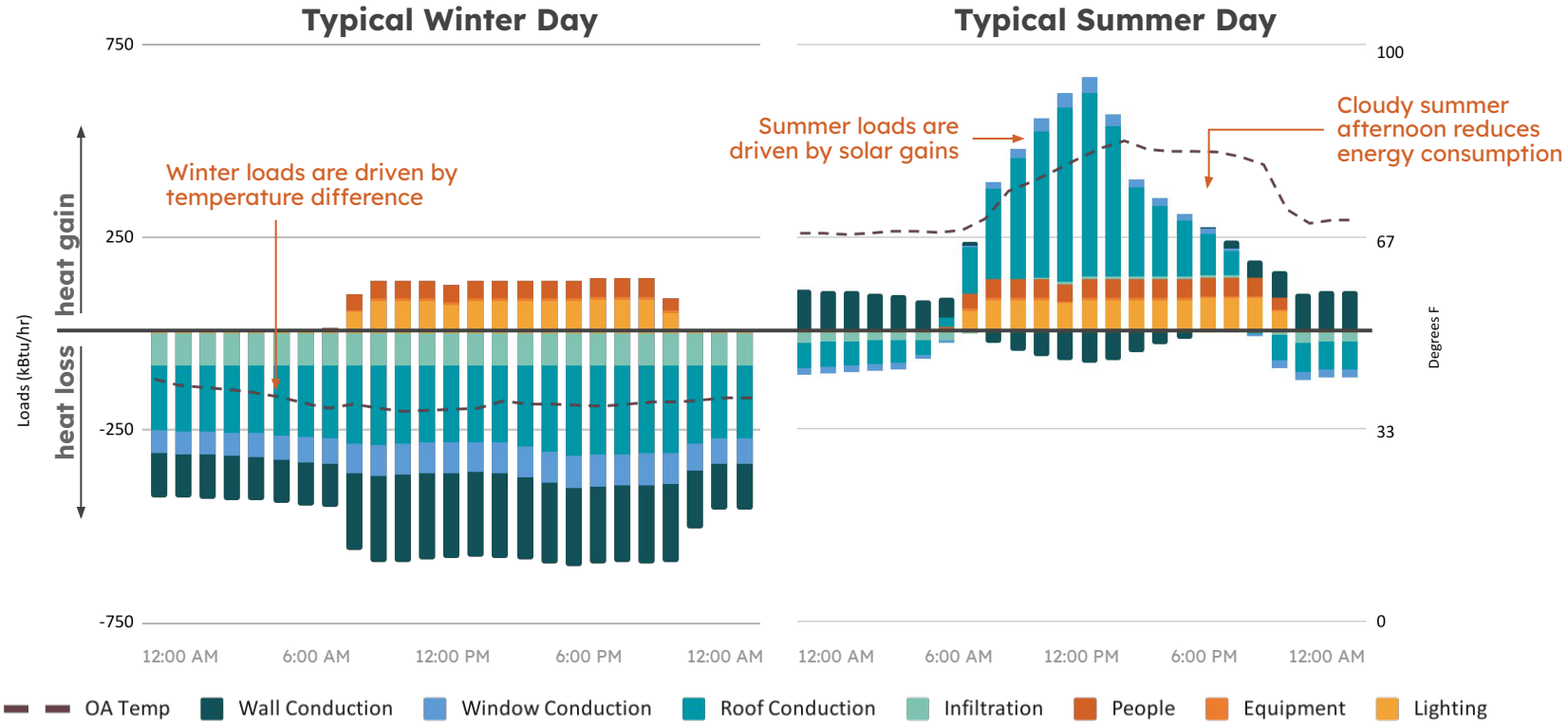
HVAC Cases + Funding Opportunities + Life Cycle Cost Analysis

Noyes Cultural Arts Center

3.17.23

Calibration - Typical Day Conditioning

Our modeled energy and gas usage is within 10% of the actual usage data.



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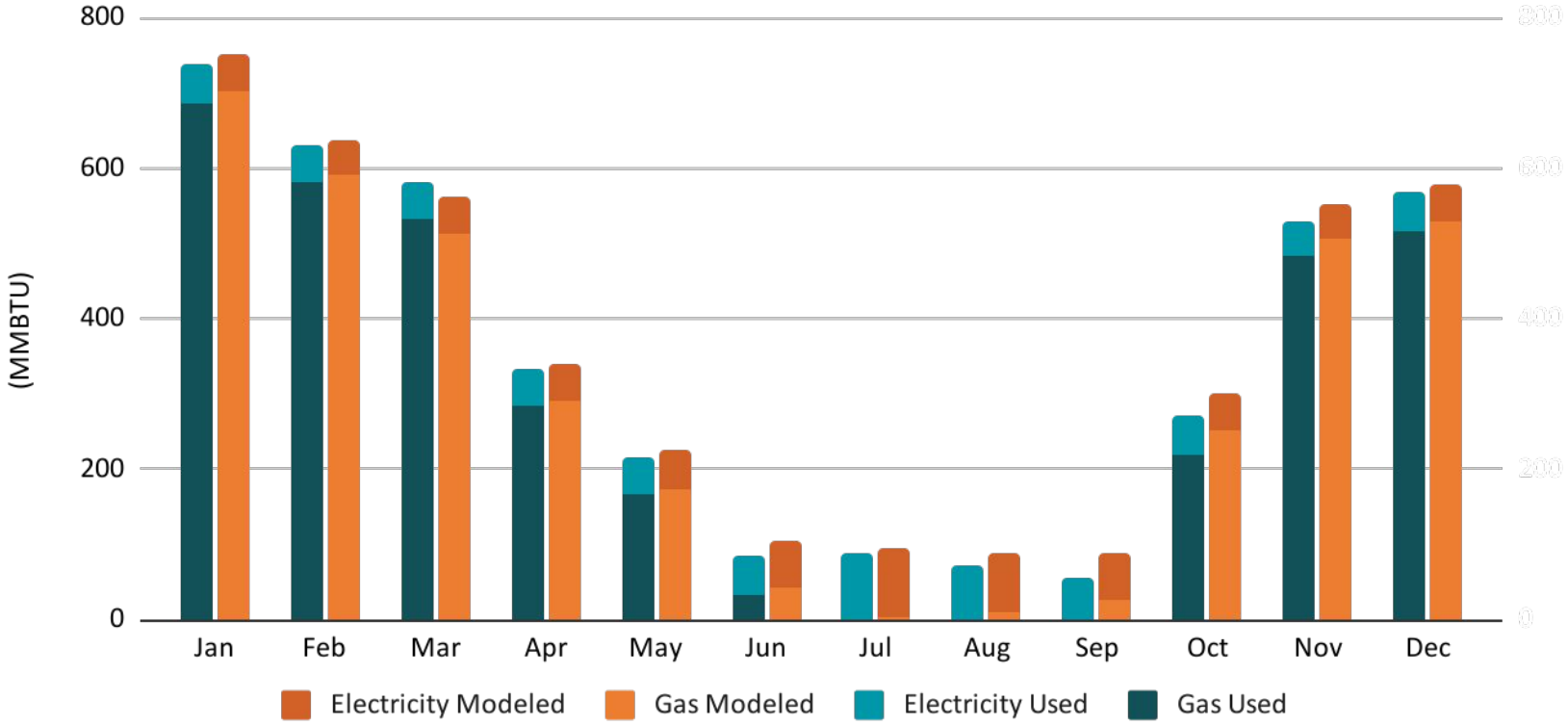
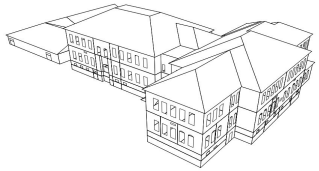
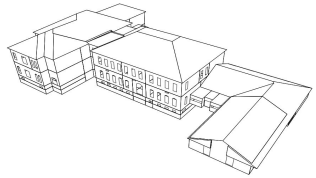
Calibration

Our modeled energy and gas usage is within 10% of the provided usage data on an annual basis.



