CUBA'S ENERGY CHALLENGE: A SECOND LOOK

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Cuba's economy and infrastructure, in shambles following the economic crisis caused by the end of Soviet aid in 1991, improved somewhat after the government enacted a series of short-lived "market reforms" in 1993. The inevitable continuation of these free market policies, particularly in a future post-central planning system, would create substantial benefits and investment opportunities for national and foreign companies alike. For the past twelve years, these market reforms, oriented toward attracting foreign investment, have certainly paid off in the energy sector.

As Cuba's future economy evolves, through a comprehensive construction boom, necessary in order to rebuild the country's service infrastructure and basic industries, and creating thousands of labor-intensive jobs in the process, the country could become a considerable target market for energy related products and services. Of paramount importance in the island's economic recovery is the development of a long-term comprehensive national energy plan, which promotes and balances three key factors: economic growth, energy conservation, and the protection of the environment.

This paper provides an overview of the current energy market situation in Cuba and presents a road map for both the private and public sectors. In so doing, it also raises issues and alternatives in the areas of hydrocarbon exploration and production; oil refining and natural gas processing; environmental remediation; oil products logistics and distribution; gasoline marketing and convenience retailing; oil products commercialization; electric power generation and transmission; renewable energy sources; and sugar cane ethanol.

EXPLORATION AND PRODUCTION

Cuba has two oil bearing provinces: the northern province, which is part of the Florida-Bahamian Plate, and the southern province, which is part of the Caribbean Plate. Most discoveries in the northern province have been low gravity (heavy), high sulphur (sour) quality crude oil, along with associated natural gas in pre-Upper Cretaceous Campanian plays along a 150 km stretch of the coastal and onshore region between Guanabo and Corralillo. The southern province has seen some exploratory work in the past in the Golfo de Guacanayabo, Golfo de Ana María, and Jardines de la Reina, with no promising results.[2]

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1. This is a condensed and updated version of the author's monograph *Cuba's Energy Challenge: Fueling the Engine of Future Economic Growth*, published by the Institute for Cuban and Cuban-American Studies, University of Miami, October 2004. In addition to the materials cited in the footnotes, sources for this paper include *CIA World Factbook 2002*, Dow Jones Newswire, Economist Intelligence Unit, *Financial Times*, *Reforma*, *Granma*, *The Miami Herald*, *CubaNews*, *Dallas Morning News*, *International Petroleum Encyclopedia*, U.S.-Cuba Trade and Economic Council, *Latin America Monitor*, *Oil and Gas Journal*, *Petroleum Economist*, U.S. Energy Information Administration, OLADE, U.S. Geological Survey, World Energy Council, American Coalition for Ethanol; Corporate Annual Reports and Press Releases from Repsol, Sherritt, Sherritt Power, Ocean Rig ASA, Pebercan, Petrobras, Braspetro, Total, Burmah Castrol, Standard Oil of New Jersey, Standard Oil of Indiana, Texaco.

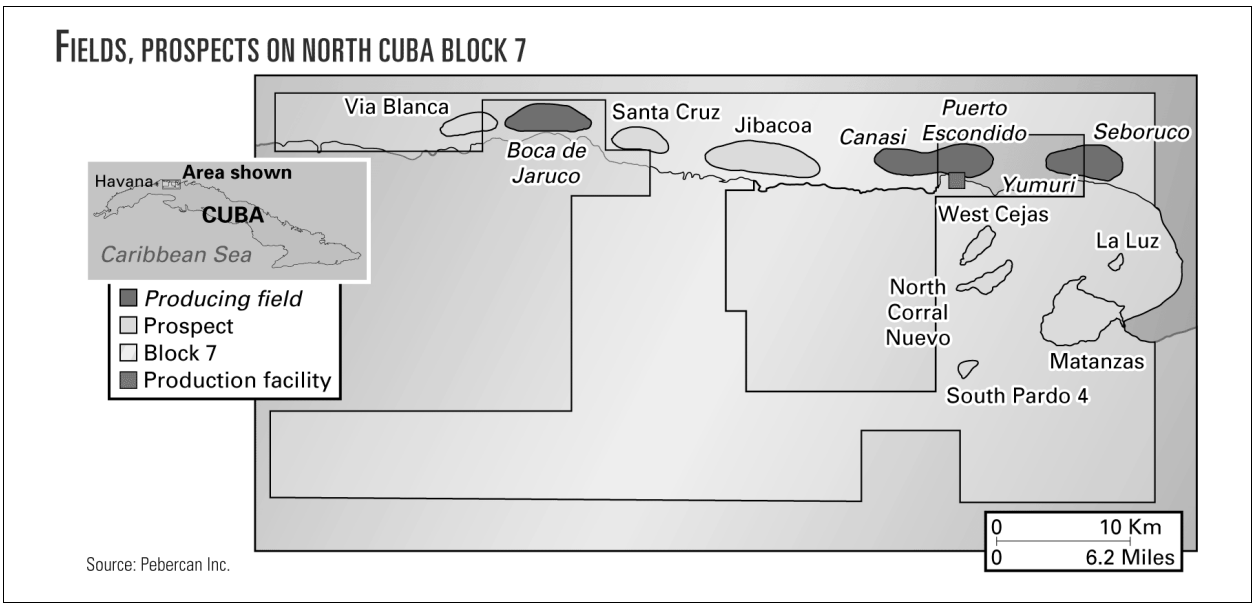
2. "¿Qué hay en Cuba?," Alvaro Franco, *Petróleo Internacional*, Julio-Agosto 1993.

