ASSESSMENT OF HAITI'S ELECTRICITY SECTOR

MARCH 2018

Boston University Institute for Sustainable Energy

TABLE OF CONTENTS

ACKNOWLEDGMENT

This report was authored by Richard Stuebi (Senior Fellow) and Jennifer Hatch (Research Fellow) of the Institute of Sustainable Energy (ISE) at Boston University. All opinions presented herein are those of the authors.

This report was produced in collaboration with EarthSpark International, a non-governmental organization with which ISE has partnered in conducting this research.

The report is based on literature reviews and research conducted between October 2017 and January 2018.

Feedback on earlier drafts of the report was provided by Dr. Peter Fox-Penner (Director) and Dr. Jacqueline Ashmore (Director of Research and Outreach Activities) of the ISE, and by Allison Archambault (President) of EarthSpark International.

Funding for this research was provided via a generous gift from Jay Cashman.

INTRODUCTION

This report summarizes the current state of the electricity sector in Haiti, to form a knowledge base from which to subsequently evaluate options for how best to increase electricity access in Haiti.

Accordingly, this report summarizes the results of an extensive review of the publicly-available information on the electricity sector in Haiti, supplemented by targeted interviews with selected individuals known to be knowledgeable about electricity in Haiti based on their recent involvement in assessing the sector or in pursuing/supporting development opportunities.

No interviews were conducted with representatives of:

- Electricité d'Haïti (EDH), the company that serves as the *de facto* monopoly service provider of electricity across Haiti, or
- Any part of the Government of Haiti (GOH), which owns EDH, or
- Any part of the U.S. government or other multinational agencies that provide aid to the GOH

This assessment was limited to profiling the activities of the primary entities involved in multi-customer electricity grids in Haiti. These can be grouped into three main categories, which also serve as the three main chapters of this report:

- The monopoly utility, EDH
- Independent power producers (IPPs) that generate and sell electricity to EDH
- Developers of independent microgrids in locations not served by EDH

Additionally, other approaches exist for providing electricity services to individual customers in Haiti – either generation/storage systems that supply a wired building or compound, or stand-alone unwired electricity devices (e.g., solar lanterns) enabled by generation/storage – but these were not evaluated for this study.

A final but important caveat: the availability of data regarding the status of the electricity sector in Haiti is very limited, and what data that exists is of uncertain or poor quality, with considerable conflicting information. As a result, subjective judgment was often required in interpreting and drawing conclusions, and whenever possible, multiple sources of information were used for triangulation purposes.

ELECTRICITE D'HAITI

Status and Legal Basis of EDH and Alternative Suppliers

Founded in 1971 when the Government of Haiti (GOH) nationalized the company and the assets that previously had been established for electricity service in Haiti, Electricité d'Haïti (EDH) is a vertically-integrated electric utility, owning and operating generation, transmission and distribution assets, and responsible for delivery and sales of electricity throughout Haiti.

Electricity service in the Port-au-Prince (PAP) metropolitan area is provided by EDH through a centralized grid, with about 200 MW of connected generating capability. Outside of the PAP area, electricity service is very scarce, with roughly 10 regional grids each of 2-20 MW in size operated by EDH serving some of the larger towns and nearby areas, plus roughly 30 village-level grids each with less than 500 kW of generating capability. Although data is very imprecise, only about 20-40% of all Haitians have some access to electricity through EDH – and even then, no-one receives reliable electricity service from EDH on a 24/7 basis.

As a state-owned enterprise, EDH reports to the so-called "Energy Cell" within the Ministry of Public Works, Transportation and Communication (MTPTC).

In spite of some decrees and practices to the contrary, EDH has generally been viewed as possessing monopoly rights to produce, transmit and distribute, and sell electricity nationwide. This monopoly right was confirmed by a decree on August 20, 1989, though the fact that such an action was necessary at all indicates ambiguity about the reality of EDH's monopoly position.[i] Somewhat paradoxically, the 1989 decree also appears to have allowed EDH to outsource electricity production to private parties.[ii]

In any event, beginning in 1996, some new power generation assets have been developed by independent power producers (IPPs), which financed these projects based on long-term power purchase agreements (PPAs) signed with EDH.[iii] Today, the majority of electricity generated in Haiti is supplied by IPPs rather than from EDH generation assets.

Moreover, as discussed below, a number of "microgrids" are being developed by independent enterprises to provide electricity service in rural communities never reached by EDH. These initiatives were enabled by a decree issued in 2006 allowing local communities not yet served by EDH to forge their own agreements with other entities for providing electricity service.[iv]

Compounding the lack of clarity about EDH's actual monopoly rights, there historically has been no regulatory agency overseeing EDH.[v] Accordingly, EDH has essentially acted as its

own regulator, making most decisions unilaterally regarding investments, operations, finances and prices.[vi] Perhaps in part due to this lack of accountability, as discussed further below, very little EDH financial data is officially published, and even electricity tariffs (prices) remain unpublished, thus producing much ambiguity about the true economics of electricity provision in Haiti.

The latest draft of a National Energy Policy for Haiti, written in 2012, articulates a vision to expand and improve energy services by reforming the country's regulatory and institutional framework and developing renewables alongside fossil fuels. It includes targets for 2020 in the three key categories of energy efficiency, renewable penetration, and electrification. However, the policy was not enacted.[vii]

The National Development Plan for the Energy Sector cites as a major challenge a lack of coordination within the GOH – specifically between EDH, the MTPTC, the Ministry of Economy and Finance, the Ministry of the Environment, and the Bureau of Mines and Energy. Stakeholders report spending a great deal of time struggling to begin constructive dialogue and reach consensus on any significant energy-related matter, in part because each player has its own distinct objectives and vested interests.[viii]

In February 2016, a decree was issued indicating the intention of establishing a regulatory agency, l'Autorite Nationale de Regularization du Secteur de l'Energie (ANARSE), though no effective action to implement this declaration was immediately taken, presumably because the GOH transitioned through multiple Presidents in relatively quick succession.[ix] On October 31 2017, under the current President of Haiti (Jovenel Moïse), the GOH announced the funding of ANARSE and the appointment of its first leader, Evenson Calixte.[x]

Assuming that ANARSE gets fully established in an effort to bring some discipline to the Haitian electricity sector, it will face a massive challenge. Outside observers generally consider EDH to be in very poor financial and operational condition, beset by management and staff that is corrupt and incompetent, operating under a political and governance umbrella of high ambiguity. The recent Haiti Priorise effort undertaken by the Copenhagen Consensus Center (with financial support from the Government of Canada) concludes that "the World Bank, IDB and US AID have failed in all attempts to improve [i.e., reform] the power sector" in Haiti.[xi]

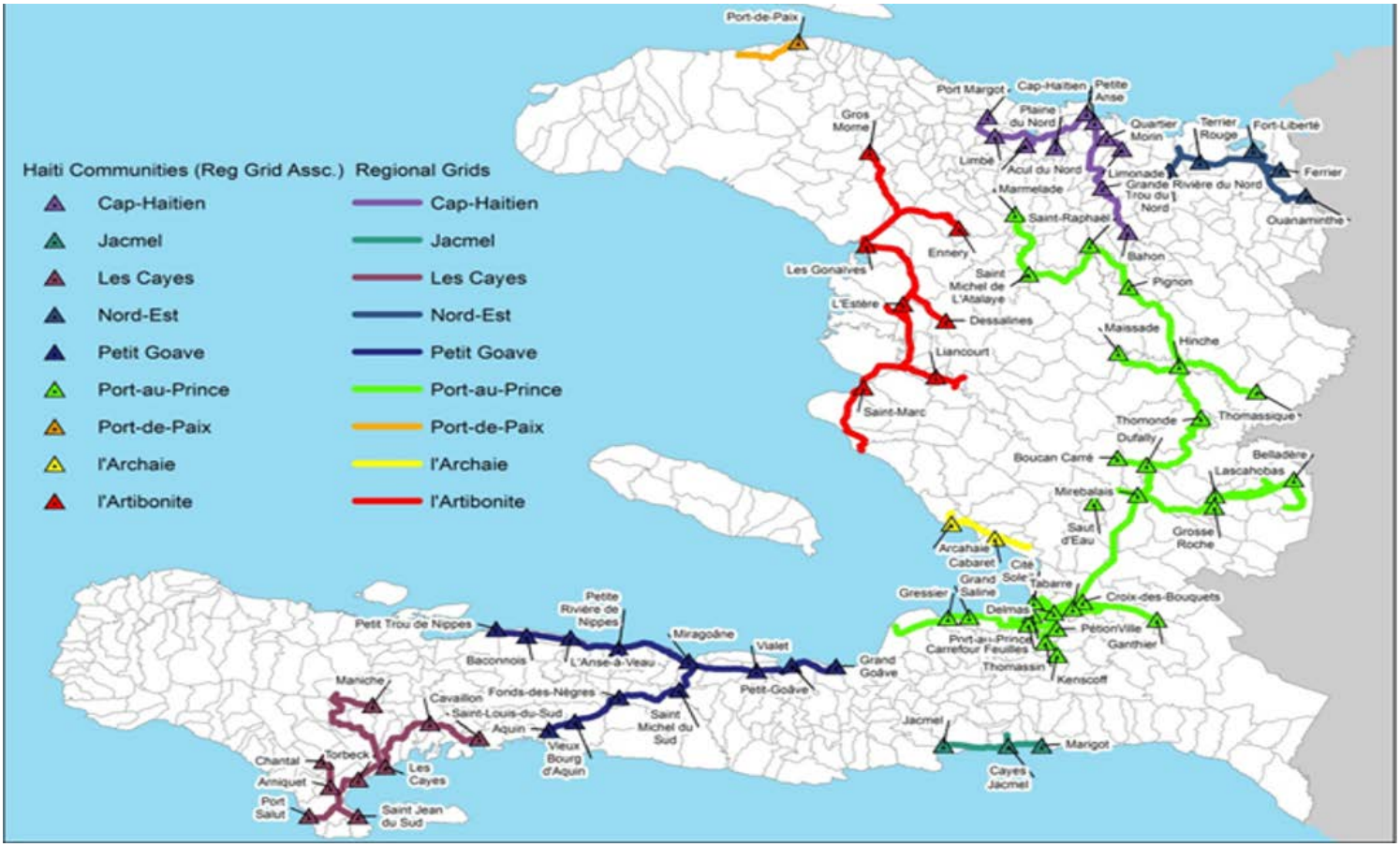
All of these factors make EDH exceptionally difficult to understand or work with in an effective manner.

Overview of EDH System and Operations

As of early 2014, EDH reported employing a staff of 2,544 to serve 240,444 customers nationwide, in a country with a population of about 10.5 million people.[xii] Across Haiti, EDH owns about 140 MW of generation assets, and roughly 1,700 km of transmission and distribution lines. Annual sales of electricity by EDH are estimated to be approximately

500 million kWh. Annual revenue collected from customers is estimated to be on the order of $50 million, which would suggest an average realized revenue of $0.10/kWh.[xiii] On top of this revenue, EDH receives subsidies from the GOH, which are estimated by some observers to be as high as $250-300 million per year.

By various measures, about two-thirds of EDH's operations are related to the ownership and management of an integrated power grid of approximately 200 MW primarily serving the PAP metropolitan area (shown in green in the map below). In addition, outside PAP, EDH owns and operates about 10 other isolated small (< 20 MW) power grids serving a few of the larger towns scattered throughout the rest of the country (also shown in the map below), plus about 30 very small (< 500 kW) village-level grids (not shown in the map below).



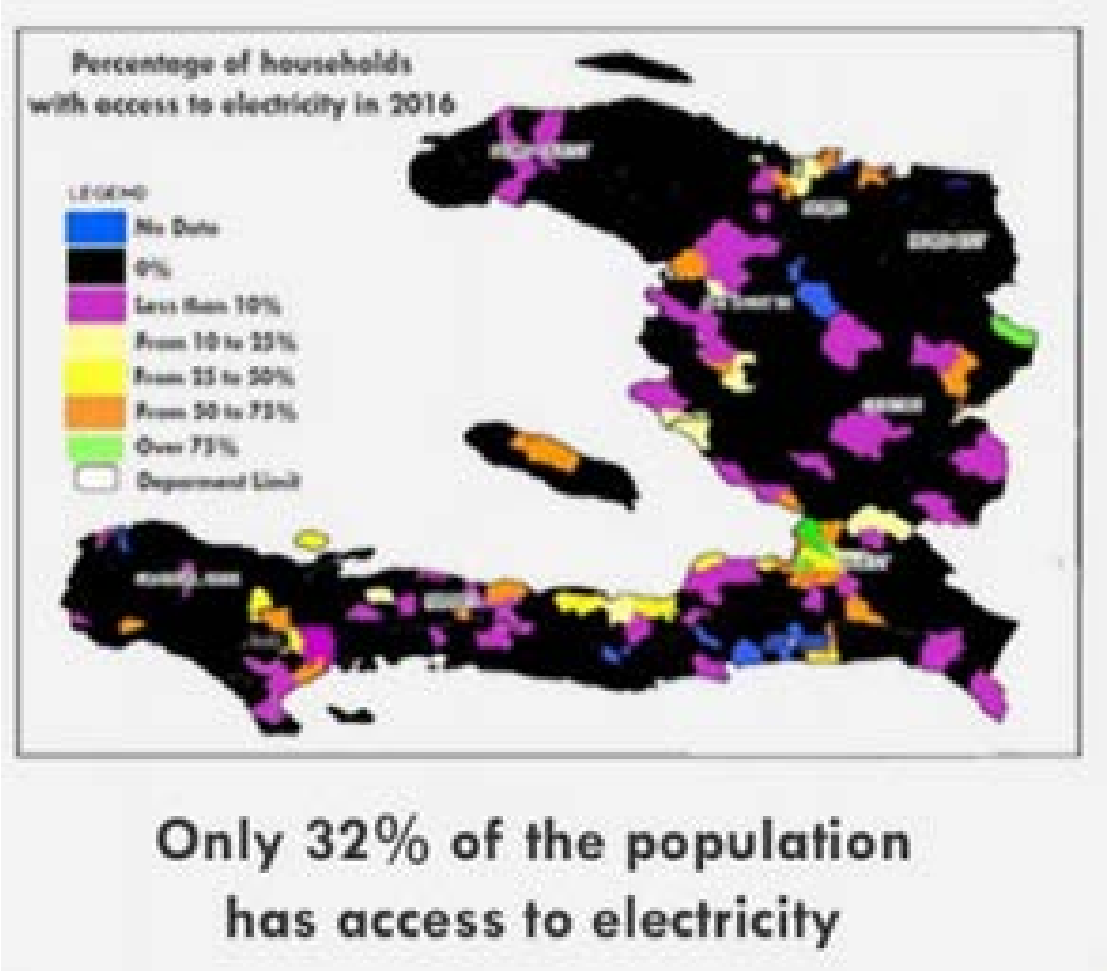
Source: "Electrifying Haiti With Intelligent Investment in Community Solar Minigrids", presentation by Navigant at Haiti Sustainable Energy Forum", June 12-13, 2017

At an estimated 36 kWh annual electricity consumption per person, Haiti's per capita use of electricity is the lowest in the Caribbean, and one of the lowest in the world.[xiv] By comparison, Haitian electricity use is only 2% of per capita levels in the neighboring Dominican Republic.

