Albertson Hall Replacement Project – Geothermal Summary

	Energy Cost			EUI			CO2			
	Annual Energy Cost	Savings ($/Yr)	Savings (%)	kBtu/sqft/Yr	Savings (kBtu/sqft/Yr)	Savings (%)	Metric Tons	Savings (metric tons)	Savings (%)	Social Cost of Carbon
Full Geothermal Design	$84,000	$12,000	10%	26	16	38%	674	-13	-2%	$34,300
Hybrid Geo/Central Plant	$86,000	$8,000	8%	30	12	27%	650	11	2%	$33,100
Proposed Design	$94,000	-	-	42	-	-	661	-	-	$33,700
Existing ALB	$256,836	-	-	119	-	-	1819	-	-	$92,769

	Opportunities	Challenges
Proposed Design	+ No design delays	- Annual energy cost
	+ No additional costs	- Higher EUI
	+ Social cost of carbon is less than full geo	
Hybrid Geo/Central Plant	+ $8,000 annual energy savings	- Requires removal/relocation of stormwater containment system under lot R
	+ Reduced EUI	- Additional maintenance cost for 6-pipe chiller system
	+ Reduced bore field size (compared to full geo)	- Increase sqft requirements for 1st floor mechanical room
	+ Reduced CO2 emissions	- Power outage affects building heating
	+ Better long-term performance when compared to full geothermal	- Project will be delayed due to engineering design
	+ Hybrid system allows for flexibility	- Added study costs to campus as this is not in the scope of the project
		- Repair costs for Parking Lot R due to bore field
		- Well depth of 150' – 400' needed, hitting bedrock around 30'
		- Increased project cost (approx. $2.25M, would need to reduce 4,000 sqft of programmed space)
Full Geothermal Design	+ $12,000 annual energy savings	- Requires removal/relocation of stormwater containment system under lot R
	+ Reduced EUI	- Additional maintenance cost for chiller system
	+ 50-year life expectancy	- Increase sqft requirements for 1st floor mechanical room
		- Power outage affects building heating
		- Slight increase in CO2 emissions
		- Project will be delayed due to engineering design
		- Potential added cost to campus as this is not in the scope of the project
		- Repair costs for Parking Lot R due to bore field
		- Removal of storm water containment system under lot R
		- Well depth of 150' – 400' needed, hitting bedrock around 30'
		- Full geothermal may cause surface instability due to hydraulic fracturing
		- Return on investment
		- Increased project cost (approx. $2.5M, would need to reduce 4,200 sqft of programmed space)

UWSP ALBERTSON HALL

ENERGY MODELING ANALYSIS

IMEG

DFD #19F3E
PR PHASE
06-01-2022 UPDATE

Assumptions

Zone:6A	Proposed Design Case	ASHRAE-90.1-2016 ECB
Envelope		
Wall	Metal Stud Wall: 0.041 Brick Wall: 0.056	Steel framed: U-0.49
Roof	R-30 Insulated roof U:0.032	R-30 Insulated roof U:0.032
Slab on Grade	6 Inch slab F-0.51 R-20 for 24 inch	6 Inch slab F-0.51 R-20 for 24 inch
Glazing	Glazing Ratio: 34% Glazing assembly U-Value:0.34 Glazing SHGC: 0.38	Glazing Ratio: 34% Metal Framing Fixed Value:0.36 Glazing SHGC: 0.40
Occupancy Equipment	0.25 W/sqft	0.25 W/sqft
Electrical systems and Process loads		
LPD	School/university [W/sqft]: 0.65	School/university [W/sqft]: 0.81
	Daylighting:Included	Daylighting:Included
Mechanical and Plumbing systems		
HVAC	Purchased heating and cooling, VAV AHUs. Packaged system for Archive space and datacenter	Purchased heating and cooling, VAV AHUs. Packaged system for Archive space and datacenter
Fans Economizer	Purchased heating and cooling, VAV AHUs Dry Bulb with high limit shut off 70 F	Purchased heating and cooling, VAV AHUs Dry Bulb with high limit shut off 70 F
Heat Recovery	Enthalpy wheel HX 75% eff	Enthalpy wheel HX 50% eff
HW Pump	[19 W/GPM]	[19 W/GPM]
Purchased CHW Pump	[16 W/GPM]	[16 W/GPM]
Ext Lighting	1000	1000
Packaged Unit EER	10	10
DHW	90% Eff condensing boiler	80% Eff Natural Draft Boiler

Energy Source	Utility Costs	
Electric	**$0.071 per kWh**	**$0.023 per kBtu**
Natural Gas	**$0.0415 per therm**	**$0.004 per kBtu**
District Htg	**$1.229 per therm**	**$0.012 per kBtu**
District Clg	**$0.596 per therm**	**$0.005 per kBtu**

Proposed System Comparison Summary

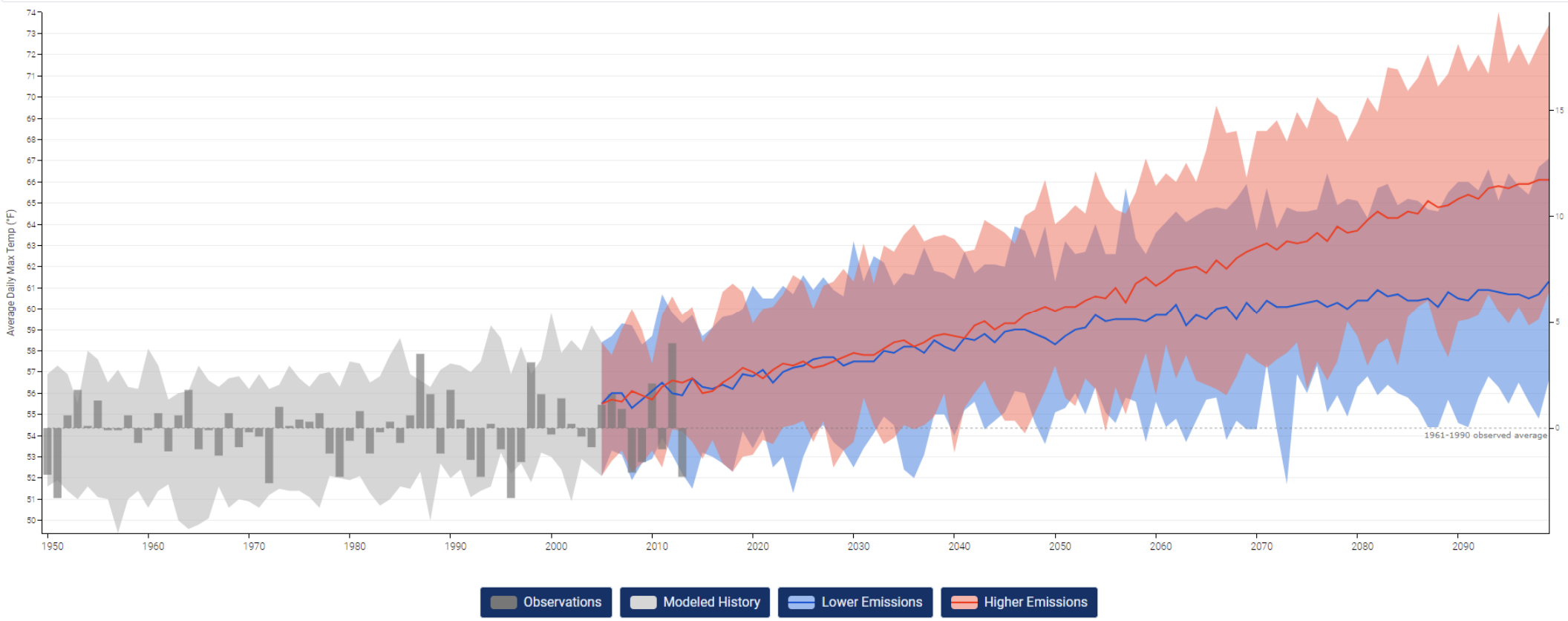
System/Option	Energy Cost			EUI			CO2		
	($/yr)	Savings ($/yr)	Savings (%)	(kBtu/sqft/yr)	Savings (kBtu/sqft/yr)	Savings (%)	(metric tons)	Savings (metric tons)	Savings (%)
Baseline ASHRAE 90.1	$102,000	-	-	44	-	-	716	-	-
Proposed Design	$94,000	$8,000	8%	42	2	5%	661	55	8%