Inputs





Items			Notes
General	Building	Noyes Cultural Arts Center	
	Location	Evanston, IL	
	Climae Zone	5A	
	Weather	Cold and humid, heating dominant, but still has considerable cooling loads	Considerable heating, cooling, and fan conumsptions are expected
	Year Built	1892	Gym and Theatre were added later
	Rennovation	1999	Steam boilers were replaced and office rooms on 1st floor renovated in 2001
	Building Use	Arts Classroom, Office, Theatre, Gym	
	Size sqft	54,718	
Schedule	Building Operation Hours	Mon-Fri 8:00 a.m. - 10:00 p.m.	Events and plays in theatre space on Friday, Saturday and Sunday
		Sat 8:30 a.m. to 7:00 p.m.	
		Sun 10:00 a.m. to 5:00 p.m.	
Envelope	Roof	R-25	Roof replacement in 2013 for roof D,E,F,G,H based on the roof replacement drawings
	Attic roof	R-20 batt insulation	
	Below Grade Wall	R-0	Estimated to be uninsulated
	External wall	R-0	Uninsulated masonary wall
	Glazing	U-0.60; SHGC-0.40	Double pane windows
	Slab on grade	R-0, F-0.73	Assumption based on the built year
	Door	U-0.70	Assumption based on the built year
	Infiltration	0.15 CFM/SF-façade	Assumption based on the building operation
Lighting	Office	0.9 W/SF	Lighting power density is estimated based on the space type
	Classroom	0.9 W/SF	
	Corridors	1.5 W/SF	
	Gym	1.0 W/SF	
	Theatre	1.0 W/SF	
Receptacle / Misc	Office	0.28 W/SF	Receptacles are modeled with a modulating profile based on building operation hours and event hours. Occupancy is modeled based on the daily and event based estimate
	Classroom	0.28 W/SF	
	Gym	0.28 W/SF	
	Theatre	0.28 W/SF	
HVAC	Boiler	Steam boilers used for heating	Three NG fired steam boilers; Eff = 75%
	AHU - Theater	Constant speed, split-system DX, steam heat	No fan info, Fan consumption estimated based on the cooling coil size
	AHU 1&2 - Gym	Constant speed, split-system DX, steam heat	
	AHU - Piven Theatre	Constant speed, split-system DX, steam radiators	
	AHU - Office	Constant speed, split-system DX, steam radiators	
	PTAC	Window units	Natural ventilation, heating for rooms with PTAC is provided by perimeter radiators
	Radiators	Permiter steam radiators	Fin tube radiation schedule based on the mechanical schedule
	SF 1-2; EF 1-2	Whole building ventlation fans	Modeled based on logic control with the sequence of operations provided in the mechanical schedule
DHW	Electric water heater	50 gal; 4.5 KW electric water heater	estimated use 2 gal/day/person

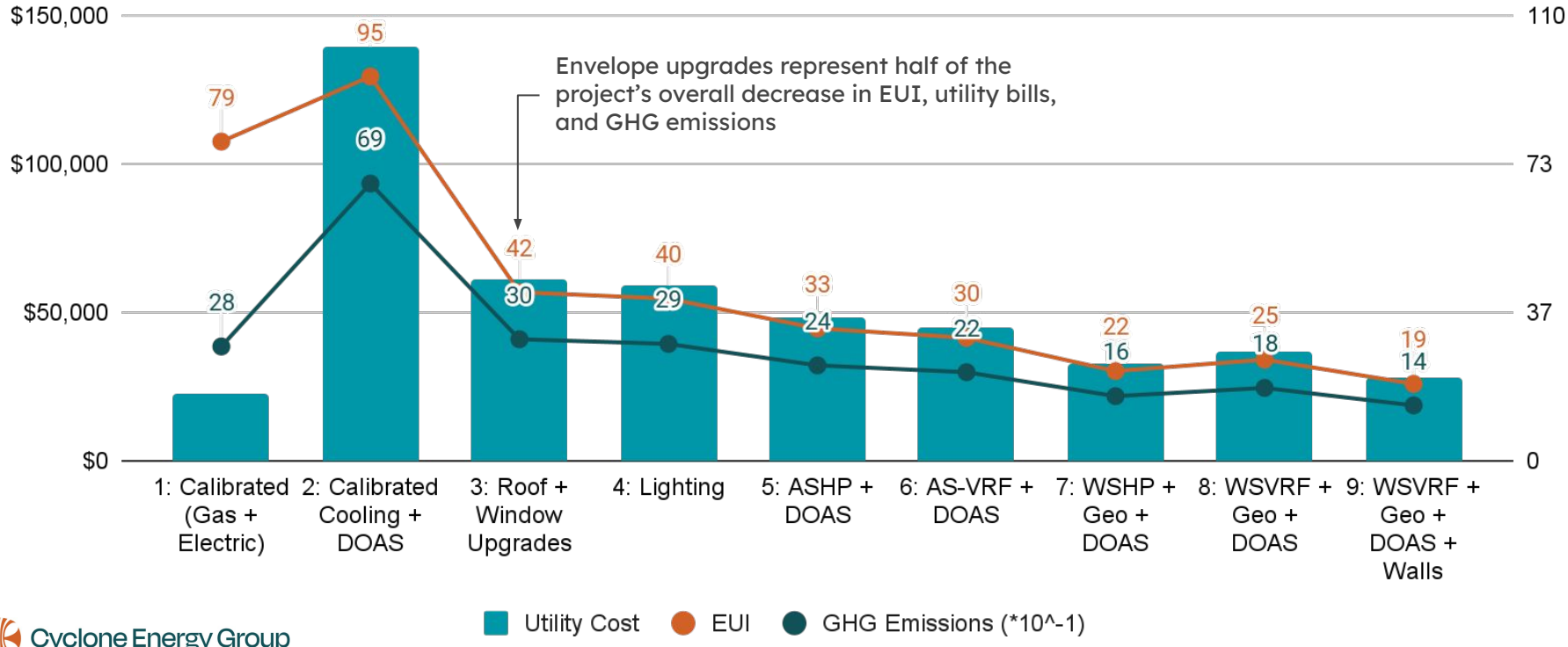
Summary of HVAC System Cases

HVAC system cases are outlined here. Each system is numbered and has O symbols that mark which descriptors are relevant in the given case.

Characteristics	HVAC Cases								
	1	2	3	4	5	6	7	8	9
All Electric		O	O	O	O	O	O	O	O
Cooling System Addition		O	O	O	O	O	O	O	O
DX/Electric Ventilation (DOAS/AHUs)		O	O	O	O	O	O	O	O
Roof Insulation			O	O	O	O	O	O	O
Windows + Air Sealing			O	O	O	O	O	O	O
Lighting				O	O	O	O	O	O
Matching Ventilation (DOAS/AHUs)					O	O	O	O	O
Geothermal Heat Exchange							O	O	O
Water Source							O	O	O
Air Source					O	O			
Heat Pump					O		O		
VRF						O		O	O
R20 Walls									O

Summary of HVAC System Cases

Adding DOAS to the calibrated model causes a significant increase in utility bills, EUI, and GHG emissions, however, envelope upgrades and an updated HVAC system improves the performance.



