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The Economic and Fiscal Impact of a Microgrid in Downtown Cleveland, Ohio

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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Executive Summary

This report relates the results of an investigation into market conditions for a proposed microgrid in downtown Cleveland, Ohio, as well the potential for additional jobs, income, and tax revenues that might accompany such an enterprise. Power interruptions have been estimated to cost commercial and industrial customers more than $100 billion each year in the United States.[1] Because microgrids can reduce or eliminate power disruptions, the proposed microgrid could position Cleveland to capture growth among those industries that experience relatively greater losses when power outages occur. This includes momentary interruptions, which account for a "substantial portion"[2] of such costs. The improved quality, reliability, resiliency, and security associated with a Cleveland microgrid could offer a locational advantage in attracting companies for which a power interruption is particularly costly. Access to clean, distributed generation is also an attribute that is of significant interest to commercial end users.

As this report will show, power downtime can have a significant impact on commercial business, and this impact is likely to increase as businesses become more reliant upon access to data. When companies experience power loss or low-quality power (such as a brownout), a wide range of businesses, including professional services, health care, data management, manufacturing and many others, are profoundly affected. Power loss not only interrupts business activity, it also diminishes production quality, disrupts supply and distribution chains, damages company brand and trust, and introduces liability for companies due to performance delays. Reliable power will become ever more critical as the role of the "internet of things" and edge data management expand. In the not-too-distant future, cities unable to provide highly reliable power are likely to become non-competitive in the global marketplace.

With these concerns in mind, the Cleveland Foundation funded an evaluation of the feasibility of building a microgrid in downtown Cleveland. This study, one of four related studies undertaken as part of this evaluation, examines what sort of market there might be for resilient power, and what impact it might have on the local economy and tax generation.

The Study Team identified industries that might have an appetite for microgrid services through two strategies. The first strategy is to undertake a "Value of Lost Load" (VOLL) analysis. VOLL measures the value of lost production associated with a power outage. Using publicly available data from the U.S. Census Bureau and Bureau of Labor Statistics, the study team estimated this value of lost opportunity in terms of dollars-per-kilowatt-hour for hundreds of industries which were categorized according to the North American Industry Classification (NAICS) system.

The second strategy undertaken was to identify industries interested in resilient power though a national survey of energy professionals working for commercial businesses. The Study Team commissioned the market research firm Qualtrics, LLC to survey individuals who directly impact the energy procurement decisions at their respective companies. The survey yielded the following for a respondent's company: (a)

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[1] Eto, J. (2016). "The National Cost of Power Interruptions to Electricity Customers." *Lawrence Berkeley National Laboratory.* http://grouper.ieee.org/groups/td/dist/sd/doc/2016-09-02%20LBNL%202016%20Updated%20Estimate-Nat%20Cost%20of%20Pwr%20Interruptions%20to%20Elec%20Custs-Joe%20Eto.pdf

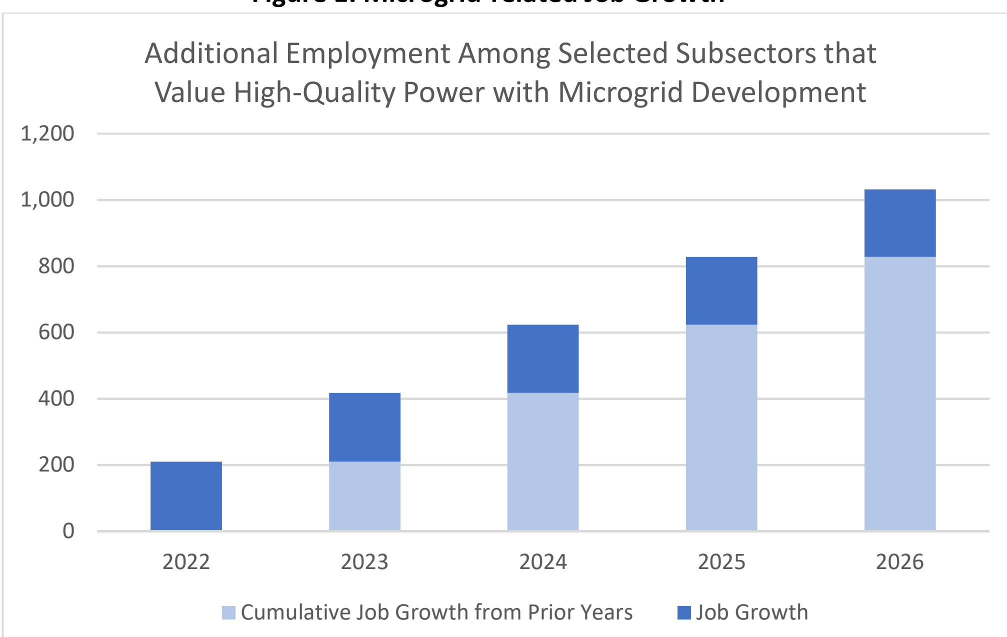
[2] *Id.*

sector and primary activities; (b) location preferences including importance of energy factors; (c) power demand and energy consumption; (d) backup power systems; (e) costs associated with power interruption; (f) familiarity with—and opinion of—microgrids; and (f) the "all in" price they would be willing to pay to locate within a microgrid offering 99.999% uptime.

Three subsectors emerged from the VOLL analysis and survey process as those that would most likely be willing to pay a premium for access to higher-quality power: Insurance Carriers and Related Services (NAICS Code = 524)**;** Professional, Scientific, & Technical Services (NAICS Code = 541); and Ambulatory Health Services (NAICS Code = 621). These subsectors are generally consistent with the broader sectors identified through the survey: about half of the respondents interested in microgrids could be placed into these three subsectors.

The Study Team then projected likely future additions to employment within these subsectors and within the footprint of the proposed Cleveland Downtown Microgrid based on two scenarios: (1) jobs created if the microgrid *were* built; or (2) jobs created if the microgrid were *not* built. The latter number was subtracted from the former, and the difference serves as the estimated number of new jobs that would likely be created by the microgrid. As seen in the figure below, we project around 1,031 additional microgrid-induced jobs within these three subsectors, over and above anticipated growth that would otherwise occur. This number includes neither indirect jobs nor direct jobs created by construction.

Figure 1. Microgrid-related Job Growth



The national survey confirmed that these industries would be interested in high quality power and reliability, and would therefore pay a premium. Around 20% of responds indicated that they were willing to pay up to $0.14/kWh for 99.999% uptime, were "very" or "extremely" interested in microgrids, and were willing to expand or relocate to an area that would enable them to connect to a microgrid.

Yet, as determined from the survey, these three industry subsectors are hardly an exclusive list of those likely to be interested in microgrid services. Many industries need resilient power, and many of such industries are growing at a pace that far exceeds normal national economic growth rates. Data centers are one common example of an industry with a lower VOLL that still values 99.999% uptime: interviews by the Study Team with local Data Centers determined that 99.999% service uptime would reduce the cost of doing business for that industry, even at $0.15/kWh.

The Study Team further estimated additional employee earnings from the new jobs created within the three industry groups. Table 1 below shows the projected additional earnings based on the 1,031 combined extra jobs within these subsectors.

Table 1. Direct Earnings from Highest Three VOLL Subsectors Induced by Microgrid Development, 2022-2026

Year	Additional Annual Earnings
2022	$16,174,689
2023	$17,145,170
2024	$18,159,323
2025	$19,218,895
2026	$20,325,697
Cumulative	$91,023,773

These are not the only direct jobs likely to be created by building the Cleveland microgrid: construction jobs would also be created, both from building the microgrid and from building facilities to support the new businesses attracted. While these would be temporary jobs, they would still have a considerable impact on the local economy. Table 2 is a projection of direct construction earnings resulting from building a microgrid in downtown Cleveland.

Table 2. Earnings from Construction

	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**Total**
Cleveland Microgrid	$7,009,467	$7,152,460	$7,298,371	$7,447,257	$7,599,181	--	$36,506,736
Attracted Businesses	--	$3,845,497	$3,923,945	$4,003,994	$4,085,675	$4,169,023	$20,028,134
Total	$7,009,467	$10,997,957	$11,222,316	$11,451,251	$11,684,856	$4,169,023	$56,534,870

Government revenue can be calculated for the direct jobs, based upon the project-related sales, income, and property taxes. Additional investments and earnings beyond that which would otherwise occur in the absence of a Cleveland microgrid are projected to lead to the additional government revenues set forth in Table 3. These estimates do *not* include revenues derived from indirect or induced economic effects.

Table 3. Fiscal Impact of Cleveland Microgrid

Public Entity	Annual Government Revenues by 2026	Present Value of Future Government Revenues (2020-2052)
City of Cleveland	$2,724,011	$59,783,330
Cleveland Metro School District	$2,697,001	$47,912,395
Cuyahoga County	$773,973	$14,381,036
State of Ohio	$6,502,996	$144,206,616
Total	$12,697,981	$266,283,377

Note: Assumes construction beginning in 2020 and 30-year operating horizon starting in 2022.

I. Introduction.

This study is one of four reports that form a microgrid planning evaluation for downtown Cleveland, Ohio undertaken by researchers at Cleveland State University and Case Western Reserve University (jointly, the "Study Team"), and underwritten by the Cleveland Foundation.[3] The evaluation has been undertaken in collaboration with Cuyahoga County and the City of Cleveland to determine the technical and economic feasibility of creating a microgrid within an area of downtown Cleveland, Ohio (hereinafter referred to as "Cleveland uGrid" or "uGrid"). The other three reports look at the value of resiliency to end-users,[4] a techno-economic model for the proposed uGrid,[5] and strategies and options for microgrid cyber-security.[6]

Microgrids are a form of localized utility infrastructure that can provide users with greater flexibility, resiliency, and security than they would normally receive through the conventional power grid. Because they rely upon local generation, storage, back-up power and smart communication systems, and because they can island off of the main grid during disturbances, microgrids offer customers significant advantages in reliability. Further, they typically offer cleaner and more efficient power than traditional grids. More and more, commercial grid end users require resilient and clean electricity, and are willing to pay a premium for access to higher-quality power. This study was undertaken to ascertain what the market conditions are for such power and what might be the economic development and fiscal impacts of building a microgrid for the City and County.

Because microgrids are new, there is little data available to show how they can affect economic development. Microgrids that do exist are almost exclusively behind the meter, meaning they are set up on campuses and not available for commercial development.[7] We know companies prefer clean power[8]

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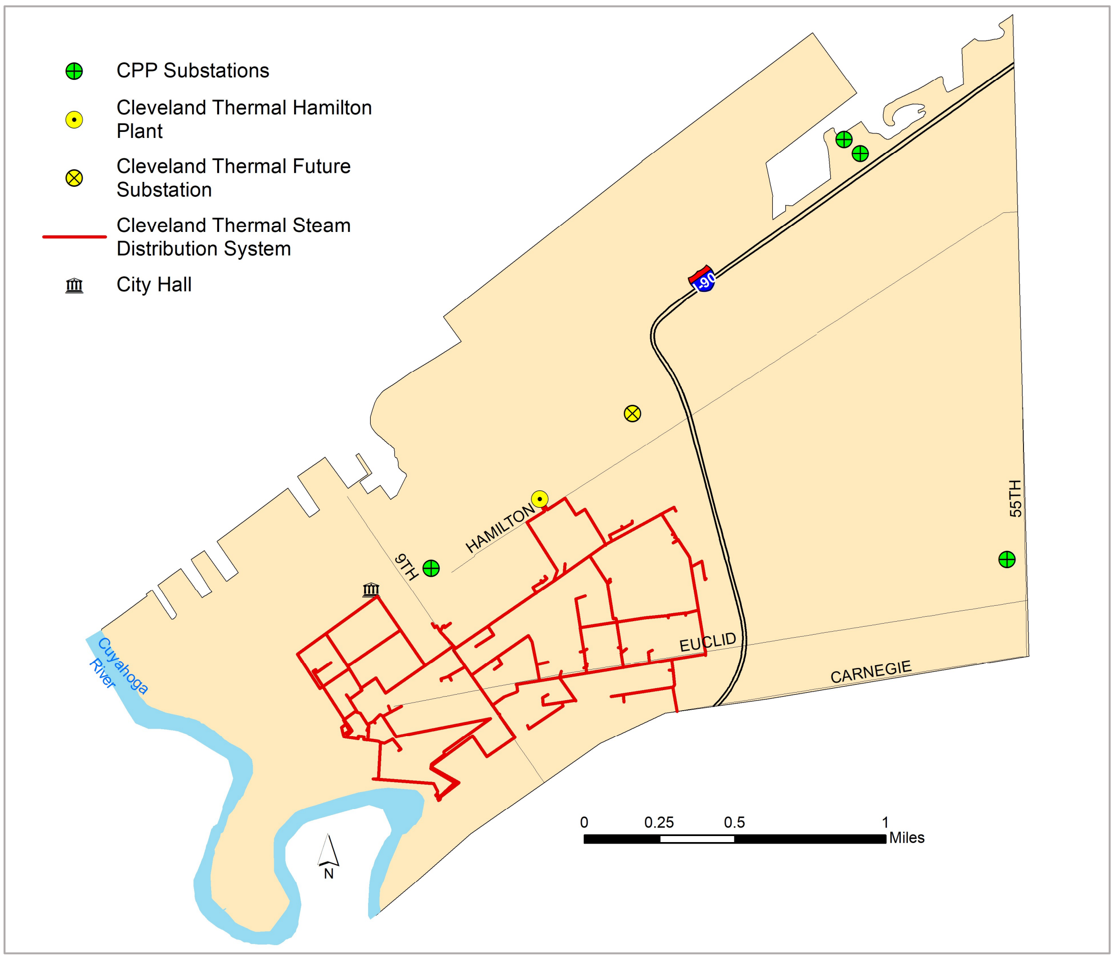
[3] The Microgrid Cleveland Study Team consists of Cleveland State University's Energy Policy Center (Urban College), Case Western Reserve University's Great Lakes Energy Institute, Cuyahoga County and the City of Cleveland, and several consultants. The authors of this particular study are: Andrew R. Thomas, Mark Henning, Kirby Date, and Roby Simons of the Levin College of Urban Affairs at Cleveland State University.
[4] *See* Thomas, A. R., & Henning, M. (2017). "Valuing Resiliency from Microgrids: How End Users Can Estimate the Marginal Value of Resilient Power." *Urban Publications* (Levin College of Urban Affairs). https://engagedscholarship.csuohio.edu/urban_facpub/1516/
[5] *See* Ahmed, A., Thomas, A. R., & Henning, M. (2018). "Techno-Economic Feasibility Analysis of a Microgrid in Downtown Cleveland, Ohio." *Urban Publications* (Levin College of Urban Affairs). https://engagedscholarship.csuohio.edu/urban_enpolc/
[6] *See* Juhasz, J., & Shull, C. A. (2018). "Cuyahoga County Microgrid System Security and Resiliency Report." *Urban Publications* (Levin College of Urban Affairs). https://engagedscholarship.csuohio.edu/urban_enpolc/
[7] *See* note 4, *supra*.
[8] A. Hopkins, T. Vitolo, and S. Fields, Synapse Energy Economics, Inc. "Powering Ohio." (2018).

and of course more reliable power. The critical questions that must be answered are: how much might companies pay for such power, who are these companies, and would they be willing to expand or relocate to a microgrid? These are difficult questions to answer. But as discussed herein, there are tools available that can give us insight into what economic development might reasonably be expected if a microgrid were to be built in downtown Cleveland.

