Utilities 2.0: Analyzing Customer Lifetime Value and Customer Transfer for a Novel Electrification Partnership

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Executive Summary

In rural Uganda, approximately twenty percent of people have access to electricity. Expanding the grid to reach these rural communities can be costly and time consuming. For the country's main electric utility, Umeme, connecting new rural customers to the grid is also likely to be a loss-generating activity, as these low-income, new electricity users are likely to consume extremely low amounts of electricity. Power for All, an international nonprofit organization focused on accelerating energy access, is developing a new model of electrification which harnesses the comparative advantages of both distributed renewable resources and centralized utilities, to deliver electricity to these communities faster and cheaper than typical grid expansion.

Simply put, in Power for All's novel business partnership model, called Utilities 2.0, a mini-grid developer will construct a mini-grid in an off-grid community, and for a period of approximately two years, they will carry out demand stimulation to increase community electricity consumption. This is accomplished by the leasing or sale of productive use of electricity assets, to increase productivity and community income, and raise electricity demand levels. After two years, Umeme connects their main grid to the mini-grid site and takes those customers on as their own. Power for All will soon pilot this model in a rural Ugandan community to test the concept.

This report details the authors' work to support Power for All's initiative through two main work streams. First, we carried out an analysis of relevant mini-grid policy and regulations to examine whether there are sufficient protocols in place to ensure a positive customer

experience through their transfer from the mini-grid operator to Umeme. We examined customer experience across three categories: service quality, reliability, and cost. For service quality, we found that current mini-grid regulations establish a standardized consumer agreement which delegates responsibility to a mini-grid operator to ensure an acceptable level of service. Post-customer transfer, we found Umeme to have established a robust online customer service interface. Regarding reliability, we found that interconnecting a mini-grid to the central grid has the potential to improve or reduce system reliability for the mini-grid community depending on the post-interconnection mini-grid function selected. Finally, we found that, upon customer transfer to Umeme, customer tariff rates would either decrease from the mini-grid tariff or remain the same. We found the customer experience will alter depending on which pre- and post-interconnection strategy chosen, but the current policy supports this initiative. Power for All has identified the benefit-risk of each strategy and will work with the utility and the mini-grid developer to choose the most suitable strategy.

Second, we developed a Customer Lifetime Value (CLV) model, to measure the value add of Utilities 2.0 relative to a business-as-usual (BAU) grid expansion scenario for the pilot community. The BAU scenario examined resulted in negative CLV, indicating a net loss for a utility serving those customers. We also examined both a Low Demand Growth and High Demand Growth Utilities 2.0 scenario, each containing a set of different business model permutations related to the pre- and post- interconnection strategies available. We found that the Low Growth scenario largely results in improved customer lifetime value relative to the BAU scenario, with four of the six business model permutations resulting in increased CLV. The High Growth scenario resulted in CLVs higher than the BAU for all business model permutations.

Overall, the Utilities 2.0 model was able to increase CLV by up to $182.14 per connection, compared to the upper end of the BAU CLV range, at -$20.04 per connection.

This report details the following key takeaways:

- Current mini-grid policy and regulations support a positive customer experience through the transfer process.
- The mini-grid tariff is modeled to be either be greater than or equal to Umeme's. A pre-integration tariff greater than Umeme's may reduce the level of demand stimulation achieved.
- Utilities 2.0 can improve CLV relative to the BAU grid expansion scenario.
- The level of demand stimulation achieved, and the specific Utilities 2.0 business model selected exhibit significant influence over the level of CLV increase.

Introduction

Power for All is an international nonprofit organization whose mission is to eradicate energy poverty by 2030 for the approximately 2 billion people currently lacking access to reliable electricity. Its approach centers around research, coalition building, and advocacy across developing energy sectors to advocate for and advance distributed, renewable energy solutions in addressing energy poverty. Our work has been in support of Power for All's Utilities 2.0 initiative, which aims to reimagine the traditional centralized electric utility model, taking advantage of distributed energy resources to expand power grids more quickly and cost-effectively to unserved communities.

Power for All has focus areas in India, Nigeria, Zimbabwe, Sierra Leone, Kenya, Ethiopia, as well as Uganda. Its Utilities 2.0 program is a global campaign aimed to unite centralized utilities with the decentralized renewable energy sector.[1] The focus of this master's project centered on a pilot project in Uganda. In a matter of 15 years, Uganda rebounded from experiencing an energy crisis to an energy surplus. In 2005, droughts caused capacity shortages from Uganda's hydroelectric dams, which reduced electricity supply to half the level of demand. As a consequence, the country suffered from economic loss and was forced to increase its reliance on diesel generation for electricity generation. Fast forward to 2019, Uganda found themselves in an electricity generation surplus due to an increase of generation capacity of 1,167 megawatts (MW) and a peak demand of 625 MW. Within the 15-year time frame, Uganda

[1] Power for All. "Utilities 2.0 Initiative, Global Campaign." *Power For All, Utilities*, 2021, www.powerforall.org/campaigns/utilities.

received substantial private capital investments to achieve their goal, but now are faced with a new issue: How to stimulate consumption of electricity from its citizens while connecting its citizens to the grid. This is where Power for All's Utility 2.0 initiative was proposed as a solution.[2]

In Uganda, where Power for All (the "Client") has launched its Utilities 2.0 initiative, less than one third of citizens have access to electricity.[3] However, its government has set a target of 80% energy access by 2040.[4] Power for All is building a coalition of energy sector players to provide expertise and research in order to facilitate a smooth and efficient transition toward Uganda's energy access goal. One component of Power for All's Utilities 2.0 work in Uganda is the development of innovative business partnership models which harness the comparative advantages of mini-grids (also referred to as microgrids), distributed renewable energy (DRE) resources, productive use of electricity (PUE) appliances, and the country's major electric distribution utility, Umeme Limited (Umeme). By integrating these elements into a single business partnership model, they hope to deliver energy access more quickly and cheaply than traditional grid expansion.

