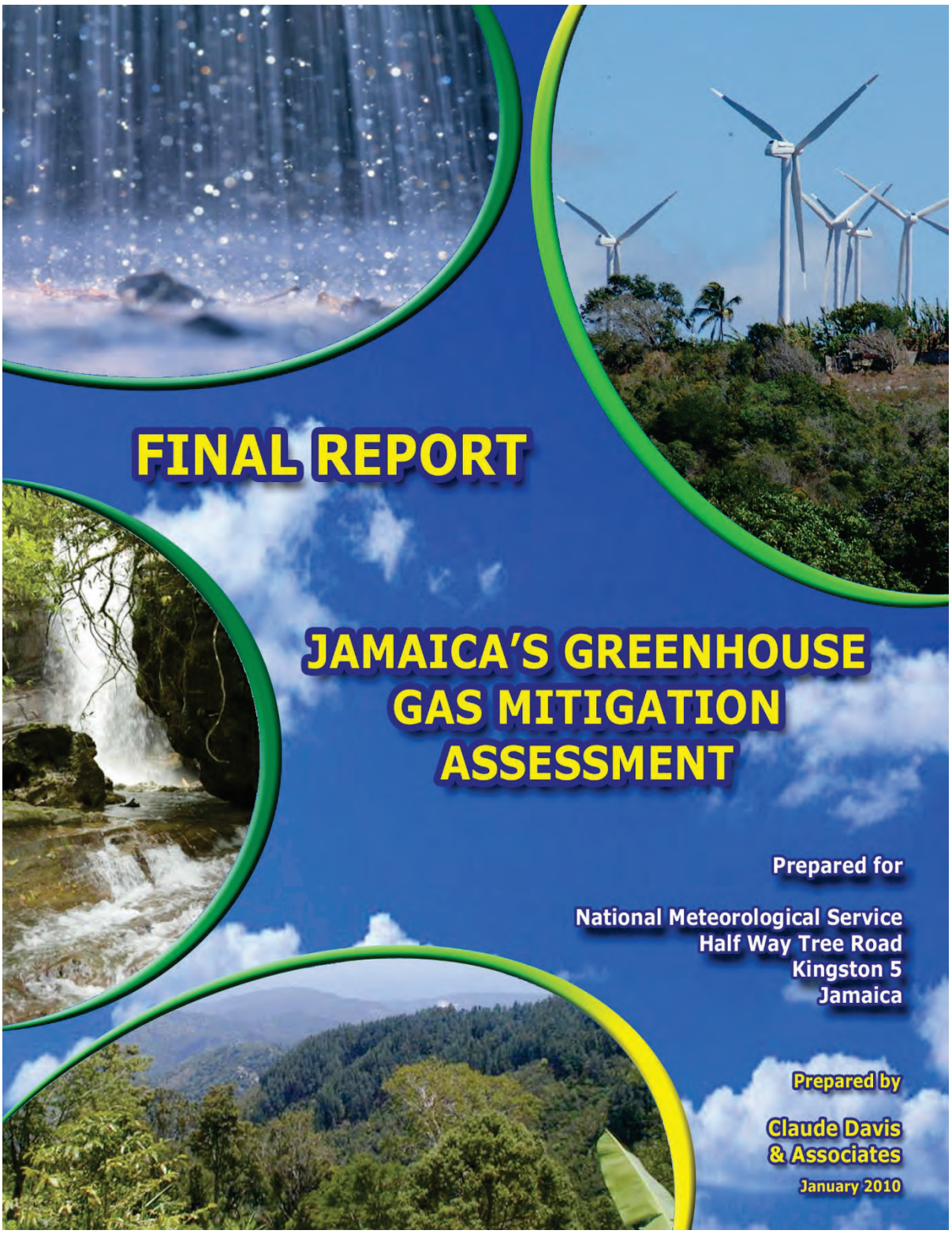

FINAL REPORT

JAMAICA'S GREENHOUSE GAS MITIGATION ASSESSMENT

Prepared for

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EXECUTIVE SUMMARY

This report presents Jamaica's greenhouse gas mitigation assessment. It provides a national-level analysis of the potential costs and impacts of various technologies and practices that have the capacity to affect energy demand and supply and hence greenhouse gas (GHG) emissions.

The mitigation assessment covers projections of selected GHGs for the period 2009 to 2035 and uses historical data for the period 2000 (the base year) to 2008 in order to calibrate where appropriate, the bases for the projections. *Vision 2030 Jamaica: National Development Plan* provides the overarching context for the assessment. Vision 2030 articulates four national goals, 15 national outcomes and over 50 national strategies all aimed at putting Jamaica in a position to achieve developed country status by the year 2030. The National Energy Policy 2009-2030 together with National Transport Policy (Draft) and Forestry Department's Strategic Forest Management Plan: 2009 – 2013 provide key direction and policy contexts for the mitigation assessment which also recognises the directions outlined in Jamaica's energy sector as well as the transport and forestry sector circumstances.

With no known petroleum or coal resources, most (86% in 2008) of Jamaica's energy needs are met by imported fuels and the remainder by biomass (bagasse), hydroelectric, wind and solar energy. Electricity is generated primarily by oil-fired steam, engine driven and gas turbine units. Smaller amounts of electricity are generated by hydroelectric and wind power. Use of solar energy is negligible and is limited to a few solar water heaters and solar crop dryers. The bauxite and alumina industry uses the highest percentage of energy (37.4% in 2008) followed by electricity generation (25%), transportation (20.4%) and the sugar industry (12.2%).

The government owned Petrojam refinery provides some of the refined petroleum products and the remainder is imported. The Jamaica Public Service Company Limited (JPS) with 80.1% private ownership and the remainder government owned, is the sole distributor of electricity. Electricity is generated by JPS and independent power producers.

Methodology

The Long-Range Energy Alternatives Planning System (LEAP) model was used to make projections for four emissions-related categories (modules): energy demand, energy transformation, energy resources and non-energy sector effects. The base year used (2000) is the same base year used for compilation of the national GHG emission inventory and is the year preferred by the United Nations Framework Convention on Climate Change (UNFCCC) for reporting national communications. The first projection year was 2009 and the last 2035. Historical data between 2000 and 2008 were used to calibrate the model. A fifth category – the key category – uses macroeconomic, demographic and other data that were used in the analysis. Projections for the years 2009 to 2035 were made for three sets of scenarios: the Reference Scenario and two others called Scenario 2 and Scenario 3. The various subcategories used (see Table 1) were determined by the level of detailed data that were available.