The proposed uGrid covers around 4.8 square miles and includes several zip codes that overlap downtown Cleveland. A microgrid footprint is set by local generation, distribution lines, and end users. In this case the proposed footprint (the "Study Area") is also centered around the existing district steam infrastructure owned by Cleveland Thermal.[9] A Combined Heat and Power plant built by Cleveland Thermal to support its steam and chilled water generation load will form the principal local electricity generation. However, the outside boundaries for the microgrid are somewhat arbitrary, and subject to adjustment depending upon end user demand and cost of connecting Cleveland Public Power distribution lines. A map of the Study Area is set forth below as Figure 2.

Figure 2. Map of Proposed Cleveland Downtown Microgrid



http://www.poweringohio.org/files/2018/05/Powering-Ohio_FINAL-WEB.pdf.

[9] Cleveland Thermal is a downtown Cleveland steam and chilled water provider for a number of government, institutional, commercial and residential users. *See* https://www.corix.com/cleveland-thermal/home

II. Understanding Impacts of Unreliable Power on Commercial Business.

A. The Value of Lost Production.

Understanding what businesses need reliable power, and what they might pay for this, begins with looking at how power loss affects different industries. There are several ways to evaluate this, and strategies for how this can be done are set forth in one of the companion reports.[10] One commonly accepted strategy is to look at the value of lost production.

Improvements in energy reliability[11] and the ability to maintain the quantity and quality of electricity demanded by users is a primary benefit associated with microgrids.[12] When companies experience a disruption in power from the conventional grid, they also experience a disruption in their ability to produce revenue-generating goods and services. A factory without power cannot produce parts. Sometimes it is sufficient for the power to just be of poor quality to negatively affect the end product. A manufacturing facility dependent on arc welding, for instance, will produce poor product welds if it is subjected to frequent voltage sags.[13] Similarly, if a medical office experiences power quality problems test results may then be unreliable. Voltage sags and surges can, for instance, induce image artifacts for medical imaging equipment.[14]

In order to estimate these kinds of damages borne by commercial and industrial users during an outage, the Study Team used what is known as the production function approach to valuing the electrical load lost during a power outage. Designated the Value of Lost Load (VOLL), this is a common method that other researchers have used to approximate the consequences of an interruption by relating foregone production during an interruption to the kilowatt-hours (kWh) that were not supplied.[15] Its functional form is the ratio of *gross value added* to *electricity consumption* within a grouping of business establishments (e.g. by sector, subsector, industry, etc.) over a given period of time. The data for such a measure is easily obtained from publicly available sources such as the Bureau of Labor Statistics (BLS) and U.S. Census Bureau, hence its common use as a way to value reliability. As VOLL reflects a customer's likely willingness to pay for reliable electricity service,[16] the Study Team used it to identify a sample of

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[10] *See* note 4, *supra*.

[11] For the electric sector, *reliability* can be defined as the ability of the power system to deliver electricity in the quantity and with the quality demanded by users; it can be considered the end goal of the power grid. *See* Clark-Ginsberg, A. (2016). "What's the difference between reliability and resilience?" *U.S. Department of Homeland Security*. https://ics-cert.us-cert.gov/sites/default/files/ICSJWG-Archive/QNL_MAR_16 /reliability%20and%20resilience%20pdf.pdf

[12] *See* Wild, A., et al. (2016). "Microgrid Benefits and Example Projects." *Schneider Electric*. https://www.schneider-electric.us/en/download/document/9982095_12-12-16A_EN/

[13] "Improving Power Quality in Arc Welding Applications." *Efficient Plant Magazine*. (2006). https://www.efficientplantmag.com/2006/05/improving-power-quality-in-arc-welding-applicaitons/

[14] Rush, D. (2003). "Properly Sizing UPSs for Diagnostic Imaging Systems." *ABB* (formerly GE Industrial Solutions). http://apps.geindustrial.com/publibrary/checkout/DAR-PSW-2003?TNR=White%20Papers|DAR-PSW-2003|generic

[15] *See* "Estimating the Value of Lost Load." *Electric Reliability Council of Texas.* (2013). http://www.ercot.com/content/gridinfo/resource/2015/mktanalysis/ERCOT_ValueofLostLoad_LiteratureReviewandMacroeconomic.pdf. *See also* Schroder, T., and Kuckshinrichs, W. (2015). "Value of Lost Load: An Efficient Economic Indicator for Power Supply Security? A Literature Review." *Frontiers in Energy Research*. https://www.frontiersin.org/articles/10.3389/fenrg.2015.00055/full

[16] *Id.*

subsectors[17] that would seem to especially value reliable power based on the amount of production they forfeit per kWh of electricity not consumed during an outage. Section VII quantifies what impact companies within these subsectors would likely contribute to the local economy, should they choose to locate within the Cleveland uGrid.

B. The Role of Information Technology in Valuing Reliability.

Firms across all industries increasingly rely on information technology (IT) to manage, store, and transmit meaningful data, not only internally, but also to share information with customers and suppliers as part of a modern profit-maximizing value chain.[18] The number one cause of IT downtime is power outages, particularly those related to failure of a company's uninterruptible power supply (UPS) system that provides short-term emergency backup as well as surge protection and voltage regulation.[19] Whether a company's IT function is housed internally or in an external co-location data center, when the power goes out, a firm cannot capitalize on the lower costs and product/service quality differentiation brought about by information technology that fosters competitive advantage.[20]

Loss of information processing is, accordingly, part of the cost a company realizes during a power outage. These losses are different from, but comparable to, those from lost production. For example, the Ponemon Institute, a security and data protection research center, found in a recent study on the costs associated with unplanned information technology downtime that companies[21] lost an average of $709,000 per IT outage caused by UPS system failure.[22] Around 28% of these costs were from lost revenues associated with customers not being able to access core products and services, while around 27% were from lost productivity during downtime among both IT and non-IT personnel.[23] Approximately 35% of the unplanned outage costs for the companies in the Ponemon study were linked to reputational damages and lost business opportunities.[24]

A lack of reliable power therefore can limit a company's ability to leverage information technology and maximize value creation that facilitates competitiveness. As John Heiderscheidt, president of AFCOM-Chicago (a data center trade association),[25] stated:

> People and businesses rely on connectivity the same way they rely on electricity, water, and even oxygen. Instantaneous modes of communication and commerce are far more than amenities of

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[17] A *subsector* conforms to the 3-digit classification level under the North American Industry Classification System (NAICS). *See* https://www.census.gov/eos/www/naics/faqs/faqs.html

[18] For a description on the ubiquity of IT deployment across all industries, *see* "The 10 fastest-growing industries in the U.S." *Sageworks*. (July 24, 2017). Data release. https://www.sageworks.com/the-10-fastest/?utm_source=forbes&utm_medium=referral&utm_campaign=05132018. *See also* note 20, *infra.*

[19] *See* note 22, *infra*. *See also* "State of Disaster Recovery 2016." *Arcserve* (formerly Zetta). https://www.zetta.net/resource/state-disaster-recovery-2016

[20] *See* Porter, M., and Millar, V. (1985). "How information Gives You Competitive Advantage." *Harvard Business Review*. https://hbr.org/1985/07/how-information-gives-you-competitive-advantage

[21] Companies surveyed as part of the Ponemon study came from a variety of industries including those in Communications, Education, Financial Services, Healthcare, Industrial, Research, and Retail.

[22] "Cost of Data Center Outages." (2016). *Ponemon Institute* (Sponsored by Vertiv). https://www.vertivco.com /globalassets/documents/reports/2016-cost-of-data-center-outages-11-11_51190_1.pdf

[23] *Id.*

[24] *Id.*

[25] AFCOM is a leading association for data center and IT infrastructure professionals. *See* https://www.afcom.com

> a modern age. They are major components of our national and global commercial ecosystem. In a connected world, there's just no room for downtime.[26]

The growing demand for constant uptime extends to industries where the need for dependable IT driven by reliable power may not seem obvious. Attorneys, for instance, increasingly use cloud-based[27] legal management software platforms to document and track case proceedings, manage documents, and collaborate with clients.[28] When IT servers and network equipment go down, law firms can lose access to these resources, resulting in a loss of billable time.[29] As illustrated in *Attorney at Law Magazine*, just one hour of downtime per month (i.e. 99.9% uptime – about the utility average) can lead to $60,000 in lost billable opportunities annually for a law firm.[30] Additionally, the consequences of an outage given the increasing number of courts requiring electronic filings can include not only potential loss of credibility with judges, but also claims of malpractice.[31] Those subsectors encompassing industry groups[32] with the greatest VOLL are also those that are likely to be attracted to a microgrid. We set forth in Section V below some of the ways that businesses within these groupings currently use information technology to improve their bottom line.

C. Relationship Between Uptime and Economic Growth.

Companies that are especially sensitive to reliable power are also forecast to experience relatively high employment growth over the next decade. For example, increased adoption of the internet-of-things (IoT)[33] within sectors such as Health Care and Finance & Insurance is expected to drive demand for UPS systems as firms in those areas try to ensure reliability for the IT systems tasked with collecting, analyzing, and reporting the vast amounts of data generated by multi-modal sensors.[34] These two sectors in particular are projected to add around 40% of the non-agriculture employment growth nationally through

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[26] Heiderscheidt, J. (2018). "Best of Industry Perspectives: Why Data Centers Are Slow to Adopt Microgrids (And Why That Will Change)." *Microgrid Knowledge*. https://microgridknowledge.com/data-centers-adopt-microgrids/

[27] The cloud is a network of hosted resources that can be accessed the internet. Cloud-based software runs directly from company servers and is accessible through a web browser. *See* note 29, *infra*.

[28] *See* "The hidden cost of IT downtime in law firms." *Doherty Associates*. https://www.doherty.co.uk/blog/the-hidden-cost-of-it-downtime-in-law-firms. *See also* "Productivity Solutions for Legal Professionals." *Microsoft*. https://www.microsoft.com/en-us/legal/productivity.

[29] A Clio Guide, "Why Law Firms Are Moving to the Cloud" in *New York State Bar Association*. http://www.nysba.org/WorkArea/DownloadAsset.aspx?id=78979

[30] Assuming a billing rate of $200 per hour and 25 timekeepers. *See* note 31, *infra*.

