THE OHIO STATE UNIVERSITY

Waste Averted and Cleaner Energy: The Future of Telehealth at The Ohio State University Wexner Medical Center

AEDE/ENR 4567 Senior Capstone

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Executive Summary

Our group assisted the Wexner Medical Center (WMC) in pursuing emerging sustainable development opportunities. Our project included two separate research objectives to fully address the waste saving benefits of telehealth and how the increasing use of telehealth can be powered and sustained.

- **Research Objective 1:** Evaluate the physical waste averted due to telehealth since March 2020 at the WMC.
    - **Results:** We were able to find that the total solid waste averted through telehealth over the COVID-19 pandemic was about **15.8 tons**. We also found that justice and equity considerations factor prominently into the growing field of telehealth.
- **Research Objective 2:** Evaluate a business case for a renewable energy microgrid at the Ackerman Data Center to power a robust telehealth system and store patient data.
    - **Results:** The Ackerman Data Center is **not** an economical location for a microgrid. However, we did determine that under certain circumstances there could be a more feasible business case for a microgrid.
    - **Ideal Business Case:** Location (rural, new building), funding (research funding, federal grants, private partnership), policy (Biden infrastructure plan, clean energy tax credits), future outlook (declining cost of solar and microgrid technology over time), community (local stakeholder support is ideal)
- **Recommendations:**
    - We recommend that the WMC continues to utilize telehealth for appointments that have no physical components to them in order to avoid physical waste. We

also recommend that our formula be added to the Wexner Dashboard and utilized to gather further data related to solid waste avoided by telehealth.

- We recommend that the WMC continues to investigate the construction of a renewable energy microgrid. Even though we do not recommend the original Ackerman site, we believe that a more promising business case could be available at a different location in the future.

Introduction

As a result of the COVID-19 pandemic, there has been an increased utilization and implementation of telehealth services at WMC. There are many positive benefits associated with telehealth services including, but not limited to, emissions reductions through avoided transportation, along with increased financial and time savings associated with technological access. The Ohio State University Wexner Medical Center currently has a dashboard that tracks the miles avoided in travel and gas savings between March - July 2020. The WMC also would like to calculate and track waste avoided with the increased use of telehealth services. This includes savings associated with energy to heat and cool spaces, paper savings, and materials from in-person visits such as paper towels, paper forms or exams, hand sanitizer, and soap. The increased use of telehealth and telework services also resulted in questions regarding the resilience and sustainability of the power system in their data centers. The investment in renewable energy microgrids to protect data, assets, and ability to meet needs in case of a grid outage was another topic of interest for the WMC. These considerations prompted the two primary objectives of this project:

1. *Conduct a waste assessment* of a patient visit by top 10 telehealth specialties: Connect and work with WMC stakeholders to understand what a typical patient visit includes and build a 'waste avoided' estimate that can be applied across telehealth visits.
2. *Build and develop a business case for a renewable energy microgrid*: Connect and work with Engie, AEP, and the WMC stakeholders to understand the needs and build a business case for a renewable energy microgrid at their Ackerman Data Center.

As a result of these two primary research objectives, the project mission and project goals are as follows:

- *Project Mission*: Develop solutions to support a more environmentally sustainable future for The Ohio State University's healthcare system while operating within their primary mission of improving the health of the local community
- *Project Goals*: Foster resilience and sustainability in the healthcare system through evidence-based research in two areas: Waste Assessment of Telehealth Services and Renewable Microgrids to Data Centers.

Research Objective 1 Recommendations: Utilizing our definition of telehealth, meaning any in-person appointment that could be completed in a completely virtual format, we recommend considering equity outcomes while also utilizing the formula laid out in this report to calculate any waste avoided through telehealth appointments.

Research Objective 2 Recommendations: Using the ideal business case template described later in this report, consider alternative locations for exploring the implementation of a renewable microgrid to support increased energy needs.

Research Objective 1: Waste Assessment

Our first objective was to assess the amount of waste avoided due to increased telehealth appointments during the COVID-19 pandemic. The following research tasks were identified:

1. *Find Background Information*: Interview external stakeholders, review waste assessment literature & past waste assessments of similarly sized hospitals, review waste and auditing operations, and record the increase of telehealth usage
2. *Interview Practitioners and Professionals*: Interview Environmental Services and physicians of varying departments, and record types and quantities of items disposed of during a "typical" in-person appointment
3. *Compile Data and Analyze Results*: Determine the amount of waste generated per appointment, use WMC telehealth data to scale up findings to the total amount of waste avoided, create a formula to replicate the process of determining the waste avoided

<u>Methods:</u>

Literature Review: Using The Ohio State University library databases, we reviewed a collection of 17 peer-reviewed journal articles, newspaper articles, and hospital waste reports. When researching, we focused on literature at the intersection of telemedicine, the COVID-19 pandemic, and the waste reduction in hospital settings.

Informational Interviews: In the last three months, we completed both live interviews and made inquiries via email with a total of 7 WMC professionals. We connected with two Internal Medicine Physicians, a Sourcing Analyst, a Nurse Manager, a Clinic Manager, a Hematology Internist, and the Senior Director of Information Technology. In interviews with the physicians, we asked for a step-by-step run through of an in-person appointment (which could be replaced by a telehealth appointment). We also asked about the impacts of telehealth on their daily practices, the benefits and costs of telehealth they have witnessed, and how telehealth has affected the amount of refuse generated. From the Sourcing Analyst, Nurse Manager, and Clinic Manager, we obtained estimates of waste/paper materials (After-Visit Summaries and exam table paper) as well as the specific products used at the WMC. The Senior Director of Information Technology gave us the information for the top five diagnoses of telehealth appointments at the WMC.

