12-20-2023

Update of Techno-Economic Feasibility Analysis of a Microgrid in Downtown Cleveland, Ohio

Ali H. Ahmed

Andrew R. Thomas
Cleveland State University, a.r.thomas99@csuohio.edu

Mark Henning
Cleveland State University, m.d.henning@csuohio.edu

Shelbie Seeberg

Repository Citation

Ahmed, Ali H.; Thomas, Andrew R.; Henning, Mark; and Seeberg, Shelbie, "Update of Techno-Economic Feasibility Analysis of a Microgrid in Downtown Cleveland, Ohio" (2023). *All Maxine Goodman Levin School of Urban Affairs Publications*. 0 1 2 3 1821.
https://engagedscholarship.csuohio.edu/urban_facpub/1821

UPDATE OF TECHNO-ECONOMIC FEASIBILITY ANALYSIS OF A MICROGRID IN DOWNTOWN CLEVELAND, OHIO

Prepared by:
Ali H. Ahmed
Andrew R. Thomas
Mark Henning
Shelbie Seeberg

Prepared for:
Pareto Energy

Energy Policy Center
Maxine Goodman Levin College of Public Affairs
Cleveland State University

Green Strategies LLC

December 2023

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABOUT THE AUTHORS

Ali H. Ahmed
Ali Ahmed is the Founder and Principal of Green Strategies LLC, a strategy consulting company helping clients understand and develop strategies around sustainability and energy management.
Contact: aliahmed@green-strategies.com, 216-392-2483.

Andrew R. Thomas
Andrew Thomas directs the Energy Policy Center in the Maxine Goodman Levin College of Public Affairs at Cleveland State University, where he conducts research on electricity, transportation, hydrogen and natural gas policy. Contact: a.r.thomas99@csuohio.edu, 216-687-9304.

Mark Henning
Mark Henning is the Research Supervisor for the Energy Policy Center. He holds a Master of Public Administration and M.S. in Mathematics (Specialization in Applied Statistics) degrees from Cleveland State University. Contact: m.d.henning@csuohio.edu, 216-875-9606.

Shelbie Seeberg
Shelbie Seeberg is a Research Assistant for the Energy Policy Center. She holds Bachelor’s degrees Environmental Science and Urban Studies, and a Masters’ degree in Legal Studies.

Executive Summary

This report is an update of a techno-economic feasibility study undertaken in 2018 to examine the efficacy of building and operating a microgrid in Downtown Cleveland, Ohio. Many factors have changed since 2018, including the 2022 passage of the Inflation Reduction Act, pursuant to which significant tax credits will make microgrids and grid edge technology adoption more attractive. Attracting political interest and capital for a major infrastructure improvement project require an expectation that the project will be technically possible and economically attractive for investors. The new investment tax credits, together with changing electricity market conditions, has made it important to reassess this project.

To maximize the availability of Inflation Reduction Act Investment Tax Credits, the Study Team made some small design changes to the 2018 microgrid model. The Study Team further updated the model for 2023 prices, in principal part by using the RSMeans database, but also by researching current market conditions in Ohio and within PJM Regional Transmission Organization for electricity generation, transmission, and capacity. The RSMeans database enabled the Study Team to update both the cost of infrastructure and labor. The infrastructure chosen is largely the same as that identified for the 2018 study, as informed by a Request for Information issued by Cuyahoga County and the Cleveland Foundation (sponsors for the 2018 study). The economic model developed for the 2023 study is from the vantage point of a potential private developer. Its goal is to understand and test the conditions under which the developer could construct and operate the microgrid to obtain an appropriate return on its investment.

The summary results of the techno-economic modelling and analysis for this specific microgrid project and study area are:

- Construction and operation of such a microgrid are complex, but technically feasible with commercially available technology and existing suppliers.
- The existing assets in the study area, specifically the existing municipal utility (Cleveland Public Power), are critically important to economic success.
- Multiple entity arrangement options exist and selecting the right entity structure is important to minimize taxes and maximize opportunities for low cost financing.
- The proposed microgrid appears to be economically feasible, but is highly sensitive to:
    - Customer rates
    - Successful and timely customer recruitment
    - Availability of long term, competitive electrical power and natural gas prices
    - Cost of capital / Interest rates
    - Distribution costs from the municipal utility

Based upon the models developed, the Study Team has concluded that 99.999% uptime can likely be delivered to end users for less than an average of 14 cents/kWh, which, based upon a related

market evaluation prepared by the Study Team, appears to be a threshold price that would likely attract businesses that value resiliency. However, end users who have a lower critical need for ongoing 99.999% (e.g. only need 2 hours of uptime during a grid outage) could participate for between 10-12 cents/kWh. These are prices that are competitive with the existing rates within CEI territory for commercial power.

It appears that a microgrid could be built under these terms and still provide a return on investment to the operator of 22.4%, without the application of federal grants. However, previous investors have indicated a minimum acceptable rate of return of 15% for microgrids. At this hurdle rate, 99.999% uptime could be delivered to end users at around 13.3 cents/kWh, while still delivering power to users with non-critical loads at 10-12 cents/kWh. Federal grants could be pursued to further reduce investor risk or to include residential or commercial end users in low income areas.

The Study Team further concluded that a microgrid district in downtown Cleveland could be a major attraction for new business that values uptime, such as is commonly found in the fast-growing digital economy. This would include industries such as finance, insurance, health and advanced manufacturing. A 50 MW microgrid in downtown Cleveland could attract 1000 direct new jobs, and could make downtown Cleveland a destination for the information-based economies of the 21st century.

Downtown Cleveland, Ohio

1. Introduction

This report is an update of a study undertaken by Cleveland State University and others originally conducted in 2018[1] to evaluate the techno-economic feasibility of building a microgrid in downtown Cleveland. Much has changed since the original study was undertaken. This includes rising prices of conventional grid power, inflation and technology improvements. Perhaps most importantly, the passage of the Inflation Reduction Act provides federal tax credits for grid edge technologies that reduce emissions and improve performance. Accordingly, the Study Team has undertaken to update the 2018 study to account for 2023 economic conditions.

The 2018 Study Team looked at several attributes in selecting a location for evaluation. These included the following:

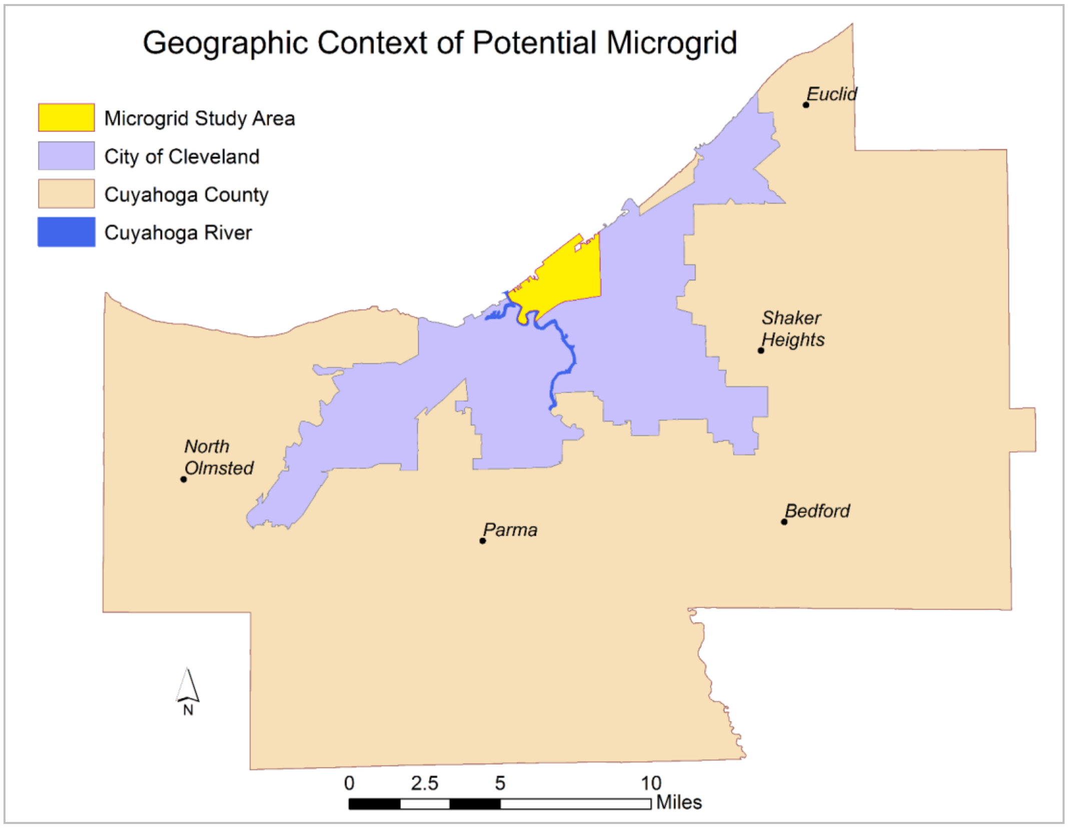
- Potential anchor tenants and institutions
- Ability to leverage existing infrastructure
- Existing loads vs. infrastructure capacity, and ability to grow either
- Economic relevance of areas
- Available land for new infrastructure and end users
- Regulatory compatibility

Based upon a review of these considerations, the 2018 Study Team chose an area of downtown Cleveland for study. A map of the proposed microgrid location is set forth below.

---

[1] The original Study Team that undertook a series of microgrid evaluations consisted of Cleveland State University's Energy Policy Center (Urban College), Case Western Reserve University's Great Lakes Energy Institute, Cuyahoga County and the City of Cleveland, and several consultants. However, the principal researchers responsible for this study are the same as those responsible for the 2018 techno-economic report. *See*: Ahmed, Ali H.; Thomas, Andrew R.; and Henning, Mark, "Techno-Economic Feasibility Analysis of a Microgrid in Downtown Cleveland, Ohio" (2018). *All Maxine Goodman Levin School of Urban Affairs Publications*. 0 1 2 3 1559. https://engagedscholarship.csuohio.edu/urban_facpub/1559

Figure 1. Proposed Downtown Cleveland Microgrid Location



This report focuses on and updates the technical and financial aspects of implementing and operating a microgrid in the study area.

2. Technical Feasibility

This updated technical-economic feasibility study was undertaken using the design developed in the 2018 study, with modifications to the financing structure to maximize available tax credits. The 2018 design was completed in two parts. First, general information on existing microgrids and microgrid technology was collected and evaluated. Second, a high-level design for a potential microgrid for the study area was developed. This conceptual design included input from Cleveland Public Power, Middough, Inc.,[2] Corix (Cleveland Thermal), Schneider Electric, Eaton Corporation, and other industry experts,[3] as well as from the knowledge and experience of the Study Team. By creating a conceptual design that the Study Team and outside experts

---

[2] Middough Inc. is a private, nationally ranked engineering, architectural, and management services company providing full-service from major projects to consulting for a range of requirements between small and global organizations.

[3] Cuyahoga County issued a Request for Information in the fall of 2017 seeking non-proprietary suggestions about microgrid control system design. The County received numerous responses to the RFI, all of which helped inform the model. However, it was clear from the responses that there are a number of ways to design the Cleveland microgrid. The Study Team leaves it to the eventual developer to establish its own ultimate design.

believed could be constructed and would operate successfully, technical feasibility was confirmed in 2018, with the understanding that an actual constructed system might differ in the details of the design.

This 2023 update of the 2018 conceptual design by Study Team demonstrates that a microgrid in the study area continues to be feasible to construct and operate. Indeed, the project is considerably more attractive in 2023 than it was in 2018. The basis for this determination is set forth below.

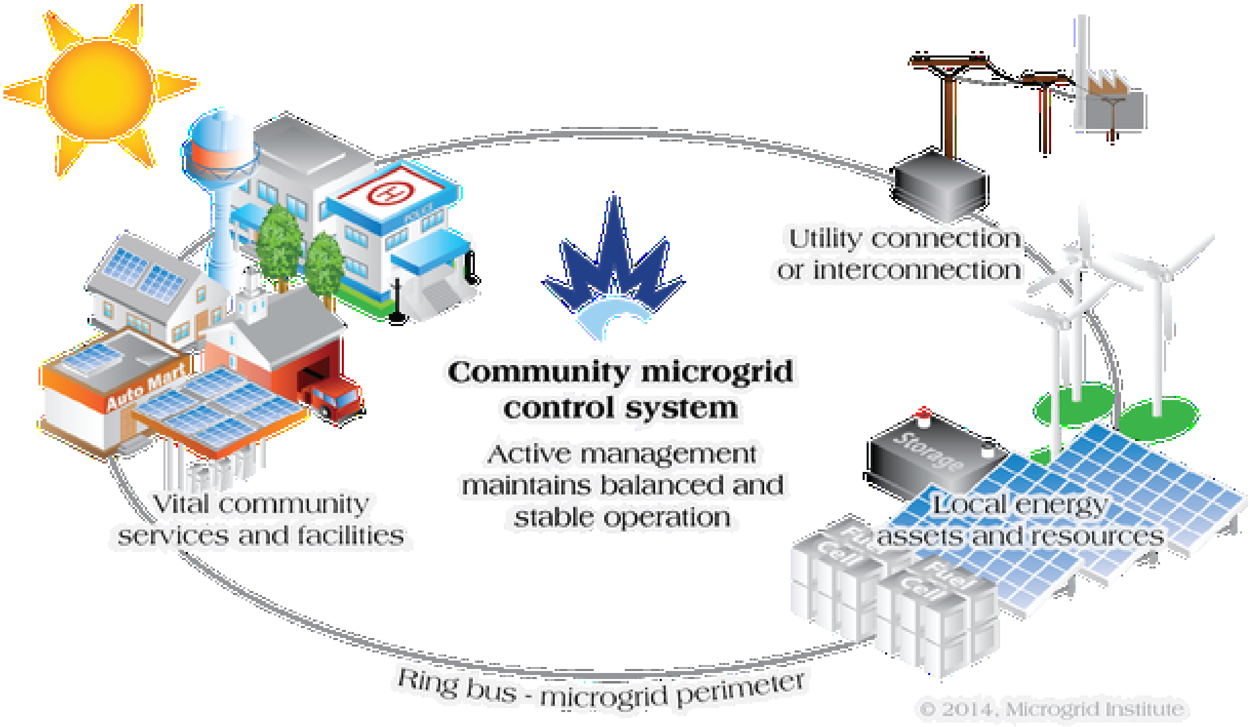
2.1. Definition of a Microgrid

A microgrid is a contained energy system capable of balancing captive supply and demand resources to maintain reliability. Microgrids have the following key elements and features:

- Defined by function, not size
- Incorporates multiple distributed technologies
- Maximizes reliability and efficiency
- Can include other utilities – steam, hot water, chilled water, network connectivity
- Can function in "islanded mode" disconnected from larger utility grid

A prototypical microgrid is pictured in Figure 2 below.[4]

Figure 2. Proposed Microgrid Generation by Source



---

[4] From Microgrid Institute, http://www.microgridinstitute.org/about-microgrids.html

2.2. Conceptual Microgrid

For the 2018 study and the 2023 update, the microgrid infrastructure has been broken into the following asset groups:

- Generation resources
- Distribution network
- Microgrid operations and controls

The conceptual microgrid design leverages an existing CPP distribution system containing both utility interconnects and distribution substations. It also leverages a proposed combined heat and power (CHP) plant for which the operator would sell the thermal energy to existing district energy customers, while the concurrently generated electricity would be sold to the microgrid. The study does not rely specifically upon any certain CHP plant in downtown Cleveland. However, a likely candidate for CHP operation for this purpose is Cleveland Thermal, LLC, a district energy company located within the study footprint. Cleveland Thermal has expressed an interest in owning and operating such a facility and contributed to the 2018 study. While Cleveland Thermal did not contribute to the 2023 update, it did express a continuing interest in owning and operating a CHP facility in downtown Cleveland.[5]

The updated model assumes the microgrid will rely primarily on purchased power from a CHP facility and, when not islanded, on external power delivered by the regional grid. Other potential power sources would include local solar, wind, and demand response within the microgrid. The chart below shows the breakdown from these various sources. The sources include:

- CHP Power
  - Baseload – generated when the CHP system is operating to meet steam demand and thus produces a minimum electrical output level
  - Intermediate – generated when the CHP system increases electricity output regardless of steam demand
- Grid Power
  - Contracted Traditional – purchased power on the PJM grid using long term contracts
  - Contracted Renewable – purchased renewable power on the PJM grid using long term contracts
  - LMP – spot power purchased at Location Marginal Pricing (LMP) on the PJM grid
- Solar from solar PV installations within the microgrid
- Customer Generators – power provided from diesel generators in place at microgrid customer locations for which the microgrid operator pays the customer for capacity, usage, and the ability to dispatch during extremely high LMP pricing events or emergencies; these generators are not directly connected to the microgrid and use automatic transfer switches to move load from the microgrid to their independent emergency bus

---

[5] Correspondence with Cleveland Thermal president Seth Whitney, October 31, 2023.

- Customer Demand Reduction – load nominated by the microgrid customer which the microgrid operator can either automatically or through a manual process reduce at a customer site based on LMP pricing or during emergencies.

In addition to sources of generation, the microgrid will need power regulation capabilities and short-term back-up power in the form of storage. Storage provides the microgrid with the ability to support frequency and voltage in the transition from normal to island modes as well as the ability to improve power quality while in either normal or island mode.[6] To support these features of the microgrid, the storage solution will need the ability to quickly transition from 'charging' to 'discharging' mode and have the capacity to monitor power quality and inject appropriate electric waveforms onto the grid. In an extreme emergency situation where the microgrid topology may need reconfiguration, the storage units proposed at different locations in the microgrid can provide short duration back-up power until a generation source is connected to that portion of the distribution system.

Notably, the microgrid model used by the Study Team can be adapted to add or substitute other sources of generation, such as terrestrial or offshore wind. The only limitation is that, based upon the Study Team's interpretation of the anticipated IRS investment tax credit (ITC) rules under the Inflation Reduction Act (IRA), distributed generation within the microgrid must be at or below 20 MW for the microgrid infrastructure to be eligible for the IRA ITC.[7] To ensure eligibility for these tax credits, the Study Team reduced the 2018 proposed microgrid generation capability from 23 to 20 MW for the 2023 microgrid.

2.2.1. Microgrid and Grid Generation

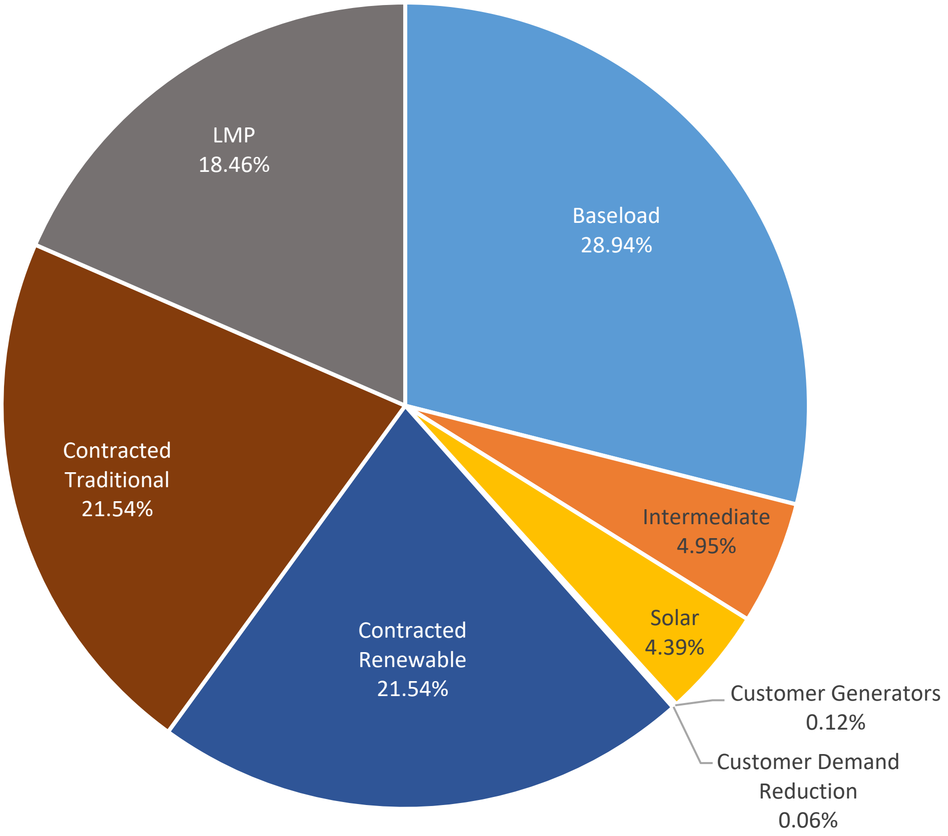
The total proposed microgrid size the model is 48.8 MW of load, with 20 MW of local generation (136,202 MWhs), with the rest of the power purchased from the grid. Total proposed capital investment for the microgrid is around $81 mm, including the distribution lines, but excluding the generation. The model includes $10 mm in equity investment, with the remainder financed by a combination of low interest loans (backed via New Market tax credits) and commercial loans, as described later herein.

---

[6] The Study Team used utility-scale lithium-ion batteries in its cost analysis. However, for purposes of this discussion, they are not included as a physical "source" of power.

[7] A *qualified microgrid* is one that "includes equipment which is capable of generating not less than 4 kilowatts and not greater than 20 megawatts of electricity." *See* 26 U.S.C. § 48 (c)(8).

Figure 3. Proposed 2023 Cleveland Microgrid Annual Generation by Source



Purchasing the power from the proposed CHP plant is the most cost-effective strategy for obtaining reliable power and will be an important factor in making the microgrid feasible. CHP plants are normally designed to generate thermal loads, and electricity generated therefrom can be considered a by-product of the process. This renders power prices as among the lowest available. This was certainly the case in 2018, and it continues to be the case in 2023, despite significant inflation (producer selling prices increased by around 25% overall from October 2018 to October 2023).[8] CHP is normally fueled by natural gas, which briefly increased in price as a result of the Ukraine/Russia war and supply chain shortages. However, natural gas prices in the U.S. have returned to prewar levels and are projected by Energy Information Agency (EIA) to not increase substantially in real terms over the next 30 years.[9]

---

[8] U.S. Bureau of Labor Statistics, Producer Price Index by Commodity: All Commodities [PPIACO], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/PPIACO, December 5, 2023.

[9] The EIA projects Henry Hub natural gas prices in $2022 dollars to go from $4.07/mmbtu in 2024 to $3.77/mmbtu by 2050. *See* U.S. Energy Information Administration (EIA). Annual Energy Outlook 2023. The EIA does not project prices for regional hubs like the Dominion South hub near Pittsburgh.
National Energy Modeling System run ref2023.d020623a [Reference Case].

In 2018, based upon quotes received from developers, we estimated that the cost of base load CHP power (set by the minimum thermal load then required by Cleveland Thermal) would be around $0.038/kWh. At that time natural gas was trading at $2.25/mmbtu at the Dominion South market hub (near Pittsburgh, PA). In November 2023, gas was trading as low as $1.55/mmbtu at that same hub.[10] Of course, it is the delivered price to the CHP facility, not the Dominion South Hub, that will be relevant to CHP. CHP operators will be able to secure long term, lower price contracts for natural gas than are otherwise available from the Dominion Energy Standard Choice Offer (SCO).[11] Still, the SCO price will be a useful guide. Dominion Energy's SCO for November 9 through December 11 of 2023 was $3.554/mcf, which equates to a price of $3.33/mmbtu.[12] According to Solar Turbine's (Caterpillar) cost calculator for cogeneration (assuming 50,000 m-lb/hr steam usage, a 13 MW cogeneration plant, and natural gas at $3.33/mmbtu), the electricity could be generated for about $0.038/kWh.[13] This price does not, however, take into account the increase in investment tax credits under the IRA, which will apply to CHP facilities that begin building before January 2025 – an ITC increase from 10 to an estimated 40 percent.[14] Accordingly, the Study Team concluded that there was no compelling reason to increase the $0.038/kWh rate used in 2018 for electricity from CHP. With a 40% investment tax credit, the 2023 price will likely be lower. But it would require starting the project by 2025.

The microgrid can also use natural gas turbines without recovering the heat. However, Cleveland is in a nonattainment zone, and the Ohio EPA might be reluctant to permit a large natural gas turbine without evidence that the microgrid system would mean an overall reduction in emissions. The Solar Turbine cost calculator projects a 77% efficiency for the described 13 MW cogeneration facility, with a resulting reduction of 8000 metric tons of carbon dioxide – a strong candidate for permitting. The costs will also be lower with CHP. According to the U.S. Department of Energy, the levelized cost of electricity (LCOE) for a CHP plant near this efficiency level can be 13.5% less than the LCOE of a natural gas combined-cycle power plant operating at an 85% capacity factor, and 23.7% less than the LCOE of a natural gas combined-cycle power

---

[10] Reflects daily cash market price for Eastern Gas South (formerly Dominion South) on November 9, 2023 as gathered from Intercontinental Exchange (ICE) trade data published by Snyder Brothers Gas Marketing. *See* http://www.snyderbrothersinc.com/wp-content/uploads/2023/11/Snyder_Bros_NG_Mkt_Update_11-09-2023.pdf

[11] The Standard Choice Offer in Ohio (called Standard Service Offer for electricity) is the cost of natural gas plus the cost of delivery to the end user. https://puco.ohio.gov/utilities/gas/resources/how-are-standard-choice-offer-rates-set

[12] *See* the Ohio Public Utility Commission's *Apples to Apples Comparison Charts* for Dominion Energy Ohio at https://www.energychoice.ohio.gov/ApplesToApplesComparision.aspx?Category=NaturalGas&TerritoryId=1&RateCode=1. The SCO price conversion was based on the heat content of natural gas consumed in Ohio, which since 2017 has averaged 1.067 mmbtu per mcf (*see* https://www.eia.gov/dnav/ng/ng_cons_heat_a_EPG0_VGTH_btucf_a.htm).

[13] https://catsolar.my.salesforce-sites.com/cogeneration

[14] CHP projects beginning construction before January 1, 2025 can qualify for a 30% credit by meeting prevailing wage and registered apprenticeship requirements, and an additional 10% by meeting certain domestic content requirements for steel, iron, and manufactured good. *See* 26 U.S.C. § 48.

plant operating at a 65% capacity factor.[15] Further, these estimated costs do not include the additional benefits from the increased ITC, which is only available for CHP.

The CHP system is assumed under the model to operate with a baseload of 13 MW and with an intermediate load of 4 MW. The 13 MW load was chosen based upon Cleveland Thermal's lowest thermal load requirement, and as such may need to be adjusted in the event the CHP is located elsewhere. The anticipated cost of the intermediate load is around $0.053/kWh, which is the amount used in the 2018 study. For the reasons set forth above, the Study Team did not increase the intermediate load price. The blended price of CHP generation purchased by the microgrid will be $0.040/kWh.

An additional 3 MW of solar power is included within the microgrid area, totaling 20 MW. A cost of $0.08/kWh is projected for this generation. This price is based upon NREL's Annual Technology Baseline (ATB) projection of the LCOE for generation by commercial rooftop solar power given the solar resource potential Northeast Ohio.[16] NREL's ATB projection assumes a 30% ITC, and we can expect at least 40% in downtown Cleveland. Further, NREL shows prices coming down over time. Most likely it will take several years to build out 3 MW of solar rooftop power, so the $0.08/kWh is a fairly conservative price.

Power generated within the microgrid network provides the most reliable energy sources since they are unaffected by potential issues with transmission into the region. The proposed enhancements to the substations and cabling further increase the reliability of delivery of this energy. And finally, the direct relationship between the microgrid operator and the generation providers for in-network power generation means that maintenance and upgrade activities can be jointly scheduled to reduce risk of customer interruption.

