Juan Belt
Senior Economist
Limestone Analytics

Bahman Kashi
Executive Director and Senior Lecturer
Program on Investment Appraisal and Risk Analysis (PIAR),
Queen's University

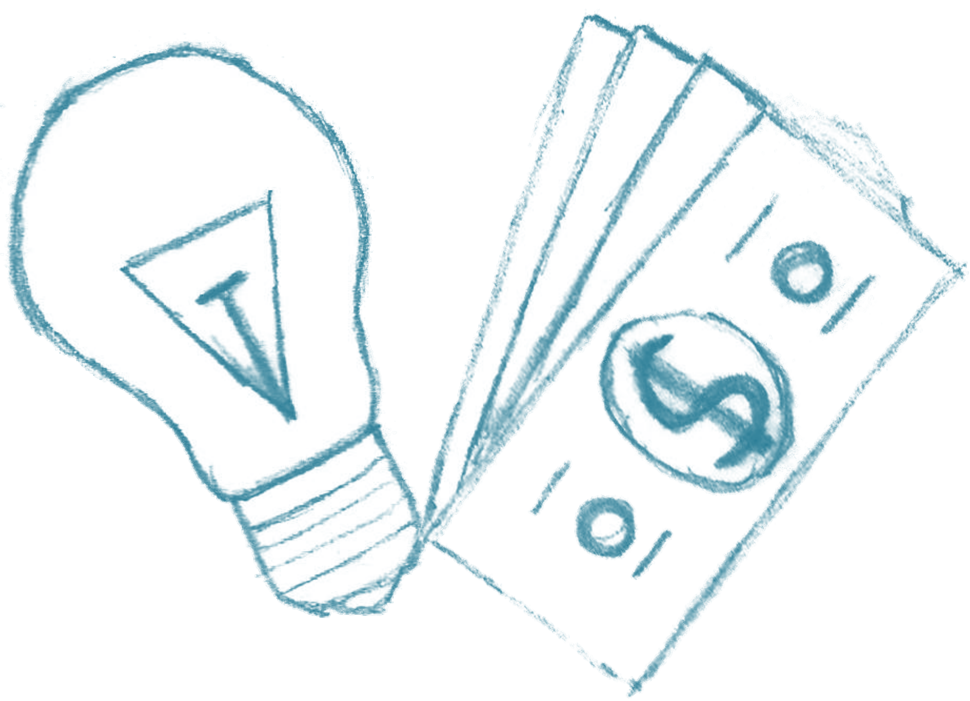
Jay Mackinnon
Economist
Limestone Analytics

Nicolas Allien
Renewable Energy and Energy Efficiency Consultant
Ministry of Public Work, Transportation and Communication

Bénaël Jean-Louis
Studies and research supervisor
Marketing directionnel, Société Générale Haïtienne de Banque,
S.A. (SOGEBANK)

Benefit-Cost Analysis

Cost-Benefit Analysis of Power Sector Reform in Haiti



COPENHAGEN CONSENSUS CENTER

Haïti Priorise
Un plan de développement alternatif

Cost-Benefit Analysis of Power Sector Reform in Haiti

Haïti Priorise

Juan Belt
Senior Economist
Limestone Analytics

Bahman Kashi
Executive Director and Senior Lecturer
Program on Investment Appraisal and Risk Analysis (PIAR), Queen's University

Jay Mackinnon
Economist
Limestone Analytics

Nicolas Allien
Renewable Energy and Energy Efficiency Consultant
Ministry of Public Work, Transportation and Communication

Working paper as of April 19, 2017.

info@copenhagenconsensus.com
www.copenhagenconsensus.com

This work has been produced as a part of the Haiti Priorise project.

This project is undertaken with the financial support of the Government of Canada. The opinions and interpretations in this publication are those of the author and do not necessarily reflect those of the Government of Canada.

Canada

Acronyms Used in this Document

ATC&C – Average Technical, Commercial and Collection Losses

BCR – Benefit-Cost Ratios

DABS - Da Afghanistan Breshna Sherkat

DISCOS – Distribution Companies

EDH – Electricité d'Haïti

GOH – Government of Haiti

IDB – Inter-American Development Bank

IPP – Independent Power Producer

KESIP - Kabul Electricity Service Improvement Program

MW - Megawatt

MWh – Megawatt Hour

PPA – Power Purchase Agreement

USAID – United States Agency for International Development

Academic Abstract

Haiti has the most underdeveloped and inefficient power sector in the Americas. Numerous past attempts to reform it have failed due to a lack of political will as well as corruption. In this paper, we consider a multi-phase program of reform. In the first phase, the Government of Haiti (GOH) carries the corporatization of units of Electricité d'Haïti (EDH), introduces management contracts, leases and concessions, privatizes EDH units as appropriate and establishes cost reflective tariffs. These tariffs can be cost plus but preferably will be some form of incentive regulation such as RPI-X. If the first phase succeeds we propose proceeding to later phases that would support EDH. Costs have been estimated based on a USAID similar program. Our estimation of economic benefits is based on a projected reduction in technical losses that would result from improved management and investment in equipment, mainly meters. The electricity is valued at the retail price of electricity for average consumers; consumer surplus associated with the increased output was not included in the benefits due to insufficient data on electricity demand in Haiti. Benefits from reductions in non-technical losses were not included in the economic analysis; these financial benefits may generate future economic benefits if EDH's improved financial situation increases their capacity to make investments and lowers generation costs. The economic and financial benefit-cost ratios of the whole project, are estimated at 3.46 and 11.52 respectively when discounted at 12 percent. This result was based on conservative assumptions about costs, and benefits, and the chances of success for the first phase, and is robust (i.e. it is unlikely that the expected net present value would drop below zero at a discount rate of 12 percent.)

Acknowledgements

We would like to thank Dr. Allen Eisendrath (USAID) for providing data on the reform program of the Kabul distribution company (DABS) and for the Haiti power sector, and for many useful discussions over the years on management contracts and their potential for turning around utilities. All errors remain with the authors.

Policy Abstract

Overview and Context

Haiti has the least developed power system in the Western Hemisphere. This is due in part to a weak institutional framework, where several actors interact in an unclear regulatory framework with a lack of strategic coordination and leadership. The Ministry of Public Works Transportation and Communication is the lead government agency in charge of the energy sector, as there is no dedicated Ministry of Energy. Decrees reorganizing the power sector published in January 2016 have called for the creation of a regulatory agency, however, as of the writing of this paper, these decrees have yet to be enforced. The electric utility, Electricité d'Haïti (EDH) runs more than 10 separate, unconnected distribution networks that have average technical, commercial, and collection losses (ATC&C) of 70 %. These grids have daily blackouts that have forced most businesses and many households to install generators on their premises as a means of coping. Many observers consider the lack of power one of the most significant constraints to economic growth. Efforts have been made by multiple donors to improve the power system, including the US Agency for International Development (USAID), the Inter-American Development Bank (IDB), and the World Bank, but these attempts have been largely unsuccessful. Lack of success is the result of a failure to reform EDH, which in turn is a result of lack of political will and alleged corruption.