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Ventilation Efficiency

Using heat pumps for ventilation air supply makes a dramatic difference for efficiency, incentives, + on-site solar net zero

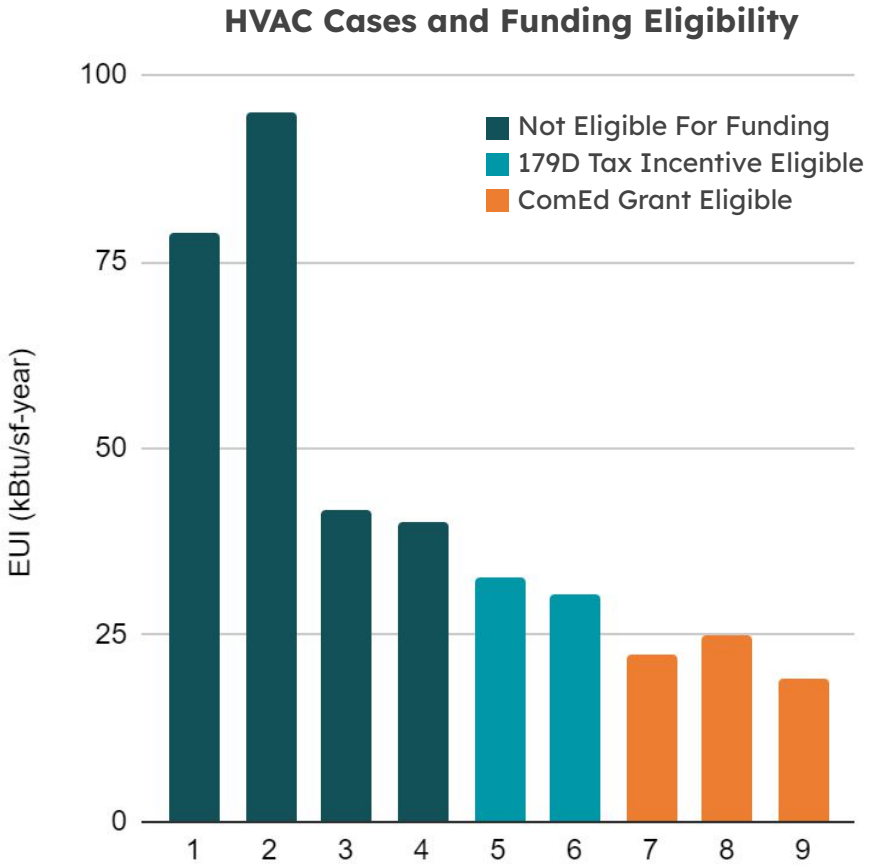
Case	Name	Utility Cost	Annual kBtu	EUI (kBtu/sf)	GHG Emissions	Approx. Net Zero PV Array Size (kW)	Case 3 Cost % Savings	179D % Cost Savings	179D % Energy Savings	179 D Incentive	ComEd Incentive
1	Calibrated (Gas + Electric)	$ 22,585	4,326,435	79	284	1060	-	-	-	-	-
2	Calibrated Cooling + DOAS	$ 139,376	5,207,750	95	686	1270	-	-	-	-	-
3	Roof + Window Upgrades	$ 61,241	2,288,264	42	301	560	35%	n/a	n/a	n/a	n/a
4	Lighting	$ 58,888	2,200,333	40	290	540	38%	n/a	n/a	n/a	n/a
5	ASHP + DOAS	$ 48,115	1,797,810	33	237	440	49%	68%	68%	$ 103,009	n/a
6	AS-VRF + DOAS	$ 44,696	1,670,050	30	220	410	53%	71%	71%	$ 103,009	n/a
7	WSHP + Geo + DOAS	$ 32,669	1,220,652	22	161	300	65%	78%	78%	$ 103,009	$ 11,101
8	WSVRF + Geo + DOAS	$ 36,822	1,375,856	25	181	340	61%	76%	76%	$ 103,009	$ 6,948
9	WSVRF + Geo + DOAS + Walls	$ 28,025	1,047,160	19	138	260	70%	82%	82%	$ 103,009	$ 15,745

Wall insulation makes a big difference once all other envelope components are improved

Incentives Summary

ComEd Incentives reference a gas baseline. Savings offset occurs once the highest performance cases are achieved, so savings isn't substantial comparatively.

The 179D Tax Incentive is only applicable once a building is brought up to code via ventilation rates, so the envelope improvements alone won't get this project there. A public private partnership (PPP) will be required to realize tax incentives.



179D Commercial Buildings Energy Efficiency Tax Deduction

- **IRA reduces necessary improvement from 50% to 25%** over existing baseline
- Buildings must fully qualify - removed partial certifications for lighting, HVAC, envelope
- Projects can take the 179D deduction every 3 years as long as a system upgrade is taking place
- All tax exempt entities are now eligible
- **This Tax incentive is now permanent and it adjusts for inflation annually**

Improvement over ASHRAE 90.1 Baseline	Deduction Available per SF*
25%	$3.00
30%	$3.60
35%	$4.20
40%	$4.80
50%	$5.00

*Prevailing wage requirements must be met

Criteria	Existing	With IRA Updates
Compliance Path	Fully Qualifying, Partial Qualifying, Interim Lighting Rule	Any Property
Savings Requirement	50%	25%
Tax Deduction per square foot	$0.63-1.88	$3.00-5.00

Inflation Reduction Act

Why is it important?

- Estimated to reduce US greenhouse gas emissions by 40% by 2030

What does it do?

- **Increases 179D Tax Deduction** - $1.80/sf → $3.00-5.00/sf, enables existing buildings to reference the current building as a baseline for improvements
- **Clean Energy Investment Tax Credit** - up to 30% of costs of clean energy property investments ie. solar, geothermal, dual heating and cooling systems, energy storage, microgrid controllers, dynamic glass
  - Credit is directly paid to government entities
- **EV Charging Credit** - credit of 30% of expenses up to $100,000 for EV charging system installation

ZERO ENERGY READY HOME
U.S. DEPARTMENT OF ENERGY

ENERGY STAR


Image Credit: Infinity Energy

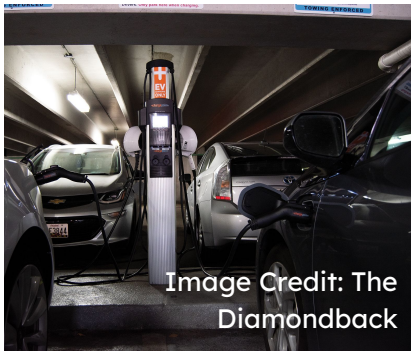


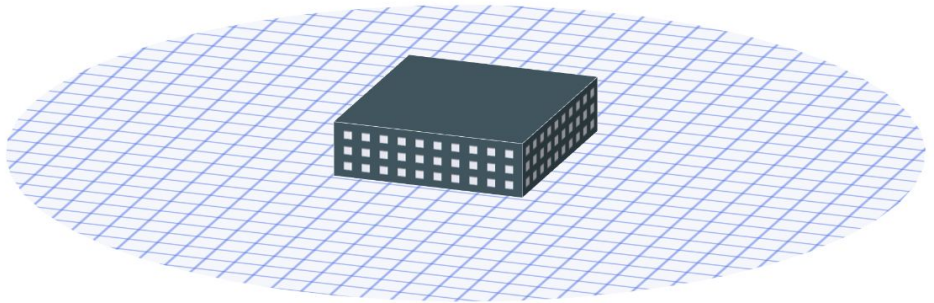
Image Credit: The Diamondback

ComEd Incentives

Savings refer to the reduction in **annual utility cost** compared to a code referenced baseline. Incentives awarded at **$0.07/kWh + 0.35/therm** saved

- ASHRAE 90.1 2019 AppG mechanical systems.
- IECC 2018 Lighting design.
- Incentives take into account existing envelope conditions
- Incentives are paid based on gas + electric savings
- Baseline system uses both gas + electric.

