



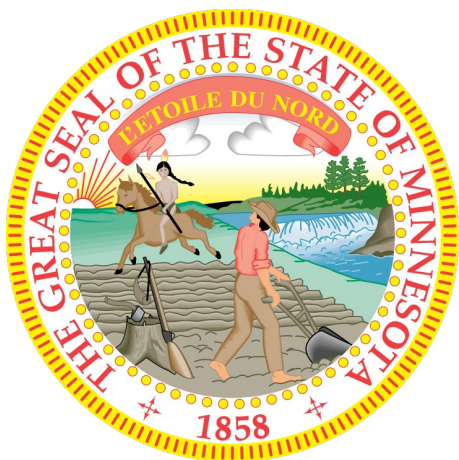
Department of Commerce
Center for Microgrid Research Grant
Project Report

Jan 1, 2023, to March 31, 2023

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infrastructure project requires advanced and complex engineering and is a collaborative effort between multiple stakeholders such as UST CMR, UST Facilities Management, and Hallberg Engineering (who is serving as the Engineer of Record since Nov 2022). Figure 1 show an aerial image of south campus that shows proposed locations of the new power equipment along with buildings. Figure 2 is a simplified one-line diagram of microgrid expansion. During this quarter, the team considered excavating a new basement level adjacent to FDC basement to place the switchgear, generators, and research and testing equipment. Factors that the project team are considering include accessibility, feasibility given structural loads, noise level and attenuation, and generator air intake and exhaust. The preliminary site plan and one-line diagram are shown in Figure 3 and Figure 4. The project team had multiple meetings with the electrical inspection department of the City of Saint Paul and local utility (Xcel Energy) to discuss the microgrid expansion preliminary plans. The city and the Utility were updated on the planned interconnection, connection to multiple buildings on campus and multiple points of connections with the utility.

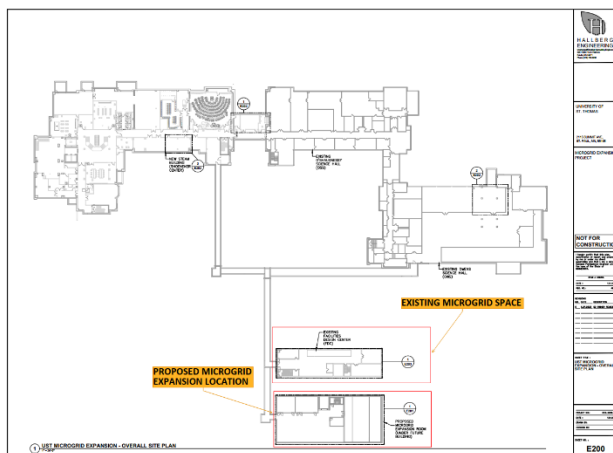


Figure 3 Expansion Site Plan as of Q1 of 2023

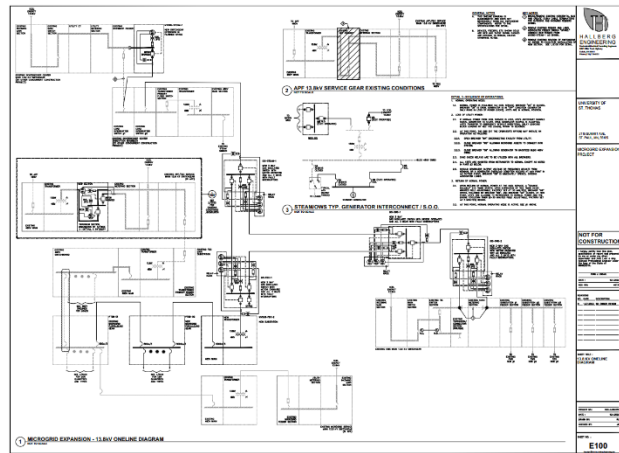


Figure 4 Expansion Single Line Diagram as of Q1 of 2023

The CMR hosted a team from the Department of Commerce on Jan 27, 2023 (Figure 5) which included the State's Authorized Representative. During the visit, the CMR team presented the status of the project and latest engineering and design updates. The CMR team shared challenges facing the expansion such as inflationary pressures and long equipment lead times. Lead times for certain equipment go beyond 80-90 weeks and are approaching 100 weeks which is an ongoing concern and does not show signs of abatement.



Figure 5: Department of Commerce team visits the CMR



As part of expanding the hands-on educational opportunities for engineering students to increase understanding of microgrid operations, the project team designed and constructed proof-of-concept education and training modules. One proof-of-concept module, shown in Figure 6 deals with power systems protection in which students and trainees learn the fundamentals of protection, relay programming, and opening/closing breakers. Another proof-of-concept module, shown in Figure 7, deals with industrial controls and automation in which students and trainees learn the fundamentals of networking, industrial communication protocols (such as Modbus), and control logic. The team is testing those prototypes to gather lessons learned in preparation for the final design which will be built at a later date.