The interventions proposed in this paper would have a systemic effect in the entire country by reducing a key constraint to economic growth. Direct beneficiaries would include present customers of EDH, who will have access to higher quality power and would suffer less unscheduled blackouts. As the EDH units are strengthened, additional customers would be served. The government of Haiti would also benefit from a decreased need to subsidize EDH. The utility currently receives a $ 200 million USD subsidy annually, a sum which amounts to 10 % of annual government budget expenditures.

Proposed Interventions

We propose two types of interventions as part of a package of reforms:

1. **Interventions to improve the legal regulatory framework**. These would be in support of the ministry in charge of energy and a regulator that eventually will become autonomous and accountable. These interventions will initially support the corporatization of EDH and establish the basis for management contracts, leases, concessions and privatization of the different units of EDH. Additionally, cost reflective tariffs would be established. These tariffs can be cost plus but preferably will be some form of incentive regulation such as RPI-X. Adequate performance by the GOH during the first three years will trigger a continuation of the program. USAID and other bilateral donors such as Canada and France could be potential donors. An upper bound for costs for five years would be US$20 million.
2. **Interventions to improve the efficiency of EDH**. These interventions will support the different units of EDH with technical assistance and equipment, mostly meters. It is envisaged that the different units will be managed through management contracts with incentives for performances, leases, concessions, and that the Jacmel utility would be privatized. The IDB and World Bank, as well as bilateral institutions, could be potential donors. Estimated costs for a five-year program would be $38 million. The economic Benefit-Cost Ratio, conditional on the success of the first intervention would be 3.5 (discount rate =12%).

The analysis conducted here is based on 50% chance of success for the first phase of the program – intervention to improve the legal regulatory framework. Sensitivity tests show the expected economic benefit cost ratio would still be above one if the chance of success drops to 8% and the financial benefit-cost ratio will be greater than one even if the probability of success is as low as 2%.

Benefits. The most difficult aspect of a project such as this is the estimation of benefits. For these interventions, we have estimated the potential reduction in ATC&C losses using data for a USAID-funded project that supported the energy distribution company in Kabul, Afghanistan (DABS). For the case of Haiti, we have assumed that the reduction in losses would take twice as long, ten years as opposed to five. For the economic benefits, we only valued the reduction in technical losses at the price paid by consumers.

Sustainability. Presently GOH subsidies exceed $200 million per year. If EDH is strengthened those would be reduced very significantly and maybe would be eliminated, thus allowing the finance of the regulatory costs. Additionally, a small fee on the total revenue of the DISCOS (say 0.3%) would be sufficient to pay for the costs of regulation. Funding the regulator with fees is considered a "best practice" as it reinforces independence of the institution.

Key Milestones.

Milestones for the proposed reform program are shown in Table 1

Table 1 – Milestones for Haitian Electricity Reform Program

Target	Baseline	Year 3	Year 4	Year 5	Year 13
PPP units established Cost reflective tariffs established	0	5-10* !0 for each unit of EDH	No change	No change	No change
ATC&C losses (%)	70	70	64	59	15

Five would be the minimum and 10 the maximum. If the minimum milestone is not met, the program would be terminated. All cost refelective tariffs, for each unit of EDH, would be established.

Precedent. USAID and other donors have been successful in implementing programs like this in other countries. A USAID-funded study that analyzed Public Private Partnerships (PPPs) for infrastructure and concluded that they can only succeed if control is fully vested in new managers either through management contracts, leases, concessions, or full privatization. A previous attempt by USAID to improve the operations of EDH failed when the GOH changed the proposed management contract to a purely technical assistance contract.

Risks. Benefits and costs were estimated using conservative assumption. The main risk is that lack of political will and/or corruption will derail the interventions.

Table 2 lists the costs and benefits of the intervention, assuming a 50% chance of success, a commercial loss target of 10.5% and a technical loss target of 4.5%.

Table 2 – Summary of Costs and Benefits before Implementation (2017 USD)

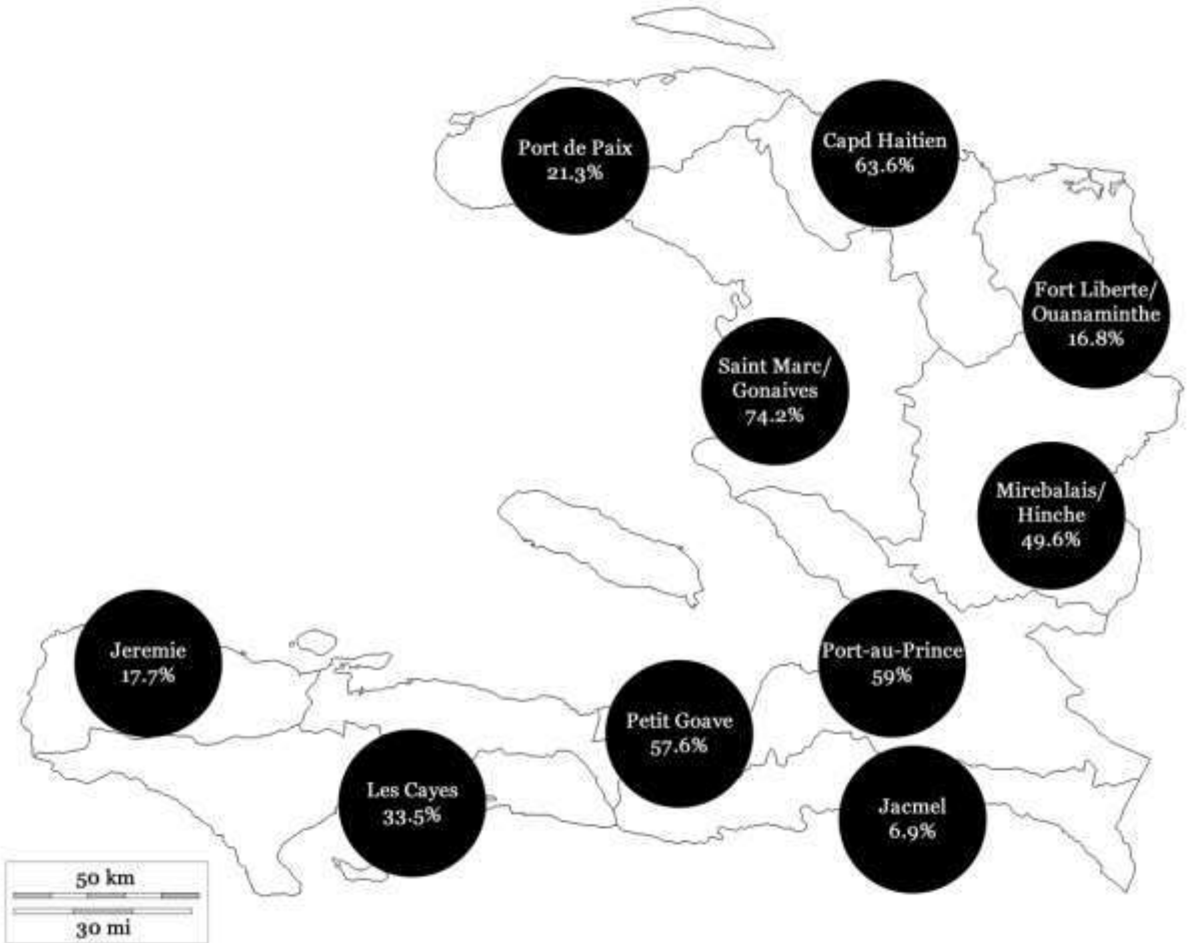
	Economic			Financial		
Discount Rate	Expected Benefits (Million USD)	Expected Costs (Million USD)	BCR	Expected Benefits (Million USD)	Expected Costs (Million USD)	BCR
3%	308.26	38.87	7.93	1,027.53	38.87	26.44
5%	216.78	33.30	6.51	722.61	33.30	21.70
12%	77.00	22.28	3.46	256.67	22.28	11.52

Table 3 lists the costs and benefits of the intervention in a scenario where we have already observed the success of the first phase.