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[2] Akena, Alexander Komakech. "Achievements and Challenges of Uganda's Power Sector." RMI, 9 Jan. 2020, rmi.org/achievements-and-challenges-of-ugandas-power-sector/.

[3] IEA. "Access to Affordable, Reliable, Sustainable and Modern Energy for All – SDG7: Data and Projections." *IEA*, Oct. 2020, www.iea.org/reports/sdg7-data-and-projections/access-to-electricity.

[4] Mahomed, Sumaya, et al. "Business Model Innovations for Utility and Mini-Grid Integration: Insights from the Utilities 2.0 Initiative in Uganda." *Energy and Economic Growth*, Oct. 2020, energyeconomicgrowth.org/publication/business-model-innovations-utility-and-mini-grid-integration-insights-utilities-20.

Utilities 2.0 Business Models

The motivation behind the Utilities 2.0 Integrated Business Model project is the idea that mini-grids – isolated electricity distribution systems that supply their own power to users via small-scale generation resources like solar, batteries, and diesel generators – can act as a steppingstone for Africa's electric utilities in delivering energy access to all. For off-grid communities, mini-grid developers can construct mini-grids far more quickly than traditional utility grid expansion, bringing with them the economic, educational, health, and equity benefits associated with electrification. As Uganda's electricity transmission and distribution networks grow, distribution utilities, such as Umeme, can eventually interconnect the mini-grids to their own networks, potentially taking ownership of certain infrastructure, and taking on the mini-grid users as their own customers. This model has the potential to offer the unique benefit to Umeme of supplying them with higher demand customers than they would otherwise receive if they were to connect these off-grid communities through typical grid expansion.

The Utilities 2.0 model focuses on off-grid, mostly rural communities, whose electricity customers can be expected to exhibit lower levels of demand relative to urban utility customers. A longitudinal study of electricity customers in Kenya, whose electrification program has nearly doubled grid connections since 2010, found that newly connected rural customers consumed about half the electricity of urban customers connected to the grid within the same year.[5] Both groups exhibited a pattern of initial demand growth followed by a leveling-off of

[5] Fobi, Simone, et al. "A Longitudinal Study of Electricity Consumption Growth in Kenya." *Energy Policy*, vol. 123, 2018, pp. 569–578., doi:10.1016/j.enpol.2018.08.065.

demand, with rural customers levelling off at demand levels about half as high as urban customers. Notably, electricity demand leveled off sooner and at lower levels the more recently the grid connection was established. Customers with extremely low demand represent a loss of profit to the electric utility, which recovers its costs through the sale of electricity. Therefore, a central function of the integrated business model is to “stimulate demand” in mini-grid customers by encouraging the productive use of electricity (PUE), thus increasing the electrical load on the mini-grid and providing a more profitable customer to the utility upon interconnection to the main grid. Productive use of electricity assets are intended to increase the productivity for the user.[6] Traditionally, these are technologies used to increase production of agriculture, commercial, or industrial activities. However, this term has been adapted to include all types of income generating assets. As an example, lighting equipment can enable a business to stay open later, providing more revenue-generating opportunities. As a result of increased productivity driven by PUE equipment, the user is expected to generate higher income, and their increased electricity demand generates higher revenues for the electricity supplier.

Utilities 2.0 partner EnerGrow offers micro-loan financing to help low-income customers purchase these types of appliances and provides continuing support to their customers through compulsory small-business and financial literacy training.[7] The Utilities 2.0 Pilot aims, in part, to demonstrate that the incorporation of these PUE loads will simultaneously improve

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[6] Stottlemyer, Jeff. “What We Mean by ‘Productive Use’-and Why It Matters.” *Power For All*, 29 Oct. 2018, www.powerforall.org/insights/technologies/what-we-mean-productive-use-and-why-it-matters.

[7] *EnerGrow*, 2021, ener-grow.com/

productivity and quality of life for newly electrified mini-grid customers while making the mini-grid a more commercially viable project for mini-grid developers and electric utilities.

Power for All and the Duke Energy Access Project team developed three distinct variations of the Utilities 2.0 business partnership model, based on potential ownership, labor, and cost-sharing configurations to examine how project costs might vary.

The three business models Power for All developed form a partnership between the mini-grid developer and the utility to achieve energy access for Ugandan citizens.[8] The three business models are:

1. The Mini-Grid Led Integration Model
2. The Flexible Asset Ownership Model
3. The Utility Led Integration Model

Mini-Grid Led Integration Model

The mini-grid developer focuses on customer development and designs, purchases, and operates the mini-grid while the utility builds the distribution network. The utility offers service and technical support throughout the process. This partnership leverages the low cost of service from the utility and provides the utility with demand stimulation data from the mini-gid.