Table 1Subcategories in the Five Categories in the LEAP Model Input Data

Key Assumptions	Demand	Transformation	Natural Resources	Non-Energy Sector Effects
Population Household Size GDP in J2003$ Population growth rate GDP Growth Rate Transportation Emission factors (for 11 pollutants in 8 vehicle classes)	Household Refrigeration Lighting Cooking Fans Stereo Air conditioners Computer equipment Washing machines Clothes iron Television All other Industry Cement (Clinker, cement mills) Bauxite mining* Bayer Process Alumina Kilns Lime kilns Sugar Sugar (Private) Sugar (SCJ) Government Hospitals National Water Commission (NWC) Other Government Municipal (Rate 60) Rate 20, Rate 40A#, Rate 50 Road Transport (8 vehicle classes)	Transmission & Distribution Oil Refining Electricity Generation Charcoal making Coal gasification	Primary Wind Hydro Wood Bagasse Municipal Waste Peat Secondary Output fuels	Landfill emissions Agriculture Animals Soils Rice Production Forestry Industry Lime kilns Cement Pet Coke limestone

The JPS defined Rate 40 was adapted and redefined as Rate 40A to avoid double counting. * Includes rail transport in the bauxite alumina sector

Historical and projected gross domestic product (GDP) and socioeconomic data were obtained from the Planning Institute of Jamaica (PIOJ) and Bank of Jamaica publications. The population and household data were obtained or derived from information published by the Statistical Institute of Jamaica (STATIN) and in annual Economic and Social Survey Jamaica (ESSJ) reports or Bank of Jamaica Reports. The projections require activity and emission factor data. Most of the activity data were obtained from government agencies. Emission factors contained in LEAP were used but vehicle emission factors were calculated from a model of the Jamaican fleet. Electricity generation, consumption and related data were obtained from the Office of Utility Regulation (OUR). Petrojam provided data for the Refinery and charcoal data were derived from the Ministry of Energy and Mining (MEM) and from Economic and Social Survey Jamaica (ESSJ) reports.

Scenarios

Three sets of scenarios are developed to project emissions – a Reference Scenario (Ref) and two other sets of scenarios - Scenario 2 (*S2*) and Scenario 3 (*S3*) - characterised primarily by different rates of growth for the gross domestic product (GDP). The Reference Scenario is linked to the Vision 2030 Jamaica-GDP and population growth targets and does not include any initiatives to mitigate GHG emissions. *S2* and *S3* assumed more aggressive GDP growth rates but lower population growth rates. Both of the scenarios *S2* and *S3* have mitigation options. The bases for the scenario options are described below and Table 2 summarises the Scenario options used in the analysis.

Reference Scenario

The Reference Scenario assumes that two (Alumina Partners (Alpart) and the Windalco Ewarton) of the three alumina refineries that were closed in 2009 would reopen. It also assumes that the Petrojam Refinery Upgrade will be completed in 2014 and will provide low sulphur diesel and gasoline for the vehicle fleet and petcoke for a 100 MW plant at Hunts Bay. The Reference Scenario also assumes continued use of oil at alumina plants and coal at the new old Harbour power station.

For *S2* and *S3*, the fuels [coal, heavy fuel oil (HFO), diesel oil (diesel), natural gas (NG), gasified coal (Syngas)] that can be used for the following processes are as follows.

- Bayer process boilers and lime kilns (Bayer/Lime kilns), new steam boilers [coal, HFO, NG]
- Slow/Medium speed diesel engines at new power stations [HFO, NG]
- alumina kilns (Al kiln) [HFO, NG, Syngas]
- Gas turbines [Diesel, NG]
- Boilers at existing steam fired electricity generating stations [coal, HFO, NG]

The feasible combinations of processes and fuels lead to the options within *S2* and *S3* and the possible combinations are limited by the following conditions and assumptions.

- Once introduced coal or natural gas is used in all possible processes except as noted below regarding retrofitting
- Alumina kilns may not use coal hence the use of syngas (from gasified coal)

- Existing heavy fuel oil fired boilers and slow speed engines at electricity generating stations would not be retrofitted to burn natural gas (since they are old and due to be retired or mothballed)
- All operating Bayer process boilers would be upgraded/retrofitted to burn either oil up to 2013 or natural gas after 2013
- Any new slow speed engines could use natural gas
- The new alumina plant (*S3* only) would use either natural gas or coal with Syngas in the alumina kiln
- When natural gas is available it would be used in some of the vehicle fleet

Scenario 2 (*S2*):

Scenario 2 assumes a lower population growth rate and higher GDP growth rate than the Reference scenario. It also includes added alumina production capacity. The main option designated as *S2* has coal as the fuel for the Bayer process and lime kilns and a coal fired station at Old Harbour and no natural gas. The main mitigation option in this scenario (designated as *S2 NG*) entails the use of compressed natural gas (CNG) for the Bayer process, lime kilns, electricity generation at the Bogue generating station and for the new Old Harbour generating station (300 MW). Other mitigation measures include Bayer process energy efficiency improvements, the use of more efficient household appliances, use of CNG in some of the vehicle fleet and improved energy efficiency in the Government sector (hospitals, National Water Commission (NWC) and the remainder of the government sector). The various options for scenario 2 are evaluated relative to *S2* and the Reference Scenario.

Scenario 3 (*S3*):

This scenario assumes a lower population growth, a higher GDP growth rate than for *S2* and a more rapid decrease in the number of persons per household. *S3* also includes all of the *S2* initiatives and has additional energy intensity reductions at two of the alumina plants. The mitigation measures are however offset by the proposed addition of a new alumina plant. The possible introduction of additional hydro generation capacity would also contribute to lower emissions across the board. Scenario 3 includes options for coal (*S3*), natural gas (*S3 NG),* syngas in alumina plants (*S3 SYN*) and nuclear power generation along with natural gas (*S3 NGNU*).

Constraints and data gaps

The analysis is constrained by the following:

- Although rail transportation is used (only) in the bauxite sector, (diesel) fuel use for rail transport was not readily disaggregated from other diesel fuel used in the sector
- Fuel use data for domestic marine activities were not always readily available. It is believed that some of the gasoline sold in retail outlets is used for fishing and other domestic marine activities.
- Projections related to hydrofluorocarbon (HFC) emissions are not yet included
- Divestment of government owned sugar factories is under way and no data were available for making projections

Table 2 Fuel and Process Combinations for Scenarios Used in the Mitigation Assessment

Scenario	Bayer/Lime Kilns /New Steam	Engines Existing /New	Al Kilns Existing/ New[#]	Gas Turbines	Existing Steam Plants
Reference Scenario					
Ref	Current use	Current use	Current use	Current use	Current use
Scenario 2 Options					
S2	Coal Jamalco 2013 Alpart 2015 Windalco 2015 JPS Old Hrbr	HFO/HFO	HFO	Diesel oil	HFO
***S2* Oil**	**HFO**	**HFO**	**HFO**	**Diesel oil**	**HFO**
S2 SYN	Coal Jamalco 2013 Alpart 2015 Windalco 2015	HFO	Syngas Retrofit Jamalco 2013 Alpart 2015 Windalco 2015	Diesel oil	HFO
*S2*NG	NG Jamalco 2013 Alpart 2013 Windalco 2015 JPS (Except Hunts Bay)	NG retrofit/ NG	NG retrofit Jamalco 2013 Alpart 2013 Windalco 2015	NG JPS (Except Hunts Bay)	HFO
Scenario 3 Options					
S3	Coal Jamalco 2013 Alpart 2015 Windalco 2015 JPS Old Hrbr	HFO	HFO/Syngas	Diesel oil	HFO
S3 SYN	Coal Jamalco 2013 Alpart 2015 Windalco 2015	HFO	Syngas Retrofit/Syngas Jamalco 2013 Alpart 2015 Windalco 2015	Diesel oil	HFO
S3 NG	NG Jamalco 2013 Alpart 2013 Windalco 2015 JPS (Except Hunts Bay)	NG retrofit/NG	HFO/Syngas	NG	HFO
*S3 NG*NU	Coal Jamalco 2013 Alpart 2015 Windalco 2015 JPS Old Hrbr Nuclear after 2020	NG retrofit/NG	HFO/Syngas	NG	HFO

[#] Note: New alumina kiln in *S3* only

[##] Although the scenario designated as *S2* Oil is possible it is not considered economically viable for the bauxite alumina sector and so was not considered.

