Public Service Commission of Wisconsin Office of Energy Innovation
Critical Infrastructure Microgrid and Community Resilience Center Pilot Grant Program

ATTACHMENT A - COVER SHEET

SECTION I - Provide information summarizing the project proposal.				
Project Title:	Feasibility Study for a Microgrid at 1600 Emil St and 1501 W Badger			
PSC Grant Request ($):	**Applicant Cost Share ($):**	**Project Total ($):**		
$50,000	$5,600	$55,600		
Choose one Eligible Activity				
×Critical Infrastructure Microgrid Feasibility Study Level 1 and 2	☐ Critical Infrastructure Microgrid Feasibility Study Level 3	☐ Community Resilience Center Feasibility Study		
SECTION II - Provide information for your organization, signatory, and primary contact for the project.				
Applicant Type:	×City	☐ Village	☐ Town	☐ County
☐ Tribal Nation	☐ Wisconsin Technical College System			
☐ University of Wisconsin System	☐ K-12 School District	☐ 501(c)(3) nonprofit		
☐ Municipal Utility (water, wastewater, electric, natural gas)	☐ Hospital (public or nonprofit)			
Name (on W-9):	City of Madison			
Address (on W-9):	210 Martin Luther King Jr. Blvd			
County or Counties Served by Project:	Dane			
DUNS Number or CAGE Code:	076147909			
NAICS Code:				
Authorized Representative/Signatory (Person authorized to submit applications and sign contracts)		**Primary Contact** (if different from Authorized Representative)		
Name:	Satya Rhodes-Conway	**Name:** Stacie Reece		
Title:	Mayor	**Title:** Sustainability Program Coordinator		
Phone:	608-266-4611	**Phone:** 608-261-9823		
E-mail:	Mayor@cityofmadison.com	**E-mail:** sreece@cityofmadison.com		
Signature of the Authorized Representative				

Office of the Mayor
Satya Rhodes-Conway, Mayor
City-County Building, Room 403
210 Martin Luther King, Jr. Blvd.
Madison, WI 53703
Phone: (608) 266-4611 | Fax: (608) 267-8671
mayor@cityofmadison.com
cityofmadison.com

August 6, 2021

Public Service Commission of Wisconsin
Office of Energy Innovation
4822 Madison Yards Way Madison, WI 53705

Dear Administrator Nieto:

I am pleased to submit the City of Madison's project proposal *Feasibility Study for a Microgrid at 1600 Emil St and 1501 W Badger Rd* to the Public Service Commission of Wisconsin's Office of Energy Innovation for the Critical Infrastructure Microgrid and Community Resilience Center Pilot Grant Program.

We are excited about this project as it represents an important step in the City's energy resilience planning to provide critical services to residents during a power outage along with other direct benefits. The project will also continue the City's efforts towards the goals of 100% renewable and net zero carbon. With the City's continued investments in infrastructure at this location, we believe this project will provide the necessary information to support future implementation of a reconfiguration to a microgrid.

We look forward to working with the proposal team if the project moves forward.

Sincerely,

Satya Rhodes-Conway
Mayor

City of Madison
Engineering/Streets Department Microgrid

Summary of Project Budget				
Line	**Description**	**PSC Grant Request**	**Applicant Cost Share**	**Total Project Cost**
1	Personnel	$4,000	$1,000	$5,000
2	Fringe			$0
5	Travel			$0
6	Contractual	$46,000	$4,600	$50,600
7	Other			$0
8	Indirect			$0
	Totals	$50,000	$5,600	$55,600
	% of Total	**90%**	**10%**	

Applicant Comments: The $45,000 Contractual line item includes Slipstream's technical support for the feasibility analysis. Slipstream will be responsible for the creation of the plan, including the systems sizing analysis, financial analysis, and environmental analysis. The $4,000 for the Applicant Personenel and $1,000 Applicant Cost Share Personnel is meant to include Madison staff labor hours. This will include the Sustainability Program Coordinator, Building Services Project Manager, and Engineering and Streets Department staff. The $ Applicant Cost Share Contractual is meant to include the 10% of Slipstream's total hours as cost share for technical analysis.

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Application Narrative

Project Description

The City of Madison seeks to perform a feasibility study for converting two adjacent city-owned facilities into an interconnected microgrid, enhancing the existing backup generators and solar photovoltaic (PV) system with the addition of battery energy storage, additional PV, and the necessary controls hardware. These facilities house the streets division and engineering operations and are city headquarters for three critical government functions: snow removal, road maintenance, and sewer maintenance. In addition, our offices in these facilities support other critical facilities such as police and firefighting and provide mapping services to a host of city agencies.

Both facilities are currently equipped with backup generators. While the engineering building has a natural gas-burning generator (300 kW) which can supply continuous full backup power, the streets division has a diesel burning generator (100 kW) which serves a limited set of critical loads in the facility and is reaching end-of-life. While the two facilities have a total of over 200 kW of solar PV (compared to average monthly peak demand of 138 kW), these are connected with grid-following inverters which cannot supply power during a grid outage.

The existing backup power systems ensure that these facilities can function in several critical ways during emergencies:

- During snow emergencies, a regular occurrence during the winter, the streets division performs and coordinates round-the-clock snow plowing operations.
- During heavy rain and flooding events, the streets division serves as a location to coordinate distribution of sandbags, the dispatch of Vactor trucks for resolving clogged storm drains and provides emergency coordination of several city agencies.
- Command centers for other critical government functions, such as water utility and public safety -- police and fire departments, coordinate with staff at the engineering and streets buildings.
- During emergencies and large public gatherings, management personnel are distributed throughout the city, including several at these facilities.

Current Challenges

There are several key challenges to our use of these facilities to provide resilience benefits to Madison residents in a way that is reliable, cost-effective, and sustainable:

- **Solar PV does not function during outages.** The existing solar arrays are connected to the building using grid-tied inverters which disconnect from the grid when an outage is detected. This safety protocol means that during an outage whether backup generators are functional or not, the solar arrays cannot supply power to the buildings.
- **Electrical configuration with open transition switches causes power interruptions.** Emergency power is currently supplied to the building with an open transition transfer switch, meaning that backup power cannot be switched on until grid power has been completely disconnected. This means that each transition causes a complete loss of power to the building, before emergency power is

supplied, and again when power is restored. This results in computer shutdowns and other disruptions to any work being performed at the facility. Because these transitions occur during or while preparing emergency response, this represents a significant risk to our operations.

- **Electrical configuration prevents grid support functions during abnormal grid conditions.** The facilities have substantial resources in the form of solar PV arrays and generators. However, the current electrical configuration means that during abnormal grid conditions, these resources disconnect from the grid, eliminating the possibility that they could be managed in coordination with the distribution utility to provide grid support services, potentially preventing or mitigating farther reaching disturbances.
- **Backup generators cause significant air pollution.** The natural gas- and diesel-burning generators cause significant local air pollution while running. As these are not utility-scale generators and are not designed for continuous operation, they are not maintained and operated with the level of emissions controls required of utility generators.
- **Backup generators operate inefficiently in load following mode.** Because the generators are the only source of backup power, they must constantly adjust their output to match load. This means that they are frequently operating outside of their most efficient operating points, and must constantly adjust output, increasing wear and tear.
- **Backup generator fuel supply is at risk.** The diesel generator supply is limited to on-site storage, competes with fleet vehicles which also require diesel, and ability to replenish this supply during an outage is at risk of local supply and road conditions. The natural gas generator is connected to the utility distribution network but does not have a backup supply. In addition, as seen during recent cold weather events in Texas[1] and the Northeast[2], natural gas supplies are increasingly at risk even without damage to distribution networks. Even when supplies remain available during extreme weather events, costs can increase to unsustainable levels.
- **Backup generators do not cover full facility load.** Due to the costs of generators and reconfiguring the on-site electrical distribution, the existing generators were not designed to cover the full facility load. While this may be acceptable for short-term, isolated outages, it limits our ability to provide services during longer-term or successive outages.

Microgrid Benefits

To mitigate these challenges, the City of Madison is exploring reconfiguring the facility as a microgrid, nearly doubling the size of the existing PV arrays, and adding a battery energy storage system (BESS), among several other changes and upgrades. In addition to

[1] Douglas, Erin. 2021. "Texas Largely Relies on Natural Gas for Power. It Wasn't Ready for the Extreme Cold." The Texas Tribune, February 16, 2021. https://www.texastribune.org/2021/02/16/natural-gas-power-storm/.

[2] Rivera, Karen. 2021. "US Northeast Spot Gas Prices, Power Prices Spike amid Lower-than-Normal Temperatures." S&P Global Platts, January 27, 2021. https://www.spglobal.com/platts/en/market-insights/latest-news/natural-gas/012721-us-northeast-spot-gas-prices-power-prices-spike-amid-lower-than-normal-temperatures.

eliminating or mitigating the challenges mentioned above, reconfiguration as a microgrid provides other direct benefits as well:

- **Automated demand management to reduce electric costs.** With a BESS on site, the microgrid controller can monitor total facility demand and automatically initiate battery discharge during peak times to reduce peak demand and limit usage during times with higher time-of-use (TOU) charges. The timing of electric vehicle (EV) charging can also be managed depending on rates and solar PV output to reduce utility costs.
- **Increased self-consumption of on-site solar generation.** While the facility is currently enrolled in net metering, excess generation is compensated at a rate of about 30% of the cost to purchase electricity. With BESS, excess solar generation can be used to charge for later re-use, reducing utility bills for the facility.
- **Cost-sharing opportunity with local utility for the BESS.** Madison Gas and Electric (MGE, the distribution utility) has expressed interest in exploring a cost-sharing structure where MGE would subsidize the cost to obtain and/or maintain a battery system. In this arrangement, MGE would operate the battery for grid benefits during normal operations, and we would operate the battery for resilience benefits during abnormal grid conditions.
- **Reduced carbon emissions.** By electrically integrating the two facilities, the aging diesel generator could be retired, and the less polluting natural gas generator could be run in coordination with the BESS and PV systems to provide sufficient power for both facilities when needed.
- **Greater support for EVs.** With more solar and BESS on site, we will be able to support a larger fleet of EVs, helping achieve our goal of being carbon neutral with transportation fuels by 2030.