Only a minority of Haitians receive electricity service. Because of poor metering and data collection, the exact proportion of Haitian population served by EDH is unknown. Although EDH reports somewhere around 250,000 customers, some believe that as many as 600,000 households are actually connected to EDH lines.[xv]

Most published estimates suggest that somewhere between 20% and 40% of Haitian households have some access to electricity. In the PAP area, which is by far the largest population and commercial center in Haiti, EDH serves an estimated 72% of households. In contrast, only about 15% of rural households have access to electricity.[xvi]

In the map below, note the tiny fraction of area shaded green – primarily the most developed parts of the PAP metropolitan region – the only places in Haiti where over 75% of households have electricity access. Note further the prevalence of areas shaded in purple or black indicating effectively zero electricity available. Admittedly, many of these unelectrified regions have very low population density and little economic activity, in part because the terrain is so mountainous.



Source: "Haiti Microgrids", presentation document by OK Haiti, November 2017

Where EDH serves customers, it does not mean they receive electricity 24 hours a day, 7 days a week. Quite the contrary: in general, it is reported that most customers served by EDH only receive power about 5-20 hours per day, due to a variety of factors (discussed further below).

Because of the poor availability and reliability of power supply from EDH, a large proportion of industrial and large commercial customers across Haiti have installed diesel generators on their premises. As of 2010, all 23 registered textile manufacturers in Haiti had installed generators on site.[xvii] This trend towards self-reliance for electricity has apparently accelerated in the past two decades. The aggregate capacity of customer-sited generators in Haiti is at least 200 MW and possibly as much as 500 MW, which would be more than the capacity of the generation resources under EDH's direct control.[xviii] EDH estimates that there are 50,000 diesel gensets in PAP alone.[xix]

Regarding prices for electricity service from EDH, there is considerable ambiguity, as tariffs do not appear to be published. And, because there is no regulatory authority to provide transparency to the process of price-setting, it is unknown how closely electricity prices reflect EDH's actual cost structure.

From various publicly-available sources, it is generally reported that electricity prices from EDH are in the range of $0.25-0.40/kWh. For instance, in 2015, NREL indicated the following price levels for different customer classes:

- Residential: $0.28/kWh
- Commercial, Public Authorities and Public Lighting: $0.37/kWh
- Industrial: $0.39/kWh

However, perhaps reflecting recent depreciation of the Haitian currency (the Haitian Gourde), some observers claimed in interviews that actual prices for electricity service from EDH are in fact somewhat lower, with residential prices possibly as low as $0.14/kWh.[xx] Indeed, review of EDH electricity bills from October 2017 to a residential customer and to a commercial customer suggest that prices more accurately can be said to be on the order of $0.15-0.25/kWh:[xxi]

	Residential	Commercial
Monthly charge	$2.61	$2.61
Energy charge: 1st 30 kWh	$0.120/kWh	$0.201/kWh
31-200 kWh	$0.126/kWh	$0.234/kWh
> 200 kWh	$0.222/kWh	$0.250/kWh
Total bill	$83.59	$36.90
Total consumption	452 kWh	152 kWh
Average price	$0.185/kWh	$0.243/kWh

Source: BU ISE analysis (EDH bills provided by EarthSpark International)

Meanwhile, EDH's average costs for electricity generation (both EDH-owned and purchased from IPPs) have been recently estimated at $0.32-0.39/kWh, reflecting the costs of oil-based fuels, all of which are imported.[xxii] Fossil fuel imports for electricity generation represents 7% of annual GDP.[xxiii] Moreover, fuel purchases are made in US dollars while EDH revenues are collected in Haitian Gourdes, which places additional financial strains on EDH as the local currency depreciates in value.[xxiv]

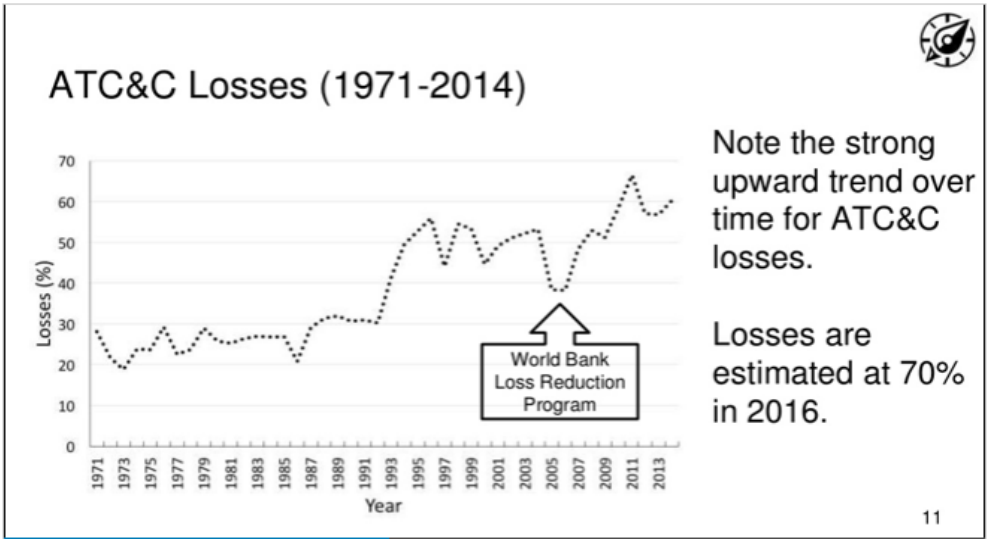
Electricity generation from EDH's Peligre hydro facility is likely to be much less costly than the indicated average, but is typically limited in practice due to a combination of degradation of the hydro turbines, silt accumulation, transmission limitations, and insufficient water flow during droughts and dry season.

With generation costs above average electricity prices, this means that EDH loses money on every kWh sold – even if there were zero losses, which is far from the case.

"Losses" – which in Haiti includes technical losses of generated electricity during transmission and distribution, theft by unauthorized users, lack of payment (or persistent delinquency) from authorized customers, or "skimming" of proceeds collected from customers by agents working on behalf of EDH – are a major problem.

Theft is especially pervasive. The recent Haiti Priorise initiative indicates that stealing electricity from EDH may not technically be illegal, and further some thieves may actually resell electricity. Moreover, some EDH employees may be complicit in this theft.[xxv]

Virtually all observers suggest total losses in excess of 55%, with some observers estimating total losses to be as high as 80%. Moreover, evidence suggests that the magnitude of losses on the EDH grid is worsening, even after the World Bank launched a "Loss Reduction Program" about 10 years ago:



Source: "Institutional Reform", presentation by Limestone Analytics at Haiti Priorise Conference organized by the Copenhagen Consensus Centre, May 1, 2017.

Given the fact that generation costs are higher than average prices, and since 50-80% of electricity generated or purchased by EDH is unrecovered due to a combination of technical losses and theft, EDH consistently runs in fiscal deficit.

Shortfalls in EDH finances between revenues and costs are covered by subsidies from the GOH.[xxvi] EDH financial losses were recently estimated to be on the order of $200 million annually, equivalent to 4% of the national budget.[xxvii] Some observers believe the actual subsidies to be even greater, and public reports of estimated subsidy levels appear to be on an upward trend over the past several years.

As of the end of 2014, delinquent electricity bills from private customers to EDH were estimated at about $70 million. In addition, debt of municipalities (for public lighting) to EDH was estimated at about $30 million.[xxviii] A few years ago, it was estimated that 43,000 customers were behind in payments to EDH.[xxix]

Haitians agree that EDH is highly problematic. In 2007, a Governance and Corruption diagnostic developed by the World Bank found that approximately 70% of Haitian households classified the services of EDH as "poor" or "very poor".[xxx] EDH officially charges $65 to establish a new customer connection – or approximately 15% of the average per capita income in Haiti.[xxxi] Moreover, it can take several months to perhaps two years for EDH to complete the connection. In contrast, "black-market" service providers (often involving off-duty EDH employees) can unofficially make a connection much more quickly for an estimated $500.[xxxii]

In June 2014, the GOH launched an open call for operators interested in acquiring EDH's assets and rights in the Southeastern portion of Haiti. Apparently, there has also been interest by the GOH to expand such privatization efforts to other regions of Haiti, excluding the Port-au-Prince (PAP) metropolitan zone.[xxxiii] According to the U.S. Department of Commerce, a recent effort to attract investors for concessionary rights for electricity provision were unsuccessful, due to terms that were considered too onerous.[xxxiv]

Under the new leadership of President Moïse (who assumed power in February 2017), the GOH is reported to have indicated interest in making EDH reform and restructuring a higher priority.

As of early 2015, EDH was reported to be preparing a new Electricity Master Plan, to replace its last iteration from 2007, to be completed by late 2015.[xxxv] There is no evidence that this plan has ever been completed.

Metropolitan PAP Grid

With a population of roughly 2.7 million people, 25% of the national total, the PAP metropolitan area is by far the most important center of economic activity in Haiti. Over 136,000 of EDH's roughly 244,000 customers are connected to the PAP grid.[xxxvi] Most industrial, institutional and commercial customers of electricity in Haiti are located in the

PAP area. Correspondingly, the electricity grid serving the PAP metropolitan area is the main asset and focus of operations for EDH.

As shown in the table below, the total nameplate capacity of the generation base supplying the PAP grid is approximately 230 MW.

GENERATION ASSETS ON PAP GRID

Plant name	Owner	Fuel	Type	# of Units	MW per Unit	Total MW
Peligre	EDH	Hydro	Francis turbines	3	15.5	46.5
Carrefour 1	EDH	Distillate	Pielstick PC2.5 generators	5	7.9	39.5
Carrefour 1	EDH	Distillate	Pielstick PC2.6B generator	1	10.3	10.3
Carrefour 2	EDH	Distillate	Hyundai generators	2	9	18
Varreux I	Sogener	Distillate	Wartsila generators	2	9	18
Varreux I	Sogener	Distillate	Wartsila generators	2	5	10
Varreux I	Sogener	Distillate	Wartsila generator	1	10.3	10.3
Varreux II	Sogener	Distillate	Wartsila generators	4	3	12
Varreux II	Sogener	Distillate	Caterpillar generators	2	4	8
Varreux III	Sogener	Distillate	Cummins generators	3	1.2	3.6
Varreux III	Sogener	Distillate	Cummins generator	1	2	2
Varreux III	Sogener	Distillate	Cummins generators	12	1.5	18
E Power	E Power	Heavy Fuel Oil	Hyundai generators	8	4.2	33.6
					TOTAL	229.8

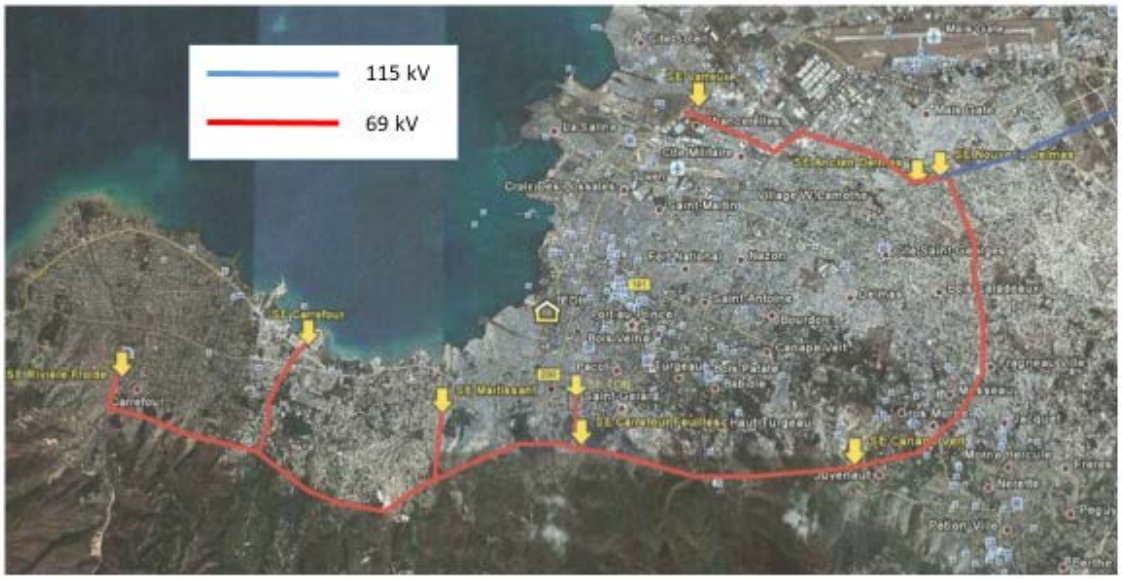
Source: EDH March 2014, Worldwatch, BU ISE analysis

From the above table, it can be seen that only about half of the capacity mix is actually owned by EDH, with the other half owned by two IPPs, Sogener and E Power. Further, about 80% of the capacity mix is oil-fired, with the exception of only the EDH-owned Peligre, a hydroelectric facility. The electricity actually generated from this capacity base is also reported to be approximately 80% oil-fired, 20% hydro (Peligre).