Data Analysis: We compiled the data we received from our literature review and informational interviews, then determined the amount of waste created by one in-person appointment (which could be replaced with a virtual or phone appointment). Using sourcing information and specific WMC telehealth data, we created an equation and calculated the amount of waste avoided for telehealth appointments since March 2020.

Data Collected

Literature Review Takeaways

- Telemedicine has many meanings. It could be considered a phone call, video call, messaging through a secure portal, such as MyChart (Schwamm, 2014).
- COVID-19 has increased the amount of hospital-generated waste. Wuhan, the COVID-19 epicenter of China, saw an increase of medical waste from between 40-50 tons/day before the outbreak to about 247 tons on March 1st, 2020 (You et al., 2020).
- Telemedicine has the potential to reduce hospital-generated waste by reducing the in-person patient flow. A waste assessment done in Ethiopia found most health centers had a

positive linear relationship between the amount of healthcare waste generated and total patient flow (Meleko et al., 2018).

- Paper is one of the largest contributors of solid waste in a hospital setting. The US health industry produces 3.4 billion pounds of solid waste each year and 50% of that is paper and cardboard (Yellowlees et al., 2010).

Informational Interview Takeaways

- 5 Most Common Telehealth Appointments at WMC: essential hypertension, generalized anxiety disorder, major depressive disorder, anxiety disorder, obstructive sleep apnea (Mitchell, 2021).
- After-Visit Summaries, on average, range from 3-6 pages, but can be up to 15 pages in certain circumstances (Susi, 2021). These are printed on standard copy paper.
- For our scope, waste generated per appointment included: An After-Visit Summary, the medical exam table paper, and a pump of sanitizer (Tayal & Schamess, 2021). No gloves would be used in an in-person appointment that could be transferred to an online appointment (Garrison, 2021).
- The WMC uses two varieties of medical exam room table paper. The WMC purchases the Owens & Minor Smooth Exam Table Paper (Mason, 2021). The dimensions of one roll are 18 in x 225 ft. The weight of one roll is 1.5 lbs.
- There are benefits of in-person appointments not captured in the numbers. Dr. Schamess noted that conversations with patients often lead to additional questions and thus, preventative measures of patients' concerns.

Data Analysis

Based on our waste assessment, we developed the following equation to assess waste avoided by telehealth:

Final Equation:

$$y = 0.0000325x$$

y = amount of waste avoided
x = number of telehealth appointments

Simplification Process:

$$y = \frac{\frac{4.5x}{100} + 1.5\left(\frac{3x}{225}\right)}{2000}$$

Simplify $\frac{3x}{225} = \frac{x}{75}$

$$y = \frac{\left(\frac{9}{2} \times \frac{x}{100}\right) + \left(\frac{3}{2} \times \frac{x}{75}\right)}{2000} = \frac{\frac{9x}{200} + \frac{x}{50}}{2000}$$

Simplify $\frac{x}{50} = \frac{4x}{200}$

$$y = \frac{\frac{13x}{200}}{2000} = \frac{13x}{400000} = 0.0000325x$$

This equation was based on the following data points:

- Average After-Visit Summary ranges from 3-6 pages of copy paper per appointment (for calculations we used the average, 4.5)
- Average amount of medical exam paper used per appointment was found to be 3 ft
- Copy paper weight: 100 sheets = 1 lb
- Owens & Minor MediChoice Smooth Exam Table Paper specs: 225 ft/roll and 1 roll = 1.5 lbs
- 1 ton = 2000 lbs

Results

Based on the equation above, and the number of telehealth appointments since March 2020 (486,036), the WMC avoided 15.8 tons of solid waste during that time frame. In context, the solid waste avoided due to telehealth makes up about .26% of the total amount of solid waste the WMC produced in the last year (6,000 tons). In the future, this waste formula can be utilized as a part of the larger dashboard the WMC IT center has created.

Justice and Equity in Telehealth

Telehealth has the potential to increase justice and equity when accessing health care. With services occurring over the phone or online, patients can be more flexible with their scheduling and attendance at these digital health appointments. By expanding the role of telehealth in our health care systems, patients who have access to technology can engage in accessible ways that might not have been possible in the past. It also provides increased access for those who have transportation and physical mobility concerns as there is a decreased need for physically traveling to a location (CDW, 2020). Financial equity is another benefit of telehealth. Although medical professionals are still figuring out how billing and insurance will handle telehealth services moving forward, there is increased understanding that telehealth will have financially accessible options for those who are under-insured or uninsured (CDW, 2020).

Despite its many advantages, telehealth could result in potential injustices and equity concerns. Inequitable access to healthcare exists without telehealth in the equation, however, the increased use of telehealth services poses unique challenges (Pierce & Stevermer, 2020). Although the use of technology does provide increased flexibility for most individuals, it is important to consider that not everyone has access to technology, broadband, or cell service that is necessary to access these services. Specifically in rural areas, the digital divide that exists does not support accessible internet-based services. Although some such individuals might have access to technological devices that would allow them to utilize telehealth services, the larger challenge is the access to broadband, internet, or cell service (Pierce & Stevermer, 2020).

