam can be considered a human health hazard and should be rectified as soon as possible. This EMR, depending on the specific circumstance of the leak/s, may propose the use of steam traps or that the piping section be repaired or replaced. Depending on the severity of the leaks to be corrected, this EMR can result in a significant amount of fuel being saved.

4.1.8. Compressed Air System

Some facilities also utilize compressed air to perform their operations. Most EMRs applicable to this area are the same applicable to motors and drives, since the compressor is really just a motor and drive. Other EMRs often recommended here include:

- **Repair all air leaks.** Loss of compressed air is tantamount to loss of energy. Such leaks can be detected simply by listening for "hissing sounds" in areas suspected of having a leak. However, some cases will require the use of ultrasonic leak detection instrumentation. Corrected air leaks, depending on the severity can save significant amounts of energy in this area.

- **Reduce compressor pressure.** Most facilities tend to run their compressors at full capacity, no matter the job. Note that a 10% reduction in compressor pressure can lead to a 5% reduction in energy use. This EMR requires the use of the operator's discretion in determining if full pressure is truly needed.

20. Most dual fuel boilers allows for the utilization of LNG or diesel oil, or any other liquid fuel with similar viscosity and flash points,

- **Develop usage policy.** Compressed air is very expensive to produce, yet many facilities can be seen using compressed air for a variety of tasks; for which other more cost-effective options could have been used. Examples include cleaning certain areas, or drying equipment. This EMR proposes that a usage policy be developed, which will see compressed air being used only in applications that warrant its use.

4.1.9. Self/Distributed Generation

Unlike the other EMRs above which focus on energy efficiency and energy conservation primarily, this area looks to generate electricity from sustainable energy sources, reducing the client's dependence on the utility. It is often a recommended course of action after all energy efficiency and conservation measures have been explored or implemented. The sustainable energy technology (SET) proposed will be dependent on whatever sustainable source can be feasible supplied at the facility. For Jamaica, this is often solar energy; however, it can also be:

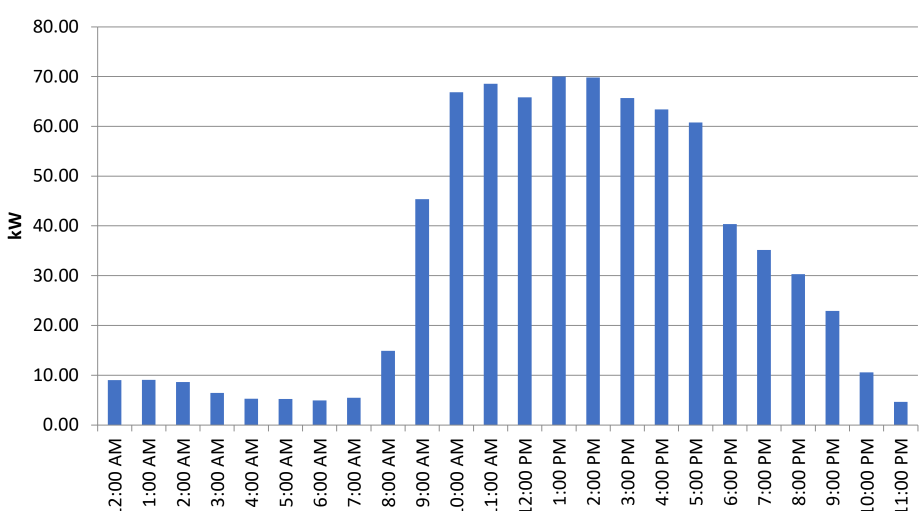
- Biodegradable waste such as effluent and foodscraps
- Municipal solid waste
- Bagasse or other solid biomasses
- Biodiesel
- Wind
- Hydro
- Natural Gas (Micro Turbines)

In addition to the availability of the sustainable source of energy; the choice of SET, it's design, configuration, and implementation is also dependent on budget, available space, scale, required modularity and the demand profile of the facility being served. The core function of a facility determines its demand profile. Administrative, schools and other facilities that operate during the day (9am – 5pm) will see the bulk of its demand between these hours. Such demand profiles are best served by grid-tied Solar PV systems that will only generate while the sun is up. Supermarkets, some restaurants and some manufacturing facilities that have heavy loads that run 24/7 (like refrigeration), will see much of their demand fall outside of sunshine hours. Such demand profiles are best served by SET systems that can store energy in batteries or fuel, dramatically increasing their dispatchability.