The energy consumption data is listed as Energy Use Intensity (EUI). EUI is a measure of how much energy the building uses per square foot of building area per year.

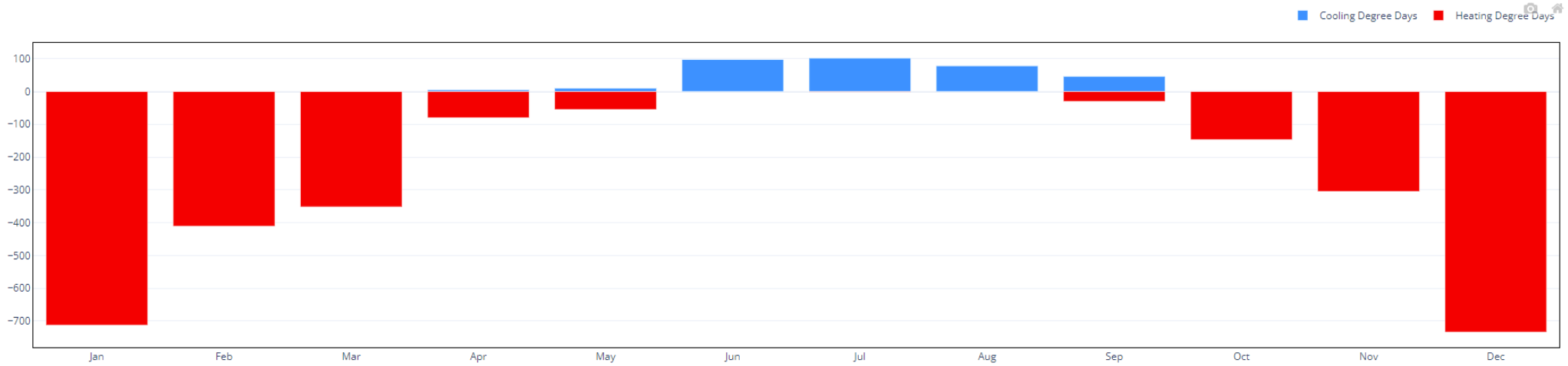
Existing Albertson Hall has EUI of 119.

Proposed 30 KW Photovoltaic System reduces energy consumption by 2.2% and has a 4.1% reduction in energy cost.

Future Temperature Estimates



Building Heating & Cooling Loading



Building site is significantly heating dominated. Unbalanced loading can cause long term temperature reduction in borefield. This requires increased borefield sizing.

Geothermal Evaluation

Evaluation of complete geothermal system and hybrid geothermal system

Complete system replaces campus steam and chilled water utilities with 6-pipe chiller system that creates low temperature heating water and chilled water system for building heating and cooling needs.

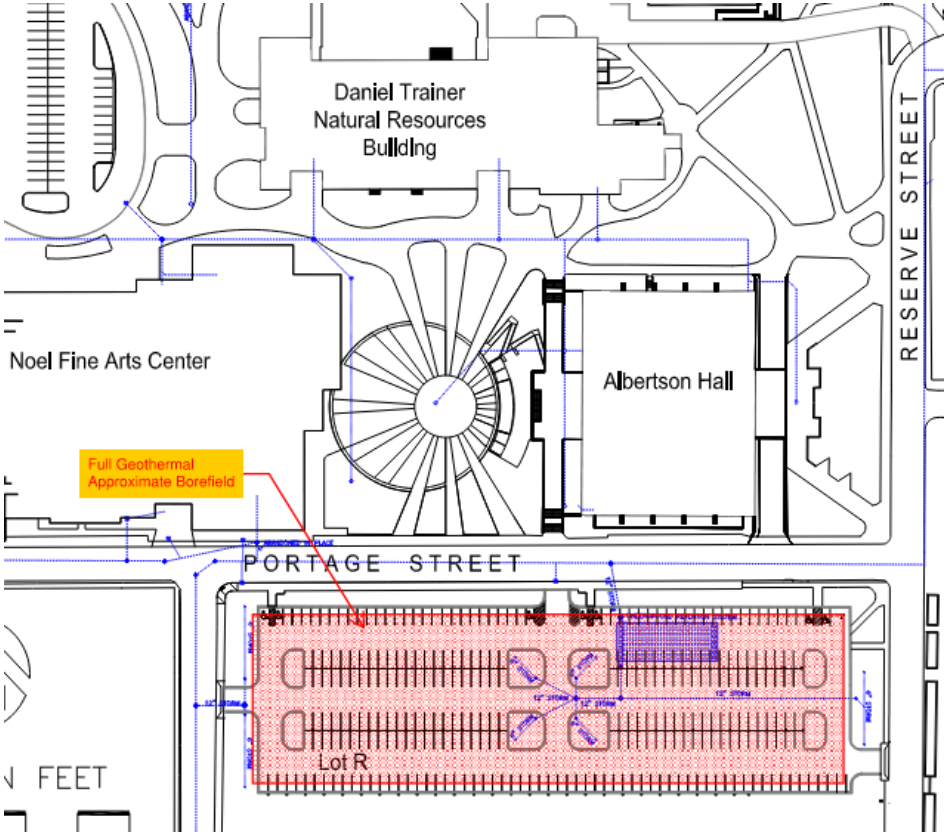
Hybrid system has 6-pipe chiller system, but system is sized for peak cooling requirements with supplemental heating from campus steam system. Reduces borefield size and equal heating and cooling to the borefield for better long-term performance.

AHU systems (4^{th} floor air handling units with VAV terminal air boxes) remain the same in all cases.

