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# USAID SECTOR REFORM AND UTILITY COMMERCIALIZATION

## Haiti Caracol Power Utility Transaction Support

### Expansion Assessment – Fort Liberté

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Deliverable 6

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## INTRODUCTION

The U.S. Agency for International Development (USAID), in cooperation with the Government of Haiti (GoH), supports the Caracol Electrification Project that included the construction of the Caracol Industrial Park Power Plant (Caracol Power Utility or CPU) and the ongoing Pilot Project for Sustainable Electricity Development (PPSELD) project, wherein the National Rural Electric Cooperative Association (NRECA) will maintain and operate the CPU until a public-private partnership is reached with the GoH. The PPSELD project is aimed at establishing a financially viable electric utility that provides dependable, affordable electricity to customers while implementing a payment structure that results in a high collection rate of electricity bills – with a key goal of creating an environment that will attract private sector investment.

This report has been developed under a Scope of Work prepared by USAID, and is in accordance with the approved work plan Technical Component 1, Deliverable #6. This report works to provide an assessment associated with PPSELD’s possible expansion of services, focusing on the commune of Fort Liberté in the Northwest region of Haiti.

## METHODOLOGY

The methodology used to complete this report included collection and analysis of data, coupled with sound judgement based on similar experience in previous engagements and in collaboration with NRECA.

Data collection was carried out at the CPU in various areas including the commercial area, focused on its management and administrative staff, and various operational points at the plant, which mainly included the control room. Expansion costs relied on data acquired from NRECA under the PPSELD project. Other costs not considered by the CPU (expansion of switchgear room, breaker, etc.,) were estimated based on data from similar utilities for 22kV equipment in close collaboration with our Subject Matter Expert (SME).

Site visits were made to communes currently being serviced by the CPU, as well as those proposed to be served. One of the main purposes of the visits was to estimate the extent of commercial activity in the area, and to examine the current condition of EdH assets. Random areas of the communes that were inaccessible were analyzed using GoogleEarth.

The result of our analysis of Fort Liberté is reflected in the assumptions that have been made in order for the commune to arrive at a commercial level of power and energy activity. Through site visits, it was observed that the provincial capital has a meaningful districting between government houses, other residential, and commercial business – the primary categories of energy users. Site visits were also made to the EdH power plant in Fort Liberté, which was useful in obtaining a reasonable idea of the current level and quality of service provided to the communes, and to solicit data on the state of the plant in considering its usefulness for future dispatch.

## OVERVIEW

The CPU, which has been operational since July 2012, is the sole power supplier for the Caracol Industrial Park (CIP) – an industrial park built after the 2010 earthquake as part of an effort to create new jobs in the



underserved areas outside of Port-au-Prince – and has since expanded to serve additional communes in the northeastern region of Haiti.

**Image 1: CPU Plant**

In its current state, the CPU is a 10 megawatt (MW) diesel / heavy fuel oil (HFO) generation plant that contains six Hyundai 1.6 MW generators where the energy produced is transmitted through 23 kilovolt (kV) electricity distribution lines. The CPU is built within the CIP, and provides reliable power to commercial and residential customers as distribution networks extend from the plant to various communes to the East and West. Currently, the CPU serves the following communes and industrial parks: CIP, Caracol, Limonade, Trou du Nord, Terrier Rouge, and Sainte Suzanne.

In order to achieve the goal of the PPSELD program in establishing a financially viable electric utility, further expansion will be required to increase customer base and peak demand, increasing both collections and economies of scale of the CPU. Tariffs will also need to be lifted significantly.