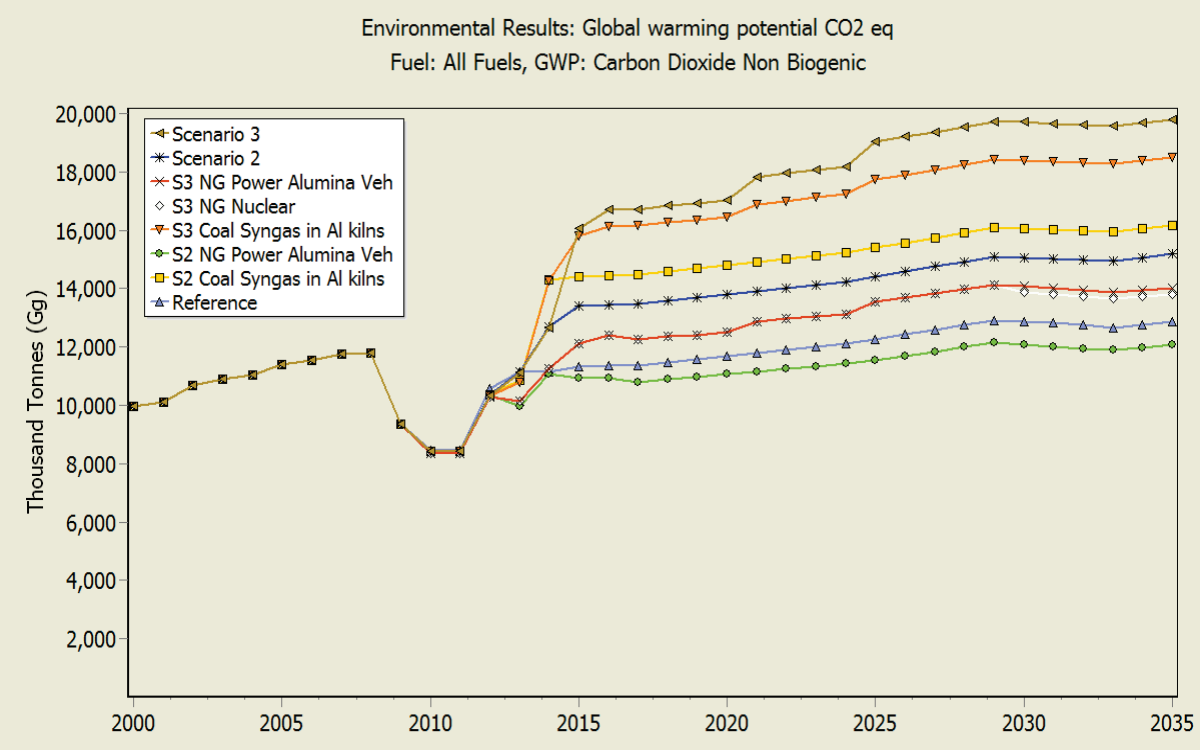
Results

The results of the analysis will focus on presenting the environmental **loadings** or emissions (CO_2 and in some cases SO_2 emissions) and the **final energy demand** broken down by sector and subsector where appropriate. The emissions can be presented either where they occur in the various branches (demand, transformation and non-energy sector effects) or by allocating the emissions in the transformation categories back to the demand branches. Thus when electricity is used we can estimate the amounts of GHG emissions used to produce the electricity. Similarly, emissions from oil refining are allocated back to the demand-side categories where refined oil products are finally consumed (and added to the emissions produced in consuming the refined oil product).

The presentation of the emissions and energy demand include the period 2000 to 2008 so that comparisons can be made with the emissions or energy consumption over this period.

The final environmental loadings of CO_2, for all scenarios are shown in Figure 1. The most striking feature in all scenario projections is the decrease in emissions between 2009 and 2011 due to the closure of three alumina plants in the first quarter of 2009 and the (assumed) reopening of two of those plants in 2011 with full production achieved in the following year. Although scenarios *S2* and *S3* have higher production levels and progressively more aggressive mitigation the effectiveness of the mitigation in *S2* is evident since the CO_2 emissions for *S2* are slightly lower than the Reference scenario even though coal is used in *S2* for power generation and the Bayer process.

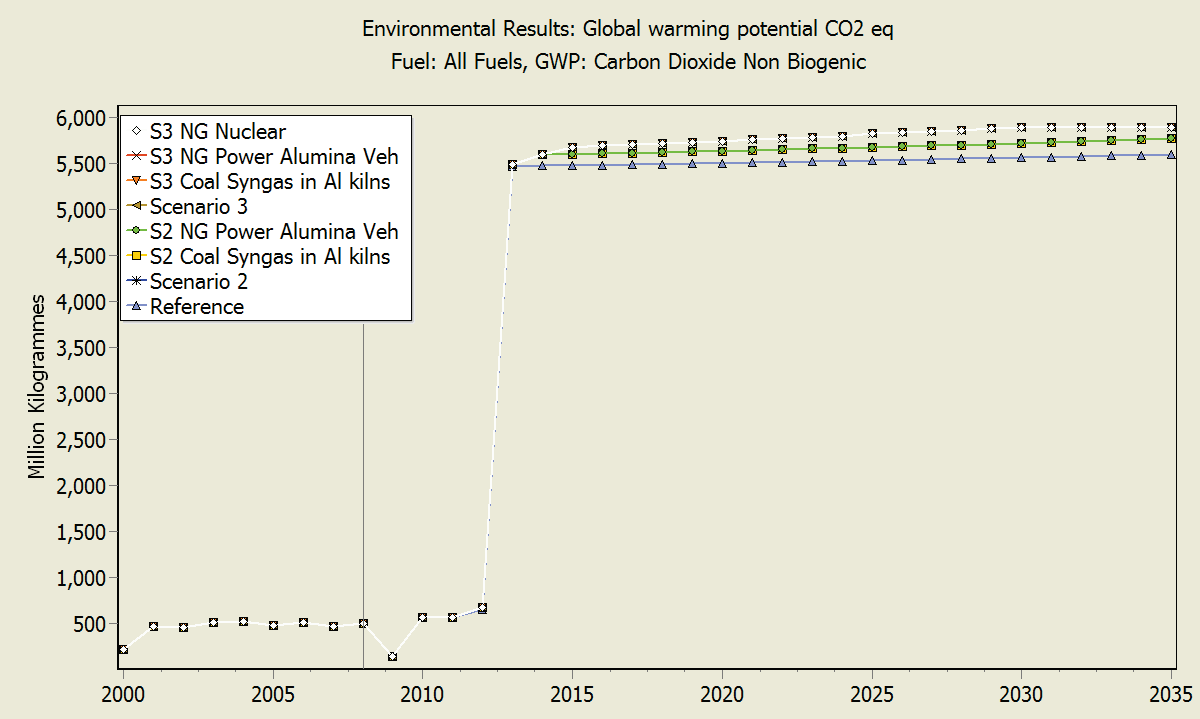
Figure 1-1 Final Environmental Loading for Jamaica, 2009 – 2035: All Scenarios, CO_2



For CH_4 and N_2O the Reference scenario emissions are generally lowest – due to the low production levels while the *S3* emissions are highest because of the use of coal where feasible. The *S3 NG* and *S2 NG* emissions are consistently lower than the corresponding *S2* or *S3* emissions and reflect the lower emission factors when natural gas is used (compared with coal or coal+syngas in alumina kilns).