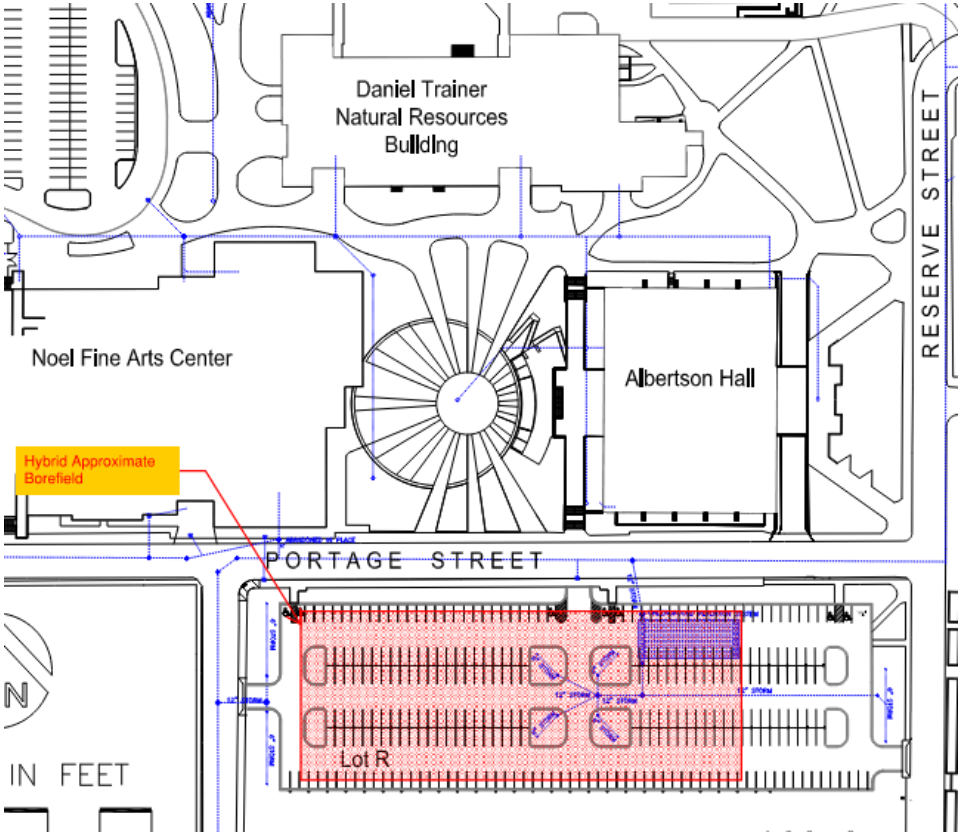
Geothermal Impacts

- Increase in first cost of project
- Additional maintenance cost for 6-pipe chiller system
- First floor mechanical room space requirements increase
- Site impacts for borefield
- Radiation sizes increase
- Power outage affects building heating

