

The Future of Cuba's Energy Sector

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Introduction

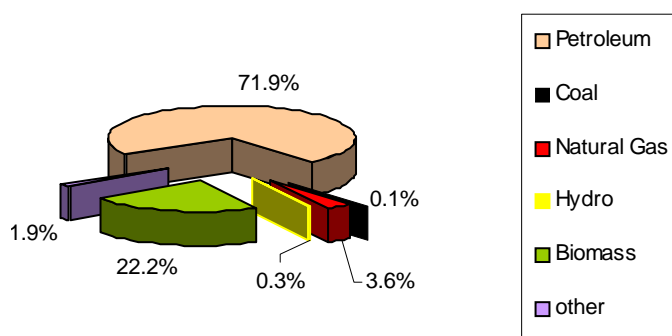
The current economic, political, and social trends in Cuba indicate that energy consumption will increase substantially in the future. Transition to a market economy would accelerate this trend. In this article the word “transition” refers to any movement towards a market economy. It does not necessarily mean regime change.

The proximity of Cuba to the United States and the possibility of massive oil deposits in Cuban waters will have a tangible impact on political, economic, and social environments, not only in Cuba, but in the whole region. The discovery of commercial deposits of oil would affect Cuba's economy on one hand and US energy policy and energy security on the other. If US-Cuba relations improve in the future, discovery of large oil deposits could affect the energy trade patterns between the two countries and affect oil trade between the US and other oil producing countries, especially in the Middle East.

The Cuban government has come to realize the importance of developing domestic energy sources, especially after the collapse of the Soviet Union (USSR) in 1991. Cuba embarked on several renewable and non-renewable projects to generate electricity and enforced a number of conservation and efficiency measures. Political instability in Venezuela, Cuba's chief energy import source, endangers the flow of cheap oil to the country. The near term goal is energy self-sufficiency, which would have a direct benefit in the manufacturing, transportation, and tourism sectors. Ultimately Cuba would like to be an oil exporter, which would generate much needed revenue to revamp its deteriorating infrastructure and to enhance its relations with other countries, especially in the Caribbean region and Latin America.

This paper provides a brief synopsis of Cuba's energy sector and outlines future opportunities and challenges. Section II presents an overview of the energy sector in Cuba with a brief summary of recent activities in the oil sector. Section III outlines the opportunities for growth in both energy consumption and production. It also outlines opportunities for domestic and foreign investment. Section IV summarizes a list of challenges that will face Cuba in developing its energy sector. Section V presents conclusions and policy recommendations.

FIGURE 8-1. Cuban Primary Energy Consumption in 2001



Source: IEA, Non-OECD Country Balances, 2003.

An Overview of Cuba's Energy Sector

Cuba's primary energy consumption is relatively small by world standards. In 2003, it reached a mere 0.474 quadrillion BTU. Cuba depends heavily on oil, which represents about 72 percent of its total primary energy consumption. The rest comes from biomass (22 percent), Natural Gas (3.6 percent), Hydro (0.3 percent), and Coal (0.1 percent), as shown in Figure 8-1. Renewable energy such as solar and other energy sources represent 1.9 percent.¹

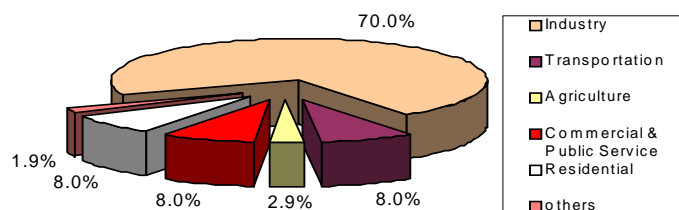
1. The US EIA provides different data in its Caribbean Fact sheet (July 2004). In its report, the EIA states that oil represents 95 percent of the total primary energy supply in Cuba. In a private correspondence, an EIA official stated that "the short answer to your question is that we only take into account renewable and combustible energy use for electricity production, whereas the IEA takes into account other uses by other sectors. Looking at the IEA statistics, I see that in 2001, for example, of domestic supply of solid biomass of 123514 (terrajoules), only 6938 were used in electricity production (only 6 percent). This is all that we capture, hence the great difference. Of course, our assessment of the use by the electricity sector might be somewhat different as well, but the difference would not be that large. So, it is a difference of methodology. I admit that this tends to underestimate energy use in countries with a large amount of wood, biomass, etc., use outside of the electricity sector, but we do not have the resources to obtain independent estimates of these uses."

Cuba's industrial sector consumes about 70 percent of total energy available, as shown in Figure 8-2. The residential and transportation sectors consume 8 percent each, and the agriculture sector consumes less than 3 percent.² The heavy dependence of Cuba's industrial sector on energy illustrates the role of energy in Cuba's economic growth and economic development.