## THE RATIONALE FOR EXPANSION:

In attempting to bring the CPU to self-sufficiency and achieve full cost recovery, it is important that the capacity of the plant be maximized and that a more diversified load pattern is achieved. The current load pattern is heavily influenced by the industrial demand of the CPU which operates a single daytime shift (8 hour) with a one hour lunch break where demand tappers off. The current estimated peak demand of the plant (10MW) is 4.5MW of which the CIP contribution is approximately 50%. The plant is underutilized. The energy potential of the plant at full capacity is far more than is being delivered today. The introduction of additional loads outside of the industrial park will help to mitigate this situation with a resulting increase in the load factor and a substantial increase in the non-coincident peak demand of the residential and other loads resulting in greater utilization and energy delivery. At the current level of usage, most of the infrastructure is devoted to the servicing of peak demand.

The ongoing transition to HFO, from the currently used light diesel fuel, will further reduce the ability of the plant to address low levels of demand. HFO fuels require heating and treatment (filtration, centrifuges, etc.) before the fuel can be used in the engine. Normally, a unit will be started with diesel for a short period of time and then will be switched to HFO. When an HFO fueled unit is to be stopped, the fuel is changed to diesel in advance of the stoppage and it is common practice to run the unit for one hour on diesel before stopping. This is done to clean the engine of all residual HFO fuel before stopping to avoid the coagulation of the remaining HFO in parts of the unit, which would require extended service periods if damage to the unit occurs. Substantial changes in load pattern to ensure continuous use of the units are required for optimal usage of the plant if a change to HFO is effected since the plant will no longer be suited to serve low levels of demand, which would require starting and stopping the unit to change/clean fuels.

## DEMAND

A 2012 census estimated a population of 20,399 in Fort Liberté with a total of 4,388 households<sup>1</sup>. In 2015, the population estimate was increased to 22,416 by the Haitian Institute of Statistics and Information<sup>2</sup> (IHSI). This suggests an increase in households of 10%, totaling

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<sup>1</sup>Album des Cartes Departmentales et Communales d’Haiti - 2012.

<sup>2</sup>www.IHSI.ht. The number of households is not published. It is estimated using the ratio from the 2012 estimate in (1).

4,822 in 2015.<sup>3</sup> The CPU plans to connect approximately 50% of households in the Fort Liberté Area. This will increase the total number of customers the CPU serves by about 25%.

Electricité d’Haiti (EdH), the public utility owned and managed by the GoH, currently serves Fort Liberté and surrounding communes. EdH operates a 6MW<sup>4</sup> high speed diesel plant and delivers power to Fort Liberté via a 23kV distribution line. Service is limited to six hours per day at Fort Liberté, commencing at 18:00 hours and terminating at midnight. EdH estimates that there are 6,000 users of the system in the service area but only 3,000 customers are registered<sup>5</sup>. In contrast, communes currently served by the CPU enjoy 24/7 power.

## SUPPLY

The CPU operates a 10MW plant in the CIP. Currently, the combined demand of the CIP and areas being serviced today is approximately 4MW with a combined load factor<sup>6</sup> of 67% and capacity factor<sup>7</sup> less than 30%. The low load factor suggests that the units of the plant in operation are oftentimes used to address peaking loads while the low capacity factor would suggest that a substantial part of the plant is idle. In addition, the characteristics of the demand, heavily dependent on patchy CIP industrial park usage, results in a highly non-diversified load pattern.

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<sup>3</sup> The calculation assumes five Haitians per household

<sup>4</sup> the exact specifications of the plant can more adequately be described in the report "Technical Assessment of Fort Liberté 6 MW Power Plant by NRECA - February 2015"

<sup>5</sup> In conversation with EdH employees, the distinction between users and customers was emphasized.

<sup>6</sup> Load Factor is defined as the average load divided by the peak load in a specified time period

<sup>7</sup> Capacity Factor is defined as the ratio of the CPUs actual output over a period of time, to its potential output if it were possible for it to operate at full nameplate capacity continuously over the same period of time.