During the 1960s, exploration results were poor, with only several small oil discoveries made. Results changed during the 1970s, with Soviet assistance and the discovery of the Varadero oil field in 1971. After the fall of the former Soviet Union in 1991, Cuba opened in 1993–94 its oil and gas exploration and production sector to foreign oil companies, with a total of 33 onshore and coastal blocks offered during its first international bidding.[3]

In order to attract foreign oil companies to explore and produce Cuba's hydrocarbon resources, the Cuban government, through Unión Cubapetróleo (Cupet), the state oil company under the Ministry of Basic Industry (Minbas), adopted a Production Sharing Agreement (PSA). A PSA is a contractual format used by many countries and generally accepted by major international oil companies. Most PSAs are contracts in which an international oil company assumes all risks and expenses, and works as a contractor to the national oil company. In the event of a commercial discovery, the foreign oil company is allowed to recover its expenses and share in profits from the field's production. The term or duration of the contract, along with costs and production share, are negotiable, and vary according to the complexity and level of risk of the work. The foreign oil company generally pays a 30 percent corporate tax on its profits to the host government. The foreign company is also allowed to dispose of its share of production by exporting it or selling it to the national oil company at world price levels.

Due to the quality of Cuba's current production of crude oil and the final end-use of the same, the price basis for the island's production is a discounted price off U.S. Gulf Coast No. 6 fuel oil, which as of June 2005 was $37.80 barrel. Under PSAs, the title/ownership of the hydrocarbons belongs to the state, along with the production's associated assets and other infrastructure. Cuba's PSAs allows for international arbitration in case of a dispute.

Cuba has seen close to $2 billion spent since 1991 in its upstream oil and gas sector with very good results. Crude oil production reached a level of 73,500 barrels per day (b/d) in 2004 from 18,000 in 1992. The majority of the production from the Varadero, Puerto Escondido, and Boca de Jaruco fields is between 9 to 12 degrees API gravity heavy crude oil, with a high level content of sulfur and other heavy metals.



3. "First License Round in Thirty Years Sheds Light on Cuba's Geology," *Oil & Gas Journal*, April 26, 1993.

Most of the recently discovered heavy oil production is the result of Production Sharing Agreements between Cupet and Canada's Sherritt, using horizontal/directional drilling technology and enhanced recovery and production methods. Sherritt Corporation has become Cuba's preferred and most successful, upstream partner.

- First quarter 2005 financial statements published by Sherritt International on March 2005, show its gross working interest oil production in Cuba was 39,219 b/d from 43,157 b/d in 1Q 2004. This drop in production is due to lower capital spending and "below expectation" production from the Puerto Escondido and Canasí fields, along with normal production decline from other mature fields.
- Net working interest, or net sales volumes, which represents Sherritt's share of gross working interest production in 1Q 2005, amounted to 17,523 b/d from 19,964 in 1Q 2004.
- The newly discovered Santa Cruz del Norte field, with estimated reserves of 100 million barrels, is not included in these figures. It is anticipated that field production would come on stream late 2005.

Another Canadian company, Montreal based Pebercan, reported gross production share of 12,626 b/d in 1Q 2005 compared with 9,111 b/d in 1Q 2004; net production share amounted to 5,888 b/d during the period compared with 5,437 b/d during 1Q 2004. Pebercan and Sherritt are partners in a number of fields in Block 7. Estimated joint capital expenditures for 2005 are budgeted at $160 million Canadian dollars. Santa Cruz del Norte, Tarará, Guanabo, and Playa Larga field in the bay of Cárdenas, are potential fields scheduled for exploratory development work in 2005. Cuba's total onshore/coastal crude oil production after the development of the Santa Cruz del Norte field could reach the 80,000–85,000 b/d range, and surpass the 100,000 b/d mark if commercial discoveries are found in Tarará, Guanabo, and Playa Larga.

In February 2005, China's SINOPEC signed a production sharing agreement with Cupet to explore Pinar del Rio province's north coast onshore and coastal areas. It also sold Cupet three directional drilling rigs, one already leased by Sherritt/Pebercan to work Block 7 prospects (see figure).

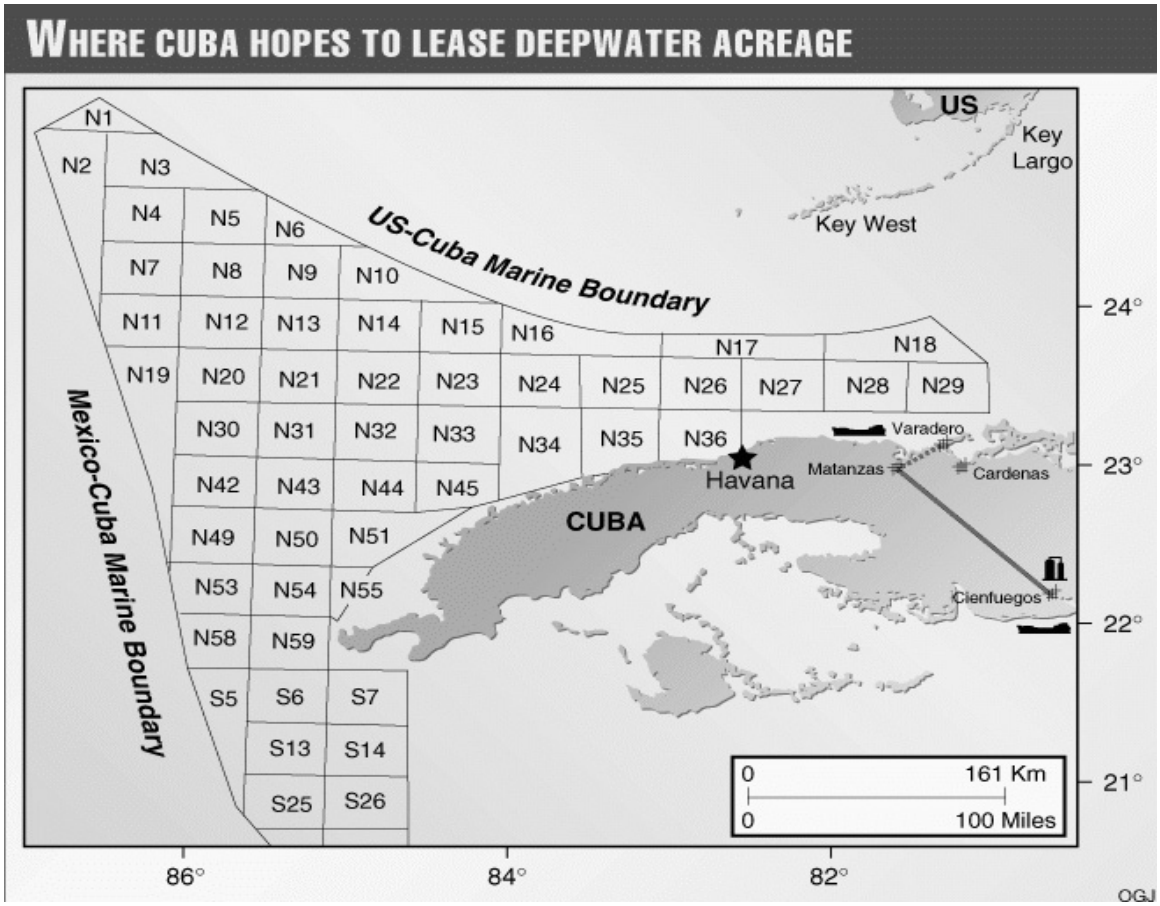
The future of Cuba's oil and gas exploration and production sector could very well be in the deep offshore Gulf of Mexico waters, along the western approaches to the Florida Straits and the eastern extension of Mexico's Yucatán Peninsula. Cuba's Exclusive Economic Zone (EEZ) in the Gulf of Mexico is an 112,000 square-kilometer (sq. km) area that has been divided into 59 exploration blocks of approximately 2,000 sq. km each at an average depth of 2,000 meters, with some blocks as deep as 4,000 meters.[4]