It should be emphasized that the effective operational capacity of the generation base on the PAP grid is somewhat lower than the capacity above, and is probably more on the order of 150-175 MW, due to a variety of technical (mechanical or electrical) issues.[xxxvii] In any event, Haitian generators are estimated to operate at a 25% capacity factor. Deteriorating condition of the generation base caused Haiti's electricity generation to decline more than 30% between 2004 and 2010.[xxxviii]

The central PAP commercial district is largely encircled by a 53 km 69 kV sub-transmission line (shown in red in the map below), serving as the backbone of the grid serving most of the load in the PAP area.

PAP DISTRIBUTION GRID



Source: Haiti Feasibility of Waste-to-Energy Options at the Trutier Waste Site, National Renewable Energy Laboratory and HDR Engineering for USAID, August 2014

This 69 kV ring is connected to the Peligre hydro facility, located 56 km northeast of central PAP, by a dedicated 115 kV transmission line.

The 69 kV ring circling PAP is comprised of nine substations, identified by the yellow arrows on the map above and listed in the table below. 900 km of 7.2/12.47 kV and 20 km of 2.4/4.16 kV distribution lines emanate from these substations.[xxxix]

PAP SUBSTATIONS

Substation	# transformers	Nominal power (MVa)	Primary/secondary voltage (kV)	# distribution circuits
VAR (Varreux)	4	10	69 / 12.47	6
CPV (Canapé-Vert)	3	25	69 / 12.47	5
TOB (Toussaint-Brave)	2	20	69 / 12.47	3
CAF (Carrefour-Feuilles)	1	4	69 / 4.16	2
	1	5	69 / 4.16	
RIF (Rivière-Froide)	2	15	69 / 12.47	3
MAR (Martissant)	2	10	69 / 12.47	3
ADM (Ancien Delmas)	2	28	69 / 12.47	7
CXM (Croix-des-Missions)	2	10	69 / 12.47	3
CXB (Croix-des-Boucquets)	2	10	69 / 12.47	2

Source: EDH March 2014

A tenth substation located at the relatively new (2011) E-Power IPP generation facility, just to the north of the top of the map shown above, is connected to the grid by a 72.5-kV transmission line.[xl]

Electricity dispatch on the PAP grid is performed in a very rudimentary fashion. The EDH dispatch center is antiquated, and according to one observer who visited in 2014, many of its controls and gauges appeared to be out of order. System frequency is managed manually, and instead of balancing being achieved by throttling generation up and down, load is shed and later reconnected by human operators at substations when called upon.[xli]

Until the 2010 earthquake, very little was known about the characteristics of the PAP power grid. The transmission system was mapped for the first time immediately following the earthquake and, as of late 2011, EDH still did not have the distribution system mapped. The map above was published by NREL only in 2014.[xlii]

The PAP grid is not capable of handling all of the available generation (which in turn is operating at well below nameplate levels), or in consistently serving demand for the entire connected customer base. In contrast to effective generation capacity levels approaching 200 MW, EDH's delivery capability in the PAP metropolitan area varies between 105 MW and 120 MW, depending on the current state of the system. Repair and upgrades of substations in the PAP area has been identified as a high priority to mitigate system deliverability constraints.[xliii]

In recent years, the World Bank has committed to investing $40 million in improving the transmission and distribution network in the PAP area, and the IDB and USAID is spending another $40 million on the rehabilitation of five substations in PAP: Canape Vert, Carrefour Feuille, Toussaint Brave, Croix-des-Bouquets, and Nouveau Delmas.[xliv]

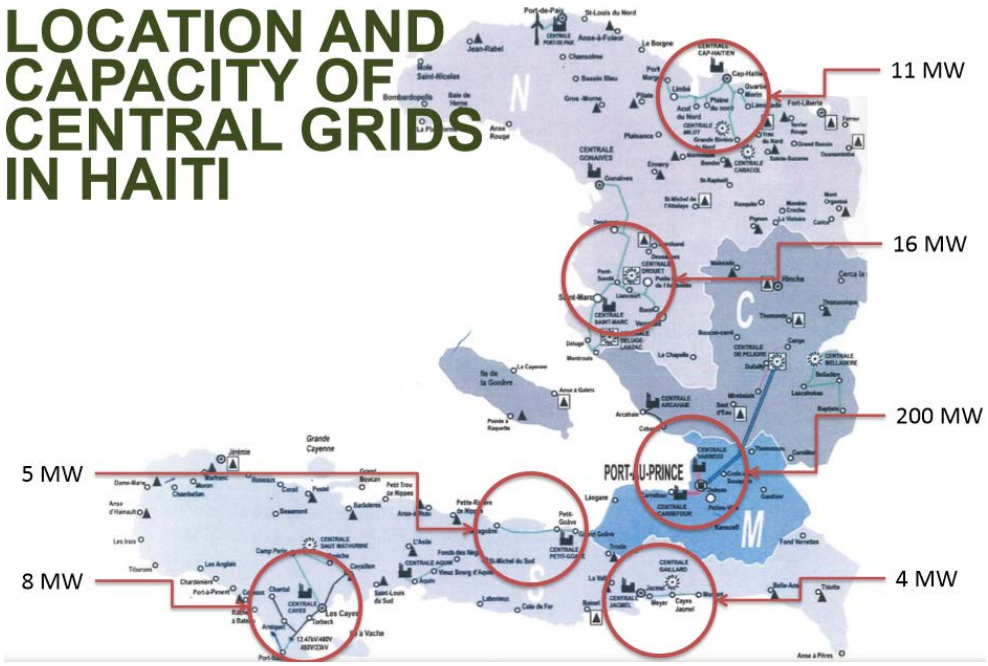
Meanwhile, demand levels on the PAP grid vary from about 75 MW overnight to about 120 MW during the day. However, this excludes electricity demand from customers who rely upon their own generation rather than buy from the grid, as well as the demand of customers that EDH interrupts to maintain system stability. When all are added together, the effective peak demand level of customers that are or easily could be served by the PAP grid is estimated at between 400-500 MW.[xlv]

According to data from January 2014 reported by EDH, the PAP grid serves 136,139 customers, of which 1,761 were industrial customers. In that month, 30.6 million kWh were sold, which translates to estimated annual sales of 367 million kWh (assuming no seasonality of electricity demand). In contrast, EDH reported that the PAP grid received 65.8 million kWh of generation in the same month, suggesting losses of 35.2 million kWh – equal to 53% of total electricity generated.[xlvi]

Regional and Village Grids Outside of PAP

As noted previously, Haiti does not have a single centralized transmission and distribution system. Rather, in addition to the main "Metropolitan" grid serving the PAP region, EDH operates about 10 isolated regional grids, and there are approximately another 30 villages throughout Haiti with very small grids serving only a few buildings.

The map and table below indicate most of the regional grids, each of less than 20 MW. These smaller local grids, based on 23 kV lines, serve some of the other larger population centers in the country, including Jacmel, Les Cayes, and Cap-Haïtien.[xlvii]



Source: "Energy Access in Haiti", presentation by EarthSpark International at World Bank 2017 Spring Meeting

Grid	Installed capacity (kW)	Available capacity (kW)	Number of active customers
Metropolitan	248,000	98,800	160,487
Centre (Onde-Verte)	650	500	788
Nord	14,400	10,500	17,435
Nord-ouest	2,500	2,200	3,557
Nord-est	5,750	4,500	4,540
Sud(Cayes)	11,600	7,600	21,246
Sud-est(Jacmel)	5,150	4,450	11,413
Sud-est(Bainet)	310	200	included in Jacmel
Artibonite	24,650	19,200	20,645
Grand-Anse (Jeremie)	2,450	2,200	3,327
Ouest(Arcahaie)	2,000	0	2,611
Ouest (La Gonave)	425	350	625

Source: SREP Investment Plan for Haiti, Climate Investment Funds, March 27, 2015

Because of the distances involved, the rough terrain and the low customer density, it is unlikely that economics will justify activity to connect the regional grids that already exist.

Excluding the PAP grid, EDH owns a reported 732 km of distribution lines, with the following regional distribution:[xlviii]

- Nord: 186 km
- Artibonite: 219 km
- Sud: 176.5 km
- Centre-Ouest: 150 km

As is presented in the table above, EDH serves roughly 86 thousand customers on these smaller regional grids. According to data from January 2014 reported by EDH, 11.6 million kWh were sold on these smaller grids, which translates to estimated annual sales of 139 million kWh (assuming no seasonality of electricity demand). In contrast, EDH reported that the regional grids received 24.7 million kWh of generation in the same month, suggesting losses of 13.1 million kWh – equal to 53% of total electricity generated.[xlix]

On the regional grids, the following generation assets are installed:

GENERATION ASSETS ON REGIONAL GRIDS

Grid	Facility	Capacity (kW)	Owner
Archaie	Archaie	2,000	EDH
Nord	Cap-Haitien	13,600	Sogener
Nord	Caracol Hydro	800	EDH
Nord	Trou du Nord	420	EDH
Jacmel	Jacmel	4,650	EDH
Jacmel	Gaillard Hydro	500	EDH
Jacmel	Bainet	150	EDH
Jeremie	Jeremie	3,650	EDH
La Gonave	Anse-a-Galets	425	EDH
L'Artonibite	Gonaives	13,600	Sogener
L'Artonibite	St Marc	2,500	EDH
L'Artonibite	Drouet Hydro (l'Estere Pont-Sonde)	2,000	EDH
L'Artonibite	Deluge Hydro (Montruis)	1,100	EDH
L'Artonibite	Gros Morne	250	Grid-assisted
L'Artonibite	Ennery	100	Grid-assisted

Grid	Facility	Capacity (kW)	Owner
Les Cayes	Cayes	10,000	Haytrac
Les Cayes	Saut-Matherine Hydro	1,600	EDH
Les Cayes	St Louis du Sud	100	Grid-assisted
Nord-Est	Chevry	5,750	EDH
Nord-Est	Fort-Liberte	500	EDH
Nord-Est	Mont Organise	175	Grid-assisted
Nord-Est	Ste Suzanne	80	Grid-assisted
Onde-Verde	Onde-Verde Hydro (Bellladare)	650	EDH
Petit Goave	Petite Goave	10,000	Haytrac
Petit Goave	Aquin	600	EDH
Petit Goave	Petite Riviere de Nippes	150	Grid-assisted
Petit Goave	Petit Trou de Nippes	150	Grid-assisted
Petit Goave	Anse-a-Veau	100	Grid-assisted
Nord-Ouest	Port-de-Paix	3,700	EDH
Nord-Ouest	Jean Rabel	500	Grid-assisted

Source: EDH March 2014

From the above table, there are about 80 MW of generation assets on regional grids, of which EDH owns roughly 25 MW. When these are added to EDH's generation ownership on the PAP grid, EDH is estimated to own about 140 MW of capacity across the entirety of Haiti.

