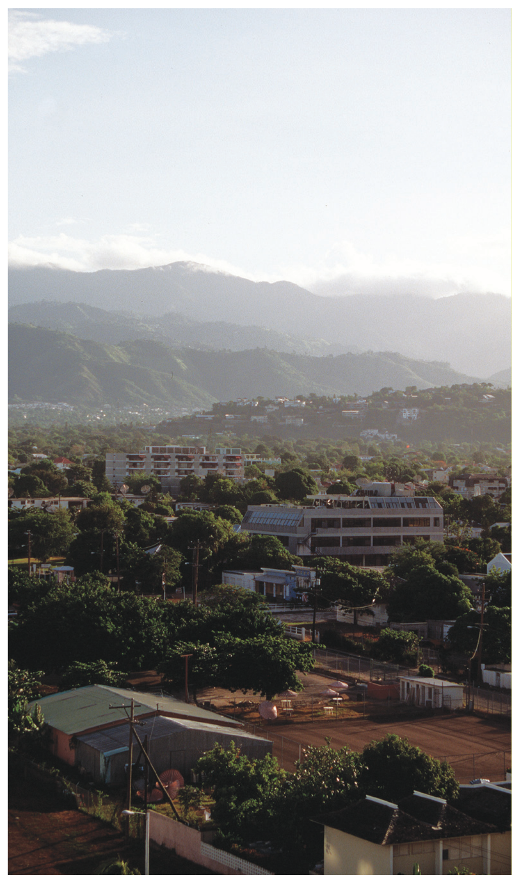
Power & Possibility
The Energy Sector in Jamaica

JORGE PEREZ ARBELAEZ | NATACHA C. MARZOLF



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Jorge Perez Arbelaez
Natacha C. Marzolf

Inter-American Development Bank

Address for correspondence:
Jorge Perez Arbelaez: jorgeperezarb@gmail.com
Natacha C. Marzolf: natacham@iadb.org

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Acronyms and Abbreviations

ADO: Automobile Diesel Oil
AMC: Acres Management Consultants
bbl: Barrels
CA: Central America
CAC : Consumer Affairs Commission (Jamaica)
CAIDI: Customer Average Interruption Duration Index (CAIDI = SAIDI/SAIFI. It measures the average outage duration experienced by a customer.)
CCGT: Combined Cycle Gas Turbine
CDM: Clean Development Mechanism
CERs: Certified Emission Reductions
CERE: Center for Excellence in Renewable Energy
CFB: Circulating Fluid Bed or Circulating Fluidized Bed
CNG: Compressed Natural Gas
DSM: Demand-Side Management
E10: A blend of 90% gasoline and 10% anhydrous ethanol, with positive effects on the octane number of the fuel.
EEU: Energy Efficiency Unit of the PCJ
ESMAP: Energy Sector Management Assistance Program
FAO: Food and Agriculture Organization
FE: Foreign Exchange
FTC: Fair Trading Commission of Jamaica
GDP: Gross Domestic Product
GHG: Greenhouse Gases
GOJ: Government of Jamaica
GT: Gas Turbine
GWh: Gigawatt-Hours (one thousand MWh)
ha: Hectare
HFO: Heavy Fuel Oil
HI or HHI: Herfindahl Index, or Herfindahl-Hirschman Index
IDB: Inter-American Development Bank
IEA: International Energy Agency
IEEE: Institute of Electrical and Electronics Engineers
IPPs: Independent Power Producers
J$: Jamaican dollars
JPSCo: Jamaica Public Services Company
JSIF: Jamaica Social Investment Fund
kV: Kilovolts

kWh:	Kilowatt-Hours
LAC:	Latin America and Caribbean
LCEP:	Least-Cost Expansion Plan
LNG:	Liquefied Natural Gas
LS Diesel:	Low-Speed Diesel
LSD:	LS Diesel
Ltd.:	Limited
MAIFI:	Momentary Average Interruption Frequency Index (A measure of momentary outages, or those that last less than 5 minutes, per customer.)
MEM:	Ministry of Energy and Mining
MCR:	Maximum Continuous Rating
MS Diesel:	Medium-Speed Diesel
MSD:	MS diesel
MWh:	Megawatt-Hours (A measure of energy representing one million watt-hours.)
NDP:	National Development Plan
NGT:	Natural Gas Turbine
NGCC:	Natural Gas Combined Cycle
NPV:	Net Present Value
O&M:	Operation And Maintenance
OAS:	Organization of American States
OLS:	Ordinary Least Squares
OUR:	Office of Utilities Regulation
PBMR:	Performance-Based Rate Mechanism
PCJ:	The Petroleum Corporation of Jamaica
PIOJ:	Planning Institute of Jamaica
PV:	Photovoltaic
REP:	Rural Electrification Program Ltd.
SAIDI:	System Average Interruption Duration Index: equals, for a given year, the sum of all customer-interruption durations divided by the total number of customers served.
SAIFI:	System Average Interruption Frequency Index: equals, for a given year, the total number of customer interruptions divided by the total number of customers served
SRC:	Scientific Research Council
SRL:	Abbreviation Equivalent to Private Limited Company
TA:	Technical Assistance
TC:	Technical Cooperation
TPES:	Total Primary Energy Supply
UERP:	Urban Electricity Regularization Programme
US EIA:	United States Energy Information Administration
WACC:	Weighted Average Cost of Capital
WASP:	Wien Automatic System Planning
WB:	World Bank
WRM:	Wind Resource Maps

1 Introduction

With an area of 11,100 km² and a population of 2.83 million people, Jamaica is the third biggest island in the Caribbean. Its gross domestic product (GDP) is US$11.430 billion and its GDP per capita is US$4,272, equivalent to US$6,079 in terms of purchasing power parity (PPP).[1]

Jamaica has a very high consumption of energy with respect to its population and its GDP, as can be observed in Table 1. With the exception of the Netherlands Antilles, Jamaica has the highest Total Primary Energy Supply (TPES) per capita as well as per unit of GDP (when expressed in PPP). It also has the highest emissions of CO_2, both per capita and per GDP. This high per-unit consumption of energy can be at least partly attributed to the importance of the bauxite industry in the Jamaican economy, as it is a highly energy-intensive industry. However, even after adjusting for this fact,[1] Jamaica's consumption is still higher than that of the other countries (except Netherlands Antilles) in most of the per-unit indicators. Compared with other Latin American and Caribbean (LAC) countries, Jamaica is a high user of energy.

Jamaica has other special characteristics and issues that are important to understanding the context within which the energy sector is placed. They are as follows:

a. **Supply**: Jamaica has very limited hydropower production because its hydro resources are quite small, a few are still unexploited, and the biggest site cannot be developed because of tourism and environmental considerations. However, even if all the remaining hydropower potential were developed (around 80 MW including the biggest site which contributes 50 of those 80 MW[3]) it would still amount to a very small fraction of the demand for energy. In the electricity sector alone, peak demand is currently 622 MW, 7.6 times more than the remaining hydro potential. Another important characteristic is that Jamaica has no indigenous petroleum or natural gas. Thus it must import all of its hydrocarbon, creating a heavy dependence on imported crude oil and oil products. In sum, Jamaica is poor in the two resources that constitute the traditional supply of energy: hydrocarbons and hydropower. But in non-traditional resources, that is, renewables, Jamaica may fare substantially better. As will be seen in this review, Jamaica has exploited wind resources, but it does not yet know how extensive they may be, since the country is lacking a set of wind resource maps covering all of its onshore and offshore locations.

[1] WB. World Development indicators. 2007 Estimates (current dollars).
[2] A rough adjustment is a reduction by 31%, which is the approximate share of total energy used by the bauxite industry in the total energy supply.
[3] Cf. Loy and Coviello (2005), p.32

Table 1 Jamaica and other LAC countries: Comparison of selected energy indicators – 2006

KEY INDICATORS	UNITS	JAMAICA	NETHERLANDS ANTILLES	DOMINICAN REPUBLIC	COSTA RICA	HONDURAS
Population	(million)	2.67	0.19	9.62	4.4	6.97
GDP (at Constant 2000 prices)	(billion 2000 US$)	8.97	1.29	25.9	21.03	7.53
CO_2 Emissions **	(Mt of CO_2)	11.54	3.93	18.65	5.92	7.11
TPES/Population	(toe/capita)	1.72	9.15	0.82	1.04	0.62
TPES/GDP	(toe/thousand 2000 US$)	0.51	1.35	0.3	0.22	0.58
TPES/GDP (PPP)	(toe/thousand 2000 US$ PPP)	0.44	0.6	0.11	0.11	0.19
Electricity Consumption */ Population	(kWh/capita)	2450	5651	1309	1801	642
CO_2/Population	(t CO_2/capita)	4.33	20.81	1.94	1.35	1.02
CO_2/GDP	(kg CO_2/2000 US$)	1.29	3.06	0.72	0.28	0.94
CO_2/GDP (PPP)	(kg CO_2/2000 US$ PPP)	1.11	1.36	0.25	0.14	0.3
Net Energy Imports/ Population		1.54	17.89	0.65	0.51	0.36
GDP/Capita	2000 US$/ capita	3359.55	6789.47	2692.31	4779.55	1080.34
GDP (PPP)/Capita	2000 US$(PPP)/ capita	3,898.88	15,210.53	7,613.31	9,620.45	3,345.77
Ratio GDP/Cap – PPP/Financial	2000 US$(PPP)/ 2000 US$	1.16	2.24	2.83	2.01	3.10

Source: IEA
*Gross production + imports – exports – transmission & distribution losses
**CO_2 emissions from fuel combustion only. Emissions are calculated using IEA's energy balances and the Revised 1996 IPCC Guidelines.

Jamaica has sugar cane, which could contribute to the supply of both bioethanol and electricity partially produced using the bagasse as fuel. Jamaica is rich in sun irradiation, which can replace many of the uses of traditional fuels and electricity for water heating (and cooling). Jamaica could also harness sun irradiation to produce electricity via photovoltaic cells; or on a less expensive and more pertitent scale it could produce electricity using Concentrating Solar Power (or Solar Thermal), as described below. One of the big challenges Jamaica faces is how to harness these non-traditional renewable resources to break its dependence on oil.

b. **Demand**: On the demand side, the importance of the bauxite/alumina industry in the overall final demand for energy is significant. The bauxite industry uses about 40% of all oil and oil product imports. The rest is mainly demand for transport and for electricity (around a quarter of total imports each). Notwithstanding the latter, an important characteristic of bauxite/alumina is that, unlike all other sectors, it has a positive—or at least neutral—effect on the current account of the balance of payments, given that the industry earns more foreign revenue with its exports than others such as transportation, and it has the potential to contribute a sizable amount of energy to the public electricity grid via the sale of surplus electricity.
c. **Energy imports increase**. Another issue faced by the energy sector is that energy imports (mainly oil and oil products) have been increasing their share in the value of all imports, such that in 2007 they represented 34.5% of all imports versus 17.8% in 2002. Perhaps the impact of fuel imports on the external balance of Jamaica is more clearly illustrated by the fact that, recently, they have reached a value similar to the value of all exports of goods (the value of fuel imports in 2007 was around 1.02 times the value of goods exports). This is a difficult situation for the Jamaican economy, and one that is bound to produce many difficulties, especially if ways of mitigating the problem—such as the diversification into locally-produced renewables mentioned before—are not found soon.

In the following chapters, we will review (i) energy policy and planning in Jamaica (Chapter II); (ii) the electricity sector in all its aspects: institutional and regulatory, technical, and economic (Chapter III); (iii) the oil/petroleum sector (Chapter IV) and (iv) Jamaica's renewable energy sector (Chapter V). The final sections of the last three chapters use the insights gained to discern the challenges that the country confronts in the respective sectors and to explore ways in which the Inter-American Development Bank can further work as a partner with the Government of Jamaica (GOJ) in surmounting those challenges.

Energy Policy and Planning

2

Several government entities are presently involved in various aspects of policy and planning related to the energy sector in Jamaica. The key institutions are the following:

The Office of the Prime Minister. In late 2006, a technical Inter-Ministerial Committee on Energy Policy and Analysis was empanelled. It is comprised of representatives from the Cabinet Office, the Office of the Prime Minister, the Ministry of Energy and Mining (MEM), the Office of the Attorney General, the Petroleum Corporation of Jamaica (PCJ), the Office of Utilities Regulation (OUR) and Petrojam.

The Planning Institute of Jamaica (PIOJ). Since January 2007 this agency of the Office of the Prime Minister has led the preparation of a National Development Plan (NDP), named *Vision 2030 Jamaica*. Twenty-seven task forces were appointed to develop plans for each sector. Among these, the Energy Task Force prepared an Energy Sector Plan to guide the development of the sector in the next decades.[4]

The Ministry of Energy and Mining (MEM). The Ministry has developed a new energy policy and has published a Green Paper on the matter,[5] whose final version was circulated for public consultation, before becoming a White Paper.[6] This policy paper is fully consistent with the NDP, *Vision 2030 Jamaica*.

The Office of Utilities Regulation (OUR). Associated with the Office of the Prime Minister, the OUR has for its main functions the regulation of public utilities, including electricity. The OUR has recently acquired a role in the planning of the electricity sector and is responsible for the Long-Term Expansion Plan of the energy sector, which was formerly produced by the private utility company, Jamaica Public Service (JPSCo.).

The Petroleum Corporation of Jamaica (PCJ). Under the MEM this statutory corporation plays an important role in the development of renewable energy through its Center for Excellence in Renewable Energy (CERE). PCJ also manages the oil refinery portfolio (through

4 See PIOJ. *Vision 2030—Jamaica National Development Plan* –"Energy Sector Plan (1st Draft)," July 2007.
5 Government of Jamaica, Ministry of Energy and Mining. *The Jamaica Energy Policy 2006–2020*, Green Paper, February 20, 2006. And Idem, "Energy Conservation and Efficiency Policy 2008–2002, An Addendum to the Draft Energy Green Paper 2006–2020," July 2008.
6 The version, revised after the consultations, is titled: *Jamaica's Energy Policy 2009–2030*.

Petrojam) and the government-owned gasoline distribution company PETCOM and oversees exploration of crude oil.

The Ministry of Agriculture. This government agency is responsible for the transformation plan of the sugar industry.

The Electricity Sector

3

THE INDUSTRY: STRUCTURE AND REGULATION

1. Industry Structure and Organization

The Jamaican electricity sector is presently organized around one single integrated company, the Jamaica Public Services Company Ltd., JPSCo, which has legal monopoly for transmission, distribution, and dispatch, and which has also generating capacity. The electricity generation activity is organized around a market in which independent power producers (IPPs) can compete for long-term generation contracts to sell electricity to JPSCo in what is known as competition for the market.[7] JPSCo can also compete for long-term generation capacity. Some rural areas, where the expansion of electricity services is not commercially viable for JPSCo, are the responsibility of the Government through the Rural Electrification Program Ltd. (REP).[8]

The ownership structure of JPSCo is presently: 80% jointly owned by the Marubeni Corporation and TAQA (Marubeni TAQA Caribbean); 19% owned by the GOJ and 1% by others. Marubeni purchased its 80% stake in 2007 from the Mirant Corporation (a US company incorporated in Delaware with a subsidiary in Barbados),[9] which had purchased the 80% stake from the Jamaican Government in 2001 for US$201 million (Paredes 2003, p.12). From 1970 to 2001 the GOJ was the main owner of JPSCo, with a controlling interest. Previous to 1970, JPSCo and the preceding companies had been private companies. JPSCo, in both its government-owned and privately owned phases, has been the monopoly provider of electricity to the island since 1923 and has had an all-island franchise since 1966.[10]

The 2001 sale of JPSCo did not follow international competitive bidding procedures. Rather, the National Investment Bank of Jamaica negotiated directly with interested investors. The process of privatization "did not meet the approval" of the Inter-American Development Bank (IDB) and the World Bank: many questions were raised as to transparency,

[7] In Competition for the Market the selling agents bid to offer a certain amount of fixed electric capacity and firm energy for a certain long-term period. This is different from what is known as Competition in the Market, where selling agents (generating companies) compete to participate in the supply curve that will meet electricity demand (the load curve) in a given day; offers from the various suppliers are accepted in order of increasing cost until there is enough energy accumulated to fulfill the load curve.
[8] See below: Rural Electrification
[9] More precisely, Mirant sold to Marubeni Caribbean Power Holdings (MCPH) Inc, a subsidiary of Marubeni Corporation of Japan. In early 2009, Marubeni transferred 50% of its shares in MCPH to Abu Dhabi National Energy Company (TAQA) of the United Arab Emirates. In addition to Jamaica, MCPH has interests in utility companies in Trinidad and Tobago, the Bahamas, and Curaçao (Information from "About Jamaica Public Service—Our History" at http://www.myjpsco.com/about_us/our_history.php.
[10] Ibid.

Table 2 Structure of Jamaica's Electricity System

COMPANY	MAIN ROLE	GENERATION. INSTALLED CAPACITY	TRANSMISSION	DISTRIBUTION	DISPATCHING FUNCTION
Jamaica Public Service Company, JPSCo	Legal monopoly supplier to final users	623 MW	Its license gives it the Transmission Function	Its license gives it the Distribution Function	Has the Dispatching function
Jamaica Energy Partners, JEP	Independent Power Producer (IPP)	124 MW	No	No	NA
Jamaica Private Power Company, JPPC	IPP	61 MW	No	No	NA
Wigton Wind Farm	IPP (Subsidiary of PCJ)	20 MW	No	No	NA
Jamalco	Bauxite Company-Cogeneration	Up to 11 MW to Sell to JPSCo for National Grid	NA	NA	NA
Jamaica Broilers Group	Cogeneration	20 MW to Sell to JPSCo	NA	NA	NA

Source: JPSCo.
* Refers only to the Integrated Grid operated by JPSCo. Does not include self-generators not selling to the Grid.

the number of bidders, a priori price, a functioning regulatory framework, and assessment weights.[11] One of the most salient critiques was that the negotiations over prices were "concurrent (or even previous) to the negotiations regarding the regulation that would rule the sector" and that as a result, "critical aspects of electricity regulation were left open for 'future determination'".[12] In spite of these initial glitches, progress has been achieved in many areas in the last nine years.[13]

Table 2 shows the present structure of the electricity system. The table presents the private agents that currently constitute the regular electricity system (the grid). To complete the picture of the sector, two more groups have to be included. The first, also private, is constituted by a group of producers (self-generators) who co-generate electricity for their own

[11] IDB, OVE. *Country Program Evaluation: Jamaica*, Washington, D.C. 1990–2002. October 2005, pp. iii and 19.
[12] Paredes (2003 pp. 12–13). Paredes argues furthermore that an initial electricity price increase may have been justified, because JPSCo was starved of investments and the sector was suffering from blackouts as a result. A proper process of privatization, he concludes, with the regulatory rules set in advance and with subsequent regulation well carried out, might have resulted in decreased future prices (op. cit. p. 13).
[13] In a recent Jamaica Electricity Sector Note (Draft, 2008) the World Bank summarizes this progress as follows: "Jamaica has reached an advanced stage of private-sector participation, built extensive regulatory capacity and implemented tough reforms (including cost-reflective tariffs)," although it goes on to note as well areas where there is still room for improvement.

use without selling any power to the JPSCo grid for general distribution. They fulfill their own need for steam and electricity and could in principle sell surplus capacity or energy to the grid. The most important among these are the sugar and bauxite industries. These industries self-generate at a capacity of approximately 200 MW,[14] of which some at 30 MW correspond to the sugar industry.[15] The second player is REP, which will be presented in the next section.

2. Rural Electricity

Rural electricity expansion is not carried out by JPSCo, because it cannot be profitable. Thus the GOJ has created a special publicly owned company, the Rural Electrification Program Limited (REP), incorporated in 1975 as an executive agency of the government to take charge of rural electrification.[16] Originally, its mandate was limited to carrying out the expansion of electricity services to rural areas, where the expansion of such service would not be financially viable to a commercial electricity retailer such as JPSCo. Today, REP concentrates its activities in the construction of electrical distribution pole lines in non-electrified areas and the provision of house wiring assistance through affordable loan programs to households that are then given access to the service from the newly erected lines. Additionally, REP offers house-wiring assistance to needy households in already electrified areas through a Revolving Fund Program. Recently, REP has also been given the mandate to carry out an Urban Electricity Regularization Program (UERP) to regularize illegal connections in urban areas as part of a larger effort to reduce commercial losses.

As of March 2009, the REP had provided electricity access to some 74,000 households. As a result, approximately 90% of rural areas now have electricity (up from 60% in the 1970s). The program has been implemented using concessional funds or government subsidies. One of its sources of funds has been the Jamaica Social Investment Fund (JSIF). The REP signed in 2006 a memorandum of understanding (MOU) with JSIF and with JPSCo, with the purpose of facilitating electricity regularization of households in twelve selected inner-city communities. The JSIF has in turn received financing from the IDB, the World Bank, and other donors, as well as from the GOJ.

