GALLAUDET
UNIVERSITY

REQUEST FOR QUALIFICATIONS AND STATEMENT OF INTEREST

CONSTRUCTION, OPERATION, AND FINANCING FOR A CHP & SOLAR MICROGRID PROJECT

DATE OF ISSUANCE: **February 1, 2018**

DUE DATE FOR RESPONSES: **May 1, 2018**

Electronic responses should be submitted to (***david.good@gallaudet.edu)*** RFQ materials may be electronically retrieved by visiting the following webpage: **https://goo.gl/6KTzs1**

PART ONE: EXECUTIVE SUMMARY

1.1 Project Background

Gallaudet is a bilingual, diverse, multicultural institution of higher education that ensures the intellectual and professional advancement of deaf and hard of hearing individuals through American Sign Language and English. Gallaudet was federally chartered in 1864 and is the only liberal arts university in the world in which all programs are tailored for deaf and hard of hearing students. Gallaudet's campus encompasses 99 acres in Near Northeast Washington, DC.

Gallaudet University, working with Urban Ingenuity and CHA Consulting, Inc. has evaluated the potential for a microgrid system (the "Project") to serve the University campus with clean and efficient district energy services including electricity, heating and cooling, and domestic hot water. Together we have determined that a Combined Heat and Power (CHP) and solar integrated microgrid is both economically viable and technically feasible. The Project is expected to provide substantial financial, environmental and operational benefits, all with a relatively clear regulatory pathway for implementation and operations.

Specifically, our site potential analysis indicates that existing electricity, cooling, and thermal loads are well matched for 4 MW of CHP, and a completed rooftop survey identifies further potential for inclusion of over 2 MW of solar PV. Preliminary financial analysis indicates that an approximately $18 M capital investment can yield an exceptional risk adjusted return based on current energy tariff rates. The Gallaudet campus is currently served by existing utility infrastructure, including steam, chilled water, and electric distribution systems, which should significantly reduce the cost and complexity of constructing the Project. In addition, with millions of square feet of new development underway in the surrounding Union Market and Ivy City neighborhoods, Gallaudet is eager to work with the selected development partner(s) to expand the Project over time to serve non-Gallaudet properties.

In short, the University seeks a project execution partner (or partners) to support the work of planning, financing, constructing, and operating an advanced district energy system. We envision development of new infrastructure to provide energy services that meet the needs of the University, and potentially future development at or near the site. The project will require delivery of comprehensive energy services, while offering superior power quality, reliability, resilience, and enhanced environmental and technical performance.

It is our expectation, through this Request for Qualifications and the subsequent Request for Proposals, to select world-class and long-term development partners to implement this state-of-the-art, green and resilient microgrid infrastructure to anchor a signature sustainable development project serving Gallaudet University and the wider community.

1.2 Purpose of the RFQ

The purpose of this RFQ is to solicit qualifications and expressions of interest from potential development partners to assist the University in the final design, construction, operations, and financing of such a district energy microgrid system. This RFQ is intended to solicit information on basic qualifications, track record of success in similar projects, and creative structuring approaches to ensure project performance. After reviewing all RFQ responses, the three to five most qualified teams will be invited to respond to an RFP to develop a fully specified proposal with greater technical and financial rigor. We have elected to structure the solicitation in this manner to encourage the broadest participation, while minimizing upfront investment of time and expense for respondents.

In order to ensure that the Project will be high-performing from both a technical and financial perspective, this RFQ accommodates independent responses from microgrid developers and financial firms. However, we also encourage integrated responses from firms that possess both the technical and capital resources in-house to provide turnkey solutions. In all cases we are looking for a transparent and collaborative partner to guide the University to identify the optimal financing, ownership, and long-term asset management solution for the Project.

Specifically, as described below, we invite responses on two distinct tracks: *Implementation* and *Financing*. Respondents to this RFQ may submit qualifications that are clearly designated as either or both:

i. *Implementation Partner:* Including Energy Services Companies (ESCOs), EPCs (Engineering, Procurement, and Construction), local general contractors with design/build expertise, central plant operators and others capable of successfully implementing and operating the microgrid system. (Please note that the engineering firm

CHA has performed all of the pre-development engineering work on the Project to date, and that the University intends to include an option in the RFP for responding firms to work with CHA as the Engineer of Record as the project moves into design, engineering, and construction. Thus respondents to the RFQ are not required to provide qualifications for the engineering role, though they may do so if they desire.)

ii. *Financing Partner:* Including financial service providers interested in direct third party ownership of these assets, as well as debt and/or equity providers interested in working collaboratively with Gallaudet University to facilitate University ownership. Financing partners should be willing to engage with Gallaudet and its microgrid team (described below) to optimize the project for economic performance.

iii. *Joint Implementation and Financing Responses:* Including partners who wish to both develop and operate the technical project as well as providing a financing solution to fund implementation. Such responses should clarify whether they are willing to be selected for one function only, and how the respondent will provide transparency on financing and ensure the opportunity for the University to engage in optimizing structuring and design choices. As noted above, please include comment on how your proposal can work with the currently engaged Owner's Representative and anticipated Engineer of Record.

The RFQ phase of this process is dedicated to identifying potential partners with the strongest combination of experience, expertise, creativity, and organizational resources. The subsequent RFP process will also provide opportunities for respondents to offer further detail on proposed strategies for assuring competitive pricing of electric, cooling, and thermal services, and for ensuring improved reliability and resilience compared to traditional grid-connected resources.

All interested firms may respond to the RFQ. Gallaudet intends this RFQ to be accessible for interested firms as an initial expression of interest. Finalist firms invited to participate in the subsequent RFP will be expected to invest substantial time, resources, and effort in developing a formal proposal.

Gallaudet reserves the right to evaluate previously completed installations and services at the locations provided as references by the firm. Responding to this RFQ will be completed at no charge to Gallaudet.

1.3 Microgrid Project Goals

The successful microgrid project must advance a number of important goals for improved service delivery and other objectives of Gallaudet University in enhancing the operational performance of campus infrastructure:

- Maximize financial benefit to the University from both from an operating cost savings and potential revenue generation perspective;

- Improve facility maintenance and operations, address deferred maintenance challenges, and reduce the need for future improvements;
- Reduce Gallaudet's carbon footprint and enhance the University's educational mission and community engagement strategies through visible improvements to environmental performance.
- Improve the performance of facilities through increased comfort, health and safety for students, faculty, and staff;
- Improve power reliability and power quality under normal operating conditions;
- Provide resiliency and community support under emergency conditions;
- Preserve the expertise and institutional knowledge of current utilities staff and provide employment continuity for existing positions;
- Provide real-world learning opportunities for students interested in energy and sustainability.

1.4 Project Team Members

Through this RFQ and RFP solicitation process, Gallaudet seeks to assemble a team of people and organizations with special expertise in the areas required to make this project successful. The selected respondent(s) will serve critical roles within a larger project team including the following members:

- *Property Owner:* Gallaudet University is the property owner and site host, and will commit its load to utilize the thermal energy and electricity generated by the Project, and to anchor any potential expansion.

- *Owner's Representative:* Urban Ingenuity, with its engineering partner CHA Consulting, represents Gallaudet University in overseeing the Project, and ensuring integration of property owner objectives within implementation planning. The cost of Owner Representation services shall be incorporated into final pricing for implementation as part of the future RFP process.

- *Engineering Services:* CHA Consulting, under contract to the Owner's Representative, will act as the Owner's Engineer for the Project. In addition, the University intends to include an option in the RFP for responding firms to work with CHA as the Engineer of Record as the project moves into design, engineering, and construction. Thus respondents to the RFP may include a specified allowance for engineering services and would not be required to provide those services within their team, though they may do so if they desire.

- *The Implementation Partner(s):* Competitively secured through this RFQ and subsequent RFP process, the Implementation Partner(s) will serve as energy services provider(s) and design, construct, project manage, and operate the Microgrid project. Partners will need to demonstrate required licensing, bonding, and insurance as part of the RFP response.

- *The Financing Partner(s):* Competitively secured through this RFQ and subsequent RFP process, Financing Partners must be interested in either owning Microgrid assets and/or participating in project financing. A Financing Partener may also be an Implementation Partner.

As part of securing the right to develop this Project, the ultimate Project Partners selected may be asked to fund specified completed and ongoing pre-development tasks necessary to ensure that the project is feasible from an economic, technical, and regulatory perspective. A detailed breakdown of these pre-development costs will be included in the RFP.

1.5 Description of the Project

The Gallaudet University spans a broad variety of buildings and energy uses spread across a historic 99-acre site. Typical peak electrical demand is approximately 4 MW, with an absolute peak of approximately 5 MW. Peak cooling loads are estimated as an additional 2 MW. Typical cold-weather steam demand is estimated at 30 MMBtu.

The proposed Microgrid system is expected to include well matched loads for 4 MW of CHP combined with over 2 MW of Solar PV, as well as a medium voltage electricity distribution network, and thermal energy distribution system. The Microgrid is anticipated to also provide islanding and black start capabilities, back-up generation and peaking resources, and may include chilled water storage.

The Gallaudet Campus already has full distribution systems in place for steam, chilled-water, and electricity. This allows development of the district energy project in a manner that minimizes the marginal capital cost for investment in a CHP system, supplementing existing steam boilers, a small pre-existing geothermal field, and imported grid electricity with more efficient cogeneration equipment.

Additionally, Gallaudet's campus is adjacent to the rapidly developing Union Market and Ivy City neighborhoods, which include potentially serviceable loads reaching millions of square feet of new construction as well as numerous public and institutional facilities. Successful microgrid proposals should also preserve the optionality for such future Project expansion.

In the conceptual design and site analysis process to date, the Project Team has:

- Developed a baseline microgrid system and applied specific load and usage data;
- Conducted an EPA Level 2 Equivalent Combined Heat and Power (CHP) Analysis;
- Completed a baseline solar sizing and shading analysis;
- Completed a 20-year cash-flow analysis based on hourly load models and on known equipment performance specifications;
- Identified available space for equipment and tie-in points;
- Completed an unstamped General Arrangement drawing including major equipment, connection pathways, and tie-in points;

- Worked with Pepco to determine interconnection constraints for existing feeder lines and to identify potential interconnection approaches;
- Evaluated switchgear replacement including estimated costs and space requirements; and
- Completed an unstamped one-line drawing for switchgear, interconnection, and generator connections.

Detailed descriptions of the planning, design, and project development work to date are included as Appendices A – G to this RFQ. We are providing this level of detail in order to further two specific goals: 1) to reliably document the Project's economic and technical potential for the respondents; and 2) to help you tell us about the specific qualifications and experiences that are most directly relevant to this proposed project. Please note that the configuration shown in this solicitation is one of many possible configurations, and was prepared to determine project feasibility and garner interest from prospective partners. Respondents are invited to propose alternative configurations and additional solutions for further considerations.

1.6 Expected Capital Costs and Anticipated Financial Returns

Based on the Project team's conceptual microgrid design and indicative financial modeling, total capital investment needs and anticipated financial returns are detailed below.

Total Capital Investment (system cost)	$18.2 million
Total 20-Year Cash Flow (EBITDA)	$52.0 million
Net Cash Flow (after investment and taxes)	$21.1 million
Internal Rate of Return (IRR)	11%

A simple analysis of a levered return using 70% debt financing (with a 15-year term and rate of 7%) and 30% equity is also show below for example purposes.

Total Capital Investment (system cost)	$18.2 million
Debt/ Equity	$12.7 m / $5.5 m
Total 20-Year Cash Flow (EBITDA)	$52.0 million
Net Cash Flow (after investment, taxes, and debt)	$16.2 million
Internal Rate of Return (IRR)	29%

An updated financial model and pro forma will be provided as part of the RFP stage for final respondents.

1.7 Timing for RFQ Response Submission

Respondents should submit their response electronically by May 1st, 2018**.** Submittals should be labeled "Gallaudet Microgrid RFQ."

Following RFQ Submissions the projected timeline is as follows:

- Complete evaluation of RFQ Submissions: **June 1, 2018**
- Notification of Next Round Selection: **June 8, 2018**
- Implementation RFP Released: **July 1, 2018**
- Implementation RFP Response Deadline: **October 1, 2018**
- Financing RFP Released: **July 1, 2018**
- Financing RFP Response Deadline: **October 1, 2018**
- Review of RFP's and Selection of Winning Proposals: **November 2018**

PART TWO: GENERAL INSTRUCTIONS

2.1 **Communications and Inquiries**. All parties interested in responding to the RFQ should notify Dave Good ***(david.good@gallaudet.edu).*** Questions regarding the proposal process or the technical aspects of the Project should also be sent to Dave Good. Questions and answers to questions of general interest will be available to all teams that have expressed an interest in responding to the RFQ. Please note that questions received less than one week prior to the submission date might not receive a response.

2.2 **Addenda to RFQ.** Any addenda to this RFQ will be emailed by Gallaudet to all Respondents who have notified the University of their intent to respond.

2.3 **Cost of Submission Preparation**. Gallaudet will not provide compensation to the Respondent for any expense incurred by Respondent for Submission preparation, product evaluations, or demonstrations that may be made.

2.4 **Proposal Submission.** Responses must be emailed to Dave Good ***(david.good@gallaudet.edu)*** on or before May 1st, 2018 at 3:00pm. All timely proposals will be considered to have been received on the Due Date.

PART THREE: RESPONSE FORMAT

3.1 Submission Format. Responses should include a straightforward, concise delineation of qualifications, capabilities, and experience. Respondents should submit their responses electronically. In addition, as described previously, we invite responses on two distinct tracks: Implementation and Financing. Respondents to this RFQ may submit qualifications that are clearly designated as any of the following:

i. Implementation Partner
ii. Financing Partner
iii. Joint Implementation and Financing Responses

3.2 Table of Contents. The response should include a table of contents properly indicating the section and page numbers of the information included.

3.3 Executive Summary. The response should include a concise abstract of no more than two (2) pages stating the respondent's overview of the project. Please summarize the scope of services (design, financial, operations and maintenance, training, etc.) that would be offered by your firm for this project. Please indicate whether your firm is providing qualifications as the Implementation Partner, the Financing Partner, or both.

3.4 Background and Qualifications. Provide an overview of the organizational philosophy for approaching this project. Include an organizational vision or mission statement if they have been developed, adopted and embraced by the Respondent.

Company Description: Including but not limited to year established, legal/organizational structure, ownership, names and titles of Directors and Officers, company philosophy, mission and strategy and primary line(s) of business and their geographic locations.

Demonstrated Experience: Provide a minimum of three (3) references for projects of similar size, scope, and complexity, indicating the Respondent's (or key personnel's) recent experience with comparable projects. Each reference shall describe the services provided, project cost, savings amount and benefits to customer. Provide the Reference's name, address, current telephone number, and contact person for each reference. Provide a brief description of the projects: type of facility, scope of work, duration of project, problems, successes, and key vendor personnel involved with the project. The Respondent should include demonstrated ability to find creative and economical solutions to problems that have arisen in the Respondent's experience with projects/ programs similar to this opportunity.

Respondent's Team & Capability Information**.** Provide a Project organizational chart that identifies the employees of the Respondent's firm that would work on the project. Provide a description of all the Respondent's team members including each member's qualifications and relevant experience, particularly the team member's role and responsibility related to the project. A one-page resume including education, experience, and any other pertinent information shall be included for each member of the Respondent's project team. Also provide a description of the project management skills that have been deployed to successfully complete similar projects

3.5 Project Specific Expertise

Technical Partner Respondents: Provide details about the firm's experience, expertise and capacity in the following areas. Please focus your response on concrete examples from previous projects. While successful projects are always best, projects that did not proceed to completion can nonetheless provide valuable experience, which you are also free to share with us. Please do *not* feel compelled to provide essays responding to each of the areas below. Instead, straightforward descriptions of individual projects are best, covering each of the specified areas of interest. It is also not necessary to provide full detail about *how* each area was addressed –emphasis should be simply on identifying the practical experience and expertise acquired by having worked on those projects.

i. CHP: Discuss experience with Combined Heat and Power (CHP) systems, especially reciprocating engines. Also discuss experience with planning, implementing, and operating District Energy systems using chilled water and steam or hot water.

ii. Solar: Solar PV multi-MW installations on existing rooftops, including community solar implementations. Also provide experience with solar parking canopies and EV charging stations, as well as the interaction of EV charging and microgrid management systems. : Grid interconnection for MW-scale, behind-the-meter projects in an urban setting. Relevant outcomes include time to completion, capital cost implications, and export capability. Please specify experience with various interconnection approaches, especially those that permit seamless islanding and avoid both nuisance trips and nuisance load-shedding. Unless barred by non-disclosure agreements, please specify the utility service territories where you have practical interconnection experience.

iii. Electricity Distribution: Experience with campus-scale medium-voltage distribution networks. Discuss any experience with multi-user microgrid systems as well as single-user campus behind the meter settings.

iv. Permitting and Compliance: Discuss the firm's experience in permitting similar projects in the District of Columbia as well as other jurisdictions. Feel free to include any relevant category of permitting, from zoning to stack heights, and be sure to discuss your team's track record of successful compliance with emissions limits, especially in the context of existing Title V permits. Also, please highlight any experience with management of regulatory issues unique to multi-user microgrids and the sale of energy services.

v. Operations & Maintenance: Discuss the firms experience and ability to provide ongoing operations services, including training and certification of existing utility plant staff. Provide examples of your use of preventative maintenance, remote monitoring services, and other methods to reduce operating costs.

vi. Risk Management: Discuss your firm's experience and methodology for assessing, monitoring, and managing physical performance risk and financial risk within campus-scale district energy projects.

vii. Site-wide Energy Planning and Load Management: Discuss experience and procedures for evaluating site demand and for carrying out Energy Conservation Measures, especially in conjunction with sizing on-site generation systems. Discuss how you have utilized demand and load risk management strategies in other similar projects, and examples of site-wide energy master planning.

viii. Energy Market Engagement: Discuss experience in maximizing project revenue from energy exports, grid services, ancillary market services, demand response, or other PJM market opportunities, as well as specific market experience engaging community solar and virtual net metering programs.

ix. Ratings & Certifications: Discuss any expertise and experience specifically using the Performance Excellence in Electricity Renewal (PEER) rating system, and/or other experience managing data disclosure, benchmarking, and other sustainability and performance certification programs.

x. Facility with Contractual Structures: Discuss your firm's experience with shared savings models or other methods for aligning stakeholder incentives, and identify opportunities for engaging Gallaudet in such models. Discuss the team's experience with billing and management of rates for energy sales as well as in contractual negotiations (related to the potential future multi-user microgrid expansion opportunities).