The non-energy sector emissions are those associated with the chemical transformation of limestone into lime which releases CO_2 or in landfill emissions (releases CH_4 and CO_2) or in the release of CO_2, CH_4 and N_2O from agriculture and forestry sectors. The majority of the non energy sector emissions are from cement manufacture and in the future generation of electricity using petcoke. Use of petcoke for power generation entails using limestone to remove SO_2 which leads to the release of CO_2 from the limestone. Figure 2 illustrates the impact of the use of petcoke on non-energy CO_2 emissions starting in 2013. Beyond 2013 the increases in lime and cement production for *S2* and *S3* scenarios result in greater non-energy CO_2 emissions for *S2* and *S3* relative to the Reference scenario.

Figure 1-2 Final Environmental Loading for Jamaica, 2009 – 2035: Global Warming Potential CO_2: Non-Energy Sector Effects

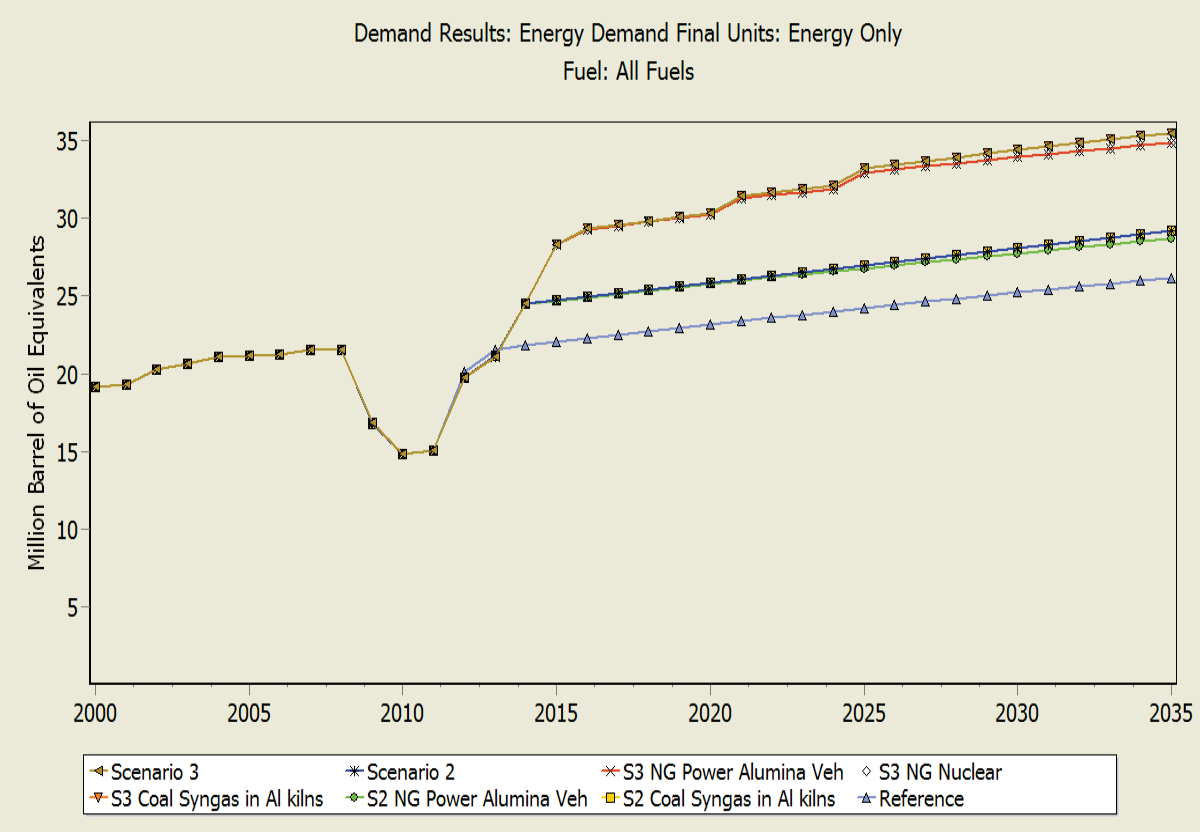


Energy Demand

As with the environmental loadings, the most striking features are the dramatic declines in energy demand in 2009 through 2012 as a consequence of alumina plant closures (see Figure 3). The final energy demand is not very dependent on the choice of fuel in the *S2* and *S3* scenario options and the demand for *S2* options are grouped together lower than the grouping for the *S3* options.

The large increase in energy demand in the *S3* options is due mainly to the new alumina plant which is included only in *S3* options and to lesser extents on population growth and the associated demands for electricity and on the increased cement production.

Figure 1-3 Final Energy Demand Projections for Jamaica, 2009 – 2035: All Scenarios



Transformation

The transformation module includes electricity generation, petroleum refining, coal gasification and charcoal production. No change in the petroleum refining capacity is anticipated although the refinery will be able to vary the output to meet demands. The data for charcoal production are uncertain and it is expected that demand for charcoal will fall as fewer households use charcoal as its use is discouraged.

The changes in total electrical generating capacity in all scenarios to meet the demands are shown in Figure 4 – noting that the added capacity was not optimised.

Gasification outputs will be used to meet the demands for calcining alumina only when coal is used in the Bayer process. The gasification requirements for all scenarios are shown in Figure 5.