Crude Oil

With the dramatic failure two years ago of the sugar industry, from which it has yet to recover, Cuba has placed greater emphasis and hope on exploiting its oil reserves. In 1999, Cuba divided the 43,250 square miles of its Gulf waters into 59 exploration blocks in preparation for opening them to foreign investment by international oil companies (IOCs) as shown in Figure 8-3. Six exploration blocks were awarded to the Spanish firm Repsol-YPF and four to the Canadian firm Sherritt.³

FIGURE 8-2. Cuban Energy Consumption by Sector in 2001



Source: IEA, Non-OECD Country Balances, 2003.

The Institute for Cuban & Cuban American studies states on its web site that oil was discovered in Cuba in 1914. In a different location, it indicates that oil was first discovered in 1881, about 20 years after its commercial discovery in the United States.⁴ However, it was not developed commercially until the early 1930s. The USGS estimates that Cuban waters may contain about 4 billion barrels of oil. Several political and economic factors have limited the development of Cuban oil. The breakup of the Soviet Union and the loss of Soviet oil shipments forced Cuba to increase its exploration activities and develop its oil resources. Several reports estimate proven oil reserves to be between 510 million barrels⁵ (mb) and 750 mb in 2004.⁶ Even conserva-

2. These percentages indicate that sugar processing is considered part of the industrial sector.

3. *World Oil* and *Oil and Gas Journal*, various issues.

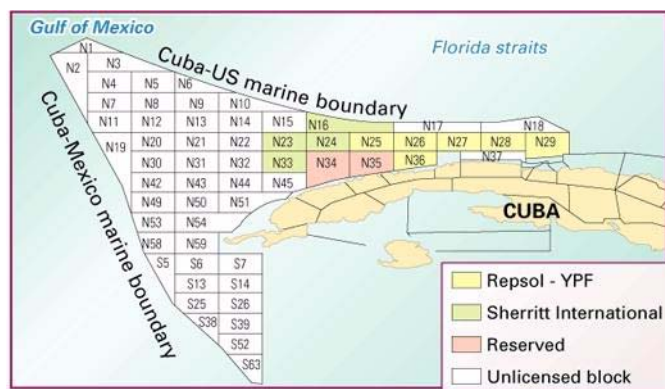
4. <http://cuba.iccas.miami.edu/>

5. World Oil estimate, *World Oil*, September, 2004.

6. Oil and Gas Journal estimate AS OF January 2005, *Oil and Gas Journal* (December 20, 2004)

tive reserve estimates reflect a substantial increase in Cuba's oil reserves in recent years, which stood at 284 mb in 2001. All current crude comes from onshore fields. Almost all Cuban crude is heavy with high sulfur content. Cuba needs to find light crude oil reserves in order to achieve its goal of self sufficiency.

FIGURE 8-3. Cuba's 59 offshore Sections and the Operating Companies



Source: Unión Cuba Petróleo. Cited in the Oil and Gas Journal, August 18, 2003.

Figure 8-4 shows Cuba's oil production and consumption since 1980. Cuban oil production increased rapidly in recent years. It increased from 3 percent of total energy consumption in the late 1960s to more than 20 percent of total energy consumption in 2004. Oil production has increased by three-fold since 1991 to reach 56,000 b/d in 2003.⁷ Production increased by 16.6 percent in 2003 alone. This increase in production resulted from the increase in development wells in recent years, as shown in Figure 8-5. The Figure illustrates the number of producing oil wells between 1997 and 2003. It also shows that most of the onshore Cuban wells are on artificial lift.

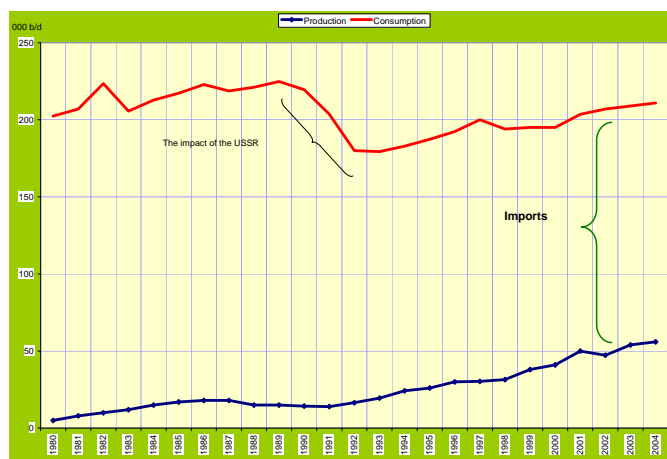
Cuba's petroleum consumption is closely related to its economic activities. Despite various conservation and efficiency measures adopted after 1991 to reduce petroleum consumption, most of the decrease in oil consumption is related to the decline in economic activity after 1991. Cuba's oil consumption reached 209,000 b/d in 2003. Oil is mostly used in transportation, fertilizer plants, the cement industry, electricity generation, nickel refining, and other mining operations. The industrial sector use about 68 percent of the available oil, followed by transportation (14 percent), residential (5 percent),