Financing Partner Respondents: Provide details about your firm's financial capacity and track record, including specific experience, expertise, and capacity in the following areas. Please focus your response on concrete examples from previous projects, including financial performance results achieved and experience with deploying innovative financial structures. Priority will be given both to demonstrated experience in capital deployment and financial asset management, as well as to the ability to thoughtfully and transparently engage the University as a property owner through shared benefits arrangements and as a potential investor within the energy project ownership structure. Please do *not* feel compelled to provide essays responding to each of the areas below. Instead, straightforward descriptions of individual projects, partners, or financial structuring approaches are best, covering the specified areas of interest. It is also not necessary to provide full detail about *how* each area was addressed – emphasis should be simply on identifying the practical experience, expertise or potential service offerings proposed.

i. Financial Capacity: Discuss examples of successful financings of this size and scale as well as total capital deployed to date, identifying asset types, regional markets, and other project or portfolio characteristics.

ii. Track Record in District Energy Project Finance: Discuss experience specifically financing CHP, district energy, and large-scale solar installations as well as community solar projects. Indicate duration of engagement in projects, demonstrated financial performance, and roll played in sourcing capital, financial structuring, and ongoing asset management.

iii. Financing Approach: Provide an outline of the expected approach anticipated for financing the Project. Provide basic information about typical desired terms and expectations, contractual requirements, and benefits to owners.

iv. Capital Sourcing: Indicate availability of committed funds available for investment, dedicated debt and tax equity resources and estimated costs of capital. Provide an indication of willingness to include participation of the University as a debt or equity partner within project financing.

v. Asset Ownership: Provide an overview of expected ownership arrangements for the energy assets, whether third party ownership or some other model. Identify key structuring considerations for managing long-term asset management, performance risk mitigation, and allocation of costs and responsibilities.

vi. Pricing Risk, Guarantees, and Contract Model: Outline measures for mitigating pricing risk over time, whether for fuel costs or the pricing of delivered energy services. Provide a brief overview of a Power Purchase Agreement or Energy Services Agreement used on previous projects that could form the basis for an Agreement used to govern this project. Please indicate any other guarantees offered to or required in the past that may also be appropriate for the University as a part of this contracting.

vii. Collaborative Development Experience: Please provide any examples of projects developed collaboratively with a property owner, including division of roles and responsibilities and project financial outcomes. Discuss your firm's experience with shared savings models or other methods for aligning stakeholder incentives. Also discuss experience or openness to working with University or its members as co-investors.

viii. PACE and/or Revenue Bond Financing: Discuss any experience utilizing Property Assessed Clean Energy (PACE) financing and/or tax exempt revenue bond financing to fund projects. In addition, please provide thoughts on your ability to include building-level energy conservation measures, other capital improvements, or energy performance contracting within the financing of the district energy microgrid.

ix. Optimizing Energy Revenues and Incentives: Discuss experience in maximizing project revenue from energy exports, grid services, ancillary market services, demand response, or other PJM market opportunities. Provide examples of experience using financial incentives to fund projects and/or examples of federal, District, or utility incentives available to offset project costs or improve revenue, as appropriate.

x. Risk Management: Discuss the firm's experience and methodology for managing financial and execution risk as well as risks inherent within tariff pricing, regional energy markets, solar or other tax credit markets, and other risks associated with district energy projects as utilized in other similar campus-scale projects.

3.6 Financial Soundness and Stability. Respondents must demonstrate the financial capability and capacity as well as stability that are necessary to financially carry out the Project. To satisfy this requirement, Respondents must supply the following information at a minimum: Financial statements (audited or unaudited) for the key firm(s). Please also provide a description of the financial and business resources available to undertake the Project. Please provide the firm's most recent credit rating report, if available.

4 PART FOUR: EVALUATION OF RESPONSES

4.1 Right of Rejection. Gallaudet may, in its sole discretion, reject any RFQ Response, in whole or in part, if it is delivered after the RFQ Response deadline, or if Gallaudet believes that the RFQ Response is not in its interests to consider or accept. In addition, Gallaudet may, in its sole discretion and for any reason, cancel this RFQ, reject all the RFQ Responses, and seek to perform the Project through a new RFQ or other means. Gallaudet shall not be liable for any costs incurred by a Respondent in responding to this RFQ.

4.2 Evaluation and Selection Procedures. Gallaudet will appoint a selection committee to formally evaluate each response. The evaluation process will grade the responses on their merit and responsiveness. The evaluation process may include verification of references and project team members and may include other information as deemed important by Gallaudet.

4.3 Evaluation Committee Review. The evaluation committee will evaluate and numerically score each RFQ Response that is complete and received by the deadline. The evaluation will be according to the criteria contained in this part of the RFQ and will include verification of references, Project Team members, and may include other information as deemed important by Gallaudet. The committee may also have the RFQ Responses, or portions of them, reviewed and evaluated by independent third parties or other Gallaudet personnel with relevant technical or professional experience. The committee may also seek the review of end users of the Project or the advice of other Gallaudet committees that have subject matter expertise or an interest in the Project. The evaluation will result in a point total being calculated for each RFQ Response. The three to five most qualified responding teams will be invited to respond to the subsequent RFP. The number of teams ultimately invited to respond to the RFP shall be within the committee's sole discretion.

4.4 RFQ Response Evaluation Criteria. In the evaluation phase, the evaluation committee will rate the RFQ Responses based on the following criteria and the following weight assigned to each criterion:

4.4.1 Responsibility, Capability, and Qualifications (25 points): The RFQ Response shall indicate the ability of the Respondent to meet the terms of the RFQ, especially the quantity and quality of recent projects similar in scope to that described in the RFQ. In determining whether a Respondent is responsible, factors to be considered include:

- The experience of the Respondent;
- The conduct and performance of the Respondent on previous contracts;
- The management skills of the Respondent;
- The ability of the Respondent to execute the Contract properly;
- The financial capacity and demonstrated longevity of the Respondent;
- References for projects similar in size, scope, and design;

4.4.2 Qualified Personnel (15 points): The RFQ Response shall indicate the competence of personnel whom the Respondent intends to assign to the Project. Qualifications will be measured by education, engineering certification, financial qualifications, and experience, with particular emphasis on experience with projects of similar scope as that described in the RFQ.

4.4.3 Project Specific Expertise (50 points): The RFQ Response shall indicate the specific expertise in a variety of different areas as defined in Part 3 above.

4.4.4 Financial Stability and Capability (10 points): Points will be awarded based upon the Respondent's financial health and capability.

4.5 Interviews, Demonstrations, and Presentations. The RFQ Response evaluation committee may require some Respondents to interview with the committee, make a presentation about their RFQ Response, and/or demonstrate their products or services. Such presentations, demonstrations, and interviews provide a Respondent with an opportunity to clarify its RFQ Response and to ensure a mutual understanding of the RFQ Response's content.

Attachments:

A. Specific Project Details
B. Financial Analysis
C. Pictures of the Central Utilities Building
D. Campus Load Heat Maps
E. Solar Capacity Report
F. General Arrangement Drawings and Description
G. Electrical 1 line, Switchgear, and Interconnection Evaluation

Attachment A

Specific Project Details

Microgrid Project Conceptual Design & Site Features:

The Gallaudet University spans a broad variety of buildings and energy uses spread across a historic 99-acre site. Typical peak electrical demand is roughly 4 MW, with absolute peak close to 5 MW. Peak cooling loads are roughly an additional 2 MW. Typical cold-weather steam demand is on the order of 30 MMBtu.

The proposed Microgrid system is expected to include onsite power generation, a medium voltage electricity distribution and thermal energy distribution network. The Gallaudet Campus already has full distribution systems in place for steam, chilled-water, and electricity. This allows development of the district energy project while minimizing the marginal capital cost for investment in a CHP system, supplementing existing steam boilers and imported grid electricity with more efficient cogeneration equipment. The project also anticipates incorporation of photovoltaic solar generation, chilled water storage, and back-up generation.

The potential exists in the future to expand the Microgrid from Gallaudet's campus to additionally serve surrounding loads. Such an expansion would have a much higher capital cost per kWh or therm of load served, because it requires a new extension to the existing distribution system. However, the marginal cost of adding additional generation to the existing Gallaudet system is much lower per unit of capacity. In addition, because excess heat is already available from the reciprocating engines, which is not high enough temperature to be used for steam production to serve Gallaudet, domestic hot water is available to serve additional sites on an ongoing basis essentially for "free" with no additional fuel cost to produce this supply, and eliminating the need to build stand-alone boilers even for peak winter loads in buildings.

A base campus Microgrid conceptual proposal has been developed and is further detailed below. The final selected partners will be encouraged to consider revisions or alternatives to the conceptual design if they can recommend better approaches.

<u>The base campus Microgrid includes the following</u>:

- A pair of Jenbacher J612 reciprocating natural gas fired engines
  - 1,980kW each
  - Excellent reliability / availability in the industry (97%), Excellent electrical efficiency (44% LHV), Excellent control technology (SCR & Urea)
  - Includes gas compressor for engine start-up
  - Includes parallel second stack for engine exhaust
- Full heat recovery
  - Steam – Heat Recovery Steam Generator (HRSG) with all steam appurtenances
  - Supplement duct-firing, to increase available steam (at 90 – 95% efficiency)
  - Insulated piping to connect to existing campus steam headers
  - Piping to connect feedwater pumps, condensate receiver and pump (if needed)
  - Hot water – secondary heat recovery generator and hot-water distribution pumps

- A pair of hot-water absorption chillers
    - 200 tons apiece
    - Utilizes recovered waste-heat with temperatures too low for steam production
    - Chilled-water piping and pumps
    - Condenser water piping and pumps, additional cooling tower cell (if needed)
- Solar PV installations
    - Maximize use of available roof space, on the order of 150,000 sf
    - Expected total installation of 1.5 to 2.8 MW
    - Use of smart inverters to interconnect with campus feeders
- Full control systems, integration, power panels and wiring, etc.

<u>Further Optional Technical Improvements Include</u>:

- Increased use of efficient steam: Utilize supplemental duct-firing to increase steam output at up to 95% efficiency, reducing (or for certain seasonal periods, eliminating) the steam required from existing campus boilers
- More flexibility for electricity production: Add a steam diverter bypass valve, to enable full electricity production even when campus steam loads are below the recoverable waste heat.
- More flexibility for chilled-water production: Add a steam-driven chiller to the chiller line-up, to replace electricity use with thermally-sourced production. To ensure maintenance compatibility and common training practices across all equipment, a single vendor for both electric and steam-driven chillers is recommended. It may therefore be necessary to postpone the addition of a steam-driven chiller until existing chillers are replaced.
- Chilled-water storage: Add chilled-water tank (not necessarily at CUB) to increase chiller capacity and reduce costs for grid-purchased peak power.

<u>Potential Grid System Benefits Include:</u>

- Adding revenue from grid-export revenues from additional electricity generation
- Adding ancillary services revenue from benefits to the regional distribution grid
- Optimizing system design through equipment enhancements including chilled water thermal energy storage, battery storage of electricity, steam-driven chillers, etc. allowing optimization of economics through time of use rates for overnight grid imports, engagement of the PJM hour-ahead market for grid exports, demand response, etc.
- Adding solar energy revenues from community-solar, net-metering, etc.

<u>Further Options for Islanding and Resiliency Include</u>:

- For standby generation, re-purpose a portion of existing diesel inventory, relying on the 2MW of relatively modern engines in good condition, by installing an additional layer of switchgear and communications (while keeping the existing failover deadman switch).
- Increase the use of demand response – economic (peak management for cost reduction), grid congestion (PJM payments), and islandability (load shedding)

- Configure the microgrid components and controls to earn additional revenues via ancillary services – engine controls, load controls, solar inverters, for DR, frequency response, dVAR, black-start, etc.
- Interconnection – engage in Level 4 Interconnection Application process with Pepco to support explicit islanding capability

Specific Background Information:

- Load Data: The four existing Pepco feeders serving the campus have modern interval meters that automatically record hourly load data. Facilities staff provided electronic versions of roughly 70,000 meter readings, which were imported and normalized to construct an hourly load projection for both cooling and non-cooling electricity usage. Steam production at the Central Utilities Building is carefully tracked in manual log books, with hourly output recorded for each of the three steam boilers. Working with facilities staff, a statistically-representative sample of hourly steam loads were imported over several years worth of data, covering all seasons and all levels of campus activity, from normal operations to summer session, from weekends to the semester break.

  These data were matched to actual temperatures recorded for each date, and a linear regression model used to account for Heating-Degree-Day variation. Hourly and diurnal variations were derived from the observed data, and used to construct an hourly steam load projection based on TMY (Typical Meteorological Year) data for the specific campus location.

  Findings: University loads behave as expected for similar campuses. Annual load profiles are shown in Section 3.4 under Task 3. Typical peak electrical demand is roughly 4 MW, with absolute peak close to 5 MW. Peak cooling loads are roughly an additional 2 MW. Typical cold-weather steam demand is on the order of 30 MMBtu.

- Existing Equipment:

  Findings: Boiler efficiency was measured at between 82% and 84%, depending on outdoor temperature conditions and boiler load factors (well within industry norms). Chiller efficiency was measured at 0.62kW / RT (well within industry norms for chillers of this age), not including the pumping and other ancillary power requirements associated with the campus chilled-water distribution system.

- Energy Costs:

  Findings: The baseline University cost for power, after 2019, was assumed to be 8.9 cents / kWh, including all delivery and tariff charges, plus $6.67 / kW demand charge. Natural gas procurement costs were determined to total $8.10 per MMBtu.

Regulatory Pathways & Permitting:

Within the confines of the Gallaudet campus, there are no regulatory restrictions or complications for operating a microgrid. In essence, the University is doing it today. Electricity is centrally sourced at the CUB, and then distributed over University-owned wires to multiple end-users. From a regulatory perspective, that situation would not change if some of the centrally-source power comes from cogeneration, or if some power is produced decentrally, through rooftop solar installations.

The key feature that enables a campus microgrid is that the University is a single owner. What triggers regulatory scrutiny, under DC statutes, is the “retail sale” of electricity. The University does not sell electricity to anyone other than itself. Similar situations currently apply to other campuses within the district, including somewhere the privately-owned non-utility distribution wires cross public rights-of-way.

Air quality and emissions permitting will be a detailed-oriented and necessary part of the implementation process for the microgrid. However, the equipment mix contemplated should enjoy relatively straightforward approvals, and the permitting process should not constitute a barrier to progress.

For criteria pollutant emissions (NOx, ozone, etc.), the existing Title V permit should accommodate the modest changes to the emissions profile for the overall site. A “major modification” review will presumably not be triggered, due to two factors: 1) the baseline approach includes after-treatment (SRC and urea); 2) the existing boilers will see a significant reduction in their use, with much of the annual steam production coming from the cogeneration systems.

Finally, DOEE's air quality division is well aware of the District's policy initiatives for microgrids. They have been open and cooperative on other similar projects, and have a great deal of statutory authority and discretion.

Attachment B

Financial Analysis

Urban Ingenuity has conducted baseline financial analysis of a conceptual microgrid design to serve the Gallaudet University Campus, as well as assessing the potential for expansion of the project to serve surrounding users. The purpose of this study is to provide an indicative view of the economic opportunity offered by a campus co-generation and solar project for potential development partners responding to this RFP. Subsequent analysis of key features of this microgrid system – including refining sizing, space utilization, capital costs and benefits, and other key aspects of the district energy system – will be required by all parties and further analysis will be presented at a later stage in the RFP process.

These preliminary results strongly indicate that the conceptual microgrid design presented here is a viable alternative to conventional energy infrastructure, offering strong economics, enhanced system reliability and improved environmentally sustainability. The analysis shows that project economics are viable from a simple payback standpoint, with sufficient returns for consideration of private capital investment, cost effective University investment, and/or shared savings agreements among the parties. In an unlevered scenario, this financial model projects and Internal Rate of Return of 11% and approximately $21 million in net cash flows over 20 years. For illustrative purposes, a simple assumption of 70% debt financing (with a 15-year term and rate of 7%) and 30% equity for the project, produces an Internal Rate of Return of 29%, and approximately $16 million in net cash flow over 20 years.

The base campus microgrid proves cost-effective for a core set of loads under the site owner's control. In addition, building on this foundation later phases of a potential system expansion could then be conducted on a marginal cost basis, with subsequent investments further improving the economics and energy efficiency of a larger district. Further, this analysis concludes that expansion to serve neighboring users is feasible from a regulatory perspective, enabling establishment of a multi-user microgrid. Such an expansion is potentially of interest to the University, and would further increase the total net cash flow from the project by about $5 million to a total of $21 million.

Core Site Feasibility – Campus Only

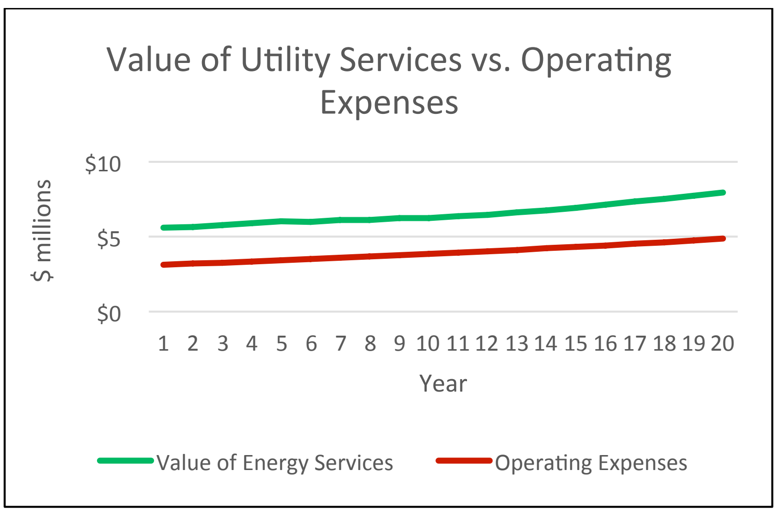
Campus-Only Microgrid: System Design

The core project is designed around a campus-style development using an existing distribution system for steam, chilled-water, and electricity. The proposed microgrid system is primarily composed of a combined heat and power plant (CHP) along with rooftop solar PV. While recent further evaluation has determined that a larger solar system of over 2 MW is likely available, this baseline financial analysis assumes approximately 1.5 MW of solar, two 2-MW CHP engines (for a total of 4 MW of CHP), along with associated controls, and is estimated to cost approximately $18 million. The existing steam infrastructure allows for development of such a district energy CHP system while minimizing marginal capital costs by eliminating the need for major distribution system investments. With much of the distribution infrastructure in place at this site, the new CHP and solar equipment will simply supplement existing steam boilers and imported grid electricity with more efficient cogeneration equipment. This feasibility analysis assumed that energy costs will be set at par with conventional electricity, heating, and cooling tariff rates. The resulting economic benefits documented here can be shared appropriately between development partners and end users.