Table 3 – Summary of Costs and Benefits of Reform, Conditional on Success in Phase 1 (2017 USD)

	Economic			Financial		
Discounting Rate	Expected Benefits (Million USD)	Expected Costs (Million USD)	BCR	Expected Benefits (Million USD)	Expected Costs (Million USD)	BCR
3%	616.52	55.10	11.19	2,055.07	55.10	37.29
5%	433.57	44.81	9.68	1,445.23	44.81	32.25
12%	154.00	25.34	6.08	513.34	25.34	20.26

Figure 1 – ATC&C Losses by Region



Port de Paix
21.3%
Capd Haitien
63.6%
Fort Liberte/
Ouanaminthe
16.8%
Saint Marc/
Gonaives
74.2%
Mirebalais/
Hinche
49.6%
Jeremie
17.7%
Port-au-Prince
59%
Petit Goave
57.6%
Les Cayes
33.5%
Jacmel
6.9%
50 km
30 mi

1. Introduction

This paper deals with Cost Benefit Analysis (CBA) of a project designed to strengthen power sector regulation and improve the efficiency of Electricité d'Haïti (EDH), a state-owned utility.

It is important to note that the authors first had to design a project and then carry out the CBA. They did this using the experience of this paper's lead author in designing development projects at the World Bank, Inter-American Development Bank (IDB), and the US Agency for International Development (USAID). Designing projects like this is usually an iterative process that involves multi-disciplinary teams that include, inter alia, engineers, project design specialists, lawyers, financial analysts and economists. Additionally, and most importantly, this would include a thorough process of consultation with the relevant authorities, officials of EDH, users, etc. Given resource limitations, only very limited consultations were carried out.

Economic development institutions follow a project cycle that begins with a strategy for the sector, identification, pre-feasibility analysis, feasibility analysis, evaluation, and monitoring and evaluation. This CBA analysis was carried out using secondary data and represents the level of analysis that would be carried out at the identification stage. Results obtained indicate that a project to strengthen EDH and reduce generation costs would be viable from the economic and financial points of view. If a donor encountered similar results in the real world, the next step would be to fund the necessary studies to move the project through the project cycle. The greatest risks this project would face stem from a lack of political will, and possible corruption driven by those who benefit from the present system.

Several donors have been involved in a multitude of projects designed to improve the operations of EDH but these projects have largely failed or have resulted in minor improvements given the level of resources expended. These projects have been somewhat timid in terms of the reforms or were weakened after approval as a result of political pressure. For example, a USAID-funded project to strengthen EDH initially contemplated a management contract, with incentives for performance, where the consulting firm would have full control of EDH, including hiring and firing of staff. [1] But eventually the Government of Haiti (GOH) converted this contract to technical assistance contract, where the consulting firm was limited in its role to providing advice to the management of EDH. Improvements of efficiency under this contract were minor. The USAID-funded program was one of a multitude of efforts by many donors, including also

[1] Conversations with USAID staff and Tetratech, (2013)

the World Bank and the IDB. It is alleged that a main reason for the failure of programs to strengthen EDH has been corruption and specifically that EDH officers benefit personally from commercial and collection losses.

Power Sector Background

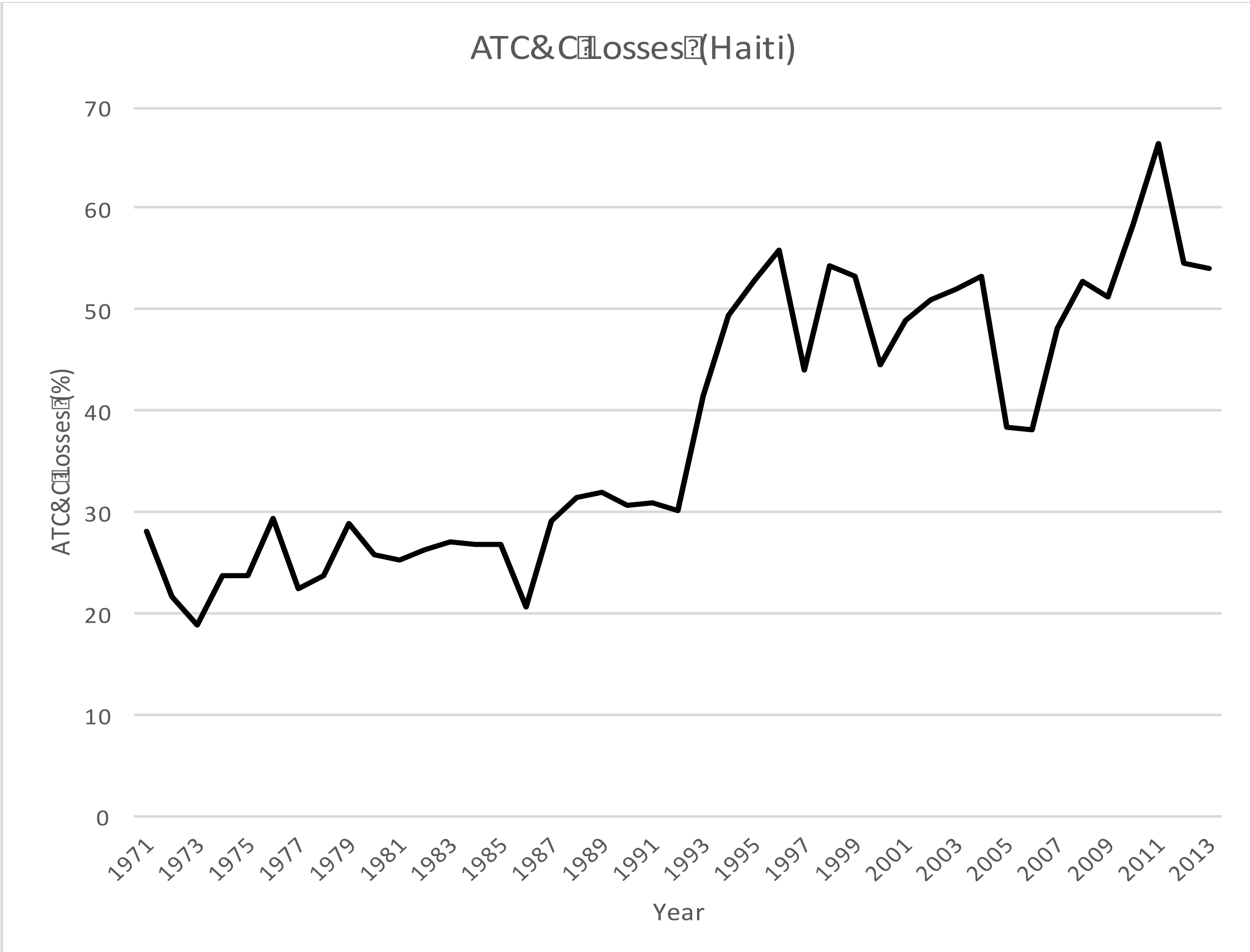
Haiti has one of the least developed power system in the Western Hemisphere. The electric utility, Electricité d'Haïti (EDH) runs more than 10 separate, unconnected distribution networks that are characterized by very large average technical, commercial and collection losses (ATC&C) and by daily blackouts that have forced most businesses and many households to install generators on their premises; many observers consider the lack of power one of the most significant constraints to economic growth. As discussed above, efforts by multiple donors to improve the power system, including the US Agency for International Development (USAID), the Inter-American Development Bank (IDB), and the World Bank have been largely unsuccessful. Lack of success is the result of a failure to reform EDH, which in turn is a result of lack of political will and alleged corruption.