The rest of the power in the model will come from bilateral or locational marginal price contracts purchased through PJM. Locational marginal pricing, which includes day ahead and real time PJM power, is set herein at $0.035/kWh, and is based upon the average day-ahead and real-time LMPs by month since the beginning of 2021 through October 2023 for the transmission zone encompassing CEI's service territory.[17] Traditional bilateral contract prices are assumed herein to be 10% lower than the LMP, and accordingly estimated to be around $0.031/kWh (assuming

---

[15] *See* U.S. Department of Energy. (February 2021). Utility Ownership of Combined Heat and Power [Issue Brief]. https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/Utility_Ownership_Issue_Brief.pdf. The levelized cost estimates found herein reflect representative scenarios based on existing CHP and natural gas combined-cycle deployments in the United States. LCOE for CHP includes the application of revenues from steam sales back to the cost of fuel for generating electricity.

[16] *See* NREL (National Renewable Energy Laboratory). 2023. "2023 Annual Technology Baseline." Golden, CO: National Renewable Energy Laboratory. https://atb.nrel.gov/. The projections reflected herein assume a Resource Class of 8 (i.e., global horizontal irradiance of 4 to 4.25 kWh/m2/day) under an expected level of technology innovation, where the technology deployed is *mature* and not *nascent*. The projections also assume an ITC of 30%.

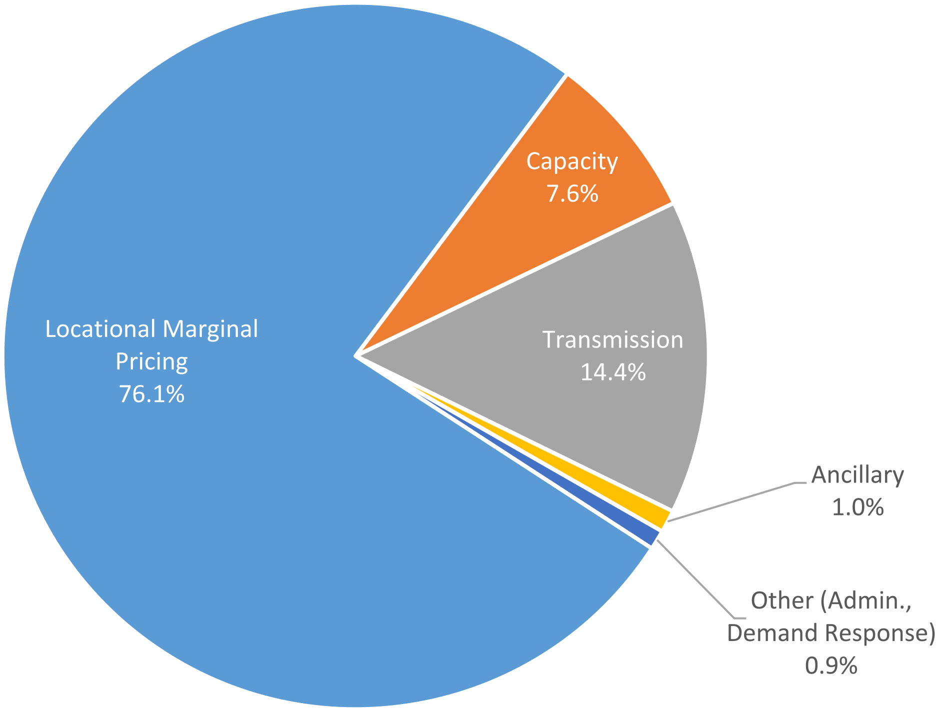
[17] American Transmission Systems (ATSI) is the transmission operator serving Greater Cleveland. For historical real-time and day-ahead LMPs within ATSI's transmission zone, see LCG Consulting's EneryOnline data portal at http://www.energyonline.com/Data/.

contracts do not start until 2026). Renewable bilateral contracts are estimated to be around $0.050/kWh.

According to PJM, transmission, capacity and ancillary charges will add 31.4% more than LMP to the cost of wholesale power in the model (see Figure 4).[18] Transmission costs in CEI territory have consistently been higher than the average cost in PJM, averaging around 2-3 cents per kWh. The microgrid, however, will have the ability to manage some of these costs through demand response and use of batteries during times of peak demand. Accordingly, it is assumed that for the proposed microgrid, the total cost of transmission, capacity and ancillary charges will be no more than the PJM average (~24% of total wholesale price).

Finally, a small amount of customer generation and demand response is included in the model. Customer generation is priced at $0.153/kWh, and demand response at $0.075/kWh.

Figure 4. Share of Total Wholesale Power Price by Category for PJM in 2022



---

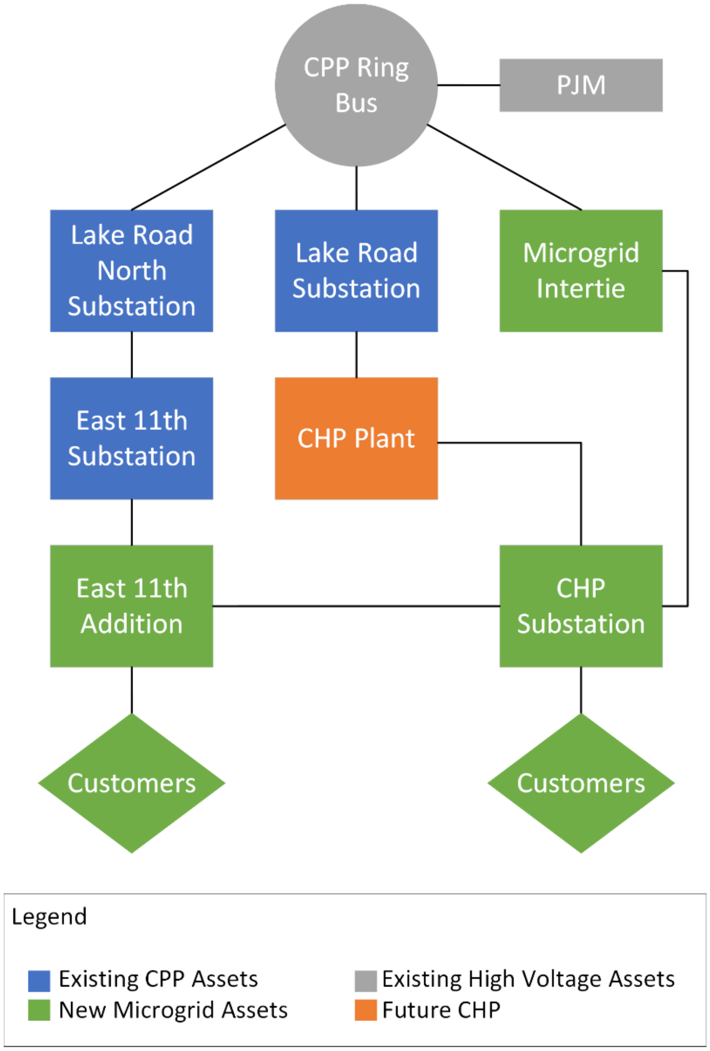
[18] Monitoring Analytics, LLC. (March 9, 2023). *2022 Annual State of the Market Report for PJM*. Volume 1: Introduction. https://www.monitoringanalytics.com/reports/PJM_State_of_the_Market/2022/2022-som-pjm-vol1.pdf

2.2.2. Microgrid Infrastructure

The distribution system for the microgrid is based on CPP's existing plus new infrastructure as shown in the diagram below. It includes the following elements:

- New primary 50 MW intertie to the CPP existing 138 kV Ring Bus system
- New CHP facility 11.5 kV substation
- Upgrades to the CPP existing E 11th Street Substation
- New 11.5 kV Battery Systems located at the E 11th Street, New CHP, and Intertie locations
- Upgrades and additions to substation feeder and tie cabling
- Additional customer distribution feeder cabling from the E 11th Street and New CHP substations

Figure 5. Conceptual Microgrid Block Diagram



This conceptual design provides for maximum resiliency and redundancy minimizing the possibility of power loss for a customer through any single point failure and providing the microgrid operator with the ability to quickly recover from a more catastrophic or wide-spread set of failures. Some examples of these redundancies include:

- Utility Interconnect.
  By having a double-ended connection to the CPP Ring Bus, the conceptual design minimizes the likelihood of loss of normal utility power due to single mode failure of any single interconnect to PJM as well as single point failure within the ring bus and with the microgrid connection to the ring bus.
- Substation.
  If either the Lake Road North substation (which feeds existing E11th Street) or new Intertie substation fails, normal utility power could be routed through the other substation and feed all the load.
- Customer Feeder.
  Should a customer want additional redundancy, the distribution from the substation to the customer can be performed from both the E11th Street and New CHP substations, or from different ends of one of the substations. This eliminates single mode failure of a distribution breaker.

The capital costs identified in 2018 for the proposed conceptual design were developed from three estimates.[19] The capital costs were updated for 2023 by use of RSMeans, an industry accepted software and data base tool used by engineers to estimate construction costs.[20] RSMeans also enabled the Study Team to break down labor and other costs for installation.

The final element of the microgrid is the control system. The control system includes a variety of components:

- Customer site equipment that monitors and controls customer loads and provide information back to the central control system
- Substation and generator equipment that monitors the substations and generators including the CHP and provide supervisory control signals to the local controls operated by CPP and the generation operators
- Central control system which includes supervisory controls, operator interface, and historian capabilities
- Fiber optic network to connect all the above components

---

[19] Contributions for the 2018 estimates came from communications with Schneider Electric, Eaton Corporation and Middough Engineering. These estimates were informed by information and drawings provided by CPP as well as a walk-through of the existing substations. The Study Team also undertook numerous conversations with various control system manufacturers and integrators as well as site visits to demonstration centers.

[20] *See* https://www.rsmeans.com/

The 2018 capital and operational costs for the control system and network were derived through an RFI performed by Cuyahoga County, based on the conceptual design.[21] For the 2023 update, the Study Team used the same control design, but used RSMeans data to estimate current costs.

The 2023 projected costs for capital investment in the microgrid infrastructure are $81,168,899, including distribution lines, but excluding generation costs. These are estimated as the following:

Table 1. Projected Costs for 2023 Cleveland Microgrid Installation

	Items	Amount
Hard Costs	• New grid infrastructure (substation upgrades and new cabling) • Microgrid control system • Cybersecurity	$52.94 million
Soft Costs	• Engineering • Construction Mgmt. • Permits & Commissioning • Taxes & Insurance • Legal • Financing & Property Acquisition	$14.70 million
Contingency[22]	• 20% of overall total design, construction, and engineering costs	$13.53 million

2.3. Business Structure

Cleveland Public Power owns the regulatory rights to operate distribution lines in downtown Cleveland, and as such, must be a partner in the microgrid.[23] Under Ohio law, a nonutility may own the distribution lines, if they are then leased to CPP. Cleveland Electric and Illuminating Company (CEI) is the local investor-owned public utility, and it also has the regulatory capability to build and operate a microgrid. However, it currently does not have a readily available mechanism to do so. It could, under Ohio law, build and operate a microgrid. But the Public Utility Commission of Ohio would have to approve a plan to socialize the microgrid system costs among all of CEI's ratepayers. It is unlikely the PUCO would approve such a plan, unless CEI could make the case that the benefits of the microgrid inure to all CEI customers, and not just to microgrid customers. CPP, on the other hand, need only obtain approval from the Cleveland City Council for a special microgrid tariff.

---

[21] The 2018 RFI respondents included Siemens, Rockwell Automation, S&C Electric, Schneider Electric, Eaton, OATI, and ABB.

[22] A contingency of 20% is consistent with best practices for microgrid design and construction. *See e.g.* Sandia National Laboratories. (2022). *Sandia 2022 Microgrid Conceptual Design Guidebook*. https://energy.sandia.gov/wp-content/uploads/2022/05/ETI_SNL_Microgrid_Guidebook_2022_SAND2022-4842-R_FINAL.pdf

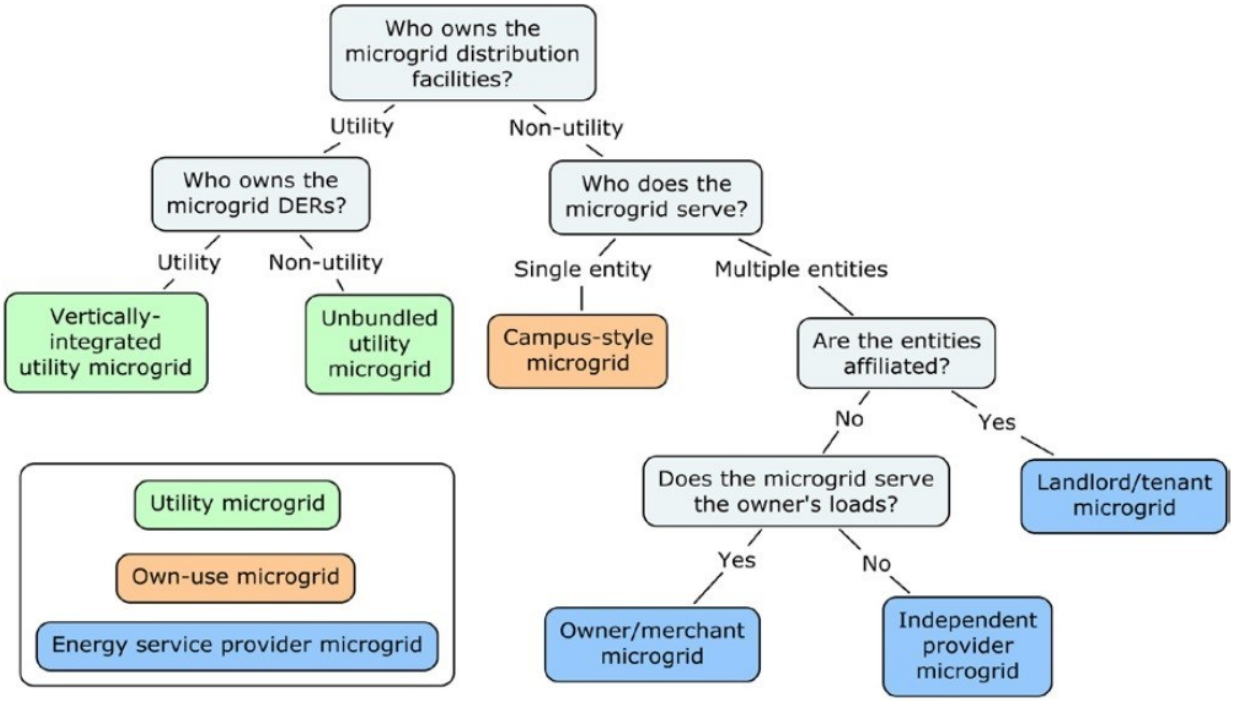
[23] Cleveland Public Power, as a municipal utility, is not regulated by the PUCO, and has broad discretion in how it might operate a microgrid. *See* Ohio Const. Article XVIII, Section 4. This Constitutional authority has been interpreted broadly, giving a municipality a great deal of freedom over the operation and management of its power distribution services. *See* R.C. § 4905.02 (excluding a municipal utility from the regulatory jurisdiction of the PUCO); *See also* R.C. § 4933.83 (excluding a municipal utility from the reach of the Certified Territory Act). *Cleveland Elec. Illuminating Co.*, 95-458-EL-UNC, 2004 WL 3142703 (F.E.D.A.P.J.P. Dec. 21, 2004) (refusing to "evaluat[e] the prudence of CPP's portfolio management").