****Only highest performing systems cases achieve incentives****



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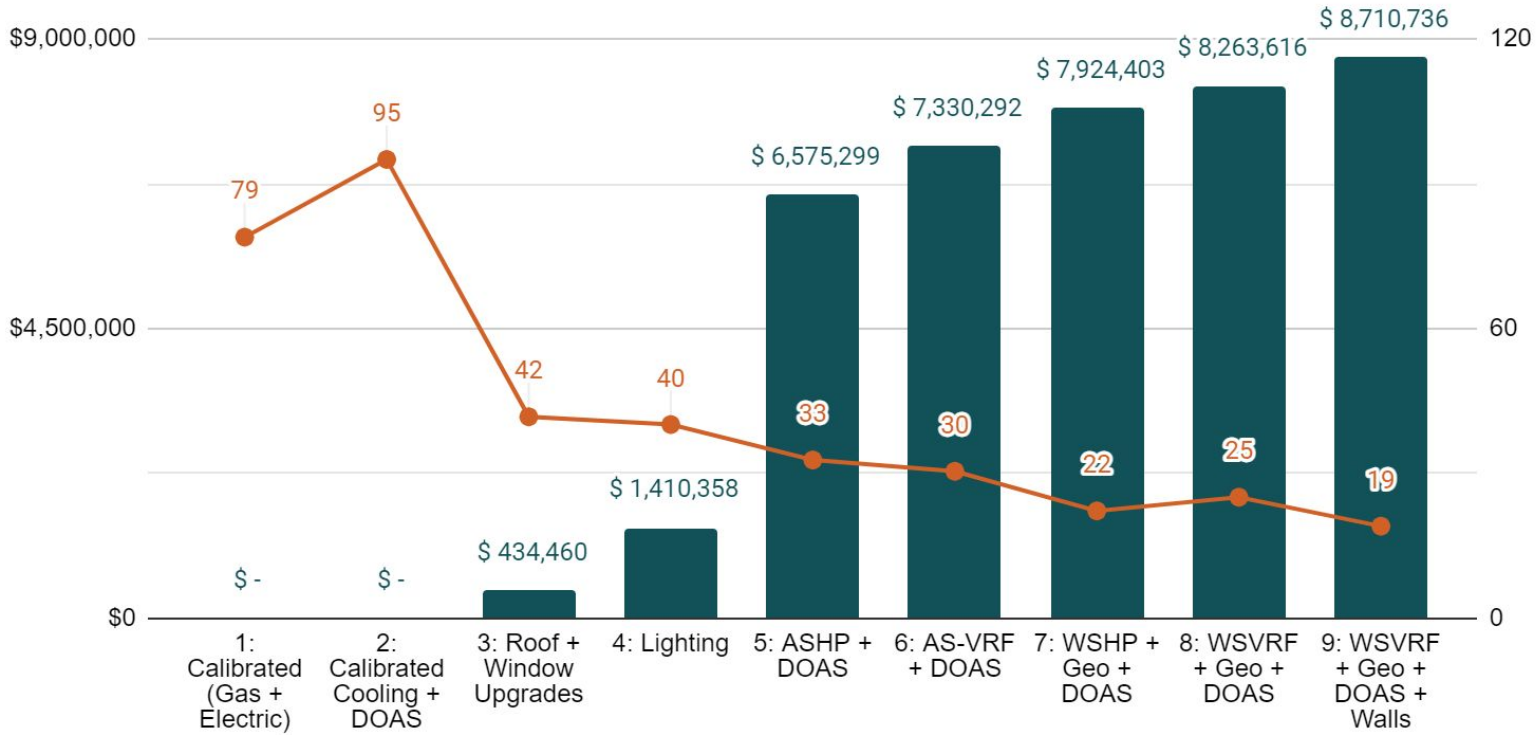
Life Cycle Cost Analysis

Heat pumps tend to have lower net present value costs than VRF systems. Adding geothermal brings the EUI down significantly but adds a significant cost.



Appendix: Life Cycle Cost Analysis

3. Attic roof upgraded to R=30 insulation

			Escalated at 3%									
Year	Initial Capital Cost	Incentives / Rebates	Replacement	Fuel / Energy	Other	Maintenance	Repair	Salvage Value	Total Escalated Cost	Present Worth Discount Factor at 3%	Total Present Value	Notes
1	$30,700	n/a							$30,700	1.000	$30,700	Insulation + Labor
2									0	0.971	0	
3									0	0.943	0	
4									0	0.915	0	
5									0	0.888	0	
6									0	0.863	0	
7									0	0.837	0	
8									0	0.813	0	
9									0	0.789	0	
10							1,957		1,957	0.766	1,500	In the event of a minor roof leak and some insulation needs to be replaced, one person half day at $100/hr + materials
11									0	0.744	0	
12									0	0.722	0	
13									0	0.701	0	
14									0	0.681	0	
15									0	0.661	0	
16									0	0.642	0	
17									0	0.623	0	
18									0	0.605	0	
19									0	0.587	0	
20							2,630		2,630	0.570	1,500	
											$33,700	

Appendix: Life Cycle Cost Analysis

3. New generation double pane windows; U=0.35; SHGC =0.35. New doors. Reduced infiltration

			Escalated at 3%									
Year	Initial Capital Cost	Incentives / Rebates	Replacement	Fuel / Energy	Other	Maintenance	Repair	Salvage Value	Total Escalated Cost	Present Worth Discount Factor at 3%	Total Present Value	Notes
1	$348,200	n/a				$1,440			$349,640	1.000	$349,640	window cleaing takes 2 person one day at $90/hr each
2						1,483			1,483	0.971	1,440	
3			3,183			1,528			4,710	0.943	4,440	One window breaks every three years which costs $3000
4						1,574			1,574	0.915	1,440	to replace
5						1,621	1,621		3,241	0.888	2,880	window sealing happens every 5 years and takes 2
6			3,478			1,669			5,147	0.863	4,440	person one day at $90/hr each
7						1,719			1,719	0.837	1,440	
8						1,771			1,771	0.813	1,440	
9			3,800			1,824			5,624	0.789	4,440	
10						1,879	1,879		3,758	0.766	2,880	
11						1,935			1,935	0.744	1,440	
12			4,153			1,993			6,146	0.722	4,440	
13						2,053			2,053	0.701	1,440	
14						2,115			2,115	0.681	1,440	
15			4,538			2,178	2,178		8,894	0.661	5,880	
16						2,243			2,243	0.642	1,440	
17						2,311			2,311	0.623	1,440	
18			4,959			2,380			7,339	0.605	4,440	
19						2,452			2,452	0.587	1,440	
20						2,525	2,525		5,050	0.570	2,880	
											$400,760	

Appendix: Life Cycle Cost Analysis

4. All remaining spaces upgraded to LED lighting - 44,963 sf (Assumed 30% better than the 2018 IECC W/SF lighting requirement)

			Escalated at 3%									
Year	Initial Capital Cost	Incentives / Rebates	Replacement	Fuel / Energy	Other	Maintenance	Repair	Salvage Value	Total Escalated Cost	Present Worth Discount Factor at 3%	Total Present Value	Notes
1	$764,371	n/a		$5,604		$1,000			$770,975	1.000	$770,975	Assume 50% is labor cost
2				5,773		1,030			6,803	0.971	6,604	replace 5% lights every 5 years
3				5,946		1,061	530		7,537	0.943	7,104	
4				6,124		1,093			7,217	0.915	6,604	
5			21,508	6,308		1,126			28,941	0.888	25,714	
6				6,497		1,159	580		8,236	0.863	7,104	
7				6,692		1,194			7,886	0.837	6,604	
8				6,893		1,230			8,123	0.813	6,604	
9				7,100		1,267	633		9,000	0.789	7,104	
10			24,933	7,313		1,305			33,551	0.766	25,714	
11				7,532		1,344			8,876	0.744	6,604	
12				7,758		1,384	692		9,834	0.722	7,104	
13				7,991		1,426			9,416	0.701	6,604	
14				8,230		1,469			9,699	0.681	6,604	
15			28,904	8,477		1,513	756		39,651	0.661	26,214	
16				8,732		1,558			10,290	0.642	6,604	
17				8,994		1,605			10,598	0.623	6,604	
18				9,263		1,653	826		11,743	0.605	7,104	
19				9,541		1,702			11,244	0.587	6,604	
20			33,508	9,827		1,754			45,089	0.570	25,714	
											$975,898	

Appendix: Life Cycle Cost Analysis

5. Air source heat pump terminal units, DOAS + AHUs with energy recovery wheel + backup electric boiler. (Heat COP=3.25; Cooling COP =4)