Installed capacity is about 320 MW, of which 260 comes from generators that burn liquid fuels and 60 MW comes from hydropower. This makes the country highly vulnerable to variations in petroleum prices. Of the 320 MW of installed capacity, only about 55% are available for generation (176 MW). There are a number of independent power producers (IPPs) that signed power purchase agreements (PPAs) through direct negotiation rather than through competitive bidding procedures. EDH rates are on average around $0.30 per kWh, which is relatively high compared the average rates in the Caribbean. Even at these high rates, EDH requires over $200 million per year from the Government of Haiti to enable it to pay for its obligations.

Haiti's power sector faces numerous challenges. Some of the main ones include:

- As discussed above, ATC&C losses are very high and have averaged in recent years around 70 % of total electricity generated; commercial and collection losses account for 70% of total losses or around 49% of total energy produced.
- The electrification rate is one of the lowest in the world. Only about 12% of the population is connected to the grid officially, while an equal percentage are connected illegally.
- There are daily blackouts and customers receive only between 5-15 hours of electricity per day. As a consequence, even small businesses and many households must have their own generators and/or batteries and this constitutes an important constraint to economic growth.

Figure 2 – Average Technical, Commercial and Collection (ATC&C) Losses in Haiti by Year



Source: World Bank (2017)

2. Context/Literature Review

Haiti's economic condition both influences, and is influenced by, its failing electricity market. Only 35 % of Haitians have access to electricity through grids. In rural areas that figure is 11 % (World Bank, 2015). Per capita consumption of electricity in Haiti is significantly lower than other Caribbean countries, and is only two percent of the neighboring Dominican Republic (World Bank, 2015, p.5).

The inability to access electricity has serious implications for all Haitians, but is especially harmful for commercial and industrial enterprises. The lack of reliable electricity supply is cited by business owners as the most binding constraint to private sector development (World Bank, 2015, p.5). Businesses in Haiti also face some of the highest costs for electricity in the region, making it hard for them to operate competitively. Households also suffer from lack of available power, and are forced to adopt coping strategies such as using small diesel generators to power household appliances, or burning kerosene oil for light. Those Haitians that do have access to electricity through grids face shortages, and it is estimated that those with connections only have electricity for 5-9 hours a day (Worldwatch Institute, 2014, p.26).

Haiti's electricity sector is also a serious financial burden on Haiti's economy. EDH requires a transfer that averages $ 200 Million USD each year to cover operating costs. This is equal to 10% of the national budget or 2% of GDP (World Bank, 2015, p.68). EDH's significant financial losses are partly due to high levels of commercial and technical losses in the electrical grid which prevent EDH from collecting revenue. If EDH could reduce technical losses sufficiently and improve the collection of payments for electricity that is consumed, it is possible that they could operate in a more financially sustainable way and reduce their burden on GOH. Reforming EDH could make other interventions on both the supply and demand side of Haiti's electricity market (which we discuss in other papers we have written as part of Haiti Priorise) more feasible.

While it is hard to predict exactly how reform will play out in Haiti, there is a precedent of large benefits being achieved through power sector reform in other parts of the developing world. The reforms we propose are heavily inspired by the Kabul Electricity Service Improvement Program (KESIP) implemented by USAID in Afghanistan (USAID, 2017). Similar to Haitians, only 30% of Afghans have access to electricity. Before KESIP, commercial and technical losses were also very high at around 60%, similar to Haiti. KESIP focused on reforming Da Afghanistan Breshna Sherkat (DABS), the national electrical utility incorporated in 2008. With a bundle of reforms that included commercialization of the utility, changes to the governance structure, installation of smart meters, changes to the procurement processes, performance management and removing illegal connections, DABS saw AT&C losses drop from 60 % to 24 % in under five years. While it would be unlikely that Haiti would be able to replicate the exact success of KESIB, even a fraction of this level of improvement could make reform feasible.

Other countries have shown the potential benefits of power reform. Kozulj and Di Sbroivacca (2004) look at electrification rates before and after sectoral reform in Argentina, El Salvador and Peru and finds large increases in all cases. In interviews with colleagues at USAID, it was noted that reforms involving smart meters in Brazil, India and other countries lead to significant drops in non-technical losses, in some cases by as much as 96%.

3. Theory

Power projects for existing markets can be classified in three types: policy and institutional reform projects (PIRs), supply projects, and demand side projects. This CBA will be focused on a PIR project designed to enhance the power sector policy and regulatory environment and to improve the efficiency of the main off taker of power, Electricité d'Haïti (EDH).

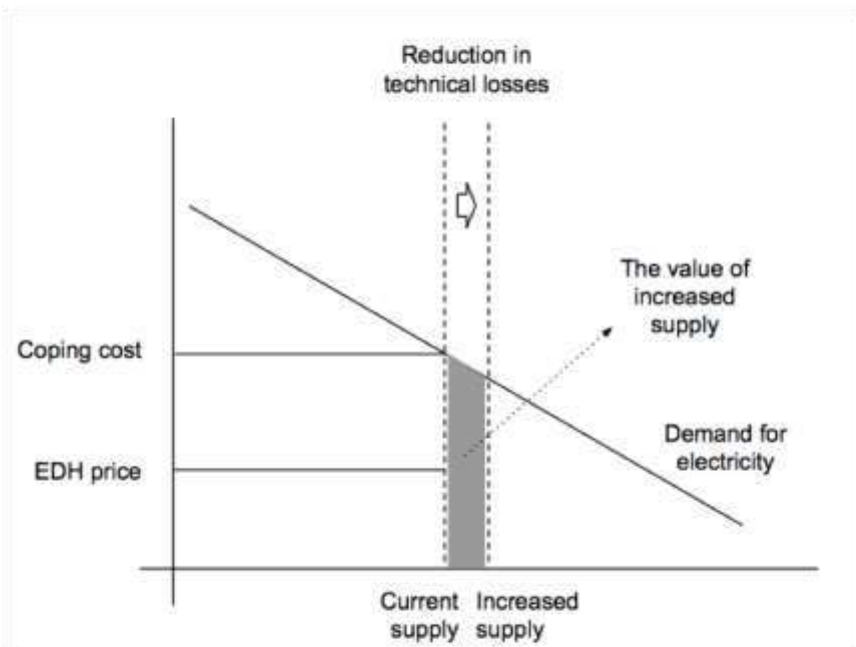
Benefits included in the evaluation of an electricity project fall under two broad categories: (i) reductions in the cost of supplying electricity and, (ii) value of improved access to energy. For instance, if investment in generation results in replacing an inefficient power plant with a more efficient one, then the main source of benefit is the saving that results from efficiency gains. However, if the investment increases the total generation resulting in increased access or improved reliability, then the benefits will mainly result from the value of access or improved reliability for consumers. It is also possible to have projects that result in both types of benefits.