Solar systems continue to be the SET of choice for all demand profiles, and for supplying hot water, for reasons outlined in section 2.0 above. However, micro turbines and natural gas CHP units having been seeing relatively good penetration in the accommodation sector. The Couples Resorts chain stands as a prime example of this success, with over 125 kW of CHP being installed – providing electricity and hot water to its guest at a 40% annual savings on electricity costs (Proactive Investors 2019).

Sustainable Energy Technologies (SETs) energy costs[21] continue to fall and are now on par or better than JPSCo energy costs in many cases. Consequently, from residential to commercial/industrial, with the exception of space and budget limiting factors; there is no reason not to implement a SET system to offset a significant portion of demand from the grid. From the all the SET assessment and projects completed by this consultant, for private clients[22], a minimum of 20% offset should be considered reasonable.

Figure 4.10 Typical Demand Profile for Large Office



21. Levelized Cost of Energy (LCOE)

22. Level 1 – 3 energy audits, energy management programs (EMPs) and renewable energy systems design and implementation management. These reports are unpublished to maintain client confidentiality.

Emerging SETs for Distributed Generation

A variety of SETs have made significant progress over the last two decades, aimed at improving technical reliability, availability[23], and economic feasibility of distributed generation from small (residential) to large scale (multiple commercial or industrial consumers). Much of these developments have focused on storage[24]– a inherent weakness with intermittent SETs. Some of these developments however have focused on providing firm capacity – such as Ocean Thermal Energy Conversion (OTEC). In fact, there have been several international companies that have been exploring Jamaica and the Caribbean most recently. These companies are:

- Makai Ocean Engineering – focusing on SWAC as described in section 4.1.5 above
- Bardot Ocean (New Energy Event Reference)
- Bluerise (Sids Global Business Network Reference)

All three companies are pioneers in their field. They are well resourced, experienced and financed; and are expected to bring a form of OTEC to this region within the next decade.

23. Renewables often have a low availability factor which makes them unsuitable baseload or firm capacity plants

24. Such as lithium-ion and lithium iron phosphate batteries, hydrogen fuel cell systems, vanadium redox flow and zinc batteries