The EEZ lies within demarcation boundaries, between Mexico, Cuba, and the United States, agreed upon during the administration of U.S. President Jimmy Carter. The northernmost of the blocks lies south of the Dry Tortugas, off Florida's southwest coast; and the westernmost blocks come close to what the industry has christened as the "donut holes," deepwater areas still disputed. In June of 2000 Presidents Clinton and Zedillo agreed on the boundaries of the Gulf of Mexico's western gap. Mexico will control sixty two percent of the 17,190 sq. km area, with the balance under United States jurisdiction. The eastern gap, which will include Cuba, is still open for negotiations awaiting a change of government on the island.[5]

Industry experts categorize this area as high risk from the technical geosciences standpoint; but some reports indicate some hydrocarbon potential exists, with Cuban government sources estimating a potential of more than 2 to 4 billion barrels of recoverable reserves. Given the possible presence of a sufficiently large structure, technical risks might be reduced to

4. "Cuba Deepwater Exploration Opportunities Described in Southeastern Gulf of Mexico," *Oil & Gas Journal*, December 11, 2000.

5. "U.S. Mexico Settle Offshore Territory Dispute," *Oil & Gas Journal*, June 5, 2000.



acceptable levels. Another advantage would be that these undiscovered reserves are likely to be of light crude oil, and not the heavy high sulfur quality that Cuba's onshore and coastal wells currently produce.

Cupet is currently in conversations with various large international oil companies, such as Brazil's Petrobras, China's Sinopec, India's OVL, Venezuela's PDVSA and others; and in 2001 it signed an agreement with Spain's Repsol-YPF to explore Cuba's new hydrocarbon "frontiers." Sherritt also acquired exploration rights to the N16, N24, N23, and N33 deepwater blocks, which span 2 million acres, in 2002, and as of July 2005 the company was assessing 3D seismic data on these four offshore blocks (see figure).

Repsol's agreement is broad and encompasses exploration and production, fuels marketing, electricity, and refining activities. In oil exploration, Repsol has partnered with Cupet to conduct seismic studies and explore six EEZ blocks: N25–N29 and N36. The Spanish oil company will provide the initial capital, and has committed to two exploratory wells. In June 2004 Repsol drilled its first test well, Yamagua 1, in Block 27 about 20 miles northeast of La Habana and about 95 miles southwest of Key West. The well reached a depth of 10,819 feet with an estimated cost of over $40 million.

According to press reports of July 29, 2004, Repsol's chief operating officer, Ramón Blanco was quoted as saying that the drilling results were promising. "The existence of a petroleum system has been confirmed. Also we have been able to prove the presence of high quality reservoirs. Nevertheless, the well has been considered non-commercial and at this stage the group is defining future exploration activities in the area." No official press release was ever issued by either Repsol or Cupet on the drilling results.[6] Repsol's new CEO, Antoni Brufau, announced in Madrid on May 31, 2005, the company's commitment to drill

two new wells in Cuba in 2006. He also announced the addition of Norwegian oil giant Norsk Hydro as a project partner. The participation of Norsk Hydro is an indication of the importance and potential of the project, as Norsk Hydro is recognized in industry circles for their deepwater exploration technology and operational expertise.[7]

Another important event is a U.S. Geological Survey (USGS) report titled "Assessment of Undiscovered Oil and Gas Resources of the North Cuba Basin 2004," published in February 2005, which estimates a mean of 4.6 billion barrels of undiscovered oil and a mean of 9.8 trillion cubic feet of undiscovered natural gas along Cuba's north coast. The high end potential of the North Cuba Basin could be of 9.3 billion barrels of undiscovered oil and of 21.8 trillion cubic feet of undiscovered natural gas, according to the report.

Deep water exploration has a high degree of geological and technical risk and is expensive. Companies like Repsol-YPF, Norsk Hydro, and Petrobras certainly have the necessary deep water expertise to handle the technical risks; however, the anticipated payoff would have to exist for most international oil companies even to consider it. If successful, the deep water project would take from three to five years to bring into full development, at an estimated total cost of between $1 to $3 billion. To be a commercial success, the well would have to produce at a long term average rate of more than 10,000 b/d. Assuming reserves of 0.7–1.0 billion barrels, and a total estimated cost of $3 billion, the approximate per barrel cost would be of $3.00–$3.50 per barrel.

Based on seismic data, Repsol has identified four possible fields: Yamagua, with an estimated capacity of 1,500–1,700 million barrels; Obatalá, with an estimated capacity of 1,100–1,300 millions barrels; Ocuje, with an estimated capacity of 400–500 million barrels of crude oil; and Charaguito, with nearly 3,000 million barrels.