In addition to the above generation assets connected to the regional grids, there are also roughly 30 village-level grids scattered across Haiti, serving customers in the "downtown" ("centre-ville") area of a village. A profile of three of these village grids is presented below:

	Coteaux	Port-a-Piment	Roche-a-Bateau
Operating since	1994	2009	2008
No. Customers	250	210	100
Nominal Schedule	7-10pm, Su, M, W, F, Sa	6-10pm Su; 7-10pm Tu, Th, Sa	7-10pm, 5 days/wk
Grid management entity	Volunteers affiliated with Mayor's office and paid EDH technician	Electricitè de Port-a-Piment (EDP)	Paid municipal staff in Mayor's office
Tariff	50 HTG/bulb (USD 1.22)	150 HTG (USD 3.66) plus 50 HTG/bulb (USD 1.22)	150 HTG (USD 3.66) plus 50 HTG/bulb (USD 1.22)
Disconnection penalty rule	3 months missed payments	3 months missed payments	3 months missed payments
Re-connection fee	Arrears	Arrears + 150 HTG (USD 3.66) penalty	Arrears + 250 HTG (USD 6.10) penalty
Typical Monthly Revenue	25,000 HTG (USD 610)	35,381 (USD 861)	24,000 HTG (USD 585)
Typical Monthly Costs	60,000 HTG (USD 1,463)	40,385 (USD 985)	30,750 HTG (USD 750)
Typical Monthly Shortfall	35,000 HTG (USD 853)	5,084 HTG (USD 124)	6,750 HTG (USD 165)
Typical Monthly Shortfall	5,084 HTG (USD 124)	35,000 HTG (USD 853)	6,750 HTG (USD 165)

Source: Microgrids for Rural Electrification, Carnegie Mellon University and University of California at Berkeley on behalf of the United Nations Foundation, February 2014

Electricity on these village grids is supplied by small diesel generators in the 60-350 kW range, as indicated in the table below:

GENERATION ASSETS ON VILLAGE GRIDS

Region	Village	Capacity (kW)
Gonave Island	Pointe-a-Roquettes	60
Nord	Dondon	150
Nord	Anse a Foleur	150
Nord	Pilate	100
Nord	Plaisance	60
Nord-Est	Capotille	100
Nord-Ouest	Bassin Bleu	350
Nord-Ouest	Chansolme	350
Nord-Ouest	Bombardopolis	200
Ouest	Arnaud	150

Region	Village	Capacity (kW)
Sud-Est	Anse-a-Pitre	150
Sud-Est	Thiotte	132
Sud-Est	Belle-Anse	100
Sud-Ouest	L'Asile	240
Sud-Ouest	Dame Marie	225
Sud-Ouest	Port-a-Piment	200
Sud-Ouest	Tiburon	150
Sud-Ouest	Anse d'Hainault	150
Sud-Ouest	Coteaux	125
Sud-Ouest	Roche-a-Bateau	100
Sud-Ouest	Baraderes	100

Source: EDH March 2014

It is claimed that many of the above-listed generators are operating without meters to measure their output.[l]

The operational, reliability and financial problems experienced on the PAP grid as described previously are magnified on the regional grids and (especially) the village grids, where EDH's exact role can be unclear.

Village grids tend to be owned by the municipality, rather than by either EDH, a private developer (if in a location not served by EDH), or the village itself. In some village grids, community involvement is present through a volunteer committee appointed by the mayor's office responsible for operations and maintenance. However, in most cases, the committee is made up of the mayor's staff or by a local NGO. In some cases, a technician paid by EDH who lives near these grids performs basic operations and maintenance.[li]

Since EDH does not perform detailed load assessments when planning, generators on the regional and village grids are often oversized for the loads they serve by a factor of two to three. As a result, generators tend to run at low set-points and thus consume fuel at very low efficiency, driving up operational costs.[lii] The average costs of generation from individual diesel gensets varies depending on their size and efficiency, but typically ranges from $0.40/kWh to almost $2.00/kWh.[liii]

Furthermore, reliability is low because modest maintenance issues (e.g., fuses, lubricating oil, gaskets) are often left untended due to shortages of funding. Poor service leads to customer non-payment, which in turn worsens service, which in turn increases non-

payment further, often leading to complete cessation of service for months. Political favoritism often influences which grids get better or worse service.[liv]

Set by local municipalities, village grid tariffs are highly insufficient relative to costs. Moreover, customers have three months to pay, and penalties (including service stoppage) are threatened, though not always enforced.

INDEPENDENT POWER PRODUCERS

Overview of Active IPPs in Haiti

Even though EDH technically has a monopoly on providing power for all of Haiti, most power sold by EDH is currently produced by independent power producers (IPPs).[lv]

The first IPP to sign a power purchase agreement (PPA) with EDH was Interselect SA in Cap Haitïen on the Nord grid in 1996.[lvi] The current status of Interselect is unknown, and as discussed further below, may have been taken over by or renamed Sogener.

Today, three companies with approximately 172 MW of total nameplate generating capacity, of which about 110 MW are located in the PAP area, have emerged as the leading IPP players in Haiti:[lvii]

- Sogener: Sogener is the largest IPP company in Haiti, with about 110 MW of generation: almost as much as owned by EDH, and roughly one-third of all capacity in the country. Sogener is wholly-owned by the Vorbe Group (reported to be one of Haiti's largest enterprises) and led by Jean Marie Vorbe.[lviii] In 2002, Sogener signed PPAs associated with two power plant developments outside of PAP, originally an 8 MW project at Cap Haïtien (possibly involving the transfer of the above-mentioned Interselect plant) and another 8 MW project at Gonaives on the Artibonite grid.[lix] The Gonaives plant is said to have been operating without a meter for several years.[lx] In addition, Sogener operates the Varreux power generation facility in PAP, with an aggregate nameplate generating capability of about 82 MW comprised of various Wartsila, Caterpillar and Cummins diesel gensets.[lxi] All three power projects have been significantly expanded in capacity in the past decade as a result of favorable financing terms provided from a tripartite aid agreement between Cuba, Venezuela and Haiti (sometimes referred to as PBM, an acronym for Petion-Bolivar-Marti, which these three power plants are sometimes called in honor of legendary political leaders from the three countries).

- E-Power. Founded by 56 Haitian citizens and Haitian-Americans in 2005 (led by Daniel Rouzier, a Haitian businessman), E-Power owns and operates a 31 MW heavy fuel oil diesel power plant located in the Drouillard, Cite Soleil section of PAP. E-Power sells power to EDH under a 15 year take-or-pay PPA signed in 2008, and was the first power project in Haiti to receive international funding, under a tendering process supervised by the World Bank and the IDB. The project was designed and built by Hyundai, commissioned in 2011, and employs a staff of 136. It is reported to be the most efficient and lowest-cost thermal power plant in Haiti, in part because it burns cheaper heavy fuel oil rather than more expensive diesel.[lxii] The

plant cost $57 million to build, of which the International Finance Corporation provided $17 million and FMO of The Netherlands provided $12 million.[lxiii]

- Haytrac: Founded in 1950, Haytrac (more formally, Haitian Tractor) is the Caterpillar distributor for Haiti. Although Haytrac's website makes no mention of it, Haytrac is widely reported to be an active IPP player, and appears to currently operate two power plants on regional grids in Southern Haiti: Petit-Goâve (10 MW nameplate, 6 MW operational) and Les Cayes (10 MW nameplate, 6 MW operational).[lxiv] A recent article suggests that the Les Cayes project has been operating under an expired PPA contract since 2012 or 2013.[lxv]

IPP Economics in Haiti

Absent very much publicly-available information, and consistent with the overall ambiguity of EDH finances and economics, the level of prices paid to the IPPs under PPAs is not completely clear.

A 2010 analysis conducted by Tetra Tech revealed base rates in the PPAs of between $0.16/kWh and $0.30/kWh, although fuel surcharges can drive the effective PPA price to be as high as $0.34/kWh.[lxvi] Perhaps reflecting these surcharges, various other accounts indicate that current PPA prices are on the order of $0.32-0.39/kWh.

On the other hand, E-Power indicates that its power sales to EDH in August 2017 were at an "average price" of $0.149/kWh, reflecting underlying production costs of $0.138/kWh, and that EDH resold the power from E-Power at $0.2254/kWh.[lxvii] Based on guidance from the World Bank, the PPA between E-Power and EDH is based on two components:[lxviii]

- A capacity payment, covering the costs of operation, maintenance and financing, which was $0.0548/kWh in August 2017
- An energy payment, based on the plant's heat rate (fixed in the contract) and the fuel cost (indexed to oil prices), which was $0.0942/kWh in August 2017

In any event, PPA prices are heavily tied to the prices of fuel, all of which is oil-based and all of which is imported into Haiti.

As of the summer of 2017, the variable generation cost associated with fuel burn was reported by Sogener to be $0.19/kWh.[lxix] This roughly corresponds to recent statements from EarthSpark International, which claims that the variable cost of IPP generation is $0.15-0.16/kWh for heavy fuel oil plants, and $0.22-0.26/kWh for diesel plants.[lxx]

IPP cash flows appear to be largely insulated from currency risk: both fuel payments made by IPPs to fuel suppliers and PPA payments made by EDH are dominated in US dollars. In contrast, currency risk is a key contributing factor to EDH's financial woes: while payments to IPPs are in dollars, receipts from customers are collected in Haitian Gourdes, which have depreciated significantly in recent years (from about 42 Gourdes per dollar in 2013 to about 63 Gourdes per dollar in late 2017).[lxxi]

As of 2013, EDH was reportedly paying $144 million each year to pay for 88 MW of electricity from IPPs.[lxxii] More recently, while the IPPs themselves estimate total payments from EDH at about $118 million in 2016, at least one senior GOH official has claimed that EDH payments to the IPPs were actually $250 million per year.[lxxiii]

EDH's financial strains appear to be placing burdens and risks on the IPP companies. EDH's stock of arrears with IPPs at end 2014 was estimated at $144 million (1.5% of GDP), while those with PBM (the counterparty underlying the Cuban/Venezuelan/Haitian tripartite trade agreement) were estimated at $142 million (1.5% of GDP). Arrears of IPPs and PBM for fuel purchases were estimated at about $220 million (2.4% of GDP).[lxxiv]

E-Power ceased operations for three months in 2013 due to lack of payment from EDH, which was then in arrears by $12 million.[lxxv] One observer commented that payments to the IPPs are now actually being made by international debt guarantors, as EDH has been unable to make these payments on their own.[lxxvi]

In any event, there has been considerable public controversy in Haiti recently about the payments made to the IPP companies for the power they produce. Several articles and letters to the editor appeared in the press in September 2017 complaining that the prices paid to IPPs under the terms of PPAs are too high.

The Future for IPPs in Haiti

There are a number of opportunities related to future IPP activity in Haiti that, on paper at least, appear to have economic merit. Alas, none appear to be active at present.

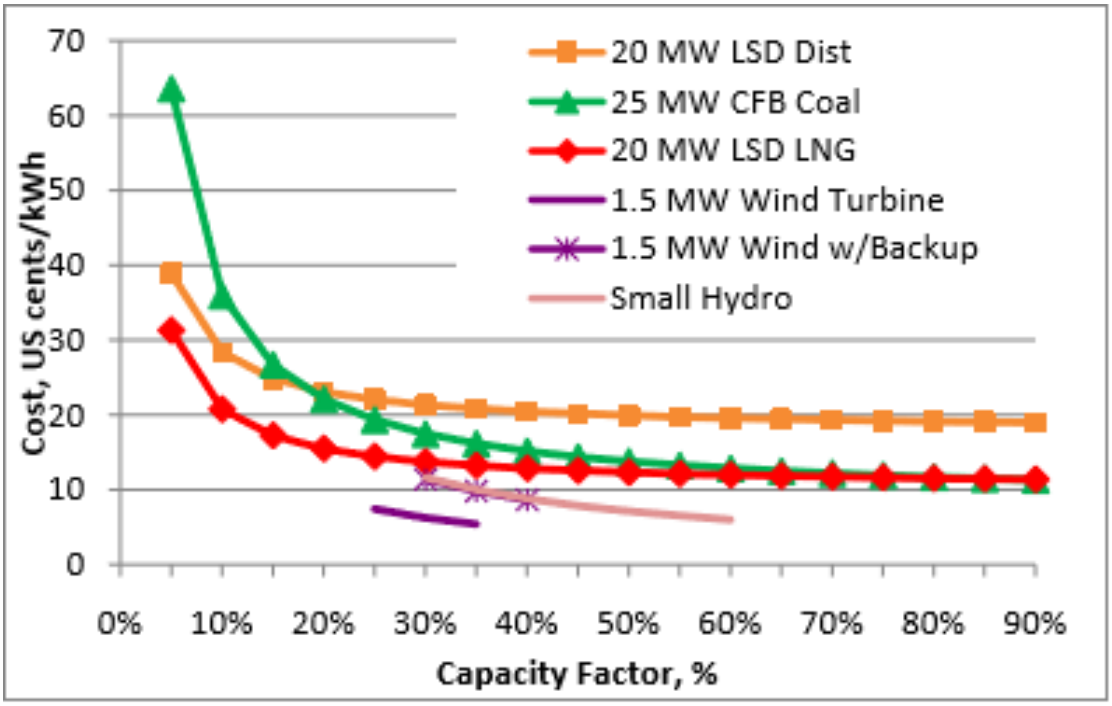
First, the existing IPP generation fleet – all based on petroleum-based fuels – could theoretically be converted to liquefied natural gas (LNG) or liquefied petroleum gas (LPG, also known as propane) to achieve both economic and environmental benefits.

In addition, given the sizable deficit between available generating capacity and electricity demand levels, there should be impetus for development of new IPP capacity in Haiti – whether based on cheaper and cleaner LNG/LPG, or based on renewable energy resources such as hydro, solar or wind.

Although Haiti domestically produces no hydrocarbons of any type, it may be economically attractive to develop infrastructure in Haiti that would allow importation and storage of LNG or LPG, given the low prices now available from U.S. exports of LNG and LPG as a result of abundant gas and gas liquids production from shale resources.

In 2013, Haytrac contracted with the engineering firm GasEner to develop a plan to construct a $123 million LNG import facility 14 km north of PAP, to support a new 40 MW power generation facility, as well as pipelines that would supply central PAP and a truck terminal to enable shipment of LNG to seven other cities around Haiti.[lxxvii] After a limited amount of construction, it appears that the LNG infrastructure project has progressed little if at all since 2014.