This modeling was developed using actual "8760" annual hourly load data for the site, resulting in a relatively robust analysis based on very detailed information about current energy use. Initial economic analysis, detailed further below, suggests that this core microgrid is viable and could provide substantial financial benefits to the site owner, whether financed by a third-party or the site owner itself.

At a basic level, the analysis shows that the value of the energy services produced on an annual basis is more than twice the annual operating cost of the system. The 'energy services' value in the site-owner context includes avoided utility costs and associated benefits (such as SRECs and tax benefits), while 'operating costs' include natural gas purchases, engines and absorption chiller maintenance, major maintenance reserves, etc. At a basic level, the fact that the value of the benefits meaningfully exceed the costs of operating the plant suggest that the proposed CHP and solar installation could provide energy services in a cost-effective manner to reduce energy costs for the host site.

Figure 1: Operating Savings for the Campus-Only Microgrid



Campus-Only Microgrid: Economics

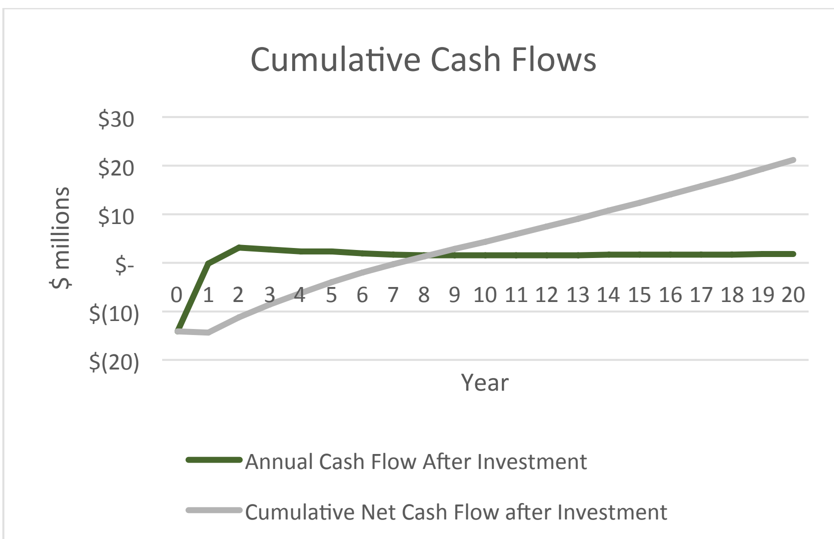
Next, this assessment explored whether the net savings generated (representing the delta between the value of the energy services and the operating expenses in the graph above) are sufficient to pay back the costs of installation while yielding appropriate margins for investors, whether funded as an upfront investment or financed through a combination of debt and equity. The unlevered project cashflows provided an 11% IRR over 20 years with net cash flow of $21.1 million. The analysis also examined a very simple levered scenario, which assumed a split of 70% debt financing (with a 15-year term and rate of 7%) and 30% equity. Under those assumptions, the economics of the base campus microgrid provided an IRR of 29% over 20 years with a minimum debt service coverage of 1.67X, and $16.2 million in net cash flows.

Campus-Only Microgrid: Financial Results Summary

Unlevered Project

Total Capital Investment (system cost)	$18.2 million
Total 20-Year Cash Flow (EBITDA)	$52.0 million
Net Cash Flow (after investment and taxes)	$21.1 million
Internal Rate of Return (IRR)	11%
Years to Cash Flow Positive / Years After Full Investment	8 years / 7 years

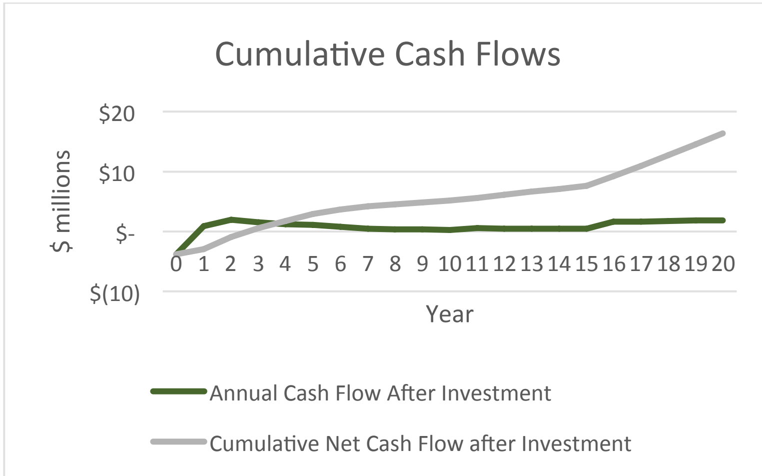
Figure 2: Cumulative Cash Flows in an Unlevered Project



Simple Levered Example

Total Capital Investment (system cost)	$18.2 million
Debt / Equity	$12.7 million / $5.5 million
Total 20-Year Cash Flow (EBITDA)	$52.0 million
Net Cash Flow (after investment, taxes, and debt)	$16.2 million
Internal Rate of Return (IRR)	29%
Years to Cash Flow Positive / Years After Full Investment	3 years / 2 years

Figure 3: Cumulative Cash Flows in a Simple Levered Example



While the numbers above assume that the host chooses to finance and directly own the microgrid system, Gallaudet is interested in pursuing third-party ownership as explored in the RFQ process.

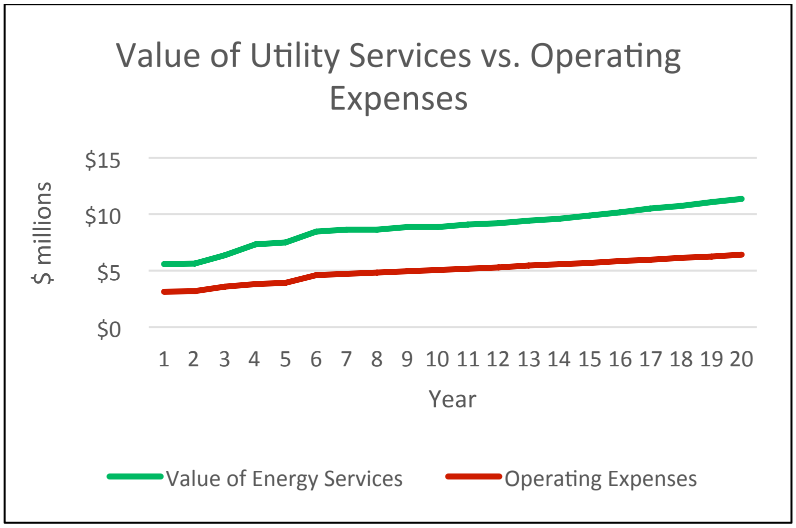
Exploring Expansion Capacity

Multi-User Microgrid Expansion: System Design

This analysis also explored the potential of expanding the microgrid in the future, which is of interest to the University. An extended microgrid system, could serve the campus as well as additional loads for a handful of neighboring parcels, both existing and planned. Such a larger microgrid would likely require an additional 4 MW of CHP and a low-end estimate of approximately 600 kW of solar, for a cumulative total of 8 MW of CHP and just over 2 MW of solar in this baseline analysis. This larger system would cost approximately $28 million, or a roughly $10 million marginal investment over the base project, and the additional capacity would be phased in over the course of about four years (compared to the two-year buildout of the core microgrid). Importantly, preliminary policy and regulatory review for DC also indicates that a privately-owned multi-user microgrid serving this core site and adjoining property owners is permissible from a legal and regulatory perspective.

Expansion to serve the neighboring parcels has a much higher marginal capital cost per kWh or therm of load served, because it requires extension of the existing distribution system, while the core microgrid was able to take advantage of a pre-existing distribution system for a lower marginal capital cost per unit of load served. However, the marginal cost of adding additional *generation* to the existing campus system is much lower per unit of capacity, resulting in an expansion project where the value of the proposed microgrid benefits, similarly exceed its operating costs, yielding strong net benefits.

Figure 4: Operating Savings for the Expansion Microgrid



Multi-User Microgrid Expansion: Economics

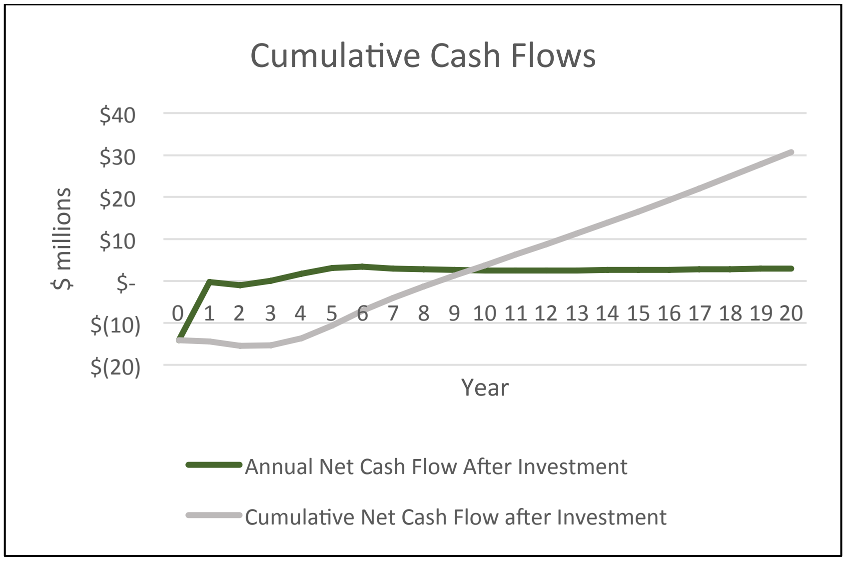
Next using comparable financing assumptions, the analysis explored whether the net savings generated are sufficient to pay back the costs of installation while yielding attractive returns. As shown in the table below, a more extensive microgrid designed to serve both campus loads and surrounding development projects, requires higher capital investment, but still offers very similar returns as a result of additional revenues associated with serving these new users. This approach would feature a series of incremental investments made as new loads are built out, delaying the date of becoming cash-flow positive compared to a campus-only system.

Multi-User Microgrid Expansion: Financial Results Summary

Unlevered Project

Total Capital Investment (system cost)	$28.2 million
Total 20-Year Cash Flow (EBITDA)	$77.4 million
Net Cash Flow (after investment, taxes, and debt)	$30.6 million
Internal Rate of Return (IRR)	11%
Years to Cash Flow Positive / Years After Full Investment	9 years / 5 years

Figure 5: Cumulative Cash Flows in an Unlevered Project

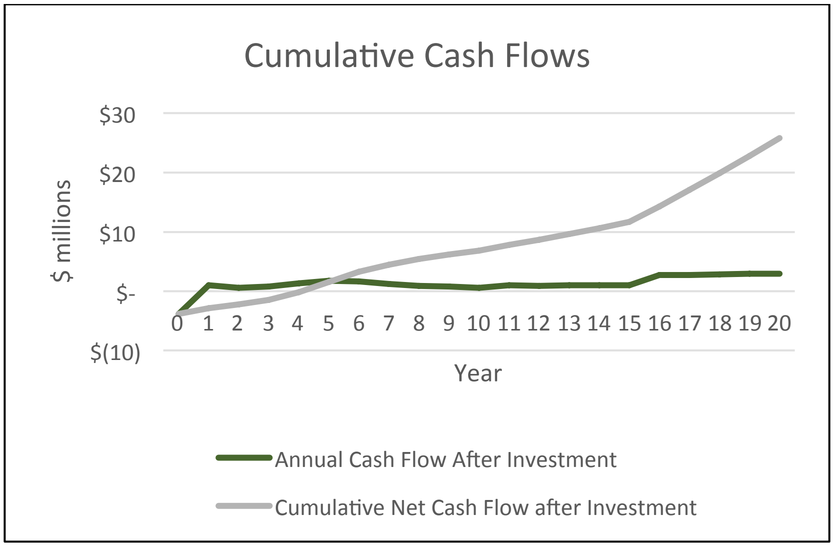


Again a very simple levered example was developed as well, which assumed a split of 70% debt financing (with a 15-year term and rate of 7%) and 30% equity as shown below.

Simple Levered Example

Total Capital Investment (system cost)	$28.2 million
Debt / Equity	$19.7 million / $8.5 million
Total 20-Year Cash Flow (EBITDA)	$77.4 million
Net Cash Flow (after investment, taxes, and debt)	$23.4 million
Internal Rate of Return (IRR)	25%
Years to Cash Flow Positive / Years After Full Investment	5 years / 1 years

Figure 5: Cumulative Cash Flows in a Simple Levered Example



Further Optimization

This preliminary analysis of the Gallaudet site indicates strong benefits from a base case microgrid to serve University site loads, as well as from expanding to serve neighboring customers. In addition, modifications to a base case design can also be explored to maximize revenue generation, cash flows, and financial performance. Such modifications might include: refining system size to meet additional new loads; optimizing financial and ownership structures; making system enhancements and other design modifications to generate new cash flows, and increasing system reliability, resiliency, and environmental performance. In addition, as part of the system design the project developer may elect to take certain steps to help protect against any project downside risks.

Exploring Upside Benefits:

This review indicates that further optimization can also yield significant additional monetary benefit and improve financial performance, while other project enhancements may cost effectively yield benefits that are more difficult to quantify and monetize. Several such beneficial enhancements are identified below, but assigned a zero value in the modeling of the base financial case. Together, these efforts will enhance the performance of an optimized project. These benefits include:

- Grid Interaction: Management of the interaction between the microgrid and the regional electric distribution grid can open additional revenue opportunities from electricity exports, ancillary grid services (demand response, frequency regulation, etc.), and community solar.
- System Configuration: The base case microgrid could likely be optimized for performance and financial returns beyond what was explored here. For example, preliminary analysis suggests adding a lower temperature heat-recovery circuit to serve domestic hot water demand would increase the efficiency and cost effectiveness of heat recovery and recycling for this system.
- Non-Utility Benefits: Beyond the utility savings modeled here, additional benefits could include reduced costs for operations and maintenance, increased equipment lifetime, greater reliability of power services (particularly valuable for hospitals, university laboratories, and emergency facilities), and 'green' marketing benefits from increased sustainability.
- Financial Structuring: While this analysis considered a relatively simple debt / equity model, the site owner could explore integration of local grants, public credit enhancements, more creative approaches to sourcing debt and equity, etc. to further optimize economic returns.

Conclusion:

The simplified analysis conducted here can provide a framework for assessing the economic potential of the proposed microgrid conceptual design for Gallaudet University. This initial feasibility study indicates that a core microgrid is economically viable to serve the campus' base site loads generating a net benefit as compared to business as usual utility expenses. Through this RFQ and RFP process, the University hopes to explore how the project may be financed by a third-party partner to develop, own, and operate the microgrid, in collaboration with Gallaudet. Further, beyond the basic microgrid design, this assessment indicates that it should be possible to improve the economics of the microgrid by further expanding generation and distribution capacity to serve additional neighboring loads.

Attachment C

Pictures of the Central Utilities Building


Onan
Genset
WARNING
GENERATOR COMES
ON AUTOMATICALLY
ON MONDAYS AT
PLANT MANAGEMENT

* This current switchgear is beyond its useful life and will need to be replaced with modern switchgear that can accommodate the microgrid project.

Attachment D

Campus Heat Load Maps

Typical peak electrical demand for the Gallaudet campus is roughly 4 MW, with absolute peak close to 5 MW. Peak cooling loads are roughly an additional 2 MW. Typical cold-weather steam demand is on the order of 30 MMBtu.

The following three heat maps summarize the campus loads that have been analyzed. The heat maps show an entire academic year's worth of hourly energy consumption, from September-to-September, whether electricity, heating, or cooling. The days of the year run along the y-axis, with the months labeled. The hours of the day run across the x-axis, going from midnight-to-midnight. Peak usage shows as red, lowest or baseline consumption shows as green, with yellow in between.