Figure 4.11 Typical Demand Profile for Supermarket

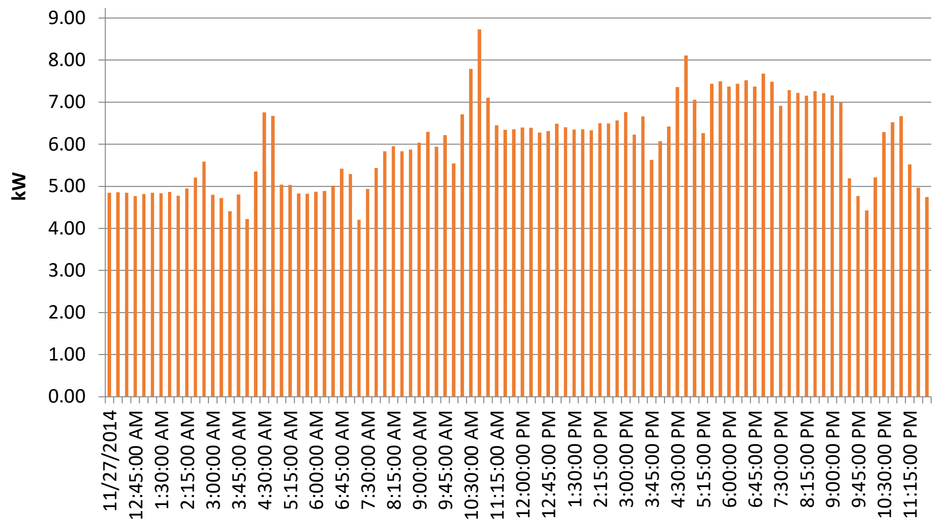


Figure 4.12 Typical Demand Profile for Secondary School

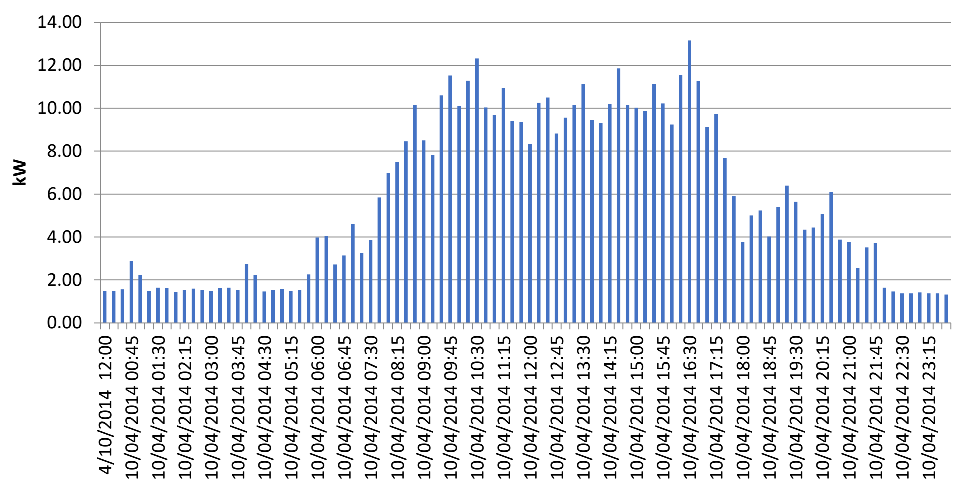
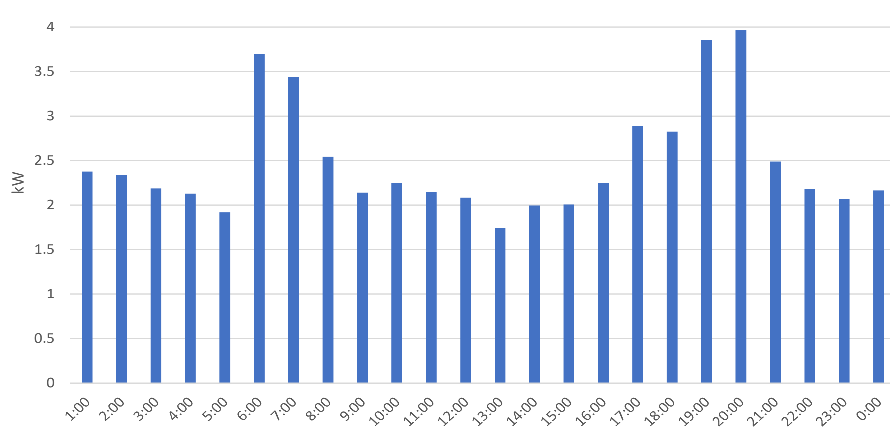


Figure 4.13 Typical Demand Profile for Residence



4.2. Summary of Energy Management Recommendations

The above EMRs all should form part of an effective Energy Management Programme (EMP) that will achieve an EUI reduction of at minimum 10% - in both commercial and residential sectors. The table below serves as summary.

Table 4.1 Summary of EMRs for Effective EMP

Area of Interest	Energy Management Recommendation	Demand Reduction in Area of Interest	Consumption Reduction in Area of Interest
Electric Billing	Ensure appropriate billing Rate Schedule is being used	Up to 12% on Charges	
Electrical Supply/Distribution	Correct grounding issues	No	Yes
	Correct voltage imbalance	No	Up to 5%
	Improve power factor	Yes	No
	Reduce THD to acceptable levels	To Compliment PF Correction	
Building Envelope and Insulation	Use airtight sealed glass windows in air-conditioned spaces	No	Up to 10%
	Use skirting/strips to reduce air gaps	No	Up to 5%
	Tint Windows or use windows with low heat gain	No	Up to 10%
	Improve Roofing Insulation	No	Up to 40%
	Improve wall insulation	No	6% - 20%
	Insulate steam lines and chilled water lines	No	Yes
Lighting	Switching to more efficient lighting technology	No	Up to 60%
	Occupancy sensors/switches	No	Up to 10%
	De-lamping	Yes	Yes
Refrigeration and Air Conditioning	Change of Refrigerant	No	Up to 20%
	Upgrade Units to Higher EER units	No	Up to 35%
	Utilize occupancy sensors/switches	No	Up to 20%
	Utilize chiller units where applicable	Yes	Up to 20%
	Utilize VRF units where applicable	Yes	Up to 40%
	Ensure condensers are clean and unobstructed	No	Up to 10%
	Utilization of Thermal Energy Storage (TES)	Yes, on Charges	Up to 55%
	Utilization of Sea Water Air Conditioning (SWAC)	Yes	Up to 90%
	Use screw or scroll compressors	Up to 10%	Up to 22%
	Use variable air volume (VAV) where applicable	No	Up to 33%
	Encourage natural ventilation	Yes	Yes
Motors and Drives	Upgrade old motors to high efficiency motors	Yes	Yes
	Use VSDs/VFDs	No	Up to 60%
	Improve motor power factor	Yes	No
Boiler and Steam System	Change to a new boiler	No	Up to 20%
	Reduce excess air to combustion	No	Yes
	Repair steam leaks	No	Yes
Compressed Air System	Repair all air leaks	No	Yes
	Reduce compressor pressure	Yes	Up to 5%
	Develop usage policy	No	Yes
Self/Distributed Generation	SETs with storage (battery or fuels)	Up to 100%, from grid	Up to 100%, from grid
	SETs with no storage	No	Up to 100%, from grid

