



Eau Claire Project

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Client: Matt Theisen, Eau Claire County Facilities Director

Problem Identified

Eau Claire County government buildings, specifically the Courthouse and Jail, experience elevated energy consumption, making up ~91% of Eau Claire County government electricity usage



Jail



Courthouse

Goal

- Provide recommendations to further improve energy efficiency, and reduce energy consumption and carbon emissions, particularly for the county courthouse and jail.
- Investigate renewable energy projects/options in order to achieve the county's goal of carbon neutrality by 2050.
- Consolidate findings of feasible solutions into a report for submission to the county facilities director, Matt Theisen.

Approach



- Set up kick-off meeting with both parties (Client and Faculty Mentor) to identify (in detail) the background of the problem, already implemented solutions, expectations, preferred layout of proposed solutions, etc.
- Brainstorm methods utilizing information provided to us and our pre-existing knowledge.
- Tailor solutions to specifically address this problem.
- Present solutions to both our client and faculty mentor, receive feedback and make necessary modifications.
- Put together a detailed report and make our recommendations
- Present final recommendations.

Background Research

- What are some renewable options available? Which are feasible?
- Total energy usage for heating
- Total energy usage for electricity (all but heating)
- Cost to replace with a more energy-efficient or renewable option
- Energy cost savings (payoff period, etc.)
- Efficiency upgrades that can lower the cost the more
- Anything to bridge the gap if we can't reach zero-emissions
- Incentives

Challenges along the way

- Tailoring solutions to exact needs of Eau Claire County based on other extenuating factors, cost and specific county goals. For example:
 - Estimating the correct size of our recommended systems (to be presented soon).
 - Estimating when decarbonization might be complete, and designing our various proposed solutions to fit within that scope.
 - Readjusting calculations to exclude some originally considered rooftop space (not available due to exhaust and other space-occupying infrastructure)
 - Estimating how some originally non-feasible solutions might be made feasible in future.
 - Finding similarly scaled projects to serve as references for some of the decisions for this project.

Research Results: First-Phase Solutions

Relatively easy solutions (already implemented) include:

- LED lights
- Proper insulation (including roof repairs, re-surfacing)
- The majority of building chillers have been replaced with VFD (variable speed) controlled chillers
 - Per the client, the only chillers that haven't been replaced with VFD yet are the ones where that is unnecessary
- Replacement of older HVAC models nearing expiration
- Rooftop solar in some parts of the buildings
- Quick fixes to infiltrations/leaks
- Available financial incentives

Research Results: Possible But Non-Viable Ideas to Reaching Carbon Neutrality

- Rooftop and/or Off-site wind energy
- Biomass/Bioenergy
- Hydro energy (harnessed from nearby river)
- Air Source Heat pumps
- Purchasing and selling of carbon credits
- On-Site Wind
- Off-Site Wind
- Off-Site Solar

Why Non-Viable?

- Biomass/bioenergy
 - Not easily implemented
 - No facility nearby that can be utilized
- Energy recovery system
- Hydropower
 - Permitting issues, especially with a dam ~1 mile upstream
- Air-source heat pump
 - Less reliable and efficient at low temperatures. For Eau Claire, that is an issue that cannot realistically be addressed currently
- Wastewater Heat Pump
 - Not yet a mature enough technology
- On-Site Wind
 - Not enough on-site generation capacity possible
 - Potential aesthetic concerns by nearby residents
- Off-Site Wind
 - On-site generation preferred
- Off-Site Solar

Research Results: Feasible Solution I - Ground-Source Heat Pumps

Why ground source heat pumps?