CPP may also own distributed generation (sometimes called distributed energy resources, or DERs). Under CPP's current business model, however, CPP is likely to prefer that DERs be owned and operated by private companies, who are paid through power purchase agreements (PPAs). Accordingly, the model used in 2018 and followed herein assumes that CPP only owns distribution lines and related equipment, and does not own generation or the microgrid infrastructure.

Instead, the 2018 and 2023 models are based upon the investment perspective for an independent, privately-owned microgrid operating company. That operating company would use CPP for its distribution operations, and would acquire generation from PPAs, from microgrid customers, and from the transmission grid. Generation acquired from the transmission grid will be through bilateral contracts or from PJM (day ahead or real time markets). The generation acquired from the transmission grid would be lost during islanding events.

The ultimate business structure chosen will be dependent upon the business objectives of the stakeholders and the design of the microgrid. Strategies will be controlled by several factors, including the role of the microgrid, regulatory environment, property rights, operating responsibilities and financing arrangements, among other considerations.[24] Brookhaven National Labs developed a decision tree for establishing microgrid business models:

Figure 6. Microgrid Business Ownership Typology



Brookhaven National Labs (2017).[25]

---

[24] R. Lofaro, "Evaluation of New York Prize Stage 1 Feasibility Assessments," Brookhaven National Labs, 2017.

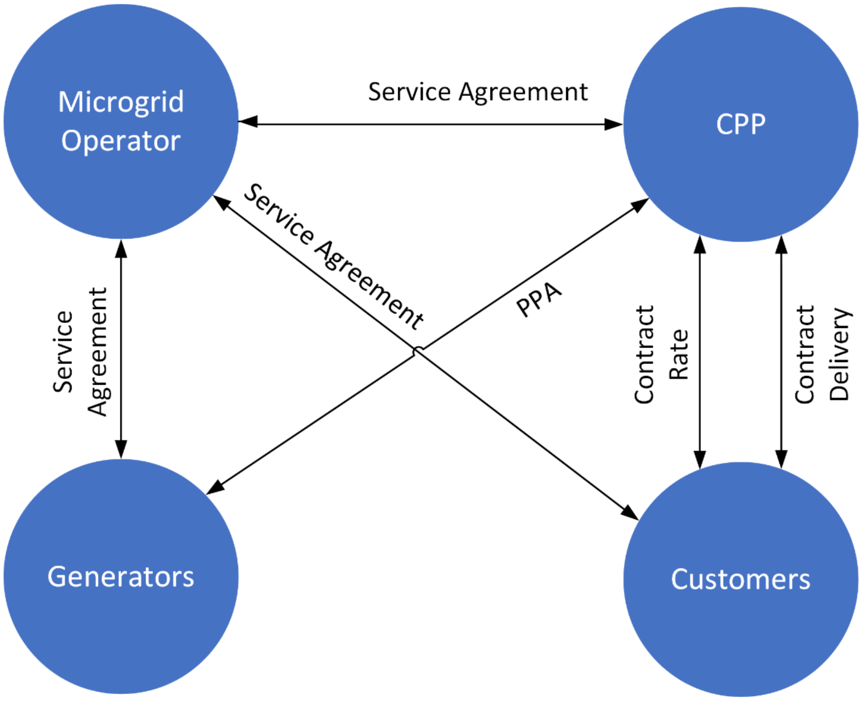
[25] *Id.*

The Cleveland microgrid being proposed herein is just one of many possible models. The model chosen for this report has been designed to (1) minimize federal and state regulation of the microgrid, (2) develop a mechanism to ensure repayment of debt incurred to construct the microgrid, and (3) accommodate achievement of other non-rate goals. The proposed plan provides that a privately-owned grid operator[26] would enter into multiple service agreements with power generators, Cleveland Public Power and end users. The operator could be a for-profit utility. Or, it could be CPP, which then subcontracts to a for-profit with expertise to operate.

Below is a diagram that outlines one proposed conceptual structure. It consists of the following:

- Generation resources supplied pursuant to PPAs between a developer and the microgrid provider, throughout the duration of at least the debt service period for the microgrid;
- CPP entering into contracts with microgrid customers to provide distribution services, and possibly to pass through microgrid services and generation costs (including transmission and capacity for PJM power). Alternatively, the microgrid provider may contract separately with end users for microgrid and generation services. There likely would need to be a new "Microgrid Rate Schedule" established by CPP for this project, approved by Cleveland City Council; and
- Microgrid operator entering into service agreements with CPP, the generation resource owners and the customers, to manage the microgrid.

Figure 7. Possible Business Structure for Downtown Cleveland Microgrid



---

[26] The 2018 Study included as a potential owner Cuyahoga County, which has created a new utility division for the purpose of developing microgrids. Cuyahoga County continues to be interested in collaborating with CPP on such a strategy, although it too would subcontract certain services to a company with grid operation expertise.

The model chosen may be impacted by taxes and sources of public financing. The model proposed here is one of a “Special Purpose Entity” building and owning all aspects of the microgrid, except the distribution lines, which are owned by the CPP. Under this scenario, the SPE could also build and own the distribution lines, but lease it to them to CPP. In the model the Study Team proposes here, the cost to lease this equipment to CPP would be nominal, and ownership of it would revert to CPP at the end of the 30-year term.

This is only one possible structure – there are many others that may be more attractive to designers, builders and investors depending upon the circumstances. Regardless which model is chosen, there will need to be some sort of relationship between the local distribution utility and the microgrid operating company. The updated model presented herein now considers the impacts of the ITC, depreciation benefits as they impact carryover loss to avoid tax liability, low interest loans and possible development grants.

3. Economic Feasibility

The 2023 updated economic model relies upon the 2018 model, which was based on the conceptual design developed in the technical feasibility and business models. The 2023 updated model balances the construction, financing, energy and operational costs against customer revenues, less fees paid to the distribution utility.

$$\begin{aligned} &Annual\ Profit \\ &\qquad = Customer\ Revenue - Generation\ Costs - Operational\ Costs \\ &\qquad - CPP\ Fees - Debt\ Payments_{Commercial} - Debt\ Payments_{Subsidized} \end{aligned}$$

where

$$Customer\ Revenue = f(Energy, Customer\ Rates)$$

$$Generation\ Costs = f(Energy, Contracted\ and\ Marginal\ Electric\ Rates)$$

$$Operation\ Costs = 25\% \times Customer\ Revenue$$

$$CPP\ Fees = \$0.025/kWh \times Energy$$

$$\begin{aligned} &Debt\ Payments_{Commercial} \\ &= f(Construction\ Cost\ less\ Equity\ \&\ Grants, 30\ year\ term, 5\%\ interest\ rate) \end{aligned}$$

$$\begin{aligned} &Debt\ Payments_{Subsidized} \\ &= f(Construction\ Cost\ less\ Equity\ \&\ Grants, 20\ year\ term, 3\%\ interest\ rate) \end{aligned}$$

The values applied for each term in the profit equation were developed based upon RSMeans data, utility market analysis, industry knowledge and industry benchmarks. The Customer Rates were then analyzed to determine a set of costs which yielded break-even profitability over the 30-year operating term.

3.1. Customer Rates

The customer rate is the most readily available parameter to change in the profit equation and ties directly to other research performed by the project team concerning price premiums customers would be willing to pay for highly resilient power. In 2018 we proposed a rate structure with three tiers, and we do so again now, with the following design parameters to develop rates:

- Tier 1 rate, which represents indefinite, ongoing uptime during an outage, should be the most expensive, but should be on par with what a customer would likely otherwise pay for 99.999% uptime.
- Tier 2 rate, which represents 2 hours of uptime during an outage, given excess in-network generation and battery storage over Tier 1 demand.
- Tier 3 rate, the least expensive rate, may be dropped during general grid outages, and should approximate preexisting power cost conditions in the microgrid study area.

To determine the approximate Tier 3 rate, the Study Team looked at existing prices in the CEI territory, as estimated by the PUCO, as well as projected EIA "all in" prices for Ohio. Ohio has a deregulated electricity market, backed up by a standard service offer (SSO) for customers who do not wish to shop. In 2021, a spike in natural gas prices caused by the Ukraine war and COVID supply chain issues led to a rapid rise in electricity prices throughout the PJM Regional Transmission Organization territory. This in turn led to end users in Ohio migrating to the SSO, which provided a "safe harbor" for customers to avoid the high cost of electricity. By 2022, new bids into the SSO began to reflect the high prices, causing the SSO to rise dramatically in the summer of 2023. In the meantime, falling natural gas prices led to the reduction of wholesale prices for electricity. Accordingly, customers are once again availing themselves of the lower prices available by shopping.

The result is that 2023 CEI standard service offer (SSO) prices—around \$0.134/kWh (see Table 2 below) for commercial customers as of November 2023—are not reflective of the actual market rate for power anticipated in Northeast Ohio in 2024.[27] The EIA also expects that this price will come down. EIA anticipates that the average all-in price for electricity in the *PJM West* subregion across all sectors (i.e., Commercial, Industrial, and Residential) will drop to below \$0.11/kWh by 2025.[28] As shown in Figure 10, most of this is due to a drop in generation costs, which EIA projects

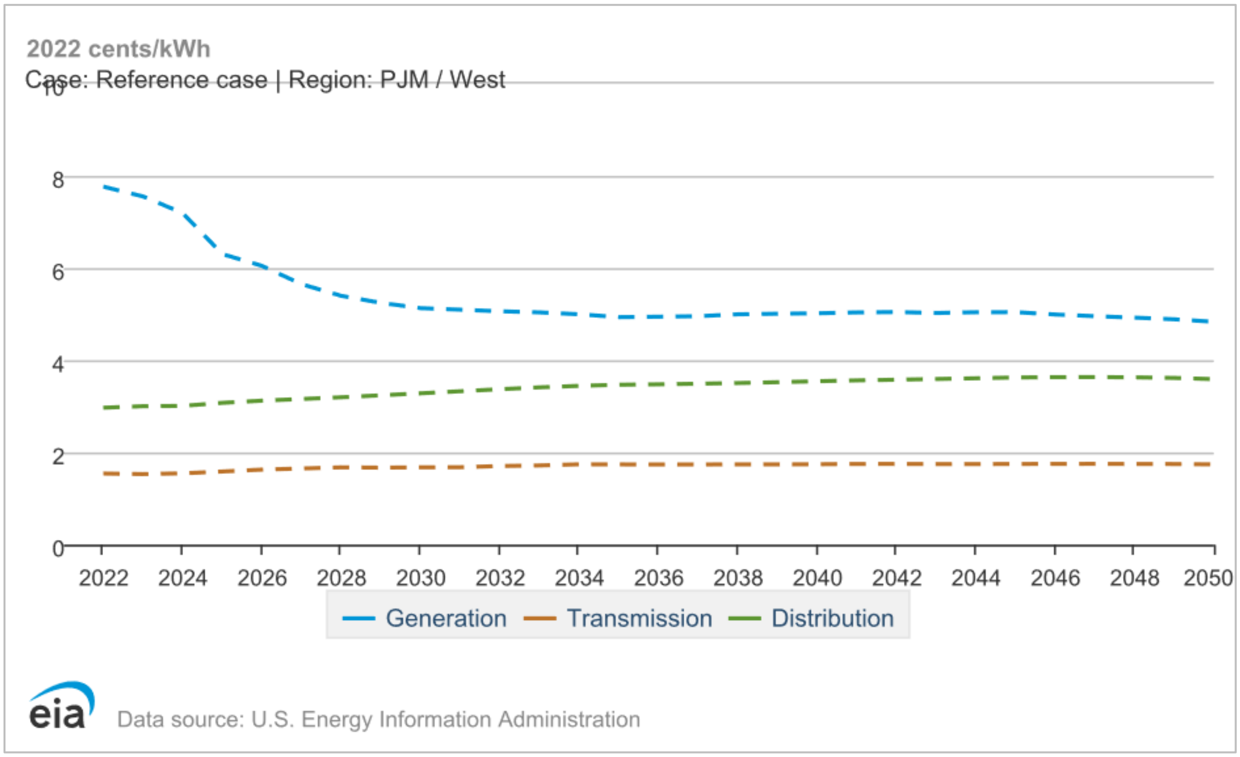
---

[27] For an overview of electric utility rates in CEI's territory, *see* the Ohio Public Utility Commission's *Ohio Utility Rate Survey Dashboard* at https://puco.ohio.gov/utilities/electricity/resources/ohio-utility-rate-survey. For commercial customers, the PUCO uses the following estimates of average monthly usage and demand: usage of 300,000 kWh; demand of 1,000 kW; and reactive demand of 484.3 kVAR. Under these assumptions, the average electric bill in November 2023 for a non-shopping commercial customer in CEI territory was \$40,259.01 according to the PUCO's monthly Utility Rate Survey. This amounts to an average all-in price of \$0.134/kWh.

