Let Communities Choose: Clean Energy Sovereignty in Highland Park, Michigan

www.ucsusa.org/resources/let-communities-choose-clean-energy

Technical Appendix: Methodology and Assumptions

This document describes the methodology and assumptions that the Union of Concerned Scientists (UCS) and Soulardarity used for developing *Let Communities Choose: Clean Energy Sovereignty in Highland Park, Michigan*.

METHODOLOGY

UCS used the Hybrid Optimization of Multiple Energy Resources (HOMER) Grid Version 1.8.6 (Pro Edition) to analyze rooftop solar and battery storage configurations for several building types in Highland Park. HOMER Grid is a model for energy system optimization and financial analysis; it is designed to analyze distributed generation and microgrids at the customer and local levels.

Originally developed by the US National Renewable Energy Laboratory (NREL), the HOMER model is now distributed by HOMER Energy LLC as a proprietary computer software package. HOMER Grid models a power system's physical operations and its life-cycle cost, which is the total cost of installing and operating the system over its lifespan. HOMER enables users to compare many different system options based on their technical and economic benefits. The model has two optimization algorithms. The original grid-search algorithm simulates all the feasible system configurations to search for the least-cost systems and displays a list of configurations sorted by net present cost; a second algorithm then simulates hourly operation of each technology configuration (Lambert, Gilman, and Lilienthal 2006; HOMER Energy LLC 2020).

We conducted off-model calculations to identify potential rooftop solar penetration according to building characteristics in Highland Park. In addition, we estimated adjusted payback periods given various monetary incentives and programs. In general, the payback period indicates how many years it takes to recover an investment. We calculated the adjusted payback periods for each investment option based on the size of each system, its investment cost, the annual solar power generation, the annual bill savings out of each system, and the various incentives.

ASSUMPTIONS UNDERLYING THE HOMER ANALYSIS

Financial

Our financial analysis assumed that the investments would be made in 2023 and that projects would have a 25-year lifetime. HOMER calculated the net present cost of each component in the system and of the system as a whole at a 7 percent nominal discount rate. Then the model minimized the net present cost to find the optimal system sizes.

To evaluate the economics of each selected system from the customer perspective, we calculated the simple payback period by comparing the nominal cash flow of the current system (i.e., purchasing 100 percent of power only from the grid) with that of the recommended solar photovoltaic (PV) system.

Building Stock and Electricity Demand by Building Type

Of the 6,978 housing units in Highland Park, 51.9 percent are single-family detached homes (US Census Bureau 2019). Therefore, we assumed that Highland Park has about 3,622 single-family homes. However, only 65.7 percent of the city's housing units are occupied. Accordingly, we assumed that there are 2,380 occupied single-family homes.

Google's Project Sunroof estimates that 82 percent of Highland Park buildings are solar-viable (Google Project Sunroof 2018). We reduced this figure to 60 percent to be both conservative and realistic about the structural conditions of Highland Park's housing stock. Therefore, our starting assumption was that 1,428 occupied single-family homes are solar-viable.

We then selected other generic building types to model within HOMER, drawing from a list of available load profiles. We used the US Department of Energy's (DOE) Open Energy Information (OpenEI) database to identify the hourly load profile of each building type selected in this analysis. OpenEI data provide commercial and residential hourly load profiles simulated for all typical meteorological year 3 (TMY3) locations in the United States. It contains hourly load profile data for 16 types of commercial and residential buildings based on the DOE commercial reference building models and the Building America House Simulation Protocols (Wilson 2014).

We adjusted the scale of the load to create an assumed hourly load profile for a typical single-family home in Highland Park using monthly power consumption data from an actual household in the city. For other building types, we used generic load profiles provided by HOMER's database for Detroit City, MI. The types were midrise apartment building, medium office, standalone retail, full-service restaurant, quick-service restaurant, supermarket, warehouse, and primary school. We developed assumptions for how many buildings of each type exist in Highland Park; these are rough approximations and do not constitute a full building inventory of the community.

Policy Assumptions

- The **federal solar Investment Tax Credit (ITC)** is currently a 26 percent credit against the federal tax liability of residential and commercial investors in solar energy property. It is scheduled to ramp down to 22 percent in 2023. After 2023, the residential credit drops to zero while the commercial credit drops to a permanent 10 percent. This analysis assumed that the investments would be made in 2023, so we applied an ITC of 22 percent in our reference and policy scenarios.