Geothermal Borefield Sizing

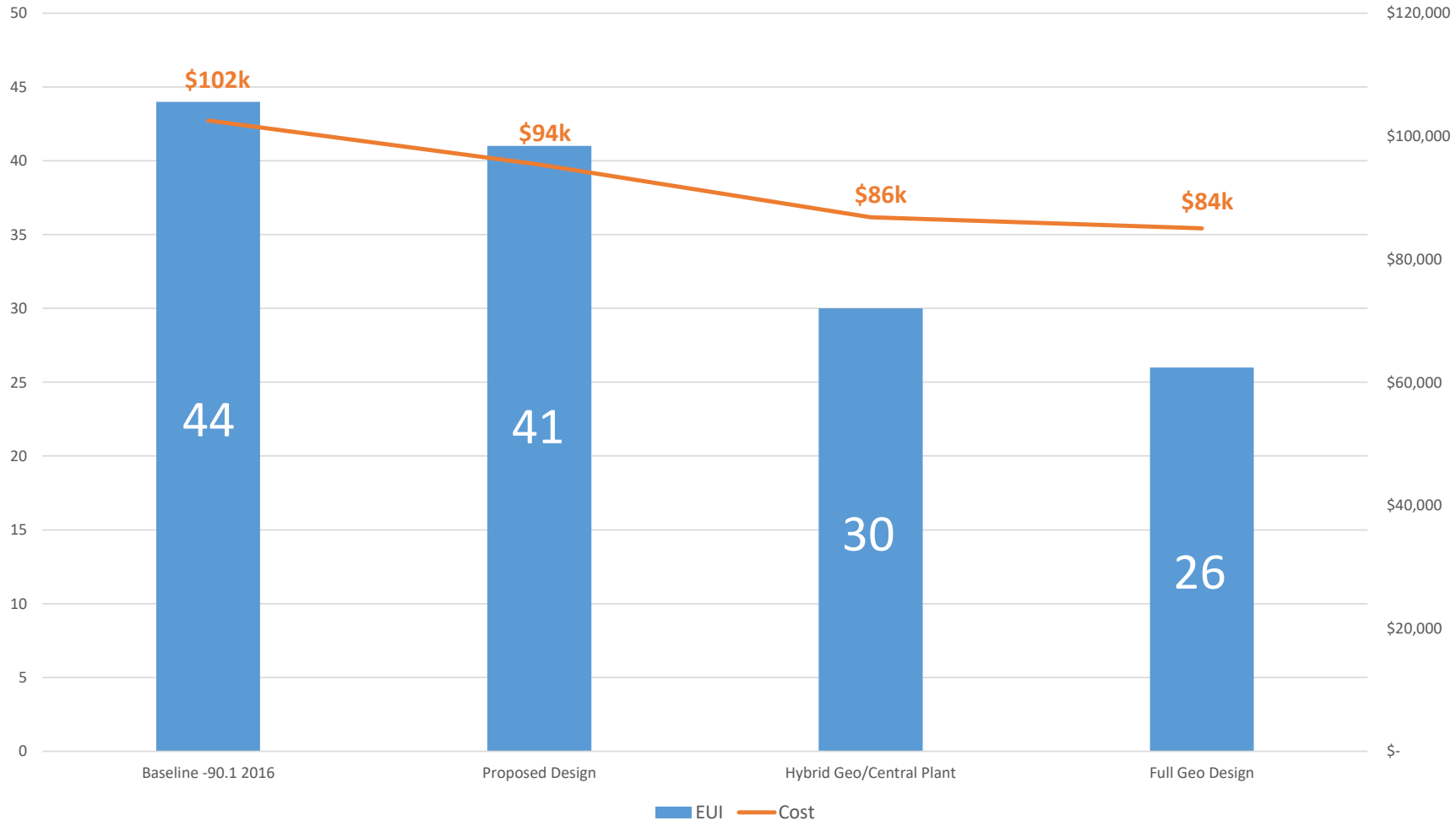


Full Geothermal Borefield

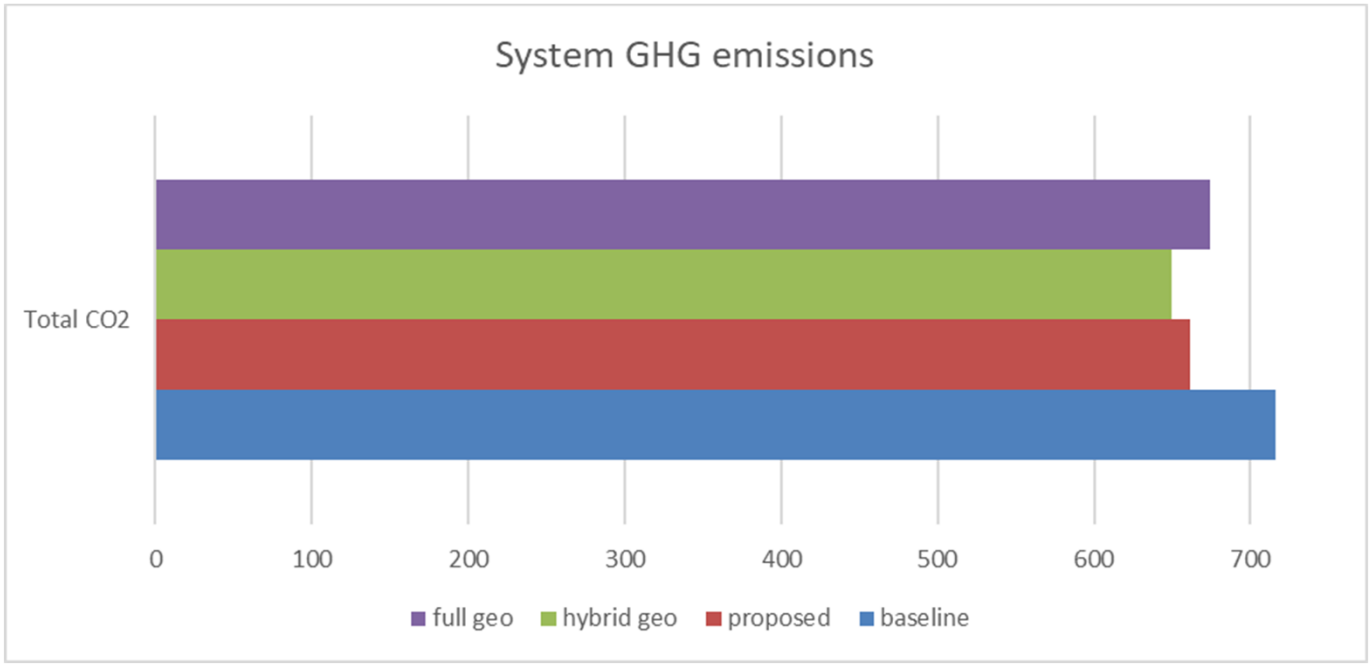


Hybrid Geothermal Borefield

EUI + Annual Energy Cost



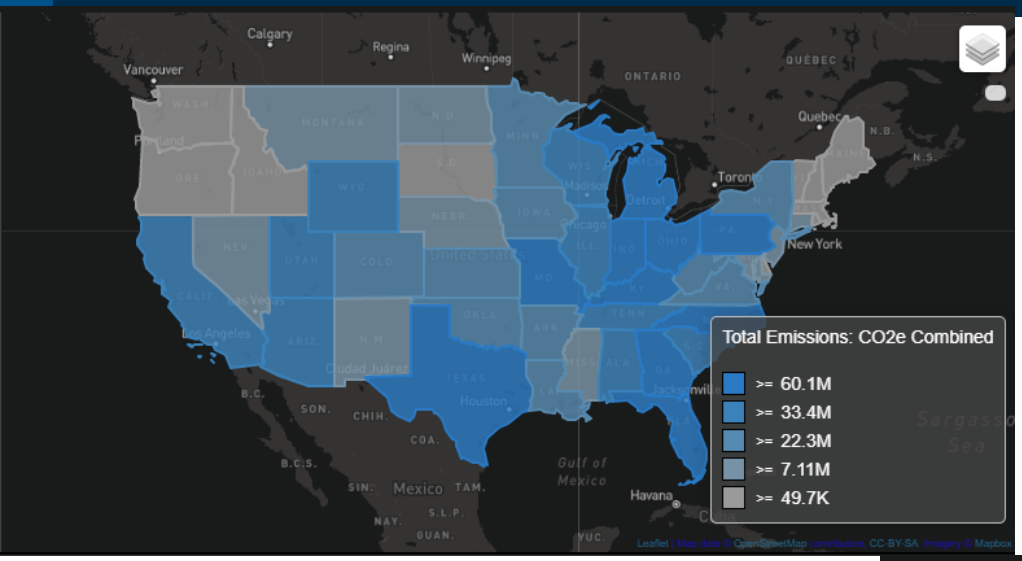
GHG emissions comparison

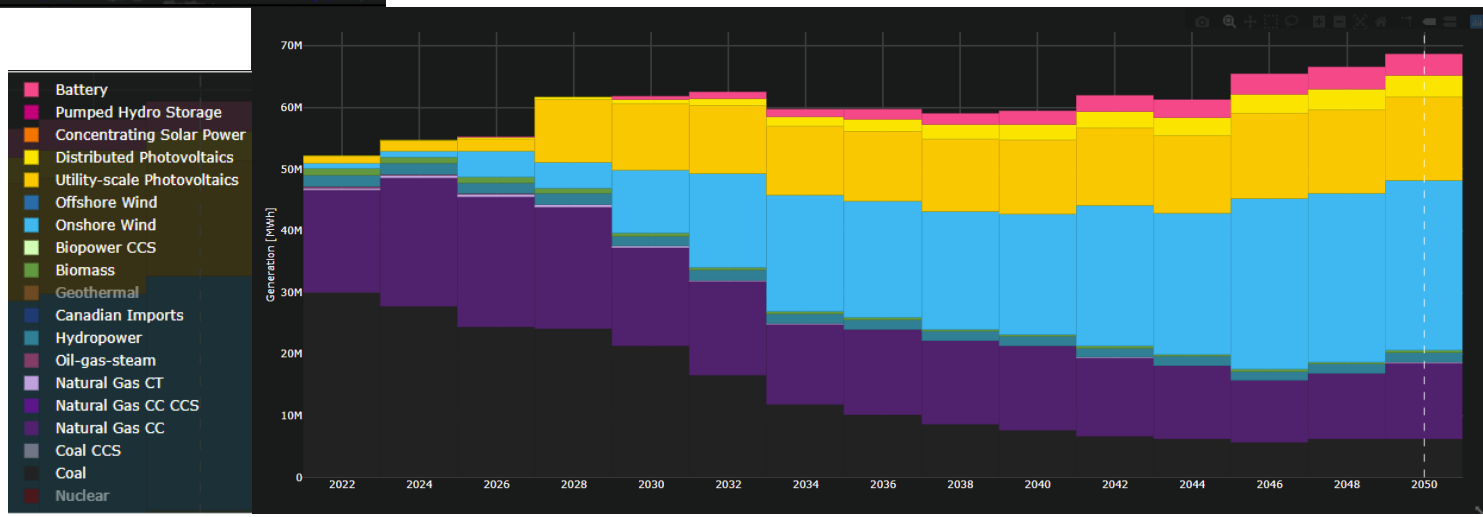


Emissions were calculated using local grid carbon density of 1,239 lbs CO2/MWh, which is higher than the national average of 818 lbs CO2/MWh.