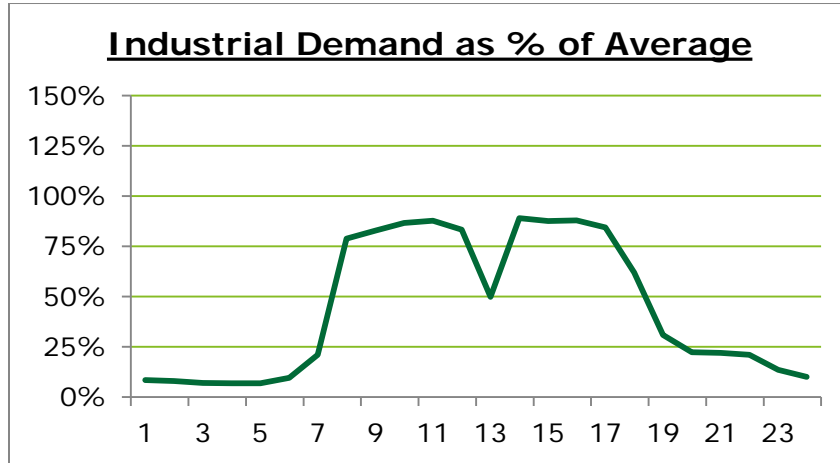


Figure 1 Industrial Demand (%) of Average by time of day

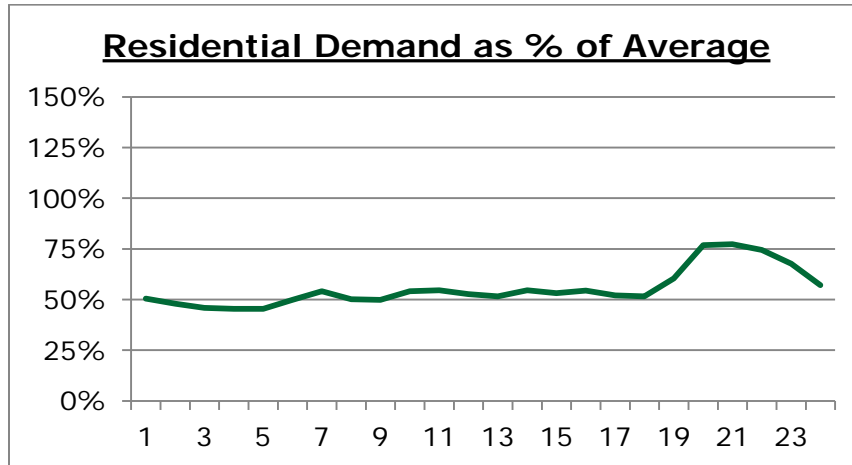


Figure 2 Residential Demand (%) of Average by time of day

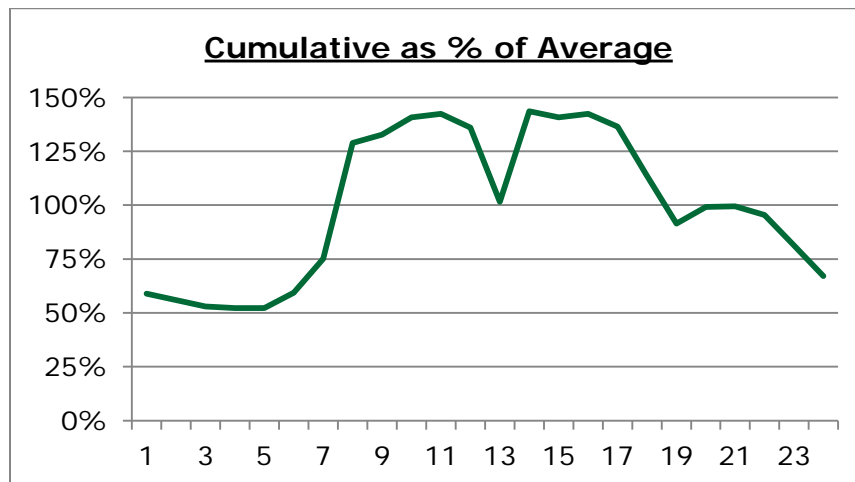


Figure 3 Cumulative (%) of Average by time of day

## FORT LIBERTÉ PROJECT DESCRIPTION

The expansion to Fort Liberté, one of the oldest cities in the country located approximately 29 km east of Caracol, provides the potential for the CPU to connect a total of approximately 4,500 additional customers – 3,000 in Fort Liberté town, 1,100 in Derac, and 353 in Malfety.<sup>8</sup> Currently, the Fort Liberté area is connected to the (EdH) network and receives 6 hours of power per day between 6:00 PM and 12:00 AM. Through conversations with NRECA, it is very important to include Derac and Malfety in the expansion plans into Fort Liberté as the distribution line from the CPU to Fort Liberté passes through Malfety and Derac, with an estimated household population of between 600 and 1000. To connect these households to Fort Liberté will only require a single phase extension for service. At present, the addition of Fort Liberté, Derac, and Malfety represents an increase of approximately 25% of the customer base,<sup>9</sup> and will help improve the performance and cost recovery of the CPU.

Notwithstanding the stated number of customers, the project will work to improve access to electricity for as many inhabitants as possible since the extension of the grid to Fort Liberté will put the necessary infrastructure within reach of inhabitants in the surrounding areas. Following the rehabilitation and extension of the medium voltage (MV) and low voltage (LV) lines, the localities will be supplied through connection to the nearest existing HV and LV grids.

Specific commercial activities to increase the number of consumers and reach the maximum number of inhabitants would, by default, be implemented. Attention to disadvantaged members of the community is considered and measures to reduce non-technical losses and minimization of fraud should be optimized through lessons learned from prior activities in other communes.

## EXPANSION COMPONENTS

In order to expand into Fort Liberté, additional investment must be made. Table 1 outlines the project components and costs required to expand service into Fort Liberté area, which we estimate to amount to \$3,130,154 in total.<sup>10</sup>