During the September 2003 visit to Cuba of Brazil's President Luiz Inácio Lula da Silva, Petrobras announced a new oil technology agreement with Cupet. This marked Petrobras' return to Cuba since its major exploration setback in 2001. In 1998, Petrobras, in association (60/40) with Canada's Sherritt International, announced their first Cuban offshore wildcat project (block 50), 32 km north of Cuba's Ciego de Avila province at Cayo Felipe, a coral formation off Cayo Coco/Cayo Guillermo.[8]

According to recent press reports, Venezuela's PDVSA has also expressed interest in exploring in Cuba's deepwater offshore Gulf of Mexico. It is most likely that PDVSA will join Petrobras or Sherritt in a deepwater project as they, unlike Petrobras, lack deepwater expertise.

We believe that Repsol and Norsk Hydro's commitment in spending an estimated $80–$100 million in two new exploratory wells, along with the USGS new estimates of undiscovered reserves, underscores Cuba's oil and natural gas offshore potential. The economic and political implications of the island, not only becoming oil self sufficient but also a possible net crude oil/products exporter, could become a major challenge for future U.S./Cuba policy makers.

We have to admit that Cuba's upstream program has been successful, reaching a milestone production threshold of 75,000 b/d of crude oil in 2004. Future exploratory results in the Gulf of Mexico's EEZ waters will determine the industry's future and investment potential, an investment potential possibly worth tens of billions of dollars.

NATURAL GAS

Cuba's natural gas production is all associated gas (natural gas-methane, found within the crude oil reservoirs). The island's geology to date has not proved to be a major source of reservoirs rich in dry, non associated natural gas, which could have made Cuba a net exporter of piped gas to Florida or a liquefied

6. "Search for Oil off Cuban Shores Yields Mixed Feelings," *South Florida Sun-Sentinel*, July 29, 2004.
7. "Repsol lo Intenta por Segunda Vez en Cuba," *Expansión,* June 3, 2005.
8. "Lula Ends Delicate Cuban Trip," BBC, September 27, 2003.

natural gas (LNG) exporter such as Trinidad and Tobago (See Table 1).

Table 1. Cuba-Trinidad and Tobago Hydrocarbon Comparison, 2002

	Reserves		Production	
	Crude Oil (million barrels)	Natural Gas (billion cubic feet)	Crude Oil (million barrels)	Natural Gas (billion cubic feet)
Cuba	750.0	2,500	49.3	17.7
Trinidad & Tobago	716.0	23,450	141.5	490.0

Source: *Oil & Gas Journal*.

Cuba's associated gas production from the Varadero fields has been flared for many years, creating considerable air and visual pollution in the tourist sensitive area, not to mention the hydrogen sulfide (H2S) smell of "rotten eggs" along the Via Blanca highway as it approaches Varadero. Pressure from tourist groups and economic incentives influenced Cupet to seek a business solution to the problem, and once again a new business venture was developed with Canada's Sherritt.

Locally-produced associated natural gas from the Varadero, Jaruco, and Puerto Escondido fields is now being used as fuel for onsite power generating plants of 173 megawatts (MW) and 33 MW respectively. The power plants and related sour gas processing units are being built by Energas, a joint venture in which Sherritt has a one-third indirect interest, along with Cupet, which supplies gas at no cost to the joint venture, and Unión Eléctrica, which buys all the power from the plants. Each has a one-third interest in Energas. The $250 million dollar project was financed by Sherritt International. Additional generating capacity of 85 MW is planed for year end 2005 in Puerto Escondido in order to monetize expected production of over 20 billion cubic feet per year.

Cupet also built a system of pipelines that transports natural gas and crude oil from Puerto Escondido to Boca de Jaruco and then on to La Habana, and crude oil to the oil super port in Matanzas. Associated natural gas processing (sour gas) plants are also on line and more are projected.

There are today approximately 240,000 households in metropolitan La Habana that are connected and use natural gas as a cooking and water heating fuel. This fuel is mostly associated natural gas from the Puerto Escondido/Boca de Jaruco fields, but it also includes some naphtha manufactured gas. Manufactured gas, "gas de la calle," plants are located in the La Habana neighborhoods of Marianao, Cerro, and Plaza de la Revolución.

The inevitable rationalization of the oil refining industry in Cuba (discussed in more detail below), and its environmentally sensitive tourist industry, will force Cuba to develop an energy policy that should rely heavily on clean burning natural gas as its fuel of choice. Cuba's future natural gas needs could be sourced as LNG from Trinidad and Tobago, as Puerto Rico and the Dominican Republic are currently doing, or by piped natural gas from Mexico or the United States, through undersea natural gas pipelines that could be built from the Yucatán or Florida. These pipeline options are technologically feasible today, just as the various proposals for the 95-mile, $650 million dollar investment, Florida-Bahamas projects have demonstrated.

OIL REFINING

It was in Regla, a suburb on the east side of La Habana harbor, where oil refining was started in Cuba during the 1890s by John D. Rockefeller's partner, John Archibold. The Belot refinery, as it was known at the time, was eventually owned and operated by Standard Oil of New Jersey (Esso), and it was expanded from 8,000 b/d to 35,000 b/d in 1958. In 1957, Shell Oil, which had operated in Cuba as a fuels marketer since 1922, built its own 28,500 b/d refinery, also in Regla. Cuba's third oil refinery, with a capacity of 20,000 b/d, was built in 1957 by Texaco in the eastern city of Santiago de Cuba. All international oil companies' refining and marketing assets were nationalized in 1960.[9]

Table 2. Cuba's Refinery Capacity, 2002 *(thousand barrels/day)*

	Distillation				Cat-Hydro
	Crude	Vacuum	Cracking	Reforming	Treating
Hermanos Díaz (Santiago)	101.5	37.5	0	7.5	29.7[a]
Ñico López (La Habana)	121.8	38.2	14.7	5.0	28.5[1]
Cienfuegos	76.0	0	0	7.5	7.7
Sergio Soto (Cabaiguán)	2.1	0	0	0	0
Total	301.4	75.7	14.7	20.0	65.9

Source: *Oil & Gas Journal*.

Note: The volumes above are name-plate capacity. Actual capacity depends on the quality of the feed, and the levels of operational efficiency and maintenance of the units.

a. Reformer feed and straight run distillates.