Institutional reform of EDH, if successful, can result in a range of benefits listed below.

- Reduction in technical losses;
- Reduction in commercial losses;
- Reduced market risk for IPPs resulting from financial stability of the offtaker; and
- Reduction in EDH operating costs (improved institutional efficiency)

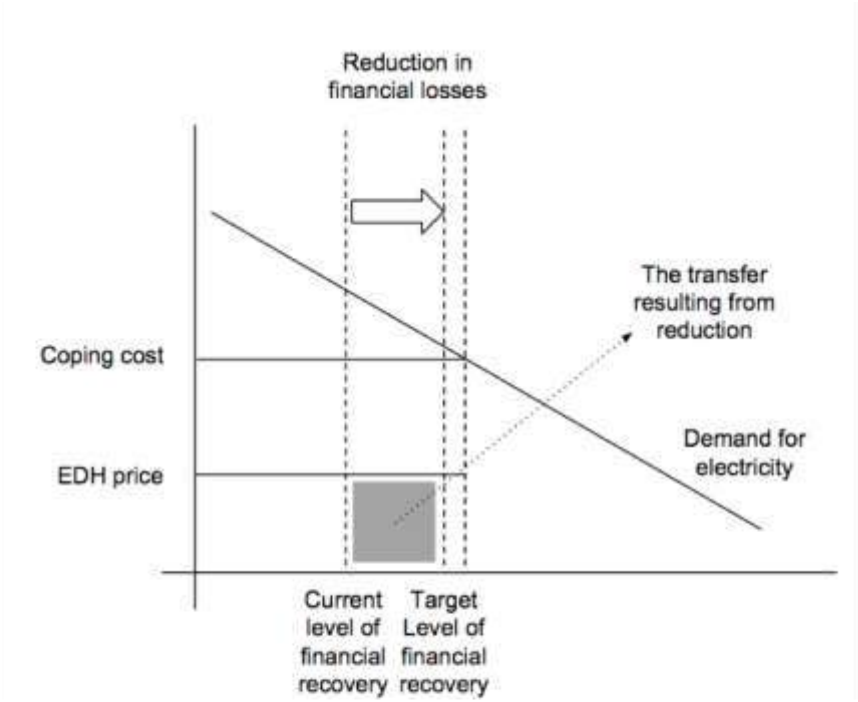
Given the inadequate supply of electricity from EDH and the prevailing market trends in distributed generation for consumers of all classes, it is reasonable to assume that any reduction in technical losses should be valued from the perspective of consumers. A reliable estimate for the value of additional electricity in this case would be the coping cost of consumers per unit of electricity obtained from sources other than EDH. To estimate the value one needs to learn about how, on average, consumers of each class use solar panels, batteries, inverters, small diesel, candles, kerosene, or other sources of energy to cope with unreliable supply of power from EDH.

Figure 3 – Impacts of Decreasing Technical Losses



A reduction in commercial losses would not, however, translate to such savings. Commercial losses reflect electricity that is consumed but not paid for to EDH. Consumption comes at a value even if it does not translate to a financial payment to EDH. Therefore, majority of what EDH gains from a reduction in commercial losses is a transfer away from consumers or resellers who do not pay for electricity. One could argue that the value of a unit of electricity consumed and not paid for can be on average lower than the value of a unit of electricity that is consumed and paid for. In other words, consumption will be at inefficient levels when the price is zero. This however can be ignored in this case since the difference is on the margin, and anecdotal evidence reflect that a considerable share of commercial losses result from non-paying resellers of the electricity.

Figure 4 – Impacts of Decreasing Financial Losses



Reduction in commercial losses can result in financial independence and sustainability of EDH, and, in the long-run, reduce the risk for IPPs that EDH is unable to pay for the power. Such risk reduction would reduce the cost of generation from IPPs and the overall cost of electricity to the economy. This benefit is however not included in the model as its estimation process relies on weak evidence.

Overall, a reduction in commercial losses is treated as a pure transfer in this study, maintaining a conservative level of benefits. Similarly, reduction in operating costs of EDH is excluded from the analysis.

The main benefits of the project are a reduction in losses. In terms of CBA, Average Technical, Commercial and Collection losses (ATC&C) can be divided into technical and non-technical. A reduction in technical losses is clearly an economic benefit. In the case of Haiti where there is excess demand for power, a reduction in losses would increase power available to consumers by, among other things, reducing the length and duration of blackouts. The entire reduction in ATC&C losses is a financial benefit for EDH. While a reduction in Commercial and Collection losses would likely result in a reduction of consumption by those users who would start paying for power, we assume in our model that revenue will not decline because there is significant unfulfilled demand in Haiti.

4. Calculation of Costs and Benefits

Introductory Comments

Financial vs. Economic Analysis. We have carried out both economic and financial analysis. For the financial analysis, we have included as benefits the entire reduction in ATC&C losses and the costs in direct support of EDH. For the economic analysis, we only include as a benefit the reduction in technical losses and as costs we include all the costs included in the financial analysis plus the costs of regulation.

Sustainability. Proposed program envisages a combination of foreign expatriates and locals so that eventually there would be no or minimal requirement for expatriate support. Eventually, the regulator should charge rates based on the value of power at the consumer level; this is considered a "best practice".

Expected Benefit-Cost Ratio. The success of the first phase of this program is subject to a great level of uncertainity, the type that is often found in oil exploration projects. Under such circumstances, we decided to build a decision-making process in the model. The decision is about the termination or continuation of the project at the end of the first phase – based on the failure or success of the first phase respectively. Therefore, in the case of the failure in the first phase, the project will only see the costs of the first phase as the costs and beenfits of the second phase will be zero as the project terminates. To estimate the expected benefit cost ratio, we introduced a parameter called the "chance of success", which is shown as α in the formula below.

$$\boldsymbol{Expected\ BCR = \frac{\alpha B_2}{C_1 + \alpha C_2}}$$

In this formula B_2 represents the benefits of the second phase, C_1 represents the costs of the first phase, and C_2 represents the costs of the second phase. Please note that the first phase itself has no benefits as it is only about building the infrastructure to enable the environment for the second phase. In other words, the costs of the first phase are the costs associated with having the opportunity to conduct the second phase.

Project Costs

We have carried out a CBA of a project that has two distinct sets of activities and 3 phases. In our proposed intervention, Phase I would last three years and would develop the minimum conditions for the success of Phase II. Given all the past failures of donor-funded projects, if the Government of Haiti (GOH) does not demonstrate commitment to reform, Phase II and Phase III would not be supported. Table 4 details the assumptions behind the costs of hiring staff. Table 5 lists the assumed annual costs of staffing, regulating reform and equipment.

Assumptions on Staffing Costs. The cost assumptions are based on USAID programs funded in Haiti and in other countries. It is assumed that an international management consulting firm will be engaged, so the costs include overhead and profit. The annual unit costs for international and local staff are shown in the table below.