The REP has attempted to use renewable technologies to provide electricity to homes where the cost of extending the distribution grid would be too high, such as in areas where the lines would connect less than 20 houses per mile. A program in 1998 equipped two villages, about 45 homes, with photovoltaic (PV) technology on a test basis using funds from the

[14] Sampson, Cezley. "Challenges in the Electricity Sector: Jamaica at the Crosswords." Presentation at the Geological Society Exhibition. University of the West Indies. 28 November 2006. The World Bank (2008) mentions that the capacity of the bauxite industry is 150 MW, and that self-generation in the sugar industry is around 25 MW. This figure is near Cezley's, which seems to include other self-generation. On the other hand, data from the US EIA put total electricity installed capacity in Jamaica at 1,161 MW in 2006 (Latest figure available. For the previous year this figure is approximately 100 MW higher). JPSCo's system capacity, including IPPs, was 816.45 MW in 2006. This figure results in an estimate for self-generation capacity of 344 MW in 2006, a higher estimate than Cezley's for that same year.

[15] A draft power/electricity policy of 2004 mentions a self-generation capacity for the sugar industry of some 30 MW.

[16] Information taken from Government of Jamaica (2008a), and Government of Jamaica (2004).

1996 World Bank DSM program. This test program showed that administrative and technical sustainability could be a problem.[17]

3. Electricity Regulation

Three legal documents frame the regulation of the electricity sector in Jamaica: The Electric Lighting Act of 1890 as amended; the Office of Utilities Regulation Act of 1995 as amended in 2000; and the All-Island Electric Licence 2001, granted to JPSCo.

The Electric Lighting Act sets the general framework for the governance of the sector, and in particular, the power of the government (represented by the relevant minister) to grant licenses to any local authority, company, or person to supply electricity and to regulate, inter alia, prices, security, and quality of energy supply and safety.

The 1995 Office of Utilities Regulation Act gives the OUR the function of regulating the provision of services by licensees as well as other functions necessary to carry out its regulatory mandate. In some instances (in particular, the approval of applications for a licence) its functions are directed at advising the Minister on the relevant course of action. In others, such as with respect to rates or fares, the OUR has the power to determine prices in accordance with the provisions of the Act. Lastly, the OUR provides guidance and relevant standards and provisions with respect to quality and safety, environment, effectiveness, reliability, and cost efficiency of services.

With respect to its finances (Section 6 of the Act), the OUR has autonomous funds coming from licence fees and regulatory service fees. Other funds "may be made available [to it] in respect of any matter incidental to its functions."

The Act also prescribes a maximum remuneration for the OUR employees [Second schedule, 11. (1) and (2)], although it gives the pertinent minister the power to increase it. It is not clear whether this provision might constitute an obstacle to acquiring, and especially retaining, highly qualified and talented personnel, who may be lured away by private providers if the remuneration is not adequately calibrated or if the procedures to determine it do not give enough flexibility. Information obtained indicates that the OUR salaries are not competitive enough with those of the private industry in the same sector. As a result, the OUR's personnel turnover rate is high. This is an important aspect, as the OUR is also responsible for planning the expansion of the energy system and management and administration, when applicable.

Energy distribution and transmission are mainly handled in the All-Island Electric Licence of 2001, which granted JPSCo the exclusive right to transmit, distribute, and supply[18]

[17] "The major requirement, which emerged from the evaluation carried out, is the need for a sustainable administrative and maintenance arrangement if PV is to be a sustainable solution. The batteries, for example, have now [2004] reached five years of age and there is no system to provide replacement" (Government of Jamaica. Ministry of Commerce, Science and Technology, 2004).

[18] "Supply" here is restricted to mean, according to its definition in the Licence, the business of "selling electricity to the customers" (Cf. All-Island Electrical Licence 2001, Condition 1.4). In certain systems distribution and "supply" in the sense mentioned, are separate activities and businesses: Some companies can sell (supply) electricity to final consumers through the network of the distribution company, subject to paying a distribution tariff. In these cases the electricity business is comprised of four activities: generation,

electricity throughout Jamaica for a period of 20 years. The Licence also granted the company exclusive right to develop new generation capacity from 2001 to 2004. After 2004, when this provision expired, JPSCo still kept the right "…together with other outside person(s) to compete for the right to develop new generation capacity…"[19]

The All-Island Electric Licence sets forth the rules that determine new investments to be made (through competition for new generation); regulate prices and corresponding tariff increases; determine the long-term expansion plan of the system (including the Least Cost Expansion Plan (LCEP) for dispatching, as well as additional aspects such as conditions for modifications and for revocation of the Licence, rural electrification (subsidized if necessary), street works, rights of way, etc.

As mentioned above, JPSCo is in charge of preparing the LCEP and submitting it to the OUR, which, if it approves the LCEP, recommends its approval to the Minister (Condition 21). JPSCo is also responsible to put together requests for proposals and to conduct tender processes if JPSCo itself is not offering a bid; or, if it is participating in the tenders, to hire an independent evaluator to conduct the tender process. Such a process must obtain the approval of the OUR. One issue raised regarding the outlined process is that, while it avoids the clear conflict of interest of JPSCo bidding and judging the bids, it does not avoid the more subtle conflict of interest of JPSCo having access to all information from all other bidders (considered "insider information") and thus begs the question regarding the transparency and competitiveness of the tender process.

In order to correct the issue raised above, and as a condition for the GOJ to accept the transfer of ownership of JPSCo to Marubeni, Marubeni consented to a Letter of Agreement in favor of the GOJ, whereby it committed to accept, inter alia, that the responsibility for the preparation and revision of all (requisite) LCEP for adding generation capacity to the national grid would be transferred to the OUR. The management and administration of the competitive process for the addition of new generating capacity would also be transferred from JPSCo to the OUR.[20] All these new responsibilities of the OUR require a great deal of specialized technical expertise and impose the additional need to strengthen the OUR in staff size as well as in its technical, legal, economical, financial, and planning expertise.[21]

The Licence also sets out in great detail the regulation of quality of service, prices, and reliability, contained in conditions 15 and 17 and their related Schedules 1 to 4 and Exhibits

transmission, distribution, and "supply." In most companies; however, distribution and supply are joined. And in practically all cases the distribution company also "supplies" (sells) electricity even if it has to allow others to sell electricity, as well, using its distribution network.

19 Ibid., Condition 2.4

20 See "Sale Of JPS By Mirant To Marubeni Approved By Cabinet" (http://www.mct.gov.jm/jps_sale.htm).

21 The World Bank, in its recent electricity sector draft note (2008) notes this as well. It puts the changes needed in these terms: "…[given that] the number of private operators in the sector is bound to increase, and the instability in the international fuel market requires a more pro-active approach than in the past to sector planning and supervision of operators. The OUR needs quantitative and qualitative reinforcement in (i) power sector planning, costing, tariff setting and finance; (ii) legal matters and contract enforcement; (iii) availability of planning, financial and tariff analysis instruments; and (iv) management of information database on the sector." It mentions the need for concomitant changes in the Energy Ministry as well, for the same reasons.

1 to 3. The regulatory framework presented corresponds to a form of incentive regulation known as a price cap regime: The average price (rate) of electricity to final consumers in J$/kWh is capped at a certain level that varies over time as a function of the performance of the company. In order to determine this rate and its variation, the Licence distinguishes several components that go into the determination of the rate: i) a non-fuel base rate; ii) a fuel rate; and iii) extraordinary costs related to government-imposed obligations.

The non-fuel base rate is determined every five years, starting in 2004. No later than March 1, JPSCo submits a Tariff Review Application proposing new ("recalculated") non-fuel base rates for the next five-year period.[22] This rate is adjusted annually for the five-year period, which commences on June 1 (Adjustment Date) of the initial year, using a Performance-Based Rate Mechanism (PBMR) described below. Rates are also adjusted monthly by an index reflecting foreign exchange variations.[23]

The non-fuel base rates are based on the Non-fuel Revenue Requirements necessary to recover non-fuel operating costs, depreciation (whose rates are tightly regulated in schedule 4), income taxes, and a return on the net investment in the regulated assets (the "Rate Base") of JPSCo "sufficient to provide for the requirements of consumers and acquire new investments at competitive costs." The allowed rate of return to apply to the rate base is JPSCo's Weighted Average Cost of Capital (WACC); this WACC should "balance the interest of both consumers and investors," take account of the risks to capital in similar businesses, and be based on the actual capital structure of the company.

The non-fuel base rates annual adjustment, heart of the price cap mechanism, adjusts for four factors. First, it adjusts the price cap for the change in a mix of US and Jamaican inflation, ΔI (reflecting in theory at least the proportion of those rates in the company's non-fuel expenses).[24] The second adjustment, the "X-Factor," takes account of the offset to inflation resulting from expected productivity improvements in the company, relative to productivity improvements in the economy.[25] The third, the "Q-Factor," adjusts the price cap for performance incentives reflected in a set of targets for quality of service provided to the customers. The fourth, the "Z-Factor," adjusts the price cap for special reasons not captured elsewhere including, inter alia, natural unpredictable disasters such as hurricanes. This combination comprises the performance-based rate adjustment mechanism (PBRM) which is summarized in the following formula:

[22] From 2001 to 2004 the initial non-fuel base rates were based on the tariff regime that was effective before the Licence, on February 1, 2001 with periodic adjustments, for inflation and exchange rate changes only, until May 31 2004.

[23] Up to 2005, this adjustment was applied not only to the non-fuel base rates but also to the fuel rates. It was corrected then.

[24] The original All-Island Electric Licence, which contains the main regulatory provisions based on The Electric Lighting Act); and the OUR usage, the Δ is written as d, a differential operator. As they describe discrete (finite) differences, they are expressed here as difference operators, Δ, as used in several JPSCo documents.

[25] More precisely, productivity improvements in firms "whose price index of outputs reflects the prices escalation measure ΔI," i.e., in the Jamaican and US economies. In the Licence's words: the X-Factor should be "… set equal to the difference in total factor productivity of the Licenced business and the general factor productivity growth of firms whose price index of outputs reflects the prices escalation measure ΔI."

$$\Delta(B_n) = \Delta I + X + Q + Z$$

where:

X and Q and Z, defined above, are algebraic variables (they can have positive and negative values, i.e., they can be $\pm|\Delta I|$, $\pm |X|$, $\pm|Q|$, $\pm|Z|$)[26] and are expressed as percentage or proportional changes;

B_n= the non-fuel base rate; and

$\Delta(B_n)$ –= the resulting annual adjustment to the non-fuel base rate, B_n.

ΔI is expressed (as of 2008) by the general formula:

$$\Delta I = 0.76*e+0.76*0.92*I_{us}*e+0 .76*0.92*I_{us}+0.24*Ij \quad (1)$$

where

e = percentage change in the base exchange rate;[27]

I_{us} = the increase in an agreed US inflation index for the previous year; and

Ij = the increase in the Jamaican inflation index for the previous year.

0.76 is taken to represent the share of the costs of imported items in JPSCo's non-fuel expenditures. Thus 0.24, its complement, is the share of Jamaica-purchased items.

As can be seen, this formula is intended to represent the (exogenous) increases in costs caused by US and Jamaican inflation as translated into Jamaican prices. The inflation plus devaluation adjustment conveyed by the formula is very specific.

Contrary to the automaticity of ΔI, the other factors in the formula, the X, Q and Z factors, have no automatic adjustment mechanism. Z depends on occurrences such as natural disasters, which have to be examined case by case. X depends on the projected relative advance of the (total factor) productivity of the firm vis-à-vis industries of the same type, which may be the subject of detailed studies every five years, when the Licensee (JPSCo) can propose new parameters for the Δ(Bn) formula.

The quality factor Q depends on the incentives the regulator establishes to improve the quality of service. They are related to indices reflecting the frequency and duration of interruptions of service (blackouts), for which the regulators establish a rate of improvement (in this case, of decrease in the indices) with a band around the resulting trend. The company receives symmetrical rewards or penalties (increases/decreases in Q) according to whether it increases or decreases quality beyond the established band in a given period.[28]

[26] In theory ΔI could of course also be negative, a value that would reflect improbable deflation and would probably force an alteration of the rules of the game.

[27] Thus change from the previous base, normally given by the exchange rate prevailing at the beginning of the previous period's new base rate, related to the exchange rate current at the beginning of the new period.

[28] The quality of service of JPSCo and the related parameters will be examined below.

The non-fuel charge is also submitted to a monthly adjustment for foreign exchange (FE) variations, computed as follows:

$$\%FE\ Adjust = (\text{billing exchange rate} - \text{base exchange rate}) / (\text{base exchange rate}) \times 76\% \qquad (2)$$

where the billing exchange rate is a monthly average spot rate (the Jamaican "Spot Market Weighted Average Selling Rate"), and the base exchange rate is the exchange rate at the beginning of the rate period (the periods run normally from June 1 to May 31).

There are thus two adjustments for the non-fuel rate which involve the (positive or negative) growth of the exchange rate: one adjusts once per period (normally per year) for the change in the annual exchange rate that affects the costs of imported inputs as expressed in Jamaican dollars. The second one adjusts for monthly changes in the exchange rate. It is not clear what the justification is for this double adjustment. It may result in increasing the total adjustment by more than the real impact of the change in the exchange rate.[29]

The fuel rate is designed as a pass-through to allow JPSCo to recover its fuel costs directly from electricity consumers. It represents the total cost of fuel (including the cost of fuel for energy purchased from IPPs) required to produce and deliver one kWh of electricity. It is adjusted monthly on the basis of the total fuel computed to have been consumed by JPSCo and IPPs in the production of electricity adjusted for the applicable system heat rate and system losses. The applicable system heat rate is determined by the OUR on the basis of JPSCo's and the IPP's contractual heat rates. The applicable system losses are also determined periodically by the OUR. The fuel rate is calculated in US dollars and translated to Jamaican dollars at the "billing exchange rate"; thus it reflects perfectly the fluctuations of the value of the Jamaican dollar versus the US dollar. It appears in the monthly bill as a J$/kWh amount.

The regulation of the privatized industry, which started in 2001, has experienced a process of growth in which inadequacies discovered in the regulatory system are being remedied. More responsibilities have been transferred to the OUR, which is in charge of implementing the LCEP and thus of the system's new investments in generation. As mentioned this has implications for the staff and training needs of the OUR.[30] Nonetheless, more progress can still be achieved; as the sector itself grows and matures, new problems will appear which will require new approaches. As recently suggested, one task that needs to be done, especially at this moment when a new five-year Tariff Review process is taking place, is the technical audit of the price cap formulas in order to better adapt them to the new challenges that the sector will be facing.[31] Some of these challenges will be examined in the following sections.

29 The World Bank (2008) has recommended a technical audit of the regulatory formulas by international experts. This could be one more aspect to examine.

30 See paragraph No. 27 and footnote No. 36, above.

31 The World Bank states that "…there is a question regarding the adequacy of the tariff formula to stimulate efficiency gains, optimum dispatch, least-cost sector development and fuel sourcing strategies as well as integration of co-generation and development of the most cost-effective PPAs with IPPs. It is suggested that the tariff formula be submitted to a technical audit."

TECHNICAL AND ECONOMIC ASPECTS

4. Coverage

Jamaica has a high degree of coverage for electricity. As mentioned above, approximately 90% of its rural areas had electricity access in 2008 and 92% of all Jamaican households at the national level. The Green Paper on Energy policy targets 100% coverage by 2015.[32]

The evolution of coverage, reflected in the following table, shows the growth of the proportion of people using electricity as opposed to other more costly, inefficient and cumbersome methods. Increased coverage has gone from 71% just 15 years ago to more than 90% (most recent available public numbers).

Table 3 Percentage of Jamaican population with sources of lighting

YEAR	SOURCE			
	ELECTRICITY	KEROSENE	OTHER	NONE
1994	70.8	26.9	0.7	2.4
1995	71.5	25.7	0.5	2.3
1996	76.9	21.1	0.8	1.3
1997	78.2	17.9	0.6	3.3
1998	80.4	15.9	0.4	3.3
1999	80.8	14.8	0.5	4
2000	86.9	11.2	0.7	1.2
2001	86.1	11.3	0.8	1.7
2002	87.1	10.8	0.6	1.4
2004	89	6.9	1.3	2.8
2006	89	7.1	0.9	2
2007	90.3	6.3	1.5	1.9

Source: Planning Institute of Jamaica, Economic and Social Survey of Jamaica. Quoted: in Crawford et al. (2009).

5. Current Demand and Supply of Electricity

Table 4 presents an overall picture of demand and supply in the system that is connected to the all-island grid. It does not include self-generators, mainly comprised of sugar cane and bauxite companies.[33]

32 2009. Jamaica's National Energy Policy 2009–2030 (Green Paper).

33 Self-generation capacity (MW) is estimated to be between 20% and 30% of all capacity in the island (different figures from the WB (2008), Cezley (2006), and the US EIA). There are no figures for energy, but given that load factors are bound to be higher in the bauxite industry, it can be said that self-generated

Table 4 **JPSCo's SYSTEM—Electricity Demand and Supply**

(A) DEMAND AND SUPPLY IN 2008	TOTAL AMOUNTS	ANNUAL GROWTH RATES 2003–2008*
AVERAGE No. OF CUSTOMERS	590,984	3.70%
ENERGY SALES (MWH)	3,179,728	1.10%
Losses & Unaccounted for (MWh)	944,236	13.90%
Total Load	4,123,964	3.70%
NET GENERATION AND PURCHASES (MWh)	4,123,964	3.70%
TOTAL		
System losses (%)	22.90%	9.80%
Peak Demand (MW)	621.7	0.60%

(B) COMPOSITION OF DEMAND AND SUPPLY IN 2007	TOTAL AMOUNTS	% SHARES IN TOTALS	GROWTH RATES 2003–2007(*)
AVERAGE NUMBER OF CUSTOMERS			
Residential	520,085	89.40%	3.60%
Commercial & Industrial (Small)	61,419	10.60%	3.00%
Commercial & Industrial (Large)	116	0.02%	–4.60%
Other	208	0.04%	3.40%
TOTAL	581,828	100.00%	3.50%
Demand			
ENERGY SALES (MWh)			
Residential	1,064,068	34.00%	0.90%
Commercial & Industrial (Small)	1,416,149	45.20%	4.20%
Commercial & Industrial (Large)	561,602	17.90%	–5.80%
Other	89,675	2.90%	8.40%
TOTAL	3,131,494	100.00%	1.40%
Losses & Unaccounted for (MWh)	947,277		12.40%
Total Load	4,078,771		3.50%
NET GENERATION AND PURCHASES (MWH)			
Steam & Slow Speed Diesel	1,671,222	41.00%	–7.50%
Hydro	159,820	3.90%	7.40%
Gas Turbines	267,503	6.60%	–21.70%
Combined Cycle Plant	701,379	17.20%	72.90%
Purchases	1,278,847	31.40%	11.40%
TOTAL	4,078,771	100.00%	3.50%
System Losses %	23.20%		8.60%
Peak Demand (MW)	629		2.40%

Sources: JPSCo 2009–2014 Tariff Review Application, 2008 Rate Schedule, and authors' own calculations.
* Fitted Annual Exponential Growth Rate 2003–2007.

As can be observed in Table 4, the electricity system is relatively small, with about 590,000 customers and a total consumption (and production) of electricity of 4.1 GWh. The number of customers has been growing at a fast 3.7% per year, whereas total consumption (sales) has only being growing at 1.10%. This implies that, as can be seen in Table 5, consumption per customer has been falling, both overall and for the residential and large industry customers.

With respect to the composition of demand,[34] it can be seen in section (b) of Table 4 that the industrial and commercial sector is the largest consumer of electricity in the JPSCo-system, with 63.1% (large plus small) of total consumption versus 34.0% for the residential sector and a mere 2.9% for others (mainly municipal lighting)[35]. Losses also represent a high proportion of net generation (22.9%) and have been growing, at an exponential rate of 13.9% per year, which, given that net generation has been growing only at 3.7% per year, results in a growth of the losses as a proportion of net generation of 9.8% per year.[36]

The average consumption for residential customers was 171 kWh per month in 2008 (Table 5) down from 200 kWh in 2003. Average consumption for all customers has also been falling from 485 to 448kWh per month. These trends are very likely related, inter alia, to the strong increase in tariffs experienced in the period and will be examined below.

In order to carry out international comparisons for the JPSCo system, the methodology proposed is to translate JPSCo's per-customer data into per-capita data. As seen above, electricity coverage in Jamaica reaches 92% of the population or the equivalent of a population of 2.48 million[37] approximately covered by the JPSCo system. This translates into 107 kWh per month per capita of average consumption (sales) for the JPSCo system for 2008 and ranks similar to that of other LAC countries of similar size,[38] such as Panama (125 kWh/month), Uruguay (155 kWh/month), Costa Rica (159 kWh/month) and substantially higher than other Central American countries (Nicaragua, 36 kWh/month; Honduras, 48 kWh/month; El Salvador, 56 kWh/month), Belize (56 kWh/month) and Guyana (81 kWh/month). It is also smaller than that of the small Caribbean islands (with ranges between 143 kWh for St. Lucia and 492 kWh/month for the Bahamas).

A similar international comparison can be done for total consumption in Jamaica (i.e. consumption in the JPSCo system plus consumption for self-generation) but this number is,

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energy (GWh) is a higher proportion of total energy than self-generation capacity. Since the bauxite and alumina industry is a very important part of the Jamaican economy and it is very intensive in energy use, including electricity, its contribution to total electricity use and production is very considerable. Thus self-generation is large vis-à-vis JPSCo's network generation but, since it refers to a single industry (or two, if the far smaller sugar industry generation is included. The cement company has some selfgeneration as well, but in relatively small quantities) it does not influence the overall picture of the energy sector, except as an external add-on, an exogenous variable. However, in the future things could, and indeed must, change radically, because the bauxite/alumina industry offers a special opportunity to cogenerate surplus energy and sell it to the grid, as is already being done by the Jamalco plant. The same applies to the sugar industry.