[31] Robins, M. (2013). "What is the Cost of Network Downtime?" *Attorney at Law Magazine*. http://www.attorneyatlawmagazine.com/kentucky/what-is-the-cost-of-network-downtime/

[32] An *industry group* conforms to the 4-digit classification level within the North American Industry Classification System (NAICS) classification system. *See* https://www.census.gov/eos/www/naics/faqs/faqs.html

[33] The internet-of-things refers to objects and devices that "talk" to each other via an internet connection in order to "gather information, analyze it and create an action." *See* Burgess, M. (2018). "What is the Internet of Things? WIRED explains." *Wired Magazine*. https://www.wired.co.uk/article/internet-of-things-what-is-explained-iot

[34] *See* "Data Center UPS Market Size, Industry Outlook Report, Regional Analysis, Application Development Potential, Price Trends, Competitive Market Share & Forecast, 2016 – 2024." *Hexa Research*. (2016). https://www.hexaresearch.com/research-report/data-center-ups-market. *See also* "Data Center UPS Market to grow at over 3% CAGR from 2017 to 2024." *Global Market Insights*. (2018). https://www.bizjournals.com /prnewswire/press_releases/2018/01/28/MN89046

2026 according to the Bureau of Labor Statistics.[35] With IoT poised to impact 11% of gross world output by 2025, companies that are unprepared to maintain consistent information technology capabilities during utility service disruptions will not be positioned to achieve maximum value creation and profitability in the digital economy.[36]

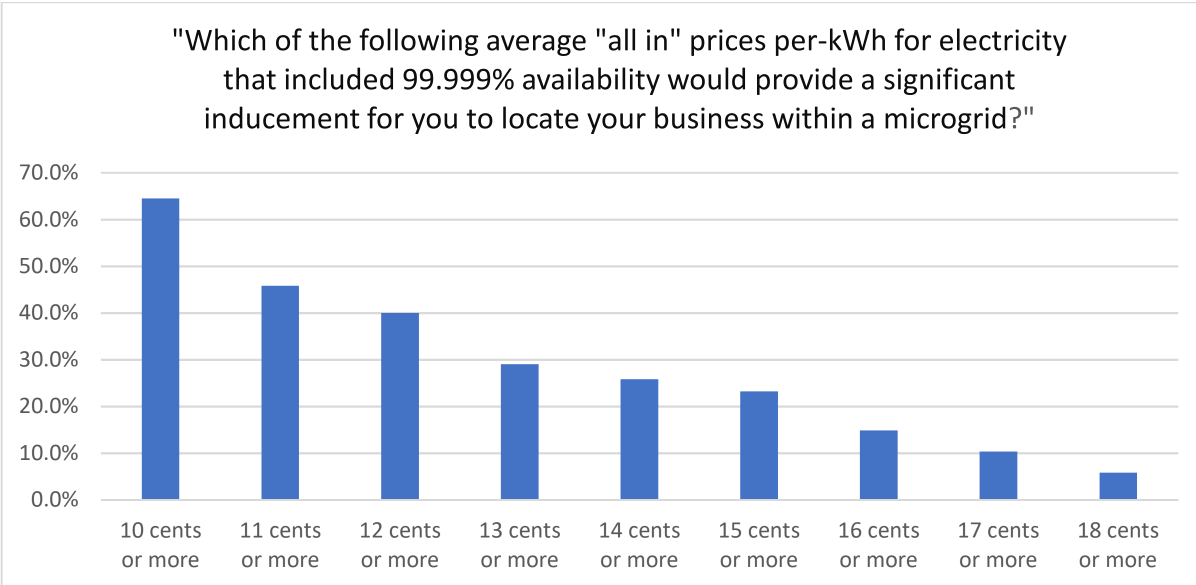
All communities will have to adjust to this increasing role of IoT in commercial and government activities. Grid uptime will increasingly need to be improved for communities to stay competitive. But the stakes are particularly high for legacy cities such as Cleveland, Ohio, where economic growth has lagged national rates in those industries with the highest VOLL.

III. Microgrid Interest Among Potential Commercial Users.

The Study Team commissioned the market research firm Qualtrics, LLC to conduct a national survey of energy procurement decision-makers having direct influence over their firm's utility purchasing so as to estimate a microgrid market penetration rate. The purpose of the survey was to determine, among other things, the interest commercial end users would have in microgrids. A description of the screening criteria used to select respondents for this commercial survey, as well as characteristics pertaining to their companies, can be found in Appendix A.[37] One question included in the survey was particularly important: "Assuming that all other considerations were equal, which of the following average 'all in' prices per-kWh for electricity that included 99.999% availability (i.e. 5.3 minutes of average annual downtime) would provide a significant inducement for you to locate your business within a microgrid?" The chart below shows the results of this survey question for prices ranging from 10 to 18 cents per kWh. Over 60% of respondents indicated they would pay 10 cents for five-9 power, while less than 5% said they would pay 18 cents. See Figure 3.

[35] *See* "Employment by Major Industry Sector." (2017). [Excel table of projections by industry]. *Bureau of Labor Statistics*. https://www.bls.gov/emp/industry-employment/industry.xlsx
[36] *See* "The Internet of Things: Mapping the Value Beyond the Hype." *McKinsey & Company*. (2015). https://www.mckinsey.com/~/media/McKinsey/Business%20Functions/McKinsey%20Digital/Our%20Insights/The%20Internet%20of%20Things%20The%20value%20of%20digitizing%20the%20physical%20world/The-Internet-of-things-Mapping-the-value-beyond-the-hype.ashx
[37] In addition to the commercial survey commissioned by the Study Team and performed by Qualtrics, LLC, a survey of residents within the Cleveland Downtown Microgrid area on the importance of electrical reliability was conducted by graduate students from Cleveland State University as part of their Master of Urban Planning and Development capstone class. The results of this residential survey can be found in Appendix B.

Figure 3. Rates End-Users Would Pay for 99.999% Uptime



In the end, only those rates that could be achieved by the uGrid are relevant to economic development evaluation. Based upon cost models[38] developed for the proposed uGrid, the Study Team determined that a microgrid could likely supply five-9 power to end users for less than 14 cents per kWh. Accordingly, the first step to determining market penetration was to identify the percentage of end users who would pay this amount. For five-9 power, 25.8% of survey respondents indicated that a price $0.14/kWh would be “a significant inducement” to locate their business within a microgrid.

Additional criteria were identified from the survey to further refine market penetration and likely end user candidates for the uGrid. From the original 155 respondents, a subsample was selected based on the following criteria:

- respondents’ indication that a price of 14 cents for 99.999% power availability was a significant inducement for locating within a microgrid;
- respondents’ impression of a microgrid as *extremely* or *very* useful;
- respondents’ identification of the price of energy to be “by itself” an influential location/expansion decision factor; and
- respondents’ indication that minimizing company exposure to brownouts, voltage sags/surges, and other electrical disturbances was either *extremely* or *very* important.

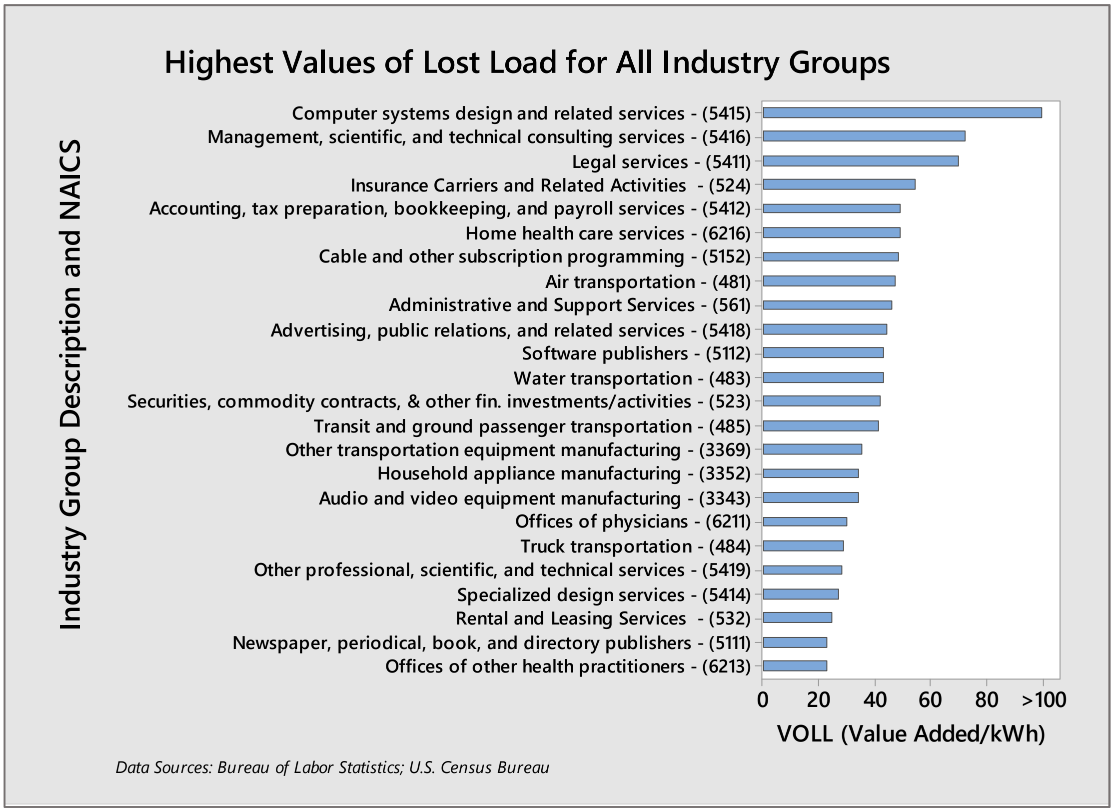
Around 20% of respondents satisfied all four of the selection criteria for this enriched sample. This 20%—those who self-identified as willing to pay $0.14/kWh for five-9 power, willing to expand or relocate based upon this alone, interested in microgrids, and very concerned about power quality—was determined by the Study Team to represent the likely national market penetration rate for microgrid services among end users.

[38] *See* note 5, *supra*.

IV. Sampling Subsectors with an Interest in Reliable Power.

After determining a microgrid market penetration rate, the Study Team sought to identify a subset of industries that value *five-9*[39] uptime and to assess likely employment growth therein. To accomplish this, we looked at industry *subsectors* (i.e. NAICS 3-digit level groupings) encompassing *industry groups* (i.e. NAICS 4-digit level groupings) that have the greatest stake in uptime, as determined by their Values of Lost Load (VOLLs).[40] Those with the highest VOLLs, as determined in a previous study,[41] were assumed to have the most interest in five-9 power reliability and microgrids. The following are the industries showing the highest VOLLs:

Figure 4. Values of Lost Load Per kWh by Industry Group[42]



The Study Team selected the three subsectors containing the highest VOLL industry groups for a comparative analysis of projected local job growth *with* and *without* microgrid deployment. These subsectors included: Insurance Carriers and Related Services; Professional, Scientific, & Technical Services;

[39] The term *five-9* refers to power being available 99.999% of the time and is one benchmark of high performance in the power industry. *See* "What Five 9's Really Means and Managing Expectations." *IEEE.* (2006). Retrieved from https://ieeexplore.ieee.org/document/4025220

[40] As introduced in Section III, the method we used to estimate VOLL as a function of lost production is calculated as gross value added divided by electricity consumption within a given year for a particular subsector or industry. The resulting unit of measure is dollars-per-kWh. VOLL, as previously stated, reflects a customer's likely willingness to pay for reliable electricity service. *See* note 4, *supra*.

[41] *See* note 4, *supra*.

[42] For the eight 3-digit groupings appearing in Figure 4, data on electricity purchased was not available at the more granular NAICS 4-digit *industry group* level was not available.

and Ambulatory Health Services. The following table lists examples of industry groups within these subsectors (three-digit NAICS codes are in parentheses):

Table 4. High-VOLL Subsectors with Included Industry Groups

Insurance Carriers and Related Services (524)	Professional, Scientific, & Technical Services (541)	Ambulatory Health Services (621)
• Life, Health, and Medical Insurance Carriers • Property and Casualty Insurance Carriers • Agencies, Brokerages, and Other Insurance Related Activities	• Legal Services • Accounting and bookkeeping Services • Computer Systems Design and Related Svcs • Mgmt., Scientific, and Tech. Consulting Svcs • Advertising, Public Relations, and Related Svcs	• Outpatient Care Centers • Medical and diagnostic laboratories • Offices of physicians • Offices of dentists • Offices of optometrists • Home health care services • Offices of mental health practitioners • Offices of other health practitioners (e.g. physical, occupational, and speech therapists)

Industries within these three subsectors show a keen reliance on information technology and internet-based software platforms to improve their bottom line. For the reasons set forth in Section III, industries within these subsectors are therefore also especially dependent on reliable power that can ensure near-constant access to IT resources. Table 5 summarizes how some of these industries[43] currently use reliability-sensitive information technologies to stay competitive in the modern digital economy.

Table 5. Examples of IT Resources That Can Become Inaccessible During a Power Disruption (by Subsector)

Insurance Carriers and Related Services (524)
Within *Insurance Brokers & Agencies* (NAICS 52421), industry operators rely heavily on technology for their business operations, using information technology (IT) to maintain customer records, process financial transactions, provide sophisticated advisory services and assist in marketing products to customers. Investment in IT enables brokers and agents to reduce the time taken to process insurance policy sales, and to gain greater access to insurance carrier information and source insurance policies from a wider variety of carriers and underwriters.
Professional, Scientific, & Technical Services (541)
Within *Accounting, Tax Preparation, Bookkeeping, and Payroll Services* (NAICS 54121), major firms have upgraded their information and research databases, which has increased productivity. Cloud computing has enabled accountants to “bring the office to the client.”[44] Cloud technologies have enabled mobile applications such as real-time audit updates that allow clients to check in on the status of an audit as it is happening and assess risk areas to grant auditors the ability to maximize the use of their time.[45] The use

[43] The example industries included in the table have among Cuyahoga County’s highest employment levels within their subsectors. *See* note 71, *infra*.

[44] As noted by Schneider Electric, maintaining uptime for a company’s remaining on-premise IT infrastructure in the age of cloud computing (e.g. equipment that runs critical applications or provides the network connectivity to the cloud) has actually become *more* critical, notwithstanding the offsite storage of data. *See* “Why Cloud Computing is Requiring us to Rethink Resiliency at the Edge.” *Schneider Electric*. (2016). http://www.apc.com/salestools/VAVR-AF3NSM/VAVR-AF3NSM_R0_EN.pdf

[45] The network infrastructure to support the cloud will have substantial demands for new features/capabilities, increased bandwidth, reliability, and scalability. Modern physical infrastructure is still needed to ensure that

of the cloud and networks to automate industry services has also resulted in a paperless payroll system, which serves to reduce businesses purchasing costs.
Ambulatory Health Services (621)
Telemedicine within *Offices of Physicians* (NAICS 62111), which is the delivery of health services via remote telecommunications, has facilitated remote expert medical advice and promoted faster dispensing of diagnostic tests, training information, technical databases and access to financial transactions. The rising prominence of telehealth services in ambulatory care settings is expected to bridge the gap between urban and rural communities that have limited access to healthcare, as well as present significant cost savings to healthcare providers. Growth in telehealth has been augmented by numerous clinical research studies, validating the efficacy of telehealth treatment.