Table 4 – Staffing Cost Breakdown.

Yearly Staff Items	Cost (2017 USD)
International Staff	
Salary & Overhead	4,000,000
Housing	400,000
Other Expenses	600,000
Total – International Staff	**5,000,000**
Local Staff	
Salary & Benefits	600,000
Total – All Staff	**5,600,000**

In our model we assume that the cost of international staff would be incurred int the second phase of the program, and that the costs of local staff would be incurred in both Phase II and III.

Table 5 Price of Project Components in Different Phases (Prices in Millions of USD per Year)

Activity	Annual Price in Phase I (3 Years)	Annual Price in Phase II (5 Years)	Annual Price in Phase III (25 Years)
Regulation	4	0.3	0
Staff	0	5.6	0.6
Equipment	0	2	1

Table 5 shows the potential costs of running the package of reform. In Phase 1, regulatory reform occurs, the success of which allows later phases to occur. In phase II and three, costs are the costs associated with improving EDH. We expect costs of this process to be higher at first (in Phase II) and to decrease as the system becomes more efficient and is able to pay for itself (in Phase III).

Costs of Strengthening the Regulatory Capacity of the GOH

Significantly more private participation in the sector would likely be the main instrument to improve performance. In order to achieve this, it would be necessary to enhance the regulatory capacity of the GOH. It is estimated that a team of five expatriate during five years and five Haitian during ten years would be needed. These professionals would lead the institutional reform of EDH and develop the privatization and concession terms for different units of the utility. It is envisaged that, given the small market in Haiti, the scheme used would be "regulation by contract" rather than more sophisticated market designs followed by the majority of countries in Latin America. The technical assistance will work with the regulator to estimate and establish cost-reflective tariffs, perhaps based on principles of incentive regulation such as RPI-X.

Costs of EDH Support Component

Previously, USAID financed a project to strengthen EDH but that project essentially failed. The main reason for the project's failure is that actual implementation did not follow the initial project design. USAID originally agreed to fund a management contract whereby a team of consultants would administer EDH with full powers to take management decisions, including developing a corporate strategy, and hiring and firing staff, as necessary. Eventually, because of political pressure, the contract was changed to a technical assistance type of contract where the consultants provided support to the management of EDH but had no power to take key management decisions. During this USAID-funded project, numerous issues were identified. The main ones were:

- Political interference. Several directors were replaced after short tenures and many projects undertaken were not justified from economic or financial points of view.
- Alleged administrative corruption. It has been alleged that EDH employees colluded with clients to enable them to avoid paying for power consumed.
- Overemployment of unqualified staff. A significant proportion of staff were unqualified and lacked sufficient basic knowledge to be able to benefit from training programs.
- Lack of knowledge and skills in information technology (IT). Lack of basic IT skills made it very difficult to modernize billing and financial management.
- Poor donor coordination. Many donors implemented programs in isolation, without considering what other donors were doing, thus wasting resources.

Given the problems discussed above, a classical investment project to support EDH, such as funding meters and Information Technology (IT), would not be very effective. Similar projects have indeed been recently carried out with the support of the World Bank and did not lead to significant results toward reductions in ATC&C losses. We have carried out the CBA of EDH activities under the basic assumption that the Government of Haiti (GOH) will introduce greater private participation in the 10 units of EDH. Given that the different units have widely different levels of efficiency, as measured by ATC&C losses, the solutions for each would vary. We believe there is scope for a management contract with incentives for performance, leases, concessions, and full privatization. These options are very tentative and are presented for illustrative purpose. The next step would be to hold in-depth discussions with the GOH and potential donors. The options are summarized in the table below.

Table 6 – Proposed Management Structures

Publicly Owned & Managed	Publicly owned & managed	Publicly owned; managed by private firm under management contract with incentives for performance	Lease	Concession	Privatization
No technical assistance	Technical assistance to state managers; investment in technology including meters	Management contract with incentives for performance	Private firm operates & maintains; investment funded by public sector	Private firm operates & maintains; investment by private firm	Private ownership & management
	USAID-funded project failed to improve performance of EDH	--Port Au Prince --Petit Goave --St Marc Gonaive --Cap Haitien --Mirabalais/ Hinche	--Les Cayes	--Fort Liberte --Port de Paix --Jeremy	--Jacmel

For this scheme to work properly, it is also necessary to carry out a reform of the sector. Most importantly would be to establish an independent and accountable regulator.

Project Benefits

Estimating potential reductions in ATC&C is, obviously, highly speculative. We use data from a USAID-funded project (KESID) with the energy distribution company in Kabul, Afghanistan (DABS) as a benchmark for estimating those reductions in losses in EDH. Before the USAID-funded project, losses in DABS were 60%, similar to EDH, and there was political interference, lack of trained staff, and many of the other problems presently faced by EDH.

Below is the estimated loss in DABS (Kabul).

Table 7 – Estimated DABS ATC&C losses

	Year 1	Year 2	Year 3	Year 4	Year 5
Losses	60%	53%	31%	28%	24%
Benefits	0%	7%	29%	32%	36%

While improving the operation of DABS in a highly conflictive and corrupt environment was very challenging, it might be more difficult to achieve similar results in Haiti. Therefore, we will assume that the rate of improvement of the ten units of EDH will take twice as long as the improvement in DABS. Total losses in EDH would decline steadily from 70% to 15% in ten years starting in Phase II; technical losses would decline during the same time period from 21% to 5%. The reduction in losses are valued at $0.30 USD/kWh.

The value of this reduction for different discounting rates is displayed in Table 8.

Table 8 –Benefits of Reductions in Technical and Commercial Losses

Discount Rate	Value of Technical Losses Reduction (Million USD)	Value of Reduction in Commercial Losses (Million USD)	Total Value of Reduction in AT&C (Million USD)
3%	308.26	719.27	1,027.53
5%	216.78	505.83	722.61
12%	77.00	179.67	256.67

Summary of Costs and Benefits

In Table 9 we list the costs, benefits and benefit-cost ratios for the reform program, from both the economic and financial perspective, for three different discount rates, assuming the project has a 50% chance of success. The economic benefits are the expected (probabilistically weighted) present value of a reduction in technical losses. Financial benefits include the expected present value of reductions in both technical and commercial losses. Economic and financial costs are the summation of the Phase I costs, and the *expected* value of the Phase II and III costs, since Phase II only occurs if Phase 1 is successful.

Table 9 – Summary of Expected Costs and Benefits of Institutional Reform before Phase 1 (2017 USD, Millions)

	Economic			Financial		
Discount Rate	Expected Benefits	Expected Costs	BCR	Expected Benefits	Expected Costs	BCR2
3%	308.26	38.87	7.93	1,027.53	38.87	26.44
5%	216.78	33.30	6.51	722.61	33.30	21.70
12%	77.00	22.28	3.46	256.67	22.28	11.52

The estimates of benefit-cost ratios in Table 9 imply that if our estimates are accurate, the project's benefits can be greatly in excess of its costs. This is true both from the financial perspective as well as the economic perspective. It is also true, even when discounting at 12 %. However, keep in mind that these estimations are based on a 50% probability of achieving targets which are already quite large. We will later analyze how sensitive our estimates are to different probabilities or targets.

