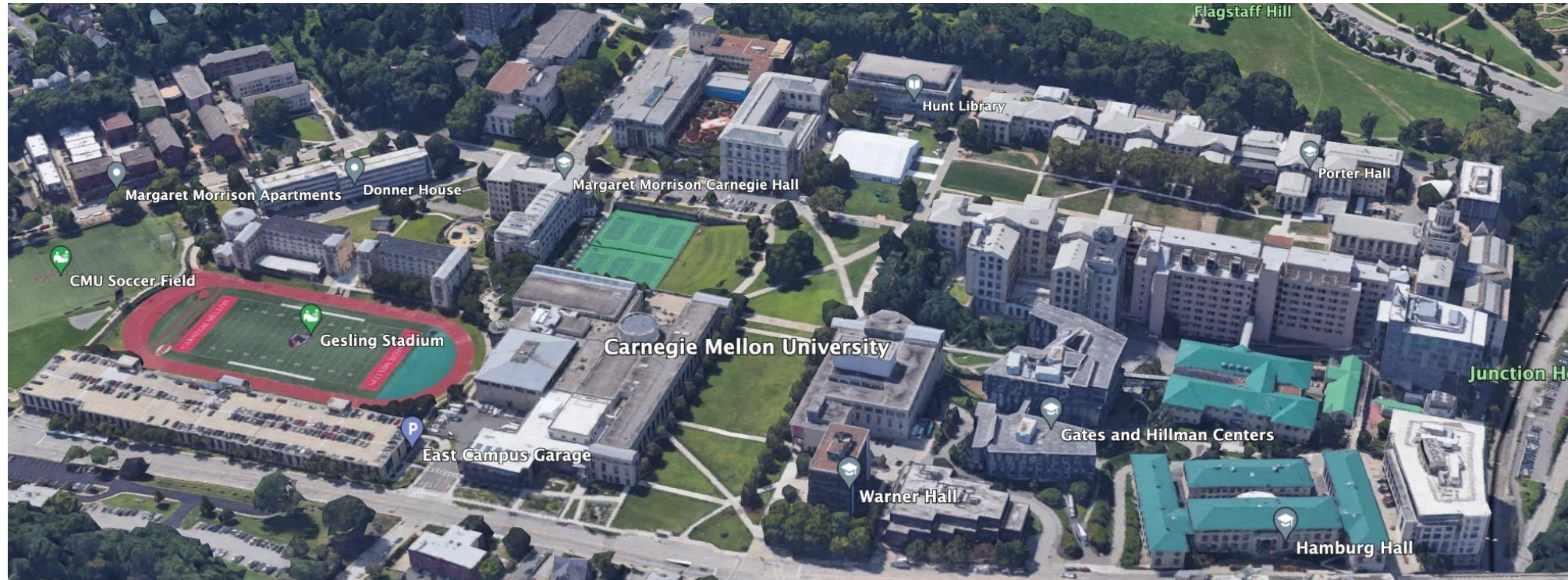




Carnegie Mellon University

Power Transmission Substation & Battery Energy Storage System

GL “Pat” Ervin
November 19, 2023

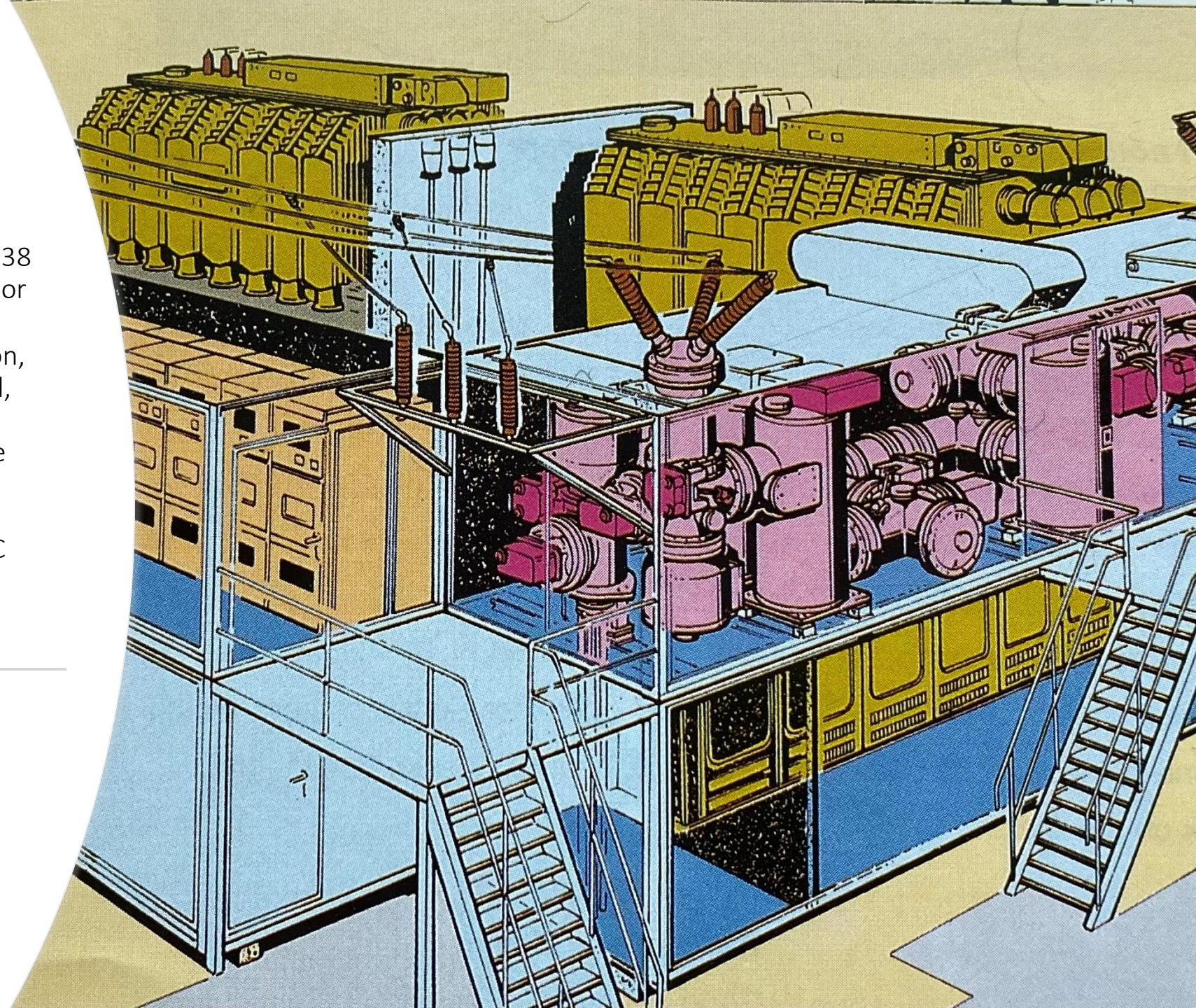


Concept: A large portion of the CMU campus does not cross utility right of way boundaries. In this area CMU can build, own, and operate an electric power *transmission* substation. Duquesne Light Company (DLC) *transmission* rates can provide approximately \$3 million in annual savings compared to *distribution* rates. Battery energy storage systems currently can provide demand reduction savings and potentially additional revenues in future PJM FERC 2222 markets starting in 2026.

[CMU Master Plan](#)