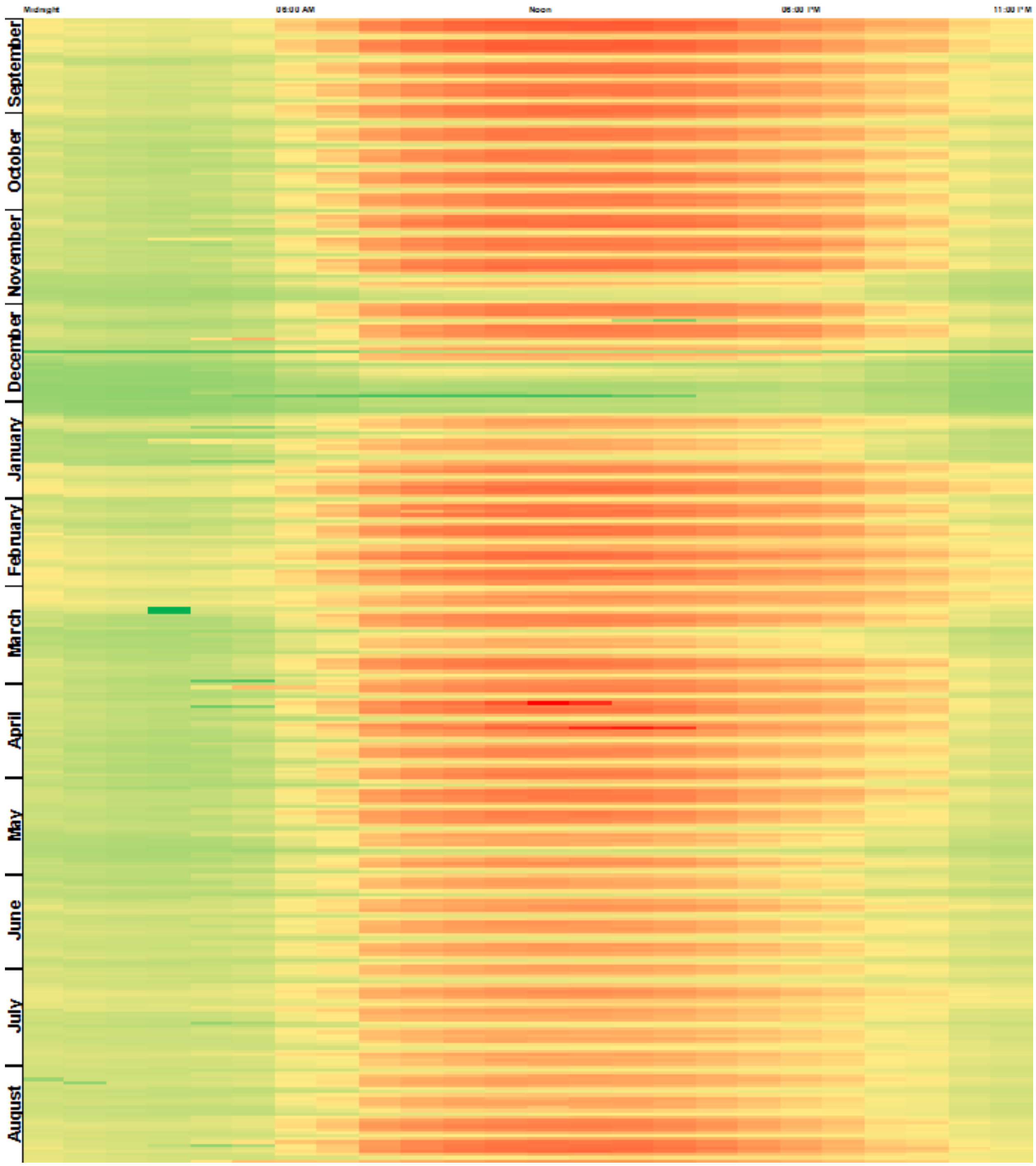


Figure 1: Heat Map of Campus Electric Loads

As expected, electric loads are concentrated during the daytime and early evening. The horizontal striation shows the lower loads each weekend, with green bands representing school breaks (Thanksgiving, spring, and semester breaks, after graduation, etc.). Because the campus has a substantial residential component, consumption is spread across all hours of the year, including nights and weekends, which provides for better utilization of on-site energy assets.

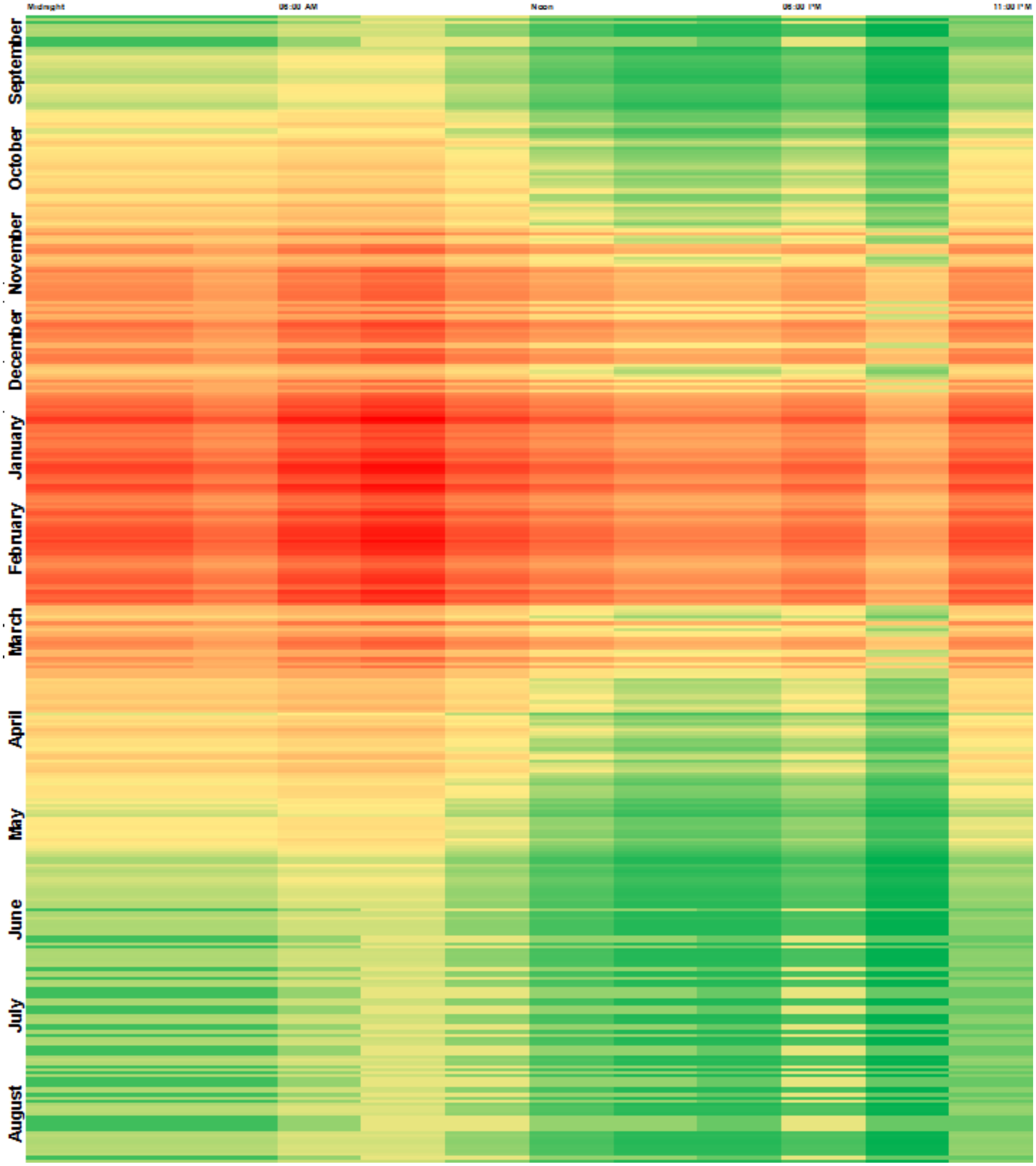


Figure 2: Heat Map of Campus Steam Loads

As expected, steam consumption at Gallaudet is heaviest during the winter months when buildings need the most heat. Warm spells and temperature variation drive modest peaks and valleys in daily or weekly steam consumption.

In the course of a typical day, notably higher loads occur each morning, when buildings enter into active use and thermostats are re-set to higher temperatures, even while colder overnight temperatures are only slowly increasing. Additional higher daily steam load is notable from food service requirements in the evening, and somewhat lower consumption during school breaks. The year-round nature of the campus's steam production is an excellent match for combined-heat-and-power efficiencies.

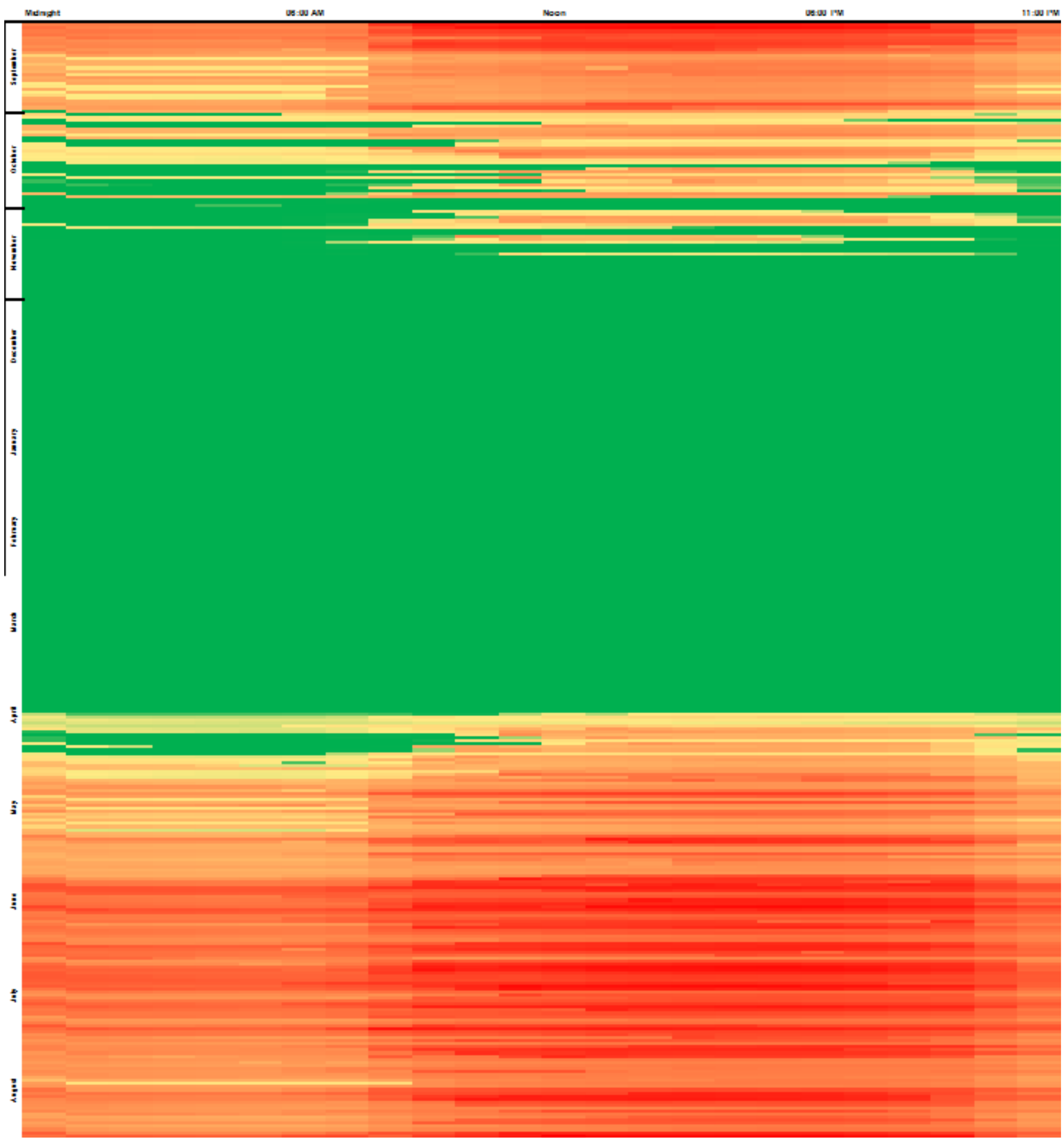


Figure 3: Heat Map of Campus Cooling Loads

As expected, cooling loads are completely absent when the campus chilled-water system is shut down between November 15th and April 15th. Peak cooling season is of course over the summer, but with slightly lower consumption in late July and early August because of lower campus activities, and slightly higher than other settings in September as the new semester begins. Heat waves drive most of the variability in cooling loads, including some intense peaks. Cooling requirements continue well into the evening, unfortunately after power production from on-site solar photovoltaics would have already ceased. Because of their seasonal and temperature-driven peaks, cooling loads are an excellent candidate for shifting electricity consumption to other modes and other times, through absorption chillers, steam-driven chillers, and chilled water storage, as described in this report.

Attachment E

Solar Capacity

Gallaudet University Photovoltaic (PV) Analysis

December 5, 2017

CHA Consulting, Inc.
6 Campus Drive
Parsippany, NJ 077054

I. EXECUTIVE SUMMARY

Gallaudet University (GU) provided 23 locations for potential solar PV rooftop installations. Of the 23 provided, 16 locations are recommended. Table 1 below breaks out each site location with CHA's recommendation to move forward.

Site Location	Recommended
6th Street - Parcel 1	Yes
Central Utilities Building	Yes
Elstad Auditorium	Yes
Field House	Yes
Field House Parking Deck	Yes
Grandstand	No
Hall Memorial Building (HMB)	Yes
Kellogg Center	No
Kendall Demonstration Elementary School (KDES)	Yes
Kendall Garage	No
LLRH6	No
MSSD	Yes
MSSD Dorm	Yes
MSSD Housing	No
MSSD Parking Deck	Yes
MSSD Gym and Pool	Yes
Peet Hall	No
Security Kiosk	No
Sorenson Language Learning Center (SLCC)	Yes
Student Academic Center (SAC)	Yes
Washburn	Yes
Merrill Learning Center	Yes
Ballard West	Yes

Table 1: Site Location Recommendations

Combining the 16 recommended sites we have estimated a system size of 2,818.8 kWDC. This memorandum summarizes each recommended site with an image of the proposed conceptual layout. The location summaries will include: module count, system size (DC & AC), estimated photovoltaic production, inverter selection, string counts, tilt angle, and azimuth assumptions.

II. PROCEDURE & ASSUMPTIONS

It should be noted that this analysis is preliminary and for planning purposes only. CHA did not conduct any electrical investigation of building infrastructure or structural analysis of the roof structures to affirmatively determine capacity. CHA used Helioscope 2016 design software to create a photovoltaic array layout for each roof structure. The parameters that were used in the analysis include:

- 5 degree ballasted system (unless the roof is peaked then the assumption would be flush mounted with penetrations) with appropriate mounting racking distances
- 10’ offset off the edge of the roof
- No more than 150’ spans without mechanical access or walkways.

The aerial images were taken from Google mapping. Obstructions and building heights were estimated. Only obstructions visible on the Google Earth images were included in the concept layout.

GALLAUDET UNIVERSITY

CAMPUS MAP

800 Florida Avenue, NE • Washington, DC 20002-3695

BUILDING

Appleby Building *A1*
Ballard House *A1*
Ballard North *E3*
Ballard West *D2*
Benson Hall *D3*
Carlin Hall *E4*
Central Receiving *E3*
Central Utilities Building *E2*
Chapel Hall *A3*
Clerc Hall *D3*
College Hall *B2*
Dawes House *A3*
Denison House *B1*
Edward Miner Gallaudet Residence *A1*
EMG Memorial Building *B2*
Elstad Auditorium *A4*
Ely Center *B3*
Fay House *B1*
Field House *B4*
Foster Auditorium *B3*
Fowler Hall *A3*
Gate House *A2*
Hall Memorial Building *D3*
I King Jordan Student Academic Center *B3*
Kellogg Conference Center *C2*
Kendall Demonstration Elementary School *E5*
Kendall Hall *B3*
Living and Learning Residence Hall *C2*
Mary Thornberry Building *C2*
Merrill Learning Center *C3*
Model Secondary School for the Deaf *F3*
MSSD Gym & Pool *F3*
MSSD Housing *G3*
MSSD Residence Hall B *F4*
Peet Hall *C2*
Peikoff Alumni House *B2*
Peter J. Fine Health Center *E3*
Plaza Dining Hall *E3*
Security Kiosk *A3*
Sorenson Language and Communication Center *C3*
Washburn Arts Building *C2*

POINTS OF INTEREST

Bison Sculpture *B4*
Contrapposto Sculpture *C3*
Edward Miner Gallaudet Statue *B3*
Museum *A3*
Riding High Sculpture E4
Rockwalls *B3*
Thomas Hopkins Gallaudet & Alice Cogswell Statue *A3*

Visitor Parking · Visitors Center *B2* · Bookstore *B3* · Library *C3* · Dining *C2, C3, E3* · Post Office *B3* · Safety & Security *E4* · Emergency Blue Lights

Map designed by the Office of Communications and Public Relations - April 20, 2015

Building	sf	year built	floors	Modules	kWAC	kWDC	Production
6th Street - Parcel 1	60,000	2019	4-5	630	180	192.2	228,719
Ballard West	57,169	1966	4	188	46	57.3	69,136
Central Utilities Building	40,099	1976	3	300	84	91.5	108,382
College Hall Surface Parking		N/A		693	180	211.4	253,195
Elstad Auditorium	40,551	1963		263	70	80.2	95,421
Field House	96,114	1982	3	575	144	175.4	208,619
Field House Parking Deck	71,005	1981	2	635	161	193.7	238,608
Grandstand	6,120	2002	1	0	0	0	0
Hall Memorial Building (HMB)	158,854	1957	4	465	120	141.8	165,831
Kellogg Center	152,144	1995	5	334	84	0	0
Kendall Demonstration Elementary	237,496	1978	5	1439	360	438.9	531,358
Kendall Garage	67,369	1980	2	0	0	0	0
LLRH6	60,000	2012	5	0	0	0	0
Merrill Learning Center	??	??		136	36	41.5	50,228
MSSD	224,170	1972	4	1287	360	392.5	472,829
MSSD Dorm	68,500	2016	3	632	180	192.8	232,661
MSSD Housing	5,576	1976	2	0	0	0	0
MSSD Parking Deck	77,127	1976	3	773	240	235.8	296,887
MSSD Gym and Pool	58,765	1976	2	652	180	198.9	240,116
Peet Hall	49,070	1957	6	0	0	0	0
Security Kiosk	83	1986	1	0	0	0	0
Sorenson Language Learning Center	87,704	2008	3	469	115	143	170,224
Student Academic Center (SAC)	121,773	1959	3	596	161	181.1	216,316
Washburn	49,613	1960	2	196	56	59.8	71,198
Totals:				10,263	2,757	3,028	3,649,728