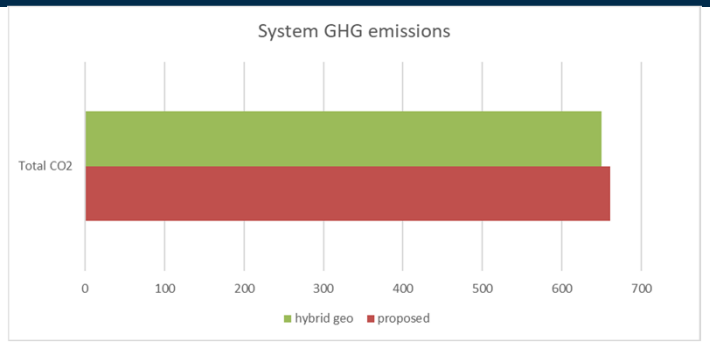
Future renewables on the grid or on site would reduce carbon in the future.

Future Grid

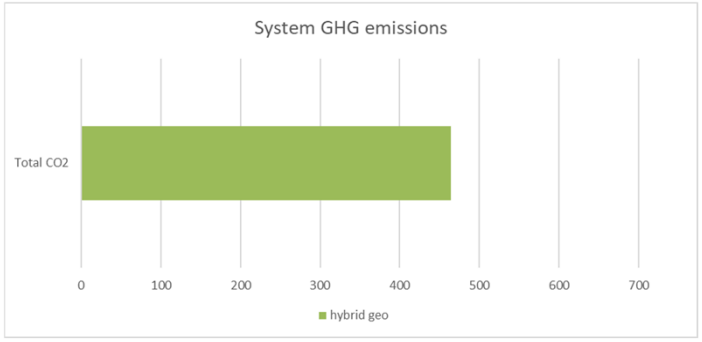

Calgary
Regina
Winnipeg
Vancouver
ONTARIO
QUÉBEC
Quebec
Toronto
New York
Total Emissions: CO2e Combined
>= 60.1M
>= 33.4M
>= 22.3M
>= 7.11M
>= 49.7K
Gulf of Mexico
Havana
Mexico


Battery
Pumped Hydro Storage
Concentrating Solar Power
Distributed Photovoltaics
Utility-scale Photovoltaics
Offshore Wind
Onshore Wind
Biopower CCS
Biomass
Geothermal
Canadian Imports
Hydropower
Oil-gas-steam
Natural Gas CT
Natural Gas CC CCS
Natural Gas CC
Coal CCS
Coal
Nuclear
Generation [MWh]
70M
60M
50M
40M
30M
20M
10M
0
2022
2024
2026
2028
2030
2032
2034
2036
2038
2040
2042
2044
2046
2048
2050

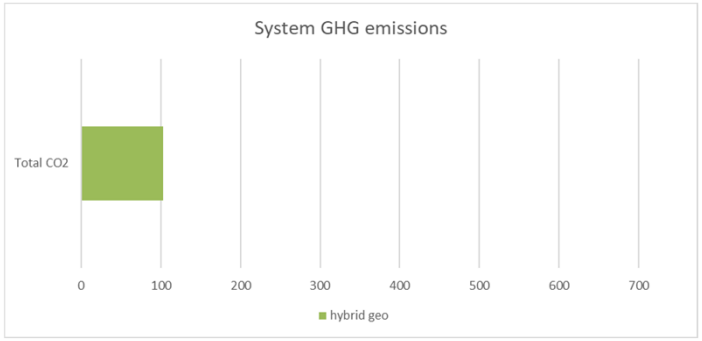
Future Grid Impacts – Hybrid Version



Today's grid in Wisconsin



National Average Grid



Fully renewable grid
(hybrid system emissions remain)

Geothermal Comparison Summary

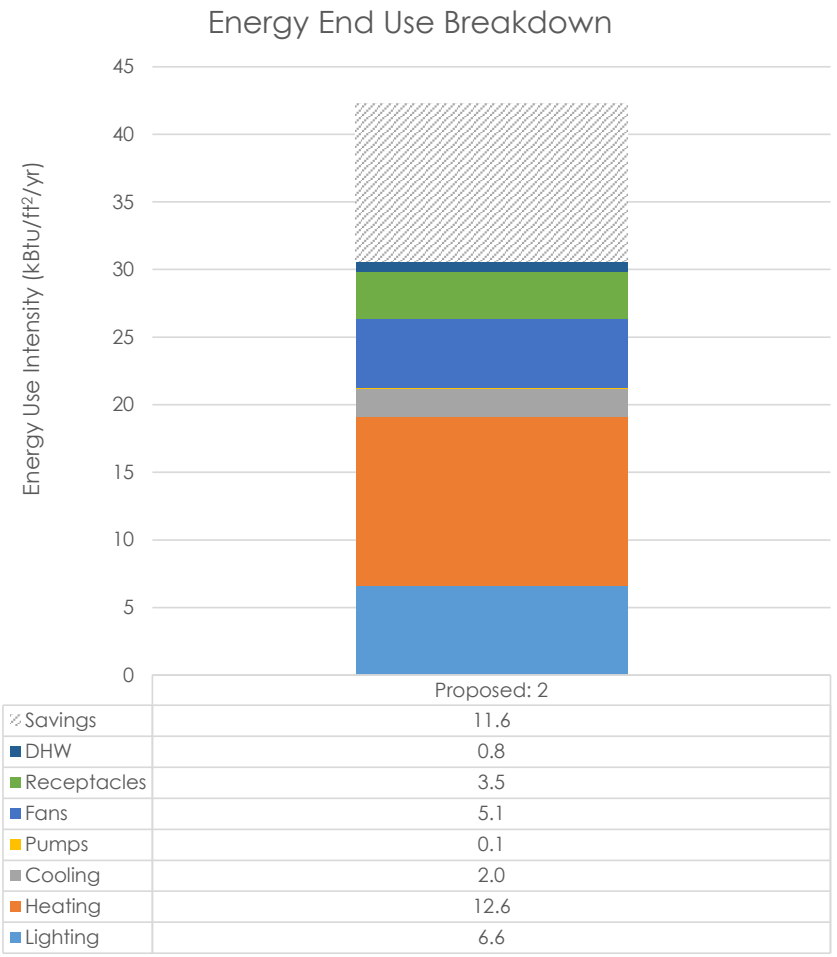
System/Option	Energy Cost			EUI			CO2		
	($/yr)	Savings ($/yr)	Savings (%)	(kBtu/sqft/yr)	Savings (kBtu/sqft/yr)	Savings (%)	(metric tons)	Savings (metric tons)	Savings (%)
Proposed Design	$94,000	-	-	42	-	-	661	-	-
Hybrid Geo/Central Plant*	$86,000	$8,000	8%	30	12	27%	650	11	2%
Full Geo*	$84,000	$12,000	10%	26	16	38%	674	-13	-2%

*Geo savings compared to proposed design

Geothermal system heating – 3 COP
cooling – 5.5 COP

Hybrid and full geothermal savings based on assumed bore field sizing. Results may vary pending final design and updated ground conditions.
Likely savings of hybrid geothermal system in the range of $3,000-$10,000 per year.
Likely savings of full geothermal system in the range of $5,000 - $12,000 per year.