Reference Materials List

We provide the following reference materials to support this proposal in the Reference Material section:

- Detailed electric utility billing information
- Contract compliance requirements
- Estimate of solar PV installation
- Letters of support and commitment
- City of Madison staff resumes
- Slipstream qualifications and resumes

Merit Review Criteria

Identification of Critical Infrastructure

The facilities we are considering for this project are Streets Division West at 1501 W Badger Road, and Engineering Operations at 1600 Emil Street, which adjoin on the back side. The facilities at this location provide critical “back of the house” services to the citizens of Madison, including snow removal, road maintenance, waste and recycling drop-off station, storm and sanitary sewer maintenance, support for other critical buildings (such as the water

utility, police department, and fire department) and mapping services. In support of their functions, both facilities also house critical computing resources.

1501 W Badger Road – Streets Division West

This building campus is home base for many Public Works city services, including street maintenance, street sweeping, pothole repair, snow plowing, road salting and sanding, yard waste drop off, recycling drop off, and fleet refueling. In total about 200 people work in the building, generally Monday through Friday. During emergencies or snow events the building can operate 24/7 as needed. The Streets Division website[3] includes more details about the functions of this facility.

1600 Emil St – Engineering Operations

This building is home base for sanitary sewer, stormwater, and facility operations, including landfills, along with land information and official map services and inspection. In total about 200 people work in the building, generally Monday through Friday. Some staff are on call and need to access the building outside of business hours. During emergencies, the building has the capacity to operate 24 hours a day. Details of some functions managed by Engineering Operations are provided below; additional detail can be found on the website.[4]

- **Sanitary Sewer.** Staff stationed in this building are responsible for:
    - 790 miles of sewer main, 29 lift stations, 10 miles of forced mains, 4.2 million feet of sewer laterals, 20,000 access structures in total moving 281 million gallons of wastewater per day.
- **Stormwater.** Staff stationed in this building are responsible for:
    - 275 miles of stormwater pipe, 26,611 stormwater inlets, 634 rain gardens, 2,000 acres of Greenway land, 578 planted medians, and 246 ponds which must function properly during rain events to mitigate flooding.
- **Facility Operations.** Staff eliminate preventable infrastructure issues while protecting the health and safety of citizens and the environment. The section also focuses on protecting citizens' investment by maximizing the useful life and capacities of infrastructure. Staff are specifically responsible for all buildings housing the police department, fire department, public works, downtown office, landfill, streets, and fleet along with the senior center and some parking garages.
- **Land Information Official Map.** Staff maintain the City of Madison official map, land base, and ownership parcel fabric, including GIS data on infrastructure assets. Mapping land information staff also provide professional and technical review, coordination, and maintenance of City of Madison official map land and utility records required to plan, develop, construct, and maintain public and private development projects. This team is critical to ensure that services are being provided in an equitable and efficient manner. While typically not considered a critical need during emergencies, an extended delay in the ability of this team to perform their function would have negative impacts on several city agencies which rely on accurate, up-to-date mapping data.

[3] https://www.cityofmadison.com/streets/
[4] https://www.cityofmadison.com/engineering

- **Inspection** Staff focus on projects being built in the City right of ways, and potential contractors looking to work through the Board of Public Works process. They ensure that infrastructure is built properly and to avoid premature failure. They also ensure that contractors are following Public Works rules, including diverse contracting requirements.

Key Partners and Stakeholders

The key partners will include the City of Madison and Slipstream. We will lead the project, while Slipstream provides technical support for the feasibility analysis. We will be responsible for stakeholder coordination as well as data compilation. Key people involved will be the Sustainability Program Manager, the Building Design Project Manager, and Engineering and Streets Division employees. Slipstream will be responsible for the creation of the plan, including the systems sizing analysis, financial analysis, and environmental analysis.

Slipstream, a nonprofit organization based in Madison with a mission to accelerate climate solutions for everyone, has worked with us previously on energy-related projects. More information on Slipstream, including resumes of key staff for this project, is included in the Reference Materials section.

Letters of Support

We have obtained the following letters of support for this project:

- **Office of the Mayor.** This project is being led by Madison's Sustainability Program, a function of the Office of the Mayor, with the Mayor's full support.
- **Madison Gas and Electric.**, the distribution utility for the site. MGE is currently involved in the planning and permitting process for two separate microgrids within their territory and expressed full support for this project.
- **University of Wisconsin-Madison.** Faculty in the Electrical and Computer Engineering Department are credited with originating the microgrid concept[5], and have been involved in development and support of microgrids for over two decades. Professor Giri Venkataramanan has committed to fill a technical advisory function during the feasibility study and beyond.

Additional Stakeholders

During the feasibility study, we will reach out to additional stakeholders to inform them of our plan and seek their input. We will inform the Madison City Council of the project and offer to present details at a city council meeting. We will also reach out to the neighboring businesses. There are several nearby institutions which could be included in a potential phase two expansion of the microgrid to provide even greater resiliency benefits to the city, including the Dane County Highway Department, a gas station and convenience store, a health clinic, and an adult day center.

[5] Lasseter, R.H. 2002. "MicroGrids." In 2002 IEEE Power Engineering Society Winter Meeting. Conference Proceedings (Cat. No.02CH37309), 1:305–8 vol.1. https://doi.org/10.1109/PESW.2002.985003.

Equitable and Local Contracting

For any goods or services procured during the feasibility study and into implementation of the microgrid, we will follow the equitable purchasing guidelines established by the City of Madison by seeking quotes or estimates from local and diverse businesses and meeting targeted business entity goals. In this way, the project will help advance racial equity and social justice. Achievement of these goals is supported by directories of targeted business enterprises provided by the city.

Project Resilience Objectives and Metrics

With the conversion of this facility to a microgrid, we will be able to provide services more reliably to the community during power outages, including snow plowing, stormwater management, and coordination with other critical city agencies.

- Support the city in achieving renewable electricity generation goals. Measured by the amount of generation provided by the solar PV system.
- Support the city in achieving fleet electrification goals. Measured by the size of the EV fleet supported on site with EV charging.
- Decrease on-site peak demand (kW), which will result in lower utility bills and reduce strain on the grid during times of high demand. Measured by the total expected kW reduced by the microgrid.
- Eliminate diesel exhaust emissions from the backup generator and reduce natural gas exhaust emissions. Measured by the amount of avoided natural gas and diesel consumption.
- Expand the functions of the Streets Division West that can operate during grid outages by fully integrating with the site electrical system. Measured by the amount of power supplied during outages.
- Improve existing building efficiency with redesign efforts, which would allow the microgrid to power more of the facility for a longer period of time. Measured by building energy modeling or other design analysis that would characterize energy savings as opposed to building code minimums in the absence of efficiency efforts.
- Reduce operating costs by enabling greater self-consumption of on-site solar PV generation, reducing backup generator fuel consumption, and implementing demand management and time-of-use energy management through microgrid controls. Measured by the change in monthly utility bills (electric and natural gas) and diesel receipts.

Evaluation of Site-specific information

The site is located on the near South West side of Madison, just off the Fish Hatchery Road exit of the beltline. There is an additional city-owned facility down the street at 1301 Badger Road, which could be considered for inclusion with the microgrid later. Permitting will involve City Zoning, Planning, Building Inspection, and MGE. Given that self-generation assets already exist on this site, which is zoned commercial, we do not anticipate any challenges with permitting.