34 Data for 2007.

35 If all self-generation is assumed to be industrial and commercial, the proportion of industrial and commercial demand in the all-island demand (JPSCo system plus self-generators) rises to 80.5 %.

36 Some plausible reasons for this will also be examined below, in the discussion of losses.

37 92% of 2.69 million. This assumes that self-generation is mainly used in industry, which seems to be the case, given the importance of bauxite/alumina and sugar self-generation.

38 See Annex 1.

Table 5 JPSCo 2003 and 2008 Average Monthly Consumption by type of customer

JPSCO AVERAGE MONTHLY CONSUMPTION BY TYPE OF CUSTOMER	MWH/MONTH 2008	MWH/MONTH 2003	ANNUAL GROWTH 03–08
Residential	0.171	0.200	–4.6%
Commercial & Industrial (Small)	1.888	1.970	0.4%
Commercial & Industrial (Large)	406.026	439.019	–2.7%
Other	20.540	31.309	26.3%
TOTAL	0.448	0.485	–2.5%

Sources: 2007 data, JPSCo Annual Report 2007; 2008 Data, JPSCo2009–2014 Tariff Review Application, 2008 Rate Schedule, and authors' own calculations.

as will be seen below, strongly influenced by the importance of the bauxite/alumina industry and distorts accurate comparisons with other similar Latin American countries.

Using data from the US EIA for 2006, total net consumption of electricity in Jamaica in 2006 (last year with information) was 2,979 GWh. As the total population of Jamaica in 2006 was 2.66 million, calculations indicate that the monthly per capita consumption is 184 GWh/month. This puts Jamaica in a consumption range greater than most countries with a population of less than 10 million people. The only countries with higher consumption are, again, some of the small Caribbean islands. The conclusion is that the high relative consumption per capita of Jamaica is thus due to self-generation, that is to say, in particular to the consumption of the bauxite/alumina industry.

6. Current Electricity Generating Facilities

Jamaican electricity supply is at present strongly dependent on fossil fuel, mainly fuel oil and diesel oil. Hydroelectricity only represents 3.9% of the total energy of the JPSCo system and 2.2% of the all-island generation (including self-generation). Wind is an even smaller proportion, 1.7% of JPSCo's energy.[39]

Although, as mentioned before, generation is not the monopoly of JPSCo, the latter still constitutes the main producer of electricity, accounting for 69% of all generation in the integrated grid, and a comparable amount of capacity (73.2%). Table 6 shows the distribution of generation among the different technologies as well the rate of growth of each type of generation and the capacity of the generating plant. In terms of their share in generation breakdown, steam and diesel dominate the picture, delivering some 71% of all generation. Combined cycle gas turbines (CCGT) come second with 17.2%, leaving the gas turbines (GT) (6.6%) and renewables, small hydro and wind (3.9 and 1.3 %), as residuals.

Generation technology evolution. The rate of growth of combined cycle plants has increased since 2003 at a steep exponential rate of 18.7% per year, whereas that of gas turbines has fallen at an also high rate of 13.3% per year. The steep increase in the price of

[39] And some 0.7% of the all-island generation (including self-generation).

Table 6 JPSCo System. Net Generation (2007)

	ENERGY GENERATED MWH	% OF ALL GENERATION	ANNUAL GROWTH 03–07 (EXPONENTIAL TREND)	CAPACITY MW (2007 AND 2008)*	% OF CAPACITY
NET GENERATION AND PURCHASES (MWh)					
JPSCo total	2,799,924	68.6%		622.4	73.2%
Steam & Slow Speed Diesel	1,671,222	41.0%	–3.60%	328	38.6%
Hydro	159,820	3.9%	4.10%	22.9	2.7%
Gas Turbines	267,503	6.6%	–13.30%	158	18.6%
Combined Cycle Plant	701,379	17.2%	30.06%	114	13.4%
IPP- Purchases	1,278,847	31.2%	7.91%	227.4	26.8%
Jamaica Energy Partners, JEP (Medium Speed Diesel)	761,998	18.7%		124.4	14.6%
Jamaica Private Power Company, JPPC (Slow Speed Diesel)	436,729	10.7%		60	7.1%
Wigton Wind Farm	51,926	1.3%	–	20	2.4%
Cogeneration					
Jamalco (Steam)	23,023	0.6%		11	1.3%
Jamaica Broilers Group (MSD)	–			12	1.4%
TOTAL	4,078,771	100.0%	3.21%	849.8	100.0%

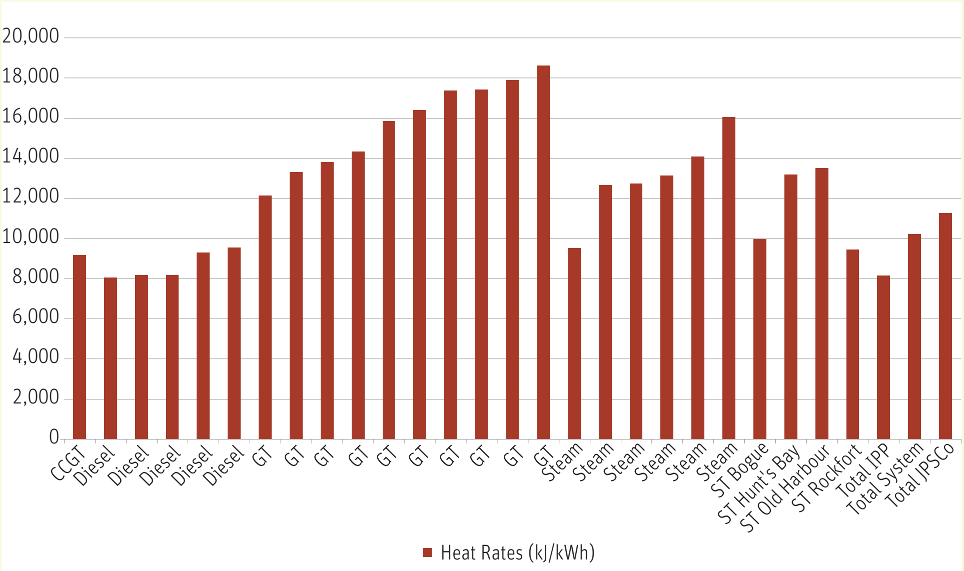
* Capacity detail in Annex 2.

fuel in recent years is one of the factors influencing this trend. For units using the same fuel, their dispatch in the optimum way to attend the load curve would result in the greater use of units with low heat rates such as combined cycle or diesel engines, and a lower use of those with a very high heat rate such as gas turbines (all using ADO as fuel). This pattern would be reinforced by the increase in fuel costs, which are the major contributors to variable costs. Another factor is the age of JPSCo's steam units. The Old Harbour plant, for example, is 40 years old. This implies more time needed for maintenance, affecting the plant factor, and higher, less efficient heat rates than the combined cycle plants.

Figure 1 illustrates the analysis mentioned above. It shows the heat rates of different units and plants in the JPSCo system. It can be seen that that the combined cycle unit (CCGT) has one of the best heat rates in the system, whereas the gas turbines have the worst (highest) heat rates, thus the resulting tendency to increase use of combined cycle and decrease use of gas turbines. The steam plants can, with the right scale and state of repair, be very efficient as well with low heat rates. Because they use the most economical fuel available so far in Jamaica, HFO, this gives steam plants a great advantage over the other technologies

FIGURE 1

Heat Rates by Technology in the JPSCo System



that use ADO, such as MSD units, even if the heat rate of the latter is lower. The graph shows a great range of efficiencies of steam units in the JPSCo system. Overall they appear less efficient than both the combined cycle units and the diesel units. The latter are mainly in the group of IPPs, explaining the very low average heat rate of the IPPs shown in the graph, as well as the tendency to their increased generation shown in Table 6. Notice that the average heat rate of the system in 2008 was 10,214 kJ/kWh, whereas that of JPSCo's own plant was higher (less efficient) at 11,257 kJ/kWh and that of the IPPs was the lowest at 8,136 kJ/kWh. Thus the IPPs helped increase the overall energy efficiency of the system (but again, for those using ADO, not necessarily per kWh cost).

A graph in Annex 3 also shows the evolution of heat rates of the main plants in the system. It is another confirmation of the trend toward less efficiency shown by the Old Harbor steam plant.

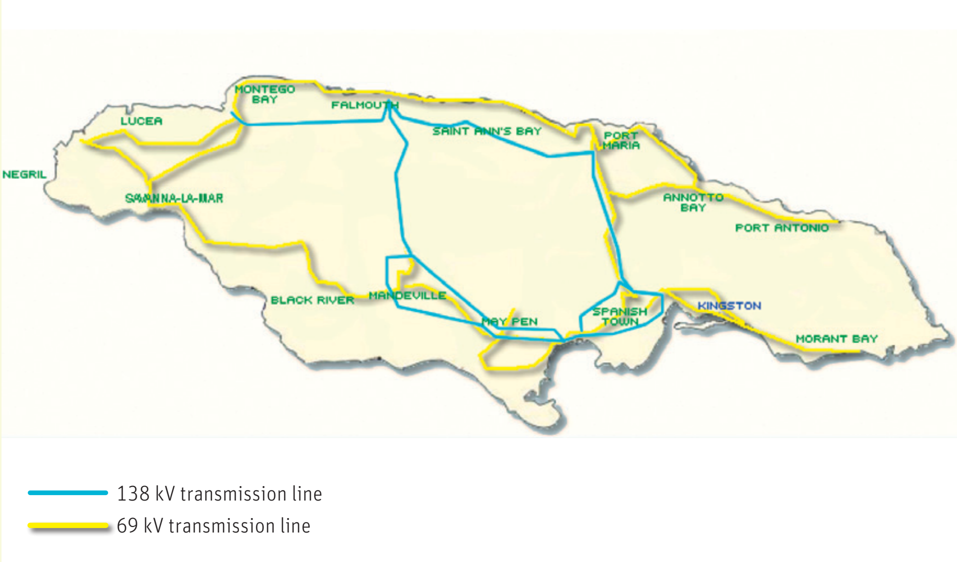
7. Transmission and Distribution

At present the JPSCo system has 16,000 km of transmission and distribution lines (Figure 2), of which 1,264 kilometers are 138 kV and 69 kV transmission lines.[40] The distribution system operates at voltages of 24 kV, 12 kV, 13.8 kV and 4 kV. Transmission and distribution losses are examined below. Most of the network consists of single-circuit lines, which, due to

[40] JPSCo 2009, p. 11.

Jamaica: Transmission and Distribution System

FIGURE 2



the danger of hurricanes and of corrosion because of their proximity to the sea, increase the probability of line failure.[41]

8. Losses

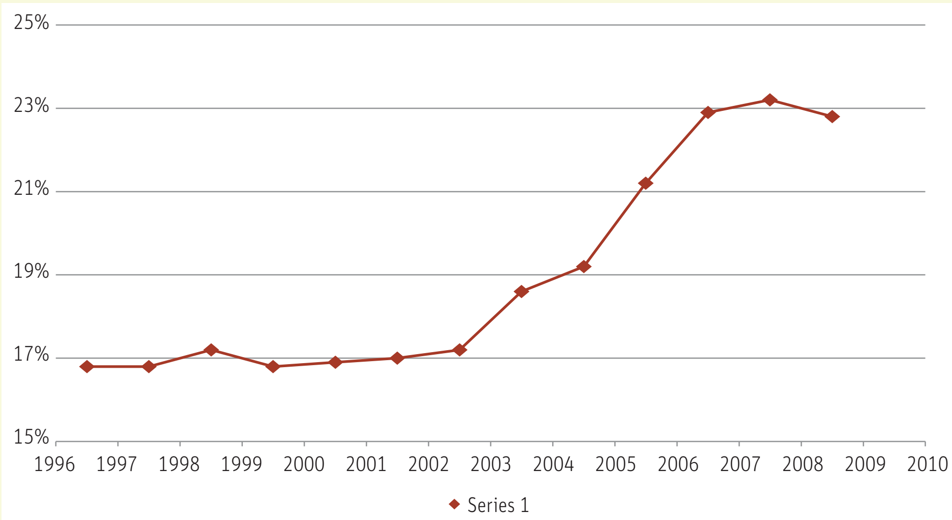
Losses have been one of the most problematic aspects of the JPSCo system. Historically, they have evolved, as shown in Figure 3. From 1996 to 2002 losses were around 17% of net generation. They started increasing in 2002 and reached a high of 23% in 2007.

The most recent eight years (since privatization) are presented in Table 7. An interesting fact to note is that the sale of JPSCo to a private investor in 2001 coincided with the increase in losses. It is all the more interesting when losses are separated into technical and non-technical or commercial. Technical losses have hovered around 10% (between 9 and 11%) since at least 1990 (Table 8) This level, as the OUR expressed it (for the 9% level), "is not unreasonable in the context in which JPSCo operates" (OUR 2004).[42] Essentially all the increase in losses can be attributed to non-technical losses. Another important fact is that losses were very high in the late 1980s. From 1985 to 1990 losses averaged 19.7% (World Bank, 1992, Table 4.1).[43]

41 WB (2008).
42 However, there is room for improvement.
43 See details in Annex 4: Losses.

FIGURE 3

Long-Term Losses Trend



Source: JPSCo (2009).

Table 7 Total Losses 2001–2

YEAR	TOTAL LOSSES
2001	16.95%
2002	17.83%
2003	18.88%
2004	19.99%
2005	22.35%
2006	23.54%
2007	22.30%
2008	22.68%

Source: JPSCo 2009.

Commercial losses are not all due to theft. A small part, the operational commercial losses in JPSCo's terminology, is due to operational problems. In 2004 JPSCo estimated these at 2%, caused by defective equipment (1.7%), incorrect installations (0.2%) and improper account set-up (0.1%).[44] These can be diminished with investment and labor by the company, which in 2004 estimated it could bring them down to 1% (op. cit.). However, the rest of unaccounted-for energy is due to theft and, as mentioned, this has been growing since 2001. Taking average technical losses at 10% and operational commercial losses at 1%, it can be seen from Table 7 that they have grown approximately from 6% in 2001 to a peak of 12.5 % in 2006. Only the last years seem to show a final downturn in the trend, having fallen to a value of 12% in 2008, but it is still too early and too little to say whether this will endure.

The problem is thus an important one for both the company and the GOJ. The company suffers from proceeds not collected from that energy and because the recovery of total losses through the regulated tariff is capped at 15.8% in the incentive regulation scheme. Any

[44] OUR 2004.

Table 8 Estimates of Technical and Commercial Losses

YEAR	TOTAL LOSSES	NON-TECHNICAL LOSSES	TECHNICAL LOSSES
1990	17.10%	7.10%	10%
2000	16.50%	5.50%	11%
2004	18.50%	9.5%	9%
2008	22.88%	12.58%	10.30%

Sources: 1985–1991: WB 2001; 1996–2008 JPS 2009; 1993–1995: JPS. "System losses. The Jamaican Experience".

losses above that level are thus absorbed by the company. Lastly the GOJ also suffers, as JPSCo's reduced sales and profits translate into less tax revenue.

The problem of non-technical losses is pervasive throughout Latin America. Many countries in the region have losses at the same level as the JPSCo system. However, JPSCo's performance has been worse. The median value of losses for 17 Latin American countries in the period 2001 to 2006[45] has varied within the range 15.3% to 16.9 %. JPSCo's range in the same period has been 16.5% to 22.9% (Table 8). JPSCo's performance has been even worse when compared to those of the small Caribbean islands, whose median in the period has been 7%.

Non-technical losses have been linked to problems that are endemic to many Latin American countries as well as to Jamaica: poverty (and income inequality) and insecurity (expressed, inter alia, by the level of violence).[46] In its last tariff review application for the period 2009–2014,[47] JPSCo presents an econometric model of non-technical losses made by a group of external consultants hired by JPSCo, which includes among its explanatory variables the levels of poverty and violence as well as an economic variable, the share of the average electricity bill of residential customers in their income (approximated by the "average residential customer electricity bill per GDP per capita", JPSCo 2009, p. 168). Non-technical losses, the dependent variable, are represented by the percentage of non-technical losses to low voltage sales of the companies in the sample. All variables were expressed in logarithms and thus their coefficients can be interpreted as elasticities. The model used panel data with 63 observations (63 distribution companies in Latin America, of which 53 were Brazilian); the regression was corrected for heteroscedasticity. This study produced highly statistically significant results for all the explanatory variables, with the right signs, as follows:

VARIABLE	COEFFICIENT ESTIMATED	T - STATISTIC
Poverty	0.9078868	4.51
Electricity bill/GDP pc	0.5256652	2.94
Violence	0.342431	4.35

45 Estimated using information from the US EIA.
46 In the last JPSCo Tariff Review Application (JPSCo 2009, Annex L), two of these studies, carried out in Brazil, are quoted to this effect.
47 Op. cit.

The model had an *R*-squared value of 0.855 and shows that non-technical losses react strongly to poverty (for every one percentage point increase in the indicator for poverty non-technical losses increase 0.91%, almost elastically). The response to the economic variable, an elasticity of 0.52, is also important as it shows that non-technical losses will be strongly responsive to electricity price increases. The violence elasticity coefficient (0.34), a proxy for insecurity and lawlessness, also shows a strong effect for the increase in lawlessness as reflected in the murder rate.

In its original theoretical formulation the model includes among the explanatory variables a vector, Ii, of variables, which represents the level of efficiency (of the companies) in tackling non-technical losses. However, the results presented do not include coefficients or specifications for this set of variables. If this is because they were finally not included in the estimation, it could cause the coefficients of the variables used in the model to be biased, and their t-statistics to be meaningless. Nonetheless, the numbers presented for these variables are intuitively compelling.

The lesson to be taken from this model is the need to find ways to somehow tackle these problems if non-technical losses are to be reduced significantly, something that JPSCo, as the OUR also recognizes, cannot do on its own. Ultimately, the reduction of non-technical losses requires a collaborative approach between the company, government, and civil society.[48]

9. Service Quality

Service quality is measured in many companies and regulatory systems by indices based on the frequency and duration of interruptions of service. There are several such indices, but the most used are those known as SAIFI, SAIDI, CAIDI, and MAIFI.

SAIFI, or system average interruption frequency index, is the average frequency of sustained[49] interruptions per customer over a predefined area.

It is defined as follows:

SAIFI = (Total number of customer interruptions)/ (Total number of customers served) and expressed in number of interruptions per year.

[48] Peru seems to have succeeded in reducing total losses from the high teens in the early 1990s to around 10% in 2004–2005 (According to US EIA data on losses and net generation and authors' own calculations. During a short period of privatization of its three distribution companies (1999 to 2003) the Dominican Republic also seemed to be making great improvements in the reduction of losses that had reached staggering amounts—near 40%—by an average of 10 percent points per year between 1999 and 2002. However, the situation deteriorated strongly again after the Government, yielding to political pressures, and with the companies having become highly unpopular for their loss reduction measures, renationalized the companies in 2003 (WB 2007). The World Bank (2007) attributes this failure in part to inadequate governance in many of its dimensions (including the rule of law). (An early World Bank study by Philip Gray (WB 2001) also mentions Argentina as a success story for the late 1990s. However, the data series from the US EIA does not seem to support this success anymore, even at the aggregate level, and even in the 1990s. The latter result could be due to the fact that Gray's is, as it should be, a study of individual companies, whereas the data are aggregate for the whole country. Aggregate data can show an aggregate decrease, but an aggregate increase could mask some individual companies that did very well but were swamped by the bad results of others.

[49] As distinct from momentary interruptions (see the definition of MAIFI).

SAIDI, or system average interruption duration index, is commonly referred to as customer minutes of interruption or customer hours and is designed to provide information as to the average time the customers are interrupted.

SAIDI = ∑(Customer interruption durations)/(Total number of customers served) and is expressed in minutes (or sometimes hours) per year.[50]

CAIDI, or customer average interruption duration index, is the average time needed to restore service to the average customer per sustained interruption.

CAIDI = ∑(Customer interruption durations) /(Total number of interruptions) and is expressed in minutes per interruption.[51]

MAIFI, or momentary average interruption frequency index, gives information about momentary outages (those of less than 5 minutes duration) per customer. It is the total number of customer momentary interruptions (for durations of 5 minutes or less[52]) divided by the total number of customers served.

Regulatory systems characterized by price cap (as well as revenue cap) need to be complemented by measures to avoid the deterioration of service quality that seems to occur if no such measures are taken. This deterioration of quality, reflected for example in increases in the SAIFI and the SAIDI, is costly for the overall economy and for the customers that endure it.[53] An empirical study by A. Ter-Martirosyan (2003),[54] based on the econometric analysis of pooled data for 78 US utilities for the period 1993–1999, found that price cap regulation led to worse service quality, as reflected in the SAIFI and CAIDI indicators,[55] if the firms were not subjected to quality regulation. Quality regulation had a particularly positive impact on the duration of interruptions. Her study also supports the conjecture that price-cap regulation without controlling for service quality can generate incentives to under-spend on quality.