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<sup>8</sup> Information regarding the number of potential connections was provided by NRECA under the PPSELD Project. Assumes 7306 households, and a 50% penetration rate.

<sup>9</sup> Based on the February 2016 consumer report

<sup>10</sup> Expansion Components and Costs compiled from the “Fort Liberté Connection.xlsx” spreadsheet provided by NRECA. Substation Upgrade estimated using 22kV switchgear pricing from other unrelated tenders.



**Table 1 Expansion Component, Cost, and Description**

No	Component Title	Cost	Description of Component
<b>YEAR 1</b>			
A1.	Project Design	\$15,200 <sup>11</sup>	Final Design of 38 km of distribution lines
B1.	Rebuild Backbone – Terrier Rouge / Fort Liberté	\$61,987	Upgrade of 10km of 23kV distribution lines, including bringing structures to standard, replacement of insulators, and line clearance
C1.	Distribution and Connection – Fort Liberté	\$525,318 <sup>12</sup>	Installation of single phase MV distribution line, transformers, service connections, meters, and accessories
D1.	Distribution and Connection – Derac	\$214,452 <sup>13</sup>	Installation of single phase MV distribution line, transformers, service connections, meters, and accessories
E1.	Distribution and Connection – Malfety	\$103,348 <sup>14</sup>	Installation of single phase MV distribution line, service connections, meters, and transformers. Note that this locality is along the route from Terrier Rouge to Fort Liberté and will benefit from the backbone upgrade in B1
F1.	Equipment and Tools	\$163,323 <sup>15</sup>	Equipment includes the purchase of an additional line truck and vehicle rentals
G1.	Staffing	\$399,097 <sup>16</sup>	Construction supervision and staff, and customer service
<b>YEAR 1 EXPANSION COSTS</b>		<b>\$1,482,725</b>	

<sup>11</sup> Project design estimated @ \$400 / km

<sup>12</sup> Assumes 12 kms required to be rebuilt, and 1,500 users to be connected @ 125 a connection

<sup>13</sup> Assumes 10 kms required to be rebuilt, and 600 customers to be connected @ 125 a connection

<sup>14</sup> Assumes 6 kms required to be rebuilt, and 200 users to be connected @ 125 a connection

<sup>15</sup> Assumes one line truck required @ \$85,000, one Pickup Truck rental for ~10 months @ \$26,400, 4 Tricycles @ \$6,800, and Equipment / Tools @ \$45,123

<sup>16</sup> Assumes the requirement of 12 Construction Staff @ \$151,137, 1 Construction Supervisor @ \$180,960, 6 Consumer Services Staff @ \$42,000, and Local Office Support @ \$25,000. Salary was taken from NRECA data.