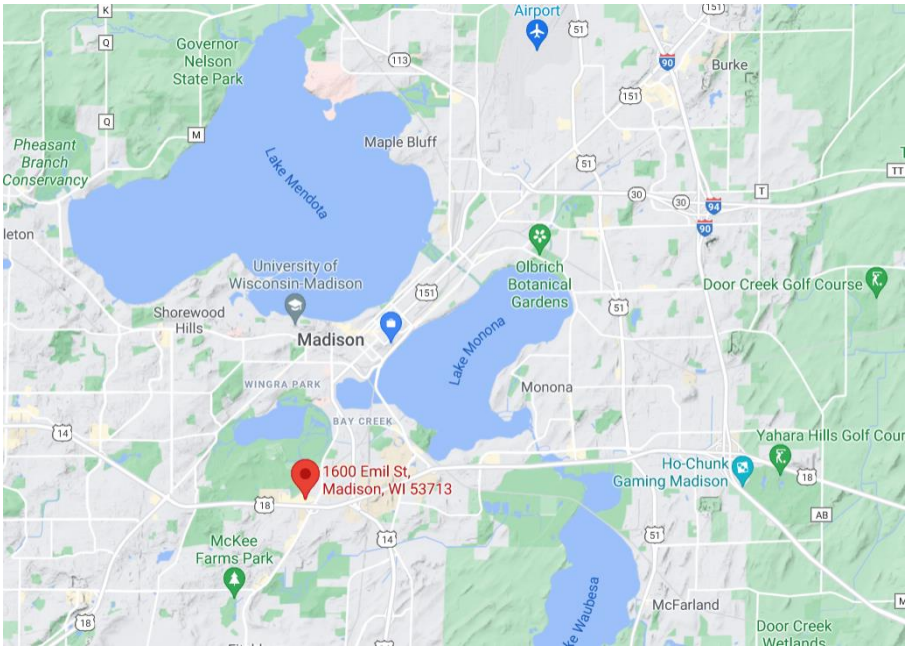


Figure 1 -- Location of the site in the City of Madison

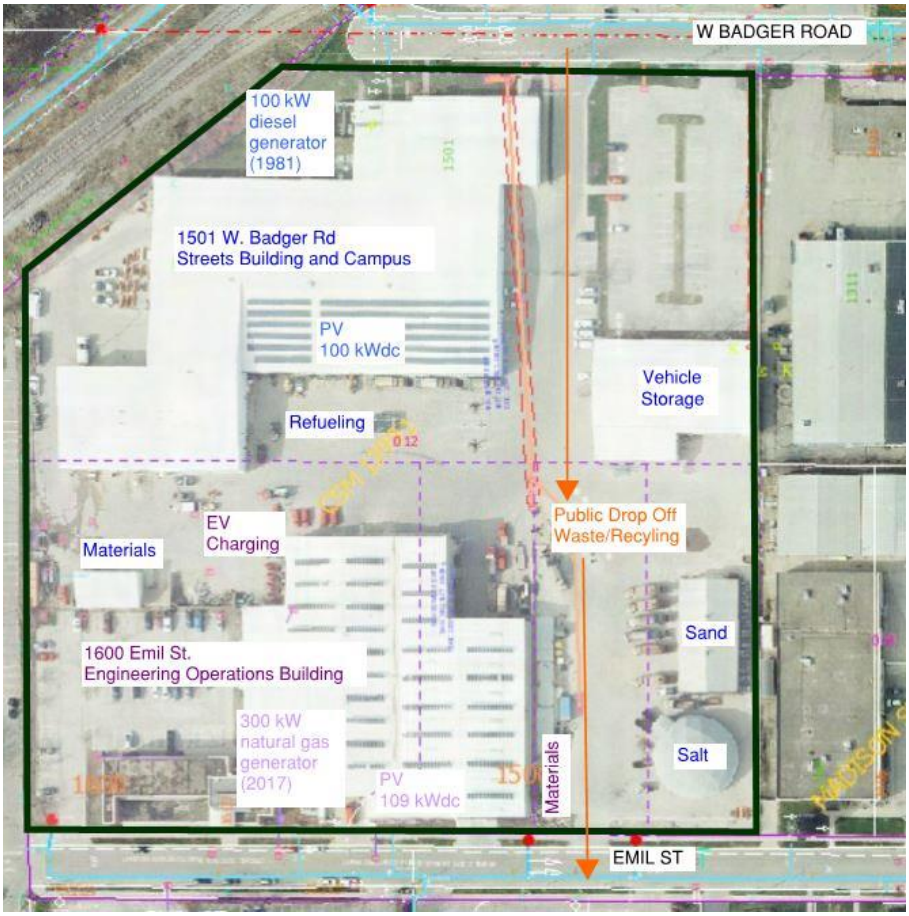


Figure 2 -- Satellite image of the site showing structures, functions, and existing solar PV arrays

Existing Site Constraints

The Engineering Operations building has one electric meter, and one natural gas meter. The Streets Division West has two electric meters and two natural gas meters. To reconfigure the site as a microgrid, the three electric meters would need to be combined into a single service connection.

The electrical service for the Streets Division West is being rebuilt in 2022. Provision for the microgrid is being planned into the design, including removal of the diesel generator and electrical integration with the engineering building, allowing both facilities to share that building's natural gas generator.

With buildings, vehicle and material storage, and waste and recycling drop-off all hosted at this site, space is currently constrained. To alleviate this, there are plans to rebuild the salt and sand storage buildings, and possibly relocate the waste and recycling drop off to another site. This would free up some space for batteries and electrical switchgear modifications but needs to be evaluated further.

Structural calculations were performed on all rooftops when solar arrays were originally added, but additional surveying would be necessary to add to these arrays.

Existing Self-generation Assets

There are currently four solar arrays on site with a combined capacity of 209 kW_{dc}. The sizes, installation dates, and inverter types of the arrays are provided in Table 1.

Table 1 -- Solar array locations, sizes, and details

BUILDING	CAPACITY (KW_{DC})	YEAR INSTALLED	INVERTER MAKE	INVERTER MODEL
ENGINEERING - 1600 EMIL ST	4.2	2008	Fronius	IG 4500-LV
	18.7	2015	SMA	SB10000LUS-10
	86.1	2018	Solaredge	SE 33.3k and SE20KUS, with P730 Optimizers
STREETS - 1501 BADGER RD	99.9	2017	Fronius	Primo 15.0-1
TOTAL	**208.9**			

All solar arrays are enrolled in net metering. In 2020, the site exported approximately 84,000 kWh back to the grid. However, current net metering rules limit the amount we could add while remaining enrolled in net metering. Any additional solar capacity would thus need to be paired with a battery energy storage system to allow for increased self-consumption of solar.

The site also includes two backup generators with a total capacity of 400 kW. The generator at the engineering building is integrated in the main panel and can supply 100% power, while the generator at the Streets building is connected to an emergency panel and only covers critical loads. Both are connected with open transition automatic transfer switches, which result in a complete loss of power to the building while transition to and from backup power. Additional generator details are provided in Table 2.

Table 2 -- Generator locations and details

BUILDING	CAPACITY (KW)	FUEL	YEAR INSTALLED	MAKE	MODEL
ENGINEERING - 1600 EMIL ST	300	Natural gas (separate meter)	2017	Generac	Olympian G300LG6
STREETS - 1501 BADGER RD	100	Diesel (day tank supplied from vehicle refueling)	1981	Cummins	100-0DYC-15R

By the end of 2021 we will have approximately 20 EVs that charge at the engineering building and would be available to utilize the battery bank or participate in a managed charging setup.

Technologies Under Consideration

To successfully convert this site to a microgrid, in addition to the necessary electrical reconfiguration and microgrid controls, we are planning to expand the solar PV array, add BESS, upgrade the natural gas generator, implement managed EV charging, and perform a number of energy efficiency improvements. Each of these changes is described below.

Solar PV expansion and upgrade. Recently, we conducted a study to determine the maximum expansion capability on site, given our existing rooftop space. The total future capacity we believe is feasible is roughly 400 kW. During the feasibility study we would perform a structural evaluation of the rooftops to verify this total.

The existing PV arrays represent a mixture of systems, parts of which may not be compatible with a microgrid. Of the four existing arrays, one is equipped with SMA inverters that are voltage-limiting so may be compatible in a microgrid with additional SMA hardware. The Fronius and Solaredge inverters do not appear to be compatible for an islanded installation and will likely need to be replaced. Additionally, some of the arrays are at 120 V distribution, and some are at 277 V distribution. In the process of upgrading inverters for microgrid compatibility, we will also evaluate whether it makes sense to unify the voltage and how they integrate with the site electrical system.

Battery energy storage system (BESS). We are currently planning to add a BESS with a capacity of 100 to 150 kW to enable increase self-consumption of our solar output, accomplished by nighttime charging of electric vehicles. This capacity range is based on preliminary analysis of what would be needed for our current fleet of 16 vehicles to be charged overnight using only energy harvested from the PV array during the day. During the

feasibility study we will re-visit this estimate, also considering an expansion of our EV fleet. We have discussed a cost-share model with MGE, whereby a larger system could be installed with their support. In this arrangement, MGE would manage the BESS during normal grid operations, and we would manage the system during grid outages.

Expanded EV fleet with managed charging. We have plans to add more EVs, including larger non-passenger vehicles over time. By combining a larger EV fleet, a BESS, and managed charging, we would have the ability to optimize when and how energy is used by the facility during normal grid operations, in order to reduce energy costs and meet our clean energy goals. Managed charging will also be an asset during abnormal grid disturbances, allowing us to cease charging of non-critical vehicles and reserve energy for more critical functions. This would also enable us to participate in any future vehicle-to-grid (V2G) program or pilot that MGE might offer.

Upgrade natural gas generator to paralleling capability. Based on an initial review of the natural gas generator specifications, it does not appear to be capable of parallel operation with the grid or other power sources. During the feasibility study, we will work with the manufacturer and vendor to determine retrofit options so that the generator can operate in parallel with the grid (enabling smooth transition from grid-connected to islanded operation), and in parallel with the solar PV and BESS inverters while islanded (allowing power sharing during islanded operation). A controls update to the generator will also be needed to enable load sharing with the BESS, so that the generator can be kept at its most efficient operating points whenever it is run.

Energy efficiency, electrification, and building automation upgrades. In addition to reconfiguring the facility electrical distribution system and adding sources, we would also investigate the following options as part of a feasibility study:

- **Electrification costs and benefits.** By converting more end-uses (such as space and water heating) from natural gas to electric, the benefits provided by PV and BESS can be enhanced. This also contributes to emissions reduction goals.
- **Energy efficiency opportunities.** To increase the capacity of the microgrid to provide long-term backup, we will look to reduce electric load in the facility wherever possible, through a combination of such measures as HVAC efficiency improvements and lighting controls.
- **Advanced load management.** Many building systems such as HVAC, lighting, water heating, and pumping can benefit from a higher degree of control, not only to reduce total usage, but to control when energy is used. This can enhance the value of the BESS and help manage load while disconnected from the local grid.

Cost Match

A number of parties involved in this project will provide cost share, primarily in the form of in-kind labor hours. The total cost share will represent 10% percent of the total cost of the feasibility study. The City of Madison will contribute $1000 to this project in cost share. Several other partners will also provide in-kind hours to contribute to the project, namely MGE and UW-Madison. All of these parties' time related to collaboration on systems design

and cost options will be cost-share hours. Additionally, Slipstream will provide 10% of its total hours as cost-share hours for the technical analysis.

This grant funding is vital to push this project forward. We are already committed to expanding our solar array, adding a BESS, and expanding our EV fleet, but this grant would enable us to robustly analyze the feasibility of integrating these systems in a microgrid. The grant will provide the ability to gain a better understanding of control options, configuration options for joint control and ownership, requisite battery and PV size, and optimal controls sequences. With a technical analysis of those items completed, City Council will be much more apt to support the project and provide the needed financial support.

Data Collection Plan

The data collection plan will focus on collecting relevant energy and equipment data from these facilities, as well as conversations with key stakeholders on cost and feasibility.