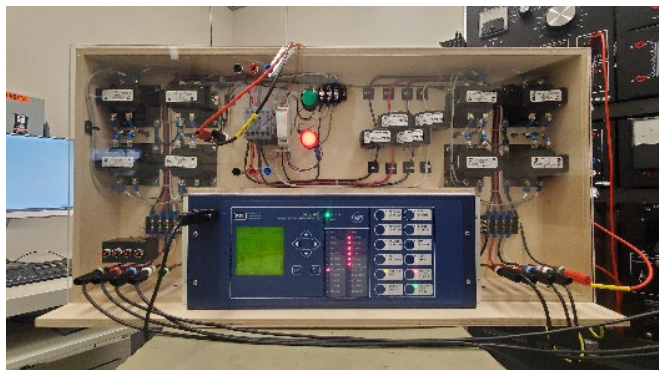


Figure 6 Protection Training Kit Prototype



Figure 7 Automation Training Kit Prototypes

To augment modeling, prototyping, and simulation of new technologies with hardware-in-the-loop testbeds, the project team finalized a public bid to procure needed testbeds. Seven vendors were invited and UST received 2 responses and Typhoon HIL was awarded. The project team continued the coordination with the Hardware in the Loop (HIL) manufacturer to ensure that the equipment is built to adhere to the relevant safety standards. Additionally, the necessary space preparation was completed to receive the equipment. The acquisition of the HIL equipment includes three workstations, a rendering is shown in Figure 8. Station 1 is for power system protection and automation testing. Station 2 is for microgrid testing and includes controllers for two inverters (energy storage and solar), diesel generator (Woodward EasyGen), SEL 451 relay, and SEL 3555 RTAC. Station 3



Figure 8: Rendering of the Hardware-in-the-loop Equipment



is for power-hardware-in-the-loop testing and prototyping and includes a power amplifier. Equipment is expected to arrive by Q2 2023.

The CMR team worked on augmenting and experimenting with state-of-the-art data acquisition systems. Experiments were conducted on industry standard issues such as power quality and harmonics. To build an infrastructure to obtain high quality data, different types of devices have been investigated to understand their capability and limitations. As an example, harmonics and transformer inrush data collected from an experiment using a grid-forming inverter and tests are shown in Figure 9. Moreover, the CMR team started collecting building electric consumption data to prepare for the microgrid power and physical expansion. As an example, a communication connection was established to the building meter located in Facilities and Design Center (FDC) to monitor the power consumption. With this infrastructure, the CMR team can collect building consumption data for power, voltage, harmonics, and frequency. Figure 10 shows an example of 1-second sampled data of the building's electrical power consumption.

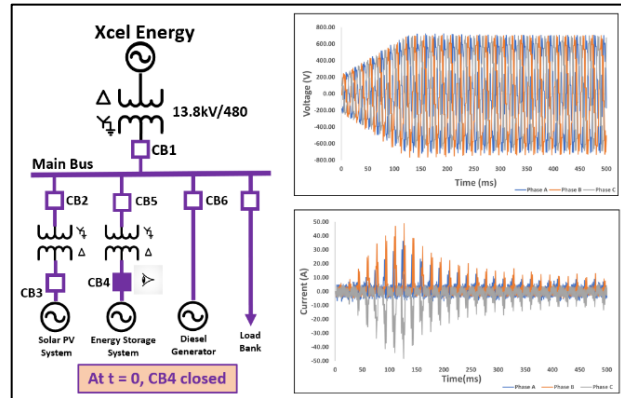


Figure 9 Transformer in-rush current and voltage when supplied by a grid-forming inverter

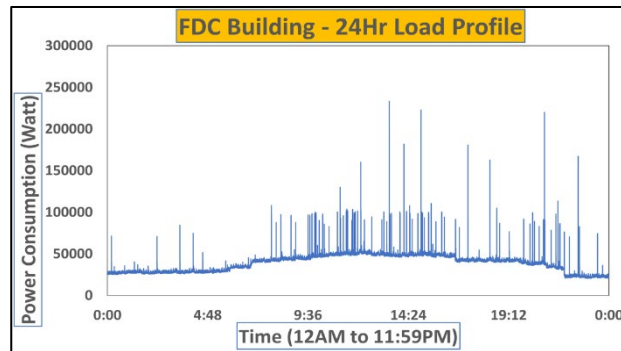


Figure 10: Facilities and Design Center (FDC) building power consumption.

During Q1 2023, multiple meetings were held with Minnesota House and Senate members to discuss the project and share updates and challenges facing the project. A hearing with the Climate and Energy Finance and Policy House Committee was held on March 8th and a hearing with the Energy, Utilities, Environment, and Climate Senate Committee was held on March 13th.

To support local and national partnerships, the CMR team hosted multiple tours of the Center and met with potential partners such as, but not limited to, National Sports Center, Hennepin County, and Grid Catalyst's PowerNorth Incubator. The project PI gave multiple talks about the CMR and the proposed expansion including Canadian Association for the Club of Rome and American Chemical Society.