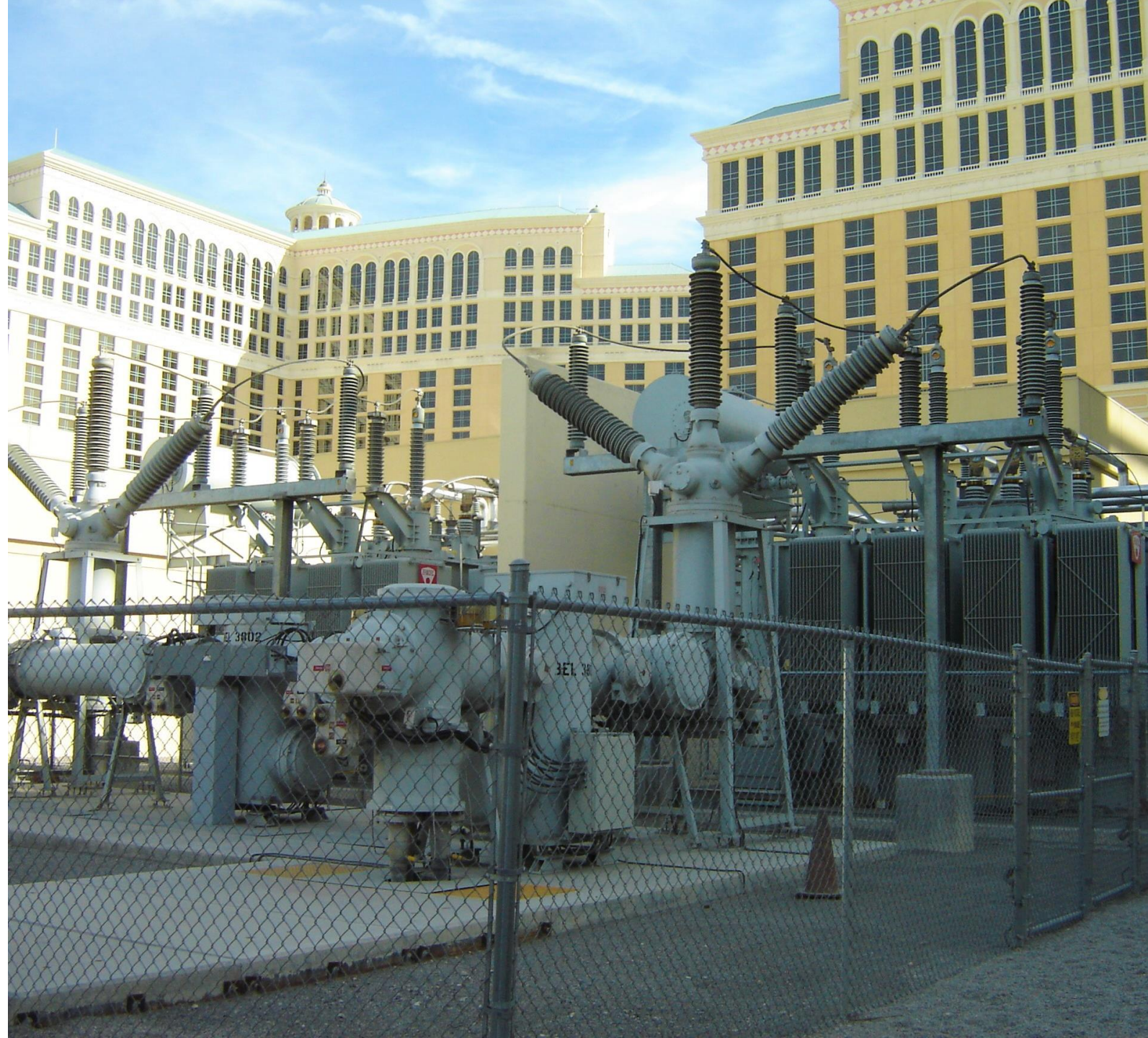
This power transmission substation rated 138 kV requires a 50' x 100' plot located above or partially below ground. Aside from the transformers, all major switching, protection, and control equipment use pre-engineered, preassembled, and pretested modular systems substantially reducing cost and site construction times. The substation would connect via underground cables to the transmission grid at or near the 138 kV DLC Riazzi Substation located across Boundary Street from the CMU campus.

Substations that can hide in a city



The Bellagio resort in Las Vegas has a power load comparable to the CMU campus. In 1996 the Bellagio built, owned, and operated a transmission substation at a \$4.2 million total installed cost. The utility (Nevada Power) transmission & distribution rate differential provided an 18 month pay back on the investment. Today a comparable substation would occupy 5000 square feet.

[Bellagio Brochure](#)