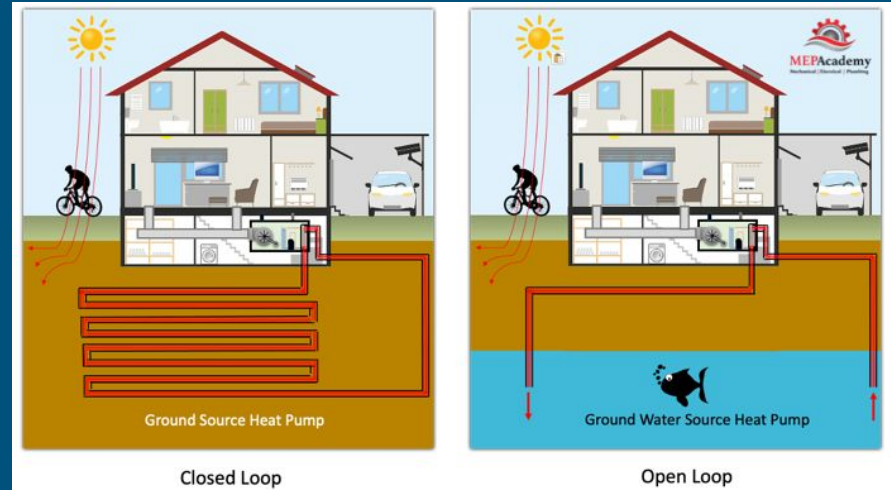
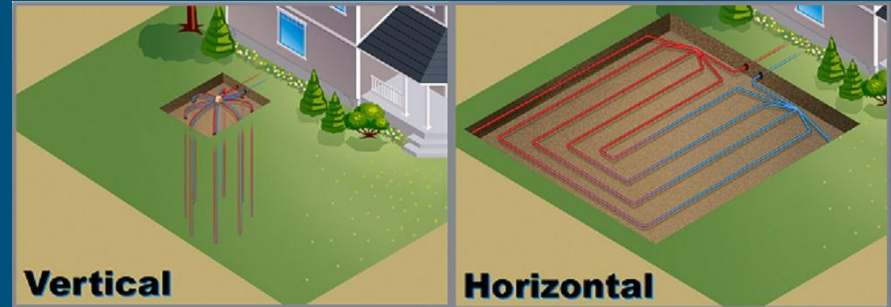
- Ground temperature is stable which allows very consistent and efficient heating
- Higher coefficient of performance (COP) than other heat pump types
- Less reliance on ambient air temperature
- No Need for Backup Heating: GSHPs, with their higher efficiency and consistent heat source from the ground, are less likely to require backup heating, resulting in lower operating costs and increased reliability
- Longer Lifespan and lower maintenance

What Type of Ground Source Heat Pump?

-Given space constraints, a vertical ground source heat pump is required to meet the heating and cooling requirements of the complex

-We recommend a closed loop system:

- Lower maintenance costs
- Higher efficiency
- Better in colder climates
- Last longer
- Lower likelihood of problems arising



Estimating the Size of the GSHP System

From data that we received from Eau Claire County regarding the complex's current heating and cooling requirements, we estimate that 280-ton closed loop system is required.