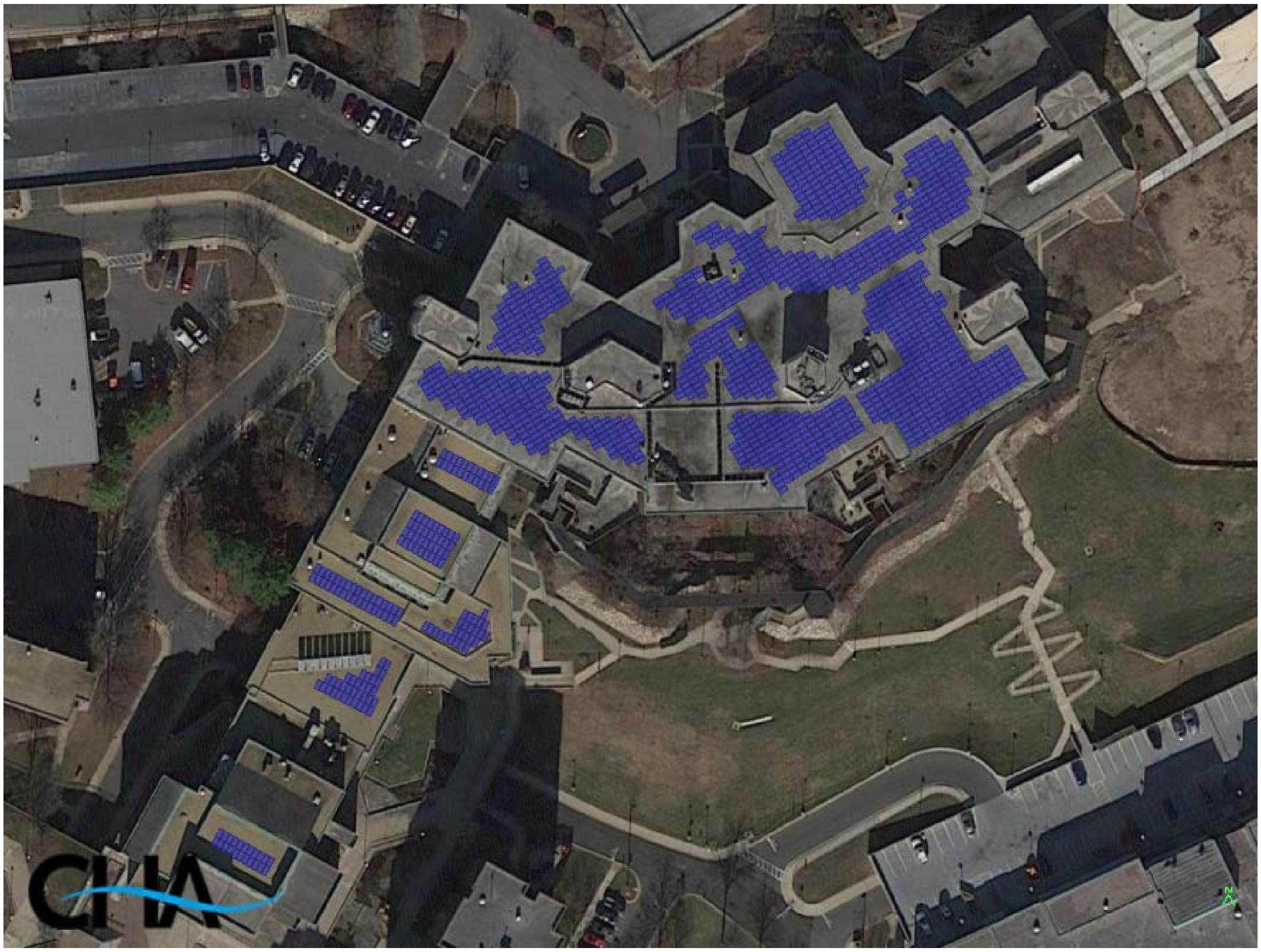
III. Building Analysis

Kendall Demonstration Elementary School (KDES)

KDES is a great candidate for a rooftop photovoltaic installation. A summary of the PV arrays are shown in the table below:

kWDC	438.9
kWAC	360.0
Module Count	1,439
kWh Production	531,358
Tilt Angle	5°
Azimuth	156°
Inverters	(6) Solectria PVI 60TL
String Count	78

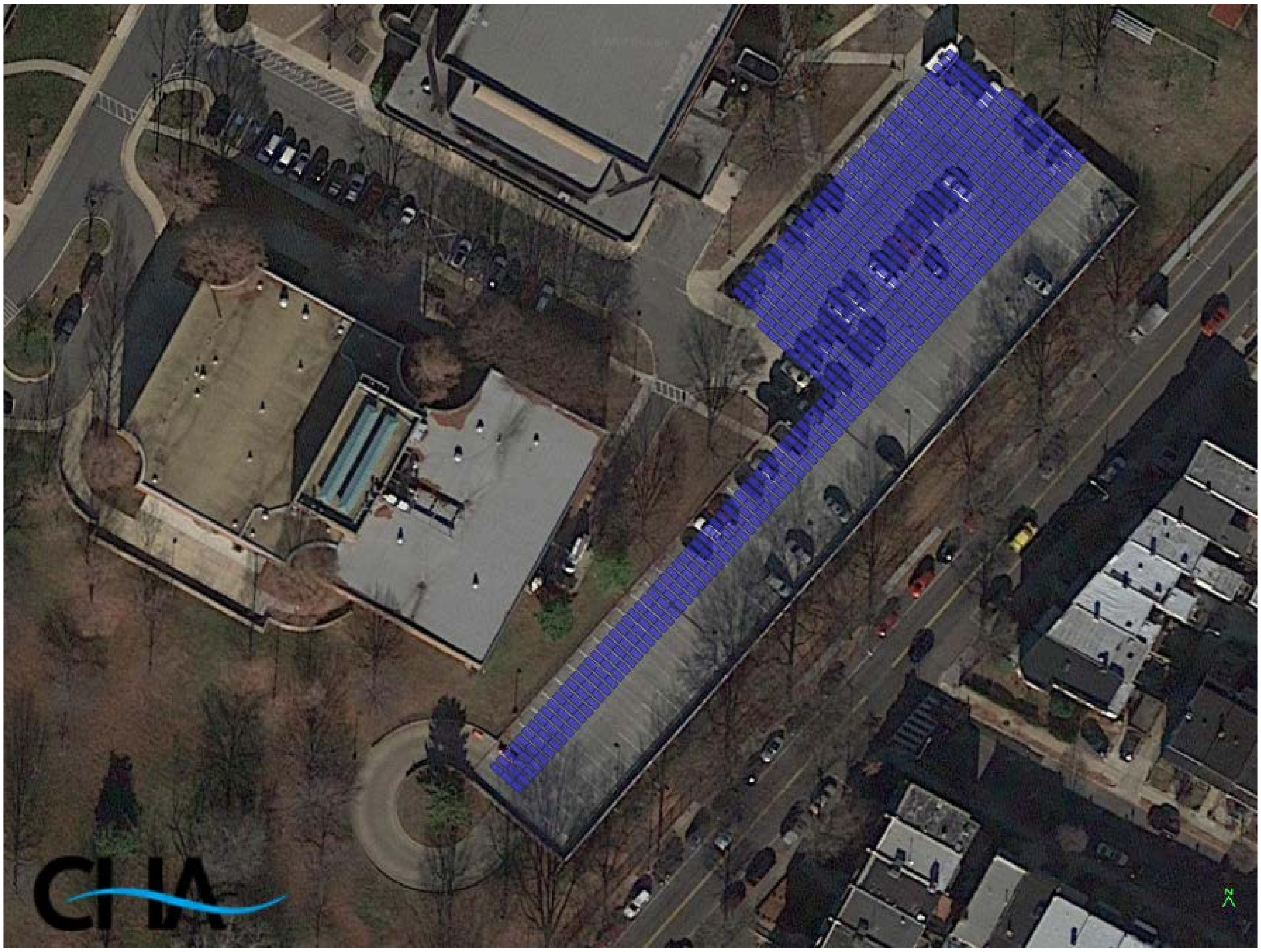
Model Secondary School for the Deaf (MSSD)



MSSD is a great candidate for a rooftop photovoltaic installation. A summary of the PV arrays are shown in the table below:

kWDC	392.5
kWAC	360.0
Module Count	1,287
kWh Production	472,829
Tilt Angle	5°
Azimuth	118, 148°
Inverters	(6) Solectria PVI 60TL
String Count	75

Field House Parking Deck



Field House Parking is a fair candidate for a parking deck structure photovoltaic installation. Several trees may not be taken down to eliminate shade for this array, this may become a structural/wind issue. Please note that the additional structure to allow the modules to be mounted to the parking deck will add significant cost to this project. A summary of the PV array is shown in the table below:

kWDC	193.7
kWAC	161.0
Module Count	635
kWh Production	238,608
Tilt Angle	10°
Azimuth	222°
Inverters	(7) Solectria PVI 23TL
String Count	35

College Hall Parking

College Hall is a great candidate for a canopy mounted photovoltaic installation. A summary of the PV arrays are shown in the table below:

kWDC	211.4
kWAC	180.0
Module Count	693
kWh Production	253,195
Tilt Angle	7.5°
Azimuth	118°
Inverters	(3) Solectria PVI 60TL
String Count	39

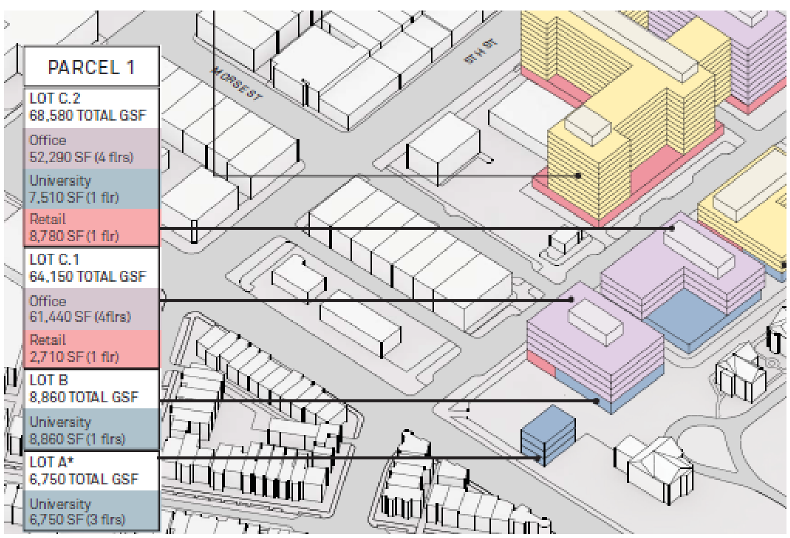
Model Secondary School for the Deaf Gym and Pool

MSSD Gym and Pool are great candidates for rooftop photovoltaic installations. A summary of the PV arrays are shown in the table below:

kWDC	198.9
kWAC	180.0
Module Count	652
kWh Production	240,116
Tilt Angle	5°
Azimuth	148°
Inverters	(3) Solectria PVI 60TL
String Count	36

6th Street – Parcel 1

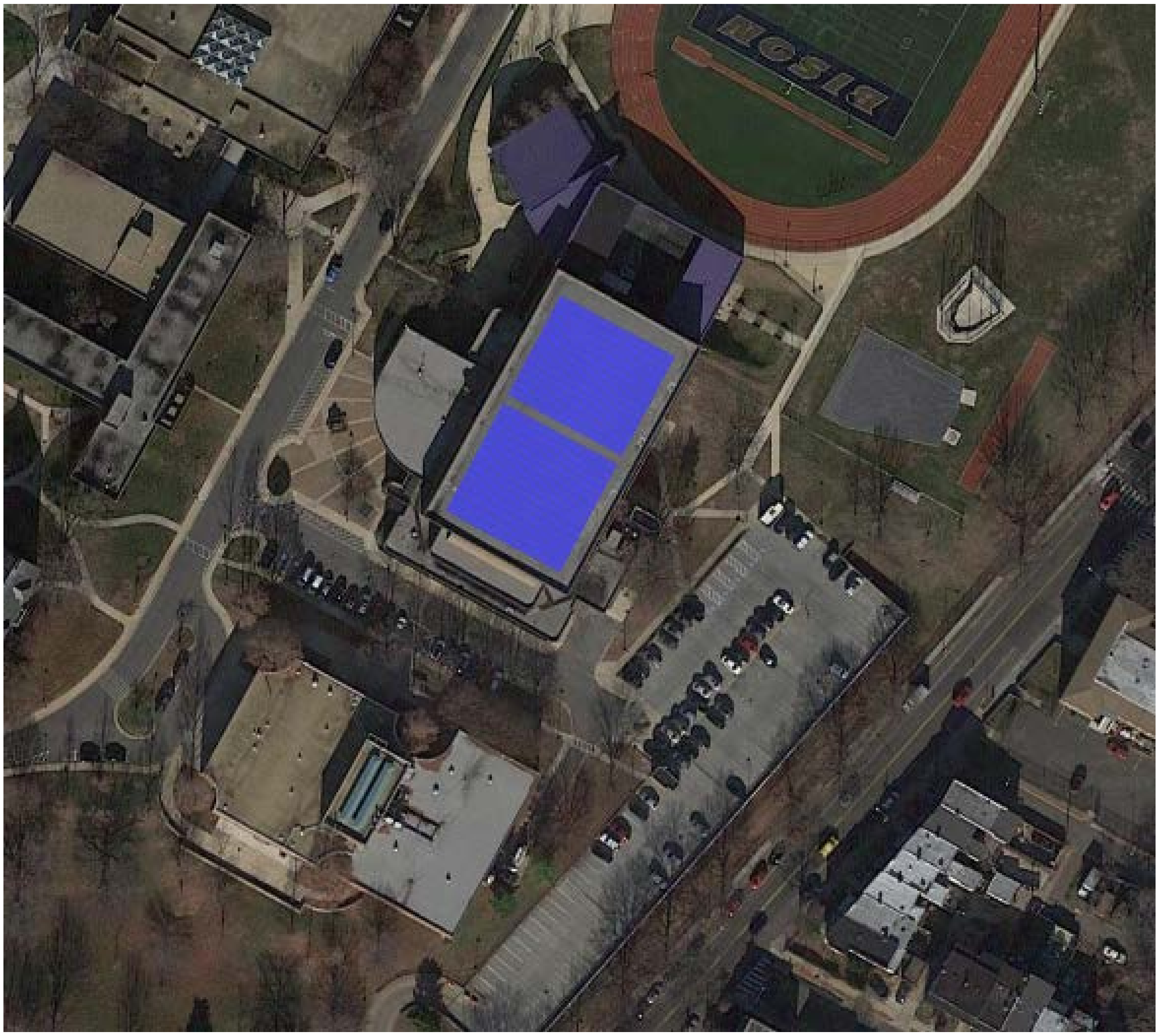
The 6th Street – Parcel 1 conceptual layout was estimated from a GU Package Scheme PDF shown below:



No exact dimensions were provided. However, the layout derived from the model should be a good estimate of potential system size for the future construction project. Even with both penthouse obstructions, they are both good candidates for a rooftop photovoltaic installation. A summary of both building arrays are shown in the table below:

kWDC	192.2
kWAC	180.0
Module Count	630
kWh Production	228,719
Tilt Angle	5°
Azimuth	120°
Inverters	(5) Solectria PVI 36TL
String Count	35

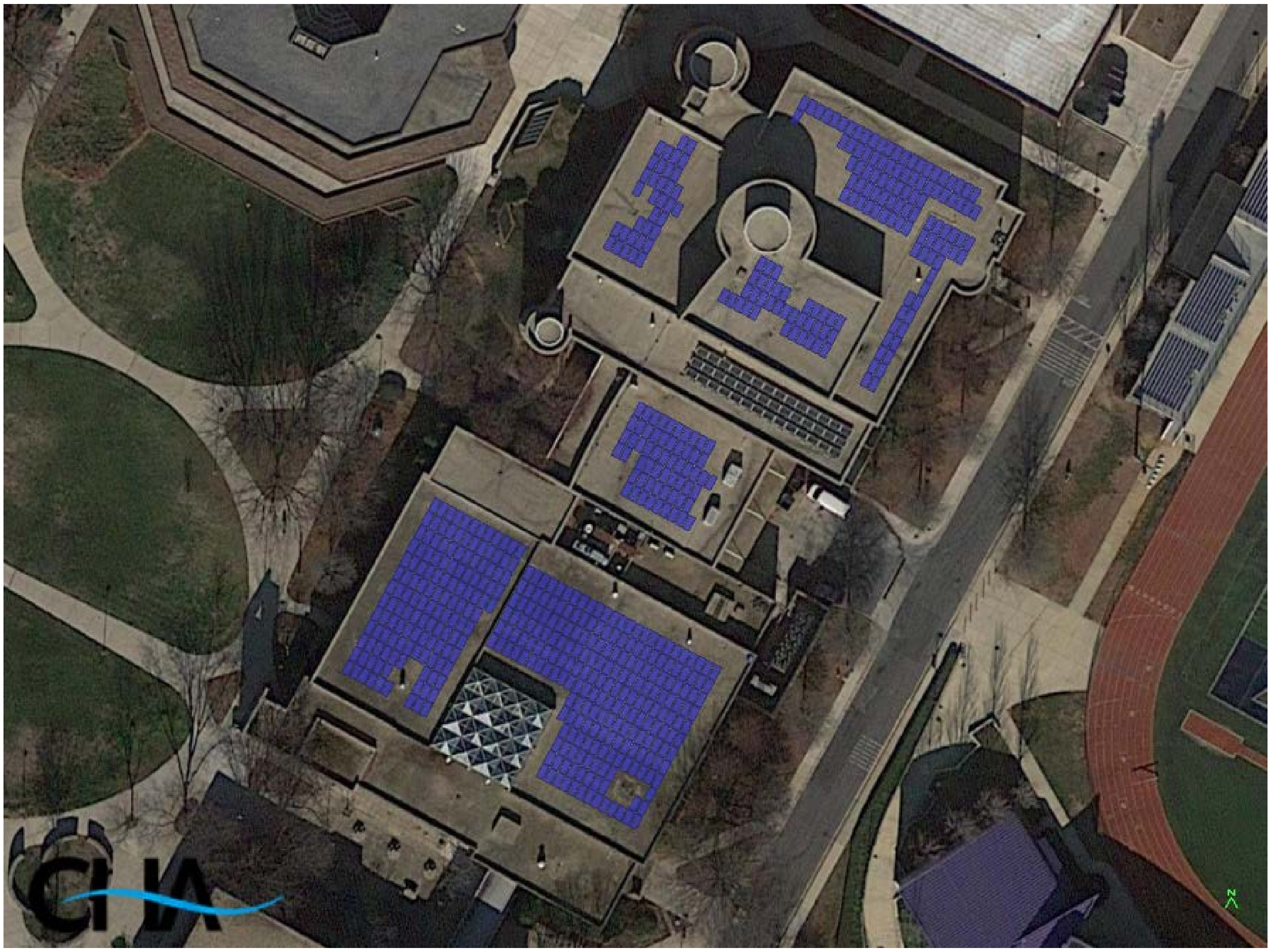
Field House



The Field House is a great candidate for a rooftop photovoltaic installation. A summary of the PV array is shown in the table below:

kWDC	175.4
kWAC	144.0
Module Count	575
kWh Production	208,619
Tilt Angle	5°
Azimuth	118°
Inverters	(4) Solectria PVI 36TL
String Count	32