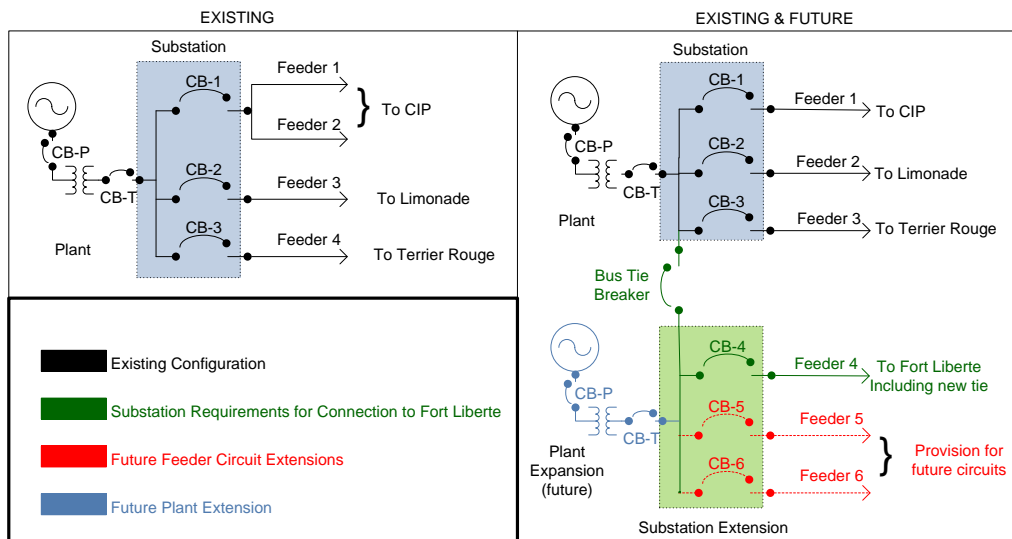
No	Component Title	Cost	Description of Component
<b>YEAR 2</b>			
2.	Project Design	N/A	Completed in Y1
B2.	Rebuild Backbone – Terrier Rouge / Fort Liberté	N/A	Completed in Y1
C2.	Distribution and Connection – Fort Liberté	\$356,509	Continuation of Y1 construction
D2.	Distribution and Connection – Derac	\$120,605	Continuation of Y1 construction
E2.	Distribution and Connection – Malfety	\$49,093	Continuation of Y1 construction
F2.	Equipment and Tools	\$42,224	Replacement / Damage Cost
G2.	Staffing	\$399,097	Continuation of Y1 staffing
<b>YEAR 2 EXPANSION COSTS</b>		<b>\$967,429</b>	

No	Component Title	Cost	Description of Component
<b>FURTHER INVESTMENT</b>			
H.	New 23kV Connecting line from CPU to Terrier Rouge	\$180,000	Build dedicated feeder to Fort Liberté. The new 23kV line will connect directly from the plant to a sectionalizing point beyond Terrier Rouge
I.	Substation Upgrade: Separation of Feeder 1 and Feeder 2; additional breakers and sectioning switchgear	\$500,000	With no room for an additional switchgear in the present substation, an extension will have to be built. This extension needs to anticipate an increase in plant capacity and utilize sectionalizing switchgear to allow greater flexibility and reliability. Future circuit additions must be considered.
<b>FURTHER INVESTMENT</b>		<b>\$680,000</b>	

<b>TOTAL COST</b>	
<b>Year 1 Expansion Cost Estimate</b>	\$1,482,725
<b>Year 2 Expansion Cost Estimate</b>	\$967,429
<b>Further Investment</b>	\$680,000
<b>Total Cost (Estimate)</b>	<b>\$3,130,154</b>

## SUBSTATION AND BACKBONE CONSIDERATIONS

To implement the connection to Fort Liberté, it will be necessary to make adjustments to the present substation arrangements. Currently, there are three circuit breakers at the main CPU plant and four outgoing feeder circuits. Figure 2 below outlines the basic arrangement of the plant circuits.