Source: IBISWorld US Industry Reports. (2018).[46]

These three subsectors are projected by BLS to experience substantial employment growth nationally in the coming decade.[47] However, it is important to note that they are *merely representative* of commercial enterprises likely to be interested in five-9 power. There are other industry groups that will have an interest in microgrids, some with growth rates that are higher than the three highlighted subsectors.[48] Data Centers, for instance, with their relatively high-power consumption per output produced, have a lower VOLL than the three identified subsectors. Yet Data Centers *must* have five-9 power, and their cost of maintaining such power is relatively high. Accordingly, we can expect Data Centers to have an interest in microgrids. Moreover, projected employment growth rates within this subsector over the next decade are among the highest in the nation.

Further, VOLL is not the only way to measure interest in resiliency. Prior research conducted by the Study Team indicated that the avoided costs associated with *not* having to build additional on-site IT infrastructure to achieve five-9 power would be worth between $0.05 and $0.22/kWh.[49] Adding this cost to general grid service suggests that data centers should readily be willing to pay $0.14/kWh for five-9 power. Indeed, industry interviews conducted by the Study Team in the Cleveland area confirmed that Data Centers would be willing to pay around $0.15/kWh for such reliability.

V. Potential Job Creation Resulting from Microgrid Construction.

The following discussion sets forth how the Study Team estimated job growth, income generation and tax generation, and the results of those estimates. A number of assumptions pertaining to the economic and fiscal impacts of microgrid deployment were made in the course of undertaking this evaluation. While most of the broader assumptions appear throughout this section, more detailed ones can be found in

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critical network and IT hardware are highly reliable, have effective thermal management, and can scale up to meet the needs for new cloud services. *See* Goldberg, A. (2018). "When SMBs Go to the Cloud, On-Premises IT Infrastructure Is Still Necessary." *Network World* (Sponsored by Schneider Electric). https://www.networkworld.com/article/3263707/data-center/when-smbs-go-to-the-cloud-on-premises-it-infrastructure-is-still-necessary.html

[46] Summary points were derived from IBISWorld US Industry Reports retrieved through Cleveland State University's Michael Schwartz Library.

[47] *See* note 35, *supra*.

[48] *Id.*

[49] *See* note 4, *supra*.

Appendix C. New products in general are intrinsically associated with high levels of market uncertainty.[50] In extending this uncertainty to the microgrid's potential ability to be an economic development driver, the Study Team sought to be conservative in its assumptions whenever possible.

Two approaches were taken in determining potential job creation consequent to building a microgrid, the results of which were compared to likely job growth in the event that a microgrid were *not* constructed. The first approach follows from the previously described national survey of energy procurement decision-makers. It considers local capture of market share among industry subsectors that are likely to be interested in acquiring power from a microgrid capable of delivering five-9 power, and then estimating downtown Cleveland's likely share of the national commercial microgrid market. The second approach considers how a microgrid might enable Cleveland to overcome apparent disadvantages, compared to other locations, in attracting industries likely to value microgrid characteristics such as power reliability, resiliency, and quality. For industries where these characteristics are particularly important to the production process, a microgrid may increase a firm's competitiveness by lowering the cost of doing business.

A. First Approach: Cleveland uGrid's Share of Overall Projected Capacity.

Projecting the Cleveland Downtown Microgrid's share of commercial growth requires a number of assumptions, one of which relates to the likely competition from other regions offering similar reliability to commercial end users. Navigant, a research and consulting group that analyzes global clean technology markets, forecasts around 1,000 MW of capacity by 2024 for commercial microgrids in North America.[51] This anticipated capacity was used by the Study Team to represent the likely North American development concurrent with Cleveland's proposed microgrid, and to serve as the principal competition for commercial and industrial customers.[52] These microgrid segments, falling under the heading "Utility and Community Microgrids," are defined by their service to multiple end users and include Commercial & Industrial microgrids. These are deemed to be direct competition for the proposed Downtown Cleveland Microgrid.[53]

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[50] Cui, A., Zhao, M., Ravichandran, T. (2011). "Market Uncertainty and Dynamic New Product Launch Strategies: A System Dynamics Model." *IEEE Transactions on Engineering Management.* https://ieeexplore.ieee.org/document/5712187/

[51] *See* "Microgrids & VPPS" prepared by Navigant for the Association of Municipalities of Ontario in 2016, which can be found at: https://www.navigant.com/-/media/www/site/events/2016/pdfs/pasmus--amo-11316.pdf. Note that the projection considered herein relates only to commercial use: Navigant projects a great deal more microgrid growth for government, university and other behind the meter applications.

[52] Other microgrids will not be the only source of competition for the five-9 power. End users requiring five-9 power also have the option of building on-site uninterruptible power supply (UPS) systems, which is what is done now. However, UPS systems that achieve five-9 uptime cost in excess of $0.05/kWh to install; alternatives to the microgrid are, as a result, projected to cost in excess of $0.15/kWh (*see* note 4, *supra*). This makes such purely UPS alternatives less attractive than microgrids – or at least the Cleveland uGrid, which is projected to be below $0.14/kWh.

[53] *See* "Beyond the Buzzwords: Making the Specific Case for Community Resilience Microgrids." *Navigant*. (2016). Accessed May 8, 2018 from https://www.navigant.com/-/media/www/site/events/2016/pdfs/djones_beyond-the-buzzwords.pdf?la=en.

The 21 MW of Cleveland's proposed microgrid with fully resilient five-9 availability (i.e. customer Tier 1 under the Cost Model)[54] was considered the relevant capacity for comparison.[55] Cleveland's potential share of the future market for Utility and Community Microgrids was therefore estimated to be 2.1%. This is probably a conservative estimate: it is unclear that many other commercial microgrids could achieve $0.14/kWh. The uGrid has access to existing infrastructure, co-generation capability and a long-term source of cheap natural gas that may not be readily available in other regions. Under this first approach, Cleveland's potential share[56] of employment growth among the three subsectors identified in Section V as likely to be interested in this nascent energy market depended on the following assumptions:

- 20% penetration rate from the survey;
- 2.1% of market share, based upon the uGrid's relative capacity for supplying five-9 power; and
- 80% of the uGrid's capacity will likely need to be subscribed in advance for investors to consider it financially viable, leaving 20%, or 4.2 MW, available for business attraction.

B. Second Approach: Eliminating Previous Relative Regional Disadvantages.

The second strategy for assessing potential economic development does not use the survey results. Instead, it assumes that if Cleveland were to build a microgrid, it would experience growth in this sample of subsectors needing five-9 power that is comparable to anticipated national rates rather than at the rates actually experienced in recent years. Table 6 below shows the annual rates of employment change in the highlighted subsectors for the zip codes overlapping the uGrid study area and the country as a whole for 2005-2015. The employment growth rate within the proposed uGrid footprint among these subsectors has been appreciably lower than the national average.[57]

[54] Under the Cost Model (*see* note 5, *supra*), the proposed Cleveland Microgrid would offer customers "tiered" levels of service based on their power resiliency needs. Tier 1 would offer the highest power availability, with 99.999% uptime including in the event of an outage to the traditional grid with a target of no disruption of utility service.

[55] 21 MW represents the lowest capacity of co-generation through an anticipated combined heat and power (CHP) plant that would be the primary source of electricity generation for the uGrid.

[56] Projections by subsector are based on BLS national employment projections for 2016-2026. *See* note 35, *supra*.

[57] Table 6 shows the annual rates of change in employment in the identified subsectors for the zip codes overlapping the uGrid study area and the country as a whole for 2005-2015.

Table 6. Average Annual Rate of Change in Employment for Identified Subsectors, 2005-2015[58]

Subsector	Rate for Downtown Cleveland[59]	National Rate[60]
Insurance Carriers and Related Services	-5.7%	0.8%
Professional, Scientific, & Technical Services	1.1%	1.9%
Ambulatory Health Services	1.7%	3.0%

Source: U.S. Census Bureau Longitudinal Employer-Household Dynamic Origin-Destination Employment Statistics (LODES)

Experts on regional economic development describe how the difference between these rates of change measures comparative advantage:[61] a local area has comparative advantage in an industry if its growth rate is higher, over a sustained period of time, than that for the country as a whole.[62] Within this context, Cleveland's ability to attract new development depends on the combination of productive factors it possesses that enables companies in these markets to produce goods and services at a cost advantage relative to alternative locales. Among other capital factors, the availability of business infrastructure, particularly high-quality electricity, is considered a major determinant of a community's relative economic advantage by institutions such as the Organisation for Economic Co-operation and Development.[63] Policies aimed at investing in the improvement of capital factors such as electrical systems have been

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[58] Average annual rates of change in employment from Table 6 for both downtown Cleveland and the country as a whole were "smoothed" so as to lessen the effects of outliers. The national rate appearing in the table is a compound annual growth rate (CAGR) which is a smoothed rate of return. *See* https://www.investopedia.com /investing/compound-annual-growth-rate-what-you-should-know. The downtown Cleveland data were "winsorized" at 90% to reduce the effect of extreme values over this period. *See* https://www.investopedia.com /terms/w/winsorized_mean.asp

[59] LODES data has the known number of employees by 2-digit NAICS sectors (but not 3-digit subsector) at the zip code geographic level. 2012 Economic Census data provides the proportion of employees belonging to a particular subsector within the overall sector for the entire city of Cleveland. The Study Team took this proportion derived from the 2012 Economic Census and multiplied it by the number of 2-digit-sector-level employees from the LODES dataset to estimate the number of employees within a 3-digit subsector at the zip code geographic level for years 2010-2015. *See* "Longitudinal Employer-Household Dynamic." (2010-2015). *U.S. Census Bureau*. https://lehd.ces.census.gov/data. *See also* "Economic Census." (2012). *U.S. Census Bureau*. http://factfinder2.census.gov.

[60] The national average annual rate of change by subsector during this period comes from the Bureau of Labor Statistics. *See* note 35, *supra*.

[61] The economic concept of comparative advantage refers to how a firm's productive efficiency depends on the combination and concentration of resources within a region that in turn provide a relative cost advantage in producing certain commodities versus others. *See* note 64, *infra*.

[62] Edwards, M. E. (2007). *Regional and Urban Economics and Economic Development: Theory and Methods*. CRC Press.

[63] OECD (2005), *Local Governance and the Drivers of Growth*, Local Economic and Employment Development (LEED), OECD Publishing, Paris, https://doi.org/10.1787/9789264013308-en.

characterized as a "trickle-up" approach where comparative advantage is affected directly by changing a region's underlying factor endowments.[64]

The Study Team assumed that a microgrid could provide the sort of business infrastructure upgrade that would eliminate Cleveland's relative disadvantage in attracting the sample of subsectors identified in Section V that value five-9 power. The reasons supporting this assumption are:

- quality of electricity is among the major drivers of regional economic growth in general;[65]
- microgrids are known to improve the quality and reliability of delivered power;[66]
- advanced microgrids can reduce energy costs by allowing for load balancing and demand response, as well as offering a pathway to participate in ancillary service markets, all of which can make holistic energy management more cost-effective;[67]
- the identified subsectors experience the largest losses per kWh not consumed in the event of a power outage according to our VOLL analysis, and are likely more willing to pay for reliable electricity;[68]
- these same subsectors are contained within overarching sectors identified through the Qualtrics Survey as most willing to make location decisions based upon issues of power quality and reliability. For example, 28.1% of the respondents from the Healthcare, Professional Services, and Finance/Insurance sectors as a group met the criteria used to define the market penetration rate seen in Section IV compared to 17.9% of respondents from all other combined sectors.

Of course, it is difficult to quantify how much greater the rate of employment in these subsectors might be due to the influence of other factors, such as local workforce development. As a result, the Study Team assumed that local microgrid-induced economic advantages would eliminate the previous disadvantage for the area, but not create an advantage. Accordingly, the jobs projected relate directly to employment growth comparable to projected national trends, and not upon any advantage. Based upon the survey data, this is probably a conservative assumption.

C. Projected Results: Combining the Two Approaches.

Since both approaches used to project microgrid-induced employment are speculative, the Study Team averaged the results of the two methods to arrive at an estimate of job growth, shown below in Table 7. Microgrid operations were assumed to begin in 2022 after an aggressive yet plausible period of uGrid construction. This growth will, in the next section, be compared to future job growth that could be expected if no microgrid were to be built and recently observed growth rates across these sectors within

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[64] Federal Reserve Bank of San Francisco. "Regional Comparative Advantage," *Economic Letter (Federal Reserve Bank of San Francisco)* (October 29, 1993). https://fraser.stlouisfed.org/content/?item_id=518044&filepath=/files/docs/historical/frbsf/frbsf_let/frbsf_let_19931029.pdf

[65] *See* note 63, *supra*.