Energy Breakdown of Hybrid Geo



	Proposed: 2
Savings	11.6
DHW	0.8
Receptacles	3.5
Fans	5.1
Pumps	0.1
Cooling	2.0
Heating	12.6
Lighting	6.6

Social Cost of Carbon

System/Option	CO2	
	(metric tons)	Cost
Baseline	716	$36,500
Proposed Design	661	$33,700
Hybrid Geo/Central Plant*	650	$33,100
Full Geo*	674	$34,300

Current Federal Social Cost of Carbon is set at $51/ton

PV Design Options

Level 4 Roof – Lower Portion

- System Size: 223.9kW(dc)/170kW(ac)
- Racking: East-West
- Tilt angle: 10 degrees

PV Design Options

Level 4 Roof – Upper Portion

- System Size: 101kW(dc)/75kW(ac)
- Racking: East-West
- Tilt angle: 10 degrees

PV Design Options

Level 4 Roof – Maximum Capacity

- System Size: 324.9kW(dc)/245kW(ac)
- Racking: East-West
- Tilt angle: 10 degrees

PV Design Options Summary

Roof System Layout Option	System Size
Level 4 Roof – Lower Portion	223.9kW(dc)/170kW(ac)
Level 4 Roof – Upper Portion	101kW(dc)/75kW(ac)
Level 4 Roof – Maximum Capacity	324.9kW(dc)/245kW(ac)
System Size Required to Offset All Power Usage of Proposed Design	1340kW(dc)/1000 kW(ac)

Proposed current design: 39 kW(dc)/30 kW(ac)

05/27/2022-Albertson Hall Reduced Sq.Ft. Roof - Lower Roofs Albertson Hall, 900 Reserve Street, Stevens Point

Report

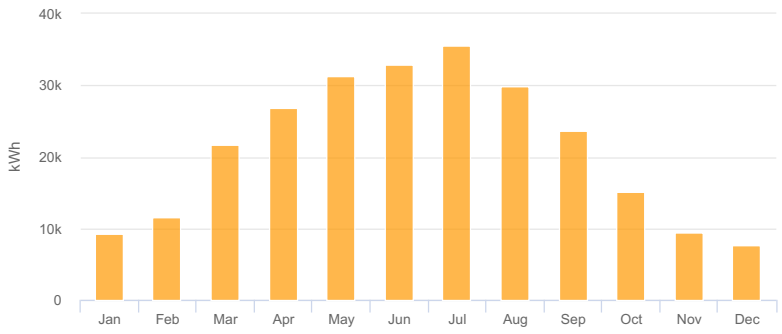
Project Name	Albertson Hall
Project Address	900 Reserve Street, Stevens Point
Prepared By	Brian Leavitt brian.j.leavitt@imegcorp.com

System Metrics

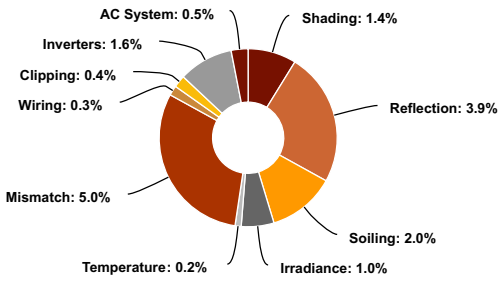
Design	05/27/2022-Albertson Hall Reduced Sq.Ft. Roof - Lower Roofs
Module DC Nameplate	223.9 kW
Inverter AC Nameplate	170.0 kW Load Ratio: 1.32
Annual Production	254.8 MWh
Performance Ratio	84.8%
kWh/kWp	1,138.2
Weather Dataset	TMY, 10km Grid (44.55,-89.55), NREL (prospector)
Simulator Version	d49abe8b4a-2bc664d9c8-68aec2f67a-a9b3f192dd

Project Location

Monthly Production



Sources of System Loss



Annual Production

	Description	Output	% Delta
Irradiance (kWh/m²)	Annual Global Horizontal Irradiance	1,348.9	
	POA Irradiance	1,342.3	-0.5%
	Shaded Irradiance	1,323.1	-1.4%
	Irradiance after Reflection	1,271.0	-3.9%
	Irradiance after Soiling	1,245.5	-2.0%
	Total Collector Irradiance	**1,245.6**	**0.0%**
Energy (kWh)	Nameplate	278,901.7	
	Output at Irradiance Levels	276,211.9	-1.0%
	Output at Cell Temperature Derate	275,710.6	-0.2%
	Output After Mismatch	261,972.2	-5.0%
	Optimal DC Output	261,218.8	-0.3%
	Constrained DC Output	260,274.3	-0.4%
	Inverter Output	256,078.0	-1.6%
	Energy to Grid	**254,797.6**	**-0.5%**
Temperature Metrics			
	Avg. Operating Ambient Temp		10.0 °C
	Avg. Operating Cell Temp		15.9 °C
Simulation Metrics			
	Operating Hours		4701
	Solved Hours		4701

Condition Set

Description	Condition Set 1
Weather Dataset	TMY, 10km Grid (44.55,-89.55), NREL (prospector)
Solar Angle Location	Meteo Lat/Lng
Transposition Model	Perez Model
Temperature Model	Sandia Model

Temperature Model Parameters

Rack Type	a	b	Temperature Delta
Fixed Tilt	-3.56	-0.075	3°C
Flush Mount	-2.81	-0.0455	0°C

Soiling (%)

J	F	M	A	M	J	J	A	S	O	N	D
2	2	2	2	2	2	2	2	2	2	2	2

Irradiation Variance	5%
Cell Temperature Spread	4° C
Module Binning Range	-2.5% to 2.5%
AC System Derate	0.50%

Module Characterizations

Module	Uploaded By	Characterization
PS455M4-24/TH (1000V) (Phono Solar)	HelioScope	Spec Sheet Characterization, PAN

Component Characterizations

Device	Uploaded By	Characterization

Components

Component	Name	Count
Inverters	CPS SCA25KTL-DO-R/US-480 (Chint Power Systems)	2 (50.0 kW)
Inverters	CPS SCA60KTL-DO/480 (Chint)	2 (120.0 kW)
Strings	10 AWG (Copper)	30 (2,288.6 ft)
Module	Phono Solar, PS455M4-24/TH (1000V) (455W)	492 (223.9 kW)

Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
South Roof	-	15-17	Along Racking
Wiring Zone 3	-	5-17	Along Racking

Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
"Ground Roof - 0 Elevation"	East-West	Landscape (Horizontal)	10°	180°	1.0 ft	1x1	180	360	163.8 kW
North Roof @ 1 FT	East-West	Landscape (Horizontal)	10°	180°	1.0 ft	1x1	76	132	60.1 kW