- *Mini-grid role and responsibility*: The mini-grid developer maintains the generation assets which includes the solar panels, batteries, and diesel generators. They will use

[8] Mahomed, Sumaya, et al. "Business Model Innovations for Utility and Mini-Grid Integration: Insights from the Utilities 2.0 Initiative in Uganda." *Energy and Economic Growth*, Oct. 2020, energyeconomicgrowth.org/publication/business-model-innovations-utility-and-mini-grid-integration-insights-utilities-20.

utility meters to ensure the connection of households are at the utility standard. Lastly, the mini-grid developer will focus on growing demand through marketing or providing PUE assets such as refrigerators and lights. The mini-grid developer will receive subsidies to alleviate the cost per connections.

- *Utility role and responsibility:* The utility will build the distribution network. Simply, this consists of the poles and wires that connect households to the mini-grid. Utilities have an established reputation which gives them leverage to encourage customers to connect to the mini-grid.

The distribution network that the utility builds provides them with an additional revenue stream while the mini-grid developer has the opportunity to demonstrate customer development, demand growth, quality of service as well as its ability to supply electricity at an increased pace.

Utility Led Asset Purchase Model

In this model, the utility is responsible for purchasing the mini-grid as well as the battery storage assets. The power cost, or levelized cost of electricity, is reduced in this model by taking advantage of the utility's lower cost of capital relative to the mini-grid developer. The capital investments and operating costs are reduced in this model through the standardization, leasing, and mobility of the capital expenditure (equipment).

- *Mini-grid role and responsibility*: In accordance with off-grid (mini-grid) policy in Uganda, the mini-grid developer will connect each household to the utility standard and use the utility’s meter and billing system. The mini-grid will focus on growing the demand of its customers through providing or marketing productive-use assets.

- *Utility role and responsibility:* The utility will build the distribution infrastructure as well as purchase all of the generating assets outright from a third-party provider, including the solar panels, diesel generators, and battery storage.

The supplier for the generation equipment is a third-party provider who designs and installs the modular generation assets with a warranty, as well as PUE assets which can be sold to the customers.

Flexible Asset Ownership Model

This model focuses on the synergistic capabilities of both the utility and the mini-grid by allowing either the utility or the mini-grid developer to be the primary asset owner depending on their agreement. Cost savings can be achieved by shifting the capital expenditures to longer-term operating costs. The flexible asset model uses standardization, leasing, and mobility and reduces the up-front costs by driving down the soft and hard up-front capital expenses for the generating assets.

- *Mini-grid role and responsibility*: In accordance with off-grid (mini-grid) policy in Uganda, the mini-grid developer will connect each household to the utility standard and use the utility’s meter and billing system. The mini-grid will focus on growing the demand of its customers through providing or marketing productive-use assets.

- *Utility role and responsibility:* The utility will manage all aspects of the distribution network including building, owning, and maintaining it. The utility will receive subsidies, including donor or national, to assist with the cost of connection.

The generation equipment supplier is a third-party distributor who will design, purchase, and install the generation assets including solar, batteries, and diesel generators. The third-party management will monitor and control the assets, as well as provide routine maintenance. Either the utility or mini-grid can lease the equipment from the third-party provider dependent on their arrangement.

Client Deliverables

The Power for All team enlisted the Duke Master's Project team, composed of Master of Environmental Management candidates Ian Reichardt ('21) and Isaac Rosenthal ('21), and advised by Jonathan Phillips, to build on the business modeling work carried out during the previous summer. The following deliverables will support the Utilities 2.0 coalition in Uganda as they begin work on demonstration projects to pilot the Utilities 2.0 integrated business model.

Customer Lifetime Value Metric Development

The complexity of the Utilities 2.0 business model makes it difficult to express the value of a project to the various stakeholders, who might invest capital, labor, operational expenses, and serve or transfer customers at varying points throughout the project lifespan. In particular, the integrated business model is predicated on the idea of demand stimulation in the early stages of the project as a means of developing a more profitable customer who will eventually be transferred to the electric utility. How can the mini-grid developer quantify the value that they add to the electric utility for the demand stimulation service they provide? Our client tasked us to answer this question by investigating the Customer Lifetime Value (CLV) metric. We aimed to research the applicability of this metric and develop a quantitative model in Excel to incorporate into Power for All's primary financial model. If proved to be an applicable metric, CLV should help Power for All quantify the financial benefit of demand stimulation in the Utilities 2.0 pilot and facilitate communication between mini-grid developers who typically use metrics such as Average Revenue per User (ARPU), and Umeme, who should be more familiar with CLV.

Policy and Regulatory Analysis

It is important to ensure the business modeling stays within the bright lines of policy to make certain the project is not only financially viable, but politically sound. To ensure that the main grid interconnects with the mini-grid equitably, clear regulatory guidelines must be present. A key aspect of a successful interconnection is the customer experience, which can be thought of as comprising service quality, reliability, and cost. We were tasked with researching Ugandan energy policy and regulations to analyze its level of support for the novel process of transferring customers from the decentralized mini-grid developer to the centralized electric utility. Transferring customers from a mini-grid to a utility has not previously been done in Uganda. We researched what policies and regulations are currently in place regarding this novel idea in order to support the Utilities 2.0 initiative. The core question Power for All asked to guide our research was: What policy or protocol must be in place such that when customers are transferred, their experience in service quality, reliability, and cost is positive? The next section will provide the findings from the policy research.