We have extensive energy data already available for these sites, including complete monthly utility bill data, 15-minute interval data, solar electricity generation and export data, and generator fuel use. The energy data is available for three separate meters at the sites. We also have plans to install a power monitor into the new switchgear for the Streets Building, which would provide additional energy data during the feasibility study. The combination of these data sets will provide many of the needed data points for systems sizing analysis and financial analysis. Namely, the load data will allow for an analysis of the battery size potential using a tool such as REopt[6] for resilience planning and financial analysis, enabling us to determine the right size for each microgrid component.

In addition to energy data, we have also completed extensive site evaluations, including an in-depth review of total solar capacity. This evaluation was completed by a City of Madison electrician, and will be available for review during the feasibility study to estimate available on-site generation. We have also begun an initial review of existing inverters, generators, and transfer switches to determine what upgrades or modifications will be needed for microgrid functionality. Lastly, the interconnection applications for previous solar at the sites will be available for review. To augment this information, Slipstream will conduct a site evaluation with a particular focus on energy efficiency and load management opportunities.

The last component of the data collection plan is conversations with stakeholders, including the contracting installers and vendors of the equipment on-site, as well as other potential installers. Through these conversations we will gather cost estimates and equipment specifications. We will also coordinate closely with MGE to determine the feasibility of different system configurations, as well as the value to the distribution grid of each candidate configuration.

Systems Sizing Analysis

To meet our sustainability goals, we anticipate maximizing solar PV at the site, adding 200 kW to the existing 200 kW for a total of approximately 400 kW. The critical loads under

[6] https://reopt.nrel.gov/

consideration will be a subset of HVAC, lighting, office loads (mainly computer and phones), and EV charging of critical fleet vehicles.

A focus of our analysis will be the appropriate sizing of the BESS. Because the site is currently equipped with fixed backup in the form of generators, we intend to design a system that will enable the current level of backup functionality with the natural gas generator, PV, and BESS. Using these three resources, the site should be able to operate in island mode indefinitely at a capacity equal to or better than the current capacity during outages. There are several factors which will guide decision of the BESS size:

- While we will implement energy efficiency and load management improvements, total load is expected to increase due to electrification efforts and the EV fleet expansion. We will perform a load management study to determine the minimum capacity and energy that a BESS must provide to enable full functionality of the site during an outage. We will also re-evaluate which energy uses are critical during outages and emergencies.
- We intend to retire the diesel generator meaning there will be a reduction of fixed backup capacity, from 400 to 300 kW.
- Conversely, we will integrate the electrical systems of the Streets and Engineering buildings, so that the natural gas generator will be available to serve load in the entire site (rather than the current setup with separate generators supplying separate buildings).
- Maximum capacity of the BESS is likely to be constrained by the limited physical space on site, but may be a function of excess solar PV output available to charge the BESS during the day.

Once we understand these upper and lower constraints on the BESS size, we can perform a financial analysis to determine the appropriate size, given our objectives and budget.

During the feasibility study we will work with MGE to explore a cost-share option where the system can be utilized to provide distribution system benefits during normal grid conditions. This could include peak shaving or load leveling, voltage regulation, power factor correction, and contribution to the generation capacity requirements set by MISO, the grid operator. These options may require a larger BESS than what the site would require independently, and could result in a system that provides longer duration outage protection for the site without any substantial increase in microgrid costs.

Financial Analysis

During financial analysis we will consider several potential microgrid configurations, which will be compared in terms of potential benefits and upfront cost. The potential benefits and upfront costs will be used to calculate both cost-effectiveness across systems, resilience benefits, and payback periods.

The first phase of the financial analysis will be upfront cost analysis. We will focus on estimating costs for the equipment needed to establish a microgrid, such as a BESS, electrical and switchgear modifications, inverter upgrades, generator modifications, and

microgrid controller. We will also consider the cost for the planned solar additions. These costs will be collected by reviewing previous City of Madison bids for solar and through discussions with installing contractors. With these options we will also explore various financing options and cost share arrangements.

Financial benefits we will estimate include potential energy cost savings, resiliency and emissions benefits, and grid benefits. Energy cost savings will include the increased on-site renewable generation, decreased use of the diesel and natural gas generators, and energy efficiency upgrades. We will balance this savings against the increase in load from the EV fleet expansion. We will estimate the change in energy consumption across equipment, as well as the change in exports, and apply current prices to estimate these savings. In addition to energy savings, the analysis will consider how operation of the BESS and managed EV charging could contribute to a reduction in demand charges and shifting of loads to time-of-use periods with lower energy costs.

Grid benefits could be optimized under the scenario where MGE is operating the BESS on normal days. These would be determined and quantified through additional conversations with MGE. However, they could include capacity savings by counting towards the generation capacity requirements set by MISO, participation in ancillary services markets, or distribution savings primarily through peak shaving and load leveling.

The last set of benefits include improved reliability and reduced emissions. The conversion to a microgrid eliminates the momentary loss of power during transitions between grid-connected and islanded states, which directly improves productivity of staff and allows for a seamless continuation of services during an emergency. These benefits are more difficult to quantify but can be estimated through estimating the value of the services and employees' work and the amount of time saved. The reduced emissions include both carbon and air quality emissions from the diesel and natural gas generator. The carbon emissions can be monetized with well-cited carbon prices and air quality emissions can be monetized in terms of human health impacts.

Environmental Impact

The technology selected for the microgrid would directly improve the environmental impact of the site, and directly support the City of Madison goal for municipal operations to be 100% renewable by 2030. The planned addition of 137 kW of solar panels will increase the amount of renewable energy on-site, increasing annual renewable generation by roughly 248,000 kWh (calculated with PV Watts). This will save close to 175 metric tons of carbon emissions each year. This additional solar energy will help serve additional load in the future as heavy-duty electric vehicles are added to the fleet and need to charge on-site.

The conversion to a microgrid, particularly the addition of a BESS, will also reduce use of the natural gas and diesel generators. In a typical year the natural gas generator uses roughly 317 therms, and the diesel generator uses roughly 240 gallons, across 40 hours (most of which is required for annual testing). If we were to eliminate use of these systems, it would eliminate 1.7 metric tons and 2.5 metric tons of carbon emissions per year along with

eliminating air quality emissions. Conversely, if a longer outage did occur necessitating use of the natural gas generator, the ability to share and manage load with the solar PV and BESS would result in greater comparative emissions reductions.

During the feasibility study, a more in-depth environmental analysis would be completed to fully understand the impact on carbon and air quality emissions. Additionally, the lessons learned will be shared through the statewide Wisconsin local government climate coalition. This would hopefully disseminate useful information to interested parties and encourage additional feasibility studies for microgrids around the state.

Reference Materials

Utility Billing Data

The figures and tables below provide a summary of electric use and net metering at the site.

Table 1 -- 2020 solar PV energy exported to the grid (kWh)

	STREETS -- 1501 W BADGER RD	ENGINEERING -- 1600 EMIL ST
JAN	848	2,064
FEB	462	1,753
MAR	2,235	4,881
APR	2,400	4,375
MAY	4,068	6,664
JUN	3,454	6,054
JUL	2,533	3,952
AUG	3,975	4,298
SEP	3,512	3,729
OCT	3,956	4,583
NOV	3,716	4,513
DEC	2,657	3,151
SUM	***33,816***	***50,017***

Table 2 -- Electric billing summary by building

BUILDING	ANNUAL ENERGY (KWH)	MONTHLY MAX ENERGY (KWH)	MONTHLY MAX PEAK DEMAND (KW)
STREETS – 1501 BADGER RD	193,169	25,324	58.6
STORAGE – 1501 BADGER RD	21,520	3,040	n/a
ENGINEERING – 1600 EMIL ST	189,753	22,224	79.7

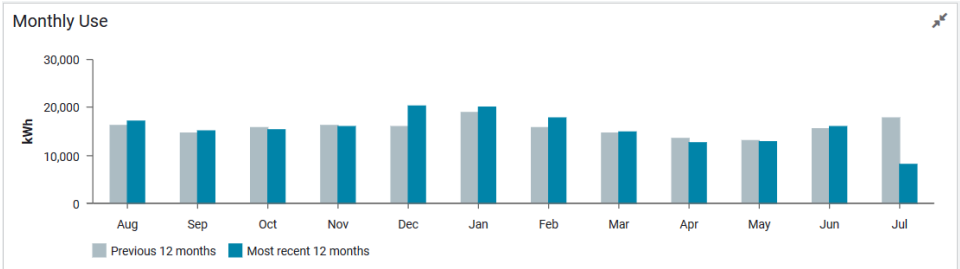


Figure 1 -- Monthly energy plot, Engineering Operations (1600 Emil St)

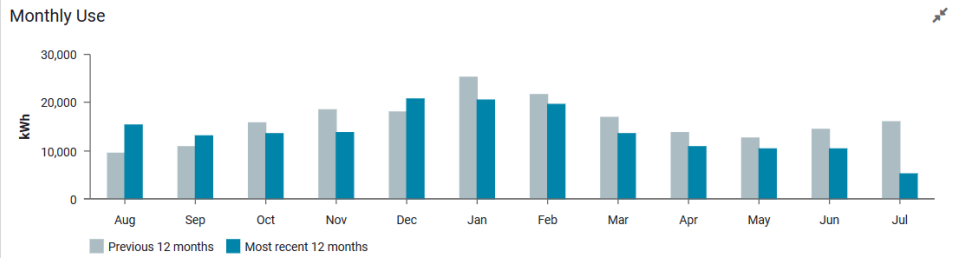


Figure 2 -- Monthly energy plot, Streets Division West (1501 W Badger Rd)

Contract Compliance Requirements

The City of Madison is proud to have *values* that support and sustain investing our resources in partners that will help us advance racial equity and social justice. In order to make sure that City of Madison dollars and the dollars of our tax payers are aligned with our values, we will conduct contract compliance on all projects we fund.