Figure 1-4 Electricity Generating Capacities, 2009 – 2035: All Scenarios

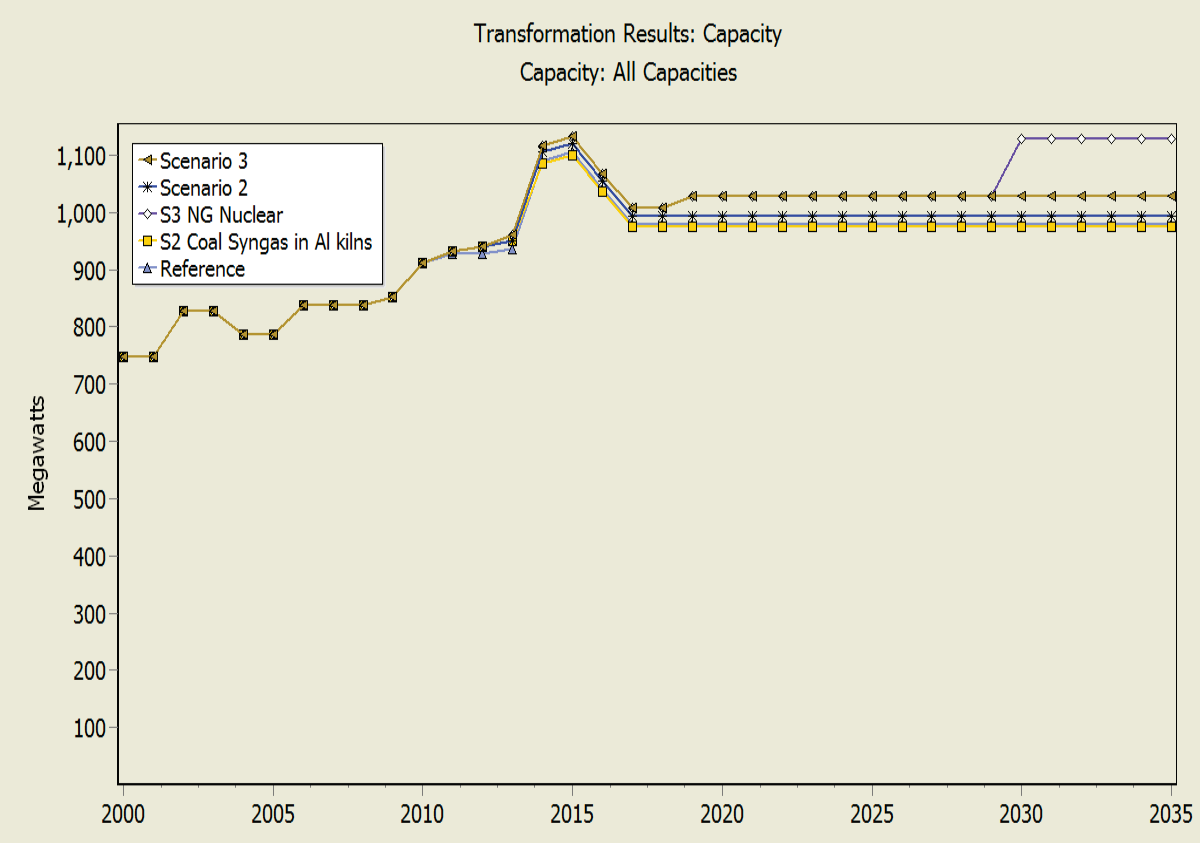
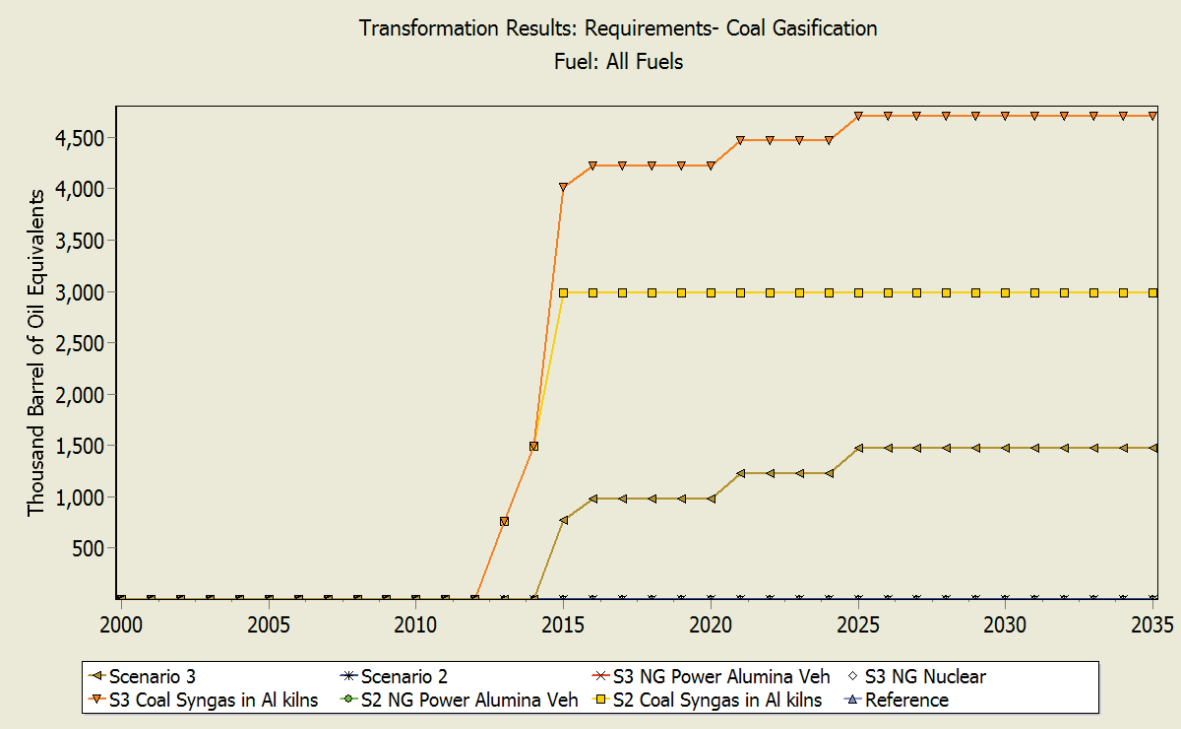


Figure 1-5 Coal Gasification Requirement Projections 2009 – 2035: All Scenarios



HOW MEASURES AFFECT CO_2 EMISSIONS BETWEEN 2000 AND 2035

For all scenarios, the percentage changes in the non-biogenic CO_2 emissions in 2035 relative to the year 2000 for the overall demand, transformation and non energy sector categories provide a measure of the impacts of factors (activity and energy intensity related) that affect emissions.

These percentage changes for each scenario are summarized in Figure 6. Also included in the figure are the percentage changes for branches in these categories. Note that in the case of electricity use and other secondary fuel use in the demand branches, the emissions occurring in the various Transformation modules are allocated back to the demand branches.

Overall Demand

The left-most grouping in Figure 6 shows Δ CO_2, the percentage changes in CO_2 emissions 2035 relative to 2000 for the overall demand in all scenarios. The overall CO_2 emissions in the energy demands for the reference (*Ref*), *S2* and *S3* scenarios increase by 29%, 52% and 98% respectively. This is consistent with the general increase in CO_2 generating (and energy consuming) activities because of population increases, fleet increases and increased bauxite and alumina production. These scenarios all entail additional coal fired electricity generation whose emissions easily outweigh the emission reductions from the much smaller additions of wind and hydro generating stations. In addition *S3* also includes a major expansion in alumina refining capacity.

The major mitigation measure is the introduction of natural gas (scenarios *S2*NG, *S3*NG and *S3 NGNU*) and a nuclear plant in conjunction with natural gas in scenario *S3*NGNU. Because of these measures, the CO_2 emissions in these scenarios are lower than those in the corresponding *S2* and *S3* scenarios.