NB: *The demand and consumption reductions that have not been quantified are considered to have too many variables to give a reasonable quantification in this report.*

4.3 Proposed Incentives Programme

Recommendations only have a chance of being effective when implemented; and implementation requires adequate incentives, disincentives or a combination of both. Effective incentive/disincentive programmes are often backed and enforced by appropriate legislation to ensure national adoption. They rate the energy performance of a facility through a standardized evaluation process, which takes into consideration the intended or designed function of the facility among other considerations. Each facility then falls within a grade category depending on its score. There are currently at least 13 different such programmes across 5 countries *(Building Energy Efficiency Taskgroup 2014)*.

These evaluations are mandated periodically or triggered under particular circumstances such as a facility that is to be built, sold, rented or leased. They also carry penalties for facilities that fail to carry them out when required. The assigned grade to the facility, which is often displayed on a certificate for reference; will allow for certain tax benefits since facilities that perform well with respect to energy, stands to benefit the state through avoided costs and expenditure on fuel and generating plants, as well as the environment. Examples of such programmes are the Energy Performance Certificates (EPC) and Display Energy Certificates (DECs) programmes in European countries.

A similar approach and programme is required for Jamaica to ensure widescale adoption of EMPs including the above outlined recommendations, and maintenance of EUI which will allow for an overall alignment with the GoJ's sustainable energy use and environmental goals and mandates. The details and proposed structure of such a programme are considered beyond the scope of this assignment but should be an immediate follow up step to this report.

5.0 Conclusion and Next Steps

With a legislated incentives programme in place, backed by well-designed EMPs inclusive of the above recommendations; a minimum averaged 10% reduction in Jamaica's commercial and residential energy demand from the grid is achievable. The impact of such a reduction has been quantified in table 5.1 overleaf. The quantified impacts show that per annum, **the residential and SME (small commercial & industrial) sectors stands to save a combined US$ 93 Million per annum in electricity expenses.**

From a national perspective, the Government of Jamaica will reduce its oil imports by 8% while saving US$ 42.6 Million in foreign exchange expenditure and **avoid over 264 Million tonnes of CO2 emissions – per annum.** These emissions are valued at over US$14.5 Million when current social costs[25] are applied to them. The US$ 93 Million in savings for the residential and commercial sectors becomes funds as well that can be spent in other areas of the economy, having an indirect and induced benefit on other sectors and industries – another benefit for the Government of Jamaica.

In addition to the quantifiable benefits, additional high-skilled jobs would also be created for energy professionals, promoting the growth of the energy consulting profession and industry.

25. The social cost of carbon is a measure of the economic harm from those impacts, expressed as the dollar value of the total damages from emitting one ton of carbon dioxide into the atmosphere. (EDF)

Table 5.1 Quantified Impact of 10% reduction in energy demand from grid, for SMEs and residential consumers

Customer Type	Residential	Small Commercial	Total Impact Quantified
Customers Impacted	587,592	69,750	
MWh Avoided from grid	106,273	139,457	245,730
Savings to Sector in JA$	$5,421,421,024	$7,114,269,600	$12,535,690,625
Savings to Sector in US$	$40,158,674.26	$52,698,293.34	$92,856,967.60
BBL of Oil Avoided	265,789	348,783	614,572
Tonnes of CO2 Emissions Avoided	114,289	149,976	264,265
Fuel Purchase Savings to Jamaica in US$	$18,413,883.79	$24,163,652.50	$42,577,536.29
Value of CO2 Emissions Avoided in US$	$6,279,637.68	$8,240,465.97	$14,520,103.65