On behalf of the World Bank, Nexant conducted an analysis in 2011 indicating the superiority of LNG over other fossil fuel options for new power generation:[lxxviii]



Source: Caribbean Regional Electricity Supply Options, World Bank, 2011

As attractive as LNG may be as an option for Haiti's electricity sector, renewable energy options are likely to be even lower cost.

Rather than expanding Haiti's reliance on imported fuels for electricity production with additional fossil generation, a strong case can be made for the development of incremental generating capacity that leverages abundant renewable energy resources available in Haiti. It is widely known that substantial opportunity exists in Haiti to develop renewable energy

to produce electricity at lower cost than is now available from the current fleet of power generating capacity. According to estimates produced by Worldwatch in 2014:[lxxix]

- Over 100 MW of incremental hydroelectricity potential can be developed in Haiti, with costs as low $0.05/kWh
- Only six square km of solar PV would be required to produce as much electricity as is currently generated in Haiti, with costs estimated to be on the order of $0.11/kWh
- Also at costs of approximately $0.11/kWh, viable wind energy resources are also available to be developed at several locations in Haiti

Unfortunately, neither conversion of existing IPPs to lower-cost LNG/LPG or development of new generation capacity – whether fossil or renewable – appear to be actively under consideration at present.

No official forward-looking electricity resource plan from either EDH or GOH has been developed for many years, so there is no current official consensus view outlining how future electricity needs in Haiti will or should be met.

Although the lack of such a plan prevents any definitive statement, it is not believed that any IPPs – either the above three companies or any new entrants – currently have serious plans afoot to expand the Haitian power generation base, either from renewable resources or by building more fossil-fired generation.

The absence of tangible future plans by IPPs in Haiti reflects several factors:

- The precarious state of EDH's finances. Given EDH's history of sometimes being unable to make PPA payments to IPPs, any project developer or financial sponsor would have significant concern about EDH's ongoing ability to pay. With a counterparty of such poor credit rating as EDH, it will be very difficult to finance any new capital outlays associated with privately-owned power generation in Haiti.

- The apparent shift of multinational agency lending strategy away from IPP development. As is evident from the above, both Sogener and E-Power received substantial financial support and/or assurances from international financial aid sources to backstop the PPAs. However, it appears that these agencies (and their peers) have become less enthusiastic about lending to new IPP-related opportunities in Haiti – perhaps because the financial burden borne in recent years by these loan guarantors to make payments to pre-existing IPPs has been much higher than anticipated. Instead, the strategy for organizations to lend into the

electricity sector in Haiti now appears to be focused mainly on microgrid development of the type discussed in the next chapter (and to some degree a continuation of efforts to reform EDH), as typified by the World Bank's recent Renewable Energy For All program.

- The inability for EDH to manage well the generation it currently sources for its grid operations. As noted previously, EDH dispatches the electricity system very crudely, which results in many hours when EDF must keep power plants shut down even when plenty of demand exists. Indeed, it is reported that a French developer named Valorem ceased planning efforts on a wind project in Haiti a few years ago because assurances could not be made that EDH would be able to accept power from the windfarm on an as-available basis.[lxxx]

- The recent controversies about PPA payments from EDH to IPPs. In addition to producing unfavorable publicity for IPP companies, this development suggests that pressure may be building to revise PPA prices downward, which is a major disincentive for IPPs (or their financial backers) to committing any further capital to Haiti.

- The continuing depreciation of the Haitian currency, the Gourde. As long as loans for major energy projects are denominated in foreign currencies, and the underlying revenue streams from Haitian energy customers are based in Gourdes, currency movements will make it difficult to finance any long-term capital-intensive project that requires more than a very short period of time to pay back the initial investment.

- The uncertain nature of the future Haitian electricity regulatory regime – particularly in light of the recent announcement to create ANARSE – creates regulatory risk that any previously-negotiated agreements might be subject to alteration. Moreover, no precedents yet exist as to how ANARSE will make decisions with respect to any future agreements that might be negotiated between an IPP and EDH. For the meantime, it is likely that IPP players will wait for more clarity on how ANARSE will be implemented and how it will act on key matters.

As a result of these various factors, the myriad economically-attractive opportunities for IPPs in Haiti remain untapped. While the current *status quo* for the existing IPPs may be tenable, uncertainties are significant enough to prevent any major new thrusts to be pursued by the private sector – current players or new entrants.

INDEPENDENT MICROGRIDS

Introduction to Microgrids in Haiti

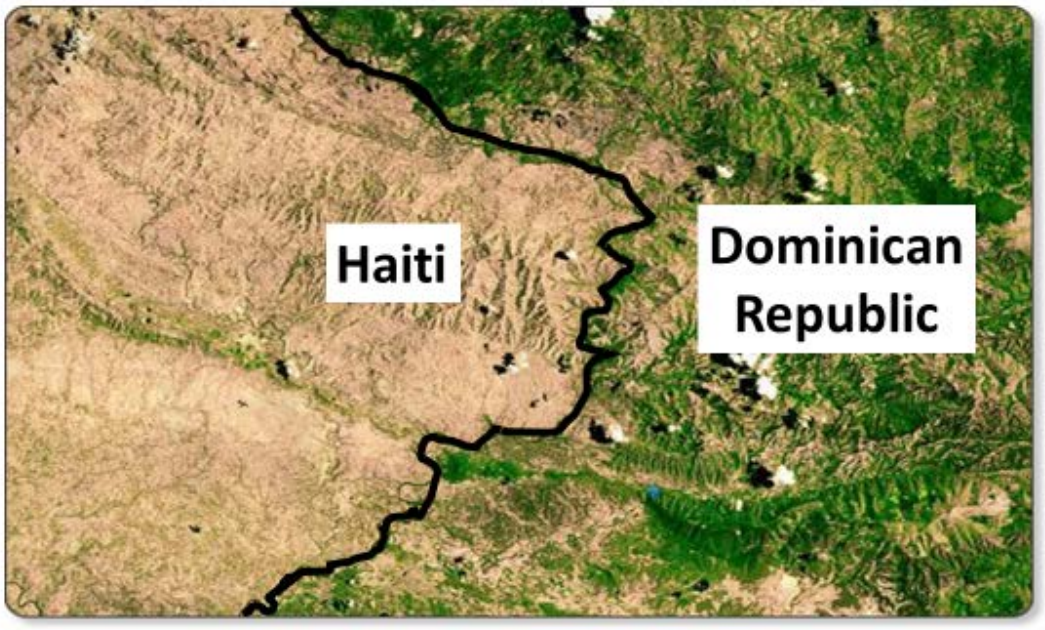
Haitian citizens that have little or no electricity access rely heavily on charcoal or wood burning and kerosene to meet their energy (primarily cooking and lighting) needs. Alas, these approaches for meeting household energy needs have many negative aspects:

- They are unhealthy and unsafe for households: burning kerosene, charcoal and wood have been demonstrated to significantly increase morbidity and mortality – not only from smoke inhalation, but also due to fire risk.

- They are burdensome: gathering wood is time consuming, and kerosene, candles and charcoal are very expensive to buy. According to research by EarthSpark International, the average rural small-town Haitian household spends an average of $10/month (6.5% of income) on kerosene and candles for home lighting.

- They don't provide energy suitable to power many essentials taken for granted in the developed world in the 21st Century: refrigeration of food/medicines, computer use, Internet access, television, etc.

- They are environmentally damaging: charcoal production and wood gathering results in deforestation, and emissions from burning wood, charcoal and kerosene are both bad for local air quality and a significant contributor to global climate change. To illustrate, the Stockholm Environment Institute estimates that electrifying a cookstove in one rural household can reduce CO_2 emissions by about 1-3 tons per year, implying a multi-million ton CO_2 emission reduction opportunity across Haiti if significant conversion to electric cookstoves can be achieved.[lxxxi] With regards to the issue of deforestation, the satellite image below shows how badly foliage has been denuded in Haiti, relative to the neighboring Dominican Republic; only 3% of original forestland remains in Haiti.[lxxxii]



Source: "An Uncertain Road Ahead for Haiti's Cooking Fuel Sector", blog post by Matt Lucky on Worldwatch Institute website, February 15, 2012

For a crushingly poor country such as Haiti, the economic consequences of these inferior approaches for household energy supply are significant. When expenditures on primitive fuels are converted on an equivalent basis to electricity prices as typically denominated, the extraordinarily high costs becomes clear: approximately $20.00-45.00/kWh for kerosene lighting (depending upon whether a CFL or LED), respectively, and $60.00-115.00/kWh for cell-phone charging (depending on the size of the phone battery).[lxxxiii]

Recognizing the humanitarian need to provide electricity access, the environmental benefits to enabling electrification of cooking, and the market opportunity in providing energy services at lower costs than the demonstrated willingness to pay amongst rural populations, many organizations have started independent microgrid projects in areas not serviced by EDH-run grids.

Defining elements of an independent microgrid in Haiti include:

- A grid connecting multiple customers to a set of electricity generation resources (often complemented by batteries to provide storage for backup)
- No or very restricted involvement of EDH
- Pay-as-you-go (PAYG) meters

PAYG meters are an essential element of the business model for a financially-viable microgrid, for three reasons:

- Elimination of credit risk, given the reliance on serving customers that are very poor and, unfortunately but inevitably, have high likelihood of payment delinquencies or defaults
- Reduction of working capital requirements, by eliminating the "float" between service provision and payment
- Reduced operational costs, by avoiding a variety of meter-reading, billing, and collections activities

One of the most challenging aspects of microgrid development is how to surmount the fixed costs of building and maintaining the system to even be able to offer basic service levels to customers. No matter how small the microgrid is, fixed costs are non-trivial. Indeed, on a relative basis, smaller microgrids are the most difficult to finance, as they offer fewer customers and electricity sales over which to spread the fixed costs. Yet, these fixed costs need to be recovered by receipts from customers (often augmented by subsidies or grants), independent of how much electricity is used.

Alas, the concept of "electricity customers" in as-yet unelectrified villages is daunting. Households in such villages have zero pre-existing ability to consume electricity: having never had access to an electricity grid, they literally possess no devices that rely on electricity. Even if a grid were brought to them, they probably cannot afford to buy appliances: households in these villages tend to be extremely poor, and while money is spent regularly on consumables like kerosene, credit facilities don't exist to provide loans to finance the purchase of capital-intensive electricity devices.

Thus, microgrids tend to start small, with few customers and small loads at each customer. PAYG is a critical element of an enabling financing strategy that supports a virtuous growth cycle. With PAYG, payments are secured from new customers (or from existing customers that want to consume more electricity) to help fund the growth of a grid until it reaches a self-sustaining level of ongoing revenue from sufficient levels of demand from enough customers to cover the system's fixed costs.

In addition to PAYG, successful microgrid development in Haiti also requires gaining the ability to proceed with minimal or no involvement from EDH, for the reasons discussed above.

Developing a microgrid independently of EDH necessitates first securing appropriate support from both local community leaders and the central GOH.

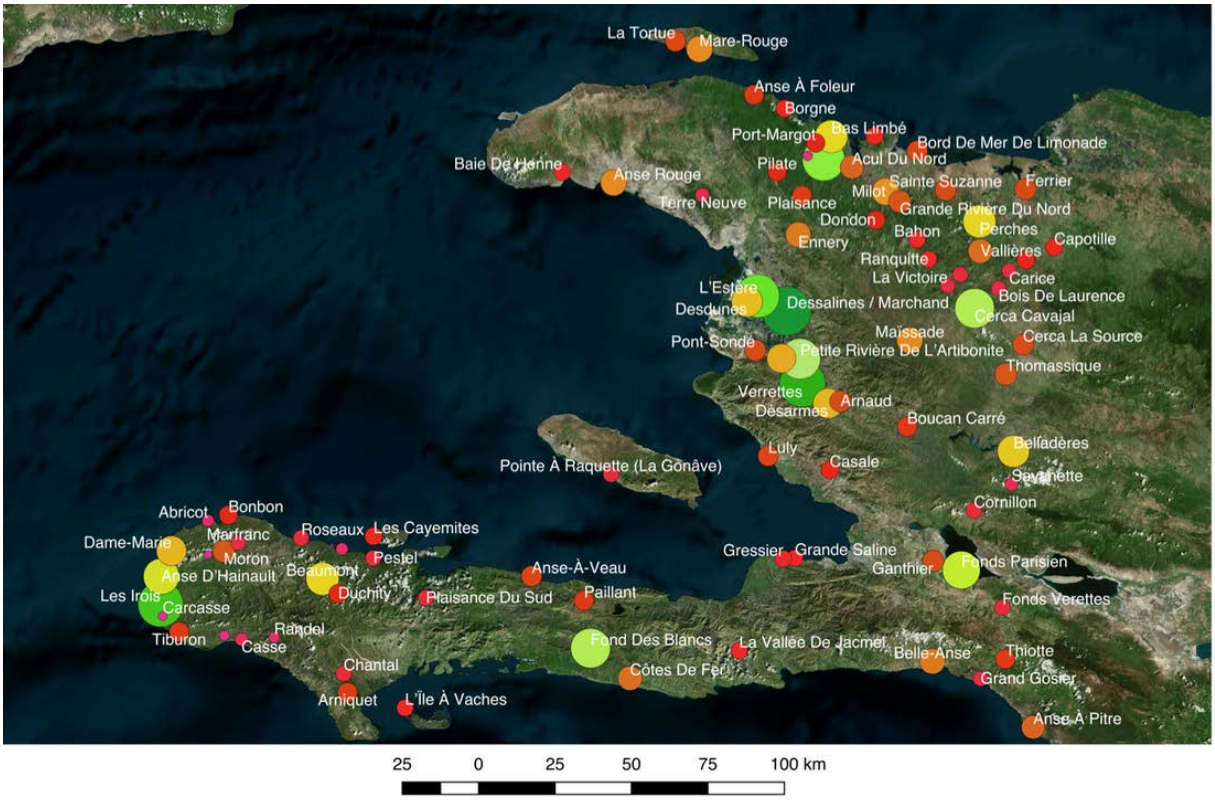
The organizations that have been successful in Haiti have secured long-term concessions granting rights to operate an electric system in the area in which they plan to do business, as allowed by a GOH decree issued in 2006. Those parties that have developed independent microgrids to date indicate confidence that they have all the necessary permissions and are therefore secure in at least their current projects. However, the

process by which permission is granted can be perilous, given the uncertain nature of EDH's monopoly on electricity supply, unclear public procurement processes, and the to-be-formed processes of establishing municipal-level public-private partnerships for community electricity grids.