[28] *See* U.S. Energy Information Administration (EIA). Annual Energy Outlook 2023. National Energy Modeling System. *Table 54. Electric Power Projections by Electricity Market Module Region* [Reference case for PJM/West]. Prices are in \$2022 dollars. The PJM West subregion encompasses all of Ohio and West Virginia, and parts of

will continue to come down until around 2028, when they will level off to around \$0.05/kWh in 2022 dollars.[29] While the EIA price projections are likely to be low for the CEI territory, which has higher costs than other regions in Ohio, it is reasonable to set the price for Tier 3 power at the long-term EIA PJM West projected end-use price of \$0.10/kWh.

Figure 8. Projected Electricity Prices by Service Category for PJM West Subregion



Data source: U.S. Energy Information Administration

Indiana, Michigan, Pennsylvania, Kentucky, and Virginia. For a map of the PJM West subregion, *see* https://www.eia.gov/outlooks/aeo/pdf/nerc_map.pdf

[29] *Id.*

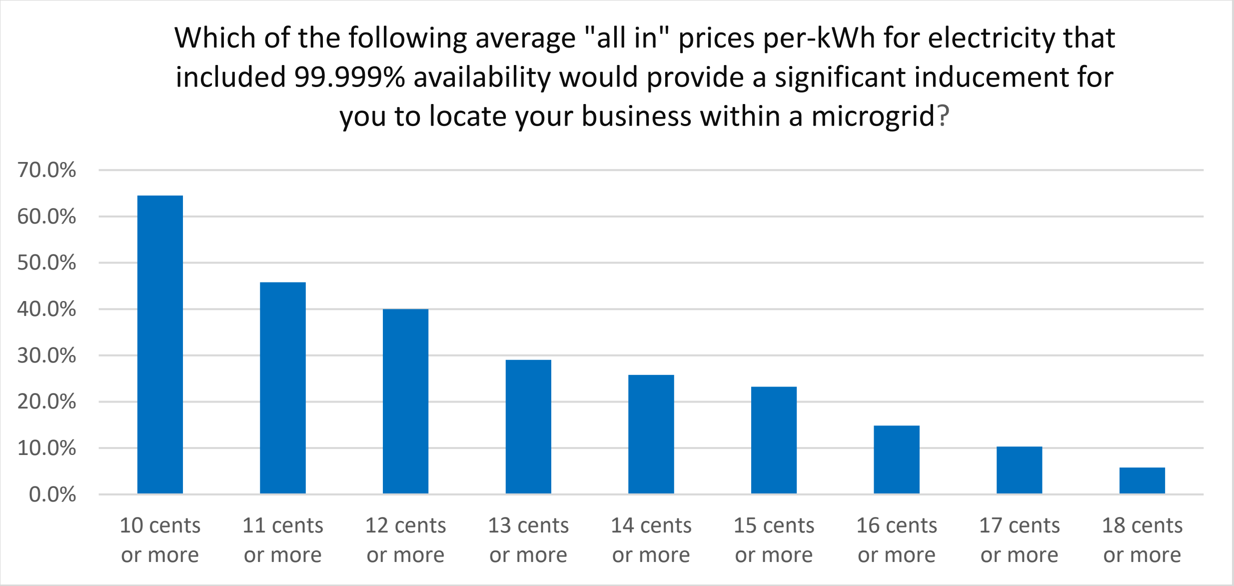
Table 2. Components of an Average Electric Bill for a Non-Shopping CEI Commercial Customer, November 2023

Charge Type	Name	Total Charge	% of Total Bill
Generation	Generation Service Rider-Energy Charges	$29,271.60	72.71%
Transmission	Non-Market Based Services Rider	$6,202.00	15.41%
Distribution	General Service-Primary	$2,405.00	5.97%
Generation	Alternative Energy Resource Rider	$2,307.30	5.73%
Distribution	Delivery Capital Recovery Rider	$1,359.40	3.38%
Distribution	State kWh Tax Rider	$1,034.55	2.57%
Distribution	Economic Development Rider-Provision 1	$890.70	2.21%
Generation	Generation Service Rider-Capacity Charge	$735.60	1.83%
Distribution	Universal Service Fund Rider	$601.80	1.49%
Distribution	Adv Metering Infrastructure/Modern Grid Rider	$178.38	0.44%
Distribution	General Service-Primary	$174.35	0.43%
Distribution	General Service-Primary	$150.00	0.37%
Distribution	Phase-In Recover Rider	$118.80	0.30%
Distribution	Solar Generation Fund Rider	$85.50	0.21%
Generation	Legacy Generation Resource Rider - Part A	$67.20	0.17%
Distribution	State kWh Tax Rider	$54.47	0.14%
Distribution	Distribution Uncollectible Rider	$36.30	0.09%
Distribution	Economic Development Rider-Provision 2	$24.90	0.06%
Distribution	Demand Side Mgmt. & Energy Eff. Rider-DSE1	$19.80	0.05%
Distribution	Econ. Development Rider-Automaker Charge	$15.00	0.04%
Distribution	State kWh Tax Rider	$9.30	0.02%
Distribution	PIPP Uncollectible Rider	$5.10	0.01%
Distribution	State kWh Commercial Activity Tax Rider	$2.70	0.01%
Distribution	Delta Revenue Recovery Rider	$0.30	0.00%
Distribution	State kWh Commercial Activity Tax Rider	$0.14	0.00%
Distribution	State kWh Commercial Activity Tax Rider	$0.02	0.00%
Generation	Legacy Generation Resource Rider - Part B	-$117.60	-0.29%
Distribution	Tax Savings Adjustment Rider	-$170.70	-0.42%
Distribution	Consumer Rate Credit Rider-Rate 2	-$250.20	-0.62%
Generation	Generation Cost Reconciliation Rider-GCR1	-$1,772.70	-4.40%
Generation	Non-Distribution Uncollectible Rider	-$3,180.00	-7.90%
	Generation Subtotal	*$27,311.40*	*67.84%*
	Distribution Subtotal	*$6,745.61*	*16.76%*
	Transmission Subtotal	*$6,202.00*	*15.41%*
	GRAND TOTAL	**$40,259.01**	**100.00%**

Data source: PUCO (2023). Total bill amount is based on sales tax rate of 8.0% for Cuyahoga County.

To determine Tier 1 rate, the Study Team relied upon prior research into the amount end users are willing to pay for 99.999% uptime. In 2018, CSU conducted a national survey of large commercial end users, asking them what price for 99.999% uptime would provide them incentive to locate their business within a microgrid. Twenty five percent of respondents indicated that they would consider moving their business to the microgrid for at least $0.14/kWh. See Figure 11 below.

Figure 9. Rate End-Users Would Pay for 99.999% Uptime

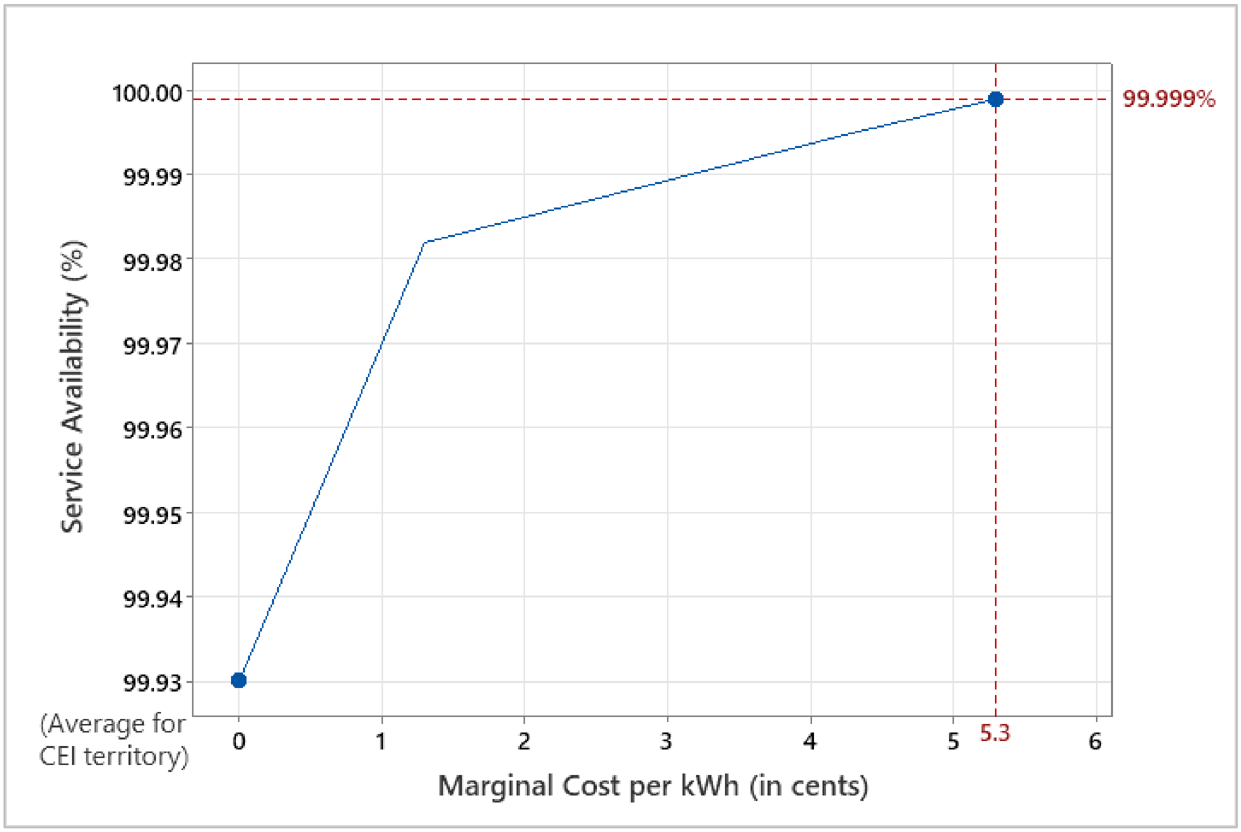


Interviews with data centers in downtown Cleveland confirmed that this price is accurate. According to data CSU collected in 2018, the cost of ensuring 99.999% uptime was around $0.15/kWh for data centers, who had to build their own backup systems. Likewise, according to the IT provider Expedient and its *Data Center Build vs. Buy Calculator*, the cost of raising uptime from the grid's existing service availability of 99.9% to a Tier 1 level of 99.999% (i.e., going from 8 hours to 5 minutes of outage time annually) is around $0.05/kWh (Figure 12),[30] also suggesting around $0.15/kWh (assuming $0.10/kWh commercial rates). Accordingly, the interviews and the Expedient cost calculator both also suggest end users looking for 99.999% uptime would pay around $0.14/kWh for Tier 1 power.

---

[30] Expedient's *Data Center Build vs Buy Calculator* is can be found at https://expedient.com/knowledgebase/tools-and-calculators/data-center-build-vs-buy-calculator/

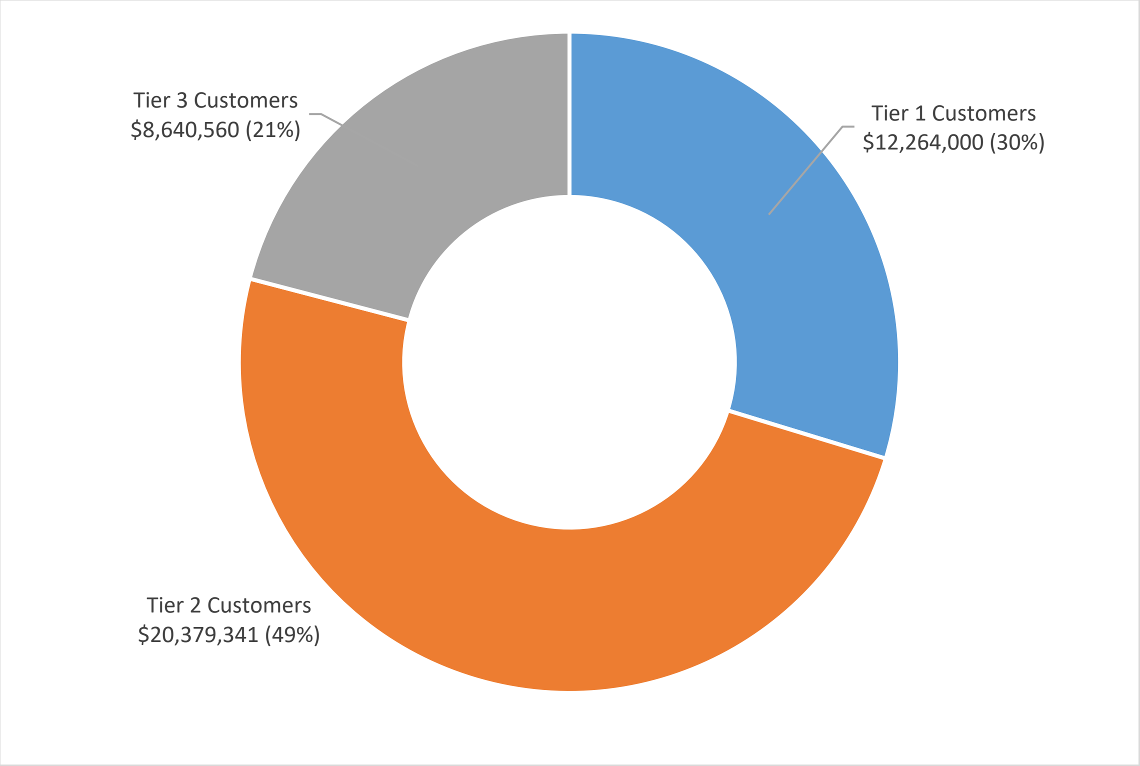
Figure 10. Marginal Cost of Additional Service Availability in CEI Territory



Tier 2 was set in the middle, at $0.12/kWh. This is assumed to be the most common rate sought by end users, since it protects against outages of two hours or less, which make up the majority of outages.