7. The Cuban Ministry of Basic Industry reported that Cuba produced 60,200 b/d of oil in 2003. This number is slightly above the reported number in the press. The discrepancy is very small and could be the result of differences in the definition of "petroleum."

construction (6 percent) and agriculture (3 percent). The remaining oil is distributed among various sectors, including defense.⁸

As production has increased in recent years, Cuba's oil imports have been decreasing, as shown in Figures 8-4 and 8-6. Cuba imports around 150,000 b/d of petroleum products. Historically, most of Cuban energy imports, mostly petroleum products, came from the USSR. Currently, most petroleum imports come from Venezuela and other Caribbean nations. It now purchases 78,000 b/d of crude and products under preferential conditions from Venezuela based on a five-year contract signed in October 2000. The dependence of Cuba on oil imports from Venezuela makes Cuba vulnerable to any political change in Venezuela or any change in the attitude of the current government of Venezuela.

FIGURE 8-4. Cuba's Petroleum Production and Consumption (Thousand b/d)



Source: EIA, 2004

The Impact of the USSR on Cuba's Petroleum Sector

The USSR was the main supplier of energy products for several decades. The Soviets bartered oil and oil products for Cuban sugar, tobacco, and other Cuban products.⁹ In such barter, Cuban sugar was overvalued.¹⁰ As a result,

8. IEA, 2003.

9. For detailed information on the oil-for Sugar deal see Alonso and Galliano (1999).

10. In 1988, the price of Cuban sugar was for times the world price. For more information see Perez-Lopez (1992) who cited data from Comité Estatal de Estadísticas, Anuario estadístico de Cuba. He also cited instances where Cuba bought sugar in the open market and resold to the Soviets and gained massive profits that help finance petroleum imports.

the collapse of the communist block in 1989 and the USSR in 1991 meant lower prices for Cuban sugar and higher oil import costs for Cuba. However, it was not the collapse per se that reduced the Cuban oil imports from the USSR. Rather, the decline in oil imports was the result of a trade protocol that was signed in 1990 that eliminated barter deals and preferential prices and replaced them with world market prices and convertible currency payments. This protocol dealt a serious blow to the Cuban economy in general and the energy sector in particular. Energy imports represented a striking 34.2 percent of Cuba's total imports before the collapse of the USSR.¹¹ After signing the protocol, Cuba had no choice but to reduce its oil imports. It was not able to pay for them. In addition, the protocol prevented Cuba from receiving additional cheap oil for re-export, which had generated additional revenues and hard currency for the government.¹²

As shown in Figures 8-4 and 8-6, the collapse of the USSR had a tremendous impact on the petroleum imports and consumption of Cuba. Petroleum consumption declined by 19 percent between 1988 and 1992; petroleum imports declined by 20.6 percent during the same period. The decline in imports was higher than the decline in consumption by about 1500 b/d. The increase in domestic petroleum production by 10 percent accounted for this difference. The ability of domestic production to cover the gap between consumption and imports indicates that the impact of conservation measures and increased efficiency programs that the Cuban government adopted after 1991 was minimal at best.¹³

Recent Exploration Activities

Almost all current production is heavy crude from onshore wells in northeastern Cuba. Several IOCs operate in Cuba today through joint ventures with Cuba Unión des Petróleo (Cupet). These companies include Sherritt International (Canada), Petrobras (Brazil), Repsol-YPF (Spain), Pebercan (Canada). Several other companies from the UK and China have also signed contracts.¹⁴ The Helms-Burton Act prohibits US oil companies from investing in Cuba despite the fact that US oil companies started the Cuban oil industry.¹⁵ In December 2003, the Government of Cuba invited US oil companies to join offshore exploration efforts. The government noted that US farmers were

11. Ibid

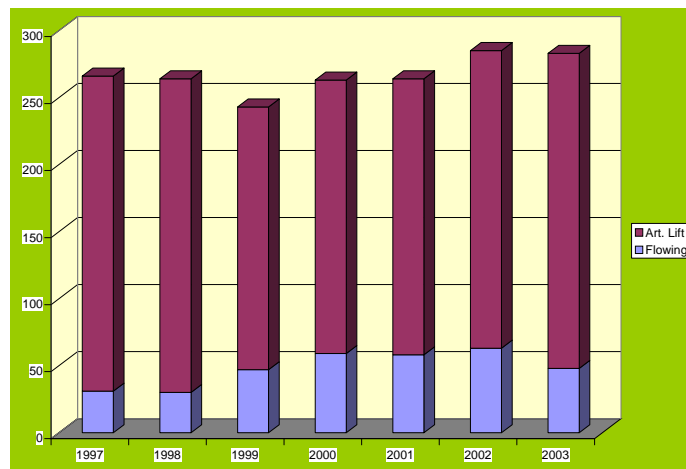
12. Cuba started re-exporting Soviet oil in 1977. The average yearly exports stood at 687,000 metric tons between 1977 and 1981. It increased between 1982 and 1988 to an average of 2,952,000 metric tons. For more information see Perez-Lopez (1992)

13. The collapse of the USSR also affected Cuba's electricity generation in various ways and forced Cuba to modify its generation plants, which increased inefficiency and widespread blackouts.