			Escalated at 3%									
Year	Initial Capital Cost	Incentives / Rebates	Replacement	Fuel / Energy	Other	Maintenance	Repair	Salvage Value	Total Escalated Cost	Present Worth Discount Factor at 3%	Total Present Value	Notes
1	$2,351,700	-$103,000		$48,115		$14,051			$2,310,866	1.000	$2,310,866	1.5x premium for DOAS+AHUs
2				49,558		14,472			64,031	0.971	62,166	
3				51,045		14,907			65,952	0.943	62,166	
4				52,577		15,354			67,930	0.915	62,166	
5				54,154		15,814	22,510		92,478	0.888	82,166	
6				55,778		16,289			72,067	0.863	62,166	
7				57,452		16,777			74,229	0.837	62,166	
8				59,175		17,281			76,456	0.813	62,166	
9				60,951		17,799			78,750	0.789	62,166	
10			200,315	62,779		18,333	65,239		346,666	0.766	265,691	DDC EM Replacement + Testing + Balance
11				64,663		18,883			83,546	0.744	62,166	
12				66,602		19,450			86,052	0.722	62,166	
13				68,600		20,033			88,634	0.701	62,166	
14			624,127	70,658		20,634			715,419	0.681	487,166	AS-HP Replacement
15			1,020,091	72,778		21,253			1,114,122	0.661	736,566	DOAS + AHU Replacement
16				74,962		21,891			96,852	0.642	62,166	
17				77,210		22,547			99,758	0.623	62,166	
18				79,527		23,224			102,751	0.605	62,166	
19				81,913		23,921	85,122		190,955	0.587	112,166	Repair + Testing + Balance
20			526,052	84,370		24,638			635,060	0.570	362,166	Electric Boiler Replacement
											$5,164,942	

Appendix: Life Cycle Cost Analysis

6. Air source VRF terminal units, DOAS + AHUs with energy recovery wheel + electric resistance boiler backup. (Heating COP= 3.5 Cooling COP = 4.5)

			Escalated at 3%									
Year	Initial Capital Cost	Incentives / Rebates	Replacement	Fuel / Energy	Other	Maintenance	Repair	Salvage Value	Total Escalated Cost	Present Worth Discount Factor at 3%	Total Present Value	Notes
1	$2,818,900	-$103,000		$44,696		$18,734			$2,779,330	1.000	$2,779,330	1.5x premium for DOAS+AHUs
2				46,037		19,296			65,333	0.971	63,430	
3				47,418		19,875			67,293	0.943	63,430	
4				48,841		20,472			69,312	0.915	63,430	
5				50,306		21,086	22,510		93,902	0.888	83,430	
6				51,815		21,718			73,533	0.863	63,430	
7				53,369		22,370			75,739	0.837	63,430	
8				54,970		23,041			78,011	0.813	63,430	
9				56,620		23,732			80,352	0.789	63,430	
10			200,315	58,318		24,444	65,239		348,316	0.766	266,955	DDC EM Replacement + Testing + Balance
11				60,068		25,178			85,245	0.744	63,430	
12				61,870		25,933			87,803	0.722	63,430	
13				63,726		26,711			90,437	0.701	63,430	
14			734,267	65,638		27,512			827,417	0.681	563,430	AS-VRF Replacement
15			1,020,091	67,607		28,338			1,116,035	0.661	737,830	DOAS + AHU Replacement
16				69,635		29,188			98,823	0.642	63,430	
17				71,724		30,063			101,787	0.623	63,430	
18				73,876		30,965			104,841	0.605	63,430	
19				76,092		31,894	85,122		193,108	0.587	113,430	Repair + Testing + Balance
20			854,834	78,375		32,851			966,060	0.570	550,930	DOAS + Electric Boiler Replacement
											$5,919,934	

Appendix: Life Cycle Cost Analysis

7. Water source heat pump terminal units, DOAS + AHUs with energy recovery wheel + geo loop with electric resistance boiler backup (Heating COP= 3.8; Cooling COP = 6.8)

			Escalated at 3%									
Year	Initial Capital Cost	Incentives / Rebates	Replacement	Fuel / Energy	Other	Maintenance	Repair	Salvage Value	Total Escalated Cost	Present Worth Discount Factor at 3%	Total Present Value	Notes
1	$3,418,700	-$103,000		$36,822		$11,709			$3,364,231	1.000	$3,364,231	2x premium for DOAS+AHUs
2				37,927		12,060			49,987	0.971	48,531	
3				39,064		12,422			51,487	0.943	48,531	
4				40,236		12,795			53,031	0.915	48,531	
5				41,443		13,179	22,510		77,132	0.888	68,531	
6				42,687		13,574			56,261	0.863	48,531	
7				43,967		13,981			57,949	0.837	48,531	
8				45,286		14,401			59,687	0.813	48,531	
9				46,645		14,833			61,478	0.789	48,531	
10			200,315	48,044		15,278	26,095		289,733	0.766	222,056	#REF!
11			335,979	49,486		15,736			401,201	0.744	298,531	HX Replacement
12			394,507	50,970		16,208			461,685	0.722	333,531	WSHP Replacement
13			1,282,044	52,499		16,694			1,351,238	0.701	947,731	DOAS + AHU Replacement
14				54,074		17,195			71,269	0.681	48,531	
15				55,697		17,711			73,408	0.661	48,531	
16				57,367		18,242			75,610	0.642	48,531	
17				59,089		18,790			77,878	0.623	48,531	
18				60,861		19,353			80,214	0.605	48,531	
19				62,687		19,934	85,122		167,742	0.587	98,531	
20			964,428	64,568		20,532			1,049,528	0.570	598,531	DOAS + Electric Boiler Replacement
											$6,514,046	

Appendix: Life Cycle Cost Analysis

8. Water source VRF terminal units, DOAS + AHUs with energy recovery wheel + geo loop with electric resistance boiler backup (Heating COP= 4; Cooling COP = 7.5)

			Escalated at 3%									
Year	Initial Capital Cost	Incentives / Rebates	Replacement	Fuel / Energy	Other	Maintenance	Repair	Salvage Value	Total Escalated Cost	Present Worth Discount Factor at 3%	Total Present Value	Notes
1	$3,652,300	-$103,000		$32,669		$16,393			$3,598,362	1.000	$3,598,362	2x premium for DOAS+AHUs
2				33,649		16,884			50,533	0.971	49,062	
3				34,659		17,391			52,050	0.943	49,062	
4				35,698		17,913			53,611	0.915	49,062	
5				36,769		18,450	22,510		77,729	0.888	69,062	
6				37,872		19,004			56,876	0.863	49,062	
7				39,008		19,574			58,582	0.837	49,062	
8				40,179		20,161			60,340	0.813	49,062	
9				41,384		20,766			62,150	0.789	49,062	
10			200,315	42,626		21,389	65,239		329,568	0.766	252,587	DDC EMS Replacement + Testing + Balance
11			335,979	43,904		22,030			401,914	0.744	299,062	HX Replacement
12			484,482	45,222		22,691			552,395	0.722	399,062	WS-VRF Replacement per the system
13			1,282,044	46,578		23,372			1,351,994	0.701	948,262	DOAS + AHU Replacement
14				47,976		24,073			72,049	0.681	49,062	
15				49,415		24,795			74,210	0.661	49,062	
16				50,897		25,539			76,436	0.642	49,062	
17				52,424		26,305			78,730	0.623	49,062	
18				53,997		27,095			81,091	0.605	49,062	
19				55,617		27,907	85,122		168,646	0.587	99,062	Repair + Testing + Balance
20			964,428	57,285		28,745			1,050,458	0.570	599,062	DOAS + Electric Boiler Replacement
											$6,853,258	

Appendix: Life Cycle Cost Analysis

9. R-20 Wall Insulation

			Escalated at 3%									
Year	Initial Capital Cost	Incentives / Rebates	Replacement	Fuel / Energy	Other	Maintenance	Repair	Salvage Value	Total Escalated Cost	Present Worth Discount Factor at 3%	Total Present Value	Notes
1	$447,120	n/a							$447,120	1.000	$447,120	Wall insulation @ 27,945 sf
2									0	0.971	0	Closed cell spray foam @$2 per sf
3									0	0.943	0	Drywall @ $2 per sf
4									0	0.915	0	Framing @ $12 per sf
5									0	0.888	0	
6									0	0.863	0	Incentives/rebates applicable based on system
7									0	0.837	0	
8									0	0.813	0	
9									0	0.789	0	
10									0	0.766	0	
11									0	0.744	0	
12									0	0.722	0	
13									0	0.701	0	
14									0	0.681	0	
15									0	0.661	0	
16									0	0.642	0	
17									0	0.623	0	
18									0	0.605	0	
19									0	0.587	0	
20									0	0.570	0	
											$447,120	

Solar Feasibility Study

Noyes Cultural Arts Center

3.17.23

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Assumptions

Estimated Costs are based on quotes we've recently received.