Standard Capacity Ratings for Open Loop (60Hz)											
Performance Rating Conditions	Model	Tons	Flow (GPM)	Outdoor dP (psi)	Heating Capacity (Btu/hr)	Input Energy (Watts)	COPh (Heating)	Cooling Capacity (Btu/hr)	Input Energy (Watts)	COPc (Cooling)	EER
Open Loop Heating EWT 104°F Cooling EWT 54°F	W-150	12	36	2.0	153,800	10,386	4.34	156,300	7,242	6.33	21.6
	W-185	15	48	2.3	207,300	13,871	4.38	188,800	8,711	6.36	21.7
	W-240	20	60	2.7	274,500	17,625	4.56	253,900	11,890	6.26	21.4
	W-300	23	72	2.7	316,900	19,360	4.80	297,700	13,330	6.54	22.3
	W-400	30	100	2.8	408,600	25,970	4.61	393,000	18,190	6.33	21.6
	W-500	40	120	4.0	569,800	36,465	4.58	493,500	23,005	6.28	21.4
	W-600	50	150	4.4	683,400	42,630	4.70	620,000	29,055	6.25	21.3
	W-800	65	190	4.6	850,600	54,885	4.54	796,400	37,335	6.25	21.3
	W-900	70	210	4.7	914,800	59,500	4.51	872,500	41,600	6.15	21.0
	W-1000	81	225	4.6	1,076,100	74,774	4.22	981,700	47,213	6.10	20.8
Standard Capacity Ratings for Closed Loop (60Hz)											
Closed Loop Heating EWT 104°F Cooling EWT 54°F 35% Propylene Glycol	W-150	12	36	2.7	115,100	10,067	3.35	140,700	9,085	4.55	15.5
	W-185	15	48	2.9	155,400	13,308	3.42	172,300	11,054	4.57	15.6
	W-240	20	60	3.3	197,900	16,790	3.45	224,600	14,635	4.50	15.4
	W-300	23	72	3.7	231,000	18,650	3.66	272,500	15,960	5.00	17.1
	W-400	30	100	3.5	291,700	24,915	3.43	365,300	22,070	4.85	16.6
	W-500	40	120	5.5	423,900	36,400	3.41	474,600	29,055	4.79	15.5
	W-600	50	150	5.9	478,900	41,150	3.41	578,000	36,415	4.65	15.9
	W-800	65	190	6.0	612,500	52,910	3.39	743,800	47,030	4.63	15.8
	W-900	70	210	6.2	683,500	57,600	3.48	802,000	52,300	4.50	15.3
	W-1000	81	225	5.9	808,900	72,771	3.26	900,300	58,812	4.49	15.3

Estimating the Cost of the GSHP System

-Cost of installation of heat exchange system:

= \$25/linear foot x 150 ft/ton x 280 ton system

= \$1,050,000

-Cost of heat pump itself:

= \$2000/ton x 280 tons

= \$560,000

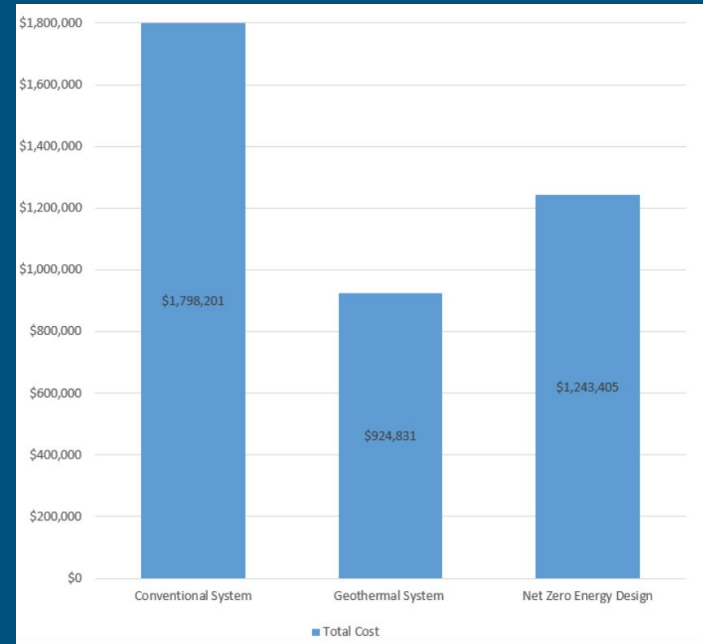
-Tax credit from the Inflation Reduction Act (30%):

= \$483,000

-Total Cost:

= \$1,050,000 + \$560,000 - 483,000

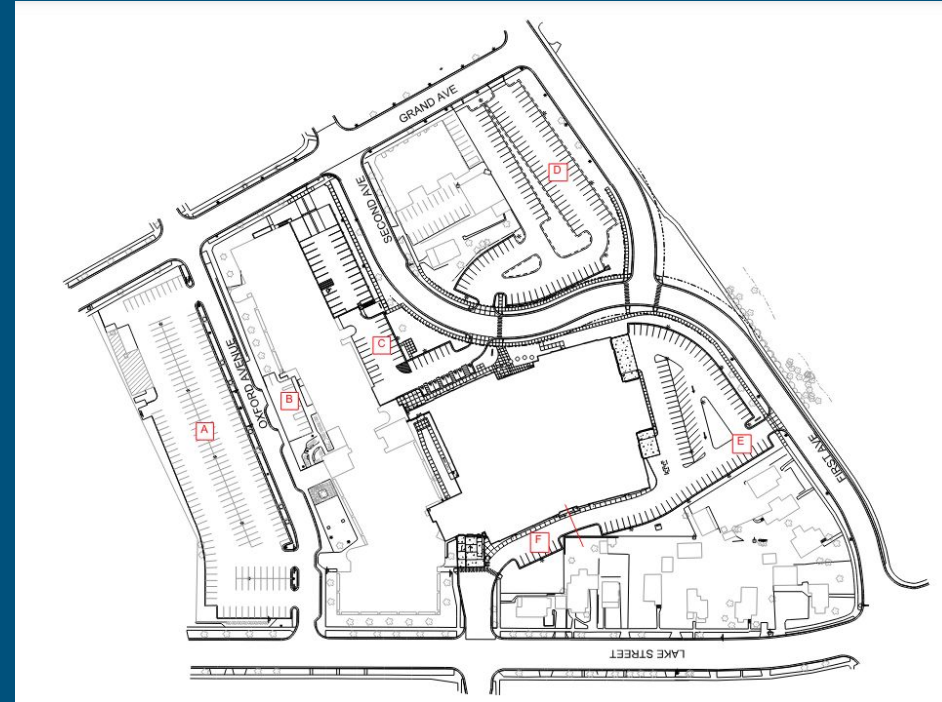
= \$1,127,000



*Estimated cost from Village of McFarland
Community Center project*

Where Would the GSHP System Be Installed?

- Required: 42,000 linear feet of piping
- Recommend: 70 boreholes, 600 feet deep and 6 inches in diameter, spaced 20 feet apart
- Two placement options:
 - In space underneath Lot E & F
 - Underneath new parking structure in lot A



Map of Eau Claire County jail/courthouse and parking lots

Scenarios: WI Grid Decarbonization Rates

To fully understand potential outcomes, we have analyzed a range of decarbonization scenarios:

- Scenario 1: No decarbonization past this point
- Scenario 2: 100% Grid Decarbonization by 2100
- Scenario 3: 100 Grid Decarbonization by 2075
- Scenario 4: 100% Grid Decarbonization by 2050

Available Space for Solar

Building Surface Area for Solar:

- 53,084 SqFt

Parking Lot Surface Area for Solar:

- Number of Spaces: 228
- Area per Space: 162 SqFt
- Total Area: 36,936 SqFt

Overall Solar Area Available: 90,020 SqFt



SAM Simulation: Decarbonization Scenarios

	No New Decarb COP 6	No New Decarb COP 4.5	No New Decarb COP3	2075 Decarb COP 6	2075 Decarb COP4.5	2075 Decarb COP 3	2100 Decarb COP 6	2100 Decarb COP 4.5	2100 Decarb COP3
KW Needed	295.6112664	316.3925088	357.9549937	139.1243429	149.3553976	169.8175069	190.826874	204.5436602	231.9772327
M^2	9344.16	10009.44	11324.88	4399.92	4717.44	5367.60	6032.88	6471.36	7333.20
SqFt	100579.60	107740.61	121899.88	47360.30	50778.05	57776.31	64937.32	69657.07	78933.83
% of Available Roof Area Occupied	189.47%	202.96%	229.64%	89.22%	95.66%	108.84%	122.33%	131.22%	148.70%
% of Available Roof and Parking Lot Area Occupied	111.73%	119.69%	135.41%	52.61%	56.41%	64.18%	72.14%	77.38%	87.68%
Parking Stalls Required	293.1827397	337.386489	424.789357	-35.3	-14.23424435	28.96487432	73.16862365	102.302913	159.566861
Total Capital Cost (Solar+GSHP)	\$4,345,879.00	\$4,575,055.00	\$5,028,198.00	\$2,642,686.00	\$2,752,065.00	\$2,976,032.00	\$3,205,208.00	\$3,356,256.00	\$3,653,143.00