Materials and Methods

Customer Lifetime Value

Customer lifetime value (CLV) is a marketing metric that represents the present value of all future revenues and costs associated with serving a particular customer or segment of customers.[9] By viewing customers as revenue-generating financial assets, firms can use CLV to estimate customer profit or loss potential and allocate the firm's resources to those customers with the greatest profit potential. For example, a firm may decide not to market incentives like coupons or discounts towards customer segments with negative CLVs (which indicates a net cost to the firm) and instead reallocate those resources towards higher CLV customer segments.

Put simply, and shown below, CLV is equal to the sum of a customer or customer segment's revenues, less the firm's cost to serve that customer or segment, for each time period under consideration, discounted to the present day:

$$\text{CLV} = \sum_{t=1} \left[(\text{Revenue}_t - \text{Cost}_t) \,/\, (1 + \text{Discount Rate})^t \right]$$

As in this example, most CLV models incorporate the following components: *revenue*, *costs*, *customer retention rate* (the probability, at any time period, that the customer ends its relationship with the firm), *frequency of transactions*, and *discount rate*. Furthermore, one may choose to calculate CLV at either the individual or the customer segment level. Customer acquisition costs are not typically incorporated into the CLV calculation. In some cases, there

[9] Kumar, V. "A Theory of Customer Valuation: Concepts, Metrics, Strategy, and Implementation." *Journal of Marketing*, vol. 82, no. 1, 1 Jan. 2018, pp. 1–19., doi:10.1509/jm.17.0208.

may be no acquisition cost to reflect. But in the cases where acquisition costs do factor in, they can be interpreted as representing the minimum CLV necessary for the firm to justify serving that customer.[10] If CLV is estimated to be greater than customer acquisition cost, the firm would profit from serving that customer.

Beyond the basic model presented above, there exist a range of quantitative models for calculating CLV, the structures and data requirements of which depend on the user's specific application and industry.[11] Flordal and Friberg, for example, developed a CLV model for smartphone customers across a selection of major telecommunications markets.[12] Their Markov Chain Model incorporates the fluctuating probability of customer retention or churn at each time period, with that probability informed by the behavior of that customer at earlier time periods in the model. This approach reflects the competitive environment of the telecommunications industry, in which consumers have their choice from a variety of smartphone providers, and where few barriers exist to prevent customers from switching providers.

Electric Utility CLV

Examples of CLV models specific to the electric utility industry were scarce. Despite wide adoption in other sectors, "[CLV] use is limited amongst energy retailers, especially in the less

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[10] Berger, Paul D., and Nada I. Nasr. "Customer Lifetime Value: Marketing Models and Applications." *Journal of Interactive Marketing*, vol. 12, no. 1, 1998, pp. 17–30., doi:10.1002/(sici)1520-6653(199824)12:1<17::aid-dir3>3.0.co;2-k.

[11] Berger, Paul D., and Nada I. Nasr. "Customer Lifetime Value: Marketing Models and Applications." *Journal of Interactive Marketing*, vol. 12, no. 1, 1998, pp. 17–30., doi:10.1002/(sici)1520-6653(199824)12:1<17::aid-dir3>3.0.co;2-k.

[12] Flordal, Peter, and Joakim Friberg. "Modeling Customer Lifetime Value in the Telecom Industry." *Semantic Scholar*, 2013, www.semanticscholar.org/paper/Modeling-Customer-Lifetime-Value-in-the-Telecom-Flordahl-Friberg/59cb4e8e6c2f4c0d0348c111efcc802dc0ec1558

competitive markets."[13] Customer lifetime value has been used primarily by electric utility companies operating within competitive retail markets like those in certain parts of the United States and the United Kingdoms. With captive customer bases and highly regulated revenues, it is possible that monopoly or quasi-monopoly electric utility firms, in general, have not prioritized the exercise of integrating CLV into operations and decision-making. However, a KPMG report recommended the following CLV formula, which assumes that revenues and costs for each period are static values that do not change from payment to payment, and therefore computes CLV similarly to the net present value of a financial perpetuity.

$$\text{CLTV} = \frac{(\text{Revenue} - \text{Costs}) \times \text{Retention}}{1 + \text{Discount rate} - \text{Retention}}$$

Figure 1: KPMG Electric utility customer lifetime value

We elected to adapt the first model described above in developing the CLV model for the Utilities 2.0 pilot project, as it aligns closely with the realities of the utility-customer dynamic in the Utilities 2.0 pilot project, where:

- Customers make regularly recurring, forecastable payments. In our case, revenues are directly related to forecasted customer electricity demand. Power for All has provided electricity demand estimates for the 20 year lifetime of the pilot project.
- Customers have no options for alternative electricity suppliers, meaning there is no probability of customer churn.

[13] van der Schrier, Bud, et al. "Customer Lifetime Value in Retail Energy Markets." *KPMG*, 2019, assets.kpmg/content/dam/kpmg/xx/pdf/2019/06/customer-lifetime-value-in-retail-energy-markets.pdf.

- The likelihood of non-payment is low given the pilot project's employment of Pay as You Go (PAYG) prepayment systems.

Furthermore, the data requirements of the model align with the data made available to the Duke team from the client, which included customer electricity demand forecasts, financial models for the Utilities 2.0 pilot project, and utility and mini-grid provider electricity rates. Finally, the model is simple and easily comprehensible, making it ideal for an industry audience who may be less familiar with the CLV concept.

Model Inputs and Assumptions

Below, we describe the inputs to, and assumptions for, our Utilities 2.0 CLV model.