Contract Requirements

Subcontracting: Provide Maximum Feasible Opportunity to Targeted Business Enterprises (TBEs)*

- Applies to: Developer and Prime Contractor
- Frequency: Once before bidding for subcontractors
- Details:
  - It is expected that the Prime Contractor subcontract with TBE firms to meet the TBE goal set by the Department of Civil Rights.
  - If the TBE goal is not met, documentation of TBE ***Good Faith Efforts*** must be submitted so the Department of Civil Rights is sure that the Prime Contractor did all that was possible to subcontract with TBEs.
  - Once the slate of subcontractors is approved and (if necessary) TBE Good Faith Efforts are approved, the contract's commitment to TBEs will be set. This will be the expected percentage of construction costs that will be paid to TBEs.

Affirmative Action Plan (AA Plan) must be approved for the project duration

- Applies to: Developer and Prime Contractor. Also, all subcontractors that earn $50,000 or more on the project.
- Frequency: One AA Plan per entity must be approved before they begin work on site
- Details:
  - Affirmative Action Plans are submitted online. Federal Affirmative Action Plans may be submitted (via email to ***aaplan@cityofmadison.com***) in lieu of the model online plan with additional appendices provided to meet the City of Madison requirements.

***Targeted Businesses Enterprises (TBE)s include:**

- Small Business Enterprises (SBE)
- Minority Business Enterprises (MBE)
- Women Business Enterprises (WBE)
- Disadvantaged Business Enterprises (DBE)
- Section 3 Businesses

Each of these business types have a directory of certified businesses that can be found on our ***website***.

The Targeted Business Enterprise (TBE) Goal that is set depends on the funding source for the project:

- City of Madison Public Works Construction Projects
  - Small Business Enterprises
- Tax Incremental Financing (TIF)
  - Small Business Enterprises
- US Housing and Urban Development (HUD)
  - Small Business Enterprises
  - Minority Business Enterprises
  - Women Business Enterprises
  - Disadvantaged Business Enterprises
  - Section 3 Businesses
- WHEDA (Wisconsin Housing & Economic Development Authority)
  - We use WHEDA's Emerging Business Enterprise (EBE) requirements and their 25% EBE goal
- Department of Transportation (DOT) (Madison Metro Projects)
  - We use the DOT's Disadvantaged Business Enterprises and their required DBE goal percentages
- Department of Natural Resources (Madison Water Utility Clean Water Fund Projects)
  - We use the DNR's Disadvantaged Business Enterprises and their required DBE goal percentages, which are usually 8%

Contract Requirements Cont.

Job Openings: post with Department of Civil Rights ***RaISE Program*** (Referrals for Interviews and Sustainable Employment)

» Applies to: Developers, Prime Contractors, and Subcontractors
» Frequency: Every time you are hiring
» Details:
  – All job openings must be posted to the ***RaISE Program*** beginning when the contract is signed and for one year after that date.
  – If you receive a referral from one of our partner agencies, it is expected for you to offer an interview to the candidate they are referring.

On Site Visit:

» Department of Civil Rights staff will visit the work site at least once during the project.

Reporting Requirements

Subcontractor Reporting: Committed Cost Status Report

» Applies to: Prime Contractor
» Frequency: Monthly, due on the 15th of the month for the previous month
» Details:
  – This report is submitted online and lists the amount paid to subcontractors. Enter the report online by following the ***online instructions***.
  – Note – if you want additional training on how to submit this report online, sign up on our ***training website***.
  – The Department of Civil Rights uses this report to track achievement of the TBE goal commitment set in #1 above.
  – As a reminder, if that commitment is not met, ***TBE Good Faith Efforts*** must be submitted and approved.

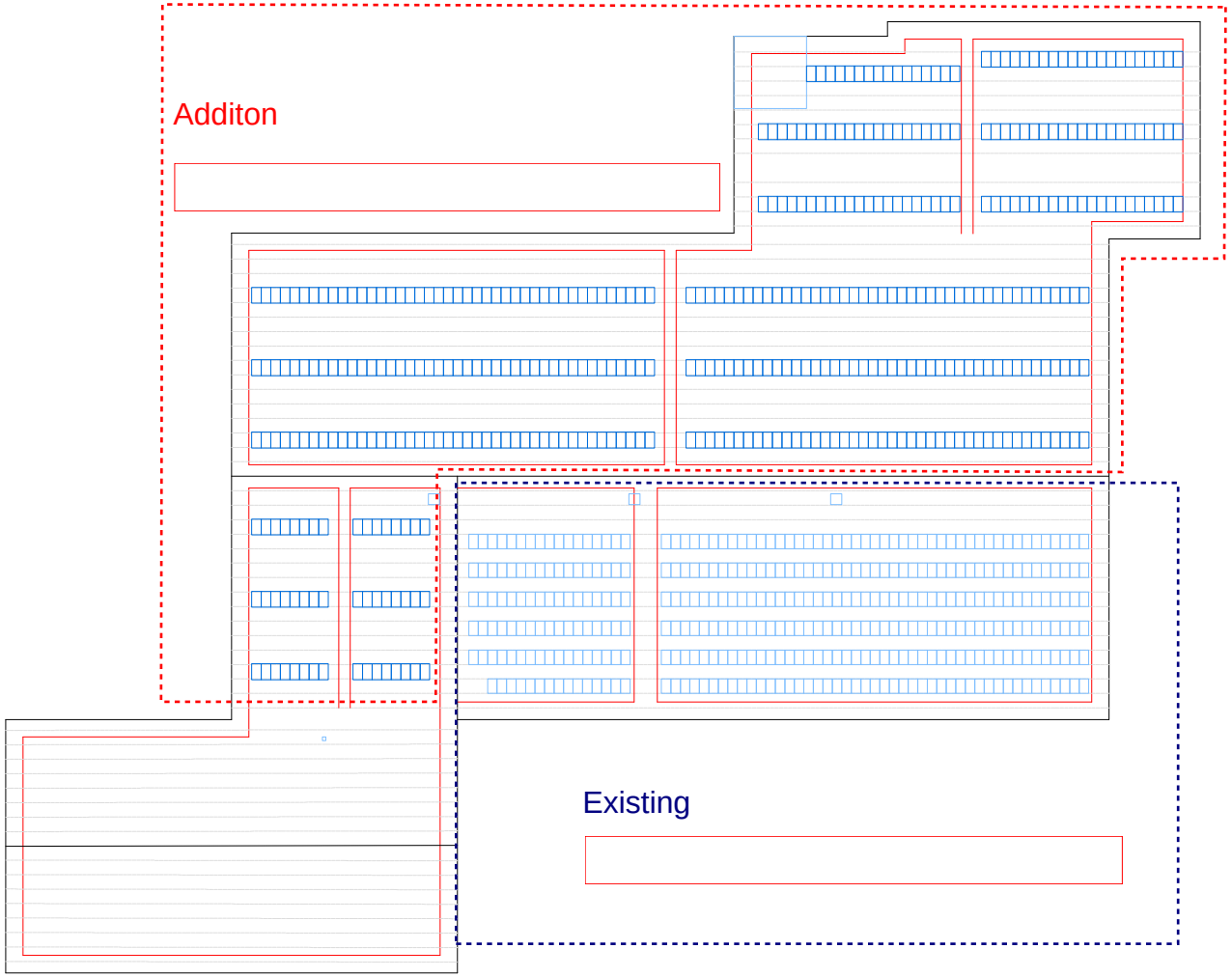
Labor (workforce) Reporting: Monthly Employment Utilization Report

» Applies to: Prime Contractor, subcontractors
» Frequency: Monthly, due on the 15th of the month for the previous month
» Details:
  – This report is submitted online and lists the demographic information of employees performing construction work. Of all hours worked on the project, 6% must be worked by people of color and 7% must be worked by women. This report allows us to track these demographics. Enter the report online by following the ***online instructions***.
  – Note – if you want additional training on how to submit this report online, sign up on our ***training website***.
  – If the project's hours worked are less than 6% for people of color and/or 7% for women, ***Good Faith Effort*** documentation must be provided and approved.

Wage Reporting (Only applicable on federally funded projects)

» Applies to: Prime Contractor, subcontractors
» Frequency: Weekly
» Details:
  – Federally funded projects require certain wages per hour for employees. Payroll records allow us to ensure that employees are being paid per federal guidelines.
  – Payroll records are submitted using ***LCP Tracker***.

1501 Badger Road



1600 Emil Street

Existing

Madison Gas and Electric Company
P.O. Box 1231
Madison, WI 53701-1231
608-252-7000
your community energy company

August 4, 2021

Sent Via Email
mkoolbeck@slipstreaminc.org
lshaver@slipstreaminc.org
jlezaks@slipstreaminc.org
sreece@cityofmadison.com

Ms. Maddie Koolbeck
Mr. Lee Shaver
Ms. Jeannette LeZaks
Slipstream
431 Charmany Drive
Madison WI 53719

Ms. Stacie Reece
Sustainability Program Coordinator
City of Madison
Office of the Mayor
210 Martin Luther King Jr. Boulevard
Madison WI 53703

Dear Sir and Madams:

Madison Gas and Electric Company (MGE) is pleased to provide this letter to support the City of Madison Streets Division Complex microgrid study.

The project application will support a stakeholder engaged process for evaluating and conducting a microgrid feasibility study. The team will study and identify potential deployment strategies for solar photovoltaics (PV), energy storage, and other microgrid technologies to bolster resilience of the City of Madison Streets Division Complex against power outages. The study will also model and analyze load profiles, microgrid designs, and project costs/benefits.

MGE understands the value of this project and looks forward to contributing as a strategic and technical partner of the applicant. Please contact me with questions or concerns at (715) 323-1686 or alindgren@mge.com.

Sincerely,

Aaron Lindgren

Aaron Lindgren
Engineer IV Energy Products and Services

dsh

slipstream 431 Charmany Drive, Madison, WI 53719 | 800.969.9322 | slipstreaminc.org

August 6, 2021

Stacie Reece
Sustainability Program Coordinator
City of Madison
sreece@cityofmadison.com
Room 403, City-County Building
210 Martin Luther King, Jr. Blvd.
Madison, Wisconsin 53703

Dear Stacie Reece:

I'm writing to confirm our intention to participate in Madison's proposed project: *Feasibility Study for a Microgrid at 1600 Emil St and 1501 W Badger Rd*. We are committed to supplying the specific staff, time and resources defined in the proposal as a partner on the project team.