14. The French oil company Total abandoned Cuba in the early 1990 after drilling two offshore dry holes for more details see *Financial Times* (January 15, 2003), USA Edition.

selling their products despite the four decades embargo and the US oil companies could follow suit.¹⁶

FIGURE 8-5. Number of Producing Oil Wells



Source: World Oil, August, 2004.

In 2001 Brazilian oil company Petrobras ceased exploration in Cuban waters after its \$17 million wildcat well in Block L resulted in a dry hole.¹⁷ The company's earlier seismic testing indicated the possibility of up to 700 million barrels of crude. In January 2003 Petrobras signed a letter of intent with Cuba to return.¹⁸

In July 2004 Spain's Repsol-YPF announced that its \$50 million, 10,800 foot exploratory well drilled in Yamagua 1 on the northwestern coast indicated the presence of a petroleum system, but concluded that extraction was not commercially viable. The company estimates the probability of finding high quality crude at less than 20 percent. It plans to further analyze test samples and drill another hole in 2005.¹⁹

15. In the 1930s, Standard Oil Company of New Jersey owned the only refinery in Cuba at Belot, across the bay from Havana ("Cut in Oil Tariff Proposed in Cuba" *NYT* (Nov 11, 1931)) In 1956, the *New York Times* reported that "Oilmen from Texas, Oklahoma, and California in particular are appearing in Cuba in increasing numbers. Various small companies and some with considerable resources have been formed." ("Rise in Domestic Oil Flow Bolsters Cuba; Exploratory Capital Pouring Into Island." *NYT* (January 5, 1956).)

16. *Oil Daily* (December 4, 2003).

17. *Oilgram News* (December 2003).

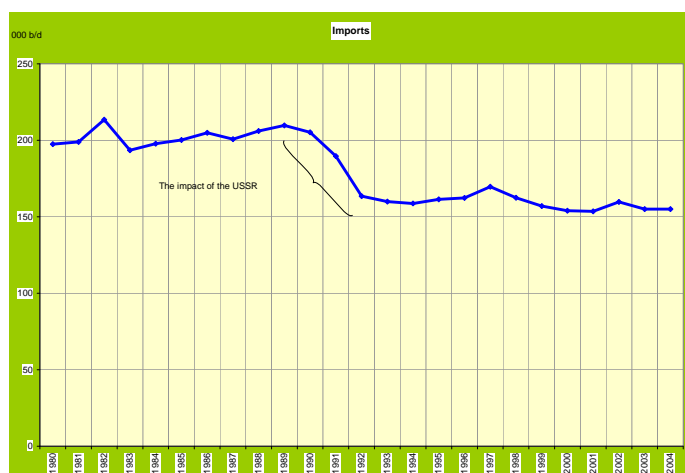
18. "Brazil interested in exploring deepwater GOM off Cuba, *Oil and Gas Journal* (August 18, 2003).

19. "Spain Strikes oil near coast of Cuba" *The Sun-Sentinel* (July 30, 2004). The same story was also reported by *Reuters* (July 25, 2004).

China Petrochemical Corporation (Sinopec) signed a memorandum of understanding with Cupet to explore four blocks and to conduct geological studies over six months. This agreement could lead to the signing of a production sharing contract.

Canada's Sherritt International recently announced plans to recommence exploratory drilling later this year in block Y off the northern coast, followed by work in blocks 9 and 10 over the following months.²⁰ The company spent \$46.2 million in the first half of 2004 on capital expenditures. At the end of 2004, Sherritt discovered a 100 million barrel deposit off the coast of Santa Cruz del Norte. The discovered crude is similar to other Cuban crudes. It is heavy (18 API) and contains high sulfur (5 percent). Sherritt plans to start production from the new field in 2006.²¹

FIGURE 8-6. Cuba's Petroleum Imports (Thousand b/d)



Source: EIA, 2004.

The Cuban government reported that it drilled 16 wells in 2003. One of them was dry. It planned to drill 17 oil wells in 2004, one of them offshore. They include 3 exploratory wells and 13 development wells.²²

Natural Gas

Cuba's natural gas consumption is minuscule and represents only 2.7 percent of its total primary energy consumption, as shown in Figure 8-1. Despite a

20. For detailed information on Sherritt's earlier operations in Cuba see "Cuba's oil output rises, other projects loom absent sanctions", *The Oil and Gas Journal* (January 7, 2002).