The Q factor in the OUR's regulatory formula (paragraph 31, above) is intended to control for the quality of service and thus, in the case of Jamaica, the problem of perverse incentives

[50] Perhaps more clearly, SAIDI is defined as the sum of the restoration time (time needed to restore power to the customer) for each interruption event, times the number of interrupted customers for each interruption event, divided by the total number of customers served in the predefined area.

[51] Notice that these definitions imply that SAIDI= CAIDI *SAIFI.

[52] Momentary interruptions are defined by the IEEE as those that result from each single operation of an interrupting device such as a recloser. They must not last more than 5 minutes (Oakland Nat. Lab. 20).

[53] This cost is reflected in the loss of production experienced by a company as a result of the service interruption or the loss of utility for the consumer, both of which can be much higher than the cost of production of the energy (kWh's) lost in the event. This is why the cost of a kWh not delivered to the consumers is valued by planners at a much higher price than the cost of producing that kWh (many times higher).

[54] Quoted by Ajodhia (2006).

[55] Thus, an increase of the SAIFI as well since SAIDI = CAIDI * SAIFI. Thus, if both CAIDI and SAIFI increase, SAIDI increases as well. Ter-Martyrosian's analysis controlled for the type of regulatory regime, the presence of quality standards, the per capita income in the state, the average length of line per consumer, the share of underground lines, the share of self-generation by the firm, and the damage caused by severe weather conditions in the territory served by the firm.

Table 9 Service Quality Indicators 2006–2008

	SAIDI (MINUTES/ YEAR)	SAIFI (INTERRUPTIONS)	CAIDI (MINUTES/ INTERRUPTION)
JPSCo, 2006	3,436	33.88	101.4
JPSCo, 2007	3,008	23.89	125.9
JPSCo, 2008	2,518	24.45	103
JPSCo, Average2006–2008	2987	27.41	110
JPSCo, Rate of Change per year (exponential)	–15.5%	–16.3%	0.8%
Belize	1852	25.96	71.4
Panama (2003, Urban) Range	252–486	3.3–6.9	76.2–70.8
Brazil (2004)	948	12.12	78.22
US Typical values	96	1.18	81.40
Sample of 21 Companies from Europe(16), US(1), Australia(2), Asia(2)-Range	7–385	NA	NA

Sources: JPSCo (2009), Ajodhia (2006), World Bank (2005), Perez (2007), and authors' own calculations.

for under-investment in quality seems to be avoided. The Q factor is based on the SAIFI, the SAIDI and the CAIFI indices. The OUR gives +3 quality points to either index if it decreases (i.e., improves) more than 10%, and subtracts 3 points (gives –3 points) in the contrary case. If the indices stay within the –10% to +10% band they get 0 points. Thus the sum of the awards can vary from –9 to +9. The OUR then determines the increase or decrease in Q based on the sum of the awards. At present Q can vary this way in the range of –0.50% for a sum of –9 points to +0.50%, for a sum of +9 points. The incentive is thus completely symmetrical. The company is rewarded for good performance and punished symmetrically for bad performance.[56]

The evolution of quality at JPSCo, as reflected in the three quality indicators, is shown in Table 9. To give perspective on their values, some indicators from companies in other countries are also shown. It can be observed in the first place that the SAIDI and the SAIFI have had a steep falling trend with an exponential rate of decrease of –15.5% and –16.3% per year. The rate of change of the CAIDI's trend is +0.8%, which corresponds to the difference of the SAIDI and the SAIFI, as it should, because of the log-linear relationship among these three indicators.[57]

[56] However, in its late Tariff Review Application (2009–2014), JPSCo has pointed to the fact that the three indicators are not independent. In fact, expressed in log form they are linearly dependent. This means that the proportional increase or decrease of two of them determines the proportional increase or decrease of the third one. [Since, from footnote 86 it results: ln(SAIDI) = ln(SAIFI) + ln(SAIDI), it follows in differential form that d(SAIDI)/SAIDI = d(SAIFI)/SAIFI + d(CAIDI)/CAIDI]. Thus regulation using these indicators only has two degrees of freedom, and determining the changes of all three indicators results in an inconsistency, since it would violate the linear dependency of their logarithmic relation.

[57] If SAIDI, SAIFI, and CAIDI are respectively named x_1, x_2, and x_3, the relationships explored in notes 86 and 95 can be written $\ln x_1 = \ln x_2 + \ln x_3$. The trends were obtained fitting to the data exponential equations

The perspective given by the other countries in the table allows placing JPSCo's numbers somewhat in context. Comparisons even with countries or regions that have similar socioeconomic characteristics are not without problems, but, at least, comparison with countries or regions that share some of these characteristics is less objectionable, as the differences among countries are reduced to a smaller set.[58]

It can be observed in Table 9 that comparing JPSCo (using its 2008 data, the most favorable) with Belize, Panama (using its high values), and Brazil, perhaps the three countries where comparisons may be more acceptable with respect to some socioeconomic characteristics, shows higher CAIDI indicators for the three countries by a range of some 32% to 45%. In other words, it takes around 37% more time on the average to restore service to customers in JPSCo than in those other countries. Vis-à-vis the SAIFI, however, JPSCo has a value comparable to, although slightly smaller (more favorable), than the Belizean utility, but up to 2 to 3.5 times worse (higher) than the Panama and Brazil values. With respect to the SAIDI, as with the CAIDI, all countries have lower (better) indicators than JPSCo, but the range is amplified from 1.4 to 2.7 times lower.[59]

It is possible to surmise, with many caveats, that there is very likely ample field for JPSCo to improve its quality of service and reach levels such as those shown in the Panamanian case. Indeed, at its present rate of improvement JPSCo will reach Belizean levels in a year, Brazilian levels in approximately five years, and Panamanian levels in approximately 10 years. When other countries are introduced, in particular the United States, the JPSCo indicators are much higher (worse) by a large order of magnitude and all that can be said is that this comparison is not very relevant or useful, given the great socioeconomic and geographic differences between the countries.

10. Electricity Prices

As was explained in the section about regulation, the Licence distinguishes three components that go into the determination of the electricity rate: i) a non-fuel base rate; ii) a fuel rate; and iii) extraordinary costs related to government-imposed obligations.[60] The fuel rate is a pass-through reflecting the monthly increase in the cost of fuel. Thus the only part of the tariff that is subject to regulation proper is the non-fuel rate. The sum of these two components determines the average rate, which is the base for the construction of the different tariff groups.

which can be reduced to their semi-log forms: $\ln x_i = a_i + b_i t$, where t is time. Replacing these relations in the previous expression results in $\ln x_1 = a_1 + b_1 t = (a_2 + a_3) + (b_2 + b_3)t$, for all t. Thus $b_1 = b_2 + b_3$. This also shows in another way that trying to control the paths of these three indicators will lead to inconsistencies.

[58] For a comparison to be possible, an econometric model, controlling for all possible exogenous factors affecting the indicators, would be needed. This is in a way what works like that of Ter-Martirosyan (2003) have attempted to do, even in contexts less heterogeneous, such as US utilities in different US states.

[59] This is a consequence of the log-linear relation between the three indicators mentioned before.

[60] In practice the third component has practically no role in the evolution of the tariffs because, as its name indicates, it goes into play very rarely, on isolated occasions, and not continuously; and its result would be, in any case, a single jump in the tariff with no influence on its rate of growth, which is what the other two components do.

Table 10 Evolution of Average Prices and Rate Components in the JPSCo System 2002–2007

	AVERAGE PRICE (J$/KWH)	AVG. FUEL TARIFF (J$/KWH)	AVG. NON-FUEL TARIFF (J$/KWH)	AVERAGE PRICE (U.S.$/KWH)	AVG. FUEL TARIFF (U.S.$/KWH)	AVG. NON-FUEL TARIFF (U.S.$/KWH)
2004	10.1	4.9	5.2	0.165	0.080	0.085
2005	13.2	6.9	6.2	0.211	0.111	0.100
2006	15.4	8.6	6.8	0.235	0.131	0.103
2007	17.3	10.1	7.2	0.251	0.146	0.104
2008	22.5	15	7.5	0.307	0.204	0.102
Growth Rate 2004–2008	18.7%	26.2%	8.8%	14.1%	21.5%	4.0%

Source: JPSCo and authors' own calculations.

The composition of current prices in the JPSCo system and their evolution is shown in Table 10. As can be seen, they have grown at a very steep rate (18.7% for the price in J$) and are currently very high, at J$22.5/kWh (US$0.31/kWh). The fuel tariff component has risen even faster, at 26.2% (Jamaican prices) reflecting the steep rise in oil prices in recent years: The US dollar prices of the diesel oil and heavy fuel oil used in generation in Jamaica have risen at the rates of 17.3% and 25.2% per year respectively, in the 2004–2008 period,[61] while the exchange rate in the same period has increased at 4.6%. Thus Jamaican prices of those products have increased respectively at 21.8% and 29.8%, numbers which bracket the fuel tariff increase. In contrast with the fuel tariff component, the non-fuel tariff component has increased by 8.8% in Jamaican dollars and 4% in US dollars. Thus the regulated part of the price of electricity, the non-fuel tariff component, has grown very moderately, below Jamaican inflation, which has grown in the period at an exponential rate of 11.9% per year.

The Jamaican average prices shown in Table 10 are among the highest in LAC, equaled only in some small Caribbean countries, as can be seen in Table 11. Indeed, the highest price for 2006 is Jamaica's, followed by those of several Caribbean countries.[62] Lack of substantial hydro resources is one of the reasons for this pattern. It can be seen in the table that countries with substantial hydrogeneration, such as Colombia, Argentina, Chile, and Costa Rica, have relatively low prices. A second reason is the obverse of the previous one. The dependence on oil products to generate electricity—and frequently not on the most economical of these products, such as Bunker C, but rather on diesel oil—joined to the enormous surge in the price of oil, has exacerbated the higher price tendency of countries dependent on oil for generation. This in turn is made worse by the small size of the market, which is subject to diseconomies of scale.

61 According to data given by JPSCo in its 2009–2014 Tariff Review Application.
62 Some very small Caribbean islands have even higher prices than Jamaica does.

Table 11 Electricity Prices in LAC 2005–2006 (US$/kWh)

COUNTRY	2005	2006	COUNTRY	2005	2006
Jamaica	0.211	0.235	Mexico	0.088	0.099
Guyana	0.233	0.233	Colombia	0.090	0.090
Barbados	0.210	0.224	Chile	0.078	0.090
Belize	0.172	0.208	Cuba	0.082	0.087
Nicaragua	0.132	0.165	Costa Rica	0.071	0.074
El Salvador	0.124	0.141	Peru	0.069	0.070
Dominican Republic	0.138	#N/A	Argentina	0.047	0.068
Brazil	0.077	0.122	Uruguay	0.058	0.065
Guatemala	0.111	0.112	Bolivia	0.048	0.047
Panama	0.102	0.104	Paraguay	0.038	0.041
Honduras	0.099	0.104	Venezuela	0.032	0.032
Ecuador	0.096	#N/A	Trinidad and Tobago	0.028	0.028
Haiti	0.090	0.102			

Sources: Jamaica, JPSCo; Belize, BEL; other countries, US EIA.

The amount of electricity production in these countries lies in the segment of the cost curve that is subject to increasing returns to scale.[63] The distribution of price versus size (represented by demand in MWh) is traced by the curve in Figure 4, which reflects the effect of the economies of scale mentioned.

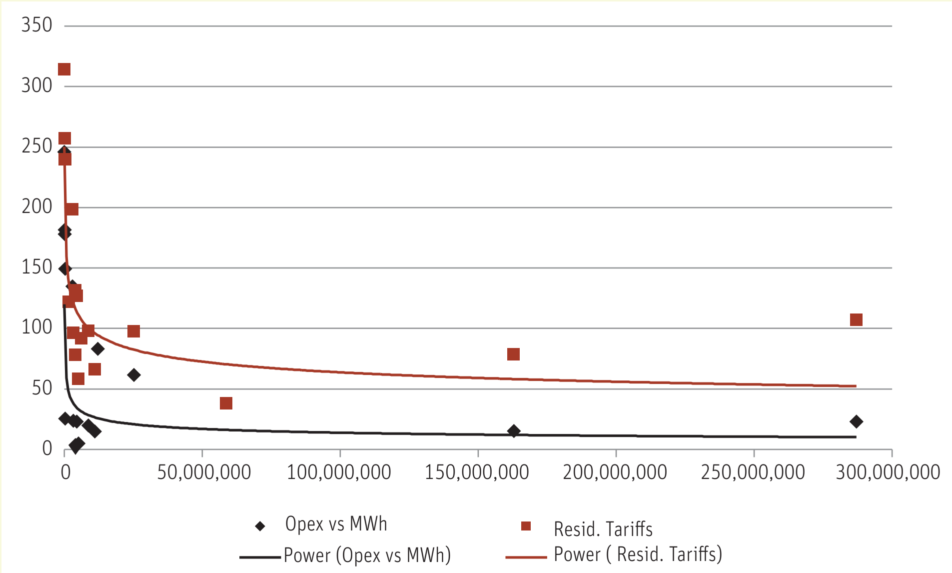
A comparison of growth patters in countries of similar population is presented in Figure 5. As can be observed, Central American (CA) countries have had, like Jamaica, a pattern of rising electricity prices. However, this growth is moderate. As a group they have had an average growth in price of 2.52% since 1997. In contrast, Jamaica has had a very rapid rate of growth (10.2% per year), which sets it apart from CA. Jamaica has a regulatory system where the cost of fuel is a pass-through; Jamaica uses much more oil products than the other CA countries to produce its electricity; and here, again, the fact that these countries produce a high proportion of their electricity with hydro resources has a lot to do with their more moderate rate of price growth.

Figure 5 shows that in the late 1990s (circa 1998) prices in Jamaica were at levels comparable to those of the CA countries but were starting a pronounced climb around that

[63] This means that, even for generation, these markets have the characteristic of natural monopolies: a single generating company would be able to produce at a bigger scale than several small ones and thus, if things were left to the market only, one company would end up supplying the whole market. (The regulated price would then be equal to the marginal cost). However, even a monopoly producer might not be able to use units with optimal scale, since one single unit may be enough to attend the full load. This is not advisable in an electrical system, for stability and reliability reasons.

FIGURE 4

LAC – Opex and Residential Prices vs MWh



Sources: WB LAC Benchmark data and authors' own calculations, 2004 data.

FIGURE 5

CA and Jamaica Average Tariffs in Current US$/kWh

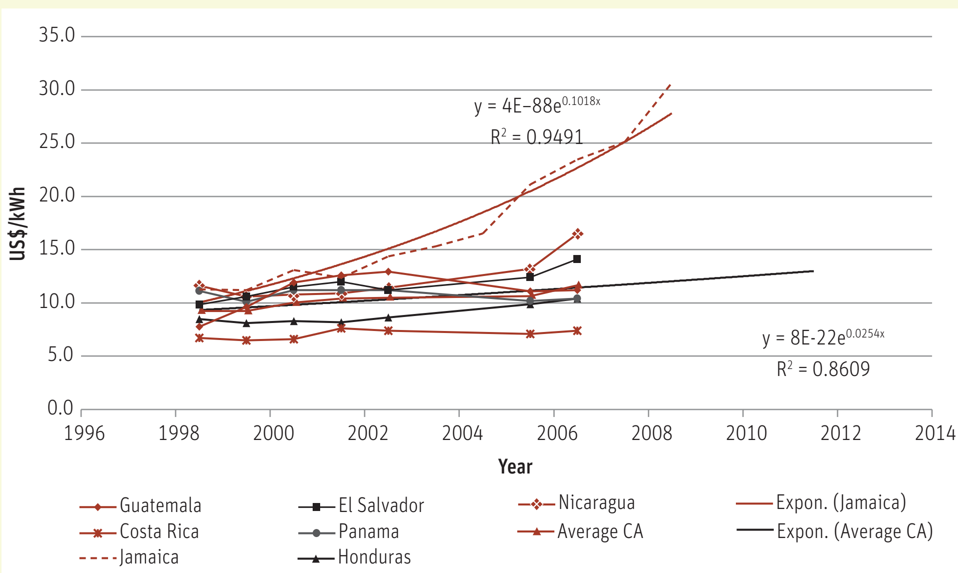
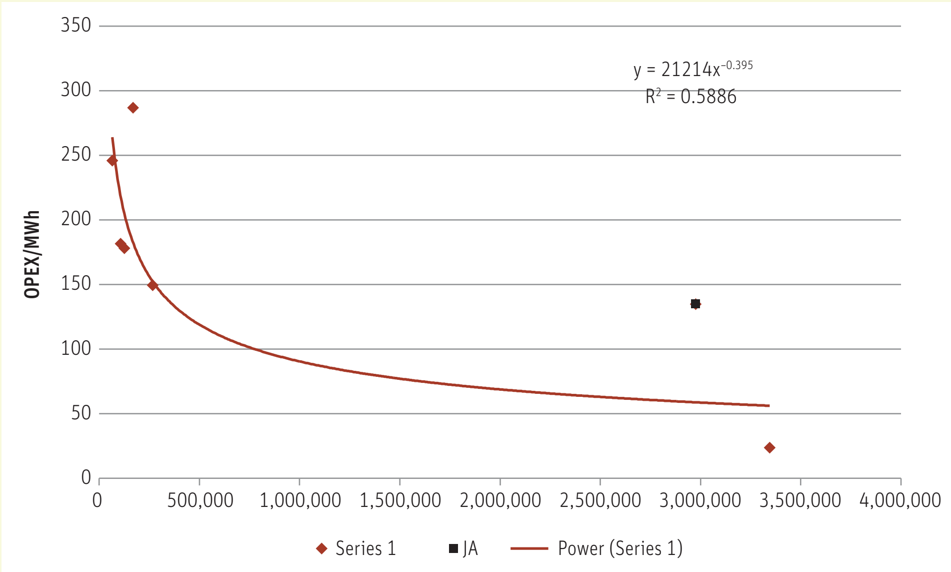


FIGURE 6

Caribbean Islands Opex vs. MWh



Sources: WB LAC Benchmark data. JPSCo data and authors' own calculations.

time. Oil prices started to increase at a steep rate, so a great deal of the steep rise in power tariffs can be traced to the rise in fuel prices. However, the unit (per kWh) fuel cost is only one of the components of the total cost. Fuel cost represented on average, between 2004 and 2008, 64% of unit operating expenditures.[64] Thus there could only be two possible reasons for the high prices: higher costs or higher margins.[65] In the case of JPSCo the margin does not seem especially high, but as can be seen in Figure 6, the costs do seem quite high.

Figure 6 presents a plot of unit operating expenses versus MWh for Caribbean countries. Jamaica is labeled JA. It can be seen that Jamaica lies substantially above the regression line. Is this distance significant enough to allow for the conclusion that Jamaica has higher operating costs than a similarly sized low- or null-hydro system as those others presented in the graph? Although it is not possible to do a rigorous test of that conjecture in this work (it would require extensive data gathering and processing and a great deal of time-consuming econometric work because the data are cross-sectional and thus may present heteroscedasticity), one can attempt a heuristic examination of this question. This can be done by means of a regression of costs versus size (MWh) using OLS. Although in the presence of heteroscedasticity, the standard errors of estimates obtained with OLS would be biased (but not the coefficients themselves), these tests are acceptable here because the economies of scale

64 Estimated from data in JPSCo (2006) and JPSCo (2009).
65 That is, the difference between prices and unit costs.

imply that costs are decreasing with demand, and it can be surmised that, because of this, the standard errors' bias will be of the "right" sign, so that confidence intervals and tests of significance done using OLS estimates will still lead to the right answer.[66] Using a log-log form, the OLS resulting estimates are as follows:

Table 12 Regression of unit operating expenses vs. Demand (MWh sold)*

	MWH SOLD	CONSTANT
Coefficients	–0.395	9.962
Standard errors of coefficients	0.148	1.888
T-statistics	–2.675	5.276
R^2	0.589	

Sources: World Bank Database (2005), JPSCo, authors' own calculations.
*Log-log regression: ln(Costs) = a + bln(MWh) or Costs = Ax^b

Figure 6 traces the graph of this equation. In order to have an idea as to whether the point representing JPSCo is far enough above the fitted line, and thus whether the costs of JPSCo are substantially higher than those of a company of a similar demand size (KWh) and low hydroelectricity, a 5% one-sided confidence band can be estimated for the fitted curve. If the value of JPSCo falls above that band, it can be surmised that there is a very high likelihood of the costs of JPSCo being substantially above those of the comparable typical company just described. This band was built and the cost of JPSCo fell outside (and above) the band.[67] Thus it is possible to conclude that JPSCo has higher costs than comparable

[66] As mentioned, since the sample data are cross-sectional, they may present heteroscedasticity (the variance of the disturbance is not constant for all the observations). Thus, although parameter estimates obtained using OLS would not be biased, the estimates of the standard errors of the coefficient will be; and this could lead to overestimating or underestimating the precision of the procedure, or to estimating narrower (or wider) confidence intervals or confidence bands than would really be the case. That is one important reason why no rigorous tests of hypothesis can be done with OLS estimates of the standard errors. However, it is well known that the bias of the standard errors is negative (thus leading to overestimation of confidence intervals and significance tests) when the transformed independent variables (X_i – $E(X_i)$) are positively associated with the variance of the disturbances, σ_i^2. Conversely, the bias of the standard errors is positive (thus leading to underestimation of confidence intervals and significance tests) if that association is negative (see for example Kmenta 1971, section 8-1). In the case under examination, because of economies of scale, the average size of the cost variable (Y_i) is negatively associated with the size of the demand variable (X_i) and thus with (X_i $E(X_i)$). Thus, it is reasonable to expect that the variance of the disturbance is negatively associated with demand (kWh). This means that the standard errors can be expected to be overestimated and thus if the test of hypothesis estimated with OLS is shown as significant, then if the model were estimated in such a way as to correct for heteroscedasticity, the test with the resulting unbiased standard errors would be even more significant, and the confidence bands would be even narrower.