Another area of telehealth that needs to be explored further is how racial disparities exist within these services. Studies indicate that Black, Indigenous, and communities of color (BIPOC) experience disproportionate rates of lack of healthcare access. Also, the quality of healthcare among BIPOC communities is less than their white counterparts (Pierce & Stevermer, 2020). As such, it is important to ensure that telehealth not only accounts for physical, financial, and technological accessibility, but that it does so with specific attention to racial disparities. There needs to be better understanding of health outcomes in BIPOC communities, and the development of trust through telehealth or phone call visits. This is vital in ensuring that those who have been disregarded in physical health spaces, can be heard, understood, respected, and assisted through telehealth services (Pierce & Stevermer, 2020).

Limitations and Discussion

Even though the waste avoided due to telehealth visits is a relatively small amount of the WMC's total waste generation, this research is still useful. The WMC has a dashboard of time savings, gasoline savings, and carbon emission savings since March 2020, so our waste equation will help the WMC have a more complete view of the impacts of telehealth.

The main limitation of the study is the lack of prior research in waste reduction from telehealth appointments. With COVID-19, telehealth skyrocketed this past year, making it a relatively new field of study. When conducting our literature review, we found it challenging to find other studies analyzing the waste saving benefits of telehealth. This limited our ability to compare our results to past findings. Another obstacle we faced was the COVID-19 pandemic. Due to the virtual nature of this semester to ensure safety, we were not able to conduct any of our interviews/surveys in person. While we are satisfied with the outcome of our virtual interviews, we acknowledge that the pandemic was a barrier we had to overcome.

Recommendations

Based on our findings, our group recommends that the WMC continues to utilize telehealth for appointments that do not have a physical attribute to them, such as medication checkups or in other circumstances where no physical exam is required. While the waste savings from telehealth are small relative to total WMC waste, the size of the waste avoided was still significant. We acknowledge as COVID-19 wanes in the U.S. that virtual meetings will likely decline. However, owing to telehealth's lower cost for patients and providers and environmental advantages, we hope and expect that WMC will increase telehealth in the long term.

Further, it is also important to consider justice and equity in the continued development of telehealth services. Telehealth provides increased accessibility across technological, physical, and financial bounds, so keeping this service available is important for the entire Columbus community. However, our group also recommends asking who would be left behind in these advancements. As such, how BIPOC communities interact with telehealth services should be evaluated further to better understand how telehealth could better contribute to environmental, social, and health care justice.

While we believe our project was a great starting place, we acknowledge that it was just that: a place to start. Due to the limited prior studies on the waste saving benefits of telehealth, we essentially had to form a methodology for this type of study. We hope that our study inspires more complex analyses evaluating both waste savings, telehealth, and their intersection at the WMC. We believe it would be beneficial to study waste in the form of time. While we found this to be out of scope, as we were assessing physical waste, we found throughout the study from our interviews that time was also an asset saved, both for the doctors and the patients. In fact, the value of time wasted/saved is commonly used by economists and businesses in cost-benefit analysis and should be monetized in future evaluations of telehealth. Additionally, we have found that justice and equity are crucial to acknowledge when assessing telehealth. In order to provide greater access to telehealth services at the WMC, we recommend diving further into these components of telehealth to understand how to make telehealth more accessible and increase awareness among patients and health care providers.

Research Objective 2: Renewable Microgrid

The increased usage of Telehealth services also raises questions regarding the need for energy resiliency. The WMC has a data center housed at the Ackerman complex, and this data center is a crucial piece of the hospital system. Disruption in the data center's energy resources can have serious consequences. There are multiple ways to increase the resiliency of an electrical power source, but the option that will be discussed in this section is a renewable energy microgrid. A microgrid is a "local energy grid with control capability, which means it can disconnect from the traditional grid and operate autonomously" (U.S. Department of Energy, 2014). Further details on how a microgrid works can be found in the Appendix.

<u>Methods</u>

In the last three months, we conducted 8 informational interviews with various stakeholders and experts in the energy and microgrid sector. We inquired about microgrid costs, requirements, benefits, renewable energy sources, and their specific professional experiences. We also reviewed many pieces of literature, including energy reports, site specifications, and microgrid research. Lastly, we conducted a policy analysis of current and upcoming pieces of legislation that would impact funding for renewables and microgrids.

<u>Ackerman Data Center Microgrid</u>

Before building a business case for a renewable microgrid supporting the Ackerman Data Center, we first determined what a microgrid would look like at this site. Due to a regulation put in place by the National Fire Protection Agency (NFPA), all healthcare facilities that contain patients on life support systems must have generators as their primary backup system (Woodstock Power Company, 2020). Similar to other hospitals, the WMC utilizes diesel backup generators to fulfill this requirement. Microgrids are not currently approved as primary backup systems for healthcare facilities, such as hospitals. The Ackerman Data Center is a part of the WMC hospital system, and it is therefore under the same requirement. As a result, the proposed microgrid for the Data Center would act as a secondary backup system in case the primary backup generators fail.