Detailed Layout

05/27/2022-Albertson Hall Reduced Sq.Ft. Roof - Upper Roof Albertson Hall, 900 Reserve Street, Stevens Point

Report

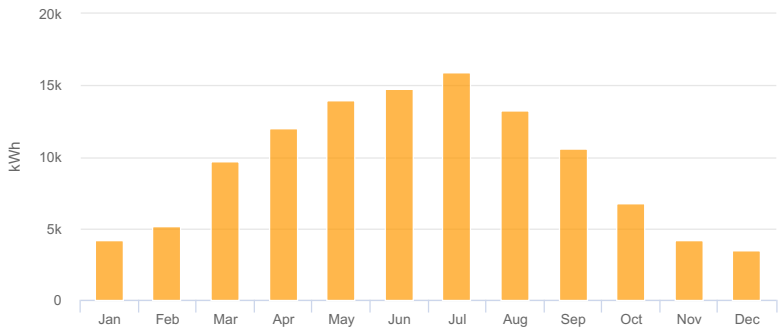
Project Name	Albertson Hall
Project Address	900 Reserve Street, Stevens Point
Prepared By	Brian Leavitt brian.j.leavitt@imegcorp.com

System Metrics

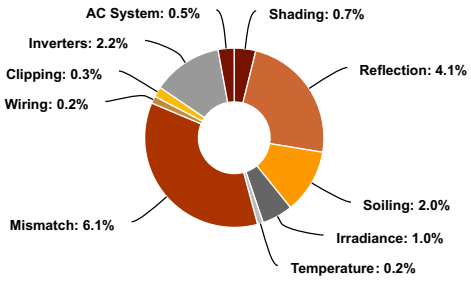
Design	05/27/2022-Albertson Hall Reduced Sq.Ft. Roof - Upper Roof
Module DC Nameplate	101.0 kW
Inverter AC Nameplate	75.0 kW Load Ratio: 1.35
Annual Production	113.8 MWh
Performance Ratio	83.9%
kWh/kWp	1,126.8
Weather Dataset	TMY, 10km Grid (44.55,-89.55), NREL (prospector)
Simulator Version	d49abe8b4a-2bc664d9c8-68aec2f67a-a9b3f192dd

Project Location

Monthly Production



Sources of System Loss



Annual Production

	Description	Output	% Delta
Irradiance (kWh/m²)	Annual Global Horizontal Irradiance	1,348.9	
	POA Irradiance	1,342.3	-0.5%
	Shaded Irradiance	1,333.3	-0.7%
	Irradiance after Reflection	1,279.0	-4.1%
	Irradiance after Soiling	1,253.4	-2.0%
	Total Collector Irradiance	**1,253.5**	**0.0%**
Energy (kWh)	Nameplate	126,650.7	
	Output at Irradiance Levels	125,439.6	-1.0%
	Output at Cell Temperature Derate	125,215.8	-0.2%
	Output After Mismatch	117,563.0	-6.1%
	Optimal DC Output	117,295.7	-0.2%
	Constrained DC Output	116,926.6	-0.3%
	Inverter Output	114,392.8	-2.2%
	Energy to Grid	**113,820.8**	**-0.5%**
Temperature Metrics			
	Avg. Operating Ambient Temp		10.0 °C
	Avg. Operating Cell Temp		16.0 °C
Simulation Metrics			
	Operating Hours		4701
	Solved Hours		4701

Condition Set

Description	Condition Set 1
Weather Dataset	TMY, 10km Grid (44.55,-89.55), NREL (prospector)
Solar Angle Location	Meteo Lat/Lng
Transposition Model	Perez Model
Temperature Model	Sandia Model

Temperature Model Parameters

Rack Type	a	b	Temperature Delta
Fixed Tilt	-3.56	-0.075	3°C
Flush Mount	-2.81	-0.0455	0°C

Soiling (%)

J	F	M	A	M	J	J	A	S	O	N	D
2	2	2	2	2	2	2	2	2	2	2	2

Irradiation Variance	5%
Cell Temperature Spread	4° C
Module Binning Range	-2.5% to 2.5%
AC System Derate	0.50%

Module Characterizations

Module	Uploaded By	Characterization
PS455M4-24/TH (1000V) (Phono Solar)	HelioScope	Spec Sheet Characterization, PAN

Component Characterizations

Device	Uploaded By	Characterization

Components

Component	Name	Count
Inverters	CPS SCA25KTL-DO-R/US-480 (Chint Power Systems)	3 (75.0 kW)
Strings	10 AWG (Copper)	15 (837.0 ft)
Module	Phono Solar, PS455M4-24/TH (1000V) (455W)	222 (101.0 kW)

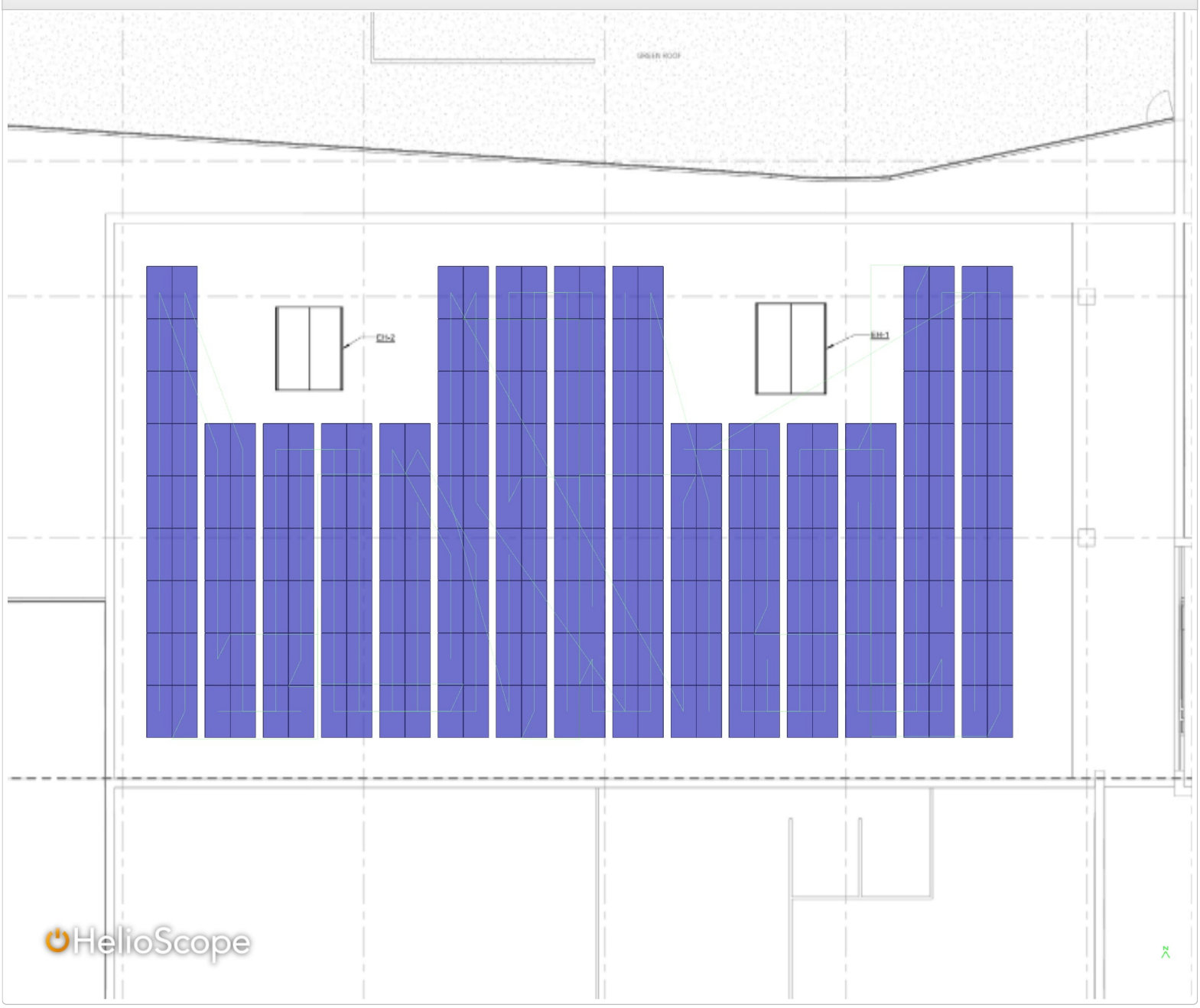
Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Upper Roof	-	5-17	Along Racking

Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
Middle Roof @ 3 FT	East-West	Landscape (Horizontal)	10°	180°	1.0 ft	1x1	115	222	101.0 kW

Detailed Layout



05/27/2022-Albertson Hall Reduced Sq.Ft. Roof -Chint Inverter Albertson Hall, 900 Reserve Street, Stevens Point

Report

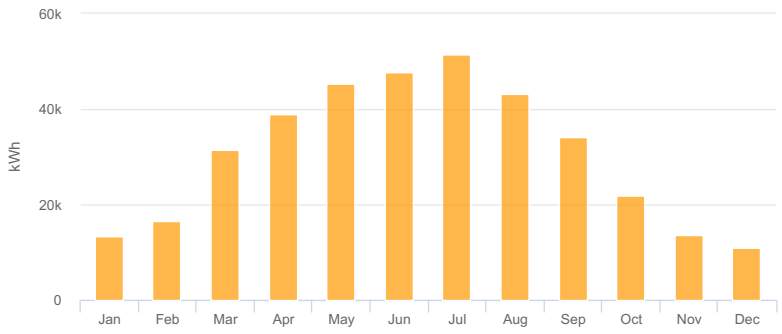
Project Name	Albertson Hall
Project Address	900 Reserve Street, Stevens Point
Prepared By	Brian Leavitt brian.j.leavitt@imegcorp.com

System Metrics

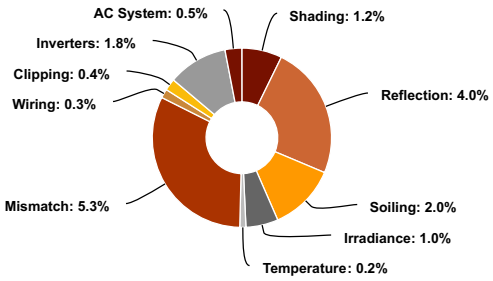
Design	05/27/2022-Albertson Hall Reduced Sq.Ft. Roof -Chint Inverter
Module DC Nameplate	324.9 kW
Inverter AC Nameplate	245.0 kW Load Ratio: 1.33
Annual Production	368.8 MWh
Performance Ratio	84.6%
kWh/kWp	1,135.1
Weather Dataset	TMY, 10km Grid (44.55,-89.55), NREL (prospector)
Simulator Version	d49abe8b4a-2bc664d9c8-68aec2f67a-a9b3f192dd

Project Location

Monthly Production



Sources of System Loss



Annual Production

	Description	Output	% Delta
Irradiance (kWh/m²)	Annual Global Horizontal Irradiance	1,348.9	
	POA Irradiance	1,342.3	-0.5%
	Shaded Irradiance	1,326.2	-1.2%
	Irradiance after Reflection	1,273.4	-4.0%
	Irradiance after Soiling	1,248.0	-2.0%
	Total Collector Irradiance	**1,248.0**	**0.0%**
Energy (kWh)	Nameplate	405,544.9	
	Output at Irradiance Levels	401,643.9	-1.0%
	Output at Cell Temperature Derate	400,918.2	-0.2%
	Output After Mismatch	379,715.8	-5.3%
	Optimal DC Output	378,694.5	-0.3%
	Constrained DC Output	377,360.2	-0.4%
	Inverter Output	370,622.4	-1.8%
	Energy to Grid	**368,769.3**	**-0.5%**
Temperature Metrics			
	Avg. Operating Ambient Temp		10.0 °C
	Avg. Operating Cell Temp		15.9 °C
Simulation Metrics			
	Operating Hours		4701
	Solved Hours		4701

Condition Set

Description	Condition Set 1
Weather Dataset	TMY, 10km Grid (44.55,-89.55), NREL (prospector)
Solar Angle Location	Meteo Lat/Lng
Transposition Model	Perez Model
Temperature Model	Sandia Model

Temperature Model Parameters	Rack Type	a	b	Temperature Delta
	Fixed Tilt	-3.56	-0.075	3°C
	Flush Mount	-2.81	-0.0455	0°C

Soiling (%)	J	F	M	A	M	J	J	A	S	O	N	D
	2	2	2	2	2	2	2	2	2	2	2	2

Irradiation Variance	5%
Cell Temperature Spread	4° C
Module Binning Range	-2.5% to 2.5%
AC System Derate	0.50%

Module Characterizations	Module	Uploaded By	Characterization
	PS455M4-24/TH (1000V) (Phono Solar)	HelioScope	Spec Sheet Characterization, PAN

Component Characterizations	Device	Uploaded By	Characterization

Components

Component	Name	Count
Inverters	CPS SCA25KTL-DO-R/US-480 (Chint Power Systems)	5 (125.0 kW)
Inverters	CPS SCA60KTL-DO/480 (Chint)	2 (120.0 kW)
Strings	10 AWG (Copper)	45 (3,113.3 ft)
Module	Phono Solar, PS455M4-24/TH (1000V) (455W)	714 (324.9 kW)

Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
South Roof	-	15-17	Along Racking
Upper Roof	-	5-17	Along Racking
Wiring Zone 3	-	5-17	Along Racking

Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
"Ground Roof - 0 Elevation"	East-West	Landscape (Horizontal)	10°	180°	1.0 ft	1x1	180	360	163.8 kW
Middle Roof @ 3 FT	East-West	Landscape (Horizontal)	10°	180°	1.0 ft	1x1	111	222	101.0 kW
North Roof @ 1 FT	East-West	Landscape (Horizontal)	10°	180°	1.0 ft	1x1	66	132	60.1 kW

Detailed Layout