[67] Put another way, the distance between the actual value of the Jamaica observation [(X_i, Y_i) = (X(JA), Y(JA)] and its expected value (given by its value on the trend line corresponding to the Jamaica observation), divided by the standard error of the expected value of that observation follows a t-student distribution with n–2 degrees of freedom (in this case n = 7, n – 2 = 5). The resulting ratio is t = 2.11 which is

companies.[68] Therefore, even in relation to other Caribbean companies, JPSCo is a high-cost company, and although this is in part due to diseconomies of scale, as is the case in the other Caribbean companies as well, the costs are higher than can be accounted for by economies of scale.

In conclusion, high Jamaican electricity prices are not just a product of high fuel prices. Even after discounting fuel costs, the company has high operating costs, beyond what can be explained by scale diseconomies. The question should then be: why are JPSCo's costs, even after accounting for the expensive fuel and diseconomies of scale, so high? Is it because of inefficiency in generation (relatively high heat rate in the system), or because of very high losses (although the amount of their effect on costs that can theoretically be passed on to consumers is capped), or high labor costs (JPSCo 2009)? There is no ready-made answer to this, which could be elucidated by theory alone. The fact is that a great deal about JPSCo and its cost structure is not known, among other reasons, because of its nature as an integrated generation–transmission–distribution company, with integrated cost accounting. The company presents the regulator with the typical principal–agent conundrum: how to know as much about the company as the company itself knows, so as to be able to take optimally informed regulatory decisions. Lastly, the atypically high costs of JPSCo warrant an independent audit of its cost structure and the methodology to account for them.

Tariff structure. The tariff is structured in two parts as shown in FIGURE 7: a fixed monthly charge and a variable charge (a well as a temporary hurricane recovery charge). Industrial tariffs also have a demand charge in dollars per kVA per month for on-peak, off-peak, and partial peak, based on the maximum demands for those categories in the month, as explained in the notes to the schedule.

larger than the one-tailed t-statistic for the 5% level of significance whose value is 2.01. Thus the ratio in question is significantly greater than zero: the costs of JPSCo are substantially greater than they would be for a company of the same size and low hydro production.

[68] As has been mentioned, since the test used a regression model with cross-sectional data, which can show heteroscedasticity, the test is used as a heuristic device that permits the gauging of whether the perceived cost difference between JPSCo and other comparable companies is substantial enough to tentatively conclude that JPSCo is a relative high cost company. However as explained in footnote 114, in this particular case, with cross-section data presenting economies of scale, the tests are bound to underestimate the significance level and to produce as well a confidence band wider than the correct band. Thus the substantiality of the claim of untypically high costs for JPSCo is very solid.

FIGURE 7

Rate summary effective June 1, 2008 – Base exchange rate J$71.50 = US$1.00

RATE CATEGORY		CUSTOMER CHARGE $ PER MONTH	ENERGY CHARGE $ PER KWH	HURRICANE RECOVERY CHARGE $ PER KWH	DEMAND CHARGE $ PER KVA PERMONTH			
					STANDARD	OFFPEAK	PARTIAL PEAK	ONPEAK
10	RESIDENTIAL							
	First 100 kWh	90	5.747	0.078				
	Over 100 kWh	90	10.068	0.078				
20	GENERAL	207	8.934	0.078				
40ALV	POWER Low Voltage	2,871	6.042	0.078	357.00			
40-LV	POWER Low Voltage	2,871	2.411	0.078	914.00	37.00	399.00	510.00
50-MV	POWER Medium Voltage	2,871	2.178	0.078	822.00	34.00	358.00	459.00
60	STREETLIGHTS	752	10.597	0.078				
60	TRAFFIC SIGNALS	752	7.155	0.078				

(1) Minimum standard Billing Demand per month: 25kVA for Rate 40 and Rate 50.
(2) Billing Demand in the on-peak period is the maximum registered demand for the On-Peak hours of that month.
(3) The Billing Demand for the partial peak period each month shall be the maximum registered demand for the on-peak and partial-peak hours of that month, or 80% of the highest maximum registered demand for the on-peak and partial-peak hours during the six-month period ending with the month for which the bill is rendered, whichever is higher but not less than 25 kilovolt-amperes (kVA).
(4) The billing demand for the off-peak period each month shall be the maximum demand for that month (regardless of the time of use period it was registered in), or 80% of the highest maximum demand during the six-month period ending with the month for which the bill is rendered, whichever is higher but not less than 25 kilovolt-amperes (kVA).
(5) Standby Rates: see details in the Schedules.
(6) With respect to the OUR Z-factor Determination (Elec 2005/05), the Hurricane Recovery Charge will be applied to all customers and remain in force for a period of 24 months commencing with bills prepared as of July 1, 2007. The per kilowatt hour charge is to be clearly identifiable on all customer bills and will be removed once the full recovery has been attained.

11. Challenges

Sector Structure. As has been shown, the present structure of the system is a source of several potential problems. First, there is the fact that JPSCo is an integrated company, where the generation, transmission, distribution, and dispatching functions are not separated and the accounting system presents only an integrated picture of the company, which does not allow finding the contribution of each function to the cost of electricity. This makes the task of the regulator harder, for example in the examination of capital expenses or non-fuel operating expenditures. Furthermore, the integration of generation, transmission, and dispatch at JPSCo can become an obstacle to opening generation to more competition, as it would in principle allow JPSCo to use transmission to get undue advantage in generation and bias the merit order dispatch. To avoid these problems of lack of transparency in costing and of strategic behavior detrimental to economic efficiency, it is highly advisable to effect the separation of generation and transmission, preferably into distinct companies or, at a minimum, into distinct, clearly delineated and separated functions. On the other hand, in order to attain some degree of competition in the market and carry out effective merit-order dispatching, the severance of dispatching from JPSCo and into a new entity is necessary.

Regulatory Challenges. As previously explained, the regulation of the privatized industry has achieved great progress, but there are still problem areas, including how to strengthen the OUR in order to carry out its new responsibilities. As was mentioned, after having acquired some experience and training from the OUR, many new recruits find better-paying jobs in the sector's industries and leave the OUR saddled with their startup costs, so to speak, while the benefits of this training are reaped by private companies, including those that the OUR regulates. As long as it is difficult for the OUR to compete with the salaries of the private industry this situation will recur. One way to remedy this situation may be to adjust the pay level and ancillary benefits at the OUR, so as to decrease the economic attractiveness of the private sector. A second challenge is related to the new responsibilities that the OUR has recently acquired in the areas of planning for the expansion of the system and the management and administration of the process of addition to its capacity. For this and other challenges, such as the increased instability of the international fuel market, which will require stronger action in sector planning and supervision (WB 2008), the OUR needs reinforcement of its capabilities in the areas of planning of the sector, tariffs, finance, contracts, financial analysis, and database building and management.[69]

Regarding the exchange rate adjustments to the non-fuel tariff rate, it is not clear what the effect of a double adjustment in the non-fuel tariff rate could have on the tariff (one adjustment is done once per period—normally once a year—for the change in the annual exchange rate that affects the costs of imported inputs as expressed in Jamaican dollars; the second adjustment is done monthly and adjusts the non-fuel rates for monthly changes in the exchange rate). Is the formula producing a compounded effect and thus resulting in an over-adjustment? Or is it giving the correct amount of adjustment? A careful review of the adjustment formula, to elucidate this problem, is warranted. Beyond this narrow issue, there is the more general concern that the present tariff setting formula (a traditional "CPI-X" price cap formula, plus quality controls) is no longer adequate to deal with the present needs of the sector. The World Bank (2008) has recently expressed doubts about the adequacy of the tariff formula to "stimulate efficiency gains, optimum dispatch, least-cost sector development and fuel sourcing strategies as well as integration of co-generation and development of

[69] See also WB 2008. Besides the OUR, the Ministry of Energy and Mining also needs reinforcement in the areas of policy formulation, energy economics and finance, legislation, and environment. As the WB notes, this training (for both the OUR and the Ministry) would need to be in depth (not short workshops), would be costly, and would need a critical mass of trainees to be cost effective. Thus it would have to be organized at a regional level and periodically, and would likely require TA resources to assist the organizations while some of their scarce personnel are on training leave.

the most cost-effective PPAs with IPPs." Because of all these issues, it is advisable to submit the tariff formula to a technical audit by experts in the field. Because 2009 is the first year of the new 5-year period with an adjusted non-fuel tariff, it is a very appropriate moment to examine the tariff formula and implement the necessary adjustments.

System losses. Total system losses in Jamaica are presently very high at 22.7% of net generation. Of these, around 10.3% are technical losses and 12.4% are commercial (non-technical losses). The technical losses, as the OUR (1994) expressed it (for the then 9% level), are "not unreasonable in the context in which JPSCo operates." However, there is room for improvement; some small Caribbean islands have total losses at 7%, according to US EIA information. Furthermore, the lower frontier for transmission and distribution losses is below 5.4%.[70] Investment in the improvement of the transmission and distribution grids should allow JPSCo to reduce losses below 10%; two percentage points is not an unreasonable goal for the next five years. Given the cost of fuel, the cost–benefit relation of this reduction is likely substantially positive.[71]

Regarding commercial losses, a small part of these, the operational-commercial losses, is due to operational problems. JPSCo estimated these operational-commercial losses at 2%, caused by defective equipment (1.7%), incorrect installations (0.2%), and improper account set-up (0.1%).[72] They can be diminished with investment and labor by the company, which in 2004 estimated it could bring them down to 1% (if this is added to the 2% of technical losses that should not be difficult to obtain by increased investment, a 3% reduction would not be too unrealistic). Thus the other non-technical losses, which can be mainly attributed to theft, are presently on the order of 10.4%. Nonetheless, no matter how this number is looked at, it is still cause for concern, as it has a serious impact in terms of lost revenues and tariff increases passed on to paying customers. Remedies to this problem are very difficult, because they are related to poverty and lawlessness (as reflected, in the JPSCo-commissioned study, in the rate of violent crime) and demonstrate that a collaborative approach between the company, the government and, civil society is required. Some partial steps in this direction have been taken already via the UERP, but a stronger collaborative effort among all concerned parties is still needed.

Service Quality. It was seen that quality of service, as reflected in the indicators of service interruption (the SAIFI, the SAIDI, and the CAIDI), has improved at a very fast pace (15 to 16% per year for the SAIFI and the SAIDI) in 2006–2008, but it still has room for improve-

70 This is the average level that the United States, as a whole, attained in 2001, and includes transmission losses in systems that are much more extended than the Jamaican grid. This figure can be used as a benchmark of what is practically attainable at present (US EIA data).

71 Some may argue that the costs are very high and thus not justified. But this is the wrong argument. What matters is how those costs compare with the savings in fuel costs (the benefits), which at the present level of prices for HFO and diesel, and at their projected levels, are likely very important. Thus in order to decide on what should be done it is necessary to do a complete cost–benefit analysis, not just look at expenditures. (On this see for example, Sotkiewicz (2007), for a discussion of loss reduction in Belize.)

72 OUR 2004.

ment when compared with countries like Panama and Brazil. At its present level of improvement, JPSCo will reach Brazilian levels in approximately five years. The OUR has a system of target incentives that attempts to encourage the improvements. However, the target system should be modified to follow only two of the three indicators, because their logarithmic expressions are linearly dependent (see footnote 56), which reduces the degrees of freedom of this system to two, instead of three. The more meaningful indicators to follow would be the SAIFI, reflecting the frequency of service interruptions, and the CAIDI, reflecting the duration per interruption. International comparisons show that there is great room for decreasing the frequency of interruptions, but the duration per interruption is much more difficult to reduce as shown in Table 9, where it ranges from 126 minutes per interruption for JPSCo (2007) to 70.8 for Panama (2007, lower than the typical US value of 81.4). Thus the targets for SAIFI and CAIDI should not be symmetrical. Indeed, when the CAIDI reaches the neighborhood of 80, targets should concentrate on reducing the SAIFI.[73]

Very High and Rising Prices. Average electricity prices in Jamaica have climbed at a very fast pace in the last decade (10.2% per year since 1998 and 14.1% per year since 2004), and they have reached very high levels (30.7 US cents/kWh in 2008).[74] The steep rise in price is related to the rising trend in the price of oil and its products in the last decade. The high level of prices, in turn, is partly due to the relatively small size of the system, which encounters diseconomies of scale in generation, and to the scarce hydroelectric capacity. The level of prices is one of the highest in LAC, comparable only with prices in the small Caribbean island systems, also dependent on hydrocarbons for their generation. These high prices can be due either to high margins above operating costs or to high costs. The data from JPSCo seem to show that the problem may be costs: unit operating costs are high, comparable only to the level of the Caribbean systems with smaller demand (kWh sold). When demand is controlled for, via regression analysis, it can be shown with reasonable certitude that, in fact, costs in the JPSCo system are substantially higher than in a comparable Caribbean system with the same demand size. The question arises then as to why costs are so high. There are no good answers at present because there is no good information, for reasons such as the integrated nature of the system and its corresponding integrated cost accounting, which present the regulator with the typical principal–agent problem of trying to obtain good information, but staying well short of what the company itself knows. At any rate, the atypically high costs of the company warrant an independent audit of its cost levels, structure, and of its accounting procedures.

[73] Notice that if the SAIFI and the CAIDI are both reduced, the SAIDI is necessarily reduced as well, since SAIDI = SAIFI*CAIDI (if both right-side terms decrease the left-side term has to decrease as well). Notice also that reducing the SAIFI by x% would be equivalent to reducing the SAIDI by x% (since CAIDI = constant = 80).

[74] See Table 10 and Figure 5.

Oil

4

1. Oil and the Jamaican Economy

Oil consumption in Jamaica has grown since 2003 at an exponential rate of 3.74% per annum,[75] much faster than its population's rate of growth (0.48% per annum) and that of the GDP (at constant prices: 1.69%) in the same period.[76] The Jamaican economy is dependent on oil for its energy needs and this dependence is growing at an unsustainable rate. Jamaica depends on oil more than most Latin American economies do for two reasons: first, because its hydroelectric potential is small compared with that of most Latin American countries; second, because its principal export industry, bauxite and alumina, is highly energy intensive. This can be observed in Table 13, which shows bauxite/alumina processing, with more than a third of total oil use, as the highest consumer, and electricity generation as the second-highest user with around a quarter of overall consumption. The third place goes to transportation, which, with 22.7%, is not very far below electricity.[77]

In spite of its bigger consumption, the role of bauxite/alumina is very different from the other two big consuming sectors because bauxite/alumina earns more foreign revenue with its exports than it expends with its oil imports; its overall impact on the balance of payments is positive. The other two sectors, being non-tradable,[78] have a negative impact on the balance of payments with their oil use and thus contribute negatively to the problem of sustainability of the whole petroleum-based Jamaican economy. Improvements in the impact of energy use on the economy and its external balance thus have to concentrate efforts first in the electricity and transportation sectors. The role of the bauxite sector is more indirect and it can contribute positively and importantly to alleviating the energy situation via surplus electricity cogeneration to sell to the grid; this would result, inter alia, in an increase in generation efficiency and, consequently, in reduced fuel use.

If the bauxite/alumina sector is abstracted from the picture of oil use, as is done in the last column of Table 13, the importance of electricity and transportation for oil use becomes more apparent: both electricity and transportation each consume more than one-third of the

75 Estimated from the series of total consumption in Table 13.

76 Exponential rates of growth estimated from information from the Statistical Institute of Jamaica for the period 2003–2007. GDP growth is estimated from the series of Gross Domestic Product in basic values at constant prices.

77 In terms of consumption by product, (average 2003–2007) Heavy Fuel Oil (Bunker C and low-vanadium) represent around 58% of total consumption. This is a reflection of the heavy use of HFO by the electricity and bauxite/alumina industries. Transportation use is reflected in the joint 30.7% share of gasoline (premium and regular) and diesel ADO. (Source: Estimates using Jamaica.Ministry of Energy data).

78 In the case of Jamaica, electricity can be considered a non-tradable good because the country is an island.

Table 13 **Jamaica – Petroleum Consumption by Activity 2003–2007 (Thousand bbl)**

ACTIVITY	2003	2004	2005	2006	2007P	AVERAGE 2003–2007	SHARES IN CONSUMPTION	SHARES IN CONSUMPTION WITHOUT BAUXITE/ ALUMINA
Road & Rail Transportation	6,037	6,076	6,248	6,373	6,080	6,163	22.7%	34.9%
Shipping	412	368	1,636	3,240	3,973	1,926	7.1%	10.9%
Aviation	1,620	1,793	1,577	1,984	1,931	1,781	6.6%	10.1%
Cement Manufacture	51	105	37	14	28	47	0.2%	0.3%
Electricity Generation	6,471	6,226	6,555	6,390	6,654	6,459	23.8%	36.5%
Bauxite/Alumina Processing	9,546	9,444	9,799	9,552	8,811	9,430	34.8%	NA
Sugar Manufacturing	112	76	40	50	61	68	0.3%	0.4%
Cooking & Lighting	906	903	925	964	912	922	3.4%	5.2%
Other Manufacturing	142	136	163	182	199	164	0.6%	0.9%
Other	226	186	181	84	80	151	0.6%	0.9%
TOTAL	**25,524**	**25,313**	**27,162**	**28,832**	**28,730**	**27,112**	**100.0%**	**NA**
Petroleum Refinery	259	223	164	332	363	268	1.0%	NA
GRAND TOTAL	25,784	25,536	27,326	29,164	29,093	27,381	101.0%	NA
Refinery Cons (%)	1.0%	0.9%	0.6%	1.1%	1.2%	1.0%		
TOTAL WITHOUT BAUXITE/ALUMINA	**15,979**	**15,869**	**17,363**	**19,281**	**19,920**	**17,682**		**100.0%**

Source: Jamaica Ministry of Energy and Mining.
p = preliminary

oil not used by the bauxite industry in Jamaica. This reinforces the fact that a reduction in the use of oil in either one of these two sectors (via efficiency increases or use of alternative fuels/technologies) has a disproportionate impact on the overall use of oil in the economy. Thus efforts to reduce or replace the use of oil should start by concentrating on what can be done in these two sectors. Of course, an alternative to the reduction of oil use is the acquisition of indigenous oil.[79] As will be seen shortly, Jamaica is also working on this alternative.

Imported oil is pervasive in the Jamaican economy and its use is growing at a greater rate than the rest of the economy. Jamaica faces the great challenge of finding a way to control this growth or redirect the economy away from oil and into alternative fuels with a better impact on its economy, external balance, and environment.

2. Policy and Institutional Setting for Crude Oil and Products

The laws. There are several laws and regulations that govern matters in the oil subsector in Jamaica. These are:

The Petroleum Act (1979), which is the paramount law in the sector; and other laws and regulations that refer to more specific matters as follows:

a. The Petroleum and Oil Fuel (Landing and Storage) Act and its Subsidiary, which specify matters relating to the safe importation, handling and storage, distribution, and licensing of retailing of oil and fuels;
b. The Petroleum Refining Industry (Encouragement) Act, which deals with the granting to "recognized refineries" of stimulus measures, such as import duty exemptions, temporary tax exemptions, and subsidies; and
c. The Petroleum (Quality Control) Act of 1992 and the Petroleum (Quality Control) Regulations of 1990, which contain prescriptions on quality and lack of contamination of petroleum products; conditions and restrictions on retailing and transportation of oil, licensing and registration of retailers, haulage drivers, and contractors; licensing of producers, importers, blenders, and wholesale distributors of oil products; designation and powers of oil inspectors; and physicochemical specifications for the different fuels.

As mentioned, the 1979 Petroleum Act is the paramount law that governs nearly all matters dealing with the petroleum sector in all its aspects: exploration, production, importation, processing, refining, storage, exchange, sale, and distribution of oil and oil products.

After asserting full state ownership of all petroleum in the ground,[80] the Petroleum Act established The Petroleum Corporation of Jamaica, to which it gave the exclusive right to explore and develop all petroleum resources in Jamaican ground (and seabed),

[79] This ignores for the moment environmental considerations; vis-à-vis this aspect, the two alternatives are not symmetrical.
[80] "There is hereby vested in the Crown all petroleum existing in its natural state in strata in Jamaica including the bed and subsoil of its territorial sea, its continental shelf and the exclusive economic zone" (Petroleum Act, Section 3).

and to carry out any necessary action to fulfill its mission, including "(a) either alone or in association with contractors, explore, develop and manage petroleum resources; (b) enter into agreements or arrangements providing for the participation, assistance or co-operation of contractors in connection with the exploration, development or management of petroleum resources; (c) either alone or in association with contractors, acquire, construct, maintain, manage or operate any refining or processing facilities, marketing facilities or outlets of any kind and type, pipelines, tankers, trucks and other facilities for the transportation of petroleum and petroleum products, and any other facilities related to the processing, refining, storage, exchange, sale or distribution of petroleum and petroleum products; (d) either alone or in association with contractors, buy, sell, store, trade, barter, exchange, import and export petroleum and petroleum products; and (e) with the approval of the Minister, form subsidiary corporations "(Section 6(3)).