- For our reference scenario, we applied **DTE Energy's Rider 18**; this is the local utility's program for distributed generation. For our policy scenario, we replaced Rider 18 with **full retail-rate net metering** for single-family homes and midrise apartment buildings and assumed that the full retail rate is applied to overgeneration exported to the grid. We added a **Michigan Residential Energy Credit** of $1,000 and an **additional solar revenue stream** with solar renewable energy credits (SRECs) as a proxy based on the Illinois Adjustable Block Program's most recent pricing for Group B (ComEd, etc.) Blocks 3–4 (Table A-1).

Table A-1. Illinois Adjustable Block Program's SREC Pricing for Group B

System Size	$/REC	Payable
10 kW or less	$67.25	15 years' worth at time of energizing
>10kW–25 kW	$64.79	15 years' worth (20% of that at time of energizing; rest paid ratably over subsequent 4-year period
>25kW–100 kW	$58.05	Same as >10 kW–25 kW
>100kW–200 kW	$47.56	Same as >10 kW–25 kW
>200kW–500 kW	$42.53	Same as >10 kW–25 kW
>500kW–2,000 kW	$39.49	Same as >10 kW–25 kW

SOURCE: ILLINOIS POWER AGENCY 2020.

Technology Cost and Performance

Tables A-2 and A-3 show cost and performance assumptions for electricity-generating and storage technologies used for the HOMER modeling.

- **Solar PV.** The cost assumptions are based on NREL's mid-case scenario of the 2020 Annual Technology Baseline (NREL n.d.).

Table A-2. Residential Solar PV Cost in 2023

Residential Solar PV	
Overnight capital cost (2021$)	2,505/kW
O&M cost (2021$)	18/kW-yr

Table A-3. Commercial Solar PV Cost in 2023

Commercial Solar PV	
Overnight Capital Cost (2021$)	1,753/kW
O&M cost (2021$)	13/kW-yr

- **Storage.** We used the technology cost and performance assumptions of two commercially available battery storages in the location.

Table A-4. Storage Cost and Performance in 2023

Behind-the-Meter Storage		
Technology Specification	Tesla Powerwall	LG Chem RESU
Usable Energy Capacity	13.5 kWh	9.3 kWh
CAPEX (2021$)	$12,600	$11,250
Lifetime	10 years	10 years
Lifetime Throughput	67,500 kWh	58,000 kWh

Electricity Rate Tariffs

To determine the total annual utility bill payment under the current electric rate structure without PV system installation, we applied DTE's D1 rate for residential buildings, D4 for commercial buildings, and D6.2 for primary schools. We assumed that the voltage of the primary schools is less than 24 kV, which is in the Primary Service category.

Table A-5. Residential Electric Service Rate (D1)

Power Supply Charges	
Capacity Charges	
First 17 kW	$0.04500 per kWh
Excess	$0.06484 per kWh
Non-capacity Charge	$0.04176 per kWh
PSCR	$0.00166 per kWh
Delivery Charges	
Service Charge	$7.5 per month
Distribution Charge	$0.06611 per kWh
Nuclear Surcharge	$0.000842 per kWh
EWR	$0.005118 per kWh
LIEAF factor	$0.92 per month

Table A-6. Large General Service Rate (D4)

Power Supply Charges	
Capacity Demand Charge	$14.07 per kW applied to the monthly billing demand
Non-Capacity Demand Charge	$2.92 per kW applied to the monthly billing demand
First 200 kWh per kW of Billing Demand	$0.04171 per kWh
Additional kWh	$0.3219 per kWh
Delivery Charges	
Service Charge	$13.67 per month
Distribution Charge	$17.10 per KW applied to the monthly billing demand

Table A-7. Primary Educational Institution Rate (D6.2)

On-peak hours: All kWh used between 11 a.m. and 7 p.m. Monday through Friday, excluding holidays	
Power Supply Charges:	
Demand Charge	$14.81 per kW of on-peak billing demand
Voltage Level Demand Discount	$0.90 per kW
Transmission Level	$0.60 per kW
Subtransmission Level	
Energy Charge On-Peak	$0.04307 per kWh
Energy Charge Off-Peak	$0.04007 per kWh
Voltage Level Discount	
Transmission Level	$0.00223 per kWh
Subtransmission Level	$0.00131 per kWh
Delivery Charge	
Primary Service Charge	$70 per month
Subtransmission and Transmission Service Charge	$375 per month
Distribution Charge	
Primary Service (less than 24 kV)	$4.21 per kW of maximum demand
Subtransmission Voltage (24 to 41.6 kV)	$1.65 per kW of maximum demand
Transmission Voltage (120 kV and above)	$0.70 per kW of maximum demand

ADDITIONAL ASSUMPTIONS UNDERLYING THE 100 PERCENT ANALYSIS

Maximum Rooftop PV Size

We used Google Project Sunroof for information on the maximum rooftop square footage available for the sample single-family home used in our analysis and for the midrise apartment category. For other building types, we used the maximum system capacity figures from Table 3 Characteristics of DOE Commercial Reference Buildings in the NREL report *Nationwide Analysis of U.S. Commercial Building Solar Photovoltaic (PV) Breakeven Conditions* (Davidson et al. 2015).