Cement Kilns

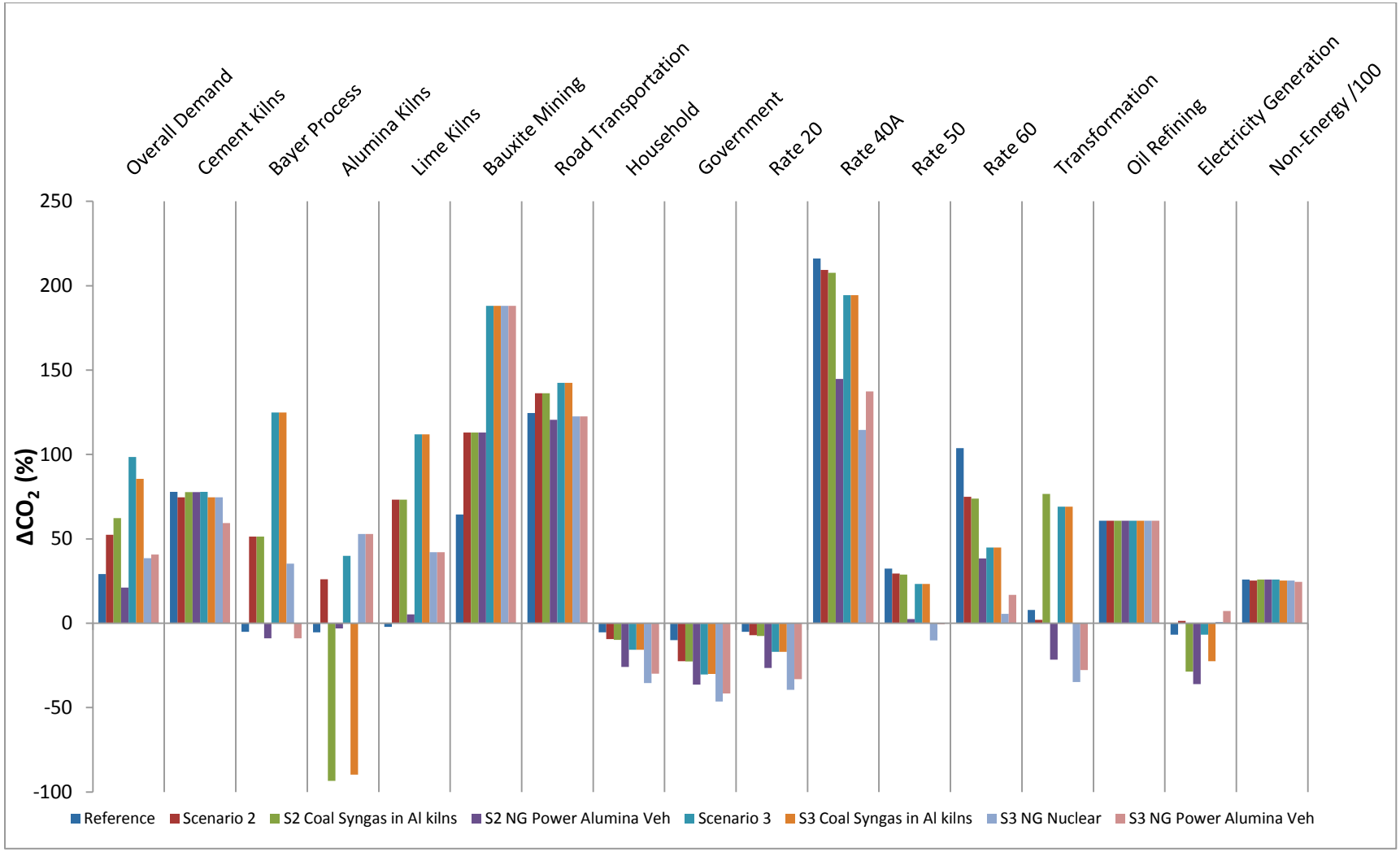
Changes in CO_2 emissions due to cement kilns are driven primarily by increased clinker production. The completion of the new kiln in 2008 resulted in a major improvement in energy efficiency and those changes are therefore present in all scenarios. Note that since the electrical energy use in the cement mills is small (1.8% to 3.5%) relative to the energy used in clinker production a grouping for cement mills is not included in Figure 6.

Bayer process and alumina and lime calcination

The emissions from the Bayer process and alumina and lime calcination that entail using coal (*S2*, *S2* coal+Syngas, *S3* an d*S3* coal syngas) all result in increased emissions relative to the reference scenario and also the *S3* scenarios having higher emissions than the corresponding *S2* ones because of increased alumina production in the *S3* scenarios.

The mitigation measure due to the use of natural gas in scenarios *S2* NG and *S3* NG and *S3* NGNU all dramatically reduce the CO_2 emissions relative to the corresponding scenarios in which coal is used.

Figure 1-6 Summary of Δ CO_2, (Percentage Changes in CO_2 Emissions in 2035 Relative to 2000) for Overall Demand, Transformation and Their Major Categories For Mitigation Assessment Scenarios



Similar patterns occur in the case of lime and alumina kilns but the reduction is more dramatic in alumina kilns since alumina kilns cannot use coal directly (syngas is used).

In the case of bauxite mining, no change in fuel is contemplated in any scenario and hence emissions increase monotonously with production. It should be noted that the vertical axis in Figure 3-46 is a percentage change and does not reflect absolute emissions.

Household Demand

The CO_2 emissions for the household and government demand show reduced emissions in 2035 relative to 2000 for all scenarios. Although there is population increase (and hence an increase in the number of households or JPS customers) the increased demand because of this is more than offset by more energy efficient appliances, mitigation (energy conservation) measures and lower CO_2 emitting electricity generation when natural gas is used. [Remember that the CO_2 emissions for electricity demand are estimated by allocating the emissions to transformation activities.]

Government Demand

The mitigation measures in the hospitals and NWC as well as a government program to reduce electricity consumption by 15% together lead to the overall reduction in CO2 emissions for all scenarios in the Government category.

Rates 20, 40A, 50 and 60 Categories Demands

No significant mitigation measures have been proposed for these rate categories. Estimates for the changes in energy demand are limited by a lack of information on the types of energy end use equipment and/or a knowledge of the distribution of activities (for example based on a knowledge of industrial classification – i.e., JIC Codes - for these customers) on which end use demand estimates could be made. The most notable percentage reduction in CO_2 emission projections is for the street lighting (Rate 60) due to the introductions of energy efficient street lighting (see Figure 3-46).

TRANSFORMATION

The overall changes in CO_2 emissions for transformation processes reflect the introduction of natural gas (lower CO_2 emissions in 2035 relative to 2000 for the scenarios in which natural gas is used for electricity generation).

The CO_2 emissions from oil refining show no variation across scenarios since all assume the refinery upgrade takes place.

The pattern for CO_2 emissions from electricity generation alone also reflects the introduction of natural gas (lower emissions in 2035 than in 2000 for scenarios *S2* NG, *S3*NG and *S3*NG NU).

NON ENERGY SECTOR EMISSIONS

The non energy sector emissions which are ~2500 times higher in 2035 than in 2000, are dominated by the process emissions from the use of petcoke in electricity generation which

is present in all scenarios (Note that the data for the non energy sector emissions are divided by 100).

Mitigation Activities for Implementation

The main and supporting energy sector institutions, policies and legislation and the requirements for implementing mitigation measures provide the context within which mitigation measures will take place. The main gaps that need to be filled and barriers to be overcome are identified so that specific recommendations for implementing some of the mitigation measures can be proposed.

The key institutions include:

- Ministry of Energy and Mining
- Petroleum Corporation of Jamaica
- Jamaica Bauxite Institute
- Electricity Generating Companies
- Office of Utilities Regulation
- Ministry of Transport and Works

Supporting institutions include: Office of the Prime Minister, National Environment and Planning Agency, National Solid Waste Management Authority, Statistical Institute of Jamaica, the Planning Institute of Jamaica, Meteorological Service, Jamaica Bureau of Standards, Forestry Department and the National Focal Point for the Clean Development Mechanism.

The range of policies and legislation that will be necessary to support the mitigation activities include the following.

- Vision 2030 Jamaica: National Development Plan
- Jamaica's National Energy Policy 2009-2030
- Jamaica's Carbon Emissions Trading Policy (draft 2009)
- Regulatory Policy for the Addition of New Generating Capacity to the Public Electricity Supply System
- Policy on Environmental Stewardship of Government Operations (draft)
- National Transport Policy (Draft)

The pieces of legislation that are of relevance to the mitigation assessment are listed below:

- Electricity Survey Act (1956)
- Petroleum Quality Act
- Natural Resources Conservation Authority Act
- Natural Resources Conservation Authority (Air Quality) Regulations (2006)
- Natural Resources Conservation Authority (Permits and Licences) Regulations (1996)

The successful implementation of mitigation measures will *inter alia* depend on:

- the provision of incentives/disincentives for the development and use of innovative technologies that improve/worsen efficiency;

- creation of relevant legislation to support the required investments in efficiency in sectors such as transportation and bauxite;
- a review of previous and existing demand side management programmes for performance, strengths and lessons learned;
- stronger institutional capacities in the energy and environment sectors;
- development of programmes designed to influence market behaviour towards more efficient use in energy across all sectors;
- development of a mechanisms to efficiently share energy related information and for public and private sector entities to collaborate on energy related projects;
- establishment of a system to identify and replace old inefficient electricity equipment and (especially) generating units/plants with more fuel efficient and cost efficient technologies and plants;
- promotion of strategic partnerships between the public and private sectors to finance and develop energy diversification projects; and
- introduction of national vehicle emission standards and regulations to reduce vehicular emissions and promote introduction of cleaner transportation fuels (especially CNG).