[66] Hirsch, A., Parag, Y., & Guerrero, J. (2018). Microgrids: A review of technologies, key drivers, and outstanding issues. *Renewable and Sustainable Energy Reviews*, doi:10.1016/j.rser.2018.03.040

[67] U.S. Department of Defense. (2017). *Department of Defense Annual Energy Management and Resilience (AEMR) Report, Fiscal Year 2016*. Retrieved from ww.acq.osd.mil/eie/Downloads/IE/FY 2016 AEMR.pdf

[68] *See* note 4, *supra*.

downtown Cleveland continued unchanged. Increased income from this combined approach was also calculated, and is set forth and discussed in the next section.

Table 7. Job Growth in Downtown Cleveland with uGrid Deployment for Highlighted Subsectors

NAICS	2022	2023	2024	2025	2026	Total
524	12	12	12	12	12	62
541	249	252	255	258	261	1276
621	118	121	124	128	131	623
Total	379	386	392	398	405	1961

VI. Direct Economic Impact: Comparing Projected Microgrid-Related Employment Growth to a "Do Nothing" Approach.

To determine the likely economic effect of the microgrid, the Study Team compared the projected employment growth from building the microgrid using an average of the two approaches described in the previous section, termed hereinafter as the "*uGrid-build"* scenario, to that projected if no microgrid were built, or the "*no-uGrid"* scenario.

To establish expected job growth under the *no-uGrid* scenario, the Study Team assumed that recently observed average annual rates of change in employment for downtown Cleveland within the identified subsectors, seen previously in Table 6, would remain constant going forward. Observed employment levels for the downtown area during the recent past were derived from LODES zip code-level data and the U.S. Census Bureau's most recent Economic Census.[69]

Using recent local growth for the zip codes within the proposed Cleveland uGrid area, projected additions to employment under a *no-uGrid* scenario are set forth in Table 8. Job growth under this *no-uGrid* scenario may well be optimistic. We know competition is developing: other communities have microgrids in the planning stages that could attract companies responsive to five-9s power.[70]

Table 8. Job Growth in Downtown Cleveland Under *No-uGrid* Scenario

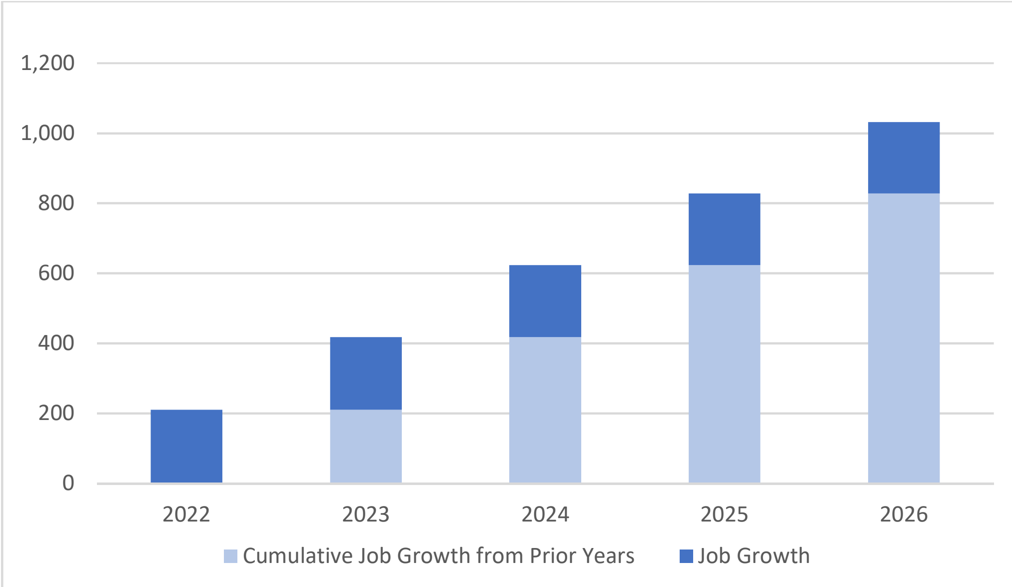
NAICS	2022	2023	2024	2025	2026	Total
524	-94	-88	-83	-79	-74	-418
541	233	235	238	240	243	1189
621	31	31	32	32	33	158
Total	170	178	186	194	202	929

The *no-uGrid* scenario was then compared to the *uGrid-build* scenario set forth in Section VI. Figure 4 below shows the projected new employment after subtracting job growth under the *no-uGrid* scenario from the projected job growth under the *uGrid-build* scenario. This accounts and corrects for the counterfactual "do nothing" scenario. The year 2022 should be considered a hypothetical starting period, since it will take at least 2 years to build the microgrid.

[69] *See* note 59, *supra.*

[70] For projected growth among potentially competing microgrids, *see* the Navigant study referenced in note 49, above. The New York State Energy Research and Development Authority (NYSERDA), for instance, is looking at possible commercial microgrids for that state.

Figure 5. Anticipated Job Creation in Highest Three VOLL Subsectors Resulting from Building uGrid, Accounting for Counterfactual, through 2026



Altogether, the Study Team projected a net creation of 1,031 jobs created. The chart below illustrates the ramp up that could occur in both construction and operations for the uGrid before ultimate infrastructure completion and service being fully subscribed. We assumed that additions to microgrid construction and customer utilization would occur at a rate of 20% per year, with a time lag separating the incremental buildout from when off-takers would come on board. The table below is a hypothetical schedule of when portions of microgrid construction and operations might commence.

Table 9. Hypothetical Time Phasing of Microgrid Construction and Operations

	2020	2021	2022	2023	2024	2025	2026
Construction							
uGrid infrastructure	20%	20%	20%	20%	20%	---	---
Businesses attracted	---	20%	20%	20%	20%	20%	---
Operations							
uGrid subscription of attracted businesses	---	---	20%	40%	60%	80%	100%

Table 10 translates the extra job growth related to microgrid development into projected additional employee earnings for the three subsectors combined. Projected additions to employment under microgrid development was multiplied by payroll per employee for each subsector which was derived from 2016 County Business Patterns data, the most recent year available.[71] This salary estimate was adjusted for subsequent years according to nominal annual wage growth of 3%, consistent with the overall

[71] "County Business Patterns." (2015, 2016). *U.S. Census Bureau*. http://factfinder2.census.gov.

rate of change for this measure nationally over the last five years according to the Federal Reserve Bank of Atlanta.[72]

Table 10. Earnings in Highest Three VOLL Subsectors Resulting from uGrid Development, Accounting for Counterfactual, 2022-2026

Year	Additional Annual Earnings
2022	$16,174,689
2023	$17,145,170
2024	$18,159,323
2025	$19,218,895
2026	$20,325,697
Cumulative	$91,023,773

Table 11 shows estimated construction earnings given the hypothetical construction schedule for the uGrid itself as well as for the attracted businesses and related catalytic retail and restaurants. Catalytic retail and restaurant employment is a kind of spillover effect where development in the subsectors attracted to the uGrid improves the quality of the area for production, income, and employment within the service sector.[73] The catalytic employment for retail and restaurant services predicted to accompany uGrid-related development in the highlighted subsectors represents an additional $2,823,147 in earnings annually across 105 jobs by 2026, a stable year by which all construction should be completed and the uGrid fully subscribed.[74]

Construction labor was assumed to represent 45% of total construction costs (see Appendix C). Construction cost estimates for attracted businesses were based on the 1,147 employees projected to accompany microgrid deployment and the extra physical space needed to accommodate them.[75]

[72] *See* "Wage Growth Tracker." *Federal Reserve Bank of Atlanta*. (2018). Retrieved from https://www.frbatlanta.org/chcs/wage-growth-tracker.aspx?panel=1
[73] *See* Zak, D., & Getzner, M. (2014). "Economic Effects of Airports in Central Europe: A Critical Review of Empirical Studies and Their Methodological Assumptions." *Advances in Economics and Business*.
[74] For background on patterns of Cleveland-area catalytic employment developing in response to new development, *see* Simons, R.A., et al. (2018). "Variety Village District Economic Analysis: Retail Market Expansion, Economic Impact, and Fiscal Impact." https://engagedscholarship.csuohio.edu/urban_facpub/1519/.
[75] The Study Team assumed *228* square feet per employee for NAICS codes 524 and 541, and *207* square feet per employee for NAICS code 621. *See* Institute of Transportation Engineers. Parking Generation, 4th Edition. Fifth printing, 2018. Washington, D.C: Institute of Transportation Engineers.

Table 11. Direct Earnings from Construction (in dollars)

	2020	2021	2022	2023	2024	2025	Total
uGrid	7,009,467	7,152,460	7,298,371	7,447,257	7,599,181	--	36,506,736
Attracted Business & Catalytic Employment	--	3,845,497	3,923,945	4,003,994	4,085,675	4,169,023	20,028,134
Total	7,009,467	10,997,957	11,222,316	11,451,251	11,684,856	4,169,023	56,534,870

VII. Additional Economic Impact.

In addition to the direct effect of added jobs among businesses attracted to the Cleveland uGrid are the secondary effects associated with this growth in employment. Indirect employment change -- and the ensuing change in earnings among all local workers -- reflects the growth in jobs among industries that supply intermediate inputs to the three identified subsectors. In a like manner, induced employment change is a function of increased household spending resulting from additions to direct and indirect employment. The Bureau of Economic Analysis' RIMS II multipliers were used by the Study Team to estimate the indirect and induced economic impact of 1,147 additional workers within Cuyahoga County.[76] Table 12 shows the county-level[77] non-construction added effects of this direct change in employment by 2026.[78] See Appendix C for more information on the assumptions forming the basis for these estimates.

Table 12. Total Estimated Economic Impact of uGrid on Cuyahoga County by 2026

	Jobs	Annual Earnings
Direct	1,147	$94,817,244
Indirect	583	$40,377,037
Induced	592	$27,724,524
Total	2,322	$162,918,805

VIII. Power and Land Capacity Required to Satisfy Demand for Attracted Businesses.

This projected job growth is necessarily constrained by space and power capacity. There must be sufficient land and available five-9 power to support a workforce of the size projected. If there is not, then the growth would need to be accordingly reduced to fit within the available constraints.

To determine the amount of five-9 electricity delivery that such job growth would require, annual electricity consumption by industry was estimated using data from the most recent Economic Census as well as other annual economic surveys—such as the Service Annual Survey—conducted by the U.S. Census Bureau.[79] This data was used to calculate VOLL in terms of lost production. The following table shows

[76] A summary explanation on RIMS II multipliers can be found at https://apps.bea.gov/regional/rims/rimsii.

[77] This is the most granular level at which RIMS II multipliers are available. Further, indirect jobs may occur anywhere in the region. Using Cuyahoga County as the most likely location for indirect jobs was considered to be a reasonable estimate.

[78] Direct employment includes catalytic retail and restaurant as well as operational staff for the Cleveland uGrid itself (e.g. on-site engineering staff to monitor and service the communications network and control system).

[79] *See* note 4, *supra*.

estimates of national annual electricity consumption aggregated by subsector for 2015, the most recent year for which all necessary data was available.

Table 13. Annual Electricity Consumption for Identified Subsectors

Subsector	Annual quantity of electricity purchased for heat and power (MWh)	Total employees[80]	Annual MWh consumed per employee
Insurance Carriers and Related Services	9,810,573	2,453,404	4.00
Professional, Scientific, & Technical Services	29,753,689	8,798,260	3.38
Ambulatory Health Services	28,216,639	7,006,624	4.03

The estimates of annual electricity consumption for these particular subsectors are corroborated by other studies. For instance, a study by the European Environment Agency found that the average service sector worker in Europe used around 4.85 MWh of electricity annually.[81] An estimate of demand for power per worker in megawatts within these subsectors can be calculated using the annual consumption per worker found in the table above and the average annual number of hours worked per employee within these industry groupings.[82]

Assuming 52-week work year where average weekly hours worked per employee within a given subsector is equivalent to that observed during the recent past,[83] the estimated average electrical load for each additional employee would be:

> 4,000 kWh ÷ 1,991.6 hours = 2.01 kW/employee for Insurance Carriers and Related Services (Svcs);
>
> 3,380 kWh ÷ 1,918.8 hours = 1.76 kW/employee for Professional, Scientific, & Technical Svcs; and
>
> 4,030 kWh ÷ 1,664.0 hours = 2.42 kW/employee for Ambulatory Health Services.

This is assumed to represent "coincident demand" – i.e. demand by the employee during periods of general peak demand within the microgrid. The Study Team estimates that microgrid customers receiving five-9 service under Tiers 1 or 2 would require peak demand capacity no more than 10% greater than coincident demand.

The table below shows peak demand for microgrid-provided electricity by 2026 among the subsectors that especially value reliable power given the average additions to employment between the two approaches for estimating potential job creation from microgrid deployment. This projected demand

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[80] *See* note 71, *supra*.

[81] "Energy Intensity in the Service Sector." (2012). *European Environment Agency*. Retrieved from https://www.eea.europa.eu/data-and-maps/indicators/energy-intensity-in-the-service-sector/assessment-2

[82] Average annual hours worked per employee was based on 2012-2017 BLS data for Average Weekly Work Hours for the identified subsectors: 38.3 hours per week for Insurance Carriers and Related Services; 36.9 hours per week for Professional, Scientific, & Technical Services; and 32.0 hours per week for Ambulatory Health Services. *See* "Current Employment Statistics: CES National Databases." Bureau of Labor Statistics. (2018). Retrieved from https://www.bls.gov/ces/data.htm

[83] *Id.*

capacity represents 12.7% of the microgrid's 21 MW capacity for Tier 1 service with complete five-9 power. This percentage is well below the 20% portion of this service projected to be available for commercial growth.