	$/kW Installed
Parking	$4,300
Roof	$2,600

Solar Array Layouts follow these guidelines.

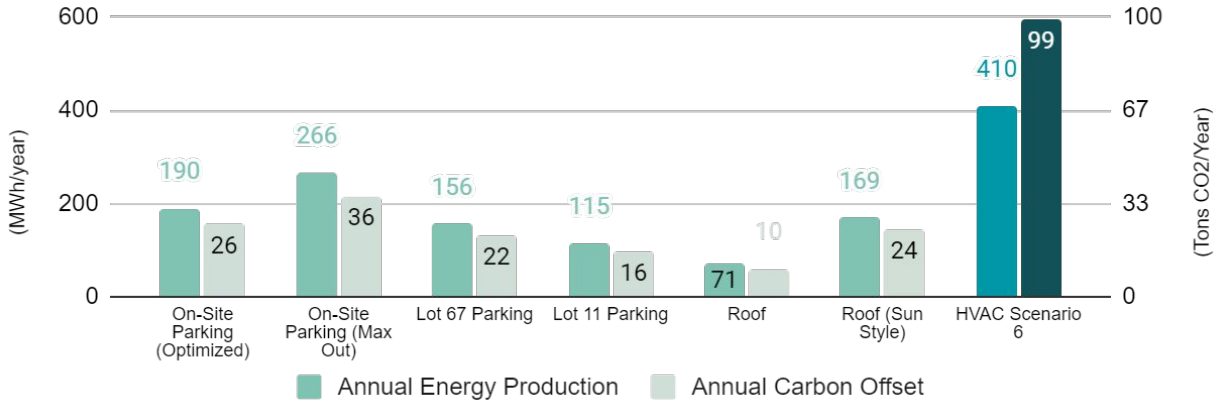
- Parking - 5 tilt South, 6" spacing between rows, 16' above the ground
- Roof - 29 tilt for Roof A, 25 tilt for Roof B, 33 tilt for Roof C
    - 3' setback for typical panels, 0' offset for SunStyle shingles

Estimated Energy Consumption is based on our Preliminary PV study using the water source heat pump with a geothermal loop (HVAC Case 6).

Estimated Energy Consumption (MWh/year)	410

Summary of Array Options

		Size (kW)	Annual Carbon Offset (Metric Tons CO2/year)	Annual Energy Production (MWh/year)	Estimated Cost	Energy Usage Offset
A	On-Site Parking (Optimized)	185	0	190	$796,000	47%
B	On-Site Parking (Max Out)	232	0	266	$998,000	66%
C	Lot 67 Parking	128	0	156	$551,000	39%
D	Lot 11 Parking	95	0	115	$409,000	29%
E	Roof	71	0	71	$184,000	18%
F	Roof (Sun Style)	153	0	169	$398,000	42%



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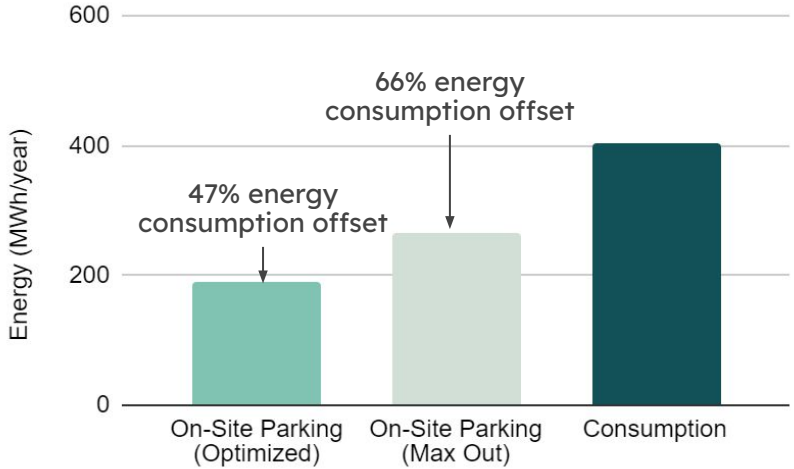
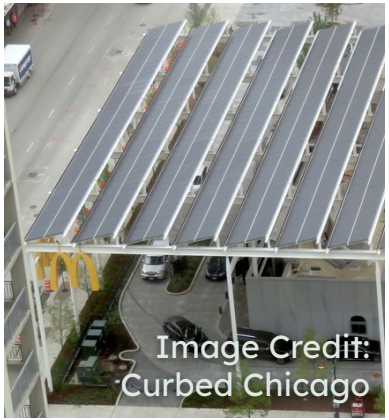
On-Site Parking Array

		Size (kW)	Annual Carbon Offset (Metric Tons CO2/year)	Annual Energy Production (MWh/year)	Estimated Cost	Energy Usage Offset
A	On-Site Parking (Optimized)	185	0	190	$796,000	47%
B	On-Site Parking (Max Out)	232	0	266	$998,000	66%

*Note that the estimated price reflects the cost of the array and not the cost associated with running conduit to the project site.





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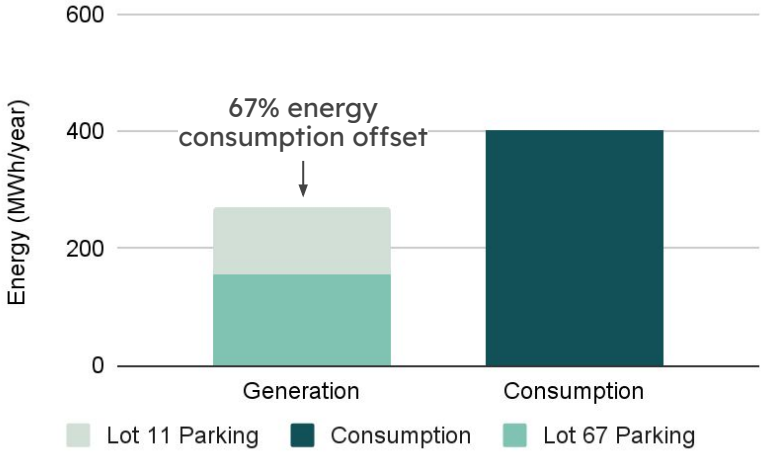
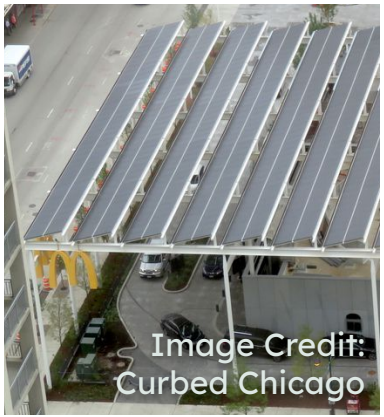
Offsite Parking Arrays

		Size (kW)	Annual Carbon Offset (Metric Tons CO2/year)	Annual Energy Production (MWh/year)	Estimated Cost	Energy Usage Offset
C	Lot 67 Parking	128	0	156	$551,000	39%
D	Lot 11 Parking	95	0	115	$409,000	29%

*Note that the estimated price reflects the cost of the array and not the cost associated with running conduit to the project site.