The Esso and Shell refineries in Regla have been interconnected and are currently operating as a single-site refinery, now called Ñico López refinery. The Hermanos Díaz (Texaco) refinery in Santiago de Cuba peaked production at 71,000 b/d in 1989, was idle for over a decade, and is currently reported to be back in production. The Hermanos Díaz refinery also has a lubricants facility, and a liquefied petroleum gas (LPG) bottling operation, both operated as joint ventures with Castrol and Elf, respectively (see Table 2).

Actual refinery production data is difficult to asses due to the lack of reliability of the units, product contamination, off-specification of product, and intermediate feedstock qualities. U.S. Department of Energy/Energy Information Administration (DOE/EIA) data shows that Cuba's refinery system processed 56,000 b/d in 2000, less than 20 percent of the system's total capacity.

Over the years, Cuba's refineries have undergone some processing upgrades, such as middle distillates and reformer feed hydrotreating, sulphur recovery, and naphtha stabilization, in order to meet new environmental standards in transportation fuels quality. According to Cupet, Cuba's refinery system has a capacity of approximately 300,000 b/d, with recent refinery production running around 45,000–50,000 b/d. The Ñico López refinery and Hermanos Díaz refinery processes medium to light Venezuelan crude oil grades blended with heavier Cuban quality crude. Even though most Cuban crude oil production is directly earmarked as electric power plant fuel, about ten to twenty percent has sporadically gone into refinery processing.

From 1985 through1991, with financial and technical assistance from the former Soviet Union, Cuba built a 76,000 b/d refinery in the southern port city of Cienfuegos, which has never become operational. This refinery, technologically obsolete today, has a similar configuration to the Schwedt (Veba-BP) refinery located near the Polish border of the former East Germany. The Cienfuegos refinery still requires completion of catalytic crackers and vacuum distillation units and other extensive modifications, at an estimated cost of at least $200 million.

Over the years, many national oil companies such as Pemex (Mexico), PDVSA (Venezuela), Ecopetrol (Colombia), and Petrobras (Brazil), have evaluated the economic and strategic potential of upgrading and activating the Cienfuegos refinery. At the time, they all reached the same conclusion: no economic or strategic justification existed for such a major investment.[10]

Anticipated future crude oil demand, as reflected in crude oil prices of around $60 per barrel, and the deficit of world refinery capacity needed to meet anticipated demand in excess of 86 million barrels per

9. Guillermo Jiménez, *Enciclopedia Económica de Cuba Republicana: Las Empresas de Cuba 1958*, Ediciones Universal, Miami, Florida, 2000.

10. "Cuba Pursuing Refining Joint Venture with Venezuela," *Oil & Gas Journal*, November 11, 1991.

day, places today a different economic and logistic perspective for Cienfuegos. An upgraded and expanded Cienfuegos full conversion refinery could help meet domestic demand, and also function as a third-party merchant refinery for refined products exports, to take advantage of price arbitrage between the United States, Europe, and the Caribbean. Within an overall national energy strategy, the Cienfuegos refinery could become the cornerstone of Cuba's oil processing industry at some point in the future.

Venezuela's PDVSA and Cupet are currently evaluating various upgrading alternatives with varying levels of capital expenditures and lead time for completion for the Cienfuegos refinery.[11] A grass roots full conversion upgrade and expansion to 100,000 b/d could take up to five years to complete, at a cost of $1.2 billion (full conversion construction cost of $12,000 per barrel as estimated by Oppenheimer and Company).[12] It is very likely that Venezuela will just upgrade the crude distillation and vacuum tower units, and process a mix of Cuban Blend (12.2 API/6.75 S%) and Venezuelan Mesa/Furrial (30.8 API/.90 S%) crude oil. The output would be a combination of naphtha and catcracker feedstock, earmarked for export to Caribbean refineries, and residual fuel oil and asphalt. The residual fuel oil would be use as electric power plant fuel replacing Cuban crude oil, whose use is ruining the generating infrastructure and equipment of the power plants. This option could have a total cost of approximately $200 million and a lead time of around two years.

Cuba's Ñico López and Hermanos Díaz refineries are technologically obsolete, energy-inefficient, and huge environmental threats and should be shut down. The 5.2 sq. km La Habana harbor is one of the world's ten most polluted harbors. According to a report by the Center for International Policy's Cuba Project, "The worst sources of pollution of the waters in the bay are the López Refinery, sewage, cargo boats and cruise ships docked at the harbor, and the untreated waters of three rivers that flow into the bay." The Hermanos Díaz refinery is similarly one of the main culprits in the contamination of the 11.9 sq. km Santiago de Cuba harbor.[13]

Even though the former refinery owners might seek some sort of financial compensation for Cuba's expropriation of their assets, in private they express very little hope of re-investing in these obsolete plants, which now are of very little value, not to mention the additional burden of assuming their environmental liabilities. In our opinion, these old sites should be remediated and turned into distribution facilities for refined products supplied via pipeline from the Matanzas superport, thereby avoiding tanker traffic in tourist-sensitive Havana harbor. Santiago de Cuba could be supplied via coastal tankers once the Cienfuegos refinery becomes operational.

Cuba's future government should also consider enacting legislation so that only doubled-hauled tankers can use its territorial waters, in order to safeguard its over $1 billion-per-year tourist trade. This would increase the cost of fuels, but the cost and impact to the tourist industry that would result from a major oil spill, as with the Exxon *Valdez* or Spain's *Prestige*, would be disastrous and should be avoided at all costs. A major catastrophe was avoided in March of 1998 when two oil tankers, the Panamanian-registered *Shavadar* and the St.Vincent/Grenadines-registered *El Bravo* collided in Matanzas Bay, spilling crude oil in the nearby coastal areas. Fortunately for Cuban tourism, no spilled oil reached Varadero. The dismantling of Ñico López and Hermanos Díaz refineries, the retrofitting of the sites into refined products import and distribution facilities, the upgrade and expansion of the Cienfuegos refinery, and the environmental remediation and clean up of the refinery sites' top and sub soil, below-ground water table,

11. "Constituyen Filiales Cubanas de PDVSA," *Granma*, April 29, 2005.