We support the proposal's efforts to bring a microgrid to city of Madison and are excited for the opportunity to collaborate with Madison and other stakeholders to study the feasibility of a battery-energy-storage system and solar photovoltaics at the Engineering and Streets Department. These types of projects are vital to advancing towards a low-carbon society, and positioning Wisconsin as a leading state in emerging renewable technology.

We are also committed to providing matching funds of 10% of labor as shown in the project budget.

We look forward to assisting you in this project to ensure that the microgrid provides the needed services for the City of Madison, if the project moves forward.

Sincerely,

Jeannette LeZaks
Director of Research and Innovation, Slipstream

THE UNIVERSITY of WISCONSIN MADISON

Department of Electrical and Computer Engineering

2559 Engineering Hall, 1415 Engineering Drive
Madison, WI 53706, U.S.A
Web: www.wempec.wisc.edu
E-mail: giri@engr.wisc.edu

Giri Venkataramanan
Professor
Ph: 608-262-4479
Fax: 608-262-5559

August 4, 2021

Ms. Stacie Reece
Sustainability Program Coordinator
City of Madison
sreece@cityofmadison.com
Room 403, City-County Building
210 Martin Luther King, Jr. Blvd.
Madison, Wisconsin 53703

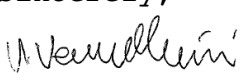
Dear Stacie Reece:

I'm writing to confirm our intention to participate in the City of Madison's proposed project: *Feasibility Study for a Microgrid at 1600 Emil St and 1501 W Badger Rd*. We are committed to supplying technical analysis and guidance during the feasibility study and beyond, should the project move forward.

The Electrical and Computer Engineering Department at UW-Madison has been a pioneer in developing microgrid solutions to meet the needs of critical infrastructures for over 2 decades and have led various research, development and field deployment projects at scales ranging from a few tens of watts to several megawatts, and are eager to disseminate our research findings into projects in our communities in Wisconsin.

We look forward to assisting you in this project to ensure that the City of Madison provides the needed services to the residents of Madison if the project moves forward. Feel free to contact me at giri@engr.wisc.edu in case you have any questions.

Sincerely,



Giri Venkataramanan
Professor

Jonathan Evans
City of Madison Department of Public Works – Engineering Division

EDUCATION

- M.S., Mechanical Engineering, University of Wisconsin (UW-Madison), Madison, 2003.
- B.S., Mechanical Engineering, Milwaukee School of Engineering (MSOE), Milwaukee, 2002.

PROFESSIONAL REGISTRATIONS

- Registered Professional Engineer – Wisconsin
- USGBC LEED® Accredited Professional & LEED $AP_{BD\&C}$

RELEVANT WORK EXPERIENCE

- ***Building Design Project Manager. City of Madison, 2016-Present***
  Manage all aspects of a wide variety of City building new construction and remodeling projects including scope development, budgeting, space programming, design, plans, specifications, bidding, contract award, construction administration, project close-out, commissioning, and warranty.
- ***Director of Sustainable Design, Sustainable Engineering Group, 2006-2016***
  Manage multiple commercial building energy efficiency projects ranging from small commercial office buildings to large university lab buildings. Duties included proposal writing, contract management, staff management, LEED consulting, commissioning, measurement & verification, geothermal design, solar design, wind turbine design, specification writing, energy modeling and research.

RELEVANT PROJECT EXPERIENCE

- ***Madison Municipal Building retrofit – 75,000 SF Historical Renovation.*** Design and Construction Project Manager. Supervised blower door and commissioning activities. Window energy modeling. Included installing new storm windows that would function with the historical window frames.
- ***City of Madison Midtown Police District - 32,000 SF New Construction.*** Design and Construction Project Manager. Supervised blower door and commissioning activities. Window energy modeling.
- ***City of Madison Fire Station 14 - 20,000 SF New Construction.*** Design and Construction Project Manager. Supervised blower door and commissioning activities. Window energy modeling.

RELEVANT GENERAL PROJECT EXPERIENCE

Quality control	Commissioning authority for many commissioning and retro commissioning projects. Have extensive experience with K-12 education, government and municipal commissioning projects.
Operation and maintenance	Commissioning of many buildings including training O&M staff on improved O&M procedures. Performed many energy audits. Written many systems manuals.

Energy Efficiency and Controls	Experienced in all aspects of energy efficiency including planning, design, installation, operation, evaluation, and troubleshooting.
Life-cycle cost analysis and energy budget	Lead author of many life-cycle studies for various technologies including geothermal, VRF/VRV, solar-PV, solar-HW and wind.
Sustainable design experience	Significant experience in working with A/E teams to develop the optimally energy efficient building. Significant experience designing geothermal systems. Some experience designing lighting, chiller and boiler plants, solar-PV, solar-HW and wind systems.
Building envelope	Experience evaluating building envelopes as it relates to HVAC operations; i.e. infiltration, vapor, convection, conduction, etc. Supervised air barrier and IR imaging testing.

Stacie Reece
City of Madison, Sustainability Program Coordinator

EDUCATION

- Bachelor of Science in Sustainable Management , University of Wisconsin, 2013

RELEVANT WORK EXPERIENCE

- ***Sustainability Program Coordinator, City of Madison, WI, 2018 – Current***
  Responsibilities include professional outreach/education/policy work that will advocate sustainability concepts throughout the City of Madison; serve as a catalyst to produce a culture change for the community that integrates sustainability and environmental value; coordinate with City staff and strategic community partners to develop sustainability initiatives and assess their cost effectiveness, technical feasibility and implementation methods; apply the equity lens to identify and address barriers to the success of the sustainability initiatives.
- ***Sustainability Coordinator, City of Middleton, WI, 2018 – 2018***
  Project Manager for City-wide sustainability projects, including updates to the City's Sustainability Plan, preparing energy benchmarking and goals for City buildings, streetlights, and vehicles, and tackling other large-scale sustainability projects, like curbside compost collection and the development of new renewable energy systems in Middleton.
- ***Director Sustainable Business Initiative, Sustain Dane, Madison, WI, 2014 – 2018***
  Manage programming including the Sustainable Business Network and the MPower Business Champions Program which helped businesses establish over 500 sustainability projects saving over $1.7 million and avoiding over 60,000 pounds of CO2 from our atmosphere.

MEMBERSHIPS

- Urban Sustainability Directors Network
- ICLEI Local Governments for Sustainability
- International Society of Sustainability Professionals

CIVIC INVOLVEMENT

- University of Wisconsin Sustainable Management Advisory Board, 2019 - Present
- City of Madison: Sustainable Madison Committee, 2016 - 2018
- Dane County Council on Climate Change, 2017 – 2019
- Leadership Greater Madison, 2018

Slipstream Qualifications

Slipstream, a 501(c)3 organization, delivers innovative climate solutions that produce equitable economic and environmental benefits. Since 1980, our research has empowered our team to develop and test solutions on complex datasets to uncover actionable information. Our experience in architecture, engineering, economics, statistics, psychology, and communications gives us a diverse skill set to characterize energy use; conduct field research to measure building and technology performance; gather and evaluate primary data on energy use patterns; model energy use in buildings; measure appliance-specific energy use; and educate stakeholders to equitably advance energy efficiency. The following qualifications demonstrate our expertise in energy planning, load management, resiliency and microgrid technologies.

Energy Innovation Planning for Dane County Municipalities (2019-2020)
The Wisconsin Office of Energy Innovation (OEI) provided funding for seven communities in Dane County to develop energy plans. Slipstream provided project management and technical support for this year-long effort to identify and prioritize near-term actions for reducing energy and carbon in each community. Through collaboration, these seven communities (Fitchburg, Marshall, Middleton, Monona, Stoughton, Sun Prairie, and Waunakee) developed actionable recommendations that each city uses to address existing energy goals and establish additional goals. Each municipality benefits from sharing best practices and lessons learned from assessing the feasibility of innovative pilot projects and programs designed to provide maximum economic benefit to their communities. WPPI Energy, the wholesale electricity provider for several of these communities, saw this project as a model for other WPPI member communities throughout Wisconsin.

Potential for reducing energy use and carbon emissions with load shifting measures (2019-2020)
Slipstream studied the energy, energy cost, and CO_2 impacts of measures that save electricity as well as shift the time that the load occurs. Due to changing load shapes, generation mix, and other factors, utilities in Minnesota are increasingly interested in measures that shift the timing of use in addition to reducing energy. Programs exist that target this goal separately from CIPs (like demand response), but there is also overlap between CIPs and load shifting. We are quantifying the potential in that overlap.

Grid-interactive efficient buildings (2020-2021)
The Department of Energy, Building Technologies Office contracted with Slipstream to develop and demonstrate integrated controls of connected lighting, automated shades, and intelligent energy storage systems for maximum building load flexibility. The objective is to investigate the integrated systems' potential in providing grid-interactive flexible building loads and validate the performance in two real buildings.

Smart Grid Application Guide for Building Professionals (2019-2020)
In partnership with GDS, Slipstream was awarded a grant from ASHRAE to develop the industry's first version of a Smart Grid Application Guide for Building Professionals. Changes occurring in the electric grid infrastructure require new design and operation considerations for

buildings and how they interact with the grid. Facilities can be operated in ways that support grid operations — economic efficiency, environmental protection and/or reliability — while potentially lowering their own costs of operation by managing loads and storage to contribute to balancing grid-wide demand and changes to the generation mix. The user's guide serves as an educational tool to inform building professionals about the smart grid and the role of buildings in it, and to provide practical information about concrete steps to prepare and operate a building in a smart grid environment.

Iowa Energy Storage Assessment (2020)
Slipstream was a subcontractor to Synapse Energy Economics, Inc. on this project that evaluated the potential benefits, as well as identified barriers, to expanding the energy storage industry and the application of energy storage in Iowa. The study was funded by the Iowa Economic Development Authority.