**Figure 4 Current and Future Arrangements of the CIP Substation and Feeders**

In the existing arrangement, feeders 1 and 2 are coupled and serve the CIP only, while feeders 3 and 4 serve areas toward Limonade and Terrier Rouge respectively<sup>17</sup>. Both feeders are built using 477AAC bare aluminum conductors capable of carrying over 600 amperes. Data from the site suggests that at today's maximum load in the CIP, only 10% of the capacity of any one line of feeders 1 & 2 is utilized. The recommendation is to use one of those circuits to serve Fort Liberté; however, in order to effect that, a 6km direct tie line must be built to connect the line from the substation (feeder 1 or 2) to a point beyond Terrier Rouge. The line to Fort Liberté will therefore become an express line that takes power directly from the plant to Fort Liberté without being subject to the operating demands of intermediate communes. In other words, if there is a major outage scheduled for Terrier Rouge to address a problem, Fort Liberté should not be affected; and vice versa.

The current substation does not have the switchgear capacity for an additional circuit. There is also no space for an additional breaker if this were to be made available. It will therefore be necessary to construct a new switchgear room or expand the existing one. The interconnection between the "old" and "new" switchgear will be via a bus-tie breaker. This is not absolutely

<sup>17</sup> The CPU designates the coupled feeders (1 & 2) as "feeder 1" and the others as "feeder 2" and "feeder 3". There is no feeder 4 designated today even though there are 4 feeders physically present at the plant site.

necessary but will allow for greater flexibility and reliability as the system expands and new circuits are added.

## CONNECTION ASSUMPTIONS

In order to estimate the costs associated with expansion, the following assumptions were made with regard to timing. In Year 1 of implementation, 2,300 normalized customers will be added into the network – 1,500 from Fort Liberté, 600 from Derac, and 200 from Malfety. In Year 2 of implementation 2,153 normalized customers will be added into the network – 1,500 from Fort Liberté, 500 from Derac, and 153 from Malfety. The total increase in customers is estimated to total 4,453. Image 2 depicts the various connection timing assumptions that were made in developing these estimates, while the preceding paragraph depicts how and when the service area will be transitioned from EdH to the CPU.