21. "Castro Announces New Oil Find" *Reuters* (December 26, 2004).

22. *World Oil* (August, 2004).

small production of associated natural gas, production potential is large given that the Oil and Gas Journal estimates natural gas reserves to be around 2.5 TCF.²³ Associated natural gas was historically flared until 1968 when Cuba decided to utilize it.

Natural gas production was 59.5 mcf/d in 2003. In 1997, Cuba established a joint venture with a Canadian firm with the goal of supplying households in the Mantanzas Province with natural gas.²⁴ Some of the gas is delivered to Havana for residential use. The IEA reports that the industrial sector uses 80 percent of the natural gas and the residential sector uses 19 percent. However, natural gas represents only 6.7 percent of the total energy used in the industrial sector and only 14 percent of the energy used in the residential sector. These low figures indicate that the potential for natural gas market growth is great, especially since Cuba has no coal. The increasing demand for electricity and the spread of blackouts indicate that Cuba will most likely utilize its natural gas to generate electricity rather than for export. The behavior of the oil producing countries supports this conclusion. They use natural gas to replace oil in utilities and for industrial use.²⁵

Renewable energy

Cuba's desperate need for energy resources, especially after the collapse of the USSR, forced it to try various renewable energy technologies and to continue its heavy reliance on biomass, especially in the sugar industry. Renewable energy generated 6.1 percent of total electricity generation in Cuba in 2001, while oil supplied the rest.²⁶ Cuba's experimentation with renewable energy has had some success, but not enough to solve the energy shortfall on the island. One of the main obstacles that faces the development of renewable energy is that most of the technology is not designed for tropical areas.

Cuba's largest potential renewable energy source is biomass, primarily in the form of sugar cane residue, known locally as "bagasse." It represents about 22 percent of total energy consumption in the country. Bagasse is used in boilers to generate electricity for sugar mills. Cuba produced 600 MW from bagasse in 2002. Many sugar plants are energy self sufficient and only about 70 sugar mills connected to the power grid.²⁷ Politics aside, consumption of bagasse is very inefficient. The traditional process produces no more than 20 kwh/ton of ground sugar cane in the older steam turbines. Efficiency

23. However, conservative estimates, such as that of *World Oil* (September 2004) show natural gas reserves to be around one-fifth this number, only 0.550 TCF.

24. Werlau (1998)

25. This conclusion contradicts the conclusion of Jaffe & Soligo (2000) that the discovery of natural gas in Cuba may lead to exporting it to Florida.

26. IEA Energy Statistics, 2003.

27. "Euro-Caribbean Island cooperation on Sustainable Energies" OLA-Caribbean Project, 2003.

is double in the newer turbines, but there is still room for improvement.²⁸ Furthermore, the high transportation costs of solid biomass have forced decision makers to locate processing sites near the sugar cane fields which limits the economical distribution of the energy produced and largely limits its use to the sugar industry. With new technology and appropriate funding, the sugar industry can generate enough electricity to prevent blackouts in Cuban cities.²⁹

Cuba also uses biomass to produce biogas from the residue of sugar and coffee processing plants. An example is “cachaza,” the residue produced from filtering pressed sugar cane juice. Cachaza is converted to methane gas to be used as cooking fuel in local communities. Cuba started using this process in the industrial sector in the early 1990s when it built the first industrial gas plant with financial help from a Christian group in Germany.

Other biomass sources include wood, charcoal, livestock waste, paper and food processing waste, and urban waste. Recent government reforestation efforts have limited the use of wood. However, the consumption of fuel wood may have increased after 1991 when energy resources became scarce.

The absence of large rivers in Cuba limits the production of hydroelectricity to small rivers. Hydropower supplies 2.7 percent of total electricity generation in Cuba, as shown in Figure 8-1. Recent estimates put Cuba’s total gross hydro power potential at 14,600 GWh/year. It will be generated mostly from Cuba’s 219 existing water reservoirs, which were constructed for water management and irrigation.³⁰ The development of hydropower started in the 1980s as part of a national plan to expand the use of this unutilized source.³¹ Four major plants were built in the 1980s with capacity up to 46250 kW. Hundreds of small scale hydro energy operations are already in place throughout the country, primarily in rural or mountainous areas.³² Very few of these operations are connected to the grid. These micro operations might have a great potential once Cuba has the financial resources to convert these micro operations from manual to automatic, thus utilize most of the hydro power potential. Cuba imports some of these plants from China and manufactures the rest with Chinese financing.³³ Downside factors, however, include

28. Santamarina (1992).

29. Even with the improved efficiency, it is still almost half of that in the West. For more information see Lippman, Lent, Hawthorn, Stone, and Duncan (1997).