Energy Management Information System (EMIS) technical potential in Wisconsin (2020-2021)
Slipstream conducted this research project for Wisconsin's Focus on Energy program. Energy management information systems (EMIS) are software tools which collect and process real-time data gathered within a building or campus to recommend, prioritize, or implement controls changes, repairs, capital improvements, or other changes to reduce energy usage, manage demand, or improve occupant comfort and productivity. Slipstream evaluated 12 EMIS products, eight service providers, and eight utility programs utilizing EMIS in North America. EMIS modeling applied to Wisconsin's stock of healthcare, office, and education buildings estimated the potential for $7.5 million in annual bill savings, 71 GWh of electric savings, and 58,000 tons of CO2 emissions reductions. Based on these results, Slipstream developed program recommendations for Focus on Energy, including a mix of new program offerings and changes to existing programs.

LEE SHAVER

Slipstream | P: 608.210.7145 | lshaver@slipstreaminc.org

Slipstream—Energy Engineer
Lee's research and analyses focus on strategies and applications for advancing the smart grid, with an emphasis on microgrids and DER integration. Lee consults with building owners, architects, and engineers to apply energy conservation measures in commercial buildings.

Selected projects

Refrigeration thermal storage. Lee is involved in data collection, analysis, and potential studies for several different research projects related to thermal energy storage systems.

Saving energy and CO_2 with load shifting. Lee is involved in two different projects that study the potential for buildings in two midwestern states to contribute to energy savings and emissions reductions through load shifting measures.

ASHRAE Smart Grid Guide. Lee contributed the microgrid chapter in ASHRAE's first-ever guide for building professionals who seek to take advantage of the opportunities afforded by the smart grid. The guide offers architects, engineers, and building management professionals a starting place to learn about smart grid technologies and opportunities and how they can prepare their buildings-operational or planned-for integration with the smart grid.

ComEd Energy Efficiency Program new construction offering. Lee performs design review and energy modeling of commercial projects on the ComEd Energy Efficiency new construction offering. He engages with stakeholders and reviews designs, provides energy conservation measure recommendations and offers advice for best practices inenergy efficiency. He uses energy models and reviews relevant literature to evaluate different architectural and engineering design decisions.

Experience

PA Consulting Group—Global Energy and Utilities Consultant (2017)
Lee consulted with power producers, utilities, and investors to understand policy and market regulation, quantify risk, evaluate assets, and improve operations.

Wisconsin Electric Machines and Power Electronics Consortium (WEMPEC) – University of Wisconsin-Madison) – Research Assistant (2014 – 2017)
Lee worked on a team developing home-scale, dc, meshed microgrids for off-grid electrification.

Quadlogic Controls, 2009 – 2014
Lee managed field service and commissioning of smart electric submeters for commercial and multifamily residential buildings across North America.

Education

- Master of Science, Electrical Engineering, University of Wisconsin—Madison, 2017
- Bachelor of Science, Electrical Engineering, LeTourneau University, Longview, TX, 2007

Professional associations and industry involvement

- Member of IEEE, 2014 to present
- Member of SEPA's Microgrid Working Group, 2019 to present
- Member of the Wisconsin PSC 119 interconnection rulemaking advisory committee, 2021

Jeannette LeZaks
Slipstream | P: 608.210.7156 | jlezaks@slipstreaminc.org

Slipstream—Interim Director of Research & Innovation
Jeannette develops and manages residential, commercial, and industrial energy efficiency research projects. She applies technical research to examine how people use energy and combines skills in billing analysis, planning and econometrics to identify energy impacts and opportunities. Jeannette also develops survey and interview instruments, conducts interviews, and analyzes energy data to develop advanced program approaches that help utilities reach efficiency goals.

Selected Projects

Energy planning for municipalities. Jeannette led a municipal energy planning effort with seven communities in Dane County, Wisconsin. Slipstream managed the project, provided analytical support to develop an energy profile for each community and identified near-term opportunities for energy and cost reductions. The project also leveraged collaborative opportunities.

Market Potential for Saving Energy and Carbon Dioxide with Load Shifting Measures. Jeannette led a Minnesota-funded project focused on understanding the energy, energy cost, and emissions impacts of measures that both save electricity and shift the time that load occurs. The project developed a framework for understanding the load shifting impacts of more than a dozen measures, and also developed cost-effectiveness calculations for each.

Minnesota commercial energy baseline and market characterization study. Jeannette led a study to characterize the energy efficiency of new and renovated commercial building and identify specific opportunities for increased energy savings through and beyond existing commercial energy codes. The study included detailed plan reviews and site visits of recently renovated or constructed buildings. Jeannette managed the project and conducted analysis of the data collected.

Minnesota Energy Efficiency Potential Study. Jeannette provided technical and analytic assistance in a statewide potential study to estimate statewide electric and natural gas energy efficiency and carbon-saving potential and produce data-driven and stakeholder-informed resources defining market segments, end uses, measures, and programs that could be targeted in the decade ahead to realize the state's cost-effective energy efficiency potential. Through the process, the team engaged stakeholders in order to help advance robust energy policies and energy efficiency. Jeannette focused on incorporating her characterization work and behavioral research to strengthen the study results.

Small commercial characterization study. Jeannette co-led a study to characterize the small commercial sector in Minnesota and identify opportunities for utility programs to better serve this sector. Surveys, site visits, and secondary data collection was used to target a large sample of buildings and identify sector segments with the greatest potential for savings. Nearly 100 site visits were conducted at offices, restaurants, and grocery stories to identify energy saving opportunities and inform recommendations for promising program approaches designed to compel small business owners to consider reductions in heating, cooling, ventilation, and process loads, in addition to lighting.

Manufactured homes characterization and performance baseline survey. Jeannette managed a CARD-funded project to identify and characterize a representative sample of manufactured homes in Minnesota. She implemented the research design to gather a comprehensive set of housing and household data from these homes. The project also mined existing data sources for useful information on energy use and savings potential in manufactured homes and incorporated GIS techniques to estimate the potential energy savings from this segment by utility.

Research-based design of residential high user program. Slipstream completed a CARD-funded study in Minnesota to develop empirically-based program approaches for utilities to better serve residential customers with comparatively high electricity and natural gas use. Jeannette conducted interviews and walk-through home audits to determine the causes of the high usage and identify energy-saving opportunities. She also assisted with data analysis.

California low income needs assessment. Slipstream assisted Evergreen Economics with a needs assessment of low-income households in California. The project helped utility weatherization and rate-based programs better serve these households and reach goals of 100 percent participation. Jeannette was on a team of three interviewers who conducted 100 in-home interviews to better understand perceptions, needs, and willingness to participate under various scenarios of eligible households, including past non-participants. Jeannette conducted most interviews in Spanish.

Minnesota multifamily energy efficiency potential. Jeannette was a key member of the team that conducted a comprehensive characterization of Minnesota's multifamily housing stock and provided a detailed accounting of the sector's energy savings potential to the Department of Commerce. We gathered information from building owners and tenants through online and mail surveys and also evaluated the payback period of 25 common energy and water savings measures in multifamily housing. Jeannette managed the development of the sampling protocols, data gathering and analysis.

Selected employment history

Affiliated Engineers, Inc.—Sustainable Planning Consultant
Jeannette worked with clients to incorporate sustainable design principles into new construction and existing building projects.

Peace Corps, Paraguay—Agriculture Extension Volunteer
Jeannette used her natural resources background to serve as a sustainable agriculture specialist in a small farming community. She provided technical assistance related to soil conservation techniques, alternative crop development, and home gardening related to nutrition education. She gained professional working proficiency in both Spanish and Guarani.

Education

- Master of Science, environment and resource, energy analysis and policy concentration, University of Wisconsin—Madison.
- Bachelor of Science, natural resources, Cornell University, Ithaca, New York.
- Nonprofit Management Certificate, University of Illinois—Chicago.

Memberships and associations

- Co-Chair, City of Madison's Sustainable Madison City Commission

Maddie Koolbeck

Slipstream | P: 608.210.7128 | mkoolbeck@slipstreaminc.org

Slipstream – Research Analyst
Maddie provides analytical support for projects relating to energy efficiency, market characterization and potential, and emerging technology. She utilizes her economics and policy background to perform statistical analyses of programs and emerging technology. She is also actively involved in work related to community energy planning, cost-effectiveness calculations, and carbon tracking. She also develops survey instruments and conducts surveys to further understand the current state of the market and stakeholder viewpoints.

Selected projects

Energy Planning for Municipalities. Maddie assisted with a municipal energy planning effort with seven communities in Dane County, Wisconsin. She provided analytical support to develop an energy profile for each community and identify near-term opportunities for transportation and streetlighting energy and carbon reductions.

Market Potential for Saving Energy and Carbon Dioxide with Load Shifting Measures. Maddie was the lead analyst on a Minnesota-funded project focused on understanding the energy, energy cost, and emissions impacts of measures that both save electricity and shift the time that load occurs. She led the development of the cost-effectiveness calculations for the project, as well as the development of the analytical framework.

Midwest Utility, Non-Energy Benefits Quantification. Maddie led the effort to quantify non-energy impacts for a Midwestern gas utility to incorporate into their regulatory filing. She quantified low-income participant benefits as well as air quality, water, and carbon benefits. She is also advising the utility on which benefits and costs to include in each cost-effectiveness test.

U.S. Department of Energy/Oak Ridge National Labs, Non-Energy Impacts for Weatherization. Maddie was a key member of a team that performed a literature review of current research on the non-energy impacts associated with the national Weatherization Assistance Programs. Maddie led the literature review and analysis of how to monetize various non-energy impacts for the project. The final report shares a discussion focused on issues for DOE to consider related to incorporating NEIs into WAP.

Iowa Energy Storage Assessment. Slipstream was involved in a project that investigated the benefits and barriers of energy storage in the state of Iowa. Maddie led interviews with several stakeholders in the state to identify the barriers to energy storage adoption, as well as what value streams stakeholders prioritized for energy storage.