Since the amount of expected power consumption per Tier is not equal, the impact of adjusting one of the Tier rates will be different for each Tier. This difference is illustrated in the percentage of steady-state annual revenue expected by Tier as shown in Figure 13 below.

Figure 11. Microgrid Customer Revenue by Tier



A sensitivity analysis of the customer rate structures performed by adjusting one rate at a time and holding the other two rates constant showed that the economic model was most sensitive to changes in the Tier 2 rate. This finding is consistent with the graph above where Tier 2 revenue is the largest revenue source.

Figure 12. Results of Sensitivity Analysis to Customer Rate

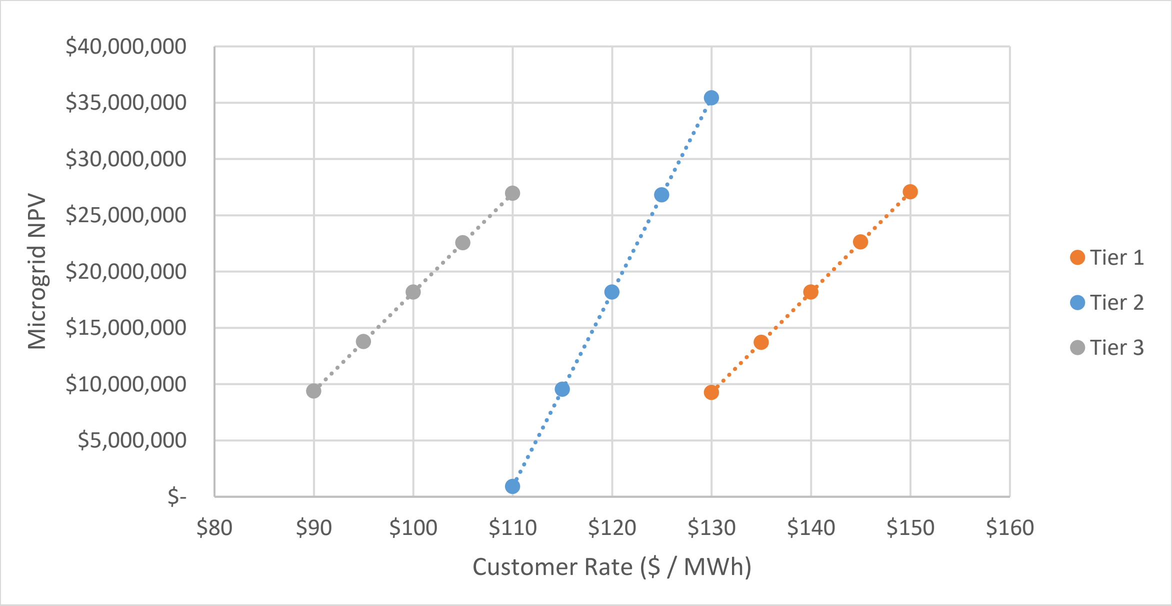


Table 3. Change in NPV on Net Cash Per $/MWh Change in Customer Rate

Customer Rate	$ NPV per $/MWh
Tier 2	$1,726,671.88
Tier 1	$890,645.82
Tier 3	$878,502.13

3.2. Successful and Timely Customer Recruitment

Because not all loads will be brought on line at the same time, the 2018 model included a strategy for the connection of end users over time. To approximate a resulting disparity between revenue and expense, the 2018 model assumed that all capital expense, and therefore the associated debt service, started in year 1, while all operational expense including microgrid operational costs as well as energy costs were incurred as energy was sold. Then a 20% per year customer acquisition rate was applied with the first 20% in year 1 as “anchor customers” and achieving full customer load in year 5 and maintaining it through the 30-year operation.

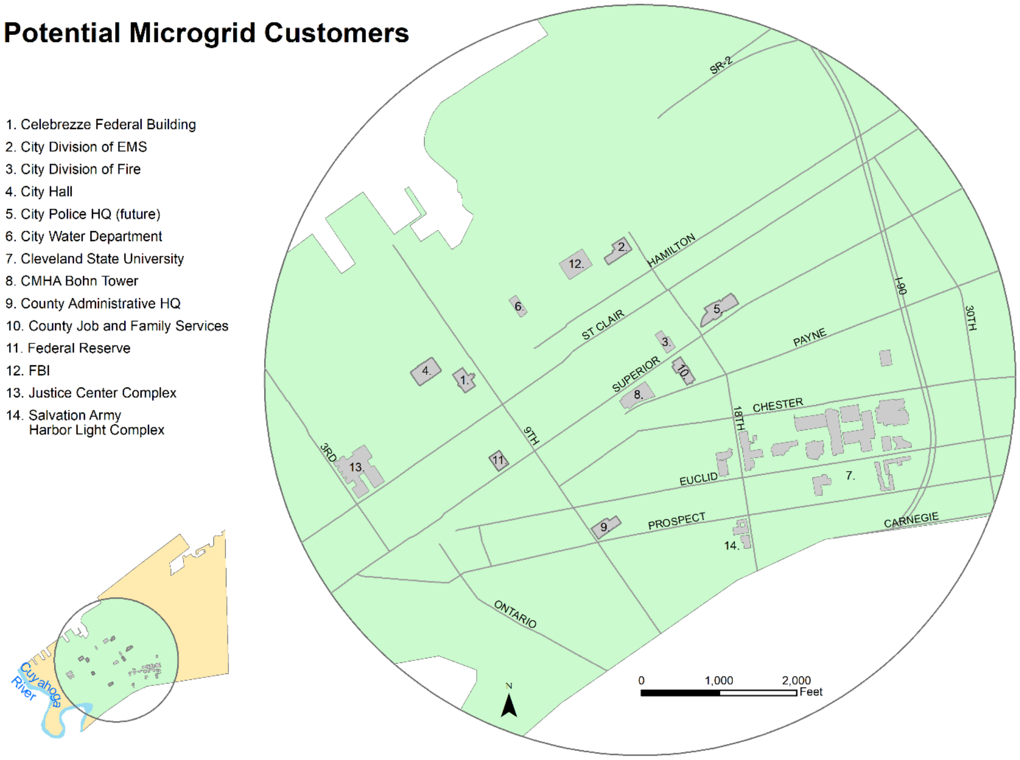
The Study Team has built this assumption into the 2023 model as well. This assumption leads to a negative cash flow in the first 3 years of operation as shown in the table below.

Table 4. Microgrid Customer Acquisition and Cash Flows in First 5 Operational Years

	Year 1	Year 2	Year 3	Year 4	Year 5
Customer Acquisition	20%	40%	60%	80%	100%
Net Cash	$(5,349,802)	$(3,443,388)	$(1,578,236)	$244,778	$2,024,761

The best way to mitigate this risk is to establish anchor customers as early as possible. The Study Team has identified (Figure 15 below) some potential customers that are in the microgrid area, are likely to be long time customers, and are likely to be keenly interested in resiliency. However, until pricing and service levels are finalized and contracted, it is impossible to confirm their willingness or ability to participate. Further, if any of these proposed anchor customers are existing CPP rather than CEI customers, CPP will need to be kept whole through the contracts.

Figure 13. Map of Potential Microgrid Customers



3.3. Availability of Long Term, Competitive Electrical Power and Natural Gas Prices

Since 2018, there has been significant fluctuation in electricity and natural gas prices. Historically, electricity prices have followed changes in natural gas prices. That continued to be the case during spikes in natural gas prices created by supply chain disruptions during COVID, followed by the Ukraine War. But by 2023, natural gas prices were back down to 2018 prices, or below. Electricity prices remain higher but are likely to soon follow natural gas trends. But events since 2018 show how difficult it is to predict energy costs.

Over the duration of the proposed microgrid, electricity prices are expected to increase. The model uses an annual growth rate of 2% for electricity prices purchased in the real-time market (LMP electricity) and uses an annual growth rate of 1% for contracted electricity prices, including both renewable and traditional electricity. These assumptions are aligned with the Department of Energy annual growth projections for electricity generation costs in the *PJM West* subregion.[31]

However, the model also assumes that other sources of electricity for the microgrid will remain fixed based on long-term contracting between the in-network generators and the microgrid operator. For renewable energy generation within the microgrid, long-term power purchase

---

[31] *See fn 28, supra*. EIA's 2023 Annual Energy Outlook projects median annual growth in the nominal cost of generation to end users in the PJM West subregion of 1.63% between now and 2050.

agreements are the standard contracting mechanism, and these commonly include fixed rates with little or no escalation. Holding prices from renewable sources constant is therefore a reasonable assumption. Due to the small percentage of overall renewable generation included in the model, variable or escalating prices will have a negligible effect on the model. Likewise, the pricing for demand response and customer generation is assumed to be constant and also represent a very small percentage of overall energy in the microgrid operation.

The contract between the microgrid operator and the owner of the CHP generation will, on the other hand, be adjustable based on the cost of natural gas. However, these prices are not expected to rise over the next 20 years at a rate significantly more than inflation.[32]

The cumulative effect of these pricing assumptions is that the projected blended cost for generation from inside the microgrid for the 2023 model starts at $45.32/MWh and experiences an average annual growth rate of 0.85% over the term. This initial cost compares favorably to the currently available total price of wholesale power in the PJM footprint, which over the first three quarters of 2023 averaged $53.26/MWh.[33]

3.4. Cost of Capital / Interest Rates

The cost of capital and interest rates have also changed significantly since 2018, due principally to inflation. The Study Team assumed a single rate of 5% for its 2018 model. However, the availability of New Market Tax Credits (NMTC) can significantly reduce the cost to finance a microgrid project. The economic model has been updated to consider two types of debt – commercial debt at a standard interest rate and subsidized debt at a lower interest rate obtained through leveraging the New Market Tax Credit program. As of December 2023, long-term corporate bond yields for very low or low risk debt issuances (i.e., by companies with a Moody's rating of Aa or A) were averaging around 5.42%.[34] Also, according to the U.S. Treasury Department's most recent transaction-level data release detailing the loans provided to low-income communities through the Community Development Financial Institutions (CDFI) that administer the NMTC program, subsidized loans to businesses for projects totaling $5 million or more in Ohio have as of late been at fixed rates of around 3% and financed about one-third of project costs on average.[35] A microgrid in Downtown Cleveland should be eligible for New Market Tax credits as much of this area qualifies as a low-income community.[36]

---

[32] *Id*.

[33] Monitoring Analytics, LLC. (November 9, 2023). *2023 Quarterly State of the Market Report for PJM: January through September*. https://www.monitoringanalytics.com/reports/PJM_State_of_the_Market/2023/2023q3-som-pjm.pdf

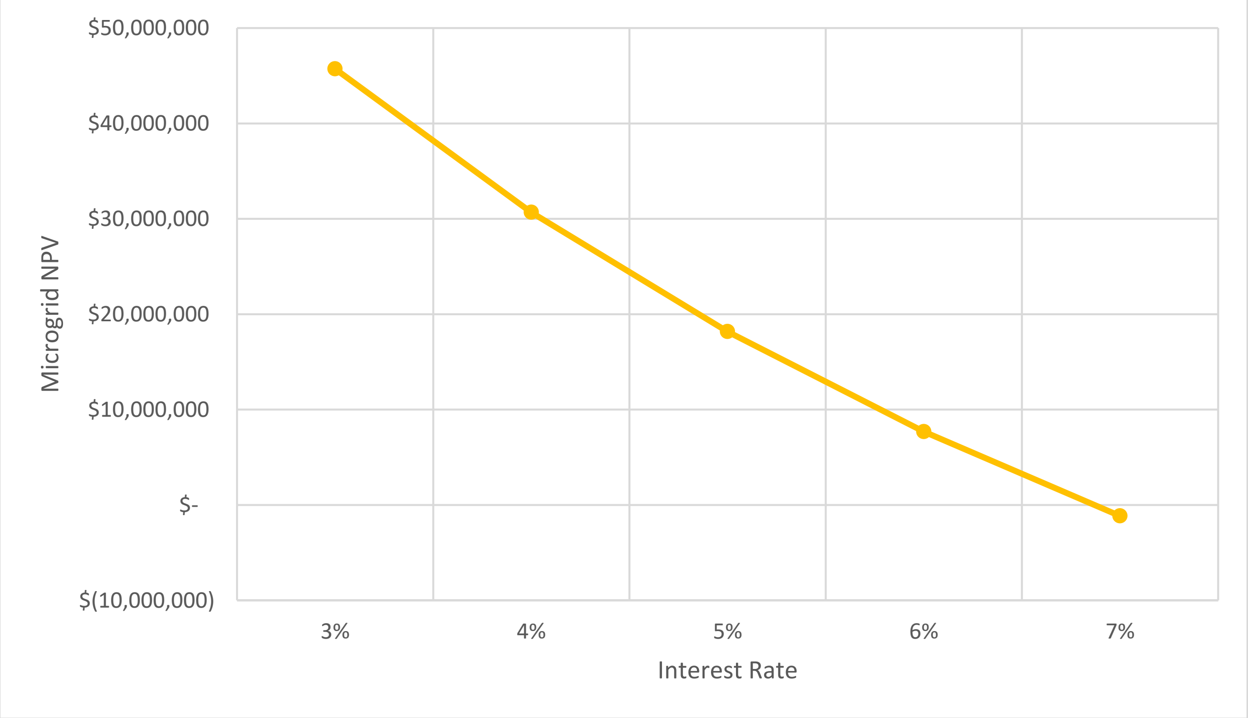
[34] This average reflects Moody's Daily Long-term Corporate Bond Yield Average for Aa and A-rated companies as of December 1, 2023. *See* https://credittrends.moodys.com/data/bondyields

[35] *See* Community Development Financial Institutions Fund. (2023, July 5). *2021 CDFI Program Awardee Data Release, Documentation and Instructions*. U.S. Department of Treasury. https://www.cdfifund.gov/documents/data-releases. *See also* "CDFI Fund Releases Public Data on CDFI Program Receipients Through 2021." (2023, July 5). https://www.cdfifund.gov/news/529.