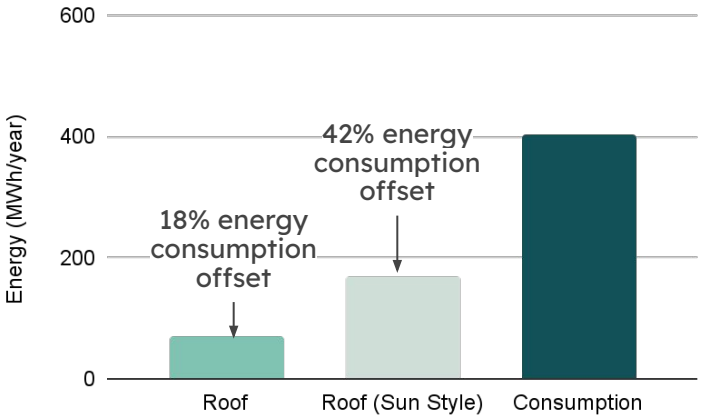


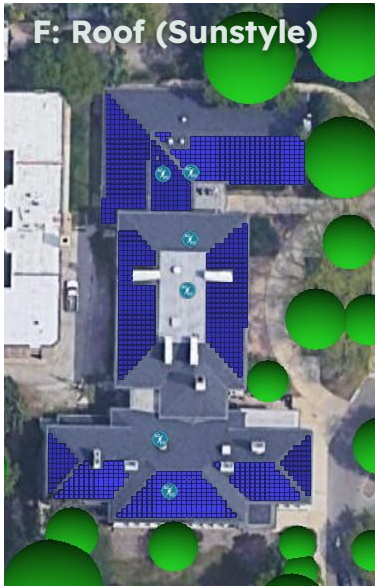
Roof Array Options

		Size (kW)	Annual Carbon Offset (Metric Tons CO2/year)	Annual Energy Production (MWh/year)	Estimated Cost	Energy Usage Offset
E	Roof	71	0	71	$184,000	18%
F	Roof (Sun Style)	153	0	169	$398,000	42%

*Note that the estimated price reflects the cost of the array and not the cost associated with running conduit to the project site.

***This estimate is reflective of the $/installed kW for typical roof systems. The SunStyle system may have a significant (2-3x) premium.

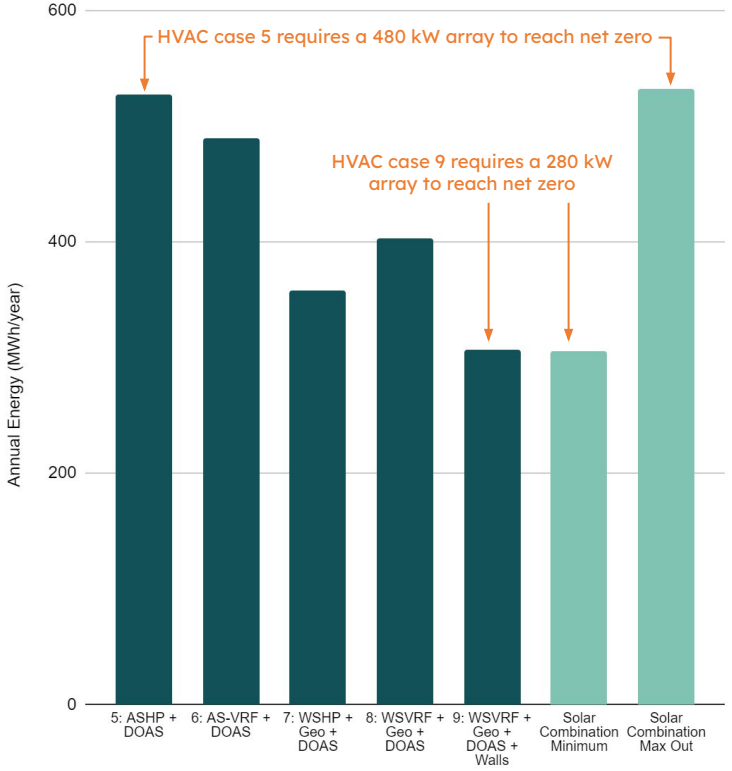




Generation Combinations vs. HVAC Case

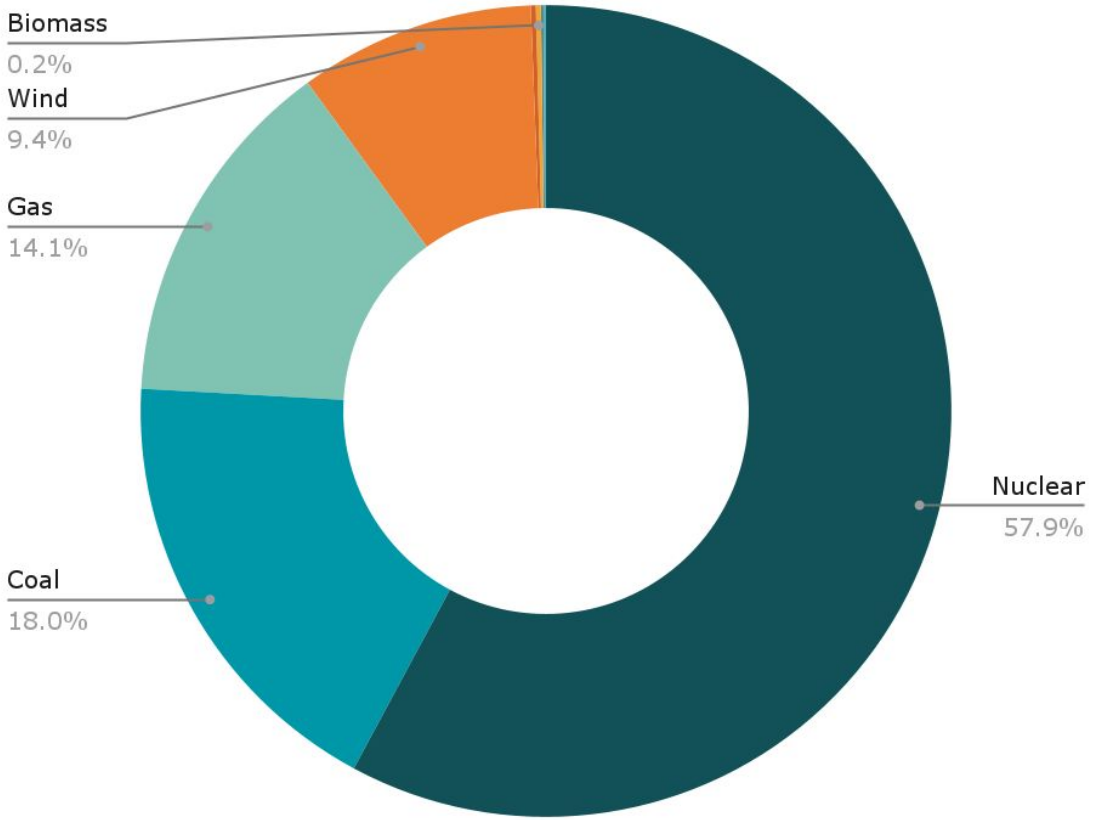
Opting for a higher performing HVAC system has a direct correlation with the downsizing of a solar array. Among the four HVAC cases that were tested out, generation production to meet net zero ranges from 300-530 MWh/year.

		Size (kW)	Annual Carbon Offset (Metric Tons CO2/year)	Annual Energy Production (MWh/year)	Estimated Cost
Solar Combination Minimum					
A	On-Site Parking (Optimized)	185	26	190	$796,000
D	Lot 11 Parking	95	16	115	$409,000
	Total	**280**	**42**	**305**	**$1,205,000**
Solar Combination Max Out					
A	On-Site Parking (Optimized)	185	26	190	$796,000
C	Lot 67 Parking	128	22	156	$551,000
D	Lot 11 Parking	95	16	115	$409,000
E	Roof	71	10	71	$184,000
	Total	**479**	**74**	**532**	**$1,940,000**