CMU 138kV 30MVA Substation Cost Benefit Analysis as of 18NOV23

Maximum Demand kW	15,000			Project Costs (does not include project finance cost)	\$
BESS				DLC Transmission Interconnection	5,000,000
Modules	4			Transmission Cable to CMU campus	1,000,000
BESS Module Power (kW)	1,300			CMU Substation (does not include site prep or civil)	10,000,000
BESS Power (kW)	5,200			BESS (does not include site prep & civil)	8,368,000
BESS Module Capacity (kWh)	4,184			Design-Build	9,000,000
BESS Capacity (kWh)	16,736			Project Total Installed Cost (\$)	33,368,000
BESS Cost (\$/kWh)	500				
BESS Financial Benefit Per Module (\$)	187				
DLC Tariff Rate L-Large Power Service	Rates		Monthly \$		
Supply					
Distribution					
Demand charges service voltage <138kV					
First 5000kW or less of demand (\$)	39,174		39,174		
Additional kW (\$/kW)	15.68		156,800		
Electric charges per Appendix A (\$/kW)	4.93		73,950		
Total monthly charge			269,924		
DLC Tariff Rate HVPS-High Voltage Power Service	Rates		Monthly \$		
Supply					
Distribution					
Fixed Monthly Charge					
Up to and including 50,000kW billing demand (\$)	2503.20		2,503		
50,001 to 100,000kW billing demand (\$)	3910.16				
Greater than 100,000kW billing demand (\$)	5545.23				
Electric charge per Appendix A (\$/kW)	2.01		30,150		
Total monthly charge			32,653		
Monthly Transmission- Distribution Rate Differential (\$)			237,271		
Annual Transmission- Distribution Rate Differential (\$)			2,847,250		
Annual BESS Financial Benefit (\$)			748		
Annual Operation & Maintenance Cost (\$)			75,000		
Annual Savings (\$)			3,160,268		

DLC rates CMU currently pays

MONTHLY RATE

SUPPLY

Customers who elect to purchase their electric supply requirements from the Company may do so under the provisions of Rider No. 9 – Day-Ahead Hourly Price Service and will be billed in accordance with the terms contained therein.

DISTRIBUTION

DEMAND CHARGES

Service Voltage Less than 138 kV:

First 5,000 kilowatts or less of Demand	\$39,174.00
Additional kilowatts of Demand	\$15.68 per kW

ELECTRIC CHARGES

The Company will provide and charge for Transmission service consistent with the PJM Open Access Transmission Tariff approved or accepted by the Federal Energy Regulatory Commission for customers who receive Default Service from the Company. The Transmission Service Charges are included, for informational purposes, in Appendix A of this Tariff.

DLC rates CMU would pay by owning a transmission substation

MONTHLY RATE

SUPPLY

Customers who elect to purchase their electric supply requirements from the Company may do so under the provisions of Rider No. 9 – Day-Ahead Hourly Price Service and will be billed in accordance with the terms contained therein.

DISTRIBUTION

FIXED MONTHLY CHARGE

Up to and Including 50,000 kW Billing Demand	\$2,503.20
50,001 kW to 100,000 kW Billing Demand	\$3,910.16
Greater than 100,000 kW Billing Demand	\$5,545.23

ELECTRIC CHARGES

The Company will provide and charge for Transmission service consistent with the PJM Open Access Transmission Tariff approved or accepted by the Federal Energy Regulatory Commission for customers who receive Default Service from the Company. The Transmission Service Charges are included, for informational purposes, in Appendix A of this Tariff.

DLC Transmission Service Charge Appendix A applicable to all rates

MONTHLY RATES

Rate Class	Energy Charge \$/kWh	Demand Charge \$/kW	Monthly Charge Per Fixture	Monthly Charge Per Fixture	Monthly Charge Per Fixture
RS	\$0.019523	—			
RH	\$0.010252	—			
RA	\$0.015871	—			
GS	\$0.011850	—			
GM < 25 kW	\$0.008273	\$1.45			
GM ⇒ 25 kW	\$0.007747	\$1.57			
GMH < 25 kW	\$0.006041	\$2.85 ⁽¹⁾			
GMH ⇒ 25 kW	\$0.005180	\$5.29 ⁽¹⁾			
GL	—	\$4.97 ⁽²⁾			
GLH	—	\$5.01 ⁽²⁾			
L	—	\$4.93 ⁽²⁾			
HVPS	—	\$2.01 ⁽²⁾			
AL	(\$0.012974)	—			
SE	\$0.001059	—			
UMS	\$0.001059	\$4.18 ⁽²⁾			
			Rate Class		
By Wattage			SH	PAL	SM
Mercury Vapor					
100			—	—	\$0.03
175			—	—	\$0.05
250			—	—	\$0.07
400			—	—	\$0.12
1000			—	—	\$0.28
High Pressure Sodium					
70			—	\$0.03	\$0.02
100			(\$0.19)	\$0.04	\$0.04
150			(\$0.26)	\$0.06	\$0.05
200			(\$0.35)	—	—
250			—	\$0.10	\$0.08
400			(\$0.63)	\$0.15	\$0.12
1000			—	—	\$0.28

(1) June through September

(2) Demand charge based on the customer's Network Service Peak Load ("NSPL").