Furthermore, as is the case in many overseas markets, having local or insider knowledge is vital for successfully conducting business. In countries such as Haiti with unclear regulatory, reporting, and business structures, this knowledge is all but essential. An additional challenge for microgrids in Haiti – both for development and ongoing operations – is the lack of a trained workforce for installing and maintaining the equipment associated with microgrid systems.

Various international institutions have provided some level of support for the microgrid concept, including the IDB, UNEP, NRECA International, and, most recently, the World Bank. The World Bank's new Renewable Energy for All project (signed in October 2017) aims to expand access to 900,000 people in Haiti through a combination of upgrades and expansion of grids, microgrids, and stand-alone distributed off-grid systems. The World Bank report suggests that "over one million households (5 million people) can be reached through solar PV off-grid solutions and mini-grids."[lxxxiv]

For further corroboration, a study was recently conducted to evaluate the microgrid potential in Haiti, assessing the relative economic viability and attractiveness for 89 villages across the country for which microgrids were deemed plausible. Two different analytic approaches, each with multiple criteria and weighting factors, were used to make the assessment, and the two sets of results were then combined to produce a final assessment. The map below indicates the location of these villages and an approximate sense of their economic viability: larger green circles represent the most microgrid-favorable towns, whereas smaller red circles represent towns less well-ranked.[lxxxv]



Source: Haitian Solar Power Micro-Grid Potential, Energy and Security Group on behalf of the United States Trade and Development Agency, 2016

Caracol: Initial Microgrid in Haiti

As part of the response to the devastation wreaked on Haiti by the 2010 earthquake, the GOH and various international parties embarked upon a concerted effort to boost national economic output and export activity by developing the Caracol Industrial Park (CIP) in northeastern Haiti to host manufacturing businesses.

Naturally, such an industrial park requires good access to electricity, which wasn't previously present, even though one of the pre-existing regional EDH grids served areas near Caracol.

Accordingly, a significant aspect of establishing the CIP was the construction of a dedicated microgrid to provide reliable electricity service to prospective customers. This initiative was soon expanded to extend the microgrid to some local communities nearby the CIP, and was renamed as the Caracol Community Electrification Program (CCEP), with a goal of providing electricity to 30,000 customers within 5 years.

Backed by $2.5 million in funding from USAID and the National Rural Electric Cooperative Association (NRECA) of the U.S., CCEP was launched at the beginning of 2012, and was substantially completed by mid-2014, with much of the work performed under the

oversight of NRECA (goods, equipment and services valued at approximately $1 million, including 5,000 hours of volunteer time).[lxxxvi]

The CCEP involved building out the Caracol microgrid beyond the CIP, consisting of 10 km of 23 kV primary distribution lines and 40 km of 240 V secondary distribution lines, resulting in the ability to serve 2,269 potential customers.[lxxxvii]

Located in the CIP, a 10 MW dual fuel (initially diesel, subsequently converted to heavy fuel oil) power plant consisting of six 1.6 MW Hyundai gensets supplies the Caracol microgrid.[lxxxviii] This power plant was installed as part of a $124 million grant from USAID to support the overall development of the CIP.[lxxxix]

As construction of the Caracol microgrid neared completion in late 2013, the assets and operations were conveyed to a newly-constituted cooperative utility named the Pilot Project for Sustainable Electricity Distribution (PPSELD), which continues to receive considerable ongoing organizational and operational support from NRECA. After CCEP was formally completed in mid-2014, and under the control of PPSELD, the Caracol microgrid has been extended to four additional villages (Terrier Rouge, Limonade, Trou du Nord and Saint Suzanne), with a total of nearly 9,000 customers now being served. The locations served by the Caracol microgrid are said to be among the very few places in Haiti where electricity is available on a 24/7 basis.[xc]

As of 2016, electricity prices on the Caracol microgrid were reported to be $0.30/kWh, comparable to prices offered by EDH where they serve customers.[xci] Of note, electricity losses on the Caracol microgrid are claimed to be much lower than typically experienced by EDH: collection rates are said to exceed 90%.[xcii]

Although perhaps necessary for industrial operations, the 24/7 availability of electricity provided from the Caracol microgrid may be a higher standard of service than rural poor households truly need, want or are willing to pay for. It is said that considerable and ongoing engagement with local customers is necessary to justify the costs that they pay to PPSELD.[xciii]

As is the case with many microgrids, a key economic challenge facing PPSELD in operating the Caracol microgrid stems from the fact that demand levels are low relative to the capacity of the installed infrastructure, which is capital-intensive.

Whereas the Caracol microgrid has 10 MW of generating capacity, the average demand level from customers connected to date still only aggregates to less than 2 MW.[xciv] Peak demand for the Caracol microgrid is estimated to be approximately 4.5 MW. [xcv]

The load profiles for industrial and household customers, and overall system load profile, relative to average demand for the Caracol microgrid, are presented in the charts below. As is evident, industrial demands are heavily weighted towards one-shift operation between 8 am and 5 pm, with a pronounced break for lunch. Meanwhile, the residential

demand profile is fairly flat, with a slight peak during the evening hours. Since industrial demand dominates residential demand in volume, the overall system load profile looks more like the industrial load profile.[xcvi]

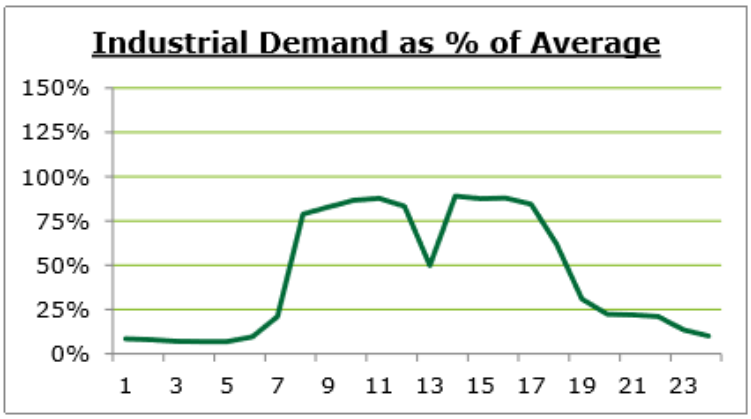


Figure 1 Industrial Demand (%) of Average by time of day

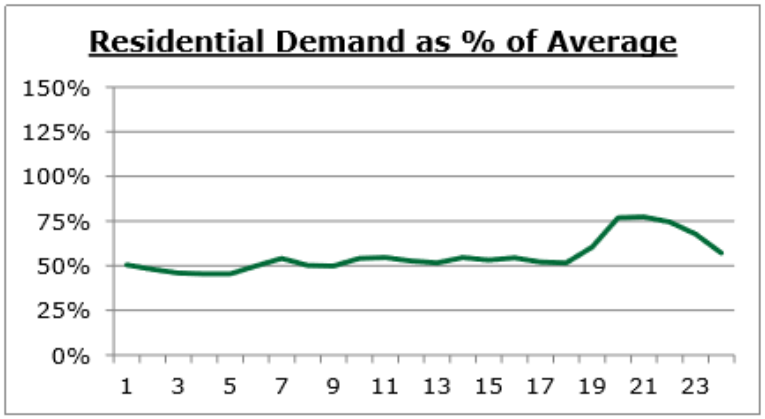
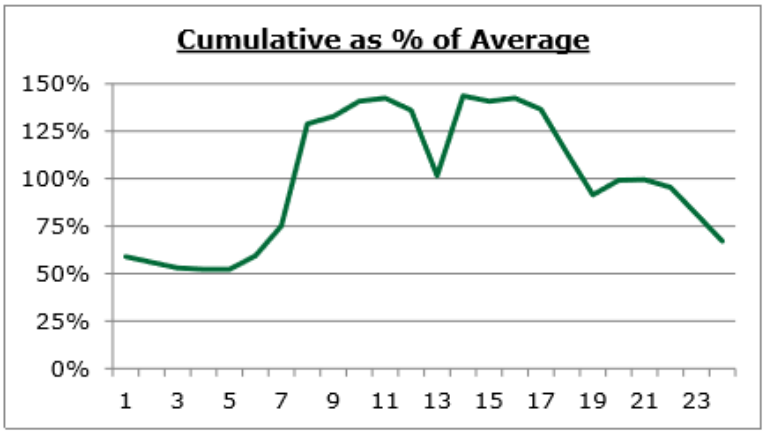


Figure 2 Residential Demand (%) of Average by time of day



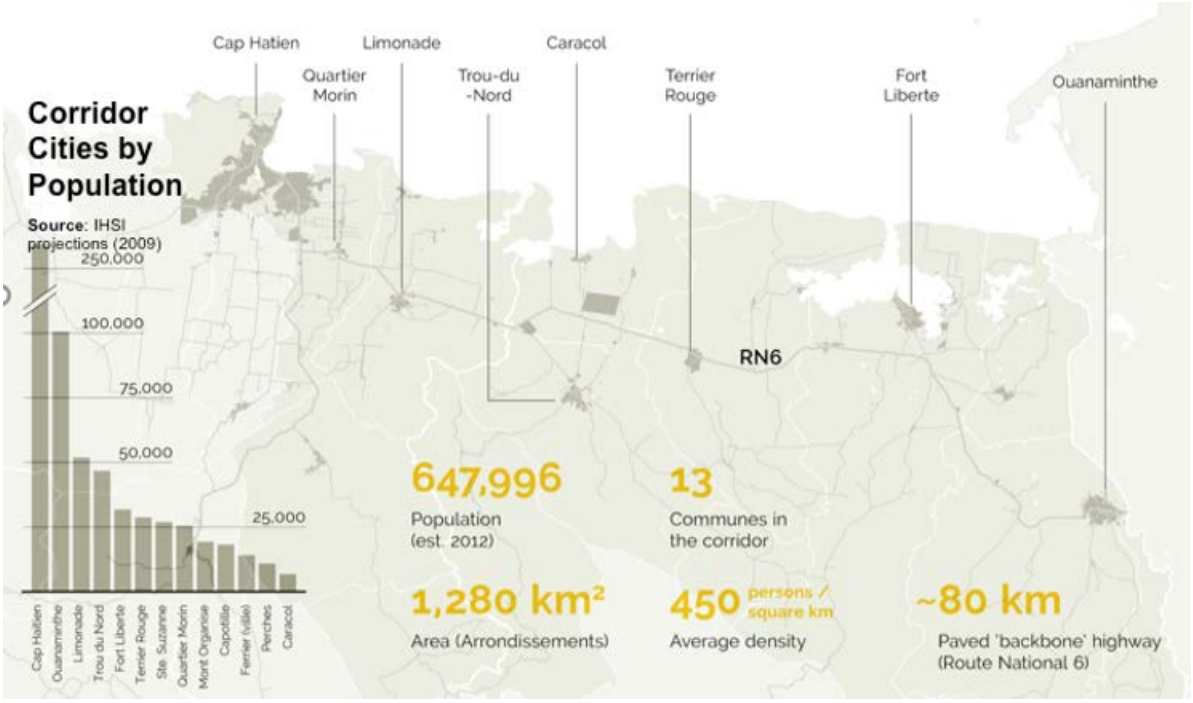
Source: Caracol Power Utility Transaction Support: Expansion Assessment to Fort Liberte, USAID, July 2016

The low level of demand on the Caracol microgrid makes for very low capacity factors (i.e., utilization rates) on the system, consequently worsening per-unit economics of both power generation and microgrid operation.

It is also notable that PPSELD has received continued funding from USAID to support ongoing operations post-CCEP. Efforts are now underway to plan the transition of PPSELD to some kind of public-private partnership, in search of a more sustainable approach for financing and operations.[xcvii]

According to news reports from mid-2017, a tender is being prepared jointly by USAID and GOH seeking an investor to take over PPSELD. The investor would secure a 30-year concession to operate the Caracol microgrid, but would be asked to make a $30 million commitment to expand the microgrid even further to other communities to the east, including Fort Liberte and perhaps as far east as Ouanaminthe on the border with the Dominican Republic.[xcviii]

This so-called "Northern Development Corridor" potentially to be addressed by expansion of the Caracol microgrid is presented in the map below.[xcix]



Source: "Haiti Plans O&M PPP for Caracol Power Plant", Chase Collum, Project Finance and Infrastructure Journal, June 2, 2017

Notably, Fort Liberte is already served by one of the EDH regional grids, but availability of electricity is typically only 6 hours per day (6 pm to midnight). Thus, expanding the Caracol microgrid to supply Fort Liberte during other periods of the day could prove to be a "win-win" for both the Caracol microgrid (by improving utilization of its 10 MW of

generation) and the pre-existing EDH regional grid serving Fort Liberte (by improving electricity availability).[c]

Independent Microgrid Developers in Haiti

While the Caracol microgrid was pathbreaking in many respects, it does not appear that it is serving as a highly-replicable model for further microgrid activity elsewhere in Haiti. For Haiti, the industrial park aspect of the Caracol development effort was a unique catalyst for electrification activity, since most rural villages across Haiti lack any industrial base and few if any others beyond Caracol are targeted for proactive economic development efforts of this type.