Gaps

Various gaps currently exist in the energy sector and the Energy Policy clearly articulates strategies to fill most of these gaps. Some of the critical gaps that affect implementation of mitigation measures are highlighted below.

Carbon Trading

The Draft Carbon Trading Policy includes a proposal to name the designation of the Designated National Authority and to "s*ecure a sustained source of funding to support the provision of DNA related activities and services".* However although the policy recognises that absence of an institution/agency and a CDM governance structure, the nature of the institution or agency that will house the DNA and some of its activities (e.g., whether or not any legislation will be needed; how it would be staffed; a timeline for its establishment and the governance structure surrounding the DNA office) are not clearly articulated.

To date the Wigton Wind Farm is the only project in Jamaica that is engaged in carbon trading and as recognised in the draft policy additional capacity is needed to successfully take advantage of CDM opportunities. Since currently there are several potential projects that could benefit from carbon trading it is essential that the policy be implemented with great urgency.

Coordination Among Energy Sector Stakeholders

The stakeholders involved in the implementation of mitigation measures span the gamut of public as well as private sector agencies and institutions and the general public. Coordination of mitigation activities and communication of vital information to and among

these stakeholders will be vital. Currently there are no formal interagency bodies or other mechanisms that will coordinate mitigation activities that span various agencies or that would facilitate information flow.

Policy and Regulatory Gaps

Some of issues and challenges the energy sector faces include legislation that lack adequate enforcement provisions and clearly articulated policies or protocols that address the pricing of electricity and petroleum products; decision making about retirement or mothballing old inefficient electricity generation plants; tax and pricing structure for road users; how to (better) address electricity system losses; and the development of renewable generation capacity. This has resulted in incremental decisions and has limited the introduction of diverse sources of energy and providing integrated monitoring and enforcement of regulations. There are also no legislative provisions for the net metering, carbon trading (as indicated above) and energy efficiency standards.

Data Collection and Information

In general various pieces of legislation include provisions that require reporting of fuel sales, electricity generation parameters and emissions and for acquisition of production and other "activity data' that are needed for estimating emissions and for planning purposes.

Data on historical electrical energy use and fuel consumption are collected by various entities, including STATIN, PIOJ, JPS, OUR, NEPA, Ministry of Transport and Works, and the Ministry of Energy and Mining.

There are however critical gaps in the collection of information that will allow forecasting of energy and fuel consumption. Recently MEM has been engaged in energy forecasting but it appears that the effort is constrained by the lack of suitable data.

Notwithstanding the collection of historical data, the energy sector is not effectively supported by databases that are accurate and precise to enable analysis, forecasting and overall management of the sector. There also are significant delays in accessing reliable information on various aspects of the energy sector. This has adverse effects on the ability to plan and make decisions on informed judgment.

The annual data compiled by STATIN in the decanal censuses and annual surveys of living conditions (e.g., ESSJ and JSLC reports) provide some of the data required for forecasting purposes based on analysis of historical trends. The JSLC surveys include good data on penetration of household electrical appliances and other amenities. *Similar survey data that would be useful for estimating electricity consumption for non-residential sectors are not available.* A recent survey of residential energy end use was a missed opportunity to obtain energy intensity data for the residential sector.

Enhancement of the survey approach is needed so that energy intensity data can be obtained on a routine basis. Specific examples include the enhancement of the JSLC surveys to include collection of information on the age ranges and numbers in each household of selected high energy consuming appliances (refrigerators, television sets, and air

conditioners). The approaches used in the U.S. RTECs or NRCAN residential energy end use surveys are examples of the approaches that would be suitable.

Since nearly all electrical appliances and equipment are imported, enhancement of the import classification to clearly distinguish between various categories of appliances (based on technology and ranges of energy use) would be useful. Examples are as follows:

- Motor vehicles – to distinguish fuel used (i.e., diesel, gasoline, CNG, hybrid, electricity only etc.)
- Refrigerators (range in SEER value, refrigerant (HC or HFC)
- TVs (based on technology and/or energy intensity)

While various energy sector projects and programmes have been planned, there appears to be a lack of timely implementation of energy sector plans and projects and limited coordination of activities and evaluation of results. Additionally, over the years, while some emphasis has been placed on the promotion of energy conservation in commercial sectors and industries, the successes of pilot projects such as Environmental Audits for Sustainable Tourism (EAST) appear not to have been expanded to embrace the entire tourism sector for example.

Least cost (electricity) expansion plans (LCEPs) that have taken place have been determined by expediency and the lack of financing but it is acknowledged that external factors have in some cases driven the decision making process.

Although there have been several sectoral plans or policies (e.g., tourism, transportation, a (albeit dated) national industrial policy) there was nominal effort directed at forecasting sectoral energy or fuel use. For example there appears to be little if any reliable energy projections (and hence potential savings from energy conservation initiatives) in the tourism sector or among JPS Rate 40 and 50 consumers. The forecasting of electricity consumption among various rate categories was based on macroeconomic data rather than on knowledge of end use equipment.

Information on more immediate or shorter term energy requirements is sometimes included in environmental impact assessments and could also be included in NEPA's permit applications.

Low levels of research in the energy sector can also be identified as a gap, resulting in low levels of adoption and adaptation of new and emerging energy technologies, improvements in energy infrastructure, and appropriate legislation.

The country also lacks a comprehensive and sustained public education programme that would encourage Jamaicans to use energy wisely and to aggressively pursue opportunities for conservation and efficiency. As a result of this, the Jamaican public has a relatively low level of awareness of the importance of energy and its use in their daily lives and the contribution that each can make to the responsible and efficient use of this vital resource. This low level of awareness also could explain the low intensity of use of solar energy for water heating in Jamaican households.

Recommendations

Specific recommendations are provided to improve the enabling environment, build institutional and human resource capacity, encourage adoption of suitable energy conservation/GHG mitigation technologies and fill data gaps. These will facilitate cost effective energy use and implementation of GHG mitigation measures.

In order to improve the enabling environment within which GHG mitigation and other energy sector activities take place it will be necessary to streamline some legislation and/or policies and in some cases enact additional legislation. The specifics are as follows.