Assuming that the proposed microgrid project at the Ackerman Data Center would be sourced with solar energy, the next area to look at would be the site-specific technicalities that would be relevant to the microgrid project being proposed at that location. Theoretically, the energy-generating portion of the microgrid would be placed on the roof in an unshaded area. This would include the solar panels and the accompanying equipment. The other components of the microgrid would be located indoors and preferably close together. These components would include the controller, the hardware technology, and access to the software technology that would need updates and regular maintenance checks. The solar power generation on the roof would feed directly into the microgrid, thereby reducing transmission loss as much as possible. A mockup of the solar apparatus was developed with the help of Engie, one of OSU's energy partners. The schematic shows how the solar energy generation system would work at the Ackerman location. The template was created using a software program that allows the user to design and place mock panels on a specified site. The template estimates the system's physical specifics, along with important data points, such as annual energy production, performance ratio, and average monthly energy production. The mockup was designed to support the Data Center's average daily energy usage, which is roughly 15,000 Kwh. In the Appendix, Figure 2 shows a visual of the solar apparatus, and further details on the solar mockup are included in the appendix.

Feasibility of Ackerman Microgrid

Based on our evaluation, we found that a solar-powered microgrid is not a feasible option for the Ackerman Data Center, in technical and monetary terms. By itself, this project would not be a realistic solution at the discussed location.

Resiliency Considerations

One of the primary goals of the project would be to increase the resiliency of the Data Center's energy source. For a microgrid to accomplish this task, it would need to be built in such a way that it would not be susceptible to the same threats that would take out the larger power grid. According to Michael Gregory, the Director of Safety and Emergency Preparedness at the WMC, the most prominent threats to energy sourcing at the Ackerman Data Center are likely to be severe weather events. In Ohio, this would primarily include flooding and high winds. The proposed microgrid would be sourced with solar energy from panels installed on a roof. High winds, or a tornado, could very easily damage the exposed panels and render the microgrid without a source of energy. This factor reduces the practicality of the project.

Another aspect of resiliency to consider is the resilience of the WMC's current energy supply. According to Tim Bray, Customer Account Manager for AEP Energy, all of the buildings on OSU's central campus are already maintained at a high level of resilience. According to Bray, OSU's internal energy grid has a high degree of resilience built into the system, with adjustments such as underground energy cables that protect the grid from external threats. Part of the resiliency built into the OSU grid is redundancy, making it so that multiple systems and energy sources would have to go offline before the Ackerman Data Center would ever lose power, which is unlikely to happen, and has historically been uncommon (Gregory, 2021). Thus, the Data Center is already within a highly resilient energy system that would only benefit very slightly in terms of resiliency from the addition of a renewable microgrid.

Cost-Benefit Analysis

The estimated cost for the Ackerman Data Center renewable microgrid is $3 million. This approximation is based on data from case studies and microgrid research. A healthcare facility called Kaiser Permanente implemented a solar powered microgrid in California in 2018. Their microgrid cost about $4.7 million, with admittedly more components than necessary, and AEP has completed microgrid projects with a cost of about $2 million(Baruch, 2021; Bray, 2021).

There are several options that could potentially offset some of the upfront costs of the project, but these have their own benefits and drawbacks. One option to offset cost would be to use the energy stored by the microgrid during peak times. In the summer on hot days, buildings use a higher amount of energy to stay cool. During these peak energy hours, the microgrid could be turned online so that the renewable solar energy would offset the high energy usage, and thus save OSU in energy costs. However, using the stored energy during these times could potentially leave the microgrid without stored energy when an emergency occurs. This would reduce the microgrid's capacity to add resiliency to the system.

Another difficulty of this solution is that electricity costs in Ohio are already relatively low, especially compared to other areas like California and New York. Therefore, peak time microgrid usage would only save the University a moderate amount of money. To be specific, peak energy usage in Ohio often occurs during the summer months from June through September from the hours of 2 p.m. to 6 p.m. (Office of the Ohio Consumers' Council). This peak energy time period accounts for less than 6% of the year. Based on data from energy usage and cost records from the year 2019, the average monthly cost of energy at the Ackerman Data Center building is about $44,400. One sixth of that cost per day would be about $247, which would be the cost savings from using the microgrid during peak times. Therefore, the cost savings per year would be about $29,600, which is about 6.5% of the total energy costs for that building in a year. Assuming that the microgrid costs about $3 million to construct, then it would take over one hundred years for the peak time usage technique to make up for the cost of the microgrid.

If the solar energy system were used as a consistent source of energy, then the cost savings would be significantly higher. The solar mockup that was discussed above has the capability of serving the energy needs of the entire building throughout the year. However, the project being discussed in this report is not meant to serve as a replacement energy source for the traditional energy grid. The goal of the project discussed is to serve as a backup source of energy. This purpose limits the usage of the solar energy generation, and therefore limits the options for cost recovery. For buildings like the Ackerman Data Center, which are already protected by layers of resiliency, a potential option to consider would be to implement the solar energy system without the microgrid. This would be a less expensive option with more possibility of monetary return, as long as the solar energy could be utilized consistently throughout the year. However, the regulations on energy sourcing, particularly for healthcare facilities, are stricter, which could make the option of continuously using solar power difficult to implement.

Another cost offsetting option that was considered was selling back excess produced energy to the provider, AEP. However, when presented with this option, Bray, from AEP, felt that it would not be feasible given the size of the University's energy grid. Due to how large and layered OSU's energy system is, any excess energy produced by the microgrid would need to be transmitted throughout the OSU energy grid before it could be transmitted to AEP. By the time this would occur, much of the energy produced would either be utilized by other building loads or lost in transmission. (However, to the extent the excess energy could be used elsewhere at OSU, it would at least provide some cost savings).