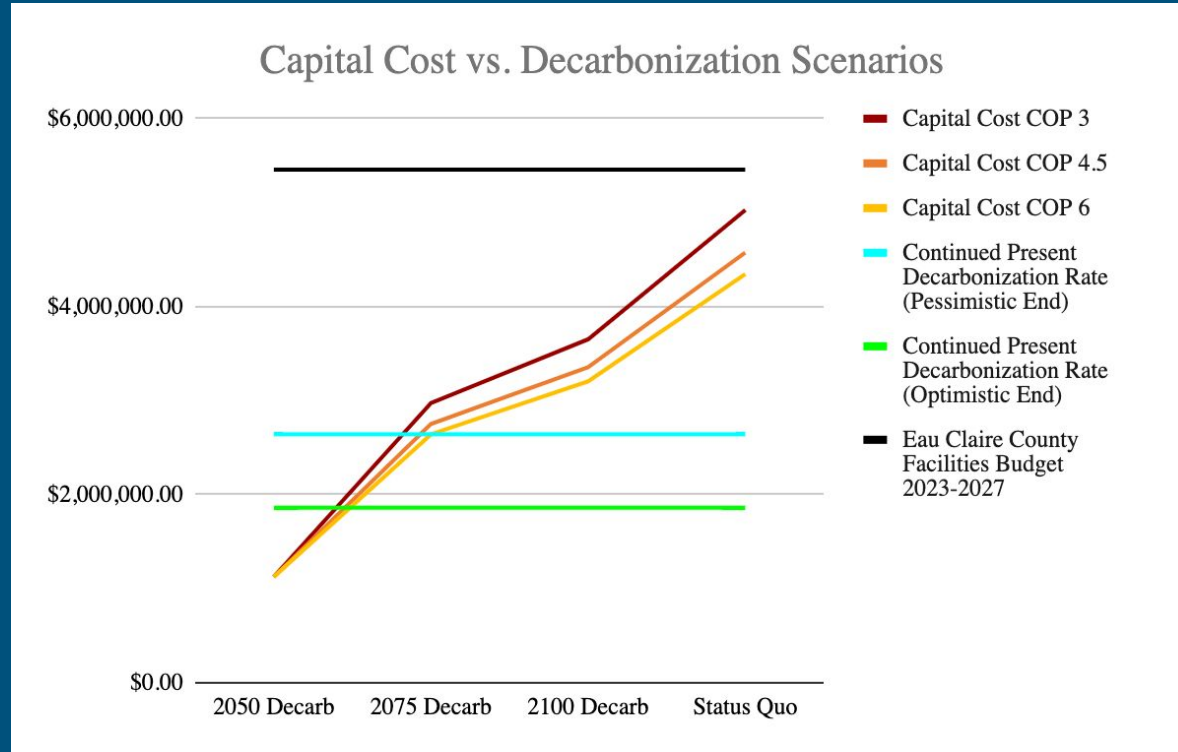
Blacked out boxes indicate 0 parking stalls would be required

SAM Simulation - Projected Outcomes

	Pessimistic Likelihood COP 6	Pessimistic Likelihood COP 4.5	Pessimistic Likelihood COP3	Optimistic Likelihood COP 6	Optimistic Likelihood COP 4.5	Optimistic Likelihood COP 3
KW Needed	113.780779	122.3031966	139.3480317	67.20875516	72.59133468	83.35649373
SqFt	38734.54	41664.04	47360.30	22947.77	24738.03	28318.53
% of Available Roof Area Occupied	72.97%	78.49%	89.22%	43.23%	46.60%	53.35%
% of Available Roof and Parking Lot Area Occupied	43.03%	46.28%	52.61%	25.49%	27.48%	31.46%
Parking Stalls Required	-88.57691368	-70.49356168	-35.33148835	-186.0260883	-174.975151	-152.8732763
Total Capital Cost (Solar+GSHP)	\$2,366,633.00	\$2,460,387.00	\$2,642,686.00	\$1,861,404.00	\$1,918,698.00	\$2,033,286.00
NPV Estimate	\$342,876.00	\$393,636.00	\$444,181.00	\$177,909.00	\$176,907.00	\$267,430.00