Accordingly, three organizations pursuing a different business model not based mainly on industrial customers as "anchor tenants" have separated themselves as being most advanced in ongoing microgrid development activity in rural areas of Haiti:

- EarthSpark International
- Sigora
- Solar Electric Light Fund (SELF)

A fourth organization, OK Haiti, is also emerging to position itself for undertaking rural microgrid development in Haiti.

These four organizations, and their microgrid development activity in Haiti, are profiled below.

Beyond these microgrid developers, one interviewee commented that several small businesses – either locally-owned solar companies or general electricians – are selling and installing solar projects on buildings, primarily in the PAP area. While the size of these companies is unclear, their existence reinforces the hypothesis that solar energy – including solar home systems and solar-based microgrids – is a growth opportunity in Haiti.

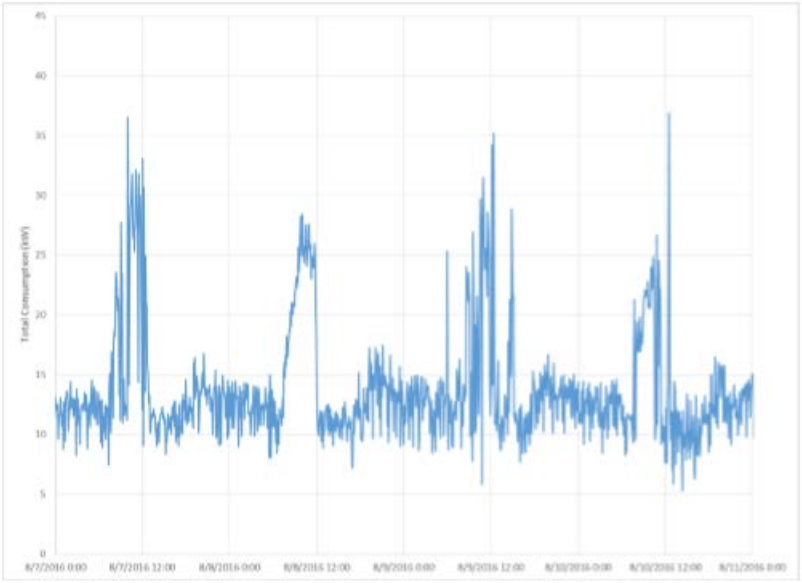
EarthSpark International

A Washington DC based non-profit non-governmental organization working in Haiti since 2009, EarthSpark International initially partnered with UNEP to help a community organization in Les Anglais in southwest Haiti develop a store to supply clean energy technologies and training.

Through this partnership, EarthSpark created a for-profit Haitian business, Enèji Pwòp, to serve as a retail store for clean energy technologies, training and education. Now a national brand, Enèji Pwòp has since sold over 18,000 small-scale clean energy products ranging from solar lanterns to efficient cookstoves.

In 2012, EarthSpark launched a microgrid in Les Anglais, with an initial customer base of 14 households. By October 2013, this had expanded to 54 customers (48 households, 6 commercial), plus some streetlighting. By June 2015, this had expanded again to serve 449 households (over 2,000 people) with 24-hour electricity availability using a combination of 93 kW of PV, 410 kWh of battery storage, and a 30 kW backup diesel generator.

As indicated in the load profile below, baseload or minimum demand on the Les Anglais microgrid is approximately 10 kW, with relatively brief daily peaks up to about 35 kW in the evening hours.



Source: RFP for Tiburon Haiti Microgrid Power Generation and Additional Two Grids, EarthSpark International, April 7, 2017

As an outgrowth of its Les Anglais microgrid development, EarthSpark developed a pre-pay meter and has spun off a separate for-profit business called SparkMeter to sell these meters to microgrid and central grid operators both in Haiti and in other emerging economies globally. According to their website, SparkMeter has an installed base of thousands of meters operating in 15 countries.

The SparkMeter meters that EarthSpark employs are customizable, enabling EarthSpark to segment customers into different user types with corresponding load limits. The dominant segments in Les Anglais are:

- 30 watts, supporting an LED light and Internet access ("Lighting" customers)
- 120 watts, also supporting the use of television ("Lighting and TV" customers)
- 360 watts, also supporting the use of a small refrigerator ("Refrigeration" customers)

According to EarthSpark's website, the community-scale grid in Les Anglais is large enough to power small industrial activity while progressive enough to offer accessible service to

every single resident living within the infrastructure's footprint. EarthSpark claims that their notable innovation is their effort to pair residential and commercial loads in a viable business model through the SparkMeter meters, seeking to manage demand on a town-size scale in a way that makes the whole grid more efficient.

Unfortunately, Hurricane Matthew in 2016 devastated Les Anglais. The grid experienced only modest damage – some solar panels were blown away and some poles were knocked down – but most of the village was destroyed. Even so, EarthSpark needed to raise money to repair and resume operations, which it has done, and the microgrid is expected to be back in service in January 2018.

With the Les Anglais grid operational again, and with the further accumulation of operating experience, EarthSpark aims to pursue the following three-pronged strategy:

- Derisk by doing – clarifying laws and regulations, codifying lessons learned
- Prove what is possible with microgrids – demonstrating high electricity availability
- Move microgrids towards market – establishing business model for subsequent projects

With more results accumulated from the Les Anglais microgrid, EarthSpark sees the integrated town-scale approach as replicable and attractive to investors as a for-profit business opportunity.[ci] Accordingly, EarthSpark is seeking grant funding to build its next three microgrids (including one located in Tiburon) and, in parallel, to build the experience-backed fundable plan for the next 40 grids across Haiti, with a long-term goal of 80 microgrids by 2022.

Sigora[cii]

Based in California, Sigora undertakes for-profit activities and projects to bring electricity to less-developed economies around the world.

Sigora's Haitian subsidiary started with the goal of electrifying a public health clinic in Mole-Saint-Nicolas, and has since grown into a full-scale "Green Utility Project" in their words. Sigora Haiti connected its first customer in December 2015, and subsequently during 2016 engineered, financed and built its first microgrid system.

Undertaken in conjunction with the IDB, Sigora currently has three active microgrids adjacent to each other in northwestern Haiti, providing 24/7 electricity access to around 2,000 active customers. By Sigora's account, the grids are supplied by about 3.5 MW of wind and solar (although it is unclear how much of this has been completed to date), backed up by diesel generators. With a capital investment to date of $3.7 million, Sigora now employs about 70 linemen, contractors, and account managers.

Sigora's grids are located in a very poor rural region of Haiti, where Sigora has negotiated and obtained from the local municipalities a 25-year agreement for electricity service, covering an area with a potential of up to 27,000 connections serving 136,000 people.

While the extreme poverty and limited commercial base of the region has been a challenge, Sigora claims to have been able to remain viable because:

- About 26% of payments to Sigora come from the Haitian ex-patriot diaspora, which sends money back to their relatives and friends in Haiti to purchase essentials.

- Sigora reduces customer acquisition and ongoing sales costs by utilizing in-village agents (typically, the owner of the local general store) to collect PAYG deposits from customers, wherein agents get to keep a 10-15% commission to incentivize sales activity.

Of note, after finding the SparkMeter meters to be too small and insufficiently scalable, Sigora has designed their own energy meter with proprietary anti-theft technology and are considering creating a spin-off venture for smart meters.

Sigora's business model is completely for-profit, with a 10-year goal in Haiti to electrify 2 million people by 2025. They are generally averse to grants and donations, believing that the only way that electrification in Haiti will ultimately be successful at scale is through projects that generate positive returns, thereby attracting further investment capital. For its initial microgrid, Sigora claims a projected IRR of 18% over the life of the concession.

Solar Electric Light Fund (SELF)[ciii]

A non-governmental organization based in Washington DC, SELF is one of the world's leading NGOs working on electricity access issues in developing economies. Among their various activities to improve energy provision in Haiti, SELF has been involved in two microgrid initiatives:

- **CEAC.** SELF was an important contractor during the 2013 implementation of the CEAC microgrid. A hybrid system consisting of 130 kW solar and 200 kW diesel generation, the CEAC microgrid is comprised of 54 km of distribution lines connecting to about 1600 customers across three towns: Coteau, Roche-a-Bateaux and Port-a-Piment. As was the case with the Caracol microgrid, the CEAC microgrid was built using substantial volunteer contributions (labor and equipment) from NRECA.

- **Feyo Bien.** SELF was the primary developer of the Feyo Bien microgrid, covering one village and with only 50 homes connected. Customers typically pay less than $10/month for their electricity service, equating to volumetric prices of $1.10-1.20/kWh. The economics work only because 9 commercial customers have been recruited to locate in a microfinance center, which is also where most of the microgrid operations are located. Indeed, the microfinance center itself first had to

be established in order to both house the businesses and provide the lending capability to offer financing for the businesses to acquire electricity consuming appliances (e.g., refrigerators, freezers).

Both of these microgrids have adopted a cooperative (i.e., not-for-profit) ownership and governance model. While this better assures local buy-in and reduces negative issues such as theft, it also adds a measure of implementation complexity. Not only does a cooperative structure take longer to form, but there is a general lack of management capability by local citizenry to professionally perform governance (i.e., Board) functions.

Of SELF's two microgrids, the CEAC experience was much more challenging, as the cooperative involved bringing together leadership from 3 adjacent communities, which in turn surfaced competing factions and assorted conflict.

OK Haiti[civ]

Led by Marc Raphael, a Haitian native based in New York, OK Haiti intends to develop a microgrid in Arcadins comprising 6 MW of solar generation and 4 MW of wind generation, augmented by 10 MW storage. Envisioning this as a pilot for their subsequent projects, OK Haiti aims to launch Arcadins microgrid development sometime in 2018, though it is believed that funding has not yet been secured.

Beyond the first project, OK Haiti has set an ambitious vision of deploying ten microgrids across Haiti by September 2021, and a further ten microgrids (totaling twenty) by September 2024, supplied by 200+ MW of renewable energy, providing an estimated 3 million people with continuous energy access.

SUMMARY

From the preceding three chapters, the following conclusions can be drawn about the current state of the electricity sector in Haiti:

1. **Electricité d'Haïti.** EDH is in dire straits, operationally and financially. Although a monopoly responsible for electricity delivery nationwide, only about 20-40% of Haitians receive electricity service, and virtually none get reliable power on a 24/7 basis (unless they have their own backup generation). Due to "losses" of both a technical and commercial nature, EDH collects revenues on only about 20% of the electricity it sells, leading them to require increasingly large subsidies from the fiscally-strained GOH. To improve EDH accountability, the GOH has launched an effort to finally impose a regulatory authority (ANARSE) to drive some discipline. While that is a positive step, there is ample basis for skepticism, as many prior efforts by international agencies to reform the Haitian power sector have borne little fruit.

2. **Independent power production.** Now responsible for a majority of all electricity generated in Haiti, three IPP companies (Sogener, E-Power and Haytrac) play a major role in the Haitian electricity sector. Alas, they are not insulated from the challenges posed by EDH, who remains the only buyer of power produced by IPPs. The financial challenges of EDH mean that IPPs are likely reliant upon international agency guarantees for PPA payments, which in turn provide the cash necessary to import fuel from outside the country. Moreover, for a variety of technical reasons ultimately stemming from a lack of adequate capital and skill, EDH has difficulty in managing and delivering all the electricity that IPPs may be able to produce. Accordingly, additional IPP development appears to be on hold – even though substantial renewable resources offering low-cost energy potential without the need for imported fuel are untapped and available.

3. **Independent microgrids.** In large part because of the many difficulties associated with working with EDH, much of the incremental activity currently underway in Haiti to improve electricity access is focused on the development of microgrids to bring electricity to rural villages that have never been (and likely never will be) reached by EDH grid. Three organizations – EarthSpark International, Sigora and SELF – are the leaders in this arena. Though the problems posed by working with EDH are largely avoided, successful microgrid development requires overcoming three significant sets of issues: ensuring strong local buy-in from the host community, clarifying the legal and regulatory framework for microgrid development and operation, and achieving long-term economic/financial viability.