- ***Revenues*** in this model are the product of customer electricity demand and the Umeme electric tariff rate. The pilot customer group for this model is made up of four Umeme customer classes:

Customer Classes & Rates		
Customer Class	**Average Rate**	**Percent of total connections**
Household 1 (HH1)	\$0.20/kWh	23%
Household 2 (HH2)	\$0.20/kWh	29%
Small-to-Medium Enterprise (SME) 1-Phase	\$0.17/kWh	37%
Small-to-Medium Enterprise (SME) 3-Phase	\$0.17/kWh	10%

The Client has assumed that demand growth occurs during the first five years of the project, starting at 45,873 kWh in Year 1, growing at a constant yearly rate, and leveling out at year six for the remaining life of the 20-year project. Electricity demand projections are held constant between the three business models when comparing CLV.

- ***Costs*** in the model are reflected by the operating expenses of the mini-grid system. Each of the three business models makes different assumptions about the project's OPEX, which include fuel costs for backup generators, system maintenance, insurance costs, staffing costs, and the cost of purchasing bulk electricity from the central grid in certain scenarios.
- ***Customer retention rate*** in this model is assumed to be 100% as there are no alternative electricity providers.
- ***Customer payment rate*** is assumed by the Client to be 100%, given the use of Pay as You Go (PAYG) mobile prepayment in the Utilities 2.0 pilot projects.
- ***Payment frequency*** is modelled at an annual granularity, meaning the model assumes payments made for electricity sales are made in the same year in which the electricity is purchased by the customer.
- ***Discount rate*** varies depending on the combination of pre-interconnection model (previously discussed) and post-interconnection model (discussed later in this report) selected. Our client had completed financial models of the Bulk Buyer and Generation Asset Removal post-interconnection models at the time of this report.

Business Model Discount Rates		
Pre-Interconnection Model	**Bulk Buyer**	**Generation Asset Removal**
Mini-grid Led	15%	10%
Flexible Asset	10%	10%
Utility Led	10%	10%

- ***Customer lifetime*** is 18 years, under the assumption that Umeme takes on the customer after Year 2 of the 20-year project.

Results and Observations

Customer Lifetime Value Analysis

We calculated customer lifetime value for the three business models developed for the Utilities 2.0 pilot project, as well as for a business-as-usual case. Our objective, as previously stated, was to compare CLV for the Utilities 2.0 model to the business-as-usual (BAU) case, representing a typical grid expansion scenario in which Umeme connects the pilot community to the main grid without a third-party first constructing a mini-grid. In this scenario, there would have been no demand stimulation carried out through the leasing or purchase of PUE equipment, so a lower level of demand growth should be assumed. By calculating CLV for a BAU scenario, we were able to examine whether, and estimate to what extent, the Utilities 2.0 model increases customer value to Umeme in comparison to a typical grid expansion scenario. Assumptions of the Business-as-Usual case are as follows.

- **Revenue** – The product of forecasted customer segment-demand and the applicable Umeme rate, detailed previously.
- **Cost** – OPEX estimates for a grid expansion scenario provided by Umeme.
- **Customer retention rate** – 100%, as there are no alternative suppliers.
- **Customer payment rate** – Client provided an assumption of 90% in the BAU case, given that this scenario would not include the use of PAYG prepayment.

- **Discount rate** – Umeme's assumed 10% discount rate.
- **Demand growth** – We evaluated the BAU scenario for a demand growth range of 0-6% annually over the first five project years. We chose 6% as the range cap because it reflects Umeme's system-wide energy sales growth rate over the previous six years. Umeme indicates that this growth has been driven by increasing industrial sector activity, so we decided to use this value as a cap on demand growth for the primarily residential pilot community.[14]

In comparison, we chose to examine Utilities 2.0 CLV for two different demand growth scenarios: a Low Demand Growth scenario, in which aggregate electricity demand is increased by 10% annually over the first five years; and a High Demand Growth scenario, where demand increases 20% annually over the same time span. In this way, we were able to examine the impact that the level of demand growth exhibited over the achieved Utilities 2.0 CLV.

Furthermore, we examined CLV for the six combinations of pre- and post- integration business model strategies which our client had so far modeled. The two post-interconnection strategies will be discussed in further depth later in this report.

Pre-Interconnection Strategy	Post-Interconnection Strategy
Mini-grid Led	Bulk Buyer
Flexible Asset	Generation Asset Removal and Handover
Utility Led	

[14] Umeme Limited. "Investing for Socioeconomic Transformation: Annual Report 2019." (2019) https://www.umeme.co.ug/umeme_api/wp-content/uploads/2020/08/Umeme-Limited-2019-Final-Annual-Report.pdf.

Business-as-Usual

We found that the BAU scenario resulted in a negative range of CLVs, between -$51.04 per connection at 0% annual demand growth, and -$20.05 per connection at 6% annual demand growth. This indicates that given a typical grid expansion scenario to the pilot community, Umeme can expect the average customer in the to result in a net loss over the 20-year period. In other words, the operating expenses associated with maintaining the community's infrastructure and providing customer service would outweigh the revenues generated from the community's energy consumption.

Utilities 2.0

We found that the Utilities 2.0 scenarios evaluated largely resulted in increased CLVs relative to the BAU scenario. Only the Low Growth Mini-Grid Led/Bulk-Buyer and Low Growth Utility-Led/Bulk Buyer scenarios resulted in CLVs within or below the range calculated for the BAU scenario, at -$48.77 and -$68.82 per connection, respectively. The Low Growth scenario produced CLVs between -$68.82 and $74.78, and the High Growth scenario produced CLVs between -$12.50 and $131.10. These results show that, based on our modeling and assumptions, Utilities 2.0 can increase CLV by as much $182.14 per connection in the pilot community.