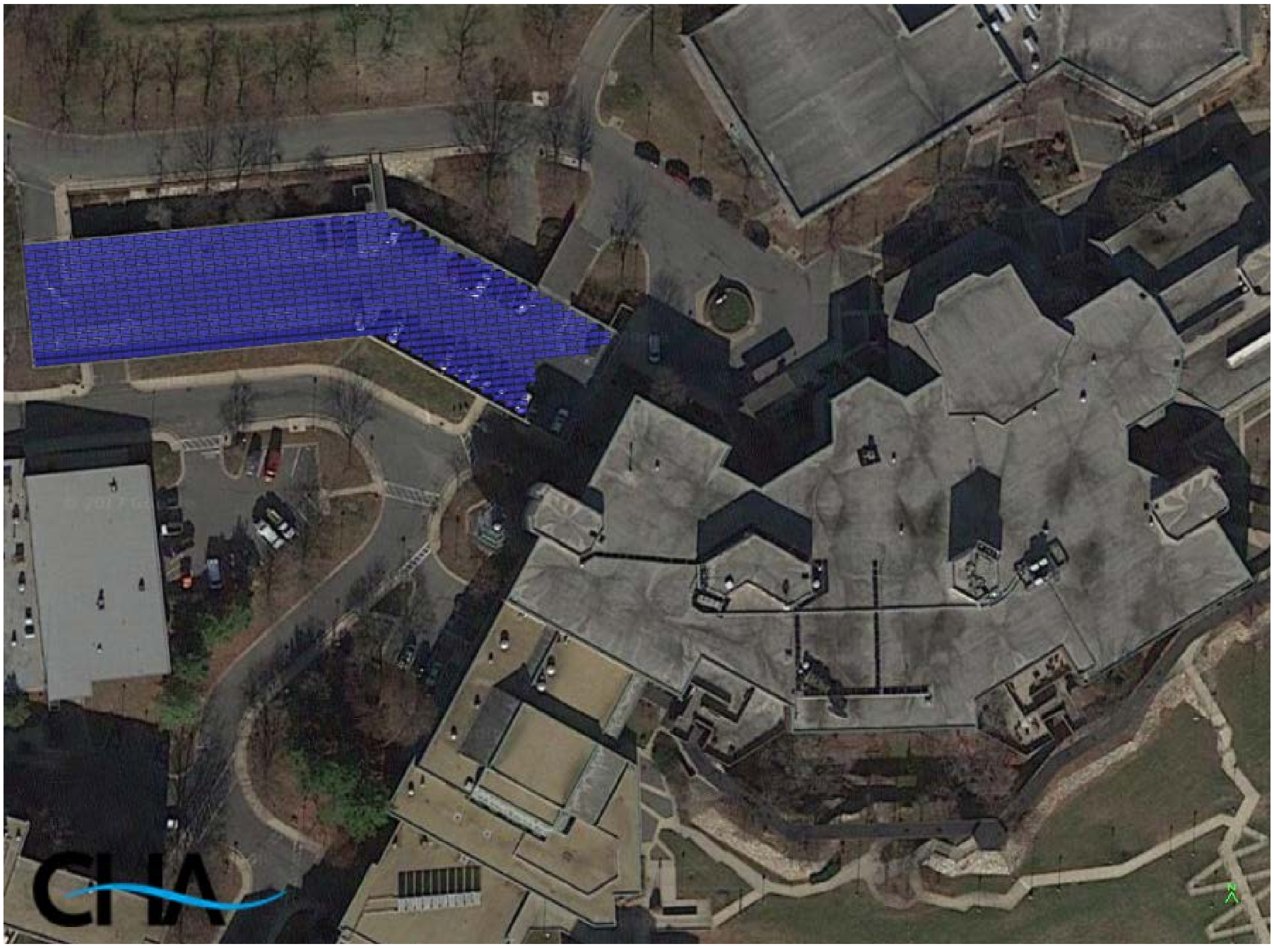
Student Academic Center (SAC)



SAC is a great candidate for a rooftop photovoltaic installation. The building appears to already have an existing PV system installed - this may lead to more planning and cost for interconnection and tie-in to the building. A summary of the PV arrays are shown in the table below:

kWDC	181.1
kWAC	161.0
Module Count	596
kWh Production	216,136
Tilt Angle	5°
Azimuth	118°
Inverters	(7) Solectria PVI 23TL
String Count	35

Model Secondary School for the Deaf Parking Deck



MSSD Parking deck is a fair candidate for a parking deck structure photovoltaic installation. Due to its shape, the allowable PV module structure span to mount the modules, and shading from the attached building, only a portion of the deck would be viable for PV install. Winding resistance may be an issue, dummy panels may need to be included to create a greater structural platform. Parking Deck structure mounts add significant cost to the overall install. Since this overall system size is large, CHA recommended the site. However, if GU wanted to make the overall project more cost effective, this should be the first site removed. A summary of the PV array is shown in the table below:

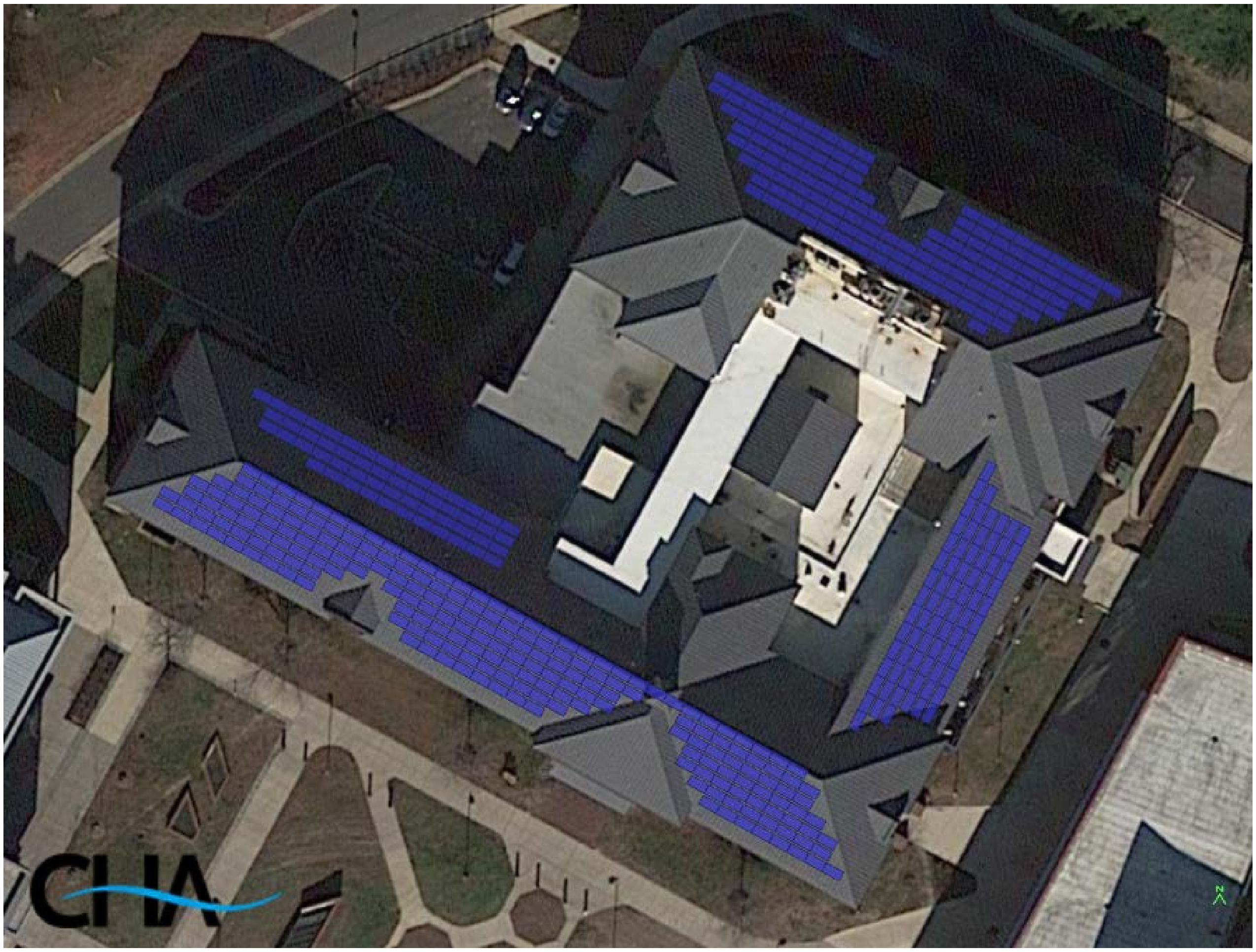
kWDC	235.8
kWAC	240.0
Module Count	773
kWh Production	296,887
Tilt Angle	10°
Azimuth	175°
Inverters	(4) Solectria PVI 60TL
String Count	39

Sorenson Language Learning Center (SLCC)

SLCC is a good candidate for a rooftop photovoltaic installation. Aggressive assumptions on shading and set-backs were assumed for this layout. A summary of the PV arrays are shown in the table below:

kWDC	143.0
kWAC	115.0
Module Count	469
kWh Production	170,224
Tilt Angle	5°
Azimuth	115, 119°
Inverters	(5) Solectria PVI 23TL
String Count	29

Hall Memorial Building (HMB)



HMB is a good candidate for a rooftop photovoltaic installation. The majority of the roofs are metal which will allow for easy installation. The north-west flat roof has future plans so no solar was proposed. A summary of the PV arrays are shown in the table below:

kWDC	141.8
kWAC	120.0
Module Count	465
kWh Production	165,831
Tilt Angle	6, 7.5°
Azimuth	29, 118, 209°
Inverters	(2) Solectria PVI 60TL
String Count	26

MSSD Dorm

MSSD Dorm is only a candidate for a rooftop photovoltaic installation with dunnage support systems to hold up the modules. This will add significant cost to the installation for this green showcase building. A summary of the PV arrays are shown in the table below:

kWDC	192.8
kWAC	180.0
Module Count	632
kWh Production	232,661
Tilt Angle	5°
Azimuth	148
Inverters	(3) Solectria PVI 60TL
String Count	36

Central Utilities Building

Central Utilities Building is a good candidate for a rooftop photovoltaic installation. The eastern roof has a slight slope - depending on the wind load and structural analysis could require penetrations to install this array safely. A summary of the PV arrays are shown in the table below:

kWDC	91.5
kWAC	84.0
Module Count	300
kWh Production	108,382
Tilt Angle	5, 8°
Azimuth	84, 174°
Inverters	(6) Solectria PVI 14TL
String Count	30

Elstad Auditorium

Elstad Auditorium is a good candidate for a rooftop photovoltaic installation. A summary of the PV arrays are shown in the table below:

kWDC	80.2
kWAC	70.0
Module Count	263
kWh Production	95,421
Tilt Angle	5°
Azimuth	119°
Inverters	(5) Solectria PVI 14TL
String Count	25

Washburn Arts Building

Washburn is a fair candidate for a rooftop photovoltaic installation. Aggressive design on the overall setbacks increased the system size. A summary of the PV arrays are shown in the table below:

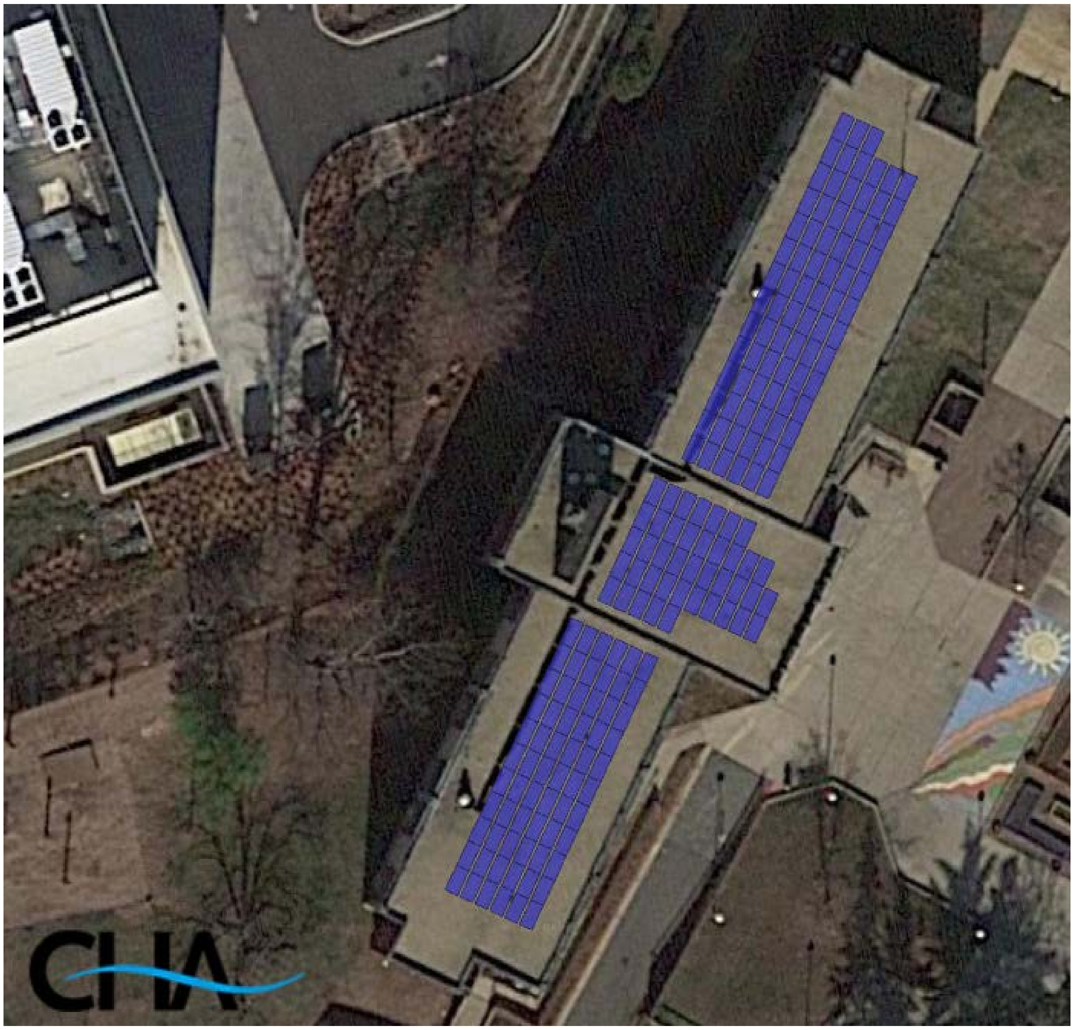
kWDC	59.8
kWAC	56.0
Module Count	196
kWh Production	71,198
Tilt Angle	5°
Azimuth	121°
Inverters	(4) Solectria PVI 14TL
String Count	20

Merrill Learning Center

Merrill Learning Center is a fair candidate for a rooftop photovoltaic installation. An aesthetically pleasing symmetric panel configuration was designed due the building's high-visibility location. A summary of the PV arrays are shown in the table below:

kWDC	41.5
kWAC	36.0
Module Count	136
kWh Production	50,228
Tilt Angle	5°
Azimuth	209°
Inverters	(1) Solectria PVI 36TL
String Count	8

Ballard West



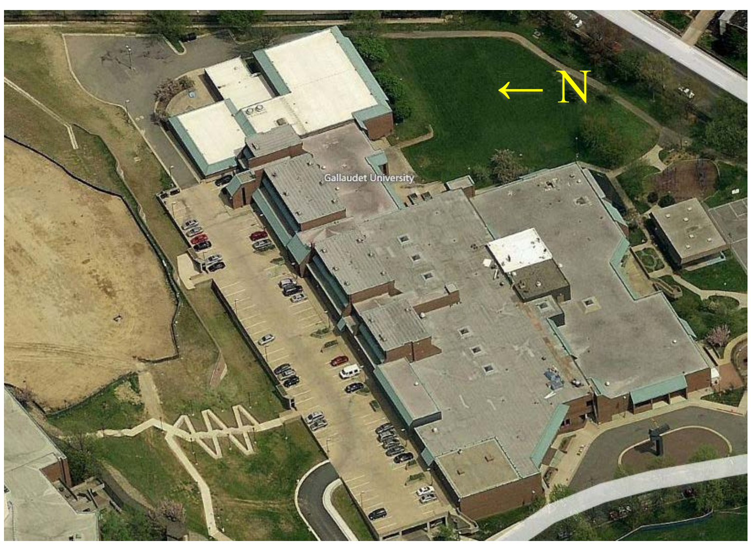
Ballard West is a fair candidate for a rooftop photovoltaic installation. A summary of the PV arrays are shown in the table below:

kWDC	57.3
kWAC	46.0
Module Count	188
kWh Production	69,136
Tilt Angle	5°
Azimuth	115°
Inverters	(2) Solectria PVI 23TL
String Count	12

Sites Not Recommended:

Grandstand – this location is not recommended for a PV installation due to the orientation and bleacher location of the grandstand. The structure to be built on top of the grandstand to mount the panels would have to slope north to prevent blocking the view of the football field. The northern positioning along with projected shade from the existing lighting fixtures would result in poor PV production on this potential PV array. In addition, the structural addition for minimal production and system size would be very expensive.

Kendall Garage – this location is not recommended for a PV installation due to shading from the higher elevation of the Elementary School. In addition, the orientation of the structure to mount the modules on the parking garage to avoid excessive distances without support, would result in poor PV production.



LLRH – this location is not recommended for a PV installation due to the small system size coupled with high construction costs of installing the array on such a tall building.

MSSD Housing –. MSSD Housing is not recommended due to the small size of the peaked roofs resulting in excessive roof penetrations for a minimal system size.