12. "Valero Makes Deal to Become Top Refiner," *New York Times*, April 26, 2005.

13. *Reclaiming Heavily-Polluted Havana Bay*, The Center for International Policy, Cuba Project, Washington, D.C., September 21, 2000.

and surrounding marine waters and wetlands could well amount to $2 billion.

LOGISTICS AND DISTRIBUTION

The main foreign crude oil unloading facility in Cuba is found in the north coast port city of Matanzas. The facility includes a 187 km, 21-inch crude oil pipeline with a capacity of 134,000 b/d, connecting the port with the Cienfuegos refinery located on the south central coast of the island. Other pipelines connect the port facility with the Ñico López refinery in La Habana, the thermal electric power plants in Santa Cruz del Norte and Matanzas, and the crude oil fields of Varadero and Jaruco/Puerto Escondido.

The oil unloading facility consists of a 45,000 deadweight ton (dwt) fuel oil dock in the Bayona area of Matanzas harbor and three deep water docks, also used for lightering, equipped to handle 150,000, 70,000, and 35,000 dwt tankers, respectively. Data on the crude oil, refined products, and LPG storage capacity of the facility are not available. This facility also addresses the inherent environmental risk associated with marine transportation of oil and oil products by localizing the risk in one site rather than multiple sites, such as La Habana and Cienfuegos.

The refineries in La Habana and Santiago de Cuba can off load ships of up to 30,000 dwt on a limited basis, and the Cienfuegos refinery can handle up to 52,000 dwt vessels. Other ports such as Mariel, Nuevitas, and Manzanillo also have limited liquids-handling and storage facilities.

It has been suggested that Cuba could also become a third party crude oil transshipment and lightering point for ultra large crude carriers (ULCCs) and very large crude carriers (VLCCs) carrying oil from the Middle East to Atlantic coast refineries. This idea lacks economic and strategic merit, because ample throughput space is available in the Caribbean and the Louisiana Offshore Oil Super Port (LOOP), which provide lightering and shipping services from the U.S. Gulf Coast to refineries in the Midwest. Even with today's high shipping standards and double hauled tankers, lightering and transshipment of crude oil is an enterprise that would jeopardize Cuba's environmentally sensitive coasts and harbors and should be minimized.

Having said this, Venezuela's President Hugo Chávez and PDVSA's officials have been recently quoted in the press as saying that they plan to turn Cuba into a refined products distribution facility for its PetroCaribe regional energy initiative. Among recent announcements has been the proposed construction of 600,000 barrels of fuel oil storage in the port of Matanzas. We believe that this is part of a strategic plan of fuel switching in the electric power plants system, tied in with the revamping of the Cienfuegos refinery.

In a future free market environment, Cuba's ports are going to be a focus of substantial investment opportunities amounting to hundreds of millions of dollars, as facilities are upgraded and modernized to accommodate anticipated increase in general dry cargo, passenger traffic, and liquids, such as transportation fuels.

FUELS MARKETING

Major oil brands began marketing operations in Cuba after 1925, when import duties were removed, which up to then had given Standard Oil of New Jersey (Esso) a virtual monopoly over the market by having the only refinery on the island. Companies such as Shell, Atlantic Richfield (Sinclair), Texaco, Quaker State, California Oil Company (Chevron), and others, participated in the Cuban market until 1960 with a wide range of products such as transportation fuels, lubricants and greases, chemicals, asphalt, and LPG.

Prior to the introduction of socialism, Cuba was one of the most advanced countries of the world in per capita ownership of automobiles, second only to Venezuela in Latin America and far ahead of Southern Europe and Asia. Today Cuba's vehicular fleet is limited to automobiles and trucks owned and operated by state enterprises, foreign entities, and state-owned car rental companies servicing the tourist trade. Private vehicles are few and the motor pool is made up mostly of 1950s vintage U.S. automobiles along with some Russian Ladas, 1970s Argentine-built Fords and 1980s Italian Alfa Romeos.

There are over 200 gasoline service stations in Cuba today, and most of them are out of service due to the lack of product or spare parts for its equipment. About 140 of them are operated by CIMEX, a company controlled by the Ministry of Interior, that services the tourist and dollar trade. A smaller number of service stations operated by Cupet and Corporación Cubalse, under the brand Oro Negro, also serve the dollar market.

In an effort to replace kerosene and electricity as cooking fuel, in 2002 Cupet formed two LPG bottling and marketing joint ventures in La Habana and Santiago de Cuba. Cubana de Gas S.A., a joint venture with the London office of Dutch-owned oil trading company Trafigura Beheer, meets the growing demand for this product in La Habana, while a similar joint venture with French-based Total, Elf-Gas Cuba S.A., operates in Santiago de Cuba.

In order to meet the demand for automotive oils and industrial lubricants and greases, similar blending, packaging, and marketing joint ventures operate in La Habana and Santiago de Cuba with participation by Total-Elf and Castrol Cuba, S.A., a Dutch subsidiary of BP's Castrol. In July 2004, Petrobras announced a joint venture with Cupet to build a $20 million lubricants plant that would be on line by the second half of 2006. Production will be earmarked for the local market and for export to the Caribbean and Central American region.

The country's road and rail infrastructures are geographically sound due to the island's topography, and reach all of its major metropolitan centers. The island's 60,000 km road network, of which half is paved and includes 638 km of expressways, and approximately 5,000 km of standard gauge railroad lines, would support quick growth for the transportation fuels sector. There are definitely considerable investment opportunities for an expanded rail and road mass transit system.

As the island's transportation infrastructure is upgraded, and the Cuban population begins the process of creating economic wealth and disposable income, substantial investment opportunities will also develop for transportation fuels marketing and its associated convenience services, such as convenience food stores, fast food and automotive parts outlets, and repair services.