Table 14. Demand for Microgrid Capacity by 2026 Among Subsectors that Value Reliable Power

Subsector	Estimated Peak Load per Employee (kW)	Extra Employment Under Microgrid Development by 2026	Projected Demand for Power by 2026 (kW)
Insurance Carriers and Related Services	2.23	479	1,068
Professional, Scientific, & Technical Services	1.96	87	171
Ambulatory Health Services	2.69	465	1,251
		TOTAL	2,491

It is important to note, however, that while there would be ample five-9 power available to support the projected growth, it does raise some important issues about the nature of companies needing five-9 power. Financial, law, consulting, and other professional services that have very high VOLLs may not need five-9 power at all times, as other industries might. Data Centers, communication industries and hospitals, for instance, might continually place a greater value on five-9 power than some of the higher VOLL sectors. These will have to deal with the same peak power constraints, but they may have different job and income projections from those subsectors identified in this study.

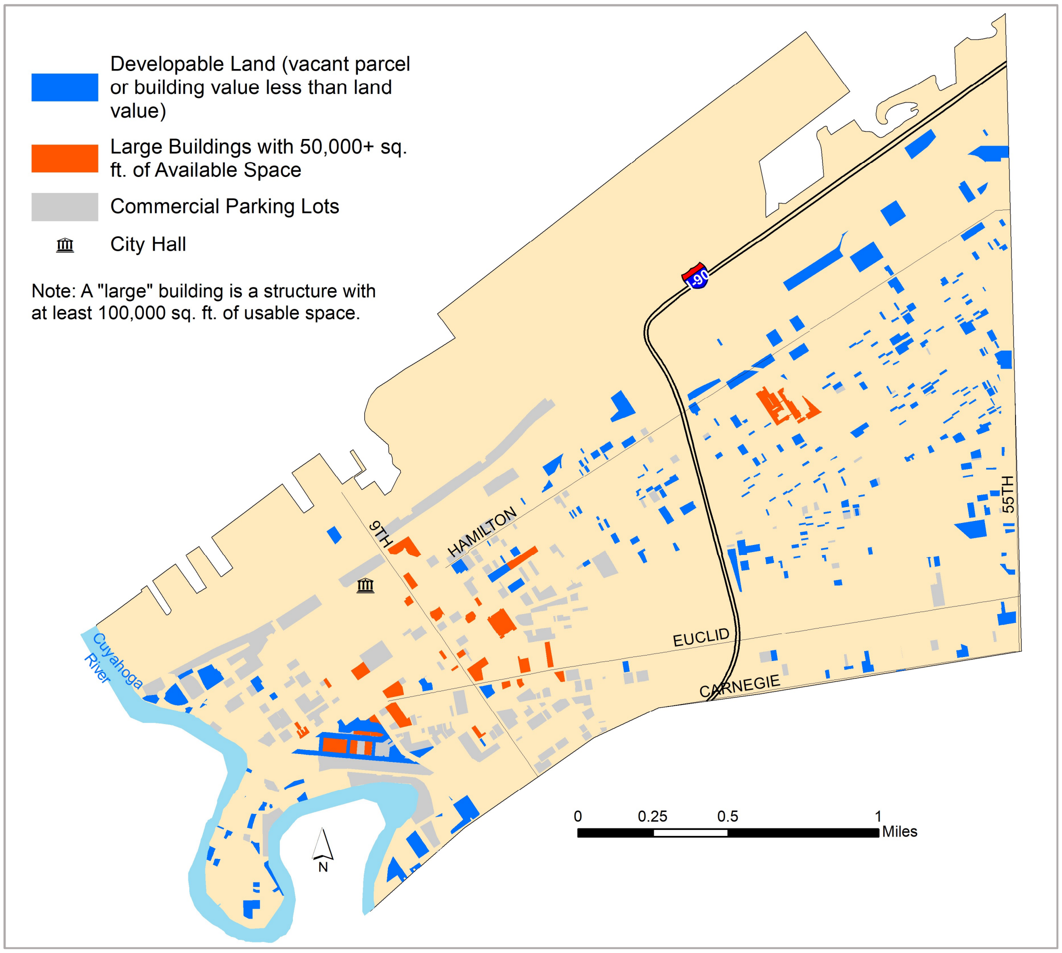
Likewise, there is ample space within the proposed uGrid footprint to accommodate the projected growth. To determine this, the Study Team assumed 218 square feet per employee on average for the previously identified subsectors. This ratio of area to employee comports with capacity requirements used by regional planning authorities for general office, finance and insurance services, and health facilities within an urban setting.[84] Altogether, around 225,000 square feet of building space would therefore be required to accommodate firms within the subsectors identified as being especially responsive to microgrid features.[85] This measure of area is far less than the over 1,000,000 square feet of vacant parcels and unoccupied office space identified by the Study Team within the uGrid study area. See Figure 5 below[86]. As set forth earlier, however, the study area boundaries are somewhat arbitrary, and it would not be difficult to change the footprint of the uGrid to accommodate space requirements.

[84] *See* note 75, *supra*.

[85] For comparison, this would represent approximately 17% of the useable area in Key Tower, the region's tallest building. *See* note 83, *infra*.

[86] Parcel data for useable area, vacancy, and land use was obtained through Cuyahoga County's *ArcGIS Open Data* page at https://data-cuyahoga.opendata.arcgis.com. Estimates of available space for large commercial buildings were based on occupancy estimates appearing in the most recent *Downtown Cleveland Market Update* published by the Downtown Cleveland Alliance and available at http://www.downtowncleveland.com/work/resources-reports.

Figure 6. Available Land for Development within the Proposed uGrid Footprint.



IX. Fiscal Impact.

An analysis of the fiscal impact of the uGrid *direct* employment additions for the identified subsectors, together with the construction and catalytic development, was conducted by the Study Team. A number of assumptions were made in determining the preliminary fiscal impact of direct employment growth for the three identified subsectors and for construction (both of the microgrid and businesses). Most significantly, the Study Team did not assume that the County or City would bear significant costs in financing the uGrid. Potential uGrid owner/operators have indicated they may be willing to bear most, if not all, of the burden in financing microgrid capital expenditures.[87]

Government organizations may need to entertain a lesser debt issuance or credit enhancement[88] to curtail the risk of operational losses during the early ramp-up phase while the uGrid operator incrementally subscribes customers. This cost could be offset in the long-term via a fee which could be passed through without pushing customer rates beyond targets that are attractive to off-takers. For purposes of assessing

[87] Based on control system RFI responses and interviews with potential microgrid operators.
[88] For more on government credit enhancements, *see* https://www.energy.gov/eere/slsc/credit-enhancements.

fiscal impact for this interim report, we focused on changes in governmental revenues until it becomes clearer what governmental costs will have to be borne.

Other assumptions the Study Team made in analyzing the uGrid's fiscal impact include:

- Approximately $88 million in total construction costs for microgrid infrastructure;[89]
- Approximately $68 million dollars in total construction costs for attracted businesses;[90]
- A 30-year planning horizon beginning with operations in 2022;
- A 3.1% social discount rate, the average yield on 30-year U.S. Treasury Bonds over the last three months;[91]
- Projected annual inflation of 2.04% over the next decade;[92]
- Income, sales, and property taxes remaining constant at their current levels;[93] and
- Construction investment as a reasonable proxy for property value increases.

The following table shows the benefits that could accrue to public entities resulting from microgrid construction. It assumes 1,147 jobs in direct employment growth and accounts for the *no-uGrid* conditions within the three previously identified subsectors. In addition, it also includes construction and catalytic retail and restaurant jobs created both from the uGrid and from businesses developing offices and other sites. The present value is based on construction that commences in 2020 overlapping with 30 years of operations beginning in 2022. The year 2026 is considered a stable year by which time all of the uGrid's capacity should be subscribed. See Appendix C for more on the assumptions that inform this table.

[89] This estimate is based on improvements to Cleveland Public Power's existing electrical infrastructure as well as investments into the microgrid control system and cyber security. More details on capital expenditures can be found in a companion study describing the cost model.

[90] Construction costs for attracted businesses are based on a series of assumptions such as cost per square foot by type of facility (e.g. general office versus medical office) and the proportion of new versus rehab construction. For example, the Study Team, under the direction of Dr. Roby Simons, assumed square foot costs of $170 for New Office and $80 for Renovated Office. Similarly, square foot costs of $450 for New Medical Office and $300 Renovated Medical Office were assume. Also, new construction for attracted businesses is likely to be more expensive than renovating an existing structure. The Study Team therefore assumed that a higher proportion of construction was rehab rather than new for attracted businesses (80% versus 20%).

[91] *See* "Daily Treasury Long Term Rate Data." *U.S. Department of the Treasury.* (2018). Retrieved from https://www.treasury.gov/resource-center/data-chart-center/interest-rates/Pages /TextView.aspx?data=longtermrateYear&year=2018

[92] "Inflation Expectations." *Federal Reserve Bank of Cleveland.* (2018). Retrieved from https://www.clevelandfed.org/our-research/indicators-and-data/inflation-expectations.aspx

[93] Current taxes include: average income tax of 2.5% for the City and 4.0% for the State; sales tax of 1.25% for the County and 5.75% for the State; sin/excise taxes of 0.44% for the County and 0.74% for the State; and commercial property tax of 12.70 mills for the City, 14.01 mills for the County, and 61.58 mills for Cleveland Metropolitan School District.

Table 15. Direct Fiscal Impact of uGrid Through 2052

Public Entity	Annual Government Revenues by 2026	Present Value of Future Government Revenues (2020-2052)
City of Cleveland	$2,724,011	$59,783,330
Cleveland Metro School District	$2,697,001	$47,912,395
Cuyahoga County	$773,973	$14,381,036
State of Ohio	$6,502,996	$144,206,616
Total	$12,697,981	$266,283,377

As set forth above, the projected growth in jobs would not use up the entire available microgrid, assuming 20% is available for commercial development. Additional capacity, for instance, could be taken by data centers, who have expressed in interviews with the Study Team an interest in the uGrid. Likewise, downtown growth is likely to also increase the steam load requirements, making it likely that an additional CHP plant will be built, which in turn will mean more five-9 power will be available for commercial growth, and then more steam demand, and so on.

X. Conclusion.

The proposed uGrid is likely to generate around 1,031 jobs in industries that are experiencing the greatest amount of growth nationally. This is expected to generate nearly $100 million in income by 2026, and additional tax revenue for the city of Cleveland of around $2.7 million a year by 2026, which tax revenue will thereafter be ongoing. The Cleveland Metropolitan School District will realize another $2.7 million per year and Cuyahoga County around $800,000 per year by 2026.

Importantly, the proposed uGrid will support downtown Cleveland with advanced energy technology. This creates additional value for the region as a leader in technology and an attraction for new industry, commerce, and residents. The new development is likely to spur growth for the district energy company, thereby increasing the need for more combined heat and power facilities, and making it likely that the microgrid will expand significantly and generate more economic development. The proposed microgrid could be transformative for downtown Cleveland, making it a destination for rapidly growing industries that rely upon resilient energy infrastructure to support data centers and other new technologies.

Appendix A. Commercial Survey.

Screening Criteria

Potential respondents were included in the survey if they selected one of the following responses to screening questions 1 *and* 2 *and* 3:

1.) *How would you best describe your role in your company's decision-making process for the purchase of utilities?*

Potential respondents were included in the survey if they selected one of the following responses to Question 1:

- I am the sole decision maker;
- I make the final decision with input from staff/management;
- I help reach the final decision as part of a group/committee.

2.) *How would you describe the effect of a power outage lasting 1 hour on your company's bottom line?*

Potential respondents were included in the survey if they selected one of the following responses to Question 2:

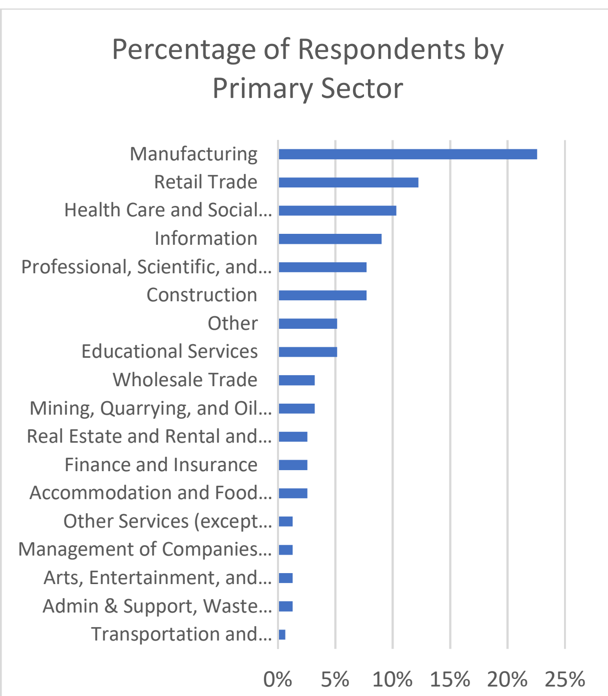
- Major effect;
- Moderate effect.