In Table 10 we list the same estimation as before, but this time we consider only a scenario where Phase I has been successful, indicating that Phase II will be proceed with a 100% probability. The costs therefore only include the present value of costs from Phase II, and both costs and benefits are weighted with a probability of 100%. Notice how the benefits of the program are extremely high compared to costs if we can guarantee the project's success.

Table 10 – Summary of Benefits and Costs Conditional on the Success of Phase 1 (2017 USD, Millions)

	Economic			Financial		
Discounting Rate	Expected Benefits (Million USD)	Expected Costs (Million USD)	BCR	Expected Benefits (Million USD)	Expected Costs (Million USD)	BCR
3%	616.52	55.10	11.19	2,055.07	55.10	37.29
5%	433.57	44.81	9.68	1,445.23	44.81	32.25
12%	154.00	25.34	6.08	513.34	25.34	20.26

Sensitivity Analysis

In Table 11 we list the economic and financial cost-benefit ratios of the entire project (both phases) calculated using different values for the probability of success in Phase I. These estimates use our standard timelines and loss reduction targets, and using a 5% discount rate. Because of the way the project is set up, costs in Phase II are only paid if Phase I is successful, thus ensuring a net benefit in Phase II and III. As such, there must be a very low probability of success for the sunk cost of Phase I not to be covered by expected earnings in Phase II and III, at least with such high expectations for the value of loss reduction.

Table 11 – Sensitivity of Benefit-Cost Ratios to Changes in the Probability of Reform Success – 12% discount rate

Probability of Success	BCR (Financial)	BCR (Economic)
0%	0.00	0.00
25%	8.05	2.42
50%	11.52	3.46
75%	13.46	4.04
100%	14.69	4.41

We may also want to consider the implications of lower than expected reductions in losses both for technical losses and commercial losses. In Table 12 we list the economic and financial cost-benefit ratios of the entire project calculated using different values for the expected final value of technical losses. Table 13 shows the same information but for commercial losses.

Table 12 – Sensitivity of Benefit-Cost Ratios to Changes in the Technical Loss Target – 12% discount rate

Technical Loss Target	BCR (Financial)	BCR (Economic)
4.5%	11.52	3.46
11%	10.16	2.09
15%	9.32	1.26
18%	8.69	0.63

The values in Table 13 seem to indicate that the financial BCR is high, even if the target for technical losses is not significantly lower than the current amount (21%). The economic BCR on the other hand is highly correlated with the targeted reduction in technical losses, and actually goes below one if technical losses do not decrease sufficiently. This implies that a reform that only targets commercial losses might be financially feasible, but may not improve the general economic situation in Haiti enough to justify its costs.

Table 13 – Sensitivity of Benefit-Cost Ratios to Changes in the Commercial Loss Target

Commercial Loss Target	BCR (Financial)	BCR (Economic)
5%	12.67	3.46
11%	11.42	3.46
15%	10.58	3.46
30%	7.44	3.46

Notice that in Table 13, the BCR (Economic) does not respond to changes in the commercial loss reduction target, since commercial losses are considered a transfer from the economic perspective. The financial BCR is fairly high, even for targets significantly more conservative than we have predicted.

We may also wish to consider a scenario where multiple variables deviate from our estimates, a worst-case scenario so to speak, to see if the project is expected to generate a positive net benefit. In Table 14 we assume:

1. A target of 30% for commercial losses;
2. A target of 15% for technical losses; and
3. A 10% probability of success.

Table 14 – Sensitivity of Benefit-Cost Ratios in "Worst Case" Scenario

Discount Rate	BCR (Financial)	BCR (Economic)
3%	5.55	1.33
5%	4.27	1.03
12%	1.92	0.46

It appears that even in a “worst-case” scenario there seems to be a net financial benefit to reform, even at a 12% discount rate, and net economic benefits at lower discount rates.

5. Conclusion

The proposed interventions would be highly beneficial to the Haitian economy. Using conservative estimates of costs and benefits, the BCR would be 3.46 (assuming a discount rate of 12%). The greatest risk to reform is that lack of political will and corruption will impede the actions necessary to improve the efficiency of EDH. This risk is high, as past efforts by all main international donors, including USAID, the World Bank and the IDB have failed. To mitigate that risk, we have proposed that donors impose strict conditions in order to fund the full program. Specifically, we believe that unless some key reforms are implemented during the first three years of the proposed program, all future activities not be supported. The analysis was done with very limited consultation with key stakeholders and could be considered less than what a donor would do at the identification stage in the project development cycle. The next step would be to discuss with the GOH, potential donors, and all other main stakeholders.

6. References

Aguirre, J., 2014. Impact of Rural Electrification on Education: A Case Study from Peru. Research Center, Universidad del Pacifico (Peru) and Department of Economics 1–18.

Anonymous, 2017. IPP PPA Prices per kWh.

Anonymous, 2016. Interview with a Doctor.

Bloomberg New Energy Finance, World Energy Council, 2013. World Energy Perspective: Cost of Energy Technologies.

Blum, N., Wakeling, R., Schmidt, T., 2013. Rural electrification through village grids - Assessing the cost competitiveness of isolated renewable energy technologies in Indonesia.

Brown, N.L., 1978. Solar Energy for Village Development.

Chen, S.X., Gooi, H.B., Wang, M., 2012. Sizing of energy storage for microgrids. IEEE Transactions on Smart Grid 3, 142–151.

Costa, P.M., Matos, M.A., 2006. Economic analysis of microgrids including reliability aspects, in: Probabilistic Methods Applied to Power Systems, 2006. PMAPS 2006. International Conference on. IEEE, pp. 1–8.

Di Bella, C.G., Norton, L.D., Ntamatungiro, J., Ogawa, S., Samake, I., Santoro, M., 2015. Energy Subsidies in Latin America and the Caribbean: Stocktaking and Policy Challenges.

Earth Spark International, 2016. Les Anglais Micro-Grid Factsheet.

EarthSpark International, 2015. Scaling Sustainable Energy for All: EarthSpark International and the Case for Micro-grid Infrastructure.

Energy and Security Group, 2016. Haitian Solar Powered Microgrid Potential: Town Ranking Report.

EPRI, 2003. Costs of Utility Distributed Generators, 1-10 MW: Twenty-Four Case Studies.

ESMAP, 2002. Rural Electrification and Development in the Philippines: Measuring the Social and Economic Benefits.

Foroudastan, S.D., Dees, O., 2006. Solar Power and Sustainability in Developing Countries.

Golumbeau, R., Barnes, D., 2013. Connection Charges and Electricity Access in Sub-Saharan Africa.

Government of Haiti, Department of Public Works, Transportation and Communication, 2015. SREP Investment Plan for Haiti.

Greacen, C., Engel, R., Quetchenbach, T., 2013. A Guidebook on Grid Interconnection and Islanded Operation of Mini-Grid Power Systems Up to 200 kW.

Hotel in Port au Prince, 2016. Interview with an Anonymous hotel.

Hutton, G., Rehfuess, E., others, 2006. Guidelines for conducting cost-benefit analysis of household energy and health interventions, in: Guidelines for Conducting Cost-Benefit Analysis of Household Energy and Health Interventions. OMS.

Inland Revenue, 2016. General depreciation rates.

Inter-American Development Bank, 2014. Natural Gas in the Caribbean: Feasibility Studies (Final Report I and II).