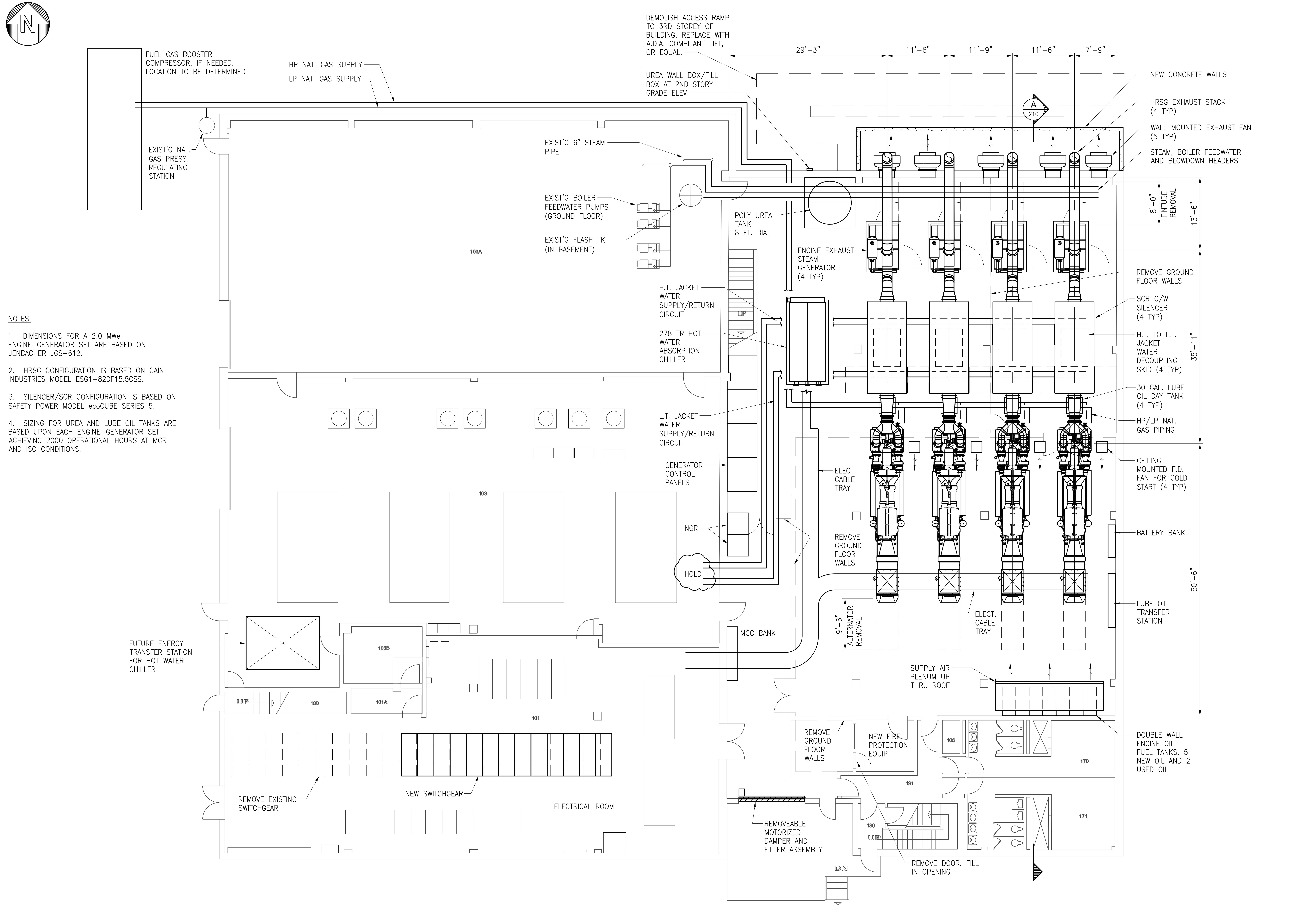
Peet Hall – this location is not recommended for a PV installation due to the small system size coupled with high construction costs of installing the array on such a tall building.

Guard House/Security Kiosk – this location is not recommended for a PV installation due to the small system size and shade resulting from surrounding trees.

Kellogg Center - this rooftop is a poor candidate for a rooftop photovoltaic installation. The roofs are peaked which will include numerous roof penetrations. This building contains very tall and steep peaked roofs, this could contribute to a higher construction cost.

Attachment F

General Arrangements



NOTES:

1. DIMENSIONS FOR A 2.0 MWe ENGINE-GENERATOR SET ARE BASED ON JENBACHER JGS-612.

2. HRSG CONFIGURATION IS BASED ON CAIN INDUSTRIES MODEL ESG1-820F15.5CSS.

3. SILENCER/SCR CONFIGURATION IS BASED ON SAFETY POWER MODEL ecoCUBE SERIES 5.

4. SIZING FOR UREA AND LUBE OIL TANKS ARE BASED UPON EACH ENGINE-GENERATOR SET ACHIEVING 2000 OPERATIONAL HOURS AT MCR AND ISO CONDITIONS.

GROUND FLOOR PLAN
SCALE: 1/8 = 1'-0"

0 4 8 12 16 20 24 28 32 FEET
SCALE: 1/8" = 1'-0"

CHA

III Winners Circle, PO Box 5269 • Albany, NY 12205-0269
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Washington, DC

COGENERATION STUDY

No.	Submittal / Revision	App'd.	By	Date
P1	ISSUED FOR REVIEW	JJ	BG	10/11/17
P2	ISSUED FOR REVIEW	JJ	BG	10/19/17
P3	ISSUED FOR REVIEW	JJ	BG	10/27/17
P4	ISSUED FOR REVIEW	JJ	BG	12/08/17

GENERAL ARRANGEMENT
GROUND FLOOR PLAN

Designed By:	Drawn By:	Checked By:
JJ	BG	JJ
Date:	Project No:	Scale:
SEPT. 2017	33425	1/8"=1'-0"

Drawing No.:

M1-201

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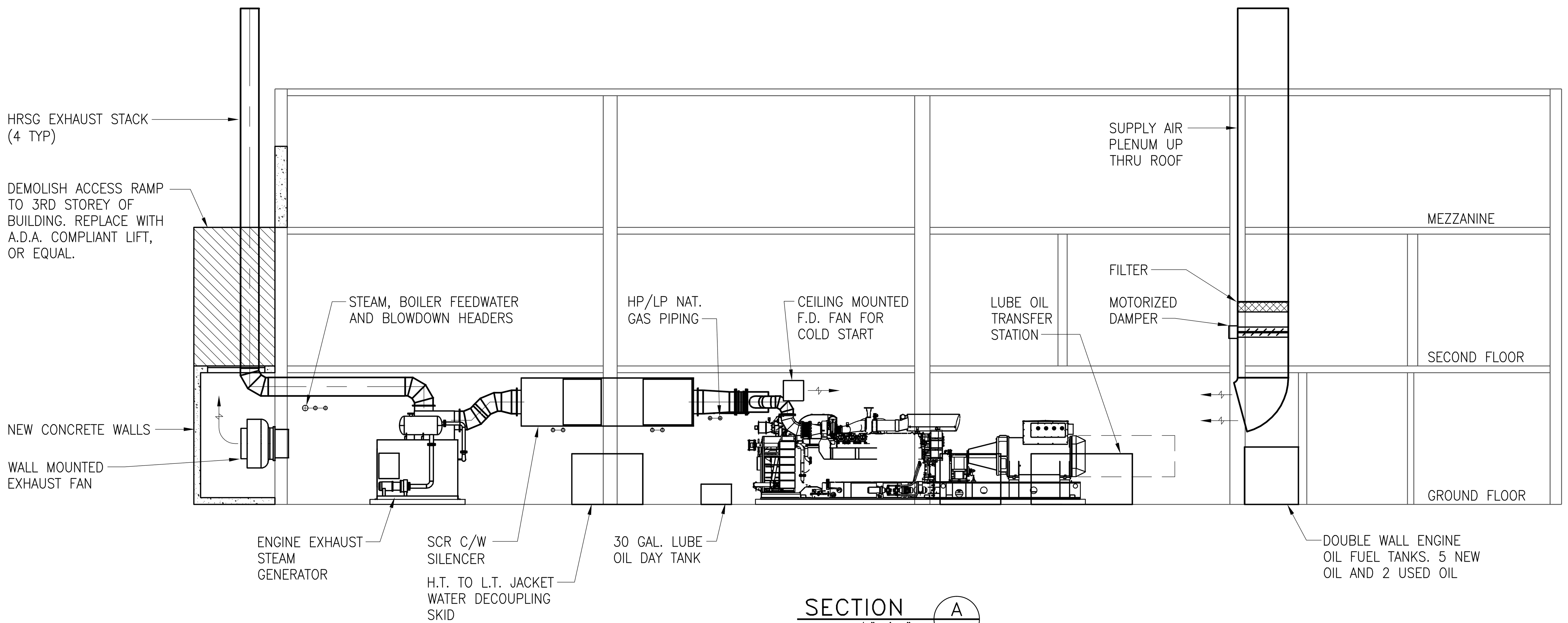

SECTION A
SCALE: 1/8"=1'-0" 201

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P2	ISSUED FOR REVIEW	JJ	BG	10/19/17
P3	ISSUED FOR REVIEW	JJ	BG	10/27/17

GENERAL ARRANGEMENT
SECTION A-A

Designed By:	Drawn By:	Checked By:
JJ	BG	JJ
Date:	Project No:	Scale:
SEPT. 2017	33425	1/8"=1'-0"

Drawing No.:

M1-210

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Narrative accompanying the General Arrangements drawings

Note: All equipment, consumables, air supply requirements, etc are sized for up to four 2 MW engines, with specific operating parameters taken from a Jenbacher JMS 612 as representative of that class of engine. To provide extra flexibility in the event of either different equipment selection or a desire to upsize the generation capacity, the engines themselves are sized at 2.4 MW apiece, with sizes, maintenance clearances, etc taken from a Jenbacher JMS 616.

1. Re-use of the existing Central Utility Building

Gallaudet University is planning to make space available for the microgrid within the existing CUB, co-located with today's chiller plant, steam facilities, and utility grid connection. The UI-CHA team has examined the space that today is occupied by a carpenter shop, machine shop, and storage rooms. We have concluded that, with modest modifications, the space can accommodate a new "CHP room" with all balance of plant components needed for integration with existing heating, cooling and electrical distribution systems. , including room for significant future expansion. This approach should result in significantly lower capital cost, compared to building a completely new facility or integrating a modular solution, as physical space within the campus is constrained.

The accompanying General Arrangements drawings (Plan and Section) show the lowest level of the CUB, on the same grade as the chillers, boilers, and switchgear. A number of the existing , non-load-bearing walls would be removed, noted as "Remove Ground Floor Walls" where appropriate.

Removal and maintenance access for all equipment can be achieved through the existing loading dock, subject to load-bearing capacity inspection. The loading dock would be modified with a customized removable louver assembly, to supplement cooling and aspiration air requirements of the internal combustion engines. The louver assembly must be capable of attenuating the operational noise spectrum generated by the CHP equipment to achieve acceptable sound levels at the dormitory "Ballard North" (or its future replacement)..

The two existing offices near the loading dock would be removed, to create room for equipment removal and for a new room with fire protection equipment dedicated to the engine-generator sets. The existing washrooms (room 106) and change facilities (room nos. 170 and 171) will remain in place. The connecting corridor (room 191) will provide a measure of sound insulation, separating the 85dbA inside the CHP room from the stairs and vestibule, washrooms, change rooms, etc.. and reduce noise propagation that could potentially spill from the south-east quadrant of the CUB building.

The baseline configuration for a campus-only microgrid includes a pair of engine-generator sets at approximately 2 MW name-plate capacity each. Future expansion of the microgrid to serve neighboring loads beyond the campus, for example across 6^{th} Street in the Union Market development, could necessitate additional generation capacity. As shown in the GA drawings, the available space would accommodate up to four engine / generator sets in a North-South orientation alongside the two units dedicated to the campus. This orientation of the engine-generator sets was selected for further study as the lay-out facilitates maintenance accessibility and ease of removal for the alternator, engine and any related balance of plant component.

2. Modifications to the CUB – external north wall and internal west wall

New self-supporting, externally lined/insulated exhaust stacks will be required for each reciprocating engine. After some consideration of both pressure-drop and stoichiometry, re-use of existing stacks was rejected, and the most appropriate location determined to be on the north wall of the CUB traversing past the CUB's third floor to a code-compliant elevation. The use of guy-wires may be required upon further structural evaluation of the CUB superstructure and the proposed foundation design for the new stack. The impact (or impingement) effects of the stack discharge for this location are minimal; as the north perimeter of the CUB, faces a parking structure.

This approach is the focus of the most extensive modifications needed at the CUB. Demolition of soil and strata will be necessary on the north face, excavating down to the footings of the ground floor. A new knee wall would be installed, including dewatering scheme tied into the existing building sump, a full story below north elevation grade. Perforated removable metal decking would be installed at grade above that area to access CHP room exhaust fans discharging into this area bound by the new knee wall (discharge plenum) Installation of the exhausters will

require saw cuts in the north face concrete wall.. The installation would include significant air plenums, with louvres and wall-mounted fans/housing. Access would be sufficient for the approximate bi-annual maintenance performed on the belt fittings for those exhausters.

These north wall modifications would also necessitate a new ADA access point for the building.. Potential concepts include include a motorized outdoor lift or a new at-level ramp from the uphill direction of the sidewalk.

Within the CUB, more modest modifications will be required for installation of the engine-generator balance of plant equipment and tie-ins to the various process systems affected; namely modifications to the west and north walls of the CHP room,. All piping would be suspended from the underside of the existing 1st floor ceiling, which is cast-in-place concrete,. The general contractor would install steam collection headers and feedwater headers, common to all HRSGs, from west to east, as well as the blow-down lines.

Interior building wall penetrations will be required for all process connections to the feedwater, steam and blowdown systems residing in the adjacent boiler room. The concept denotes that these tie-ins can easily be achieved by core-drilling or saw-cut through the reinforced concrete wall above the existing doorway, as shown, without interfering with existing boiler room equipment. . Penetrations through the same west wall provide the connections shown for chilled-water supply and return, for access to the cooling tower cells west of the CUB (via the existing circuits within the chiller room), and for medium-voltage power cabling, auxiliary LV power and 24 VDC control-circuit power, via the ceiling-level 36" cable tray entering the existing electrical and switchgear room, as shown.

3. Layout of Gensets and BOP equipment

The current slab in the future CHP room is probably not sufficient to accommodate the new dead/live and dynamic loads associated with the installation (and operation) of the reciprocating engine-generator sets. Each set will require a dedicated foundation (island/raft slab) embedded within the existing floor-slab to match the existing top of concrete (TOC) elevation.An example excavation would be for 24"-depth concrete around a perimeter defined by the engine plus a 2' margin. It is envisioned that a new electrical grounding scheme for the CHP components would be installed and tested in parallel with excavation and remediation efforts for the engine-generator foundations.

Balance of plant equipment and components serving engine-generator sets consists of the following:

- New lube oil tanks
- Used lube oil tanks
- One (1) day tank serving each engine generator
- One (1) energy transfer station serving each engine generator's jacket water cooling system complete with heat exchanger, circulation pump, bypass, and pressure/temperature/flow indicators.

Housekeeping pads (for example, of 4" concrete) would be poured around the perimeter of decoupling skids, which include the heat exchanger, pump, bypass, and pressure and flow indicators.

In the absence of a sufficient thermal load for HT HW, the engine generator's logic controller will modulate the engine's cooling media (50% ethylene glycol solution, aka 'jacket water') to fin-fan coolers or cooling towers, to achieve the required return temperature (75C) to the engine jacket. Each LT engine circuit serving the r the engine's lube oil and intercooler contains relatively low amounts of recoverable rejected heat; potential heat loads that could be considered consist of building ring heating or unit heater coil circuits. Additionally in the absence of a heat load to provide cooling of the LT circuit, heat could be rejected into an existing cooling cell or newly-installed fin-fan cooler.

Above, mounted to the underside of the 1st floor ceiling, would be the ammonia SCR plus silencer – for example, Safety Power's EcoCube module. A single polyurethane urea tank would be installed as shown, with sizing described below.

Each engine generator shall be equipped with a dedicated heat recovery steam generator (HRSG) complete with a bypass diverter / damper, integral to each engine generator's exhaust. The diverter system shall be controlled by the engine's controller and would make full exhaust gas bypass of the HRSG possible when steam demand is not present (for example, during maintenance operations). . Examples include Cain Industries' forced circulation HRSG or Hering.

Adjacent to the engine-generator trains an overhead electric cable tray provides routing for conductors/cabling/communication leads from the alternator terminals, generator control panels, HRSG controls, and other operator I/O panels located along the western wall of the CHP room. That cable tray meets another 36" cable tray, suspended east to west above the alternators, which provides a 13KV cable connection straight into the electrical room as shown.

A Motor Control Center (MCC) bank resides south of the engine-generator control panel array providing the starter/control for various drives, pumps and motors associated with balance of plant equipment, with monitoring and control also possible from the main control room upstairs and/or by 3rd-party remote operators.

4. Air intake, exhaust, and tempering

As shown, cooling and aspirating air is supplied to the engine-generator trains from a new inlet plenum emanating from the the CUB roof-line. The plenum would penetrate the floor slab and roof decking in the machine shop on the 2nd floor and terminate below the ceiling of the CHP room in the vicinity north of the new/used oil tanks and south of the lube oil transfer station. In accordance with best practice recommendations from engine-generator manufacturers, this configuration distributes cooling/aspirating air over each alternator, turbo-charger intake, and BOP equipment, prior to being induced out the north face of the CHP room through dedicated wall plenum/exhaust fans.

During start-up, the engines would start to draw air from both this rooftop air plenum and from the louver assembly above the loading dock entrance, as described above. To temper incoming cold air during the winter, the ceiling-mounted forced draft fans shown in the spaces between turbo areas would take warm air rejected from turbos to mix (tempering) with the outdoor intake air.

5. Provisions for access, maintenance and removal of equipment

The layout shown ensures 3' minimum clearance between units, and to any existing surface in the CUB, including for all recommended maintenance accesses. The arrangement avoids any interference with existing structural columns in order to access filters, valves, stations, etc.

Space is available as shown for alternator removal, engine removal, or a combined sled. Similarly, clearance is provided for the removable, motorized damper and filter assemblies. In the event of equipment removal, the same jack-and-roll method will enable egress back out through loading dock, in the same manner as the original ingress.

6. Engine lube oil and urea: system layout and basis of design

Floor-mounted 30 gallon day tanks for lube oil are shown to the north of each engine-generator set. The lube oil day tanks act as a buffer to serve/replenish the lube oil reservoir; the day tank is replenished by operators using the lube oil transfer pumping train. Standard procedure would be to swap out the engine oil during general maintenance and plug-change maintenance.

An operator interface would be provided to monitor lube oil in each day tank and to pump fresh oil from the storage tank into the day tank. Operators would use the same array to pump out spent oil from engine crank case to the used oil receptacle by reversing the valving array to the suction side.