Furthermore, the Act gave the GOJ the power to extend the functions of PCJ to energy resources other than petroleum. And in fact PCJ has been mandated by the GOJ, inter alia, to develop indigenous energy resources and to prevent adverse environmental effects; at present it works in the areas of renewable energy and energy efficiency and conservation, in addition to being present at all stages of the oil cycle.

The Act also gave the PCJ other faculties necessary for its entrepreneurial functions, for instance the power to seek financial resources in various forms, such as the creation and issuance of stock, including debentures and bonds. The GOJ can also make advances and grants to the Corporation and can guarantee its loans.

Although the law gives the Corporation enormous powers in the sector, in the area of importation, wholesale distribution, and retailing of oil products, the Corporation is not the only player: the market is free in those areas and, as will be seen below, it has a certain degree of competition in distribution and retailing.

Exploration and production of Petroleum. Exploration and eventual production of petroleum or gas have been clearly and precisely specified by a draft prototype contract prepared by PCJ. The contract combines the features of a pure production-sharing regime with those of a tax/royalty regime, although the income tax is waived for the first 15 years after discovery of an exploitable field.[81] The balance of oil left after payment of royalties (which are negotiable from 12.5% down to zero), or "split oil", is shared between PCJ and the contractor in a scale ranging from 30% to 60%, in favor of PCJ, depending on the amount of split oil.

Oil products. Wholesale distribution and retailing of oil products, mainly gasoline and diesel, has been deregulated since September 1990. Imports were also liberalized in 1993. Prior to those dates, prices were regulated with a formula that contained four broad categories (and several sub-categories): ex-refinery prices, industry loading rack fees, government taxes, and industry margins. Jamaica imports both oil products and crude oil. The latter is refined by Petrojam, a subsidiary company of PCJ.

[81] For a thorough explanation of different contract types in petroleum exploration and production, see Sunley et al. (2002).

3. Exploration, Importation, and Refining

Petroleum Exploration

Jamaica has had hydrocarbons exploration activity since 1955. It has included geological, geochemical, and geophysical data gathering, as well as the drilling of exploratory wells. From 1955 until 1982, 11 exploratory wells were drilled; none of them produced significant results,[82] and no more wells have been drilled so far. However, the early work, carried out by private companies until 1973 and by PCJ from 1978 to 1982, showed that Jamaica has several structures that may contain oil and gas. PCJ received loans from the IDB and the World Bank to assist in carrying out the later exploration work, including the drilling of four wells.[83]

Jamaica has entered a new exploration phase, starting in 2005, which is using more advanced geological and geophysical tools than were available in the previous period. This is being done with private financing, using the production sharing contract that was mentioned above. Recent studies have indicated the Walton basin located southwest of the island may contain oil in significant amounts, with reservoirs up to 1 billion barrels (Finder and Gippsland, 2009). In a 2005 Licensing Round, exploration companies were invited to bid on 24 blocks (four onshore and 20 offshore), situated in the Walton basin, the Pedro Banks, and around the perimeter of the island, where five offshore blocks were granted to Finder Exploration Pty. Ltd. (in joint venture with Gippsland Offshore Petroleum Limited). They have carried out aeromagnetic and gravity surveys. Another three blocks were awarded to a Canadian company, Rainville Energy, which is carrying out a seismic survey of the contracted blocks. Finally, another company has signed a production-sharing contract for four blocks, has completed geological evaluations with encouraging results, and plans next to conduct seismic surveys. Thus 12 offshore blocks out of 20, or 60%, have already been contracted out.

Finally, in November 2008 Jamaica and Colombia signed an agreement to conduct surveys in a 52,000km^2 joint-regime area south of the Pedro Banks, in preparation for defining exploration blocks and attracting exploration activity.

The next few years may thus see several new exploration wells drilled in Jamaica and the possibility of some of these finding oil.

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82 However, 10 of the 11 wells showed traces of oil or gas [the exception was one well onshore (interviews with Dr. Gunter and Dr. Wright at PCJ in July 2009)]. See also the brochure "Exploration opportunity offshore southern Jamaica –Executive Summary" by Finder Exploration Pty Ltd and Gippsland Offshore Petroleum Limited. (http://www.finderexp.com/Portals/0/docs/Jamaica/Jamaica%20FO%20flyer%20June%202009.pdf).

83 The IDB loan had a value of US$23.5 million from the Fund for Special Operations. JPSCo contributed US$6.5 million for a total of US$30.0 million. (JA0054: Hydrocarbon & Geological Exploration, Dec. 1980). The loan was to finance exploration work, including geophysical surveys, geological studies, and geochemical analysis, as well as the drilling of onshore exploratory wells. The WB loan, approved in June 1981, was for US$7.5 million to be used for exploration work offshore. Part of the loan was cancelled.

Imports of Crude Oil and Products

Although Jamaica has its own refinery, the Petrojam refinery, the latter does not have sufficient capacity to fulfill all the needs of the internal market. Jamaica thus imports both crude oil and products to meet internal demand. Total imports of crude oil and products were 26.8 million barrels in 2007. The amounts fluctuate over time, although they have a slightly increasing trend (exponential growth trend in 1998–2008 was 1.56% per year[84]). The share of the Petrojam refinery in total imports was around 62% in 2007 (Table 14); it has fluctuated between 49% and 63% since 2000, and its average value in the period was 56%.

Table 14 Jamaica – Oil Imports

(A) CRUDE AND PRODUCTS IMPORTS – TOTAL AND PETROJAM *	2004	2005	2006	2007
Petrojam				
Crude	5.51	3.29	7.15	5.97
Products	8.79	9.03	9.25	11.81
Total Petrojam	14.30	12.32	16.41	17.78
Total Imports	26.21	25.31	27.25	28.31
Share of Petrojam in Total Imports	54.6%	48.7%	60.2%	62.8%
(B) DESTINATION OF OIL IMPORTS – AVERAGE SHARE**				
Avg. Volume Share (%)				
REFINERY				
Crude & Spikes	27.8%			
Refined Products	26.2%			
Subtotal	54.1%			
BAUXITE COMPANIES				
Bunker C	26.6%			
Low Vanadium	7.4%			
Subtotal	33.9%			
MARKETING COMPANIES				
Refined Products	11.4%			
Lubricants	0.6%			
Subtotal	12.0%			
NON-BAUXITE TOTAL	66.0%			
GRAND TOTAL	100.0%			

*Sources: Petrojam and US EIA
** 2000–2004. Source: Jamaica, MEM. Compiled from: Refinery Statistics; Marketing; Bauxite Companies' Data

[84] Based on USEIA data, originating in the IEA.

Crude oil only represents around a quarter or less of total imports. Of the other three-quarters, composed of diverse products, Petrojam imports again around a quarter, the bauxite companies around a third, and private multinational marketing companies directly import around 12% for the transportation sector. Petrojam imports the refined products from Trinidad and Tobago. They amount to approximately 35% of the products Petrojam supplies to the market.

Refining

The petroleum refinery operated by Petrojam Limited, one of PCJ's subsidiaries, has a nominal capacity of 36,000 bbl/day. It was built in 1962 by Esso West Indies (a subsidiary of Exxon), which owned and operated it until it was purchased by the GOJ in 1982. The refinery currently operates at 69% of its crude unit capacity, producing 25,000 bbl/day of its potential capacity of 36,000 bbl/day.[85]

Presently, the refinery uses a bare-bones process known as hydro skimming, which results in a very high proportion of the output being residual fuel oil (47%). Petrojam is in the process of upgrading the refinery so that it would be able to produce a greater proportion of lighter fuels and less residual fuel oil; use heavier crudes as feedstock; and produce low-sulphur, lead-free fuels. It would also increase its nominal capacity from 36,000 to 50,000 bbl/day. The engineering studies are now under way and the upgrade is to be completed by 2012. The Venezuelan company PDVSA has taken a 49% equity stake in Petrojam, and is working with Petrojam on the upgrade.

The refinery uses crude oil purchased mainly from Venezuela and Mexico, under the San Jose Pacts and the Caracas Energy Accord; more recently the latter has been replaced by the PetroCaribe initiative signed in 2005, inter alia, with Venezuela. With this initiative Venezuela agreed to increase its supply to Petrojam to 21,000 bbl a day, up from the previous 7,400 bbl/day (Jamaica, 2005). This oil is sold to Petrojam at world market prices. Jamaica is supposed to benefit from the arrangement, though, because as part of the transaction it receives a long-term, low-interest, government-to-government loan, equal to a portion of the purchase cost, which is to be dedicated to national development projects. This later arrangement is essentially similar to the previous arrangements such as the San Jose accord. It is not clear how much net benefit, if any, Jamaica receives from these arrangements. In the past, the World Bank estimated that the benefits of a similar arrangement would be smaller than the savings Petrojam would have obtained if it had bought the crude at spot prices.[86]

The refinery has total crude oil and product storage capacity of some 2.2 million bbl, including about 300,000 bbl of tankage used for marketing and loading rack sales.

Past studies have shown that with the size of its market and the level of its refining margin, the refinery output can be price-competitive with directly imported products, although a reduction in either margins or demand beyond a certain threshold could alter the situa-

[85] In the past, this low utilization has been caused by factors such as: process bottlenecks, forced outages, and crude shortages caused by shortages of foreign exchange (ESMAP 1992, par. 3.9).
[86] WB (1985), p.34. The arrangement then used Caribbean Postings for pricing the purchases.

tion.[87] However, even then Petrojam might still have an advantage over other importers, as it benefits from an exemption of 12% import duty on petroleum products, and it also controls large storage facilities, which compounds its advantage.

Until 1990, the internal and external markets for oil and products were controlled by the GOJ, which regulated all prices in the import, production, and distribution chain. In September 1990 the (internal) markets for distribution of oil products were liberalized. However the GOJ, via its company PCJ/Petrojam, kept the monopoly on imports of crude oil and products and continued fixing prices ex-refinery by means of a formula. First established in 1963, the formula was intended to mimic the importation of products in an open market, adjusted for indirect taxes and duties; that is, it was supposed to reflect the cost of imports brought into Jamaica. Petrojam was thus still the sole wholesale supplier into the internal market. Other marketing companies had to acquire their products from Petrojam.

In 1993, liberalization was completed, and the market for imports was open. As a result, three of the marketing companies, Esso, Shell, and Texaco, started to jointly operate a terminal facility in Montego Bay to import and deliver gasoline to retail stations. They were able in this way to acquire a share of 15% in the gasoline market. This introduced an element of competition to the import market, although it still has an oligopolistic structure, which may affect prices, as will be examined below.[88]

Although an official formula is not used anymore, Petrojam still prices its products to attain import parity in principle, that is, an estimate of the price that an importer would have to pay to import its own products (essentially the CIF price). Before 1993, the prices obtained with the old formula were charged by JPSCo to all purchasers and they were not necessarily the prices that would result in a free competitive market: in 1985 in a joint study by the UNDP and the World Bank, the prices obtained by the formula were shown not necessarily to be the lowest (WB 1985, p.34).

The current Petrojam pricing algorithm could have the same deficiencies noticed by the World Bank in 1985. But now, one could expect a better outcome: with the market liberalization of 1993, the other importing companies are free to charge a different, lower or higher, wholesale price than Petrojam. In principle, assuming sufficient competition, prices charged by Petrojam and the other importers should approach the competitive (lowest-cost reflecting) CIF price. However there are only four players in this import market and three of them already collaborate (they share terminal facilities).[89] Thus the price resulting from this oligopolistic market may not be the economically optimum price and may not offer a way of gauging the fitness of the new Petrojam algorithm to reflect economically efficient prices.

87 ESMAP (1992) p. 24, pars. 3.6–3.7. According to ESMAP, for the 1992 demand size and prices a reduction of 20% in either margin or volume would have rendered the refinery uncompetitive then.

88 A market share of 0.85 for Petrojam and 0.15 for the three companies, distributed in different ways, produces a Herfindahl index of market concentration in the range of 0.730 to 0.745, which denotes extreme concentration in the import/production segment of the oil market (see notes 93 and 94 below).

89 Although the sharing of the facilities is the economically efficient way to act to avoid inefficient duplication of assets (there is an element of natural monopoly-scale economies for the terminal and storage), this collaboration provides other opportunities to engage in colluding behavior. For the degree of concentration, see note 88.

4. The Petroleum Products Market

Downstream from refining, the market is divided into two segments: wholesale distribution and retail. The wholesale distribution segment is currently composed of seven marketing companies (or groups). The retail segment is composed of all the gasoline service stations, about 300 in number, in the island.[90] The two segments are closely interrelated. The retail companies, which obtain the gasoline, diesel, and other products from the marketing companies, can either be company-owned or independent dealers. In 2004, wholesale companies directly operated only 9% of retailers,[91] while independent dealers operated the other 91%. The independent dealers generally enter into contracts with one of the marketing companies to sell that company's brand of fuel exclusively. There are, though, a few retailers who do not bear the brand of any of the marketing companies.[92] The exclusiveness of the contracts between retailers and wholesalers makes it appropriate to analyze the market in terms of the concentration reflected in the number of retailing companies that carry each wholesaler brand.

The current wholesale marketing companies/groups are:

1. The Cool Group with two Companies: Cool Petroleum Ltd./Shell and Cool Oasis;
2. Epping Oil Co. Ltd.;
3. Petcom (Petroleum Company of Jamaica Ltd.);
4. Texaco/Chevron Caribbean srl;
5. Total Jamaica ltd (which acquired the Esso marketing business in 2008), which includes the station still using the Esso name;
6. United Petroleum (Jamaica) ltd (Unipet); and
7. Jampet

The present situation reflects some recent consolidation of the wholesale marketing companies. In 2004 there were nine marketing companies: Esso and Shell were independent marketing companies distributing products to their branded stations. The evolution of the market share between 2004 and 2009 as a result of this consolidation can be seen in Table 15. The table shows the market shares and the concentration indices that can be derived from them.

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90 In 2004 Jamaica's Fair Trading Commission put the figure at 278 retail stations (FTC, 2004). More recently a former president of the Jamaican Gas Retailers Association estimated them at around 320 (*Jamaica Gleaner*, 2009). On the other hand the Jamaican Consumer Affairs Commission (CAC) uses a sample of 178 retailers in its all-island price surveys (CAC 2009) which in another CAC document (CAC 2007) it is suggested to be approximately equal to half the population of service stations.

91 Either through commission agents or through employees. That figure is unlikely to have changed much (FTC 2004).

92 There are very few of these. An excellent report on anticompetitive practices by fuel marketing companies carried out by Jamaica's Fair Trading Commission (FTC) finds that there are at best very few non-branded retailers: "There is, however, at least one retail outlet that does not bear the brand of any of the nine marketing companies" (FTC, 2004, p. 23). In the sample for the CAC's March 2009 *Survey of Prices* there were nine stations that did not mention any of the brands in their names. It is not clear whether some of these have exclusive arrangements with one of the marketing companies.

Table 15 Evolution of Market Share in Jamaica's Wholesale Distribution of Oil Product

	2004 MARKET SHARE*		2009 MARKET SHARE (**)
Shell	20%	Shell is Now with Cool Group	–
Cool Oasis	5%	Cool Group (Cool Oasis/Shell)	30%
Epping	7%	Epping	7%
Petcom	11%	Petcom	11%
Texaco (Chevron/Texaco)	28%	Texaco/Chevron Caribbean srl	21%
Total (National)	8%	Total/Esso	20%
Esso	18%	Esso is now with Total	–
Unipet	3%	Unipet	4%
Jampet	1%	Jampet	1%
Not Branded	NA	Not Branded	5%
SUM	**100%**	**SUM**	**100%**
TOTAL No. OF COMPANIES	**278**	**TOTAL No. OF COMPANIES**	**300**
MARKET CONCENTRATION INDICES			
Herfindahl index	0.1356	Herfindahl index	0.1973
CR2	48%	CR2	51%
CR3	66%	CR3	71%

*From FTC (2004) report on anticompetitive practices by fuel marketing companies. 278 is the population in 2004.
**From CAC's sample for March 2009 gasoline and diesel price survey (Sample size: 178).

Table 15 shows that market concentration has increased substantially as a result of the past mergers. In 2004 the Herfindahl index[93] was 0.1356, which indicates moderate concentration; in 2009 it jumped to 0.1976, which indicates it is bordering on high concentration.[94] The corresponding concentration ratios CR2 and CR3 have increased substantially as well: three firms now control 71% of the market.

In spite of this movement towards greater concentration, the Jamaican retail market is still less concentrated than many LAC markets as shown in Table 16: Costa Rica, Honduras, and Belize have higher concentration indices, and Panama similar ones.

93 The Herfindahl index, HI, also known as the Herfindahl-Hirschman index (HHI), is the sum of the squares of market shares in the industry: HHI = $Sum(S_i^2)$, for I = 1,n; where S_i is the market share of firm i and n is the total number of firms in the market. The concentration ratio "m", CR_m, is the sum of the market shares of the m firms with the largest share (m < i). The HHI can also be expressed on a scale of 0 to 10,000 (which corresponds to using percentage quantities for the ratios).

94 An HHI of less than 0.10 can be seen as indicating an unconcentrated market (0.10 would be the index corresponding to 10 firms of equal size). An HHI between 0.10 and 0.18 can be seen as indicating a moderately concentrated market (0.18 would be the index corresponding to five firms of equal size). An HHI of more than 0.18 can be seen as indicating a highly concentrated market. The classification just presented is based on the US Federal Trade Commission and Department of Justice (DOJ) guidelines (see FTC (Jamaica), 2004, p. 26).

Table 16 Market Concentration in Jamaica and Some LAC Countries

CONCENTRATION INDICES	HHI	CR3
Jamaica 2004	0.1356	0.66
Jamaica 2009	0.1973	0.71
Costa Rica	0.2545	0.66
El Salvador	0.1741	0.71
Guatemala	0.1310	0.53
Honduras	0.1986	0.71
Nicaragua	0.1707	0.67
Panama	0.1936	0.67
Belize	0.3400	1.00

Source: CEPAL/ECLAC 2008, and authors' own calculations.
* Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Panama: 2007 data. Belize: 2002 Data.

The retail prices (at the pump) in Jamaica are quite similar to those in the Central American countries, as can be seen in Table 17. The table compares the prices in Jamaica with those in Central American countries for the first quarter of 2007.[95] In the case of premium gasoline, for example, the Jamaican price, at US$127 per barrel,[96] (3.03 US$/gallon), lies between the upper and lower boundaries of the CA prices and it is indeed very near their average of US$128.7 per barrel (US$3.06/gallon). The same is true of the prices of regular gasoline and diesel as well. The table also shows the average import prices of crude oil in the same period, and again the Jamaican price at US$50.46 per barrel lies between the higher and lower CA prices and is very near to the CA average of US$49.38 per barrel. This means that the ratio of retail prices to imported crude oil is quite similar, as the last line of Table 17 shows. The internal price in Jamaica is 2.4 times the imported crude price, which coincides with the average ratio for CA of 2.4 times as well; again the ratio is in the middle of the CA ratios.[97] This result is consistent with the previous finding that the Jamaican market has a degree of concentration that, although growing lately, is between those found in CA.[98]

95 This period was chosen because it was possible to find internal prices for Jamaica and for the CA countries for that period. There were isolated internal prices for CA and Jamaica in other periods but those periods did not overlap.
96 Expressed in terms of US dollars per barrel of 42 US gallons
97 It was not possible to obtain the different margins between the FOB, CIF, ex-refinery, wholesale, and retail prices for Jamaica or the CA Countries, which would have permitted a more rigorous analysis. However the comparison of the ratio of retail fuels to imported crude prices (related to the overall margin between those two prices), a second best, gives a good idea of the comparative state of these markets.
98 Some of the CA countries have small refineries like Jamaica's. They have oil market sizes comparable to Jamaica's and thus at the importing and refining levels they also have oligopolistic and in some cases, monopolistic structures (see CEPAL/ECLAC, 2005); this validates the comparison of concentration ratios in wholesale/retail distribution and price impact. Unlike Jamaica, some of these markets (Costa Rica and Honduras) are regulated; however, the other markets are not, and the comparison with them is thus valid.