Grid Emissions

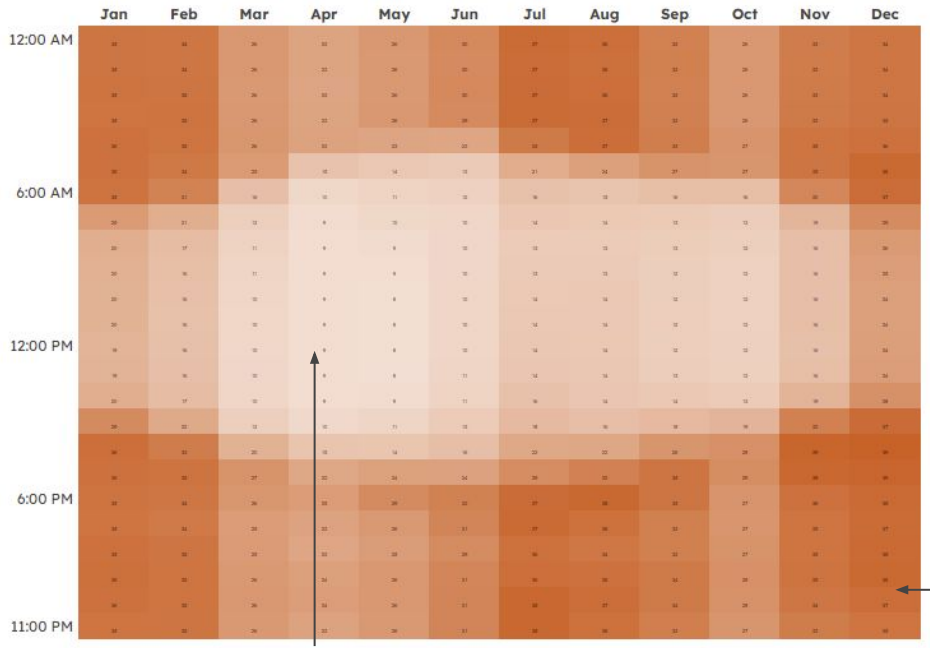
The Illinois grid mix is primarily made up of nuclear, coal, gas, and wind.



Carbon Emissions vs. HVAC Case 6

Illinois's utility grid is more dependent on non-renewables both in winter and at night. Modeled energy usage decreases slightly in the summer due to more available daylight and reduced buildings loads compared to winter.

Utility Grid Carbon Emissions Factor



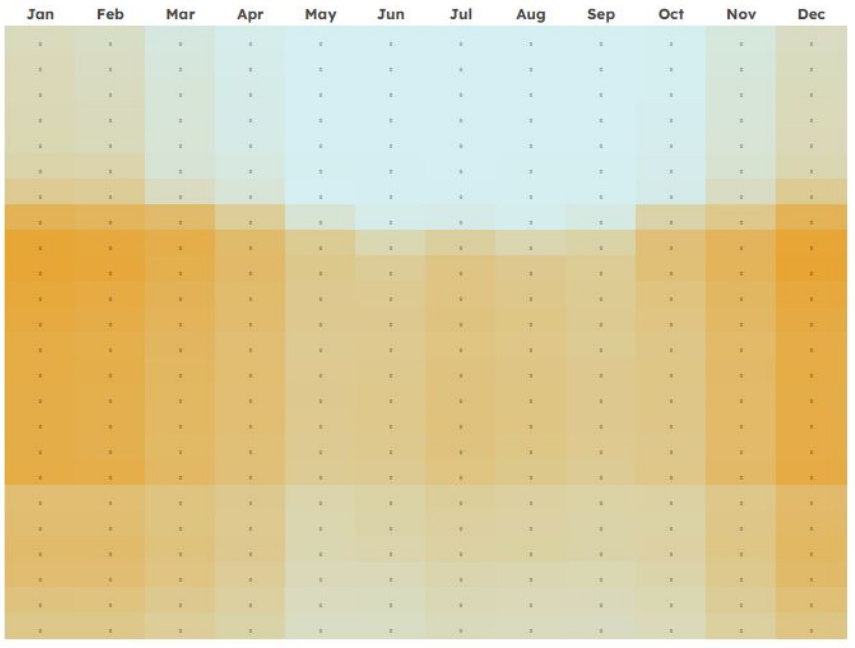
Summer peak production is produced with renewable energy.

Carbon Emissions (kg/hr)

-20 0 40

Net Positive!

Modeled Energy Usage



Winter evening emissions are high because coal is the main source of energy.

Energy Usage (kWh)

0 55 110

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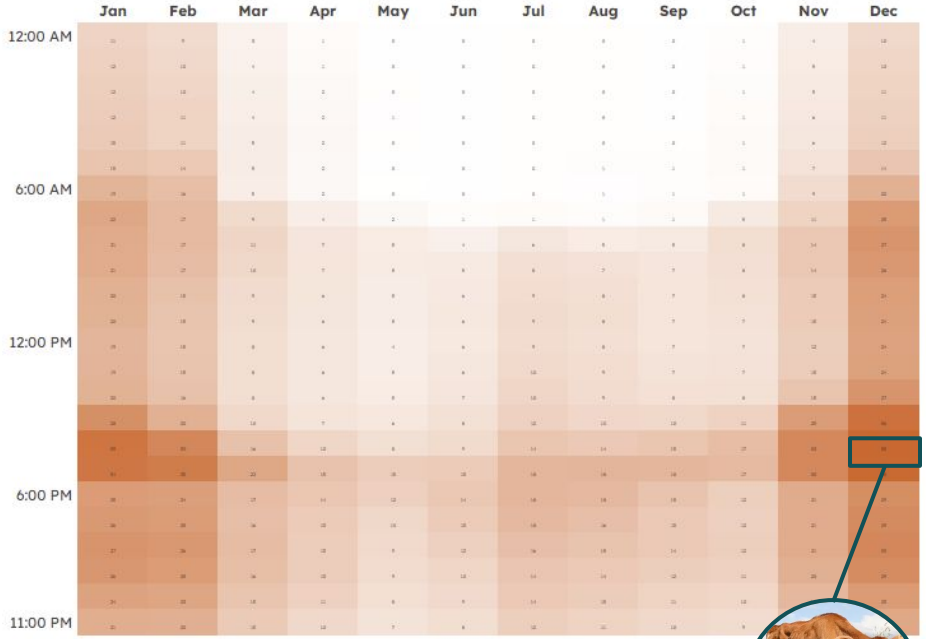
Carbon Emissions vs. HVAC Case 6

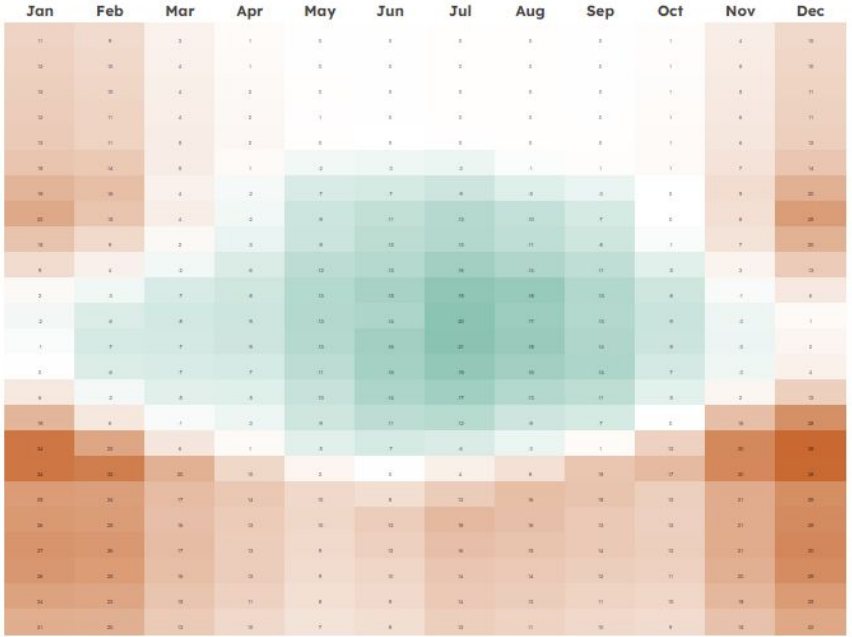
On-site PV production from a net zero array size (~390 kW) will reduce carbon emissions from the grid by 60% annually. This offset rate can be scaled based on array size.

Modeled Carbon Emissions



Peak carbon emissions are equivalent to the weight of a baby calf.

Modeled Emissions + Solar Offset



Carbon Emissions (kg/hr)

-20 0 40

Net Positive!

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