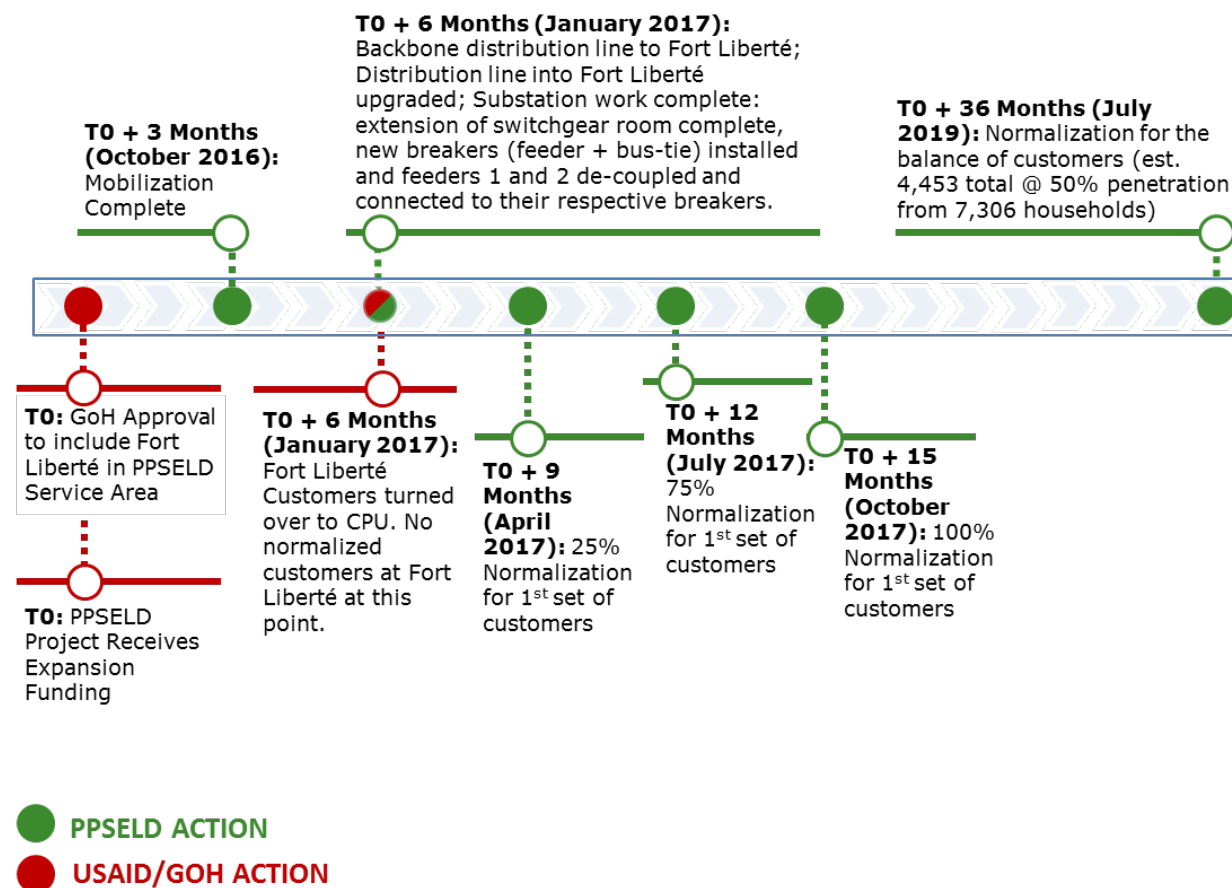


Figure 5 Connection Assumptions

It is suggested that customers from the EdH network remain connected to it, while the substation, tie-line and backbone work is ongoing from the CPU to the Fort Liberté junction. Once the

aforementioned work is completed, and the upgrade to the commune itself is started, it will be necessary to transfer the commune entirely from the EdH network on to the CPU's newly built and refurbished backbone.

From the standpoint of operational safety, the two networks are mutually exclusive and real-time communication is not shared by the two utilities. Even if this were the case, working at the high voltage of 23,000 volts poses a risk to personnel safety and security first and then the system as a whole. Furthermore, it would seem irregular that the CPU would begin normalization of customers in Fort Liberté and surroundings while still on the EdH network. The work would entail the replacement of currently installed EdH meters and installing new ones where they do not exist in the normalization of customers. Again, the two utilities do not share any commercial information and so the accounting for energy usage will be, in effect, non-existent. This emphasizes the point that the entire commune must be turned over to the CPU.

The CPU, when it receives an area for the first time, will assume a 0% normalization rate. As the network is upgraded and customers are connected according to CPU specifications, the normalization rate begins to increase. Accounting for energy usage and collection efficiency from normalized customers is high, in most communes, about 95%. Non-normalized customers billed on a flat rate, on the other hand, report a collection rate of 30% or less. That is to say that once the entire commune is turned over to the CPU, there is a huge incentive to quickly normalize the area and ensure accountability for energy usage if power to the area is to be maintained. The first set of customers targeted is those that are already connected to the EdH network. Potential customers not yet attached to the network will remain detached until 2nd phase normalization is started. The second phase of normalization is anticipated to begin in the second year of connections.