30. “Cuba takes up hydro” *International Water and Dam Construction* (January 1, 2003).

31. Experts argue that Cuba’s mountainous landscape can support an estimated hydro potential of 14,600 GWh/year. This amount could substitute for one million ton of oil costing an estimated \$120 million. For more information see Oladle and Martinez (2000).

32. *Ibid.*

33. *Economic Eye on Cuba* (April 10, 2000). US-Cuba Trade and Economic Council.

the normal fluctuations in the depth and flow of the water as well as the seasonal need to divert water to irrigate crops.

Solar energy has large potential but its use is still limited despite the financial support of several countries and world organizations. Cuba has implemented a photovoltaic program to serve numerous locations not on primary power grids, especially schools, municipal buildings, and medical clinics in remote sections of the country.³⁴ Photovoltaic devices also provide electricity for other uses such as communications, electric cattle fences, and forest guard stations.³⁵ The use of solar energy in Cuba suffers from several problems. Most of the solar energy technology installed was not designed for tropical areas.³⁶ Lack of financing prevented Cuba from producing or importing new technology that suits its climate. Solar energy is also used to dry crops. Recent reports indicate that the Cuban government intends to expand these operations.

The harnessing of wind has become widespread in Cuba. It is estimated that there are more than 8,000 windmills throughout the island. These are used primarily to irrigate fields and provide water to livestock. More recently, with financial backing from several European countries, several modern "wind farms" have been constructed to generate electricity in addition to small 1 kW turbines. The first wind farm, which generates 0.45 MW, was commissioned at Turigwanò Island in 1991. Studies indicate that at 400 MW power could be generated in windy areas such as the northern coast.³⁷ The government intends to combine microgenerators with small wind mills that are designed to charge batteries.³⁸ Some of the limitations of wind power include lack of funding and the inability to repair thousands of idle wind mills.³⁹

Nuclear energy

Cuba attempted to build its first nuclear power plant for electricity generation in 1958 when it signed an agreement with an Anglo-American consortium to build a 220,000 kW nuclear power plant in Santa Lucia. The revolution of 1959 halted the development of the plant. Cuba started its own nuclear program in 1969 with the hope that it could develop its own nuclear plants. Cuba signed an agreement with the USSR in 1976 to build a nuclear power plant. The inability of Cuba to finance the project delayed the project for several

34. The OLA Caribbean Project reports that solar energy supplies electricity to more than 350 medical centers, 2364 primary schools, 1864 TV rooms, and 150 social centers. For description of various PV panels see Lippman (1997).

35. Santamarina (1992).

36. Stone (1996).

37. OLA-Caribbean Project, 2003.

38. Santamarina (1992).

39. Lippman (1997).

years.⁴⁰ In 1983, with considerable financial backing from the Soviet Union, Cuba began construction of two 440 megawatt pressurized water reactors for the purpose of generating electricity. Located southeast of Havana near Cienfuegos, Juragua 1 and 2 are Eastern European design VVER-440 reactors. Although the first reactor was to be operational by 1995, the breakup of the Soviet Union and its rapid transition to a market economy dramatically changed both technical assistance to and commercial relations with Cuba. On September 5, 1992, after spending about \$1.1 billion, Castro formally announced the termination of the project. Civil construction on Juragua was estimated by the GAO to be approximately 90-97 percent complete with 37 percent of the reactor equipment installed. Juragua was estimated to be 20-30 percent complete with reactor equipment installation unknown. In October 1995, a Russian delegation traveled to Cuba to negotiate an \$800 million agreement to complete both reactors. In 2000, both Russia and Cuba agreed to abandon the project. Cuba needs at least \$1 billion to finish both projects.⁴¹

The Juragua project met with considerable opposition from the U.S. government as well as the world scientific community. Concern was expressed that shoddy construction, structural defects, lack of a proper quality control processes, poor training, and the inexperience of Cuban personnel had created the potential for disaster, especially given that the design is not intended for tropical areas. The Helms-Burton Act specifically states that the construction of a Cuban nuclear reactor would be considered “an act of aggression.” Consequently, nuclear energy is not a viable option at the present time to satisfy Cuba’s energy needs.⁴²

Opportunities

While the number and size of opportunities depend on future policies, they exist in all scenarios. Under any future scenario, the Cuban energy sector has no other way but to grow in both consumption and production. Such growth creates several profitable investment opportunities for the Cuban government, the Cuban people, Cuban expatriates, and foreign investors. Three important factors will play a significant role in increasing future energy consumption: economic growth, private ownership growth, and tourism growth. While population growth currently hovers around zero, a move toward a market economy and the return of expatriates might increase population growth. Such an increase in population would also increase demand for energy.