[36] *See* the Community Development Financial Institutions Fund's NMTC Mapping Tool at https://cimsprodprep.cdfifund.gov/CIMS4/apps/pn-nmtc/index.aspx#?center=-81.538903,41.45187&level=10

For the 2023 study, the model has again been run using an assumed interest rate of 5% as a starting point to reflect a reasonable cost for commercial debt. The model was also run assuming the incorporation of NMTC financing for one-third of project costs at a subsidized rate of 3%, for an overall blended rate (i.e., the weighted average of the commercial and subsidized rates) of a little over 4%. These numbers were used in the calculation of the debt service costs as well as the net present value calculations on the cash flows. The capital investments consist of additions and enhancements to the electric power distribution system, the microgrid control system, and the engineering and technical services to deploy the microgrid. As shown in Figure 16, the NPV is highly sensitive to changes in the interest rate losing approximately $12.5 million in NPV per rate point.

Figure 14. Results of Sensitivity Analysis to Interest Rate



This sensitivity creates opportunities for the stakeholders in the microgrid to assist in the economic viability of the project. First, the County and City can potentially be involved in the raising of the initial capital thereby lowering the interest rate. A survey of long-term municipal revenue bonds in the state of Ohio issued by public entities with a Moody's rating of Aa or A shows a yield that has averaged 4.66% in recent trading.[37] These rates indicate that assistance from the County and/or City could potentially reduce the interest rate that the microgrid operator would obtain for the capital expense debt. Secondly, the importance of cost of capital creates a distinction in the selection of a microgrid operator. Potential operators who have

---

[37] Based on 122 Aa and A-rated municipal revenue bonds in Ohio with maturity dates after 2040 and trading activity during the months of June through November of 2023. *See* EMMA Electronic Municipal Market Access. Municipal Securities Rulemaking Board. https://emma.msrb.org/

access to lower cost capital will be able to provide more competitive rates while ensuring their rate of return.

3.5. Distribution Costs from the Municipal Utility

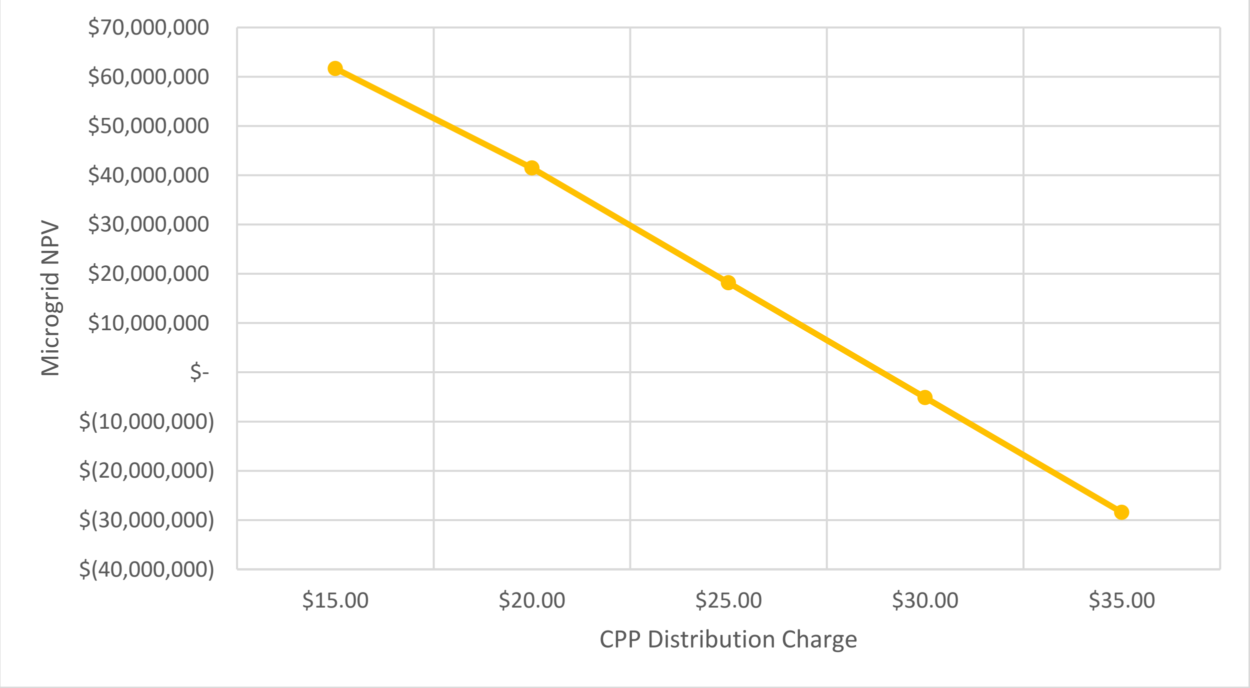
The municipal utility, Cleveland Public Power (CPP), must play an integral role in the proposed microgrid. CPP provides not only the regulatory capability to create the microgrid, but will also be responsible for customer management including:

- Meter reading
- Billing and invoice management
- Tariff approval and maintenance

CPP owns and operates the interconnection to the PJM grid and is responsible for all the regulatory and operational responsibilities that entails. CPP also owns the distribution network for the transmission of electricity to the customers, and they must manage and maintain this infrastructure.

The model developed in 2018 included a distribution charge payable to CPP of $25/MWh for all electricity delivered to microgrid customers, regardless of generation source. Since this fee must be subtracted from the rate that would be otherwise collected by the microgrid operator, it is not surprising that the model is highly sensitive to amount charged by CPP, as shown in Figure 17. A charge of $5/MWh more by CPP results in a reduction of $25 million of NPV.

Figure 15. Results of Sensitivity Analysis to CPP Distribution Costs



The Study Team undertook conversations in 2018 with CPP about this fee, however there has never been any determination that a $25/MWh fee would be acceptable to CPP. However, in reviewing the published rates for CPP, this charge appears to be in line with existing CPP rates and charges for 2023.[38] The fee will need continued discussion and finalization should the microgrid development move forward.

3.6. BRIC and Other Federal Grants.

Because the proposed Microgrid in downtown Cleveland includes a number of critical public services within its footprint (see Figure 15 above), it is as a result a potential candidate for a Federal Emergency Management Agency “Building Resilient Infrastructure and Communities“ grant.[39] The BRIC grant could provide a significant cost offset for capital investment, and might be critical for attracting investment, especially given that the Microgrid as proposed will entail significant losses in the first several years.

The BRIC grant application does not limit reward amounts, however previous awards suggest that the most likely amounts to be awarded range from around $5 to $15 million. These amounts are included in a sensitivity analysis for project feasibility in Figure 18 below. The award of a typical BRIC grant would increase the operator’s return on invested capital from 22.4% without this funding, to somewhere between 23.9% and 27.5%. However, it would likely require the operator to add certain high-risk end users, such as residential apartment buildings or commercial end users in low income communities, to the microgrid customer base. The users would likely not include significant Tier 1 demand but would benefit from the higher uptime from Tier 2 and potential rate advantages for Tier 3 load.

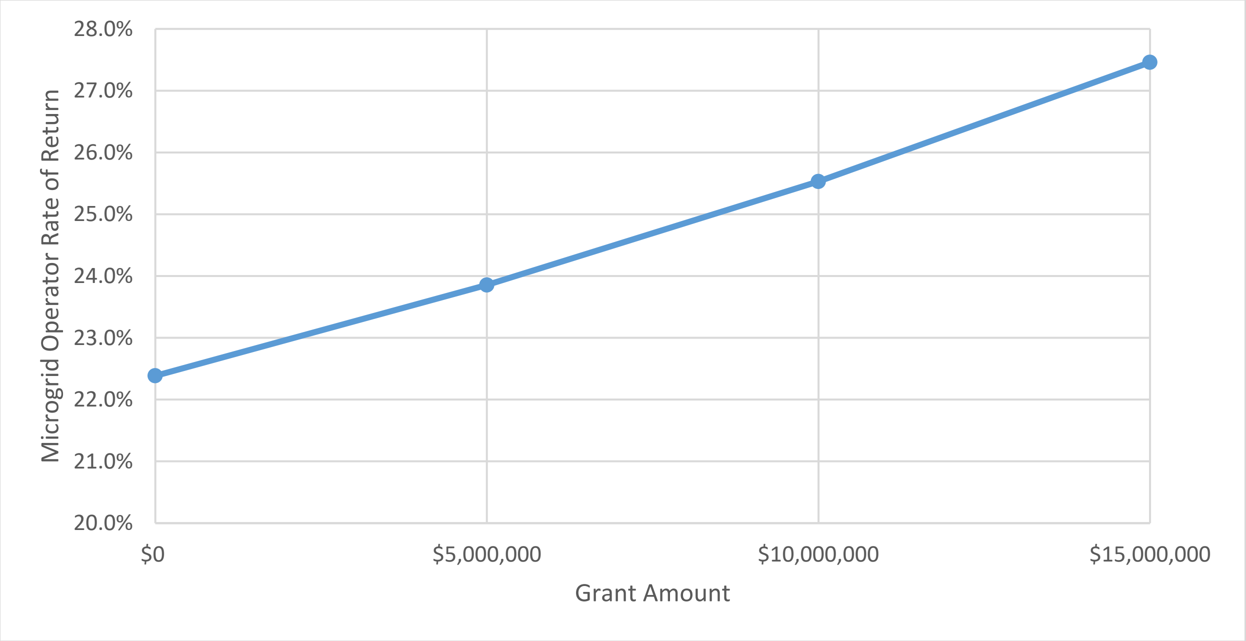
Other federal grants may also be available for microgrid development, such as the Department of Energy’s “Grid Resilience Innovation Partnership.” The microgrid developer will need to evaluate the design and operational requirements and costs posed by any of these available grants to determine their value.

---

[38] *See* CPP rate schedules available at http://www.cpp.org/rs.html. CPP distribution charges also include demand charges, which are set based upon end-user peak demand and upon how that demand coincides with grid peak demand.

[39] https://www.fema.gov/grants/mitigation/building-resilient-infrastructure-communities

Figure 16. Results of Sensitivity Analysis to BRIC Grant Award



4. Other Benefits Provided by a Downtown Microgrid

The Study Team identified other factors that could provide benefits to the various stakeholders in a microgrid beyond the direct cost/benefit model analysis set forth herein and that could be monetized by the microgrid operator or other stakeholder to improve the financial performance of the microgrid. Some of those factors are set forth below.

4.1. Indirect Community Benefits

There are many indirect benefits from a microgrid to the community, ranging from emergency power services to clean air to economic development. Indeed, the culture of innovation and technology advancement is likely to significantly enhance economic development opportunities for the region. The Brookhaven study sets forth how some of these can be put into a cost benefit analysis for the community and is discussed in section II(B) above. Some of these indirect benefits are discussed below.

4.1.1. Reduction in Demand, Capacity and Other Charges.

The National Renewable Energy Laboratory, for instance, examined the value that energy storage has in reducing demand charges which are utility charges that are typically based on the peak amount of energy that a customer uses in a specified time interval. Demand charges are designed to enable the utility to recover costs associated with having to build distribution capacity that is idle except for during peak demand periods. The end user's demand charge is usually set by a formula that considers, among other things, how that end user's peak demand coincides with the grid's peak demand. An end user whose own peak coincides with grid peak pays a higher demand charge.

Demand charges are not trivial. NREL determined that 25% of commercial customers pay demand charges greater than $0.015/kWh.[40] A microgrid can reduce this cost substantially. The microgrid operator can manage coincident peak contribution during peak grid times, such as hot summer afternoons. Likewise, a microgrid operator could manage peak load contribution for PJM capacity charges and could even sell power back to the grid during peak load periods. These actions would in turn allow the microgrid operator to pass on the savings to the microgrid customers.

4.1.2. Economic and Workforce Development.

The proposed downtown Cleveland microgrid will trigger significant investment into the local workforce. The proposed work will require the deployment of a well-qualified, skilled and trained workforce for construction and operation of the microgrid system, creating many quality jobs. But the investment will do much more than this: it will place Cleveland on the leading edge of the ongoing transformation from legacy, rust-belt communities into 21st century smart cities.

Modern grid edge and broadband technology are key to unlocking growth in the new economy. The fastest growing sectors in the U.S. (e.g. research, finance, medical services) all require high uptime. This includes manufacturing, where information and operational technology convergence (IT/OT) demand grid resiliency. Quality jobs will be triggered by microgrid development in three areas: (1) microgrid supply chain activation, (2) retention and/or attraction of businesses that experience the greatest costs from power outages (highest value of lost load, or VOLL) and (3) construction and operation of the microgrids. The microgrid proposed by the Study Team is estimated to include up to 50 MW of capacity. Based upon that estimate, jobs can be summarized as follows:

- Microgrid Supply Chain and Manufacturing. According to a recent study from Guidehouse (formerly Navigant), building microgrids will trigger around 15 employees per MW built.[41] Using the 50 MW estimate, this will generate around 750 jobs. Not all will be local, but Northeast Ohio's high engineering location quotients and energy storage

---

[40] *See* J. McLaren et al, "Identifying Potential Markets for Behind the Meter Battery Energy Storage: A Survey of the U.S. Demand Charges." National Renewable Energy Laboratory (2017) https://www.nrel.gov/docs/fy17osti/68963.pdf See also: E. Wood, "Wondering if Energy Storage Can Reduce Your Demand Charges," Microgrid Knowledge, August 24, 2017, found at: https://microgridknowledge.com/demand-charges-energy-storage/

[41] Renewable Energy Economic Benefits of Microgrids (Guidehouse, Nov. 2021), at 18, found at: https://static1.squarespace.com/static/5472abbae4b0859145039552/t/6193d0e801c64e39c1662e1d/1637077225523/CSI+Final+Report_FINAL+%2811-16-21%29.pdf. Guidehouse estimates around 11 employees per MW for solar-based microgrids, 17 for storage and around 25 for biomass-based microgrids. The County plans a mixture solar, storage and natural gas, so used 15/MW as its estimate in this case.

cluster development suggest the region will retain a significant share of these jobs.[42] The adoption of microgrids will also spur further development for regional clusters around smart grids, sensors, information technology and advanced manufacturing – all of which value uptime and resiliency.