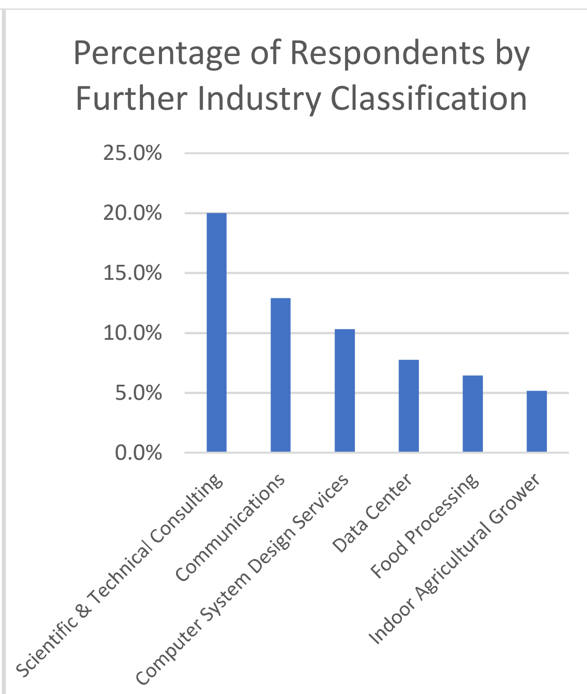
3.) *Does electrical power represent a high or moderately high percentage of your company's operating costs?*

Potential respondents were included in the survey if they selected "Yes" in response to Question 3.

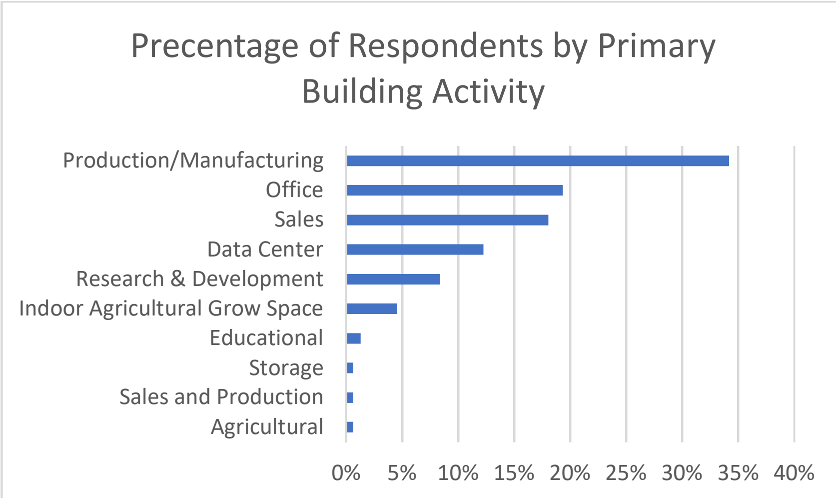
A total of 155 respondents participated in the survey administered through the Qualtrics online platform.

Sector/Industrial Classification of Respondents

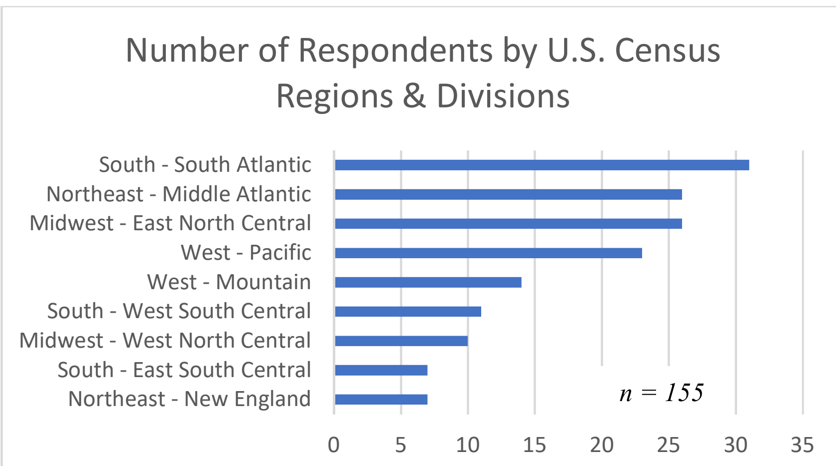




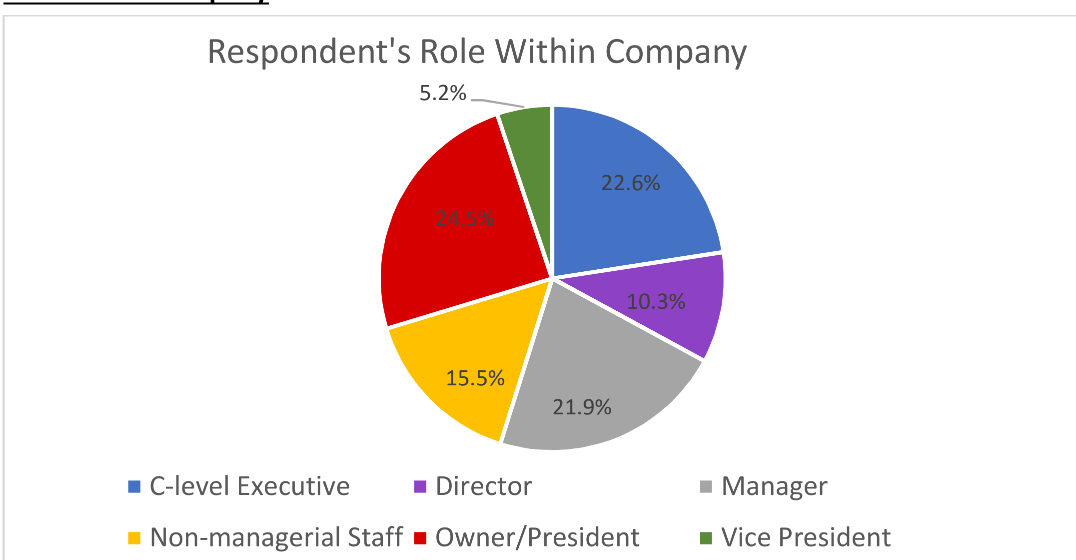
Primary Building Activity of Respondents



Geography of Respondents



Role Within Company



Usable Area and Number of Employees at Typical Facility

The Jenks Natural Breaks method was used to categorize the approximate usable area for a typical facility, as indicated by the survey respondents, into five classes. This method of data clustering groups similar values together so that the difference between classes is maximized. The following table shows the distribution of a typical facility's square footage among survey respondents using this method.

Class	Usable area of a typical facility	Number of respondents	Percent of overall survey sample
1	900 sq. ft. or less	23	14.8%
2	1,000-6,000 sq. ft.	48	31.0%
3	7,000-24,000 sq. ft.	31	20.0%
4	25,000-185,000 sq. ft.	40	25.8%
5	200,000 sq. ft. or more	9	5.8%

*Four respondents did not answer this question on usable area of a typical facility.

The Jenks Natural Breaks method was also used to categorize the approximate number of full-time equivalent (FTE) employees at a typical facility, as indicated by the survey respondents, into five classes. The following table shows the distribution of a typical facility's number of FTE employees among survey respondents using this method.

Class	Number of FTE employees at a typical facility	Number of respondents	Percent of overall survey sample
1	14 or less	32	20.6%
2	15-56	37	23.9%
3	57-220	29	18.7%
4	231-999	31	20.0%
5	1000 or more	25	16.1%

*One respondent did not answer this question on number of FTE employees at a typical facility.

Electrical Loads and Consumption at Typical Facility

Respondents were generally not familiar with the load profiles or electricity consumption at a typical facility. For instance, two-thirds of respondents provided no answer to the following questions:

1.) *What is your company's peak demand for power in terms of load for a typical facility (in kilowatts)?*
2.) *What is the approximate annual energy consumption for a typical facility at your company (in kilowatt hours)?*

Some respondents who did provide answers may have assumed a different measurement scale than what was included in the above questions. For instance, 30 of the respondents who replied to the question on annual energy consumption gave two-digit and three-digit answers, which would seem appropriate in MWh but unlikely in terms of kWh.[94]

We therefore attributed annual electrical consumption per typical facility to the respondents using Commercial Building Energy Consumptions Survey (CBECS) data on electricity consumption intensity

[94] *See* 2012 Commercial Building Energy Consumptions Survey (CBECS) for average annual electrical consumption per building by principal building activity. https://www.eia.gov/consumption/commercial/data/2012/

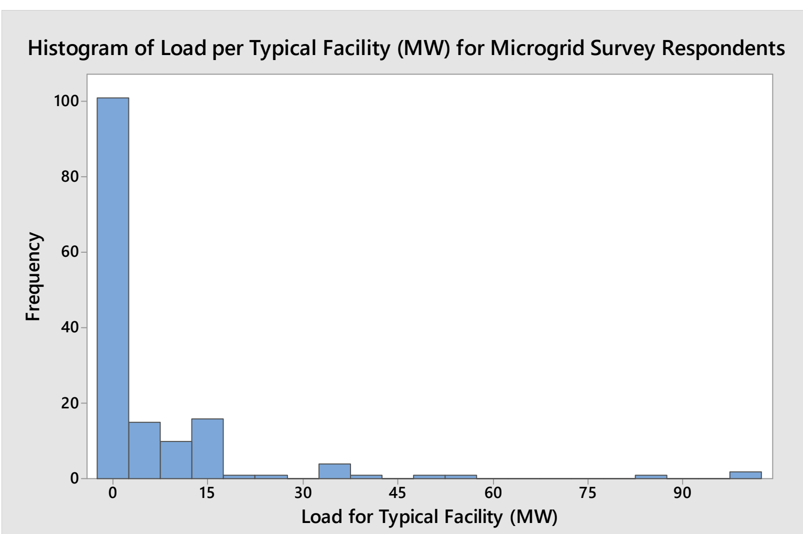
according to primary building activity.[95] As part of our microgrid market survey, respondents were asked to identify a typical facility's primary activity for their company which allowed us, along with other questions on the respondent's company's industrial classification, to match them to CBECS building types based on primary activity.[96]

We received 100% response rates for survey questions pertaining to both primary building activity and industrial classification. The specific CBECS data we used to estimate annual electrical consumption for a typical facility among survey respondents were kWh per worker according to primary building activity. The CBECS building types we attributed to respondents, along with average annual kWh per worker, were: Education, 12.3 MWh; Health Care (outpatient), 10.0 MWh; Mercantile, 22.7 MWh; Office, 7.5 MWh; and Other (including data centers and manufacturing), 34.7 MWh. The following table shows the number and percentage of respondents from our microgrid market survey that were matched to each CBECS building type as well as the load for the average worker based on a 40-hour work week and a 52-week work year.

Matching CBECS Building Types to Survey Respondents

CBECS Building Type by Primary Activity	Number and Percentage of Matched Survey Respondents	Load for Average Worker (kW)
Education	2 (1.3%)	5.9
Health Care (outpatient)	10 (6.5%)	4.8
Mercantile	8 (5.2%)	10.9
Office	42 (27.1%)	3.6
Other (including data centers and manufacturing)	93 (60.0%)	16.7

Given the load for the average worker we attributed to survey respondents according to CBECS building types, the histogram below shows the frequency distribution of loads for a typical facility among respondents based on the number of employees per facility they indicated in our microgrid market survey.



[95] *Id.*

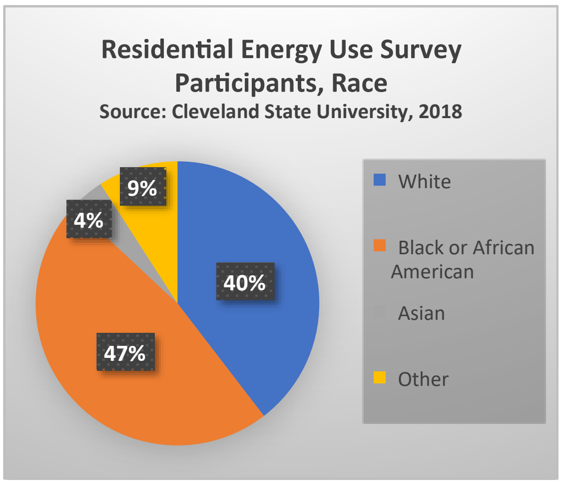
[96] *See* Building Type Definitions. https://www.eia.gov/consumption/commercial/building-type-definitions.php#HealthOut

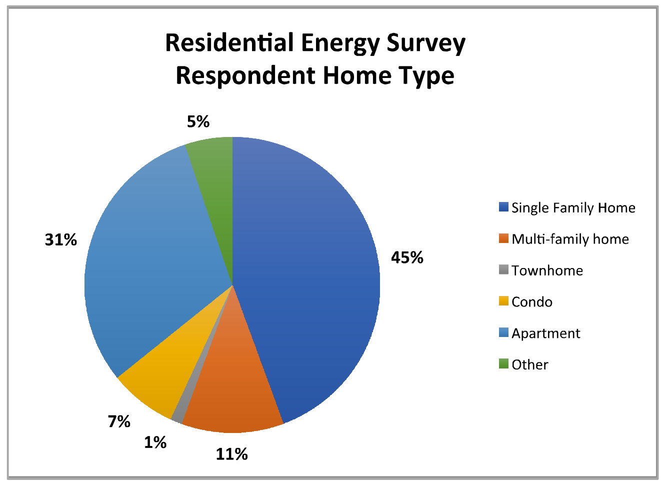
Appendix B. Residential Survey Summary.