Table 17 **Central America and Jamaica: Import and Internal Market Prices of Oil Products and Crude Oil. 1st Quarter 2007 US$/bbl**

	JAMAICA	COSTA RICA	EL SALVADOR	GUATEMALA	HONDURAS	NICARAGUA	PANAMA	CA AVERAGE
IMPORT PRICES (US$/BL)								
Premium Gasoline(*)	NA	69.1	75.15	75.59	77.06	74.2	NA	74.14
Regular Gasoline (*)	NA	NA	71.42	72.26	72.87	72.56	NA	72.28
Diesel	NA	69.45	73.13	71.75	74.55	76.26	NA	73.03
Three-Product Average	NA	69.28	73.23	73.20	74.83	74.34	NA	72.98
Crude Oil	50.46	49.77	53.64	NA	NA	44.73	NA	49.38
INTERNAL PRICES (US$/BBL) (**)								
Premium Gasoline (*)	127.09	145.74	125.16	122.22	133.98	134.82	110.04	128.66
Regular Gasoline (*)	119.66	137.76	113.4	119.28	124.32	129.36	105	121.52
Diesel	110.13	106.26	103.32	100.38	112.14	115.08	90.3	104.58
Three-Product Average	118.96	129.92	113.96	113.96	123.48	126.42	101.78	118.25
Ratio of Average Internal prices of Gasoline and Diesel to Imported Crude Oil Prices								
(Average of 3-Product Price)/(Crude Oil price)	2.4	2.6	2.1	NA	NA	2.8	NA	2.4

Sources: CEPAL/ECLAC (2008); CAC (2007); Petrojam Website, authors' own calculations
(*) Unleaded
(**) Price at the pump

Challenges

Oil and the economy. As seen above, oil presents Jamaica with many challenges: the impact it currently has on the economy with its price shocks is highly destabilizing. The economy is presently very dependent on imported petroleum and products, whose consumption is growing faster than the population and the GDP. This challenge has many faces, including the two prominent ones of high consumption of the electricity and transportation sectors. It is essential to explore alternatives fuel sources to mitigate the dependency on oil.

Exploration. There has been much progress in the area of exploration, with four companies already holding production-sharing contracts and 60% of the 20 exploration blocks already taken. The geological prospects seem much improved as well, as compared with the results from the previous round of exploration. One fact that stands out is that all the companies that have taken contracts are independents; that is, they are not related to the big multinational oil companies, such as Exxon, Texaco, etc., which in the past were exploring in these areas and some of which still have a presence in the distribution segment of oil products in the island. This seems to be a common pattern observed in other countries with no previous known oil but favorable geology, such as Belize, where a small but commercially viable oil field was found recently and is being exploited. This has implications for the development of the fields in case oil is found. If the field found is small, then the independent companies might have difficulties raising the capital to develop it. That will present a challenge to the GOJ, since the GOJ and PCJ will have to participate in the search for finance.

Another challenge that the GOJ and PCJ will face in the case of an oil discovery will be the need to train personnel to take on the new tasks and the increased load that will occur in the case of a positive discovery. Although the PSJ leaves the responsibility of developing the field to the private partner, there will be new legal, administrative, and technical tasks that will emerge, related to the oil that PCJ will receive. Thus, PCJ will have to develop a plan to handle the eventuality of a positive discovery and its impact not only on its staff but in other areas as well, such as equipment and infrastructure.

Importation and Refining. As seen in the latest agreement with Venezuela, the PetroCaribe initiative, Petrojam can import from Venezuela 21,000 bbl/day for its refining needs. This quantity is enough to satisfy the refinery's needs for feedstock.[99] The benefit of this arrangement is indirect, because Petrojam pays world market prices, but the GOJ gets a loan for part of the cost, given in concessional terms, to use for development projects. This results in a small subsidy toward the full world oil price. However it is not clear that this arrangement results in net savings for Jamaica. A past study concluded that the small benefit obtained was less than the savings Jamaica would have obtained if it had bought the crude in the spot market instead of with a long-term arrangement as examined.[100] It would thus be beneficial

[99] At least for the years 2005, 2006 and 2007. In those years imports were respectively: 9,000, 19,600 and 16,400 bbl/day. (Data from Petrojam's website converted to bbl/day).
[100] (WB 1985, p.34). The arrangement then used Caribbean Postings for pricing the purchases.

to Petrojam to do a similar exercise with the present arrangement and market conditions. It is likely that the exercise may confirm the net positive benefit of the PetroCaribe arrangement, but there is a possibility as well that it will find again that it is not, in the end, favorable to Jamaica. More generally, it would be beneficial for PCJ/Petrojam to completely analyze the full spectrum of its crude supply options in terms of cost minimization as well as for strategic reasons, in case the present supply sources were suddenly to become unavailable.

Distribution. With respect to the distribution market, Jamaica's market currently has a Herfindahl-Hirschman concentration index of around 0.20, which is within the high concentration category (HHI > 0.18) used by the US Federal Trade Commission and the US Department of Justice; this concentration has shown a growing tendency since at least 2005. Although it has not resulted in prices that are much higher than in other small markets in LAC (the ratio of pump prices to crude import price is similar in those markets), it is important to stay vigilant in this market, to spot further increases in concentration that could then have negative price effects, and to ensure that prices stay reflective of costs plus reasonable margins within the current market structure. Fortunately, Jamaica presently has public bodies, such as the CAC and the FTC, that have been doing this job and can continue doing it. Nonetheless, the GOJ should remain attentive to the issues.

5 Renewables

Currently the domestically produced supply of renewables in Jamaica is comprised of small hydro, wind, charcoal, bagasse, and fuelwood, as well as lesser amounts of solar energy and PV. Renewables contribute a very modest share, estimated at 5.6%,[101] to Jamaica's energy mix. There is also an important production of anhydrous ethanol, mostly for export purposes, but currently Jamaica uses hydrous ethanol imported from Brazil as feed-stock; any ethanol produced by the sugar factories is used in the production of rum.

Table 18 presents a series of consumption of energy from renewables for 2003–2008. That consumption has represented approximately 5.4% to 5.5% of total energy consumption in Jamaica.[102] The table shows the importance of fuelwood and bagasse, with 40% and 39% average shares respectively. The bagasse consumption reflects its use for the energy needs of the sugar industry, although, as will be seen later, the industry currently uses very inefficient processes for energy production and is thus not energy self-sufficient. The fuelwood consumption is mainly used for domestic cooking. Furthermore, part of the fuelwood is considered non-renewable because its extraction is not completely balanced by reforestation.[103] As can be seen, hydropower and wind are still a very small part of the consumption mix of energy in Jamaica.

Table 18 Jamaica's Total Renewable Energy Consumption 2003–2008 (in Thousand BOE)

ALTERNATIVE ENERGY	2003	2004	2005	2006	2007	2008	AVERAGE 2003–2005	% SHARE 2003–2005
Hydropower	91	83	94	104	99	98	89	6%
Wind	–	20	32	34	32	31	26	2%
Charcoal	207	196	186	#N/A	#N/A	#N/A	196	13%
Bagasse	600	695	467	602	591	#N/A	587	39%
Fuelwood	650	585	556	#N/A	#N/A	#N/A	597	40%
Total Renewables	1,548	1,579	1,335	#N/A	#N/A	#N/A	1496	100%

Source: PCJ and authors' own calculations.

101 Source: Ministry of Energy and Mining. 2007 Value. Loy and Coviello (2005) give this proportion as 7.1% in 2003.
102 Based on the average share for 20032005. Authors' own estimate from figures for total and renewable consumption sourced from the MEM and renewables consumption sourced from PCJ's website.
103 Cf. Loy and Coviello 2005 p. 15.

Institutional Framework

The Ministry of Energy and Mining is the principal organism in charge of energy policy, and its recent Energy Policy Green Paper 2009–2030 explicitly proposes the development of renewable energy sources as one of the goals of the policy (Goal 3). The OUR, which by the nature of its business has to deal, inter alia, with the promotion and development of renewable electricity production, has recently published guidelines that contain a special set of rules for choosing small projects using renewable technologies, aiming at leveling the playing field for these plants. The GOJ, more specifically the MEM and the Ministry of Agriculture, has recently also created a task force for biofuels. The Biofuels Task Force is comprised of representatives from local and international organizations, such as the Planning Institute of Jamaica (PIOJ), Scientific Research Council (SRC), Petrojam, Food and Agriculture Organization (FAO), Organization of American States (OAS), the World Bank, and the US and Brazilian Embassies. It is thus a partnership between the GOJ and a consortium of multilateral partners.

The PCJ is the institution with the most direct mandate to deal with renewables: indeed, the development of renewable energy has been explicitly vested in the PCJ by virtue of the Petroleum Act of 1979, which authorizes the Minister (the Government) to extend PCJ's functions to include energy resources other than petroleum (Section 6, Article 6). PCJ has adapted its organizational structure to better carry out that endeavor: it has a renewable energy department that includes the Center of Excellence for Renewable Energy (CERE); it is the owner of the 20-MW Wigton Windfarm; and it has a group working on energy conservation and efficiency. Furthermore its fully owned subsidiary, Petrojam, has itself a subsidiary, Petrojam Ethanol, dedicated to the production of anhydrous ethanol, mainly for export. Although at present Petrojam Ethanol uses imported ethanol as feedstock, there are plans to eventually use ethanol that would be produced with Jamaican sugar cane as well.

Small Hydro, Wind, and Solar

Small Hydro

All hydroelectric capacity installed in Jamaica can be classified as small hydro. Currently there are eight small hydro plants in the JPSCo system with a total capacity of 23 MW.[104] The capacities vary between a maximum of 6 MW (MCR) and a minimum of 0.25 MW (MCR). JPSCo has recently rehabilitated five of these very old plants[105] and is planning to rehabilitate the other three in 2009–2010.

There are still hydro sites that have not been developed. Their total technical potential is estimated by studies mandated by PCJ to be 80 MW, but this figure includes a 50 MW plant in the Back Rio Grande, which has strong obstacles related to its use for tourism, and to the

[104] JPSCo states a nominal capacity 22.9 MW (MCR of 21.59 MW). Loy and Coviello (2005) have a slightly different number: 23.8 MW. The PCJ website also has 23.8 MW. MCR = Maximum Continuous Rating.

[105] Starting in 1943, two were commissioned in the 1940s, three in the 1950s, and three in 1988. See PCJ's website for the list of hydro plants, existing and potential.

environment. The other 30 MW correspond to 12 sites ranging in capacity from 0.8 MW to 8.0 MW, but most of them have less than 3.0 MW. In the past these sites have not had a favorable economic assessment, but now with much higher oil prices at least some of these sites will likely have a different, positive, result[106]. Indeed, JPSCo, which a few years ago was uninterested in developing hydro, has recently (October 2008) participated in a competitive bid and was awarded by the OUR a project to carry out a 6.4-MW expansion of its existing hydro plant at Maggotty (currently with a capacity of 6 MW), with a cost of US$26 million.[107] That is a cost of US$4,330/kW, which not long ago would have been considered too high,[108] even for small hydro.

Wind

The cost of wind power has fallen rapidly in recent years. Currently the US cost is estimated to be in the range of 9 to 12 US cents/kWh.[109] This makes wind energy very attractive for Jamaica because, as shown in Table 10, average prices for the JPSCo system have been higher than 12 cents/kWh since well before 2004. Even fuel costs alone have been higher than the higher limit of 12 US cents/kWh since at least 2006, and higher than the lower limit of 9 cents since at least 2005; indeed they reached 14.6 cents/kWh in 2007 and 20.4 cents/kWh in 2008. Even if the 2008 prices were an anomaly, reflecting unsustainably high petroleum prices (in the short term) average costs are bound to stay above the 21 US cents of 2005.[110] Developing wind generation therefore seems like a good investment in Jamaica, even before taking account of the favorable effect on the Balance of Payments and of credits (CERs) for reduction of greenhouse gases within the Clean Development Mechanism (CDM) of the Kyoto Protocol, which these projects may be able to be part of.

Currently, Jamaica only has one commercial wind power plant: the Wigton Windfarm. This plant has an estimated power capacity of 20.7 MW. It consists of twenty-three 900-kW

106 Cf. Loy and Coviello (2005, p. 32).
107 JPSCo (2009 p. 36 and p. 60).
108 The US IEA projected, in 2008, costs for small hydro in Latin America to be US$2,900/kW for 2015. For the United States the cost is projected at US$3,650/kW. (It used those values for its World Energy Model). The latter value may be more adequate for Jamaica than the former.
109 Komor 2009, Table A1. These are levelized costs of energy. They are made under the following assumptions: investment cost, US$1,900–2,400/kW; operation and maintenance cost US$0.01/kWh; capacity factor, 0.32; cost of capital (discount rate), 9%; plant life, 15 years. The IEA (2008) has comparable estimates of investment costs. In a planned expansion of the Wigton farm (see par. 140), PCJ is projecting costs of US$49.9 million for 18 MW, i.e. US$2,772 /kW of capacity investment, higher than both those of Komor (2005) and the IEA (2008). The per-kWh cost in this case, with all other assumptions similar, would be: around 13 US cents/kWh.
110 The 9- to 12-cent cost does not include transmission and distribution; however, there are no figures for JPSCo's costs of generation alone. It would be the fuel cost plus part of the non-fuel cost but it is not available. For this reason it is important to compare the wind costs to both total and fuel costs of JPSCo; in both cases the conclusion is clearly that wind is very competitive with those costs. Besides, JPSCo's prices are underestimated in the comparison, since they are expressed in current (US) dollars and not in constant 2009 dollars. They would be even higher if converted to 2009 (US) dollars. Unless those adjustments are made, the comparisons are somewhat biased in favor of the JPSCo prices, and yet, wind still compares favorably.

wind turbines of Dutch manufacture. The turbines are situated at 49 meters high and spaced about 100 meters apart on land leased from the aluminum companies Alcoa and Alpart in the parish of Manchester. The farm supplies the grid with an average capacity of 7 MW (due to the variability of the wind). Because there is no storage, the electricity system takes the energy from the farm as it is produced, displacing the energy from the highest cost thermal plant in the system, which would have been dispatched otherwise. The plant started operations in July 2004. The total cost of the project was US$26.2 million, that is, US$1,267 per kW of installed capacity (at 2005 prices).

The PCJ is planning the expansion of the Wigton Windfarm to add another 18 MW of capacity using nine 2-MW wind turbines. Construction of the new plant is expected to be completed within 17 months at a cost of US$49.9 million. This will bring the total nominal capacity of the Wigton farm to 38.7 MW.[111]

Jamaica's potential for wind power has been very sparsely studied. Of the wind speed assessments conducted so far, many carried out by the PCJ, a good proportion has concentrated on the Manchester plateau, in the parish of the same name, where the Wigton Windfarm is located.[112] Although the studies so far resulted in the choice of Wigton for the first wind farm and have shown, according to the PCJ, potential for at least another 20 MW (which, as mentioned, are to be added soon), there is still no systematic study of wind speeds done for periods long enough to give reliable results. Jamaica needs to build a wind atlas of the island, a complete set of wind resource maps. With respect to the wind speed offshore, there does seem to be even less (if any) assessment done. A wind atlas is needed in the zones with an adequate depth for installation of wind turbines. Observations at a macro scale done from space by NASA indicate wind speeds of 8 m/sec and more at 50 meters altitude in the seas surrounding Jamaica ((Source: U.S. Department of Energy's National Renewable Energy Laboratory (NREL)). Since these speeds could be adequate for the development of wind plants, there should be an added interest in fully assessing that potential.

Wind power also has the added advantage of being a clean technology with zero production of greenhouse gases. As mentioned above, these projects are thus eligible to participate in the Clean Development Mechanism (CDM) of the Kyoto Protocol for the reduction of greenhouse gases and therefore may be able to reduce their costs, by means of the sale of Certified Emission Reductions (CERs).

Solar Energy

Jamaica is rich in sunlight and heat. Studies carried out by Dr. A. A. Chen of the University of the West Indies have shown that Jamaica receives an average solar irradiation of approximately 5 kWh/m^2/day (1,800 kWh/m^2/year).[113] Unfortunately only a minimum amount of this radiation is been harnessed today; according to the PCJ, only about 1% of Jamaica's annual

[111] These figures imply a cost of 13 cents per kWh, under the hypotheses presented in footnote 109. Even these costs compare very favorably with the present costs of JPSCo's electricity.
[112] For details of the wind assessments carried out see Loy and Coviello (2005).
[113] Loy and Coviello (2005).

energy demand is satisfied with solar energy[114] delivered inter alia by solar water heaters, photovoltaic (PV) cells, and crop driers.

All these forms of solar energy have very low penetration in the population so far. Only 0.9% of households in Jamaica have solar water heaters (7,800 units).[115] There are only 31 known solar crop drying units installed, some not operational; and photovoltaic capacity, both residential and commercial, is very small (around 0.29 MW). The PCJ Energy Efficiency Unit (EEU) has also installed solar PV systems in four hospitals and solar water heaters in seven hospitals, but all this is still small compared with the demand for energy. PCJ is also pursuing multiple activities seeking to develop and incentivize the use of solar energy.[116]

Solar water heaters cost between three and six times as much as electric water heaters, although the savings they provide in the energy bill could pay for them in a couple of years.[117] Their big upfront cost compared with the cost of electric heaters is a big barrier to their spread, especially since all the capital cost has to be paid up front or with very onerous credit. Remedying these obstacles could help increase their penetration in the population.

Photovoltaic systems are still very costly per kWh delivered, compared to traditional thermal technologies. Currently their levelized cost can be of the order of US$0.45/kWh to US$0.59/kWh,[118] that is around four to five times more than the wind generation costs presented before, and six to nine times more than the cost of traditional thermal technologies (for efficient equipment using natural gas). They are thus so far only suitable for use in isolated places where the cost of extending the distribution grid would be prohibitive or, otherwise, for certain special applications, where an autonomous energy supply is of paramount importance. Their application for isolated rural areas in Jamaica in the 1990s was fraught with problems. The systems had very high rates of failure after five years, due mainly to water damage and to a lack of maintenance and spare parts (most systems were by then unusable). Because there may not be many more methods for delivering electricity to these remote areas, the lessons of this experience have to be well absorbed and countering measures adopted in future isolated installations.

There are other applications of solar energy that have not been much explored in Jamaica and that could nonetheless be an important component of the energy mix that will be needed to increase the country's energy independence. One is the use of solar thermal energy to power air-conditioning systems. A common opinion is that the reason why solar heating systems are not in very great demand is because there is really not much need for hot water in Jamaica (at least in households). The same could not be said of cooler air. This is an area where it would be worth exploring the market's extent and possibilities.

114 Cf. PCJ's website

115 Solar water heaters can transform about 550 kWh/m2 of energy per year (i.e., 30% of the irradiated energy), and they could essentially fulfill all hot water demand in Jamaica (Loy and Coviello 2005).

116 Ibid.

117 Cost ratios estimated based on figures from Loy and Coviello (2005, p. 54). The estimated payback period in Loy and Coviello (2 to 3 years) was based on a US$0.20/kWh tariff; now, with a US$0.30/kWh tariff, that period would shorten somewhat (if equipment prices have not risen as much as electricity prices, which is bound to be the case).

118 Komor (2009).

Finally, given the very high irradiation in Jamaica mentioned above, another promising technology would be concentrating solar power (or solar thermal): heating a carrier fluid with sunlight concentrated with parabolic mirrors and using this fluid to heat water into steam to drive a turbine coupled to an electric generator. This technology has strongly advanced and is very much in use in other sunny countries like Spain, although it is technically complicated. It has the advantage that it can be used in plant sizes suitable to Jamaica, such as 50-MW. It is costlier than traditional thermal plants but much less so than photovoltaic, and costs could come down as the technology spreads. The levelized cost of solar thermal energy is currently estimated to be 24 to 29 US cents/kWh (around the current cost of electricity in Jamaica, although this estimation does not include the transmission and distribution costs). It is thus another solar technology worth exploring for Jamaica.

Biofuels

Bioethanol and the Sugar Industry

The production of bioethanol from sugar cane is the most cost-effective and environmentally friendly of all bioethanol technologies. Indeed, ethanol from sugar cane is the only bioethanol that produces savings of GHG emissions which offset more than 100% of the emissions produced using gasoline as a vehicle fuel. Corn ethanol, on the contrary can even, in certain cases, produce emissions that are greater than those of gasoline. In certain cases it can increase, instead of decrease, the total emissions from replacing gasoline.[119] In general its savings are less than the emissions of the gasoline displaced. Jamaica is in principle well suited to produce bioethanol to satisfy at least the demand for E10: at the present rate of consumption of gasoline, the production of E10 for all gasoline in the island would require producing some 18 million gallons of anhydrous ethanol per year. Indeed, Jamaica could perhaps produce indigenous ethanol well above that quantity, with considerable positive impacts on its balance of trade as well as on the environment, via the ensuing reduction of GHGs. However, this will not be easy given the recent history of the sugar industry in Jamaica.

There was a time when Jamaica's sugar industry had much higher production than now. In 1965 it reached the peak of its production with 506,000 tons.[120] At present it produces approximately one-third of that amount (Table 19). Current cane production fluctuates around 2 million tons per year, down from the peak of 6 million tons in 1965.[121] Currently, the area cultivated has a size between 30,000 and 33,000 ha,[122] but it was much bigger in the past. For example, in 1978 it was 74,000 ha. Now, most of that land is idle (around 90%). Current average countrywide productivity (at country level, but not for all agents) is low both

119 Sims et al. (2008) figure 2.
120 Cf. Loy and Coviello (2005).
121 Figure given by Mr. Karl James. Some of the information presented in what follows was obtained in two separate interviews with Mr. James and with Mr. George Callaghan.
122 Figure mentioned by Mr. George Callaghan.

Table 19 **Jamaica – Historical production of sugar**

YEAR	1,000 TONS		YEAR	1,000 TONS
1965	505		2002	170
1977	296		2003	124.6
1980	250		2004	181.4
1999	207		2005	122.1
2000	203		2006	141.2
2001	199		2007	158

Sources: Jamaica Ministry of Agriculture, and Loy and Coviello (2005).

for the land and for sugar production. Average land yields are around 60 tons of cane per ha; average sugar yields are around 11 to 12 tons of cane per ton of raw sugar.