Utility pilot program evaluation and surveys. Slipstream completed an evaluation of pilot demand response programs for Madison Gas & Electric. As part of these projects, Maddie directly aided in the development of the survey, the phone interviews with participants, and the analysis of both energy and survey data. She helped consolidate these results to communicate the impact of the programs on energy behavior as well as customer perceptions of the programs to the utility.

CenterPoint Energy, Integrating Health and Energy. Slipstream is also currently conducting a market research project focused on exploring how health and energy efficiency services could be integrated to better serve Minnesota families. Maddie is a key member of this team and will lead an analysis related to how the inclusion of non-energy impacts will include cost-effectiveness of CenterPoint's programs.

State energy policy analysis support. Maddie has been involved in Slipstream's support of the development of a clean energy plan for the state of Wisconsin and the analysis of the impacts of a proposed clean energy bill in another Midwest state. Maddie supported analysis of the impacts of various policy options, including the impact on carbon emissions, economics, and health. For one analysis, Maddie led the health impact analysis, utilizing the Environmental Protection Agency's Co-Benefits Risk Assessment Health Impacts.

Columbia Gas of Ohio impact evaluation. Maddie leads the impact evaluations of six residential and commercial efficiency programs for Columbia Gas, including their low-income weatherization program. The evaluations include analysis of pre/post billing data, and the application of engineering calculations from the state technical resource manual. She also performs cost-effectiveness calculations for each of the programs. Lastly, she performs ad-hoc analyses on potential programs to help Columbia Gas determine the viability of new programs or changes to program design.

Wisconsin Income-qualified Weatherization. Maddie helps with the analysis of the technical assistance portion of the Wisconsin Weatherization Assistance Program. She uses billing analysis to estimate the energy savings for close to 5,000 homes each year. The evaluation also includes the calculation of savings-to-investment ratios across all homes and across various heating fuels.

Heat pump pilot for Midwestern utility. Slipstream conducted a market characterization and technology analysis for heat pumps in Michigan. As part of this project, Maddie completed cost-effectiveness and emissions analyses on heat pump technologies and on several other emerging electric technologies.

Selected employment history

Chicago Council of Global Affairs. | Chicago, IL | May 2018 to August 2018
Intern, Global Cities – Energy and Climate
Maddie co-authored a Council report, "Building Urban Futures: City Carbon Actions Anchored in Building Codes and Standards," contributing to the literature review, interview, writing, and revision process.

Education

- Master of Public Affairs, energy analysis and policy concentration, University of Wisconsin—Madison
- Bachelor of Arts, economics and environmental studies, Coe College, Cedar Rapids, Iowa

XIAOHUI "Joe" ZHOU, Ph.D., PE, CEM.

Slipstream | 608.210.7115 | jzhou@slipstreaminc.org

Summary

More than 25 years of professional experience in building energy efficiency and demand response as an engineer, researcher, and project manager. Currently serving as a Principal Engineer, Dr. Zhou leads commercial building emerging technology R&D with a focus on advanced building controls and Grid-interactive Efficient Building (GEB). He possesses a combination of strong technical background (electrical and mechanical engineering) and research capability, hands-on industry experience in building design and applications, and program and project management and leadership skills, covering areas of building HVAC, sensors and controls, lighting, windows, building energy simulation, building-to-grid integration, and technology commercialization. Dr. Zhou collaborates with several DOE national labs, universities, utilities, manufacturers, building owners, ASHRAE, and federal agencies such as DOE, DoD, GSA, DOC/NSIT, and state and local governments.

Education

- 2005-2010, **Ph.D.**, Mechanical Engineering, Thermal Energy Systems, Iowa State University.
- 1998-2000, **M.S.**, Electrical Engineering, Control and Communication Systems, University of Connecticut.
- 1985-1989, **B.S.**, Electrical Engineering, Industrial Electrification and Automation, Zhejiang University.

Relevant Past Work Experience

Slipstream, Madison, WI.

Principal Engineer, 2018-present

- Strategy development and implementation of business activities including business development, new research ideas, research project design and execution, and client relationship management.
- Lead emerging technology R&D and serves as Principal Investigator (PI) or project manager for multi-million dollar projects sponsored by DOE, DoD, state agencies, ASHRAE, and utilities (See selected R&D project list below).
- Establish connections and collaborate with DOE national labs, universities, utilities, manufacturers, building owners, ASHRAE, and state and federal agencies.

Iowa State University/Iowa Energy Center, Ames, IA.

Program Manager, Energy Efficiency, 2011-2017

- Develop and manage Iowa Energy Center's competitive R&D grants
- Manage the Iowa Energy Center Energy Resource Station (ERS) – a facility for emerging building technology R&D**,** testing, and validation.
- Lead proposal writing and serve as PI for multi-million dollar external R&D projects sponsored by DOE, DoD, state agencies, and ASHRAE (See selected R&D project list below)

Assistant Scientist II / Associate Scientist, 2003-2011

- Conduct building R&D in the areas of sensors and controls, lighting, windows, and building energy simulation.
- Create, organize, and deliver energy efficiency-related educational and training programs for Iowa building professionals.

- Manage the ERS building automation systems

The University of Iowa, Iowa City, IA.
Research Assistant, 2002-2003
- Assist in building R&D projects conducted at Iowa Energy Center ERS. Provide technical support for the ERS building automation system (Johnson Controls METASYS and Andover Continuum).

Johnson Controls, Beijing, China.
Building Controls Application Engineer, 1996-1998
- Design and implement building controls and fire protection projects for large commercial buildings.

Selected R&D Projects (2011 to present)

- **2021. Minnesota Department of Commerce:** MN CARD ASHRAE Guideline 36 field demonstration. $390k. PI.
- **2020. GSA/DOE:** Grid-interactive efficient building (GEB) software pilots. 70k. PI.
- **2020. Slipstream:** Grid-interactive efficient building (GEB) testbed. $120k. PI.
- **2020. DOE:** DE-EE0009083 Demo. of integrating connected lighting, automated shades, and intelligent energy storage to provide flexible building loads. $914k. PI.
- **2020. ComEd:** Switch Reluctance Motor (SRM) pilot project. $84k. Project advisor.
- **2020. Iowa Economic Development Authority (IEDA):** Iowa Energy Storage Economic Development Assessment. $100k. Project advisor.
- **2019. DOD:** ESTCP EW19-5055 Comprehensive Information Transfer Approaches for Advanced Building Controls and Management Projects. $470k. Key presenter.
- **2019. DOE:** DE-EE0008190 Integrated Controls Package for High-Performance Interior Retrofit. $909k. Project manager.
- **2019. ASHRAE:** Smart Grid Application Guide: Integrating Facilities with the Electric Grid. $99k. Primary author.
- **2019. ComEd:** Smart Valve Demonstration. $60k. Contributor.
- **2018. ComEd:** Q-Sync Motor Field Demonstration. $108k. PI.
- **2018. ASHRAE:** 1819 CO2 Demand Controlled Ventilation in Multiple Zone VAV Systems with Multiple Recirculation Paths. $96k. Co-PI.
- **2018. ASHRAE:** 1814 Actual Energy Performance of Secondary Schools and Medium Offices Designed to Comply with ASHRAE Standard 90.1-2010. $144k. PI.
- **2018. DOE:** All-Digital Plug and Play Passive RFID Sensors for Energy Efficient Building Control. $1.4 million. Team member and consultant.
- **2017. ASHRAE:** RP-1702 Case Studies to Test Performance Measurement Protocols. 160k. Co-PI.
- **2017. ASHRAE:** RP-1710 Effects of Dynamic Shading Devices on Daylighting and Energy Performance of Perimeter Zones. $112k. Field Testing.
- **2017. ASHRAE**: RP-1747 Implementation of DCV for Multiple Zone HVAC Systems. $173k. Co-PI.
- **2017. DOD:** ESTCP EW-201408 Demonstration of Energy Savings in Commercial Buildings for Tiered Trim and Respond Method in Resetting Static Pressure for VAV Systems. $497k. PI.
- **2016. ASHRAE:** RP-1681 Low Energy LED Lighting Heat Gain Distribution in Buildings. $160k. P.I.
- **2016. ASHRAE:** RP-1587 Control Loop Performance Assessment. $110k. Field Testing.
- **2015. DOE:** Iowa Building Benchmarking Project Phase II. $395k. PI.

- **2013. DOE:** Iowa Building Benchmarking Pilot Project. $495k. PI.
- **2012. DOE/PLEOTINT:** Sunlight Responsive Thermochromic Window Demonstration. $56k. PI.
- **2012. ASHRAE:** RP-1353 Stability and Accuracy of VAV Box at Low Flows. Field Testing.
- **2012. ASHRAE:** RP-1312 Fault Detection and Diagnostics. Field Testing.
- **2011. DOC/NIST:** Building HVAC System Faults: A Controlled Laboratory Experiment and Analysis. $234k. PI.

Professional Association

1. Member of ASHRAE. 2002-present. Current and past positions:
    - Distinguished Service Award, 2017.
    - Voting member, ASHRAE Standard Project Committee 195 (SPC 195) Method of Test for Rating Air Terminal Unit Controls.
    - Voting member, ASHRAE SPC 211 Standard for Commercial Building Energy Audits.
    - Voting member, ASHRAE Standing Guideline Project Committee 36 (SGPC 36) High-Performance Sequences of Operation for HVAC Systems.
    - Member of technical committees TC 1.4 Control Theory and Application, TC 1.5 Computer Applications, and TC 7.5 Smart Building Systems.
    - TC 1.5 vice-chair, emerging technology subcommittee chair.
    - TC 7.5 program subcommittee chair, the handbook subcommittee chair, secretary.
    - ASHRAE Central Iowa Chapter program committee chair.
    - ASHRAE Madison Chapter Chapter Technology Transition Committee (CTTC) chair, director-at-large.
2. Member of Association of Energy Engineers (AEE). 2017-2020).

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