## ECONOMIC IMPLICATIONS OF FORT LIBERTÉ EXPANSION

Financial modeling projects that if tariff levels remain at current levels, then the Fort Liberté expansion would produce significant negative cash flows for the foreseeable future, as would also be the case in the current CPU service areas.

Therefore, if the case for investing the estimated \$3.1 million for expansion is to be substantiated, then tariff levels will have to be increased. There are various hypothetical combinations of higher tariffs by customer group that can be reasonably expected to produce

commercially acceptable returns. Following is an example of one such levels of tariffs in 2020, pursuant to gradual increases in the preceding years:

	<b>Price per kWh, 2020</b>
Caracol Industrial Park clients	US\$0.27 to \$0.30
Small Residential & Commercial clients, ≤31 kWh/month	HTG 13.3
Residential & Commercial clients, 31 to 200 kWh/month	HTG 23.5
Large Residential & Commercial clients, >200 kWh/month	HTG 26.7
Institutions	HTG 27.3

The tariff examples are in real terms (2016 US\$ or HTG) and are assumed to be modified periodically (e.g. quarterly) to reflect changes in fuel prices (up or down) and inflation. Therefore the nominal tariffs in 2020 are likely to be somewhat higher than the tariffs in real terms above. The tariffs are reasonably compatible with those found in other countries and significantly lower in some cases.

The assumptions underlying the assessment of the above tariffs can be found in the financial model that is submitted with this report. (Reference in particular the “Fort Liberté cash flow” tab.) Based on its assumptions, the model shows positive returns on investment of 15%, which is above the estimated cost of capital of 14% (also in real terms, i.e. excluding inflation). *The model is intended to facilitate the decision maker’s assessment of various tariff combinations and assumptions, including current tariff levels.*

The ability of clients to pay will be a relevant consideration in selecting a tariff combination, as will the Cost of Service assessment that allocates costs according to customer classes. Therefore *the above tariffs do not at this time represent recommendations.* The fact that tariffs were about 50% higher in real terms in 2009 when the current tariffs were fixed can help to support the case that significantly higher tariffs will be accepted, and particularly *if such increases are associated with a 24-hour supply of electricity from which current CPU clients benefit and as many citizens of Fort Liberté are demanding.*

In addition to revenues from tariffs per kWh, the model reflects the monthly fixed fees that are currently charged to clients. No increases in fixed fees are projected in real terms in the model, although it is assumed that the fixed fees will also be periodically adjusted to reflect changes in fuel prices and inflation.

## SUMMARY

In summary, further expansion of residential and commercial loads is a necessary step in enabling the CPU to achieve the goals of the PPSELD program in developing a financially viable electric utility. Expansion to serve additional customers would allow the CPU to continue to increase capacity utilization and revenues. This, along with a more cost reflective tariff and continued effective methods for bill collection, could better position the asset for private investment.

The total cost for expansion of services into the Fort Liberté area is estimated at \$3,130,154 USD, with \$680,000 attributed to the upgrade to the substation and backbone. Such an expansion would result in an increase of approximately 4450 customers over the two year implementation period. This would increase base load and non-coincident peak demand, helping the CPU to increase its capacity, achieve a more diversified load pattern, increase billing and collections, boost revenues, and achieve greater levels of economies of scale. It would also provide for a drastic and much needed improvement in power service within Fort Liberté, where households and others connected to the network can access electricity only about six hours a day.

Higher tariffs will be necessary to justify economically the expansion of CPU service to Fort Liberté. Private investors could then be incentivized to consider the necessary investment. *By contrast, if current tariff levels are maintained, even with periodic adjustments to reflect fuel price changes and inflation, annual subsidies would be necessary and would increase to over \$2 million per year for Fort Liberté alone if demand increases as projected.* These subsidies would be in addition to the estimated \$3.1 million in capital investment that would be required. Failure to expand into Fort Liberté would be to the detriment of the citizens, who would significantly benefit from a 24-hour supply of electricity and as observed in neighboring communes served by CPU.