ELECTRIC POWER

According to EIA, installed thermal production capacity in Cuba in 2002 was 4,490 MW, generating 13.35 billion kilowatt-hours (kwh) of thermal electric production, covering 13.40 billion kwh of demand during the same period. Cuba's oil fired system is made up of obsolete and aging equipment from the United States, the former Soviet Union, and Eastern Europe. The average age of the units is over twenty years, with some units with over 60 years of service. The newest units are located in Matanzas, Felton, and Cienfuegos; these were built with Japanese, French, and Slovak technology.[14]

Table 3. Cuba's Thermoelectric Power Plants

Name	Location	Units	Generating Capacity (MW)
Máximo Gómez	Mariel	5	450
Este Habana	Santa Cruz del Norte	3	300
Antonio Guiteras	Matanzas	4	330
Carlos Manuel de Céspedes	Cienfuegos	6	500
10 de Octubre	Nuevitas	4	425
Lidio Ramón Pérez (Felton)	Mayarí	2	500
Antonio Maceo (Renté)	Santiago de Cuba	5	450
Energas	Varadero/Jaruco	3	180
Total Unión Eléctrica			3135
Other Producers[a]			1205
Total Capacity			4340

a. Hydro, solar, wind and sugar industry cogen among others.

The distribution and transmission network has been deteriorating due to lack of maintenance, and consists of 6,816 km of 220 kv and 110 kv transmission lines, 9,224 km of sub-transmission lines to 33 kv, and 33,400 km of primary distribution lines and 26,923 km of secondary distribution lines. Cuba's

14. José Altshuler, *Etapas de la Electrificación en Cuba*, Instituto de Investigación Técnica Fundamental, La Habana, Cuba, 1999.

power plants boiler systems and burners have been retrofitted over the years in order to process, as discussed earlier, the island's heavy high sulfur crude oil production as plant fuel. Some small hydroelectric capacity exists (43 MW) in Manicaragua, along with approximately 800 MW of biomass (bagasse) electricity generated by the sugar industry. Due to extensive drought in Cuba's eastern provinces and declining sugar production, electric output from these sources has been minimal in recent years.

The Cuban electric system also suffers from substantial "losses," as much as 30 percent, due to the inefficiencies of the generation and transmission infrastructure. According to Unión Eléctrica's Juan Manuel Presa, as quoted in *Granma*, operational capacity of the system would have to be at 60–65% in order to "provide good service." During 1988–89, the system was operating at a high of 80% of capacity, reaching its lowest historical level in 1993–94 at 50 per cent.

The myopian strategic decision of fuel switching, from a fuel oil fired system to the use of heavy high sulfur Cuban crude oil as a fuel source, promoted in order to save hard currency by limiting the import of fuel oil, has proven to be disastrous. The already old electric power plants, in need of modernization, deteriorated further by the burning of highly corrosive Cuban crude oil, and finally came to a breaking point in May 2004 with the shutting down of the Matanzas 330 MW plant due to equipment failure. The generating loss represented 32 percent of the eastern district's capacity and 10 percent of national generating capacity. The plant came back on stream in November 2004, but not before losses in the manufacturing and service industries valued at over $500 million. During this period (May-October 2004) the system operated at 57–58% of capacity. By October 15, Fidel Castro had sacked Basic Industry Minister Marcos Portal León and the head of Unión Eléctrica, Juan Antonio Pruna. Portal was replaced by Yadira García Vera.

The strategic policy of using Cuban crude oil as plant fuel, if it continues, will eventually collapse the country into total darkness. We strongly believe that the recently announced construction of 600,000 barrels of fuel oil storage in the port of Matanzas, along with possible upgrading and revamping of the Cienfuegos refinery, are part of a crude oil for fuel oil switching strategy.

According to the projections of Medlock and Soligo of Rice University,[15] total generating capacity of 9,110 MW by the year 2015 would be needed as a result of the growth created by a free market economic system. These future upgrade and modernization improvements to the electric power industry, undertaken to support a developing economic and industrial system, could very well require billions of dollars of investments.

We should also again underscore the importance of evaluating, within a national energy policy, the economic and strategic validity of a fuel switching program from oil-fired to natural gas/LNG-fired boiler systems for electric power plants and other major industrial projects.

SUPPLY–DEMAND BALANCE

An analysis of Cuba's past petroleum supply/demand patterns during the twenty year period (1970–1991) of Soviet economic influence would be quite complicated. According to economist Jorge Pérez-López, an economic central planning system, along with sugar-for-energy barters, subsidized sugar prices, and the re-exports of Soviet oil and refined products, "contributed to questionable investment decisions in energy intensive industries and to wasteful consumption practices."[16]

Therefore, it is more productive to look toward future energy consumption trends based on an anticipated free market system, and on the island's eco-

15. Kenneth B. Medlock and Ronald Soligo, "Economic Development and End-Use Energy Demand," *The Energy Journal* (April 2001).

16. Jorge Pérez-López, "Cuba's Transition to Market-Based Energy Prices," *The Energy Journal*, vol. 13, no. 4 (1992).

nomic growth engines of tourism, agriculture, oil and mining, and a highly educated labor pool willing to work at competitive rates. This labor advantage, along with possible advantageous tariff regulations, and the close proximity to U.S. markets, could create large number of jobs in the *maquiladora*, pharmaceuticals, engineering design, and financial and computer customer service industries.

Rice University economists Amy Myers Jaffe and Ronald Soligo project that as the result of these events, generating an annual per capita gross domestic product (GDP) growth rate of 4 percent, along with an annual population growth rate of 0.5 percent, Cuba's oil energy consumption would nearly double from 179,000 b/d in 1998 to 349,000 b/d by the year 2015.[17]

As of 2004, estimates showed that Cuba had a deficit of approximately 100,000 b/d of oil/products in order to meet internal demands. Almost all of Cuba's heavy oil production is used directly as boiler fuel in the electric power, cement, and nickel industries. Less than 10 percent goes into refinery (Ñico López) processing.

Under an advantageous financial agreement, Cuba contracted for the purchase of 53,000 b/d of crude oil and/or refined products from Venezuela. This agreement, made in May 2002, calls for a portion of the oil to be repaid over a fifteen-year period at an annual interest rate of 2 percent and an initial two-year repayment grace period. Currently this agreement has reached levels of 90,000 b/d of Venezuelan crude/refined products exports to Cuba, reflecting increased consumption levels. At current crude oil/refined product prices, Cuba's estimated debt to Venezuela is of over $1.3 billion annually.