An additional cost issue is the problem of constructing the microgrid onto an already existing building. According to Seth Baruch, the National Director for Energy and Utilities at Kaiser Permanente, microgrids often require a different system of wiring than what is put in place for traditional energy sourcing. Rewiring a commercial building can be expensive. On average, rewiring costs about $2.65 per square foot (HomeGuide, 2021). The Ackerman building is about 30,000 square feet in size, which would lead to a cost of approximately $79,500 to rewire the building so it can accommodate a microgrid. In addition, roof stability for the solar panels would potentially be an issue. In general, roofs can last anywhere between 10 and 40 years (J&M Roofing, 2020). Solar panels generally last about 25-30 years (Berg, 2018). The Ackerman complex was built in 1984 (Corna, 2017). This would make the roofs at the Ackerman building over 30 years old. There would be high potential that the roof would not last long enough to sustain the lives of the panels. The solution then, would be to replace the roofs, however that would add another cost to the project. Roof replacement for a commercial building costs on average about $4.00 per square foot (Standpoint, 2020). The roof space being considered for the Ackerman Data Center microgrid would be about 46,000 square feet (Landow et al., 2020). Therefore, the cost for replacing the roof to ensure it is stable and a long lifetime would be about $184,000. These costs would be in addition to the $3million price tag of the microgrid itself.

Ultimately, we found that making the microgrid cost effective would push it outside of its intended usage at the Ackerman Data Center. Based on data from the years 2017-2019, if the microgrid were to save as much money as it cost over the span of ten years, it would need to be used continuously for over eight months out of the year. If the consideration for this project was to investigate the feasibility of making a renewable microgrid as the Ackerman Data Center's main source of energy, then this estimation would be encouraging. However, since that is not the goal being considered at this time due to the NFPA regulatory barriers in place, the microgrid project under consideration is not feasible.

Microgrid's Ideal Business Case

A renewable energy microgrid may not be a realistic solution for the Ackerman Data Center, but that does not mean that the WMC should discontinue their consideration of microgrids. The following section outlines the ideal conditions and circumstances for the implementation of a microgrid.

Key Business Case Considerations:

- Location: preferably rural, and added to a building in the construction phase
- Funding: research funding, federal grants, third party ownership of solar energy system
- Policy: Biden administration infrastructure plan, and leverage of clean energy tax credits
- Future Outlook: decreasing cost for solar technology and microgrid technology over time
- Community: local support is ideal, and communication with on-site stakeholders

The first circumstance to consider is location. The Ackerman Data Center is well insulated within OSU's main campus energy grid. However, there are other building locations that have less energy resilience. For instance, the OSU East Hospital has had several issues with power outages over the last few years (NBC4 Staff, 2018). Building locations that are more rural are less likely to be protected by the type of resiliency measures that are undertaken in more urban areas. As a result, rural locations would benefit more from the presence of a microgrid that can generate its own power through renewable sourcing.

Additionally, it would be ideal for a microgrid to be built within the construction phase of a building rather than installing one onto an existing structure. By doing so, the highly complex technicalities of reconfiguring an existing building would be avoided. There would also be the added benefit of being able to adjust aspects of the overall design while the building and microgrid system are still in the planning phase.

The cost of a microgrid and the potential for return on investment is a crucial aspect to consider. According to Wanda Dillard, the Director of Community Development for the WMC, one key strategic decision could be to fund the operation as a research project. Research funding is more readily available, and often longer term than other types of funding such as community development grants. Also, the WMC puts a high priority on research and innovation (Wexner Medical Center, 2021). Using a renewable energy microgrid project as a platform for research could open the door to a wide array of research opportunities and could significantly contribute to the study and development of microgrid technology.

Another option would be government grants. According to Baruch, the Kaiser Permanente facility built their microgrid using the support of a $4.7 million grant from the government of California. Recent policies in Ohio, (e.g. House Bill 6) may make it difficult to secure any kind of renewable energy funding from the state government in Ohio (Sawmiller, 2020). However, the Biden administration has proposed policies that could increase the availability of federal grant funding. For example, the Biden administration's $2 trillion infrastructure plan would require all states to generate electricity from climate safe fuel sources by 2035, with $180 billion directed towards research and development (Luhby et al., 2021).

Another cost saving consideration js the funding the solar energy system. The microgrid has its own structure and technology, while the solar generator is a separate system that would feed into the microgrid. One way to fund this energy apparatus would be to make an agreement with a private third-party company who would build the solar generator and own it, and then sell the produced energy back to OSU. According to representatives from AEP**,** OSU has previously made an agreement like this, which has led to the construction and operation of several solar panels on the roof of the Recreation and Physical Activity Center (Bray, 2021). Kaiser Permanente has used this funding method as well for their solar energy production, with a third-party operator owning and maintaining the solar structure and selling the energy produced to the hospital at a cheaper rate than traditional energy, because of the low operation costs for solar. Kevin Kent**,** who works in the microgrid industry, suggested that another avenue to consider is having a private energy company donate funds for the construction of the solar generator. The logic behind this decision would be based on tax incentives. OSU is a nonprofit organization, and therefore does not directly benefit from renewable energy tax credits. A private company, however, could donate the renewable energy operation and gain financially through the resulting tax benefits. The outlook for potential gains from renewable energy tax benefits is positive, especially given the strong support from the Biden administration. Recently the Biden administration expressed support for the extension of many clean energy tax credits that encourage renewable energy development (Natter, 2021).