Pre-Integration Option	Post-Integration Option	Low Growth CLV	High Growth CLV
MG-Led	*Bulk Buyer*	$ -48.77	$ -9.20
	Asset Removal	$ 18.41	$ 74.73
Flexi Asset	*Bulk Buyer*	$ 74.78	$ 131.10
	Asset Removal	$ 18.41	$ 74.73
Utility-Led	*Bulk Buyer*	$ -68.82	$ -12.50
	Asset Removal	$ 18.41	$ 74.73

Notably, the Generation Asset Removal and Handover post-interconnection scenarios resulted in the same CLV across each of the pre-interconnection scenarios. This is due to the Asset Removal OPEX assumptions holding constant regardless of the pre-interconnection method selected.

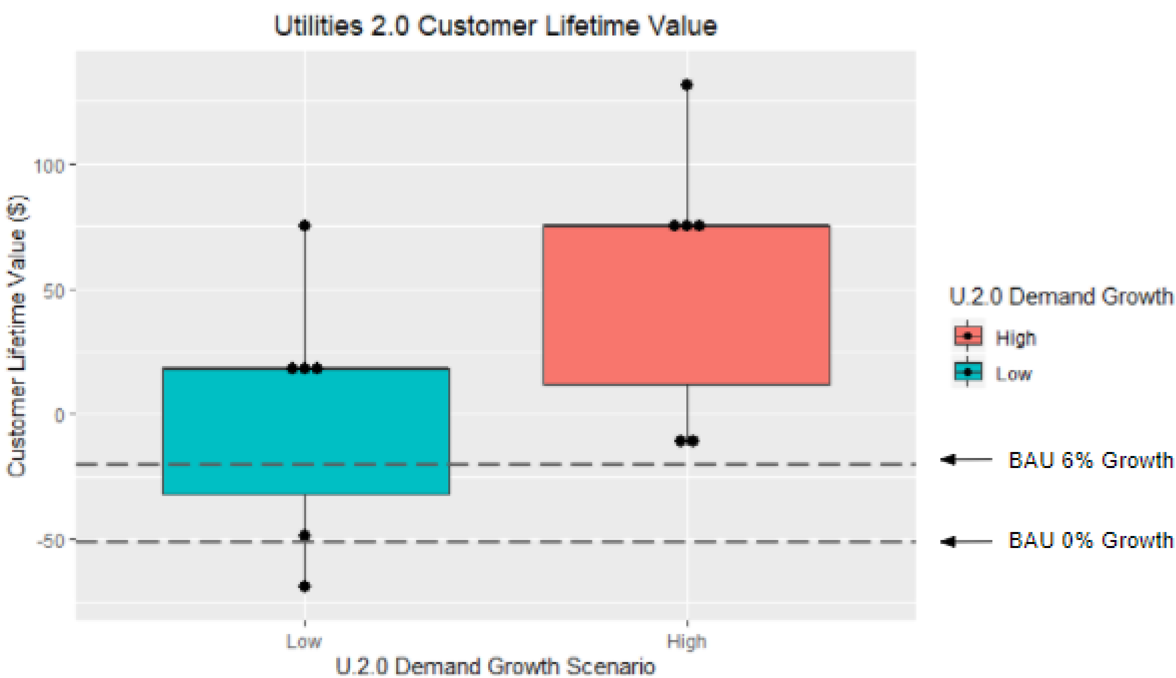

Figure 2: Utilities 2.0 and Business-as-usual CLV results

Policy and Regulatory Findings

We researched the current mini-grid policy in Uganda. The current policy put forth by Uganda's Rural Electrification Agency (REA) has limited information on interconnection regulations. Power for All provided our team with the current Draft of Off-Grid Regulations for Uganda that is not yet published, and from which we derived our analysis.[15] From that extensive document, we were able to answer the guiding question for our research and determine how policy will affect the Utilities 2.0 pilot. Below are the findings from the three core areas of research.

Service Quality

Service is an important component of owning a customer base given the relationship that is built over the lifetime of the project. The current Electricity Regulatory Authority (ERA) policy draft includes a Consumer Service Agreement which constitutes the agreement between the mini-grid developer and the consumer detailing the clauses related to provision of services and dispute settlements, as well as specific clauses on dispute settlement between the operator and its consumers. An example from the Consumer Service Agreement details consumer relations, ensuring transparent information to customers, routine maintenance, and allowing customers to refuse service. In addition to ERA's Consumer Service Agreement, NREL supported the implementation of consumer protections for an improved consumer service. The purpose of these consumer protections is to address the challenges of delivering quality service and maintaining a favorable relationship between the customer and developer.

[15] Electricity Regulatory Authority. *Draft isolated-grid system regulation: support to uganda electricity regulatory authority on isolated-grid electrification* . National Association of Regulatory Utility Commissioners (NARUC), 2019.

Pertaining less to policy, ERA also provides an avenue for customers to file complaint if the service from the energy provider is not adequate. Again, this reinforces the goal of providing satisfactory service.