Cuba is advantageously located within the oil producing and processing Caribbean/Gulf of Mexico Basin region, which today has nearly 50 percent of the Western Hemisphere's oil producing and refining capacity. This will allow Cuba, in a future free-market environment, to exploit the economic benefits of oil products as a commodity, as well as to take advantage of its arbitrage and fungible characteristics, along with its associated short-haul transportation cost.

ETHANOL

Sugar cane-based ethanol deserves high consideration and focus within Cuba's national energy policy. It would create considerable economic benefits in new investments and employment creation. It would also support the sugar cane industry, preserving a large number of agricultural jobs, that otherwise would have been lost. Also, it would have a positive impact on the national balance of payments by reducing the demand for imported oil and creating a new export revenue source.

Ethanol (ethyl/grain alcohol) is made by the fermentation of sugars (e.g., sugar cane), or starches from potatoes, corn, or wheat. Ethanol is used today as an additive to gasoline in many countries, particularly in the United States and Brazil. In the United States, approximately 2 billion gallons of ethanol are added to gasoline each year to increase octane and improve emissions quality. In most areas ethanol, or other "oxygenates," are blended in a 10 percent ratio with gasoline even though ethanol can be used in higher concentrations or in its pure form. The demand for ethanol in the United States will increase in the future due to environmental and underground water contamination concerns related to other oxygenates currently used, such as methyl tertiary-butyl ether (MTBE).

Cuba's increased production of ethanol would reduce its dependence on imported oil and would supplement refinery capacity, saving hundreds of millions of dollars per year in imports plus it would become a new source of export revenue. Cuba has the production capacity (in sugar cane) to compete with Brazil as a major exporter, and its proximity to the U.S. gives it a price advantage over Brazil. Ethanol is low in reactivity and high in oxygen content, making

17. Amy Myers Jaffe and Ronald Soligo, *Energy in Cuba*, James A. Baker III Institute for Public Policy, Rice University, Houston, Texas (2002).

it an effective tool in reducing ozone pollution, and it is a safe replacement for petroleum-based toxic octane enhancers, such as benzene, toluene, and xylene.

It was no surprise that during President Luiz Inacio Lula da Silva's visit to Cuba in September 2003, a $20 million fuel ethanol production agreement was signed between Brazil and Cuba. This aid will finance the planting of sugarcane and the construction of a 100,000-liter per day processing plant. The production of 100,000 liters per day of ethanol, assuming a 10 percent blending ratio and a domestic demand of 1.7 million liters of gasoline per day, would represent about a 6 percent reduction of import needs, valued at about $8 million per year.

RENEWABLE ENERGY

As part of its energy conservation policies after the 1991 economic crisis, Cuba began an aggressive program of developing renewable energy projects. Conventional sources such as biomass, hydro, solar, wind, and even exploiting the peat reserves located in the Ciénega de Zapata. have been considered and pursued.

For many years Cuba's sugar mills have burned waste cane solids (bagasse) as fuel to power their boilers, but the process is inefficient due to the age and condition of the turbines. With a more advanced and efficient technology the system could become an important contributor of co-generation to the national grid, generating up to 100 kwh/ton of sugar cane from the current average of 20 kwh/ton. Due to poor sugar cane production levels, low sugar world prices, and the deteriorating conditions of its older-than-fifty-years processing technology, Cuba announced in June 2002 the closing of 71 of its 156 sugar mills. Today, only 22 of Cuba's sugar mills co-generation plants are connected and able to contribute to the national grid.[18]

The only major hydro project in Cuba is the hydroelectric plant Robustiano León, a 3–units, 43 MW plant located in the central town of Manicaragua, using the waters of the Hanabanilla River. Throughout Cuba there are more than 175 small rural hydro-generators (138 <50 kw, 32 <500 kw, 5 <5000 kw), 26 of which are connected to the national grid. Just like the small hydro projects, solar (photovoltaics) and wind power projects are important contributors of electricity for schools, health clinics, irrigation, and small rural communities, particularly in Eastern Cuba. These hydro power plants are currently not contributing to the national grid due to the severe drought experienced in Eastern Cuba.

Table 4. Cuba's 2005 Petroleum Supply-Demand Profile—Estimates (b/d)

Domestic Crude Oil Production		75,000 b/d
Cupet	51,600	
Sherritt/Pebercan	23,400	
Domestic Refined Products Demand		170,000
LPG	7,000	
Gasoline	26,000	
Jet/Kero	5,000	
Diesel	52,000	
Fuel Oil	80,000[a]	
Imports		95,000
Crude oil	35,000	
Refined products	60,000	

Note: Estimates based on author's industry sources and marine tanker movements.

a. Supplied as diluents blended crude oil in order to meet acceptable viscosity and pour point levels.

SUMMARY

Cuba's short term energy outlook is dismal, and possibly catastrophic due to the possible total collapse of its electric generating system. No amount of "free" oil from Venezuela will save the sector; time is running out. The damage to the units has been so prolonged and consistent that it would take a lead time of eighteen to twenty four months just to upgrade and revamp the system. This revamping and upgrading would have to go hand in hand with the implementation of the fuel switching strategy discussed earlier in this paper.

18. Roger Lippman, *Renewable Energy Development in Cuba: Sustainability Responds to Economic Crisis*, National Center for Appropriate Technology, Seattle, Washington (1997).

Cuba's long term energy challenge begins with its future economic growth and rising standard of living within a free market environment. This anticipated growth will depend largely on the development of a competitively priced, readily available, environmentally sound, long-term energy plan. There will be no sector, industry, or infrastructure group that will not be directly impacted and/or influenced by such a comprehensive energy policy.

A national energy policy should embrace energy conservation, modernization of the energy infrastructure, and a balance sourcing of oil/gas supplies in a way that protects the island's environment. This future reconstruction period, along with the search and development of new energy sources, will also provide national and foreign firms alike many investment opportunities in the island worth billions of dollars.