The future outlook for the cost of a solar powered microgrid also becomes increasingly feasible with time. According to Bray**,** the cost of solar has been on a steady decline, and in the next ten years, solar energy costs could become low enough that it would offset some of the major expenses associated with renewable energy microgrids; and microgrid technology itself is also following that same trend. According to Baruch**,** even though the Kaiser Permanente microgrid was built just a few years ago in 2018, the costs of some of the technology that was utilized for that project have already dropped significantly, from about $ 2-3 million dollars to a range in the hundreds of thousands. Continuing to monitor the costs of solar energy and microgrid technology could be a key strategy for correctly timing the implementation of a renewable energy microgrid project. The technology costs may not be low enough yet, but this may change in just a few years.

In addition to the factors of cost, location, and policy landscape, the level of local community support is important. Baruch pointed out that when Kaiser Permanente was considering what facility at which to install the microgrid, the opinions and perspectives of the facility leaders were a crucial determinant. Community cooperation and support were key aspects to the success of the operation. Therefore, having local support for the project is the ideal situation for the implementation of a microgrid, because community cooperation can reduce resource waste and improve the efficiency of construction (Baruch, 2021).

Recommendations

While we determined the solar-powered microgrid at the Ackerman Data Center is not feasible, research into the topic of renewable energy microgrids has uncovered a range of opportunities and alternatives that may make such a project feasible for the WMC. We recommend that the WMC continues to consider renewable microgrids as an option. By continuing to explore the available opportunities to implement a renewable microgrid, the WMC has the potential to contribute to the development of an innovative field that is integral to the future of renewable energy in healthcare. California's Office of Statewide Health Planning and Development has stated, in reference to healthcare facilities, that microgrids can "increase reliability and enhance utilization of renewable generation" (OSHPD, 2021). The nonprofit organization, Health Care Without Harm, wrote a letter addressed to the Biden administration that advocated for the funding of renewable microgrid construction at healthcare facilities (Health Care Without Harm, 2021). Therefore, it is logical to continue to consider renewable energy microgrids at the WMC, especially as the technology becomes more accessible and the support for renewable energy increases.

Conclusion

Through our research project, we developed two broad conclusions. For the waste assessment objective, we were able to identify that using telehealth appointments, the Wexner Medical Center has averted approximately 15.8 tons of waste since the start of the COVID-19 pandemic. For the renewable energy microgrid business case, we determined that the Ackerman Data Center may not be an economically feasible location, but there is still a potential business case for a renewable microgrid at the WMC.

We recommend that the WMC continues to invest in telehealth for appointments that have no physical components to continue to reduce physical waste and provide other cost and environmental benefits. We believe our formula can be utilized to develop further data related to solid waste savings via telehealth. The data on virtual healthcare is still limited, and the current global pandemic is rapidly changing the technology and its usage. As a result, this report can only address the available preliminary data that has been gathered. We hope that research on this topic will continue to be prioritized, and that more healthcare facilities will contribute their own data to this field. Additionally, we also believe that it is vital to incorporate justice and equity into conversations surrounding telehealth. Telehealth could increase or limit accessibility depending on an individual's given situation. Further research on this topic will assist the WMC to ensure they are marketing to those who will benefit most from telehealth and working to improve the accessibility of the service overall.

Additionally, we recommend that the WMC continues to investigate the construction of a renewable energy microgrid. We do not recommend the original Ackerman site due to the current resilience of the location, and its high costs. However, we hope that our ideal business case can serve as an outline as to how a renewable microgrid, under the right conditions, could be a worthwhile investment for the WMC. With the ideal location, sufficient funding, policy leveraging, and local stakeholder support, a renewable energy microgrid could become a profitable project. This possibility will likely increase with time also, as technology improves and costs go down.. Also, the technicalities and specifics of microgrid implementation are difficult to estimate, and the findings in this report are limited by this difficulty. Further research and exploration into the topic would be beneficial in expanding the initial findings presented in this report.

We hope that our project assists the WMC in its sustainability efforts, and that we have successfully outlined why telehealth and renewable energy microgrids can play an important role in future sustainable development.

References

Armstrong, Luke. (2019, December 30). How Long Do Commercial Roofs Last?. Retrieved from: restorationmasterfinder.com/restoration/how-long-do-commercial-roofs-last/.

Baruch, Seth. Informational Interview. 7 April 2021.

Berg, N. (2018, May 11). What will happen to solar panels after their useful lives are over? Retrieved April 13, 2021, from https://www.greenbiz.com/article/what-will-happen-solar-panels-after-their-useful-lives-are-over#:~:text=But%20the%20solar%20panels%20generating,t%20long%20from%20being%20retired

Bray, Timothy. Informational Interview. 16 March 2021.