ENDNOTES

[i] EDH March 2014, p. 3
[ii] Haiti Energy Policy 2012 presentation, p. 8
[iii] IADB Matrix, p. 35
[iv] Interview with Andy Bogdan Bindea (Sigora)
[v] WB PID/PSDS 2017
[vi] Worldwatch, p. 150
[vii] Worldwatch p. 147
[viii] Worldwatch, p. 150
[ix] USAID Caracol presentation Jan. 2017, p. 20
[x] Le Moniteur, Oct. 31, 2017.
[xi] Haiti Priorise Reform presentation
[xii] EDH March 2014
[xiii] US Dept of Commerce Export.gov website, July 2017
[xiv] IADB Matrix, p. 34
[xv] "Les vrais causes du déficit de l'EDH ne sont pas abordés"
[xvi] Mortality/Morbidity Survey, p. 2
[xvii] Worldwatch, p. 13
[xviii] WB PID/PSDS 2017
[xix] NREL Waste-to-Energy, p. 47
[xx] Interview with Andy Bogdan Bindea (Sigora)
[xxi] EDH customer bills provided by EarthSpark International
[xxii] SREP April 2015, p. 22
[xxiii] UNEP, p. 7
[xxiv] WB PAD 2017
[xxv] Haiti Priorise Reform
[xxvi] SREP March 2015, p. 22
[xxvii] SREP April 2015, p. 23
[xxviii] IMF, p. 19
[xxix] NREL feasibility p. 49
[xxx] Worldwatch, p. 150
[xxxi] SREP March 2015, p. 13
[xxxii] Interview with Andy Bogdan Bindea (Sigora)
[xxxiii] Worldwatch, p. 30
[xxxiv] US Department of Commerce Export.gov, July 2017
[xxxv] SREP March 2015, p. 37
[xxxvi] EDH March 2014.
[xxxvii] NREL, Waste-to-Energy, p. 47
[xxxviii] Worldwatch, p. 37
[xxxix] EDH March 2014, p. 19
[xl] NREL Waste-to-Energy, p. 47
[xli] Interview with Peter Lilienthal.
[xlii] NREL Waste-to-Energy, p. 47
[xliii] NREL Waste-to-Energy, p. 47
[xliv] NREL Waste-to-Energy, p. 50
[xlv] NREL Waste-to-Energy, p. 47
[xlvi] EDH March 2014
[xlvii] Worldwatch, p. 73
[xlviii] EDH March 2014
[xlix] EDH March 2014
[l] "Les vrais causes du déficit de l'EDH ne sont pas abordés"

[li] UNF, p. 103
[lii] UN Foundation, p. 42
[liii] WB PID/PSDS 2017
[liv] UN Foundation, p. 42
[lv] Worldwatch, pp. 24-26
[lvi] Worldwatch, pp. 24-26
[lvii] SREP April 2015, p. 22
[lviii] Business Wire, Dec. 9, 2009.
[lix] Worldwatch, pp. 24-26
[lx] "Les vrais causes du déficit de l'EDH ne sont pas abordés"
[lxi] EDH March 2014
[lxii] E Power website information.
[lxiii] "Haiti commissions 30MW power plant", January 19, 2011
[lxiv] Worldwatch, pp. 24-26.
[lxv] "Les vrais causes du déficit de l'EDH ne sont pas abordés"
[lxvi] NREL waste to energy feasibility study p. 50
[lxvii] "E-Power S.A undignified reveals the margin of EDH on each Kw"
[lxviii] E Power Facebook post, Oct. 17, 2017
[lxix] "Epower et Sogener: Réponse au Sénateur Latortue", Sept. 28, 2017
[lxx] EarthSpark 2017 presentation
[lxxi] WB PAD 2017
[lxxii] "Electricity Of Haiti (ED'H), A Middleman For Three Private Providers", Feb. 18, 2013
[lxxiii] "Epower et Sogener: Réponse au Sénateur Latortue", Sept. 28, 2017
[lxxiv] IMF, p. 19
[lxxv] UN Foundation, p. 61
[lxxvi] Interview with Andy Bogdan Bindea (Sigora)
[lxxvii] "LNG Imports: A Case Study in Developing Haiti's Energy Sector", March 2, 2014.
[lxxviii] World Bank "Caribbean Regional Electricity Supply Options", 2011.
[lxxix] Worldwatch.
[lxxx] Interview with Peter Lilienthal.
[lxxxi] Stockholm Environmental Institute.
[lxxxii] "An Uncertain Road Ahead for Haiti's Cooking Fuel Sector", Matt Lucky, Feburary 15, 2012
[lxxxiii] UN Foundation p. 17
[lxxxiv] WB PAD 2017 p.4
[lxxxv] USTDA 2017.
[lxxxvi] NRECA CCEP Final Report, 2015.
[lxxxvii] NRECA CCEP Final Report, 2015.
[lxxxviii] USAID Caracol Power Utility Transaction Support, July 2016.
[lxxxix] "IDB Inaugurates New Caracol Industrial Park", October 22, 2012.
[xc] NRECA website.
[xci] "Haiti Plans O&M PPP for Caracol Power Plant", June 2, 2017
[xcii] "Getting Rural Electrification Right: Lessons from Northern Haiti", blog post, February 12, 2015
[xciii] Interview with Dana Brosig (formerly NRECA).
[xciv] "Haiti Plans O&M PPP for Caracol Power Plant", June 2, 2017
[xcv] USAID Caracol Power Utility Transaction Support, July 2016.
[xcvi] USAID Caracol Power Utility Transaction Support, July 2016.
[xcvii] USAID Caracol Power Utility Transaction Support, April 2016.
[xcviii] "Haiti Plans O&M PPP for Caracol Power Plant", June 2, 2017
[xcix] "Getting Rural Electrification Right: Lessons from Northern Haiti", blog post, February 12, 2015
[c] USAID Caracol Power Utility Transaction Support, July 2016.
[cici] UNEP, p.17
[cii] Interview with Andy Bogdan Bindea (Sigora)
[ciii] Interview with Bob Freling and Jeff Lahl (SELF)
[civ] Interview with Marc Raphael (OK Haiti)

BIBLIOGRAPHY

Belt, Juan A.B., et al. "Benefit-Cost Analysis of Interventions in Haiti's Electricity Sector: Institutional Reform." Copenhagen Consensus Centre. Limestone Analytics presentation at Haiti Priorise Conference, May 1, 2017. http://warrington.ufl.edu/centers/purc/purcdocs/papers/1705_CBA_of_Power_Sector_Reform_in_Haiti_2017_10_12(3).pdf

Blommenstijn, Charlotte, Marina Grushin and Elodie Manuel. "LNG Imports: A Case Study in Developing Haiti's Energy Sector." SAIS Perspectives, March 2, 2014. http://www.saisperspectives.com/2014issue/2014/10/12/lng-imports-a-case-study-in-developing-haitis-energy-sector-

BusinessWire. "Haitian Economic Development Foundation Announces That Sogener, One of Haiti's Largest Independent Power Producers (IPP), Adds Capacity With New 10-Megawatt Generator." December 21, 2009. https://www.businesswire.com/news/home/20091221005714/en/Haitian-Economic-Development-Foundation-Announces-Sogener-Haiti%E2%80%99s

Collum, Chase. "Haiti Plans O&M PPP for Caracol Power Plant." *Project Finance and Infrastructure Journal*, June 2, 2017. https://ijglobal.com/articles/106607/haiti-plans-o-and-m-ppp-for-caracol-power-plant

EarthSpark International. "Energy Access in Haiti." World Bank Spring Meeting, 2017. http://www.worldbank.org/en/results/2014/04/04/energy-access-expansion-in-haiti

Earthspark International. EDH Customer Bills.

Electricite d'Haiti (2014) Electricite d'Haiti Presentation. March 17, 2014. https://www.usea.org/sites/default/files/event-/EDH%20-%20Presentation%20%2817mars2014%29.pdf

E-Power. Various Facebook posts. October 17, 2017.

Haiti Libre. "E-Power S.A. Undignified Reveals the Margin of EDH on Each KW." September 28, 2017. https://www.radiotelevisioncaraibes.com/nouvelles/haiti/epower-sogener-reponse-latortue.html

Haiti Libre. "IDB Inaugurates the New Caracol Industrial Park." October 22, 2012. http://www.haitilibre.com/en/news-6965-haiti-economy-idb-inaugurates-the-new-caracol-industrial-park.html

Haiti Observer. "Electricity of Haiti (ED'H): A Middleman for Three Private Providers." February 18, 2013. http://www.haitiobserver.com/blog/energy-environment/electricity-of-haiti-edh-a-middleman-for-three-private-provi.html

HOMER Energy. "Interview with CEO Peter Lilienthal." November 2, 2017. http://microgridnews.com/homer-ceo-peter-lillienthal-asian-microgrid-market-video/

ICF International for USAID, et al**. "**Haiti 2012 Mortality, Morbidity and Service Utilization Survey: Key Findings**."** 2012. https://dhsprogram.com/pubs/pdf/SR199/SR199.eng.pdf

Inter-American Development Bank. Energy Matrix Country Briefings, 2013.

International Monetary Fund. "Haiti: Selected Issues." #15/158, May 6, 2015. https://www.imf.org/external/pubs/ft/scr/2015/cr15158.pdf

Le Moniteur. October 31, 2017.

Lemothe, Laurent Prime Minister. "Energy Policy Proposal." Government of Haiti, July 24, 2012.

Lerebours, Raymond. "Les Vrais Causes du Deficit de l'EDH Ne Sont Pas Abordes." October 16, 2017. http://haititalkonline.com/forum/main-category/haitian-politic/19742-les-vrais-causes-du-déficit-de-l-edh-ne-sont-pas-abordés.

Lucky, Matt. "An Uncertain Road Ahead for Haiti's Cooking Fuel Sector." *Worldwatch Institute*. February 15, 2012. http://blogs.worldwatch.org/revolt/an-uncertain-road-ahead-for-haitis-cooking-fuel-sector/

National Renewable Energy Laboratory and HDR Engineering for USAID. "Haiti Feasibility of Waste-to-Energy Options at the Trutier Waste Site." August 2014. https://www.nrel.gov/docs/fy14osti/60585.pdf

NRECA. "Bringing Power to Haiti." http://www.nrecainternational.coop/where-we-work/haiti/

NRECA. "Interview with former Project Manager Dana Brosig." November 10, 2017.

OK Haiti. "Interview with CEO Marc Raphael." November 9, 2017.

Sigora. Interview with CEO Andy Bogdan Bindea. November 8, 2017.

Solar Electric Light Fund. "Interview with Bob Freling and Jeff Lahl." November 20, 2017.

SREP. "Climate Investment Funds: Investment Plan for Haiti." April 15, 2015. https://www.climateinvestmentfunds.org/sites/default/files/meeting-documents/srep_13_5_srep_investment_plan_for_haiti_0.pdf

SREP. "Climate Investment Funds: Investment Plan for Haiti." March 27, 2015. http://ciat.gouv.ht/sites/default/files/docs/Plan%20Investissement%20SREP_Document%20Principal_30mars.pdf

Stockholm Environmental Institute. "Assessing the Climate Impacts of Cookstove Projects: Issues in Emissions Accounting." February 15, 2012. https://www.sei-international.org/mediamanager/documents/Publications/Climate/sei-wp-2013-01-cookstoves-carbon-markets.pdf

The Gleaner. "Haiti Commissions 30 MW Power Plant." January 19, 2011. http://jamaica-gleaner.com/gleaner/20110119/business/business71.html

U.S. Department of Commerce. https://www.export.gov/article?id=Haiti-Energy.

United Nations Environment Programme. "The Haiti Sustainable Energy Programme." May 2015. https://postconflict.unep.ch/publications/UNEP_Haiti_sustainable_energy.pdf

United Nations Foundation. "Microgrids for Rural Electrification." Carnegie Mellon University and University of California at Berkeley, February 2014. https://rael.berkeley.edu/wp-content/uploads/2015/04/MicrogridsReportEDS.pdf

United States Trade and Development Agency. "Haitian Solar Power Micro-Grid Potential." Energy and Security Group, 2016. http://www.earthsparkinternational.org/uploads/1/3/4/4/13442473/final_report_-_public_version_-_microgrid_development_assessment_and_ranking_in_100_haitian_towns_20171206.pdf

US Agency for International Development. "USAID Sector Reform and Commercialization: Haiti CPU Transaction Project." January 2017. http://pdf.usaid.gov/pdf_docs/PA00MZJW.pdf

USAID and NRECA. "Caracol Community Rural Electrification Program Final Report." 2015. http://pdf.usaid.gov/pdf_docs/PA00MD1B.pdf

USAID. "Caracol Power Utility Transaction Support: Expansion Assessment to Fort Liberte." July 2016. http://pdf.usaid.gov/pdf_docs/PA00MZJF.pdf

USAID. "Caracol Power Utility Transaction Support: Workplan." April 20, 2016. http://pdf.usaid.gov/pdf_docs/PA00MZJC.pdf

World Bank. "Caribbean Regional Electricity Supply Options." 2011. http://documents.worldbank.org/curated/en/734601468242100020/Caribbean-regional-electricity-supply-options-toward-greater-security-renewable-and-resilience

World Bank. "Haiti Renewable Energy for All PID/ISDDS." Report, April 28, 2017. http://documents.worldbank.org/curated/en/592221494306770405/pdf/114825-PSDS-P156719-Concept-Stage-Box402908B-PUBLIC-Disclosed-5-8-2017.pdf

World Bank. "Project Appraisal Document for Haiti Modern Energy Services for All Project**."** PAD 1466, Octrober 3, 2017. http://documents.worldbank.org/curated/en/248481507662348381/Haiti-Modern-Energy-Services-For-All-Project

Worldwatch Institute, et al. "Haiti Sustainable Energy Roadmap." Report, November 2014. http://www.worldwatch.org/system/files/Haiti-Roadmap-English_0.pdf

Zambrano-Barragan, Patricia. "Getting Rural Electrification Right: Lessons from Northern Haiti." IADB, February 12, 2015. https://blogs.iadb.org/energia/en/2015/11/23/getting-rural-electrification-right-lessons-from-northern-haiti/