IRENA, 2016a. The Power to Change: Solar and Wind Cost Reduction Potential to 2025.

IRENA, 2016b. Solar PV in Africa: Costs and Markets.

IRENA, 2015a. Renewable Energy in Hybrid Mini-Grids and Isolated Grids: Economic Benefits and Business Cases.

IRENA, 2015b. Renewable Power Generation Costs in 2014.

IRENA, 2015c. Battery Storage for Renewables: Market Status and Technology Outook.

IRENA, 2012a. Cenewable Energy Technologies Cost Analysis Series: Solar Photovoltaics.

IRENA, 2012b. Renewable Energy Technologies Cost Analysis Series: Hydro.

IRENA, IEA-ETSAP, 2013. CSP Technology Brief.

Ishigaki, Y., Kimura, Y., Matsusue, I., 2014. Optimal Energy Management System for Isolated Micro Grids.

Kashi, B., 2015. Risk management and the stated investment costs by independent power producers. Energy Economics 49, 660–668.

Kurtz, J., Saur, G., Ainscough, C., 2014. Backup Power Cost of Ownership Analysis and Incumbent Technology Comparison.

Larocque, A., 2014. Comprehensive Planning for Electric Power Supply in Haiti – Regulatory, Institutional & Tariff Report.

Larocque, A., Nadeau, D., Landry, M., 2014. Comprehensive Planning for Electric Power Supply in Haiti - Expansion of the Supply for Electricity Generation.

Lenin Balza, Christiaan Gischler, Nils Janson, Sebastian Miller, n.d. Potential for Energy Storage in Combination with Renewable Energy in Latin America and the Caribbean.

Lucky, M., Auth, K., Ochs, A., Fu-Berteaux, X., Weber, M., Konold, M., Lu, J., 2014. Haiti Sustainable Energy Roadmap.

Machala, M., 2011. Kerosene Lamps vs. Solar Lanterns. Stanford University.

McMannus, R., 2015. Interview with Rachel McMannus.

Mills, E., 2003. Technical and Economic Performance Analysis of Kerosene Lamps and Alternative Approaches to Illumination in Developing Countries.

Nicolas Allien, 2017. 100 kW diesel Quote.

NREL, 2014. Distributed Solar PV for Electricity System Resiliency.

Obama, B., 2017. The irreversible momentum of clean energy. Science 355, 126–129. doi:10.1126/science.aam6284

Paul L. Joskow, 2011. Comparing the Costs of Intermittent and Dispatchable Electricity Generating Technologies.

Pauschert, D., 2009. Study of Equipment Prices in the Power Sector.

Perkins Engines Company Limited, 2012. 400 Series 404D-22G ElectropaK.

Perkins Engines Company Limited, 2007. Perkins 1104D-E44TAG ElectropaK.

Rangarajan, K., Guggenberger, J., 2011. Cost Analysis of Renewable Energy-Based Microgrids for Rural Energy Management, in: IIE Annual Conference. Proceedings. Institute of Industrial Engineers-Publisher, p. 1.

Rao, N.D., Agarwal, A., Wood, D., 2016. Impacts of Small Scale Electricity Systems: A Study of Rural Communities in India and Nepal.

Singh, R.J., Barton-Dock, M., 2015. Haiti: Towards a New Narrative (Systematic Country Diagnostic.

Smith, K.R., Rogers, J., Cowlin, S.C., 2005. Household fuels and ill-health in developing countries: what improvements can be brought by LP gas? World LP Gas Association Paris, France.

Squires, T., 2015. The Impact of Access to Electricity on Education: Evidence from Honduras.

Staton, D.M., Harding, M.H., 1998. Health and Environmental Effects of Cooking Stove Use in Developing Countries.

Technical Aspects of Grid Interconnection, n.d.

Tetratech, 2013, Interinm Final Report: Lessons Learned During the Haiti Transmission Management Contract.

The World Bank, 2017. Haiti Overview [WWW Document]. URL http://www.worldbank.org/en/country/haiti/overview (accessed 3.13.17).

The World Factbook — Central Intelligence Agency [WWW Document], n.d. URL https://www.cia.gov/library/publications/the-world-factbook/rankorder/2004rank.html (accessed 3.15.17).

Thys, P.K., 2017. Interview with Pierre Kénol Thys, IDB Energy Specialist.

Tol, R.S.J., 2011. The Social Cost of Carbon.

UNdata | country profile | Haiti [WWW Document], 2017. URL http://data.un.org/CountryProfile.aspx?crName=haiti (accessed 3.13.17).

United States Energy Information Administration (US EIA), 2017a. Cost and Performance Characteristics of New Generating Technologies, Annual Energy Outlook 2017.

United States Energy Information Administration (US EIA), 2017b. Short-Term Energy Outlook Data Browser - March 2017.

United States Energy Information Administration (US EIA), 2016. Carbon Dioxide Emissions Coefficients.

U.S. Energy Information Administration, 2016. Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2016.

Verner, D., Egset, W., 2007. Social Resilience and State Fragility in Haiti. World Bank Publications.

Wärtsilä, Marine Solutions, 2016. Wärtsilä 46F Product Guide.

Wilson, M., Jones, J.B., Audinet, P., 2010. Benefits of Electrification.

World Bank, 2017. Data on Statistical Capacity: SCI Dashboard [WWW Document]. URL http://datatopics.worldbank.org/statisticalcapacity/SCIdashboard.aspx (accessed 3.13.17).

World Bank, 2008. The Welfare Impact of Rural Electrification: A Reassessment of the Costs and Benefits. The World Bank.

Zhang, J., Smith, K.R., 2007. Household air pollution from coal and biomass fuels in China: measurements, health impacts, and interventions. Environmental Health Perspectives 848–855.

Haiti faces some of the most acute social and economic development challenges in the world. Despite an influx of aid in the aftermath of the 2010 earthquake, growth and progress continue to be minimal, at best. With so many actors and the wide breadth of challenges from food security and clean water access to health, education, environmental degradation, and infrastructure, what should the top priorities be for policy makers, international donors, NGOs and businesses? With limited resources and time, it is crucial that focus is informed by what will do the most good for each gourde spent. The Haïti Priorise project will work with stakeholders across the country to find, analyze, rank and disseminate the best solutions for the country. We engage Haitans from all parts of society, through readers of newspapers, along with NGOs, decision makers, sector experts and businesses to propose the best solutions. We have commissioned some of the best economists from Haiti and the world to calculate the social, environmental and economic costs and benefits of these proposals. This research will help set priorities for the country through a nationwide conversation about what the smart - and not-so-smart - solutions are for Haiti's future.

Haïti Priorise

Un plan de **développement** alternatif

For more information visit www.HaitiPriorise.com

COPENHAGEN CONSENSUS CENTER

Copenhagen Consensus Center is a think tank that investigates and publishes the best policies and investment opportunities based on social good (measured in dollars, but also incorporating e.g. welfare, health and environmental protection) for every dollar spent. The Copenhagen Consensus was conceived to address a fundamental, but overlooked topic in international development: In a world with limited budgets and attention spans, we need to find effective ways to do the most good for the most people. The Copenhagen Consensus works with 300+ of the world's top economists including 7 Nobel Laureates to prioritize solutions to the world's biggest problems, on the basis of data and cost-benefit analysis.