CDW. (2020, June 13). How telehealth is Evolving Healthcare. Retrieved from https://www.cdw.com/content/cdw/en/articles/professionalservices/2020/07/13/how-telehealth-is-evolving-healthcare-from-covid-19-to-rural-locations.html?cm_ven=acquirgy&cm_cat=google&cm_pla=SEO+Articles&cm_ite=Telehealth+E&ef_id=Cj0KCQjwgtWDBhDZARIsADEKwgNVMjB0Rulr9stAgO6N6zitSbkuLirN4KMXTMlHq4Eb_9BKxli_jbMaAqSeEALw_wcB:G:s&s_kwcid=AL!4223!3!473108199520!e!!g!!benefits%20of%20telemedicine&gclid=Cj0KCQjwgtWDBhDZARIsADEKwgNVMjB0Rulr9stAgO6N6zitSbkuLirN4KMXTMlHq4Eb_9BKxli_jbMaAqSeEALw_wcB

Climate Central. (2020, September 30). Power off: Extreme Weather and Power Outages. Retrieved April 13, 2021, from https://medialibrary.climatecentral.org/resources/power-outages

Corna Kokosing Construction Company. (2017, August 01). OSU Ackerman Building Complex. Retrieved April 13, 2021, from https://corna.com/project/600-690-700-ackerman/#:~:text=The%20majority%20of%20the%20renovation,which%20includes%20approximately%20108%2C000%20GSF.

Dillard, Wanda. Informational Interview. 17 March 2021.

Garrison, Jennifer. Informational Interview. 23 March 2021.

Gregory, Michael. Informational Interview. 16 March 2021.

Hameed, Zia. (2020). Re: What is the difference between smart grid and microgrid infrastructure?. Retrieved from: https://www.researchgate.net/post/What_is_the_difference_between_smart_grid_and_micro_grid_infrastructure/5e7e3d8fa3d1c474ed6529c5/citation/download.

Health Care Without Harm. (2021, January 19). Recommendations for the Biden-Harris Administration. Retrieved April 13, 2021, from https://noharm-uscanada.org/sites/default/files/HCWH%20Recommendations_Biden-Harris%20Administration%201-14-2021.pdf

HomeGuide. (2021). Electrical Wiring Installation Cost. Retrieved April 13, 2021, from https://homeguide.com/costs/cost-to-rewire-a-house#:~:text=The%20average%20cost%20to%20wire%20a%20house%20is%20%241.56%20to,cost%20to%20wire%20the%20home.

J&M Roofing. (2020). What Is The Average Lifespan Of A Commercial Roof? www.jandmroofing.com/what-is-the-average-lifespan-of-a-commercial-roof

Kelly, Morgan. (2014, October 23). Two Years after Hurricane Sandy, Recognition of Princeton's Microgrid Still Surges. Retrieved from:

www.princeton.edu/news/2014/10/23/two-years-after-hurricane-sandy-recognition-princetons-microgrid-still-surges.

Kent, Kevin. Informational Interview. 24 February 2021.

Landow et al. (2020, April 22). Prime Locations for Nine Megawatts of Solar Energy on Ohio State's Main Campus.

Laskey, Scott. (2021, January 25). What Is the Best Roof Material for Solar Panels? 5 Factors to Consider. Sandbar Solar & Electric. Retrieved from: sandbarsc.com/news/best-roof-for-solar-panels/.

Lifehacker International. (2020, August 12). How to estimate the data you spend streaming music and video. Retrieved April 12, 2021, from https://www.lifehacker.com.au/2020/08/how-to-estimate-the-data-you-spend-streaming-music-and-video/

Livecare Health. (2018, November 07). How much data does a 10-minute telehealth visit require? Retrieved April 12, 2021, from https://livecare.ca/faq/how-much-data-does-10-minute-telehealth-visit-require

Luhby, T., Lobosco, K., & Sullivan, K. (2021, March 31). Here's what's in Biden's infrastructure proposal. Retrieved April 13, 2021, from https://www.cnn.com/2021/03/31/politics/infrastructure-proposal-biden-explainer/index.html

Mason, Maria. Informational Interview. 20 March 2021.

Meleko, A., Tesfaye, T., & Henok, A. (2018). Assessment of Healthcare Waste Generation Rate and Its Management System in Health Centers of Bench Maji Zone. *Ethiopian Journal of Health Sciences*, *28*(2), 125–134. https://doi.org/10.4314/ejhs.v28i2.4

Mitchell, Brian. Informational Interview. 21 February 2021.

Natter, A. (2021, March 25). Renewable Energy Backers Want 10-Year Tax Credits in Biden Plan. Retrieved April 13, 2021, from https://www.bloomberg.com/news/articles/2021-03-25/renewable-energy-backers-want-10-year-tax-credits-in-biden-plan

NBC4 Staff. (2018, July 06). Power Outage Affecting OSU East Hospital. Retrieved April 13, 2021, from https://www.nbc4i.com/news/local-news/power-outage-affecting-osu-east-hospital/1285198793/

Office of the Ohio Consumers' Counsel. (n.d.). Smart Grid: Dynamic and Time-of-Use Pricing. Retrieved April 13, 2021, from http://www.occ.ohio.gov/sites/default/files/publications/electric/Factsheet_Smart_Grid_Dynamic_Pricing.pdf

Pierce, R. P., & Stevermer, J. J. (2020). Disparities in use of telehealth at the onset of the COVID-19 public health emergency. *Journal of telemedicine and telecare*, 1357633X20963893. Advance online publication. https://doi.org/10.1177/1357633X20963893

S&C Electric Company. (2019, September 9). How to Build a Microgrid. Retrieved from: www.sandc.com/globalassets/sac-electric/documents/sharepoint/documents---all-documents/educational-material-180-4505.pdf?dt=637534174228688842. educational, 9 Sept. 2019.S&C Electric Company. (2021). Energy Storage for Microgrids. Retrieved from: www.sandc.com/en/solutions/energy-storage-for-microgrids/.