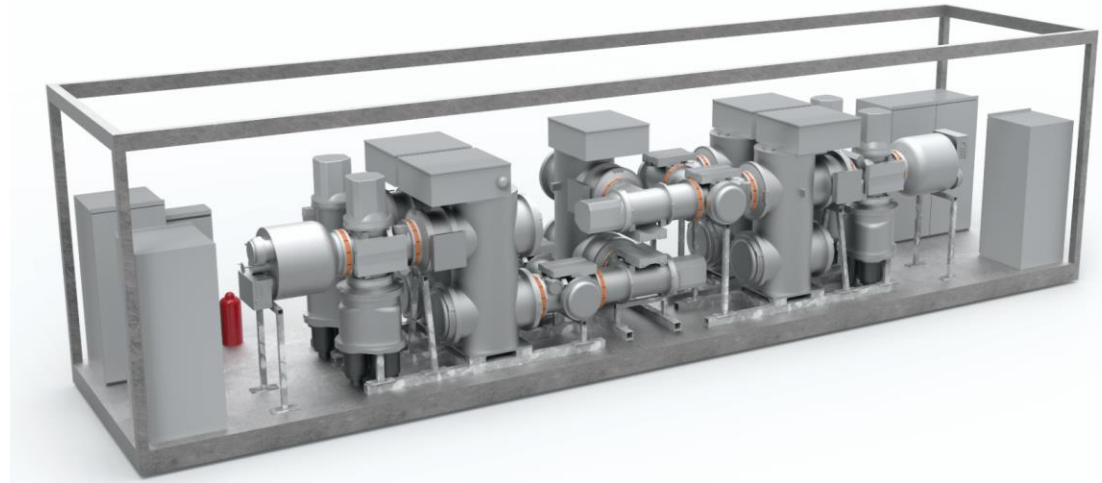
CMU Battery Energy Storage System (BESS) Cost Benefit Analysis as of 21MAR23
Point of Connection (POC) CMU 4160 Volt Grid

BESS Maximum Power (kW)	1300
BESS Energy Capacity (kWh)	4184
BESS Total Installed Cost per RMI (\$/kWh)	500
Number of charges & discharges per day	1
CMU Contracted Supply Charge (\$/kWh)	0.036
Demand Charges (\$/kW)	
DLC Tier 2	15.68
DLC PA EEA	0.33
Supply Charge Unforced Capacity	1.6
Supplier Transmission	5.33
Supplier TEC	0.16
DLC Standby Charge (\$/kW)	3.09
DLC Interconnection Cost (\$)	TBD
PJM Interconnection Cost (\$)	0
Annual O&M Cost (\$/kW)	20

PJM Services Benefit	\$/year	Project Costs	\$
Energy Arbitrage	TBD	BESS Total Installed Cost (RMI)	2,092,000
Frequency Regulation	TBD	Total	2,092,000
Spin/Non Spin Reserves	TBD		
Voltage Support	TBD		
Black Start	TBD	Grant/Endowment	2,092,000
Duquesne Light Services Benefit			
Resource Adequacy	0		
Distribution Deferral	0		
Transmission Congestion Relief	0		
Transmission Deferral	0		
CMU Benefits			
Time of Use Bill Management	0		
Increased PV Self Consumption	0		
Demand Reduction	187,803		
Backup Power	0		
Sub Total	187,803		
Annual O&M Cost	20		
Total	187,783		

DLC Transmission Interconnection

Connection to the DLC transmission grid requires additional DLC switching equipment inside or next to the DLC Riazzi substation. If DLC cannot accommodate interconnection inside the Riazzi Substation, a small switching station is required next to the Riazzi Substation. A pre-engineered, preassembled, and pretested switchyard in a box solution costs approximately \$2.5 million. An additional \$2.5 million was added for installation costs to arrive at the \$5 million estimate.



Underground transmission cable was estimated at \$2 million per circuit mile x 0.5 miles x two circuits= \$1 million. See [Power Grid article](#).





DLC Riazzi
Substation

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