The industry is composed of seven large estates which have 60% of the cultivated sugar cane land, and 9,600 sugar cane farmers, 60% of whom own less that 2 ha (but some have as much as 300 ha), owning the other 40% of the land. Four estates are currently private (two, Appleton and Worthy Park, were always private; the other two were recently privatized) and three are still under GOJ control but in the process of privatization. The two old private estates have high productivity.

The industry lost its captive European market, starting in 2006, as a result of the reform of the European Union special sugar regime for the Asia, Caribbean, Pacific (ACP) countries, which had given these countries preferential access to the EU's internal sugar market at highly subsidized prices.[123] This situation prompted the GOJ to produce a plan to adapt the industry to the new circumstances: the "Country Strategy for the Adaptation of the Sugar Industry. 2006–2015" (PIOJ, 2006). This document planned a rationalization of the industry, which included, inter alia, increases in land and factory productivity, privatization of three of the five estates then owned by the Government, and a closure of the other two government-owned estates (this has not occurred to date).

Jamaicans with great experience and knowledge of the industry interviewed for this review[124] are of the opinion that it is possible to attain the increases in productivity postulated in the Country Strategy and to go even farther. The rationale for this goes as follows: historically, it is known that Jamaica can produce much higher levels of sugar than current levels. As seen, there is land good for sugar cane production that is idle, about 36,000 ha (90% of 74,000 minus 33,000). Today's field productivity of 60 tons/ha can be increased using

123 The reform of the EU regime meant that Jamaica would by 2009 receive a price in the EU market 36% lower than the preferential EU price for its quota of 126,000 tons of raw sugar. Since at that time the average cost of production for raw sugar in Jamaica was approximately US 28 cents per pound, almost equal to the ACP preferential export price to the EU (29 US cents/lb), this meant that the sugar exports to the EU would have had a negative margin equal to 36% of the preferential price, i.e. Jamaica would take enormous losses on its sugar exports.
124 Mr. Karl James and Mr. George Callaghan.

modern drip irrigation instead of the traditional flooding irrigation (40% of the total area for cane is irrigated land). This and other improvements would make it possible to increase yield to 77 tons of cane per ha.[125] Expanding the cultivated area from the 30,000 ha of today to 50,000 ha, using some of the idle land, would then give a production of 3.85 million tons of cane, that is, around 2 million tons more than the 1.8 million tons obtained in the 30,000 ha cultivated today with yields of 60 tons/ha.

But to fulfill the needs of E10 at the current level of demand for gas a much more modest effort than that presented in the previous paragraph would suffice. As mentioned above, in order to produce a quantity of E10 that would satisfy the present demand for gasoline (4.3 million barrels or 179.1 million gallons per year) around 18 (17.9) million gallons of ethanol would have to be produced. Brazil has been producing more than 80 liters (21.13 gallons) of ethanol per ton of sugar cane (using all the sugar in the plant, not just the molasses).[126] Thus assuming, as in the previous exercise, that productivity in the fields will reach 77 tons of cane per hectare, the calculations presented below show that the ethanol requirement for a full supply of E10 will need an extra production of 847,000 tons of sugar, which can be obtained at a yield of 77 tons per ha with 11,000 extra hectares of cane culture. Even at today's yields of 60 tons of cane per ha, 14,000 ha of new cane cultures would suffice to supply the E10. And afterwards, if the cane culture is extended to 50,000 ha, as was mentioned above, there would be more than a million tons of cane left to produce more ethanol for export to the United States or for any other use as Jamaica sees fit.

Ethanol gallons needed for E10	17,911,043
Gallons produced per ton of cane	21.134
Tons of cane needed	847,509
Tons of cane produced per hectare	77
Hectares needed for E10	11,007

The investment costs of ethanol plants are in the range of US$2.0 to US$2.5 per gallon/year of capacity. Ex-plant prices of ethanol would be very competitive with Jamaican gasoline prices.[127] If hydrous bioethanol were to be produced, it could also be used in the Petrojam ethanol plant as feedstock in the production of anhydrous ethanol, displacing Brazilian imported bioethanol.

125 Colombia has 84 tons/ha.

126 Cf. Loy and Coviello (2005, p. 44).

127 The US$2.0 to US$2.5 of costs per gallon/year of capacity are calculated from current data quoted by Vogelbush, a leading producer of ethanol plants, for a plant of 29 million gallons/year. (http://www.bioethanol.vogelbusch.com/en/faq.php). For a plant near the 18 million gallons/year needed for E10, costs would be somewhat higher. Loy and Coviello (2005) quote estimates for Hawaii of US$32 million for a 21-million gallon/year plant (US$1.60 per gal/year) but this estimate dates from 2003. Ex-plant prices for the Loy and Coviello estimation would be US$1.57 to US$1.68. They would be below US$2.00 for the Vogelbush plants, assuming 8% cost of capital, 25-year life of plant, and the same non-investment expenses (M&O) as in Loy and Coviello (2005).

The efficient use of the sugar cane stock of Jamaica does not stop with bioethanol. There is the other form of biomass resulting as a byproduct of the production of sugar or ethanol: the bagasse. At present it is being used to provide the sugar mills with electricity and heat, but in most cases the processes used are very inefficient and the equipment obsolete. As a result, the sugar industry as a whole is not self-sufficient for its power needs and must draw electricity from the public grid, with resulting costs in imported oil and unnecessary expenses for the industry. This presents an opportunity to turn the industry into self-sufficient net exporter of electricity to the grid. This would require upgrades to the equipment, such as installing high-temperature and pressure boilers, which increase the efficiency of the system almost threefold.[128] The byproduct of bagasse amounts to approximately 600,000 tons per year at the current rates of production of sugar cane and sugar. If it were properly employed for cogeneration with upgraded equipment, it would produce a surplus of electricity to sell to the grid. With the increased production of cane needed to supply ethanol for the E10 fuel, Loy and Coviello (2005) quote studies that estimate that five formerly government-owned estates (2005) could provide up to 85–95 MW of new capacity and could supply more than 266 GWh of energy per year to the grid. This would have a positive impact on oil consumption, and thus imports, of 637,000 bbl/year. Given the stress that the oil imports are bringing to the external balance of Jamaica, this is a highly advisable action. It merits strong consideration by the Jamaican authorities.

Biodiesel

Currently, world production of biodiesel amounts to 6.5 billion liters and is highly concentrated, with shares as follows:[129] European Union: 75%, United States: 13%; other countries 12%. Biodiesel production worldwide is based mainly on four crops: canola (rapeseed), sunflower, soy, and African palm. Rapeseed and sunflower are the main feedstock in Europe, soy in North America, and African palm in South America and Asia. Some yields in liters of biodiesel per hectare are: rapeseed (canola), 1,190; sunflower, 952; soy, 446; palm, 5,950; castor, 1,413.

In Jamaica, the PCJ is leading the effort to study and develop the production of biodiesel. PCJ is presently engaged, at its 1093-hectare farm, in a rigorous evaluation of the potential of diverse crops—castor, jathropa, sunflower, and rapeseed—to serve as feedstock for biodiesel in Jamaica. The result of this exercise will give PCJ[130] a base of knowledge that will allow them to choose the best alternatives for production of biodiesel feedstock in the island. It will increase knowledge adapted to the Jamaican environment about yields, the use of marginal lands for these crops, and the financial costs and benefits of farming biodiesel feedstock and of small-scale production of biodiesel.

The PCJ's goal is to produce 16.5 million gallons of biodiesel for the Jamaican market. This will require the identification of about 50,000 acres of sub-par or marginal lands and the collection of waste vegetable oil. PCJ is proposing a phased approach to biodiesel production

128 Cf. Loy and Coviello (2005, p. 37).
129 World Bank (2008b).
130 And perhaps as well, eventually the Jamaican private sector.

and development at the national level: i) a small-scale, 5-ton-a-day plant (500 gallons per day) and nut sheller will be procured to process the biodiesel; ii) the project will subsequently be expanded by procuring a 50-ton-a-day plant (5,000 gallons per day) with grain storage silos and testing capabilities; iii) finally, PCJ intends to meet the national market demand by building a large-scale 16-million-gallon-per-year plant, with the requisite tank storage, lab testing, and quality control capabilities. PCJ plans to design this plant to use the transesterification process; byproducts such as fertilizer meal and pharmaceuticals will be recovered for resale.

Challenges

With the high costs of thermal generation in Jamaica due to the increase in oil prices, interest in the small hydro sites that are still incompletely developed or undeveloped is reviving. JPSCo will develop two small sites in the next years. There are still, however, 12 small hydro sites to be developed. These would have investment costs, using the estimate for the JPSCo's sites as a benchmark, in the range of US$3.5 million to US$36 million.

Although there have been some scattered assessments of wind velocities and other characteristics, there is not yet a systematic compilation of the wind characteristics in Jamaica, in all parts of the island and seemingly even less offshore. Thus Jamaica lacks a set of comprehensive Wind Resource Maps, a necessary prerequisite, which could serve as the basis for investors to explore possible development of favorable sites. This is especially problematic for offshore, since macromeasures of wind velocities in the oceans surrounding Jamaica, done by NASA, seem to indicate speeds adequate for the proper functioning of wind plants.

As explained above, solar water heaters have high upfront costs that become an obstacle to their dissemination, as buyers prefer the much lower upfront costs of traditional water heaters, even though the total life cost (expressed, for example, in present value) of the solar option may be lower. To counter this preference for the short term (economic myopia), or in some cases as well to counter obstacles that big initial disbursements pose to many households (a form of market failure in a certain way), schemes to smooth out those costs over the long or medium term should be designed and implemented. Similarly, Jamaica may not have much need for hot water: this market may be small, some argue, but the market for cooling (air conditioning) with solar power surely would not be small. This does not seem to have been explored in Jamaica.

Another technology that could prove profitable in Jamaica is Concentrating Solar Power or Solar Thermal. As was shown, some sunny countries like Spain have plants using this technology and it can be installed in sizes suitable to Jamaica's grid expansion (50 MW).

Production of bioethanol using local sugar cane as feedstock is another area where Jamaica may benefit. But the speculations presented have to be fleshed out into real projects, for which the first step would be prefeasibility and feasibility studies. Likewise, efficient bagasse cogeneration to produce surplus electricity for the grid is in an almost similar state of speculative reasoning. But here, more elements are in place than for bioethanol. Feasibility studies for these projects would be necessary.

References

UNFCC (United Nations Framework on Climate Change). 2008. "Jamaica's Initial Climate Change Technology Needs Assessment." Bonn, Germany: UNFCC. Available at unfccc.int/ttclear/pdf/TNA/Jamaica/870.pdf.

Ajodhia, Virendra Shailesh. 2006. *Regulating Beyond Price; Integrated Price-Quality Regulation for Electricity Distribution Networks.* Delft, Netherlands: Technische Universiteit Delft.

CAC (Consumer Affairs Commission – Jamaica). 2007. *Petroleum Industry Highlights – FY 2006/2007*. Jamaica.

———2009. "Petroleum Products Price Survey Results (87, E10, 90 Octane, Auto Diesel) March 24–25, 2009 – Island-wide Analysis." Jamaica.

CEPAL /ECLAC (Economic Commission for Latin America and the Caribbean) 2008. *Istmo Centroamericano: Estadísticas De Hidrocarburos, 2007*. Santiago de Chile: ECLAC

———2005. Istmo Centroamericano: Diagnóstico de la Industria Petrolera, Mexico: ECLAC

Crawford, Tazhmoye V., et al. (2009) "The Implication of Utility Access on Gender: The Case of Jamaica." *European Journal of Social Sciences* 8(4), ,

Del Roccili, John A. and Godfrey Gordon. 1998. "Establishment Of The Office Of Utilities Regulation [Jamaica]" Ex Post Evaluation Report. Washington, DC: IDB,

ESMAP (Energy Sector Management Assistance Program).1992. *Energy Sector Strategy and Investment Planning Study*. Washington, DC/New York:World Bank/United Nations Development Program.

Finder Exploration Pty Ltd and Gippsland Offshore Petroleum Limited. 2009. "Exploration opportunity Offshore Southern Jamaica – Executive Summary" (http://www.finderexp.com/Portals/0/docs/Jamaica/Jamaica%20FO%20flyer%20June%202009.pdf)

FTC (Fair Trading Commission of Jamaica. 2004. *Report on The Supply of Gasoline in Jamaica*. Jamaica.

Government of Jamaica, Ministry of Energy and Mining. 2008. "Energy Conservation and Efficiency Policy 2008–2002. An addendum to the Draft Energy Green Paper 2006–2020." Jamaica.

Government of Jamaica, Ministry of Energy and Mining. *The Jamaica Energy Policy 2006–2020*, Green Paper. Jamaica..

IDB. 2005. *Country Program Evaluation: Jamaica*, *1990–2002*. Washington, DC: IDB

IEA (International Energy Agency). 2008. "WEO 2008 Power Generation Cost Assumptions," *World Energy Model*. Paris: IEA.

Inkson, Mike. 2000. "Co-Generation For Export: A Review." Gauteng, South Africa: Biotherm Ltd.

Government of Jamaica. Ministry of Commerce, Science and Technology. 2004. "Power/Electricity Policy for Jamaica (including fuel diversification and conservation on fossil fuel)". Draft. Jamaica.

Government of Jamaica. Ministry of Industry, Technology, Energy and Commerce. 2005. "Solutions for Energy Security," in Petrojam. Jamaica.

Government of Jamaica, Ministry of Industry, Technology, Energy and Commerce. 2007. "Performance of the Rural Electrification Program Limited for Financial Year 2006/2007 and Focus for Financial Year 2007/2008,". Jamaica.

Government of Jamaica, Ministry of Energy and Mining. 2008. "Performance Of The Rural Electrification Programme Limited For Financial Year 2008/2009 And Focus For Financial Year 2009/2010" *Ministry Papers 2008- 2009*. Jamaica.

Government of Jamaica,Ministry of Energy and Mining. 2008. "Energy Conservation and Efficiency (ECE) Policy 2008–2022. An Addendum to the Draft Energy Green Paper 2006–2020." Jamaica.

Jamaica *Gleaner*. 2009. "Industry slows to a throttle 10 years after gas riot," April 26.

JPSCo (Jamaica Public Service). 2009. "Tariff Review Application 2009–2014.". Jamaica.

———2005 *Annual Report*. Jamaica

———2006 *Annual Report*. Jamaica.

———2007 *Annual Report*. Jamaica.

Komor, Paul. 2009. *Wind and Solar Electricity: Challenges and Opportunities*. Arlington, VA: Pew Center on Global Climate Change.

Krishnaswamy, Venkataraman and Gary Stuggins. 2007. "Closing the Electricity Supply–Demand Gap." Energy and Mining Sector Board Discussion Paper No. 20. Washington, DC: World Bank.

Lord, Richard. 2003. "Wigton Windfarm". PowerPoint presentation. The Hague, Netherlands: Ecosecurities.

Loy, Detlef and Manlio F. Coviello. 2005. Renewable energies potential in Jamaica. Santiago de Chile: ECLAC, GTZ (*Deutsche Gesellschaft für Technische Zusammenarbeit*).

Neins, Ricardo. 2007. "Renewable Energy for the Caribbean." IEEE, PowerPoint presentation.

Government of Jamaica, Office of Utilities Regulation. 2004. "Jamaica Public Service Company Limited: Tariff Review for period 2004–2009. Determination Notice." Jamaica.

Paredes, Ricardo D. "Privatization and Regulation Challenges in Jamaica." Economic and Sector Study Series, IDB Region 3. Washington, DC: IDB.

Perez, Jorge. 2007. *Belize: Review of the Energy Sector*. Washington, DC: IDB.

Petrojam (2005). Annual Report.

Petrojam Website (2009). Statistics at: http://www.petrojam.com/index.php?q=statistics .Visited in September 2009

Gray, Philip. 2001. "Private Participation in Infrastructure:A Review of the Evidence." Working Paper 24938. Washington, DC: World Bank.

PIOJ (Planning Institute of Jamaica). .2006. "The Jamaica Country Strategy For The Adaptation Of The Sugar Industry. 2006–2015." Jamaica: Planning Institute of Jamaica.

———2007. *Vision 2030 – Jamaica National Development Plan* –"Energy Sector Plan (First Draft)," July.

Reece, Niconor. 2005. "Combined Heat and Power Generation in Jamaica's Sugar Cane Industry. PowerPoint Presentation. Manchester, Jamaica: Sugar Industry Research Institute.

REEEP (Renewable Energy and Energy Efficiency Partnership). 2005. "Jamaica. Country Overview." Vienna, Austria: REEEP.

———2008. REEEP's Approach to Innovative Clean Energy Financing. Vienna, Austria: REEEP.

REN21 (Renewable Energy Policy Network for the 21st Century). 2009. *Renewables Global Status Report 2009* Update.

Sampson, Cezley. 2006. "Challenges in the Electricity Sector: Jamaica at the Crosswords." Presentation at the Geological Society Exhibition. Kingston, Jamaica: University of the West Indies.

Sims, Ralph, Michael Taylor, Jack Saddler, and Warren Mabee. 2008. From 1st- to 2nd-generation Biofuel Technologies: an Overview of Industry R&D Activities. Paris: OECD (Organisation for Economic Co-Operation and Development)/IAE.

Sotkiewicz, Paul M. 2007. *Final Report of the Independent Expert in the Matter of the Public Utilities Commission Initial Decision in the 2007 Annual Review Proceeding for Belize Electricity Limited Final Revision*. Gainesville, FL: Public Utilities Research Center, University of Florida.

Sunley, Emil M., Thomas Baunsgaard, and Dominique Simard. 2002. "Revenue from the Oil and Gas Sector: Issues and Country Experience." Background paper prepared for the IMF conference on fiscal policy formulation and implementation in oil producing countries, June 5–6. Washington, DC: IMF (International Monetary Fund).

Ter-Martirosyan, A. 2003, "The Effects of Incentive Regulation on Quality of Service in Electricity Markets, Working Paper. Washington, DC: Department of Economics, George Washington University.

UNEP (United Nations Environmental Program). 2009 Global Trends in Sustainable Energy Investment. Nairobi, Kenya: UNEP.

World Bank/UNDP. 1985. *Jamaica: Issues and Options in the Energy Sector*. Washington, DC: New York: World Bank/UNDP.

World Bank. 1981. Jamaica: Petroleum Exploration Project Doc. R81–132. Washington, DC: World Bank.

World Bank/ESMAP. 1992. Jamaica. *Energy Sector Strategy and Investment Planning Study*. Volume I: Main Report. Report No. 135A/92 Washington, DC: World Bank

World Bank. 2005. *El Salvador Investment Climate Assessment, Volume I*: "Main Findings and Policy Recommendations." Washington, DC: World Bank.

———2008a. *World Development Report: Agriculture for Development*. Washington, DC: World Bank.

———2008b. "Biofuels: The Promise and the Risks. Agriculture for Development". Policy Brief. Washington, DC: World Bank.

World Bank. 2003. "Jamaica--The Road to Sustained Growth." Country Economic Memorandum. Washington, DC: World Bank.

Jamaica. List of Institutions Visited and Persons Interviewed

Ministry of Energy & Mining

Mr. Fitzroy Vidal – Sr. Energy Engineer

Mr. Conroy Watson – Sr. Director of Energy

Mr. Omar Alcock – Economist, Energy Div.

Petroleum Co. of Jamaica (PCJ)

Dr. Ruth Potopsingh – Group Managing Director (Was unable to attend)

Mr. Richard McDonald – Deputy Group Managing Director, PCJ (Attended on behalf of Dr. Potopsingh)

PCJ – Petrojam – Refinery

Mr. Winston L. Watson – Managing Director (Petrojam)

PCJ – Renewables

Dr. Gary Jackson – Center of Excellence for Renewable Energy (CERE), Manager

PCJ- Wind

Mr. Earl Barrett – WIGTON Windfarm, General Manager

PCJ – Exploration Activities

Dr. Gavin Gunter – Senior Geologist, Crude Oil Exploration

Dr. Raymond Wright – Special Projects Manager

Planning Institute of Jamaica (PIOJ)

Ms. Barbara Scott – Director, External Co-operation Management Division

Ms. Claire Bernard – Director, Sustainable Development and Regional Planning

Office of Utilities Regulations (OUR)

Mr. Maurice Charvis – Senior Director, Regulation and Policy

Mr. Richard A. Brown – Chief, Electricity Regulation

Jamaica Public Service Company (JPSCo)

Mr. Valentine Fagan – VP Generation Expansion

Mr. David C. Cook – Head, Project and Infrastructure Management

Mr. Clava Mantock – General Manager, Business Support and Administration, Generation Expansion Division.

Mr. Sangeet Dutta, Vice-President, Customer Operations

Ministry of Agriculture
Mr. George Callaghan – Head Sugar Transformation Unit

Jamaica Bauxite Institute
Mr. Dennis Morrison – Senior Director, Economics & Projects
Mr. Michael Mitchell – Senior Market Analyst

Petrojam Ethanol Ltd.
Mr. Ricardo Neins – General Manager.

Jamaica Cane Products Sales Ltd.
Mr. R. Karl James, C. D., General Manager

National Environment & Planning Agency (NEPA)
Mrs. Paulette Kolbusch – Sr. Manager

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