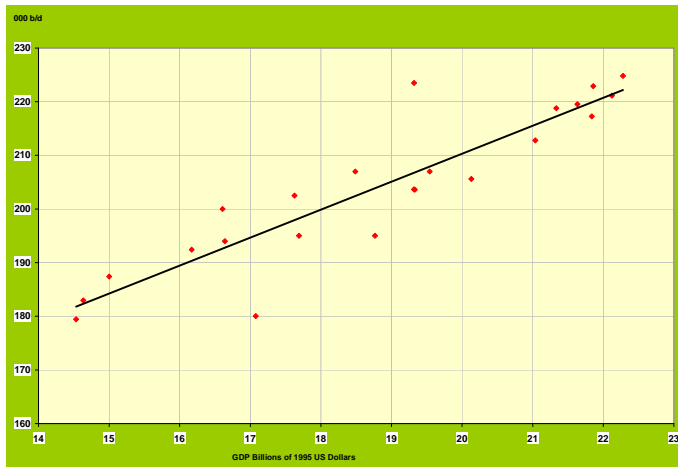
40. Institute of Cuban and Cuban-American Studies database, 2001.

41. For detailed information of Cuba’s nuclear projects see. Perez-Lopez (1987) and Benjamin-Avarado (1998).

42. Parrish (1997).

Based on the current situation in Cuba, energy consumption will grow. Cuba's energy consumption is positively correlated with economic growth, as shown in Figure 8-7. The Figure shows the positive relationship between petroleum consumption, which represents 72 percent of total energy primary consumption, and GDP.⁴³ Increased openness and movement toward a market economy will accelerate energy consumption to the extent that Cuba may face a future energy crisis as supplies cannot keep up with demand. Three factors cause acceleration in energy consumption. First, countries in transition experience higher economic growth than countries not in transition. Second, countries in transition, in general, experience faster growth in energy consumption than economic growth. Third, growth in energy consumption in Cuba could be even higher than other countries in transition. Cuba has one of the lowest per capita energy consumption, per capita electricity consumption, and cars per 1000 people in the world. Countries in transition typically experience large growth in both per capita energy consumption and number of cars per 1000 people. To meet such demand, Cuba will need massive investment in energy infrastructure and energy services.

FIGURE 8-7. GDP vs. Petroleum Consumption (1980-2002)



International Energy Annual 2002, EIA, 2004.

Under any future scenario, the potential for Cuba to become a net oil exporter is great. Its proven oil reserves are higher than that of Sudan, but it produces only about one fifth of Sudan.⁴⁴ Sudan is planning now to double its production from the same reserves, which also indicate the potential increase

43. The relationship between per capita energy consumption and economic growth is also positive.

in production in Cuba. While oil in Cuba is more expensive to produce than in Sudan, Cuban oil is more accessible and closer to world markets than Sudanese oil. In addition, it is very close to major refining centers and storage facilities in the Caribbean. Unlike Cuba, Sudan suffers from a long history of civil war and political instability. Like Cuba, Sudan is under US sanctions.

Opportunities for Foreign Investment

As indicated above, Cuban energy production and consumption will increase in the coming years under any scenario. Moving toward a market-orientated economy will only enhance and accelerate these trends, which require ever-increasing investment. The experience of the oil producing countries indicates that IOCs will invest even in the direst of circumstances as long as governments offer good investment terms to reflect the high risk in these countries. Foreign oil companies will invest despite political instability, dictatorship, human rights abuses, and unilateral sanctions as they have done in Algeria, Colombia, Sudan, Yemen, Myanmar, Iraq, and Iran. IOCs have increased production in several oil producing countries despite adversity and high risk.⁴⁵

Based on Cuba's optimistic reserve figures and the experience of other countries, we estimate that Cuba will produce more than 700,000 b/d by 2015 under any possible scenario, even if US sanctions stay in place. The differences among various scenarios will have an impact only during the initial years, mostly between 2005 and 2009, but the outcome is the same after 2010. Cuba needs at least \$9 billion to reach that level of production.

While we believe that US sanctions have an impact on Cuba's energy sector and that lifting them will accelerate its development, we believe that Cuba, with the right changes, can attract foreign investment and develop its energy sector despite the sanctions. In this case, sanctions would have a bigger impact on US oil companies than on Cuba. Countries that were able to develop their oil sectors despite the sanctions include Iran, Iraq, Libya, Sudan, Syria, and Myanmar.

Renewable energy, especially biomass, has a great potential in Cuba. New technology and increasing efficiency may eliminate the possibility of future blackouts in Cuban cities. The ability of biomass to solve the blackouts problem indicates the existence of a large market for its power, which in turns creates opportunities for investment and expansion. Investment opportunities also exists in other renewable resources, especially wind and solar. Wind

44. Sudan's proven oil reserves are 563 mb as of January 2004. Its production stands at 345,000. Sudan plans to increase its production to 700,000 in the next few years (EIA, Country Briefs, 2004).