- Strengthen the regulations so that there are adequate enforcement provisions and clearly articulated policies or protocols that address the pricing of electricity and petroleum products; decision making about retirement or mothballing inefficient electricity generation plants; how to (better) address electricity system losses; and the development of renewable generation capacity
- Develop and implement a regulatory framework to allow carbon trading to take place. This should include legislation to establish the designated national authority (DNA) and associated entities and specification of the trading modalities for local and international entities (e.g., licensing, certification or regulation of such entities, owning certified emission reductions (CERs) and Verifiable Emissions Reductions (VERs) etc.)
- Establish enabling environment to encourage local and foreign financing of innovative energy projects, especially in renewables. This could entail developing policies and programs that will encourage use of biogas and solar heaters as well as other alternate energy sources such as photovoltaic systems. These could for example entail revolving loans, and/or import duty concessions and incentives for energy efficiency improvements
- Implement incentives that will encourage tertiary level institutions to develop research programmes for the application and implementation of renewable energy projects
- Adapt/adopt or develop energy efficiency standards for consumer and industrial electrical equipment (e.g. by adopt the Energy Star program) and base import duties for such equipment in part on energy efficiency standards.
- Introduce national motor vehicle emission standards and regulations
- Develop regulations and safety standards in anticipation of the introduction of CNG infrastructure and CNG use in industry and in vehicles
- Revise the bases for tax/customs duties so that they are based on vehicle weight class and fuel type (not cc rating)
- The National Environment and Planning Agency (NEPA) in collaboration with MEM and the Petroleum Corporation of Jamaica (PCJ) should include as a requirement in selected permit applications and environmental impact assessments the provision of

projected electrical energy and fuel use and associated technologies and appropriate benchmarking information. In order to focus attention on energy conservation NEPA should rename the EIA as an Environmental and Energy Impact Assessment (EEIA).

- Make use of the energy efficiency fund to increase energy projects such as those related to renewable energy
- Implement the building code

Capacity-building Needs

Capacity building in the energy sector institutions will be required if mitigation measures are to be effectively implemented. The capacity building needs in the public sector centre on institutional arrangements for the collection, compilation, reporting and analysis of energy information and for public education. Implementation of private sector measures requires increased private sector technology awareness and capability and an environment that facilitates and encourages investment for implementation of mitigation measures. Public sector agencies with regulatory or other responsibility for the energy and environment must also be aware of the technologies, be able to assess them and to develop policies that are responsive to private sector and national needs.

The following specific capacity building needs are identified:

Enhance capacity to compile GHG (and other) emission inventories and the capacity to perform energy and GHG emissions forecasting/modelling

- Develop an energy information clearing house
- Train staff to perform functions of the DNA and the supporting institutions (National Carbon Trading Promotional organization)
- Establish the DNA institutions and identify and enact any necessary legislation (e.g., to enable certification or licensing of trading modalities)
- Expand the role of the Energy Efficiency Unit (EEU) within the Petroleum Corporation of Jamaica to provide technical assistance for ECE initiatives in the public and private sectors
- Strengthen regulatory agencies to improve the efficiency of the system and compliance with established benchmarks, procedures and standards
- Develop stronger links with the energy sector and academic institutions to drive the adoption and adaptation of new technologies in the energy sector
- Engage in research towards adoption and adaptation of new and emerging technologies and improvements in energy infrastructure
- Develop and sustain Public Education on energy efficiency and conservation
- Review the sustainable development and energy conservation curriculum needs throughout the (primary, secondary and tertiary levels) in the educational system and enhance the curriculum accordingly

- Take advantage of carbon trading opportunities

Adoption of Clean and Energy Efficient Technologies

- Develop capacity to facilitate greater energy efficiency in the bauxite and alumina industry and the manufacturing sector (Rate 40 and Rate 50 JPS customers). Initiatives such as the recently announced partnership between JPS and NWC could be applied an a sectoral basis (once suitable information is available)
- Implement incentives/disincentives to enable the development and use of innovative technologies to improve energy efficiencies in all sectors and in households
- Research and develop alternative fuels for the transport sector, including the use of biofuels and CNG when it becomes available
- Encourage the use of solar powered water pumping by the NWC
- Mandate that all new hot water installations in all public buildings be solar
- Promote more widespread use of solar water heating in hotels
- Promote the adoption of solar powered cooling/air conditioning especially in the hotel/tourism sector
- Implement a more aggressive demand side management program including the use of energy-efficient appliances, equipment, and building designs, setting and enforcing standards for public sector organizations, and public awareness and educational programmes

Address Data and Information Gaps

- Improve motor vehicle fleet database (ensure correct assignment of fuel type, add off road categories, weight units; clearly distinguish between non-motorised trailers and motorised trailers, add allowance (categories) for hybrid and CNG vehicles. This could be achieved by quality assurance checks during data entry and use of databases with manufacturers' specifications.
- Compile statistics for annual vehicle kilometres travelled (VKMT)1 through periodic surveys or routinely collect and record odometer readings during vehicle inspections for certificates of fitness
- Require fleet management companies to report VKMT and other general vehicle class data
- Code JPS customers (at least the Rate 40 and 50 customers) by JIC and require reporting of energy use statistics by JIC accordingly. This type of information will inform the design of appropriate end use surveys in the commercial/manufacturing sectors and in planning/forecasting demand

[1] A study is currently under way

- Survey industrial and commercial customers for end use equipment
- Conduct periodic surveys for charcoal and wood use
- Conduct proper residential energy use survey in conjunction with data from JPS smart meters
- Compile data on appliance imports or sales for refrigerators
- Assess impact of distributed electricity generation and water storage and if appropriate develop a suitable program to promote its implementation

List of Acronyms

AAJ	Airports Authority of Jamaica
Bbl	Barrel
BSJ	Bureau of Standards Jamaica
bsd	barrels per stream day
CDM	Clean Development Mechanism
CO_2	Carbon dioxide
COP	Conference of Parties
DNA	Designated national authority
DSM	Demand side management
EAST	Environmental Audits for Sustainable Tourism
EDB	Environmental Data Base
EIA	Environmental Impact Assessment
ESSJ	Economic and Social Survey Jamaica
FOEB	Fuel oil equivalent barrel
GDP	Gross domestic product
GEF	Global Environment Facility
Gg	Gigagram (10^9 g or 1000 tonne or 1 kilotonne)
GHG	Greenhouse gas
CNG	Compresses natural gas
GJ	Gigajoule
HDDV	Heavy duty diesel vehicle
HDGV	Heavy duty gasoline vehicle
HFC	hydrofluorocarbon
HFO	Heavy fuel oil
JAMPRO	Jamaica Promotions (now Jamaica Trade and Invest)
JTI	Jamaica Trade and Invest (formerly JAMPRO)
JBI	Jamaica Bauxite Institute
JIC	Jamaica Industrial Classification
JPS	Jamaica Public Service Company Limited
KMR	Kingston Metropolitan Region

LDDT	Light duty diesel truck
LDDV	Light duty diesel vehicle
LDGT	Light duty gasoline vehicle
LDGV	Light duty gasoline vehicle
LEAP	Long-Range Energy Alternatives Planning System
LPG	Liquefied petroleum gas
LTO	Landing and take-off cycle
MC	Motorcycle
MCF	Maximum capacity factor
MEM	Ministry of Energy and Mining
Mg	Megagram (10^6 g or 1 tonne)
MOWH	Ministry of Water and Housing
MWT	Ministry of Transport & Works
MW	Megawatt
MWh	Megawatt hour
NEPA	National Environment and Planning Agency
NIBJ	National Investment Bank of Jamaica
NMIA	Norman Manley International Airport
NRCA	Natural Resources Conservation Authority
NRCAN	National Resources Canada
NWC	National Water Commission
OTEC	Ocean Thermal Energy Conversion
PCJ	Petroleum Corporation of Jamaica
PIOJ	Planning Institute of Jamaica
PV	Photovoltaic
RECS	Residential Energy and Consumer Survey
SIA	Sangster International Airport
SIA	Sugar Industry Authority
SIRI	Sugar Industry Research Institute
SRC	Scientific Research Council
STATIN	Statistical Institute of Jamaica

TA	Transport Authority
UNDP	United Nations Development Program
UNFCCC	United Nations Framework Convention on Climate Change
UWI	University of the West Indies
VKMT	Vehicle kilometres travelled