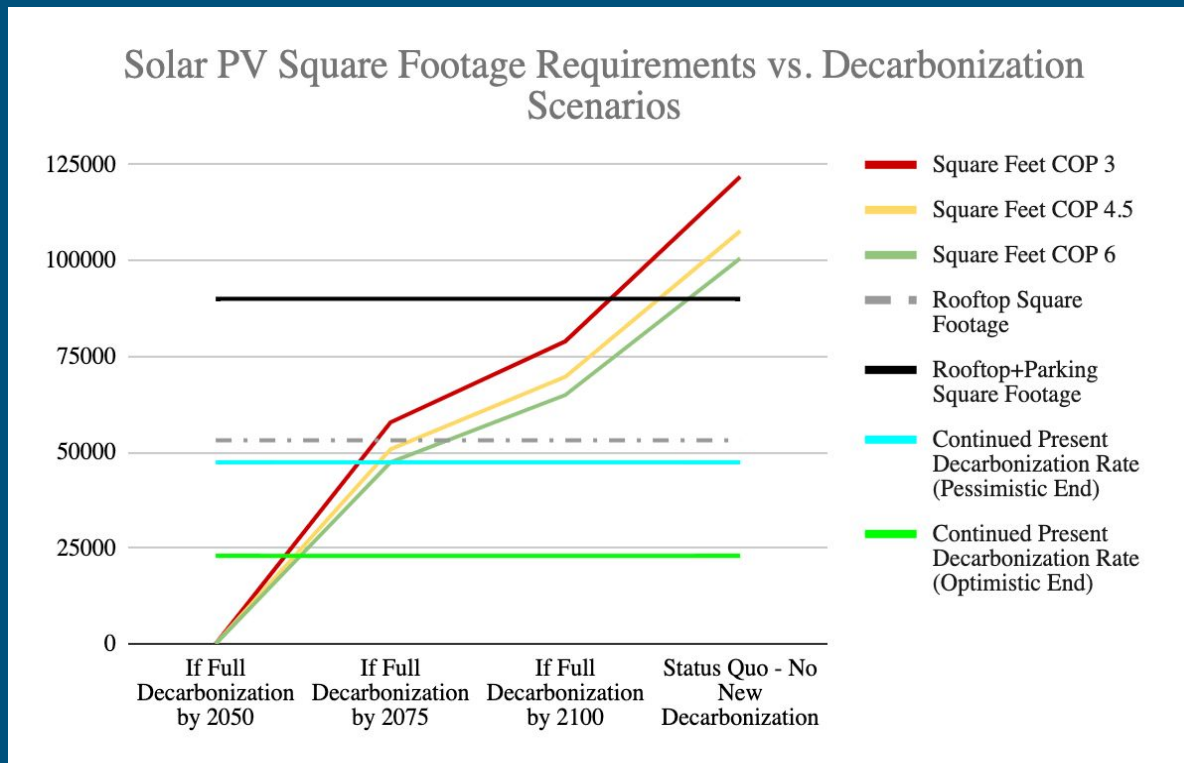
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Capital Cost Requirement vs. Decarbonization Scenario



* Based on external research, SAM model simulations, and our correspondence with Salas O'Brien

Square Footage Requirements vs. Decarbonization Scenarios



* Based on external research, SAM model simulations, and our correspondence with Salas O'Brien

Conclusion

- Net-zero is fiscally and technologically attainable in all reasonable projections
- Most reasonable scenarios indicate that only rooftop solar and GSHP will be required for this complex to meet Eau Claire County's target of net-zero by 2050
- Solar capacity requirements will vary based on decarbonization rates
- Ground-source heat pump installation will be required to reach net-zero regardless of decarbonization rate