Sawmiller, D. (2020, July 30). Ohio needs Forward-Thinking clean energy policy. Retrieved April 13, 2021, from https://www.nrdc.org/experts/daniel-sawmiller/ohio-needs-forward-thinking-clean-energy-policy

Schamess, Andrew. Informational Interview. 4 March 2021.

Schwamm, L. H. (2014). Telehealth: Seven Strategies To Successfully Implement Disruptive Technology And Transform Health Care. *Health Affairs*, *33*(2), 200–206. https://doi.org/10.1377/hlthaff.2013.1021

Sheppard Mullin Richter & Hampton LLP. (2020, December 23). Congress Extends Renewable Energy Tax Credits in 2021 Omnibus Spending Bill. Retrieved from: www.jdsupra.com/legalnews/congress-extends-renewable-energy-tax-98223/.

Standpoint. (2020). Evaluating the Cost of a Commercial Roof Replacement. Retrieved April 13, 2021, from https://www.standpointonline.com/standpoint-blog/evaluating-the-cost-of-a-commercial-roof-replacement#:~:text=The%20average%20cost%20for%20single,%2D%247%20per%20square%20foot.

Stout et al. (2018, April). Distributed Energy Planning for Climate Resilience. Retrieved April 12, 2021, from National Renewable Energy Laboratory

Susi, Sarah. Informational Interview. 24 March 2021.

Tayal, Neeraj. Informational Interview. 17 February 2021.

The California Office of Statewide Health Planning and Development (OSHPD). (2021, January 13). Microgrids for Healthcare Facilities. Retrieved April 13, 2021, from https://oshpd.ca.gov/wp-content/uploads/2021/01/White-Paper-ECM-1.21.21-A.pdf

Union of Concerned Scientists. (2016, August 30). The hidden costs of fossil fuels. Retrieved April 12, 2021, from https://www.ucsusa.org/resources/hidden-costs-fossil-fuels

United States Department of Energy. (2014, June 17). How Microgrids Work. Retrieved April 12, 2021, from https://www.energy.gov/articles/how-microgrids-work

Wexner Medical Center. (2021). Our mission. Retrieved April 13, 2021, from https://wexnermedical.osu.edu/about-us/our-mission

Woodstock Power Company. (2020, November 09). What are the Requirements for Hospital Backup Generators? Retrieved April 13, 2021, from https://woodstockpower.com/blog/what-are-the-requirements-for-hospital-backup-generators/#:~:text=In%20addition%20to%20being%20a,meet%20various%20requirements%20and%20standards

Yellowlees, P. M., Chorba, K., Burke Parish, M., Wynn-Jones, H., & Nafiz, N. (2010). Telemedicine can make healthcare greener. *Telemedicine Journal and E-Health: The Official Journal of the American Telemedicine Association*, *16*(2), 229–232. https://doi.org/10.1089/tmj.2009.0105

You, S., Sonne, C., & Ok, Y. S. (2020). COVID-19's unsustainable waste management. *Science*, *368*(6498), 1438–1438. https://doi.org/10.1126/science.abc7778

Appendix A: Important Figures

Dataset # 1: Ackerman Complex Helioscope Solar Estimates.pdf

Source: Caitlin Holley at Engie

Description: This report was created by Caitlin Holley from Engie using a software program that predicts the solar energy production annually at the Ackerman Complex. This report is a theoretical solar structure that is not currently in place, it provides information on predicted energy production, along with predicted technology specifications.

Figure 1. Microgrids and Smart Grids

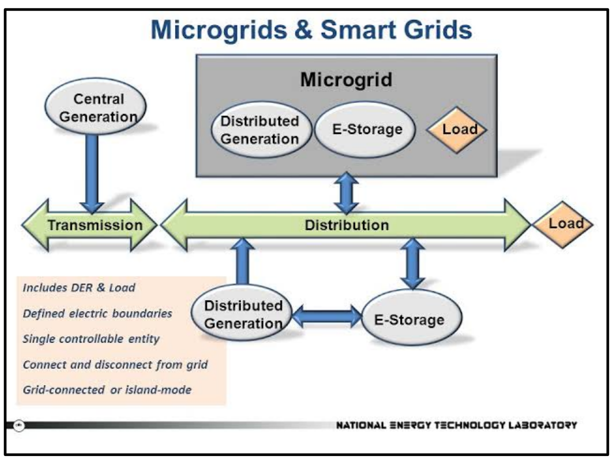

Figure 1 shows the differences between the traditional grid and the microgrid system. In the figure, the traditional grid is referred to as "Central Generation" and the one-way movement of energy is depicted by the blue arrow. The "Microgrid" section on the other hand has a two-way energy flow, storage capabilities, and the ability to be self contained.

https://www.researchgate.net/post/What_is_the_difference_between_smart_grid_and_micro_grid_infrastructure/5e7e3d8fa3d1c474ed6529c5/citation/download

Figure 2. Ackerman Complex Solar Site Map

Figure 2 is the proposed map of solar panels at the Ackerman Data Center. Most of the solar panels are located on the top floor of a parking garage. This map was created by Caitlin Holley at Engie.