Oil Import Reduction

8%

Notes and Assumptions:

1	Average residential rate for electricity as of March 2020 is $9.66 per 100 kWh for first 100, $22.49 per next kWhs
2	Average small commercial (Rate 20) rate for electricity as of March 2020 is $19 per kWh
3	Fuel and IPP charge for March 2020 of $21.87/kWh was used in above calculations
4	GCT of 15% was added to the relevant above calculations
5	JPSCo Average Heat Rate as indicated in 2018 Annual Report is 11,221 kJ/kWh
6	JPSCo T&D losses as indicated in 2018 Annual Report is 26.5%
7	CO2 Emissions per BBl of oil consumed (EPA 2019) is 0.43 Tonnes CO2 per barrel consumed
8	Cost per Barrel of oil Calculated from MSET's 'Petroleum Imports 2018' Sheet is US$ 69.28/BBl
9	The current social cost of Carbon according to the Environmental Defence Fund is US$ 54.95 per Tonne
10	The USD exchange rate used in the above calculations it US135:JMD1
11	Total Oil Import in 2018 from MSET's 'Petroleum Imports 2018' Sheet is 7,454,658 BBls

5.1 Next Steps

Following this report and assignment:

1. Subject to the availability of funding, an energy consultant/s should be contracted by GoJ, UWI/ISD or a leading agency on energy development; to develop and tailor an incentive programme for Jamaica's residential and commercial sectors. Existing programmes such as the Energy Performance Certification (EPC) and the Display Energy Certifications (DECs) from Europe can be used as templates.

2. Use the incentives programme to best facilitate the above proposed approach and recommendations.

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7.0 Annex 1

Table 7.1 JPS Operational Statistics (2009 to 2018)

AVERAGE NO. OF CUSTOMERS	2013	2012	2011	2010	2009
Residential	541,691	531,827	513,970	509,660	521,837
Commercial & Industrial (Sml)	64,559	63,740	61,401	60,782	62,029
Commercial & Industrial (Lrg)	150	151	145	138	130
Total Commercial	64,709	63,891	61,546	60,920	62,159
Other	254	253	246	221	222
TOTAL	**606,654**	**595,971**	**575,762**	**570,801**	**584,218**

AVERAGE NO. OF CUSTOMERS	2018	2017	2016	2015	2014
Residential	587,592	574,458	564,242	536,462	531,363
Commercial & Industrial (Sml)	69,750	67,874	66,750	62,517	62,294
Commercial & Industrial (Lrg)	169	162	157	150	150
Total Commercial	69,919	68,036	66,907	62,667	62,444
Other	486	450	419	401	389
TOTAL	**657,997**	**642,944**	**631,568**	**599,530**	**594,196**

ENERGY SALES (MWH)	2013	2012	2011	2010	2009
Residential	996,429	1,035,377	1,064,535	1,090,619	1,082,599
Commercial & Industrial (Sml)	1,366,797	1,383,296	1,437,283	1,402,748	1,435,285
Commercial & Industrial (Lrg)	605,402	615,314	615,041	593,360	589,560
Total Commercial	1,972,199	1,998,610	2,052,324	1,996,108	2,024,845
Other	101,060	99,979	99,131	100,761	96,435
TOTAL	**3,069,688**	**3,133,966**	**3,215,990**	**3,187,488**	**3,203,879**

ENERGY SALES (MWH)	2018	2017	2016	2015	2014
Residential	1,062,732	1,068,594	1,077,148	1,016,428	981,730
Commercial & Industrial (Sml)	1,394,572	1,381,376	1,380,791	1,360,131	1,347,514
Commercial & Industrial (Lrg)	682,132	646,669	625,219	602,618	589,236
Total Commercial	2,076,704	2,028,045	2,006,010	1,962,749	1,936,750
Other	62,214	110,500	96,150	92,172	94,499
TOTAL	**3,201,650**	**3,207,139**	**3,179,308**	**3,071,349**	**3,012,979**

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