A positive customer experience is reliant on quality control and retention. As long as the proper technological standards are in place, the quality of service provided is largely dependent upon mini-grid ownership. While the customers will not have influence over quality control upon interconnection with the main grid, the mini-grid developer will. The primary grid will provide a minimum of six months written notice of the intention to interconnect with the mini-grid. The mini-grid developer then has three options regarding how it will operate upon grid arrival as shown below.

Mini-Grid Ownership Following Main Grid Connection		
Distribute	Generate and Sell	Terminate
Distribute electricity to the existing isolated grid consumers	Generate and sell electricity to the Distribution Licensee	Issue a notice to terminate its interests or regulated business

The quality of electricity provided will be dependent on the mini-grid developer's choice of ownership upon interconnection. The mini-grid is a resilient system and provides consistent energy generation, while a main grid, due to its large distribution network, is more prone to blackouts. If the mini-grid terminates its business operations upon interconnection, the customers will experience more blackouts. If the mini-grid decides to continue generating and selling electricity post interconnection, the customers will experience fewer blackouts due to the ability of a mini-grid to generate electricity independent of the grid. Power for All has developed different business model options with different configurations for asset ownership between the mini grid developer and the utility to analyze which yields the best results. In each model, the mini-grid and utility have specific roles for managing customers and the distribution network with the purpose to own different components of the process. The four post-interconnection strategies are:

1. *Generation asset removal*: There are no regulations currently stated allowing generating facilities smaller than 500kWp to acquire an IPP license.
2. *Bulk buyer*: There is clear regulation for mini-grids to buy bulk power from the utility. The utility and regulator have experience managing a bulk buyer on the network.
3. *Small power producer*: There are no regulations currently stated allowing generation systems smaller than 500kWp to acquire an IPP license.
4. *Asset buy out*: The current policy states a mini-grid developer could be compensated for asset purchases from the utility.

The table below illustrates the four post-interconnection options and whether the reliability of the system will be expected to increase or decrease.

Interconnection options	**Outcome**	**Reliability**
Generation Asset Removal	Reliability will be lower than expected from mini-grid.	Decrease
Bulk-Buyer	Mini-grid retains service territory and customers.	Increase
Small Power Producer	Reliability will be lower than expected from mini-grid.	Decrease
Asset Buy-out	Reliability will be lower than expected from mini-grid.	Decrease

Reliability

Interconnection with the main grid should not disrupt the reliability of the electricity connection. According to the International Renewable Energy Agency (IRENA), Tanzania found that mini-grid technologies were twice as reliable as the main grid according to their smart meter data.[16] In order to ensure the continuation of such reliability, there are three policy provisions provided by ERA. First, the current policy states that all mini-grid operators are to supply 24 hour, 7 day a week power unless otherwise agreed upon with each customer in their Consumer Service Agreement. Second, the mini-grid developer is responsible for responding to power outages and attempting to restore power within 24 hours. Lastly, the mini-grid developer must comply with the reliability of supply provisions stated in the electricity regulations. By holding developers accountable, the policy ensures reliable service provision.

Cost

Before consumer costs are determined, proper policy considerations must be made. The mini-grid developer's retail tariffs must be approved by ERA before generating and distributing electricity to customers. There are several policy provisions that must be upheld by the developer in order to gain approval by ERA. Initially, the tariff for the mini-grid will be calculated based on capital costs; operation and maintenance costs; capital recovery; interest expenses; taxes; subsidies or grants received; and reasonable return on equity that reflects risks

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[16] Irena. "Policies and Regulations for Renewable Energy Mini-Grids." *IRENA, International Renewable Energy Agency*, Nov. 2018, irena.org/publications/2018/Oct/Policies-and-regulations-for-renewable-energy-mini-grids.

faced by the Isolated Grid Developer. Relating to the customer experience, alternate retail tariffs may be proposed by the mini-grid developer dependent on the following consumer categories: the place and time of supply; the quantity of electricity supplied; consumers' load and power factor; the purpose for which supply is taken; and consumers' ability to pay.

Before each retail tariff proposal is approved, it must be discussed and agreed upon by both the mini-grid developer and the ERA. Incorporating these costs must be clear given that tariffs can be rejected by ERA. This transparent process allows customers to be included in the electrification process. Power for All has modeled different tariff prices depending on the model. The pre-integration scenario will determine the mini-grid tariff customers pay. The price will either be higher pre-integration or the same as the utility tariff post-integration. There is no scenario where the tariff increases upon customer transfer. The table below outlines which scenario yields a higher or lower pre-integration tariff as compared with the utility tariff post-integration.

Interconnection options	**Tariff**	**Decrease?**
Generation Asset Removal	Reduced upon interconnection	Yes
Bulk-Buyer	Remain the same	No
Small Power Producer	Reduced upon interconnection	Yes
Asset Buy-out	Reduced upon interconnection	Yes

Discussion

CLV Key Takeaways

Our CLV model and sensitivity analysis indicates several important findings for the Utilities 2.0 pilot program.