45. For more information on the behavior of IOCs in unstable or embargoed countries see Alhajji (2004).

farms create a good opportunity for foreign investors. Cuba's need for PV panels that operate efficiently in tropical areas also creates new investment opportunities.

Challenges

Despite the above optimistic view regarding future opportunities, Cuba has to overcome several serious technical, legal, economic, political, and social challenges. Most of the Cuban oil is in the deep waters of the Gulf of Mexico. Deep-water exploration is always risky and very costly. Attracting such a large investment for a naturally risky venture is difficult, quite apart from legal and political factors. While the remaining 4 billion barrels in deep water are the only hope for Cuba to become a net oil exporter and generate badly needed revenue, the quality of crude in these reserves might be detrimental to such hopes. Most of Cuban crude in the onshore fields is heavy with high sulfur content, which has limited uses. Heavy crude with high sulfur contents is usually cheap and sold at a large discount in the world oil markets. It is becoming less attractive as industrial countries impose stiffer environmental restrictions.

Several legal issues may slow down investment in the Cuban energy sector. A change in the legal framework is required to encourage investment, guarantee property rights, and create a suitable, fair, and stable tax system. Creating such a framework takes time and may face stiff domestic opposition under any political regime. Cuba has to resolve legal challenges that some US and other international firms pose to the development of certain oil and gas fields and some parts of the downstream sector. The nationalization of the foreign companies' assets about 4 decades ago without fair compensation entitles these companies to sue the companies that operate in their nationalized properties. For example, in 1996 a US company sued a Canadian consortium and the Canadian government for profiting from illegally seized oil drilling leases that it once operated in northern Cuba.⁴⁶

Several economic challenges may hinder Cuba's efforts to attract foreign investment. These include the ability to create fiscal and monetary policies that are hospitable to foreign investment, the ability to borrow from foreign institutions, privatization of government commercial enterprises, liberalization of markets, and reduction of government subsidies.

Cuba also has to deal with several political issues that may affect investment in its energy sector. These issues include US sanctions, the possibility of regime change in Venezuela, allegation of human rights abuses, the fate of Cuban expatriates, and the role of Cuban Americans.

46. "US Firms Sues over Cuban Oil Leases." *Knight Ridder* (July 3, 1996).

Changing the legal framework and moving toward a market economy may create social tension. Under such a change, the regime would have no choice but to lower subsidies and increase prices. The experience of countries in transition, and countries that partially opened their economies, indicate that the income gap between the poor and rich increases initially. Cuba has to deal with such a possibility in a way that prevents social unrest.

Despite encouraging steps in the development of renewable energy, it is still in its infancy. Most of the problems that face the development of renewable energy are technical and financial. Most of the renewable energy technology was not designed for tropical climates, and Cuba's researchers are not yet able to solve this problem. In addition, Cuba is not able to finance these projects and the R&D needed to develop and improve these projects.

Finally, detailed data on Cuba's energy sector is scarce. The problem became more severe when IOCs could not find significant oil deposits in the Cuban waters. Drilling and more seismic studies can provide better information to attract foreign investors. The Cuban government may need to start the initial phase of data collection on its own to present to the IOCs in an effort to attract investment.

Conclusions

Cuba offers unique opportunities. Based on historical energy trends in Cuba and countries in transition, and based on trends in IOC's investments, energy consumption and production in Cuba can only grow. Historical trends in Cuba confirm this point. Since Cuba suffers from one of the lowest levels of per capita energy consumption in the world and has one of the lowest levels of cars per capita in the world, consumption may grow faster than production and imports to the extent that Cuba may face energy shortages and possibly an energy crisis.

Under any scenario, several investment opportunities exist in the Cuban energy sector. These include renewable energy. During any sort of transition, energy production, consumption, and investment will boom. Even if US sanctions remain, Cuba will likely become a net oil exporter. Regardless of the political future of Cuba, lifting US sanctions alone will speed up the development of Cuba's energy sector and increase its energy production, especially of oil and gas. However, several countries (Iran, Iraq, Libya, Sudan, and Syria) developed their energy sectors despite sanctions.

Under any scenario, Cuba will face several challenges. Technical challenges include the remote location of its offshore fields and the low quality of its crude. They also include lack of advanced deepwater technology and shortage of qualified personnel. Economic challenges include lack of funding

and difficulty in attracting foreign investment. Legal challenges include establishing a legal framework that encourages investment, creates a fair and stable tax system, and protects property rights. They also include settling property rights issues with foreign oil companies that lost their assets to nationalization. If Cuba moves toward a market economy and goes through a transition, additional challenges will emerge. The most important transitional challenges would be the political, economic, social, and legal ramifications of liberalization and privatization of its energy sector. The increase in energy demand during a transition and how to meet such a demand is another important challenge with which any future government must deal.

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