A lube oil transfer station is shown along the east wall, which would include a series of isolation valves and pneumatic pumps. A set of seven 1000-liter engine oil storage tanks, under the supply air plenum on the south wall of the CHP room, would be ganged in christmas-tree arrangement (when one is full, the next one is used). These are standard off-the-shelf double-walled Roth stainless tanks, with sufficient clearances to fit underneath the aspirating/cooling air supply plenum.

Each hour of run time at an engine's maximum continuous rating (MCR) would consume 620 ml, or 2.5 liters of oil if all four engines were installed and operating. That consumption equates to 3600 liters over the course of two months (1440 hours). With a 25% margin, the needed storage volume is up to 4,500 liters, or a set of five supply tanks. 2000 hr run-time at MCR would produce 415 liters of spent lube oil or 1700 liters across all four engines, requiring two spent oil tanks, or seven in total.

An operator interface would be provided to monitor lube oil in each day tank and to pump fresh oil from the storage tank into the day tank. Operators would use the same array to pump out spent oil from engine crank case to the used oil receptacle by reversing the valving array to the suction side.

An off-the-shelf polyurethane urea tank is shown along the north wall, including a levy for spill containment. Per operating hour at MCR, each 2 MW engine is rated to consume 4 liters of 34% aqueous solution urea to achieve Tier IV emissions control. The tank was sized assuming 2000 hours of run-time across all four engines amounting to 16,000 liters, thus requiring a 4,000 gallon poly tank. The tank would installed at grade on the north face of the CHP room, with a lockable fill box and light and/or buzzer annunciation for level indication on the tank.

A 3rd party fluids distributor for oils and other consumables could be contract for bi-monthly deliveries and would top-off the tanks regardless of operating hours, with integral spill containment.

7. Tie-ins: Steam, BFW, blow-down, HW S/R, electrical

Steam:
The proposed tie-into the steam system (6" header) is located inside the Boiler Hall near the west wall of the CHP room. This header is already part of the high-pressure steam network, feeding the existing let-down station.

Boiler Feedwater (BFW):
BFW can be supplied from the existing boiler feederwater pumps, using an existing elbow that bends west to supply the existing 3 boilers. This elbow would be replaced with a T-junction, as shown, to tie in BFW for the HRSGs.

Blow-down:
For blow-down, a connection can be made through the same west wall of the CHP room, into the existing french drain with existing flash tank in basement, as shown.

Hot-water supply and return:
The jacket water decoupling skid would be mounted on a housekeeping pad of 4" concrete, poured onto the existing floor, positioned directly under the EcoCUBE SCR module, as shown. Valving would determine HW utilization for the absorption chillers, as described below, or for a future hot-water system distributed to appropriate loads, including off-campus loads.

SWGR, Aux LV Power and 24 VDC:
All electrical cables and connections would travel along the 36" electrical cable tray, as shown, into the existing electrical room, where all new switchgear would be installed as part of the microgrid project (see Attachment G).

8. Absorption chillers and cooling scheme

A single-effect two-stage Thermax hot-water driven absorption chiller would provide supplementary cooling capacity for the campus during the April to November cooling season, and help round out the heat-recovery process by making use of the engine jacket water as a complement to the HRSGs.

In the current, campus-only, phase of the microgrid project, a single absorption chiller would be positioned just west of and parallel with the decoupling skid (energy transfer station) first engine-generator, as shown. In subsequent phases, which may also include installation of the 3rd and 4th engines, it is anticipated that a full chiller plant replacement would be warranted, with the University's existing electric chillers having then reached the end of their useful life. At that point, chiller replacement could be accompanied not only by the installation of additional absorption chillers within the current footprint of the existing chiller plant, but also combining electric and steam-driven chillers and a new chilled water storage tank for maximum flexibility and peak-load management.

Hot water recovered from the engine jacket water in the decoupling skids would be transferred to the absorbers with supply and return piping as shown. Further heat rejection from the absorbers via the cooling tower array to the west of the CUB (denoted as Future Energy Transfer Station) would bring the HW return temperature below the maximum approach temperature back to the engines.

The absorbers would be dispatched before the electric chillers to meet campus cooling loads, and therefore would be operating during cooling season months essentially 100% of the time. However, during winter months, heat rejection from the engine jacket water would be achieved through fin-fan coolers installed on the CUB roof. Alternatively, an existing small shell and tube heat exchanger located in the Chiller Hall uses cooling tower water to condense low pressure steam or overly hot condenser water, before recovered as condensate and deployed back into the steam cycle. . The same area could house another heat exchanger, which would combine the cooling load for the jacket water header, coupled to all four of the decoupling skids. Both of these approaches provide a stand-alone solution for the engine controls to monitor and maintain its own heat rejection and approach temperature, regardless of any productive utilization of the low-temp jacket water circuit.

In the future, a dedicated hot-water distribution system could supply year-round domestic hot water (DHW) loads, especially in conjunction with serving residential off-campus loads such as the nearby Union Market developments. As a final measure, a bank of emergency dump radiators integral to the engines would mitigate temporary and simultaneous unavailability of absorbers and utilization of other hot-water loads (contemplated),, and cooling tower cells as heat sinks.

9. Additional design considerations

Several other design issues may be taken into consideration before finalizing a design for the microgrid system. For example, a duct burner scheme could be implemented in any one of the exhaust systems of the engine-generator. However, this would require a larger North-South footprint between the SCR and the HRSG in addition to increasing the free area of the air supply (and exhaust) plenums, and therefore may not be advisable for the limited additional steam duty achieved, considering the net capacity from the line-up in the adjacent Boiler Hall.

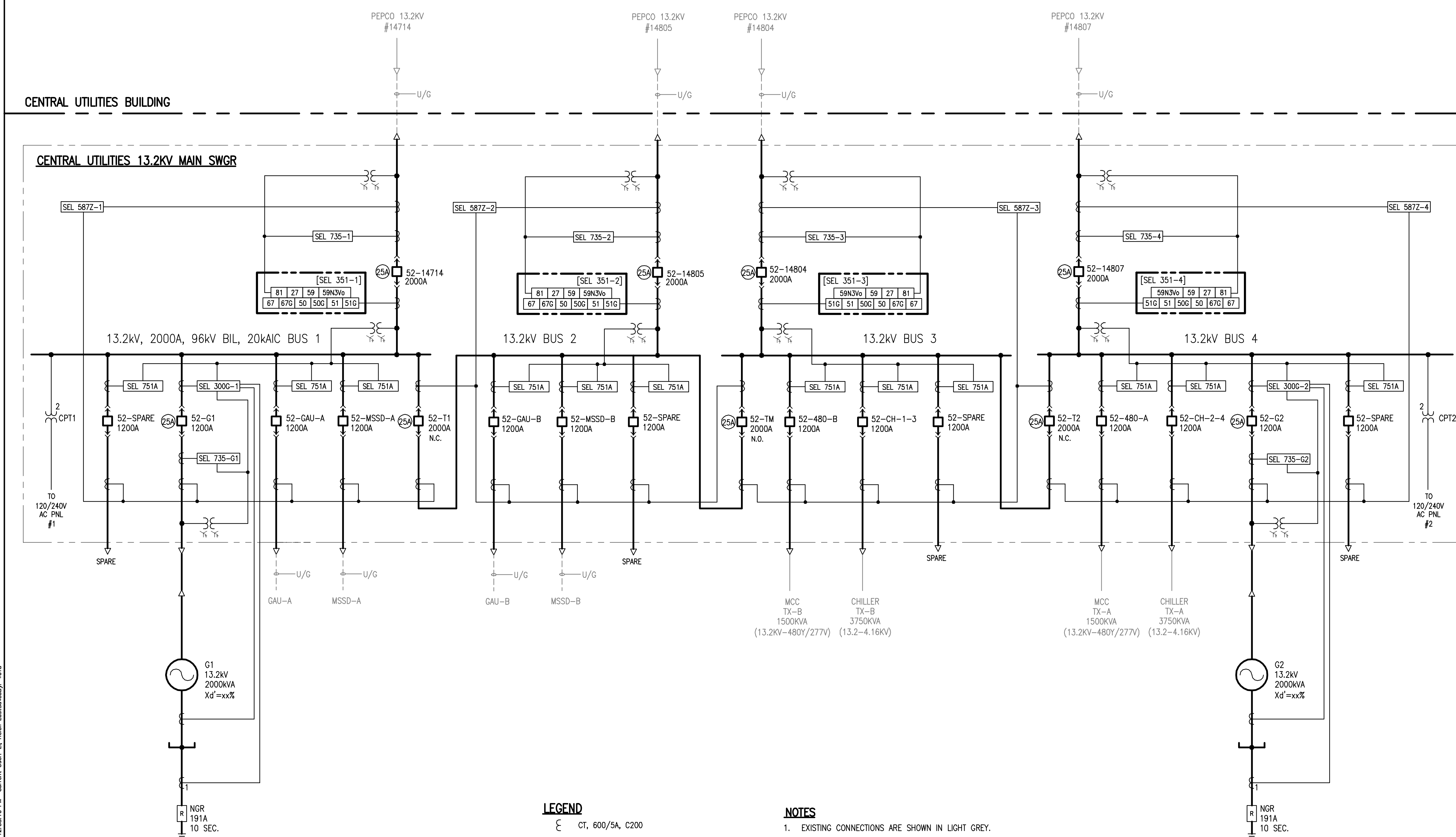
It may also be desirable to connect absorption chillers to existing cooling cells for heat rejection. This aspect of the design will require a heat and mass balance for the design/operational cases being considered. For now, the schematic has denoted spatially an area in the Chiller Hall for the location of an energy transfer system (ETS) wherein the absorber(s) would connect to utilize any spare cooling capacity within the towers.

The contemplated replacement of existing switchgear in the electrical room (see Attachment G) is expected to free up space currently occupied by larger, older switchgear equipment. The most effective use of this space has yet to be determined.

Operator control is currently provided for both boilers and chillers in a small control room on the second level of the CUB. The optimal arrangements for HMI facilities, operator rooms, and potential combination with 3rd party monitoring services has yet to be determined.

Attachment G

Electrical 1-line, Switchgear, and Interconnection Evaluation



LEGEND

- CT, 600/5A, C200
- PT, 8400/120V, 0.3WXYZ
- (25A) SYNCHRONIZER

SWGR –SWITCHGEAR
TX –TRANSFORMER
SEL –SCHWEITZER ENGINEERING LABORATORIES, INC.
MCC –MOTOR CONTROL CENTER
N.O. –NORMAL OPEN CONTACT
N.C. –NORMAL CLOSED CONTACT
GAU –GALLAUDET
MSSD –MODEL SECONDARY SCHOOL FOR THE DEAF

NOTES

1. EXISTING CONNECTIONS ARE SHOWN IN LIGHT GREY.

PRELIMINARY
NOT FOR CONSTRUCTION

CHA
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GALLAUDET UNIVERSITY

GALLAUDET UNIVERSITY
Washington, DC

COGENERATION STUDY

No.	Submittal / Revision	App'd.	By	Date
PA	ISSUED FOR REVIEW	SK	HL	10/31/17

ELECTRICAL SIMPLIFIED SINGLE LINE DIAGRAM - 13.2KV SWGR

Designed By:	Drawn By:	Checked By:
SK	HL	SK
Date:	Project No:	Scale:
OCT. 2017	33425	NONE

Drawing No.:
33425-E101

File: V:\PROJECTS\ANY\K4\33425\CADD_ACAD\EL\33425-E101.DWG Saved: 10/31/2017 11:57:47 AM Plotted: 10/31/2017 12:58:10 PM Current User: LL Helen LastSavedBy: 4018

Switchgear Replacement Cost Estimate

Based on a Proprietary Vendor Quote to UI/CHA, dated 9/27/2017

Description	**Cost**
Material Cost for 15kV- 50kA- 2000A Indoor NEMA-1 Metal Clad Switchgear (*see Attachment C*)	$560,000
Demolition, Installation & Commissioning (*see Attachment A*)	$327,000
Engineering incl. Design, Material Procurement Support & On-Site Construction Support (*see Attachment B*)	$245,000
Contingency (20%)	$88,700
Total Base Cost	**$1,220,700**
Additional material cost for engine-generator switchgear	$90,000
Installation & Commissioning	$56,000
Engineering – included within base engineering	
Contingency (20%)	$29,200
Additional CHP Cost	**$175,200**
Total Estimated Switchgear Cost	**$1,400,000**

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Modes of Operation

Grid Parallel Mode:

For normal grid-parallel operations, a single Pepco feeder provides sufficient capacity in combination with on-site generation to meet all campus peak loads. E.g.:

Status	52-14714	52-14805	52-14804	52-14807	52-T1	52-T2	52-TM	52-G1	52-G2
Open	X		X	X					
Closed		X			X	X	X	X	X

Planned Feeder Maintenance:

Upon notification from Pepco, a manual closed transition will take place from the feeder that will be lost for maintenance to an available feeder, potentially from the other Pepco service. During the transition, feeders from both services would be briefly connected via 52-TM, for under 60 cycles. E.g.:

Status	52-14714	52-14805	52-14804	52-14807	52-T1	52-T2	52-TM	52-G1	52-G2
Open	X	X		X					
Closed		X	X		X	X	X	X	X

Pepco Fault:

Differential relays will detect a Pepco fault, as shown on the accompanying 1-line diagram. If no fault is detected on the other service, then power will be drawn from another feeder, potentially using a closed transition as shown for planned feeder maintenance (see above). If faults are detected on both services, then the campus will transition to islanded operation (see below). Zero sequence voltage will be measured at all times using 69 and 67 protection functions, with protection in place at 52-TM.

Single Generator Fault:

The campus engine-generators will provide power at 13.8kV and will have a neutral grounding resistor as part of the design, so the generator output in not part of Pepco's zero path. In the event of a fault, the dedicated breaker will open. Even with a single generator operating, the campus will not exceed the capacity of a single Pepco feeder.

Status	52-14714	52-14805	52-14804	52-14807	52-T1	52-T2	52-TM	52-G1	52-G2
Open	X		X	X				X	
Closed		X			X	X	X		X

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Two Generator Fault:

If a generator fault or other failure mode were common to both generators, then no on-site generation would be present, and the switchgear configuration would revert (with closed transition) to today's settings, with the inter-tie between the two Pepco services opening:

Status	52-14714	52-14805	52-14804	52-14807	52-T1	52-T2	52-TM	52-G1	52-G2
Open		X		X			X	X	X
Closed	X		X		X	X			

Islanded Operation:

Upon loss of utility the facility will transition to islanded operation. Automated load-shedding may be required, depending on the load and generation. Peakers or back-up generation may be used to lessen the operational impact of load-shedding, and could be synchronized to the campus network. Contingency plans may be considered in the future if the frequency of nuisance generator trips or nuisance islanding due to surges, spikes, harmonics, voltage drops, etc. on the in-service Pepco feeder becomes too high, including routines for fail-over to a secondary Pepco feeder until either the transient instability subsides or all utility feeder breakers open and the system transitions to full island mode.

Status	52-14714	52-14805	52-14804	52-14807	52-T1	52-T2	52-TM	52-G1	52-G2
Open	X	X	X	X					
Closed					X	X	X	X	X

- Upon restoration of the utility, any utility intertie is going to synch back to the utility, thus restoring Grid Parallel operation. Restoration would be a seamless (closed) transition.

Additional Notes:

Exports: Import/Export condition is going to be set in place via a controller while having the parameters set in ANSI standard devices.

Black Start Condition: The facility will have the capability of starting under Black start conditions.

pepco
An Exelon Company

November 15, 2017

Dave Good, LEED-AP BD+C
Energy and Sustainability
Gallaudet University
700 Florida Avenue N.E.,
Washington, DC 20002

Subject: Gallaudet University-CVG 166
2200 East Capitol St. SE, Washington, D.C
Calculated Back-up Impedances, Fault Currents
X/R Ratios and Relay Settings Data

The back-up impedances, fault currents, and X/R ratios have been calculated to the cable terminations of the subject customer.

The impedances shown below have been calculated in Per Unit on a 100-MVA base utilizing nominal system values for existing normal operating conditions. The actual values may be different during times of emergency or maintenance conditions. As a result of system changes due to construction and switching, they are subject to change at anytime without prior notice.

Since PEPCO's present requirements state that the customer's 15kV switchgear shall be 750 MVA class or greater, the rated interrupting capability 750 MVA (31.5kA) should be considered the maximum available duty possible and used for design purposes for any new/future equipment.

CALCULATED BACK-UP IMPEDANCES (P.U. ON 100 MVA BASE)

13.8kV Bus Supplied by Feeder No.	Z_1	Z_0	X_1 / R_1 (see note)
14714	0.3157+j0.7345	2.6601+j1.9681	2.33
14804	0.3137+j0.6966	2.0783+j3.7242	2.22
14805	0.2827+j0.7275	1.9670+j1.2582	2.57
14807	0.3697+j0.7335	2.0912+j4.6183	1.98

Note 1: This is the ANSI X/R Ratio of the Thevenin equivalent positive sequence back-up impedance.

FAULT CURRENTS (AT 13.8kV V_{LL})

13.8kV Bus Supplied by Feeder No.	Three-Phase	Single-Phase-to-Ground
14714	5230 Amperes	2640 Amperes
14804	5480 Amperes	2170 Amperes
14805	5360 Amperes	3380 Amperes
14807	5090 Amperes	1870 Amperes

In the relay settings shown below, the "Inst" is the instantaneous value of current, expressed in primary amperes, at which the breaker will operate with no intentional time delay. The "Disc" is the minimum value of current, expressed in primary amperes, for which the relay will pick-up and "Time" is the total time, expressed in cycles on a 60-hertz base, for the relay and five (5) cycle breaker to operate at six (6) times the minimum pick-up of the relay.

RELAY SETTINGS AT SOURCE SUBSTATION, Benning. SUB-007

			Settings		
Protection	C.T. Ratio	Relay	Inst.	Disc	Time (Cy.)
13.8kV Fdrs. 14804,14805,14807					
Phase O. C.	600/5	COM-9	INOP	840	65
Ground O. C.		COM-9	INOP	600	65

If I can be of further assistance or should you have any questions please contact me at 202-236-8149.

Signed November 15, 2017
James Pringle

cc: Mr. J. N. Wolete
P&CE Files