Background

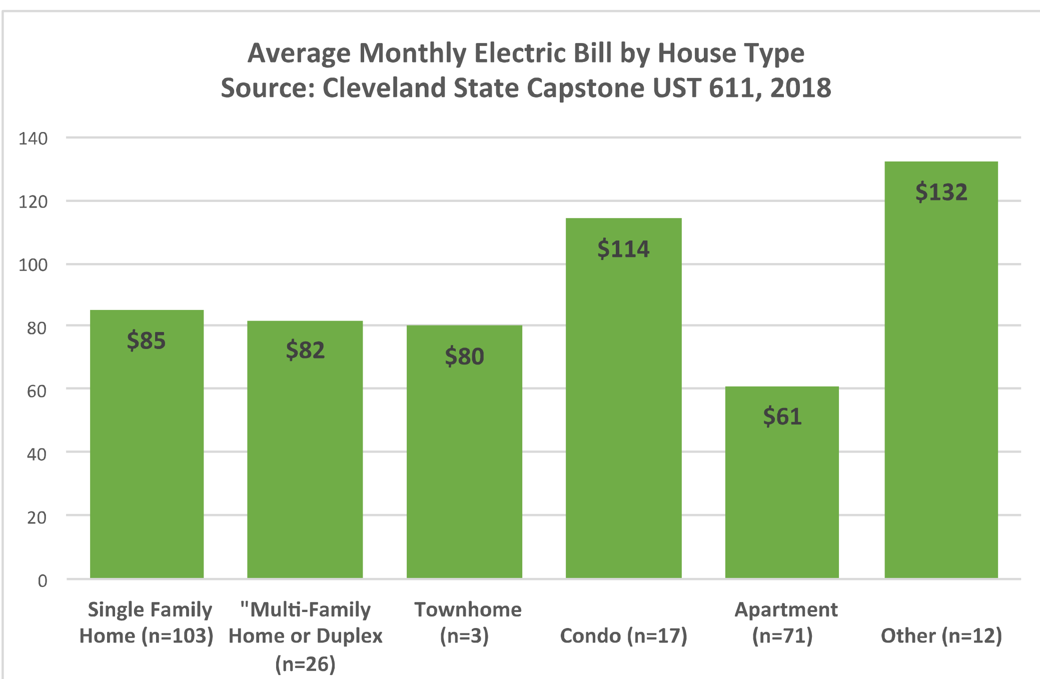
As part of the spring 2018 Master of Urban Planning and Development capstone class at Cleveland State University, students conducted a survey of residents within the Cleveland Microgrid area to ask about the importance of electrical reliability. A total of 232 respondents participated in a paper survey, administered in-person by students over a 2-week period in April of 2018. Surveys were collected in public spaces outside shopping venues in the microgrid area. A copy of the survey instrument is attached. "Reliable Electricity" was described to participants as "electrical power not susceptible to blackouts or brownouts."

Respondent Demographics

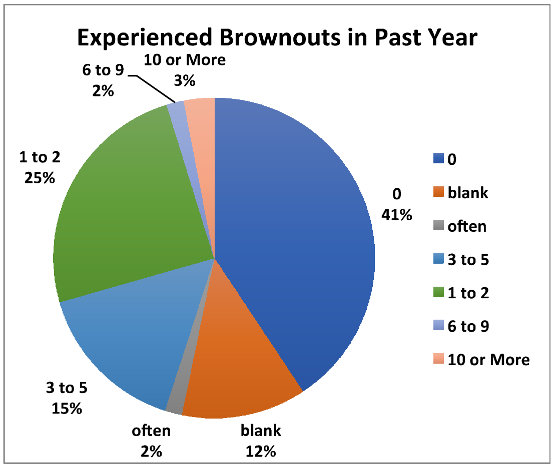


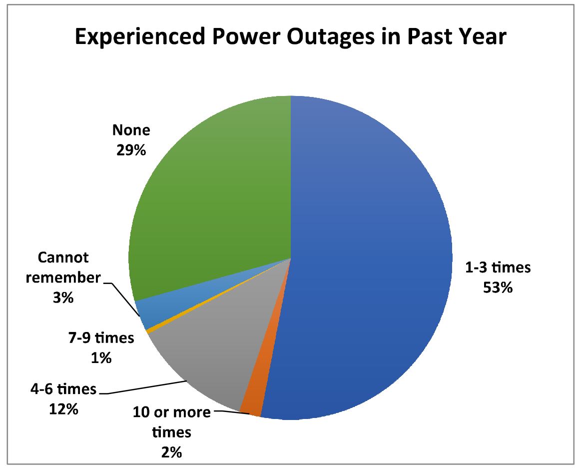


Cost of Electricity



Brownouts and Outages

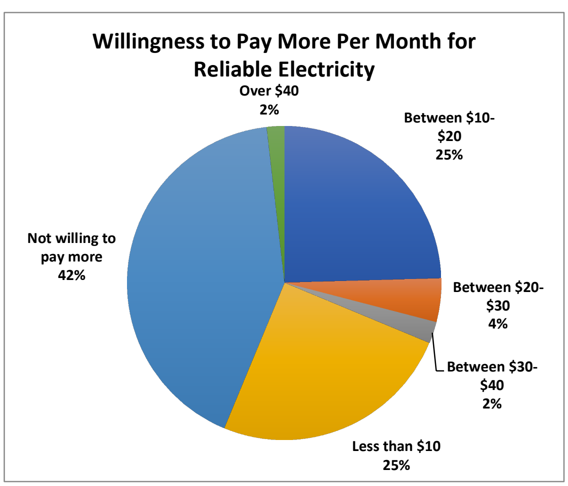


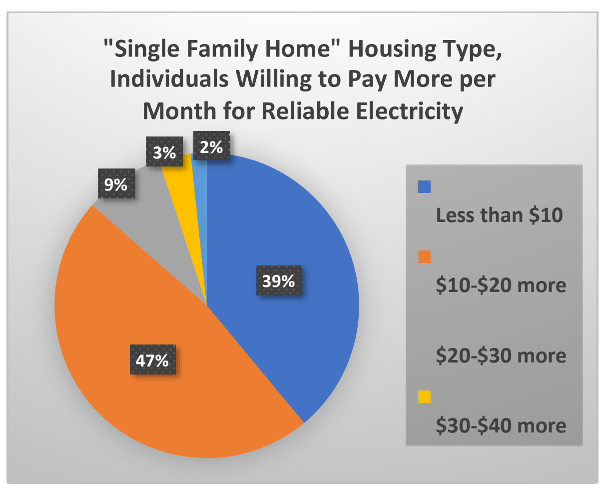


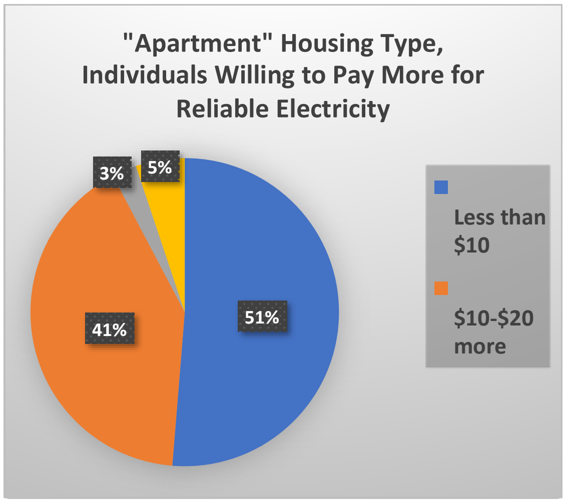
41% of respondents reported experiencing no brownouts in the past year, and 29% reported experiencing no power outages. 25% reported experiencing 1 to 2 brownouts, and another 15% reported experiencing 3 to 5%. 53% reported experiencing blackouts 1 to 3 times per year, 12% reported 4 to 6 times, and 2% reported 10 or more blackouts in the past year.

Electrical Reliability and Willingness to Pay for Improved Service

83% of respondents reported finding power reliability “extremely important” or “very important”; and 55% to 57% reported they were willing to pay more for electrical reliability. Responses were similar between apartment, single family home, and other types of home dwellers. When asked how much per month they would be willing to pay, 25% reported they would be willing to pay only less than $10 per month, and another 25% would be willing to pay $10 to $20 more per month. 42% stated they would not be willing to pay more. Only 6% would be willing to pay between $20 and $40 per month, and another 2% would be willing to pay more than $40 per month for resilient power. There was some difference between home type of respondents; a higher proportion of single family home owners would be willing to pay more than $20 per month for resilient power.

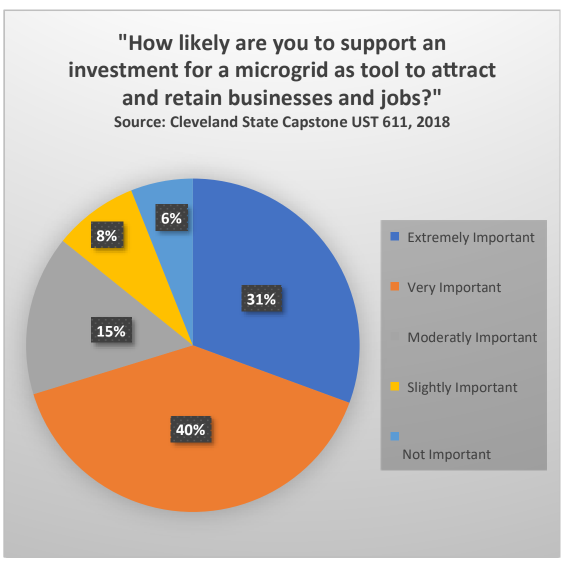


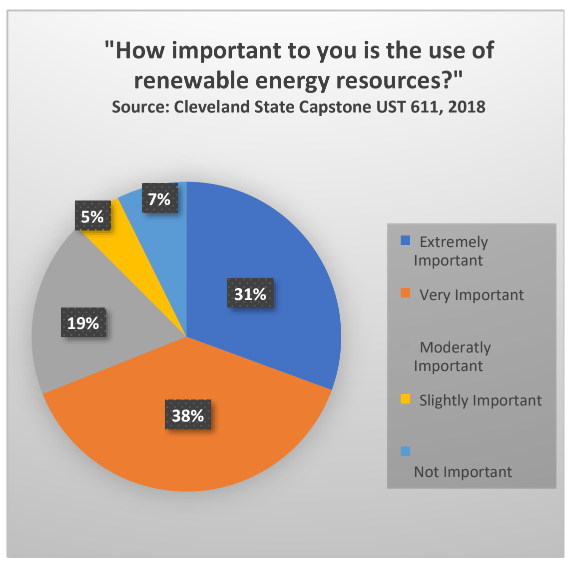




Support for the Microgrid

When asked, "how likely are you to support an investment for a microgrid as a tool to attract and retain business and jobs?", 71% responded that the idea was extremely or very important to them. When asked, "how important to you is the use of renewable energy resources?", 69% reported that it was extremely or very important.





Conclusions

- 30% of residents experienced no power outages in the past year, while 53% experienced 1 to 3 outages
- 41% experienced no brownouts, while 40% experienced 1 to 5 brownouts
- 83% reported that reliable electricity was “extremely important” or “very important”
- Between 55% and 57% would be willing to pay more for reliable electricity
- 42% were not willing to pay more for reliable electricity; 25% would pay less than $10 more per month; another 25% would pay $10-20 more per month.
- 71% were extremely or very likely to support a microGrid as a tool to attract and retain businesses and jobs
- 69% reported that renewable energy sources were extremely or very important

Power outages and brownouts are a common occurrence for many residents in the area. While a majority reported that reliability electricity was extremely or very important to them and would be willing to pay more for reliable electricity, they preferred modest increases of under $10 per month, or $10-$20 per month, on their electric bills.

There is general support for the microgrid as an economic development tool, and for renewable energy sources overall.

Appendix C. Economic and Fiscal Impact Assumptions.

RIMS II Multiplier Assumptions

- Backward linkages approach (demand driven) – measures impacts of subject industry's demand on their suppliers. Does not measure potential impact the subject industry's supply could have on users going forward.
- Assumes industries are homogeneous in their inputs
- Assumes no constraints in supply to the subject industry
- Does not account for cross-hauling; if inputs needed are available within the region, assumes they will be used
- Does not account for regional feedback (i.e. outside-region suppliers obtaining inputs themselves from the subject region) (choosing larger study regions helps to reduce concern)
- Does not account for time, treats impacts as permanent/persistent impacts no matter how long the impact chain may take to operate

Economic Impact Assumptions

- All new businesses are new to the region (city/county/state) examined, and are not "poached" from elsewhere in the region… if they come from within the region, new businesses fill in the space left
- County Business Patterns average payroll per industry is a reasonable estimate of earnings for individuals in the uGrid area within that industry
- 80% of attracted business space will be rehabbed existing vacant space; 20% will be new
- 85% of construction costs are hard costs; 15% are soft costs. 45% of construction hard costs are attributed to labor, and 55% are for goods. 20% of construction goods will be taxable in Cuyahoga County, and 80% of construction goods will be taxable in Ohio.
- For office industries, 90% of costs are salaries/labor, and 10% are goods.
- For retail industries, 40% of costs are salaries/labor, and 60% are goods.
- For restaurants, 60% are salaries/labor, and 40% are goods.

Fiscal Impact Assumptions

- Construction investment is a reasonable proxy for property value increases.
- Income tax calculations are based on assumption that 66% of labor will be skilled (higher tax bracket), and 34% will be unskilled (lower tax bracket), in any industry.

Tax Assumptions

Tax Category	Tax Rates					
	City	County	State	CMSD	Other	Comments
Income Tax	2.50%		3.66%			
Commercial Activity Tax			0.26%			After first million
Sales Tax		1.25%	5.75%		1.00%	RTA
Alcohol Excise Tax		0.44%	0.74%			
Admissions Tax on Alcohol	8.00%					
Commercial Property Tax (mills)	12.7	14.01		61.58	13.32	RTA, library, metroparks
Kilowatt hour tax (cents per kwh)			0.00419			