- Construction Jobs. Construction jobs are temporary, but important. In 2018, CSU projected the microgrid in downtown Cleveland would create 132 construction jobs for work on the microgrid itself, and 398 construction jobs to support businesses attracted to the microgrid. By 2030, investments in renewable microgrid assets alone are estimated to generate 435,700 construction jobs nationally and $72.3 billion in gross domestic product.[43]

- Retention and/or Attraction of Businesses that Value Uptime. A study conducted by Cleveland State in 2018 indicated that over 1000 jobs would likely be created or retained over a 5-year period if the City of Cleveland were to build a 50 MW microgrid in downtown Cleveland.[44] This estimate was based upon an evaluation of the growth rate of those industries with the highest Value of Lost Load. Using an VOLL analysis based upon U.S. Census Bureau data, CSU's 2018 Study identified those industries that most value power availability and power quality, and would therefore be candidates to locate or expand within the proposed microgrid territory.[45] For these industries—which included Health Services, as well as Professional, Scientific, & Technical Services—the 2018 Study estimated potential job creation and related earnings under the assumption that a microgrid could mitigate previous regional disadvantages and bring local job growth for these industries into alignment with national projections.[46]

If a microgrid such as the one proposed for Cleveland were to indeed bring job growth for uptime-sensitive industries in line with national projections, the 2018 Study estimated that it could result in 1,031 direct jobs locally within those industries, along with long-term annual income of $91 million (see Figure 19). Given the investment required for microgrid construction and the construction costs incurred by attracted business, this corresponds with close to 7 direct permanent local jobs—along with $583,000 in annual earnings for those jobs—per $1 million invested. Of course, energy availability is not the sole factor in business location decision making – but it is important, ranking 4th among site selection criteria, according to *Area Review's* latest

---

[42] M. Henning and A. Thomas, *Energy Policy Roadmap for Northeast Ohio,* 2019, https://engagedscholarship.csuohio.edu/urban_facpub/1624/

[43] https://www.microgridknowledge.com/google-news-feed/article/11427086/report-how-many-jobs-will-microgrids-produce

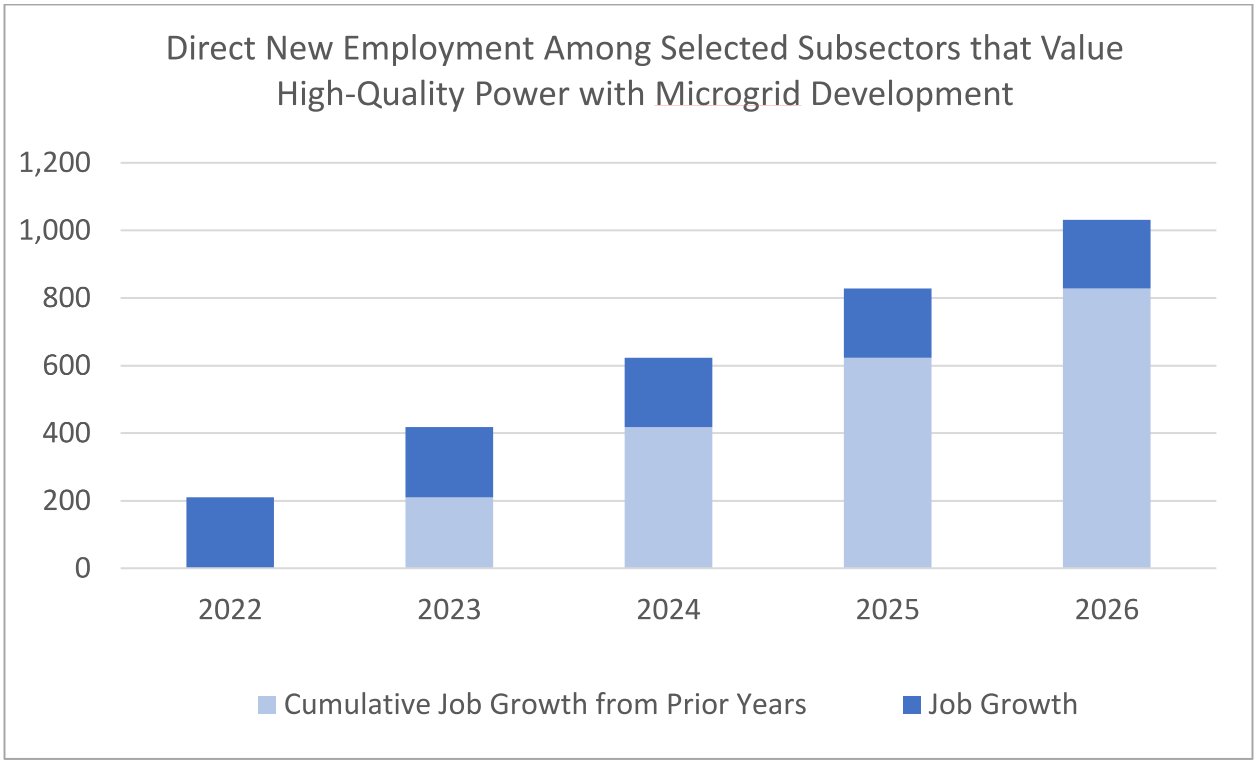
[44] Thomas, Andrew R.; Henning, Mark; Date, Kirby; and Simons, Robert A., "The Economic and Fiscal Impact of a Microgrid in Downtown Cleveland, Ohio" (2018). *All Maxine Goodman Levin School of Urban Affairs Publications*. 0 1 2 3 1560. https://engagedscholarship.csuohio.edu/urban_facpub/1560

[45] *Id.*

[46] For current national employment projections by industry, *see* "Employment by Major Industry Sector." (2023). Bureau of Labor Statistics. https://www.bls.gov/emp/industry-employment/industry.xlsx

corporate survey (energy cost is ranked 8th).[47] Indeed, large-scale microgrid projects currently under development—such as the 420 MWh solar and storage microgrid that will serve a titanium melt facility in Jackson County, WV—are projected to support 1,000 direct permanent jobs on $500 million invested, or a rate of about 2 jobs per $1 million invested.[48]

Figure 17. Projected Employment as Direct Result of Microgrid Development in Downtown Cleveland, Ohio (2018)



4.2. District Energy

District Energy provides additional value to the community and opportunity to the grid operator. It is commonly defined as a shared thermal load between co-located buildings on a campus or a downtown area. They may or may not have more than one customer, but in Ohio, if they do, they are considered as utilities and as such, regulated by either the Public Utility Commission of Ohio or by the municipality in which they operate. Private companies must seek a franchise agreement in most municipalities to operate a multi-customer district energy system.

Cleveland Thermal owns a district energy franchise in the City of Cleveland. It operates a system in downtown Cleveland that provides both steam and cooling, and the system has capacity to

---

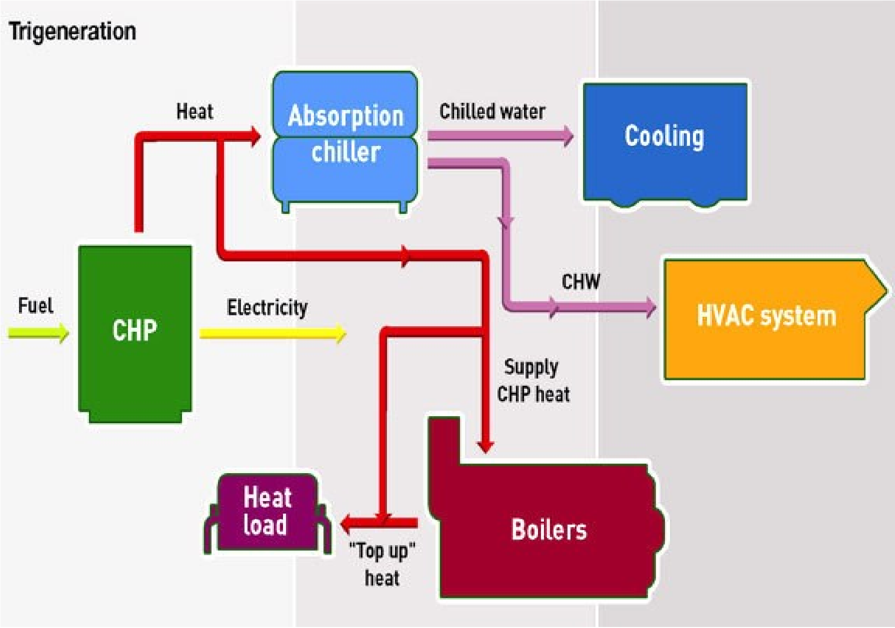
[47] *See* https://www.areadevelopment.com/Corporate-Consultants-Survey-Results/Q1-2023/37th-annual-corporate-survey-decison-makers-feel-economic-pressures.shtml

[48] *See* https://www.newsandsentinel.com/news/business/2022/09/diversifying-berkshire-hathaway-to-build-new-plant-on-century-aluminum-site. *See also* https://www.world-energy.org/article/30013.html

grow. A district energy system is complementary to the microgrid: together they provide opportunities for system efficiencies that could reduce costs and improve reliability. The Combined Heat and Power system is the anchor source of generation for both thermal and electrical loads.

Steam generated from a Combined Heat and Power system would be able to provide more than just heat and byproduct electricity. In the summertime, when heat loads are minimal, the thermal energy from the CHP plant could be recovered to generate chilled water through a process known as absorption chilling. Commercial and industrial settings where chilled water could be utilized for cooling applications include data centers, food processing, cold storage warehouses, office buildings, hospitals and for process cooling in manufacturing. Figure 18 shows a high-level configuration for this sort of co-generation (also known as tri-generation) where electricity, heat, and cooling are products of a natural-gas-fed CHP plant.[49]

Figure 18. Simultaneous Production of Three Sources of Usable Energy



CleanTechOps (2016).[50]

Figure 18 illustrates how cooling can be achieved through an absorption chiller, one of the two main technologies for making chilled water.[51] Absorption chillers work with two fluids: a refrigerant and an absorbent. One common refrigerant-absorbent pair is water-lithium bromide.

---

[49] Wright, I. (2016). “Could Cogeneration Become the Norm in US Factories?” https://www.engineering.com/AdvancedManufacturing/ArticleID/13191/Could-Cogeneration-Become-the-Norm-in-US-Factories.aspx

[50] https://www.cleantechloops.com/what-is-trigeneration/

[51] The other main technology, a steam turbine-driven centrifugal chiller, is similar to an absorption chiller but instead of a heat-driven thermal compressor system uses a mechanical compressor to move refrigerant around the system. *See* “Absorption Chillers for CHP Systems.” *U.S. Department of Energy*. (2017). https://www.energy.gov/sites/prod/files/2017/06/f35/CHP-Absorption%20Chiller-compliant.pdf

In this scenario, water under very low pressure near vacuum conditions has a low boiling point (around 40° F). When this combination is heated by steam or hot water, the absorption fluid is evaporated, removing heat from the chilled water.[52] A heat source such as steam, exhaust gas, or hot water is used to regenerate the absorption solution.[53]

District Energy also enables companies to be more conservative in their growth planning. Companies do not have to overbuild to support future growth, and they do not have excess capacity in the event of business slowdowns. The same sort of companies that are likely to be attracted to a microgrid will also be attracted to district energy, especially chilled water.

5. Conclusion

Microgrids have been found to be cost-effective based upon indirect value to the community, providing emergency power, cleaner energy, and economic development. The proposed Cleveland microgrid will offer these advantages as well. However, the microgrid will require a cost model that will attract investors, possibly without being able to monetize such indirect value. Accordingly, it is important for microgrids to be economically feasible based upon direct value realized by the developer.

The cost model developed herein suggests that investors may find sufficient direct value to be interested in building a microgrid in downtown Cleveland. It appears that a microgrid could be built that offers end users 99.999% uptime service for around $0.14/kWh, while retaining a 22% return on investment -- without the application of federal grants, such as the FEMA BRIC grant.[54] This is a noticeable increase from the 3% return on investment under likely cost and price conditions in the 2018 Study. These gains under the proposed 2023 Cleveland microgrid compare favorably to the return on investment for commercial rooftop solar installations in Ohio, which have recently averaged around 9%.[55]

Commercial microgrids have as yet not been as widely deployed as commercial solar installations. However, for those microgrids that have been developed, investors have indicated a minimum acceptable rate of return of 15%.[56] At this hurdle rate, the proposed 2023 Cleveland microgrid could offer 99.999% uptime to Tier 1 customers at 13.3 cents/kWh, holding constant the rates of 12 cents/kWh and 10 cents per kWh for Tier 2 and Tier 3 customers, respectively.

---

[52] "How does an absorption chiller work?" *Goldman Energy*. (n.d.). http://goldman.com.au/energy/company-news/how-does-an-absorption-chiller-work/

[53] *Id.*

[54] This return is also based on the likely rates of $0.12/kWh for Tier 2 customers and $0.10/kWh for Tier 3 customers.

[55] *See* "Payback and ROI of Solar Energy for Farms & Businesses." (2022, September 30). https://www.paradisesolarenergy.com/blog/payback-and-roi-of-solar-energy-for-farms-businesses#comm-pennsylvania

[56] https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/Programs/NY-Prize/studies/19-Brownsville-Van-Dyke-Community-Brooklyn.pdf

Whether an energy company would be willing to build and operate the microgrid under these sorts of conditions will likely depend upon how much risk can be reduced or eliminated. It will also depend upon how much Cleveland Public Power will need to recover for its costs for the distribution system and billing support.

The proposed model is just one strategy for how a microgrid could be designed and built. Industry experts who examine this opportunity will likely have alternative strategies that they prefer. What is clear, however, is that the support for microgrids and other grid-edge technologies found in the Inflation Reduction Act has created an important new opportunity to transform Downtown Cleveland into a major draw for locating businesses that rely upon uptime, such as found in the growing digital economy.