- **The Utilities 2.0 business model has the potential to increase CLV relative to the typical grid-expansion scenario at Power for All's pilot site.**

  On the upper end, our analysis indicates that the High Demand Growth scenario, using the Flexible Asset/Bulk Buyer Utilities 2.0 model, can increase CLV as much as $182.14 relative to the BAU 0% demand growth scenario. On the lower end, we found that the Low Demand Growth scenario, using any pre-interconnection option and the Generation Asset Removal and Handover Utilities 2.0 model, can increase CLV as much as $69.45 relative to the BAU 0% demand growth scenario. These results show that Utilities 2.0 can, in fact, deliver a higher value customer to Umeme upon grid interconnection.
- **The typical grid-expansion (BAU) scenario modeled results in a negatively valued customer for the pilot community.**

  For demand growth levels between 0% and 6% annually over the first five years of the project, our model returns negative CLVs. This means that the costs of maintaining the distribution network, administering customer service, and providing wholesale energy to the community would outweigh the revenues generated through retail energy sales.
- **Not every Utilities 2.0 business model results in increased CLV.**

Both the Low Growth Mini-grid Led/Bulk Buyer model and Utility Led/Bulk Buyer model result in CLVs within or below the BAU CLV range, at -$48.77 and -$68.82, respectively. These CLV losses relative to the BAU scenario are due to higher operational costs incurred by the third-party mini-grid developer relative to what Umeme would incur.

- **Level of demand growth and interconnection strategy are key factors in determining whether, and how much, Utilities 2.0 increases CLV over the BAU scenario.**
  As mentioned previously, two of the six Low Growth Utilities 2.0 models examined resulted in CLVs within or below the BAU CLV range. Including these two models, we found a range of $143.60 in both the Low Growth and High Growth scenarios. We found that the Flexible Asset/Bulk-Buyer model resulted in the highest CLVs, while the Utility-Led/Bulk-Buyer model resulted in the lowest CLVs. The Generation Asset Removal post-interconnection model resulted in the mid-range CLVs for both the Low and High Growth scenarios. Additionally, this post-interconnection model resulted in identical CLVs regardless of the corresponding pre-interconnection model selected.

Policy and Regulatory Key Takeaways

The current policy for mini-grid integration is nascent and has yet been published. Our research focused on how the customer’s experience is affected upon interconnection of the main grid from the mini-grid. Our analysis pertained to three core areas for the customer, namely service quality, reliability, and cost. We had three main takeaways from our research.

- First, the policy states that the mini-grid infrastructure is built at the utility standard. This includes using the utility meter, customer management, as well as the billing system. The Utilities 2.0 pilot has acknowledged these requirements and has mandated in each model that the mini-grid has proper technical requirements.

- Second, the mini-grid policy requires the developer to determine the function of the mini-grid after interconnection. The Utility 2.0 initiative has developed a plan for the mini-grid post integration: The mini-grid upon interconnection will pack its modular assets and move its operations to another village, operate as a small power producer, the utility will purchase the assets from the mini-grid developer, or the mini-grid will be a fixed asset and bulk buy electricity from the centralized grid.
- Lastly, the policy requires the tariff to be set at a particular price and to be approved by the regulatory authority. The Utility 2.0 pilot has done extensive modeling to determine the tariff in each business model suitable for the operations. Depending on the model, particular costs will be incurred by the utility and the mini-grid developer which can affect the price of the tariff. In three of the four post-interconnection strategies, the tariff will decrease upon interconnection.

Limitations

While the results of our CLV analysis are promising and in line with expectations, our client will want to consider the following limitations of the CLV model.

- **Rural population decline.**

  While our Utility 2.0 financial model only considers population growth, it is important to consider the possibility of a declining population as citizens migrate from a rural to urban setting. While this was out of the scope of our study, The World Bank recognizes the potential consequences of the increasing migration from rural to urban communities in Uganda:

> "This dramatic increase may exacerbate the challenges already facing urban areas, constraining their ability to drive growth; to create productive jobs; and to provide decent housing to urban residents. Investment in cities is critical for the achievement of equitable growth and poverty reduction and is therefore central to the next stage of Uganda's development, particularly in the context of East African integration and the upcoming exploitation of the country's oil resources."[17]

- **Elasticity of electricity demand.**

  Demand growth projections are not responsive to changes in electricity rates based on the financial model. Higher utility rates are likely to suppress electricity demand, especially for low-income customers, while lower rates would incentivize greater consumption. While beyond the scope of our study, it is important for the Client to consider how the rates for the Utilities 2.0 pilot may impact demand levels, and the ability of PUE assets to stimulate demand. This would be a useful area for future study, and ongoing analysis as Utilities 2.0 is piloted and scaled.

- **Capital expenditures.**

  In our literature review, we did not find evidence of CLV models incorporating CAPEX into their calculations. As such, the capital costs involved with the Utilities 2.0 project

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[17] The World Bank. "Uganda Economic Update: Fifth Edition: The Growth Challenge: Can Ugandan Cities Get to Work?" *The World Bank*, 3 Mar. 2015, www.worldbank.org/en/country/uganda/brief/uganda-economic-update-fifth-edition-the-growth-challenge-can-ugandan-cities-get-to-work-fact-sheet#:~:text=The%20process%20of%20urbanization%20in%20Uganda%20is%20still%20at%20its,within%20the%20next%20two%20decades.

are not captured by our CLV model. Therefore, it is important remember that CLV is only one metric and should be considered within the larger context of the project and Utilities 2.0 initiative. Metrics like return on investment, internal rate of return, and levelized cost of electricity are all critical metrics to consider when deciding whether or not to invest in a project.

Conclusion

Our hope is that the work carried out during this Master's Project will support our client, Power for All, in their work to accelerate electrification to Uganda's rural communities. Should the Utilities 2.0 initiative prove successful in Uganda, it could serve as a replicable model for other countries to follow. We look forward to watching this project evolve from concept to reality, and we are incredibly appreciative of the opportunity Power for All has provided us.

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