Table A-8. Maximum System Capacity by Building Type

Building Type	Maximum System Capacity
Medium Office	84 kW
Stand-Alone Retail	118 kW
Full-Service Restaurant	26 kW
Quick-Service Restaurant	12 kW
Supermarket	276 kW
Warehouse	376 kW (188 kW x 2)
Primary School	454

Table A-9. Peak Load, Annual Consumption, and Rooftop Maximum Capacity, by Building Type

Building Type	Peak Load	Annual Consumption	Rooftop Maximum Capacity
Single-Family Home	4.3 kW	5,876 kWh	15 kW
Midrise Apartment	66 kW	230,892 kWh	51 kW
Medium Office	327 kW	755,477 kWh	84 kW
Stand-Alone Retail	110 kW	317,152 kWh	118 kW
Full-Service Restaurant	70.1 kW	314,064 kWh	26 kW
Quick-Service Restaurant	39.1 kW	190,107 kWh	12 kW
Supermarket	383 kW	1,644,982 kWh	276 kW
Warehouse	98 kW	268,775 kWh	376 kW
Primary School	352.3 kW	849,903 kWh	454 kW

Community Solar

Using a Google Maps Area Calculator Tool provided by Daft Logic, we identified four potential parcels for larger-scale community solar installations (Figures 1–4). We assumed that one megawatt of solar requires roughly five acres of land. DTE Energy's O'Shea Park Solar Farm in Detroit consists of fixed-tilt panels, is two megawatts in capacity, occupies roughly 10 acres, and had net generation of 2,842 MWhs in 2019 (S&P Global Market Intelligence). We assumed that fixed-tilt community solar facilities in Highland Park would perform similarly.

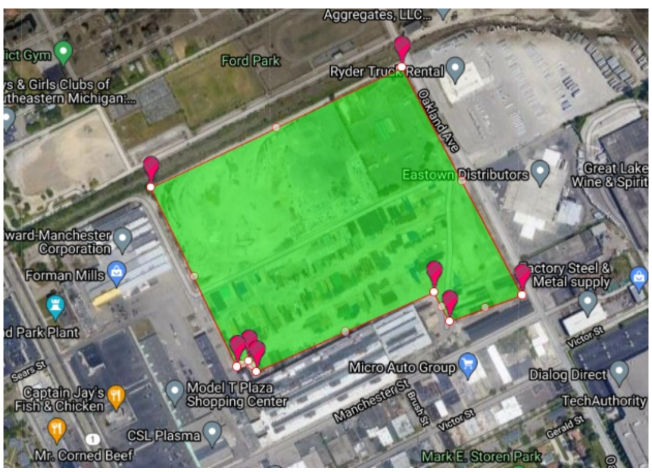

Figure 1. Former Ford Highland Park Plant

Figure 2. Former Ecoworks Site

Figure 3. Land Between Johnson Controls and Coca-Cola

Figure 4. Land North of Nandi's Knowledge Cafe

Solar Carports, Canopies, and Trees

We based assumptions for solar carports on a 11 kW installation in Ann Arbor, Michigan, that occupies four parking spaces and has a production output expectation of 13,400 kWhs per year (Stanton 2019). For solar canopies, we assumed that a canopy such as those installed by Suncommon in Vermont and New York State has a capacity of eight kW (Testa 2021) and would produce at an annual capacity factor of 13 percent. For solar trees, we based our assumptions on Alliant Energy's solar tree project in Madison, Wisconsin, that has an average size of 2.87 kW per tree (Spotlight Solar n.d.). We further assumed the trees would produce at an annual 13 percent capacity factor.

Table A-10. Distributed Solar Installations

Type	Capacity	Number of Installations	Annual Output
Solar Carport (covers 4 parking spaces)	11 kW	50	670 MWh
Solar Canopy	8 kW	50	456 MWh
Solar Tree	2.87 kW	100	327 MWh
Various Other Ground-Mounted Solar	3,250 kW	N/A	3,701 MWh

Table A-11. Results of Policy Scenario: How Policy Components Affect the Payback Period

Building Type	Assumed Number of Structures	PV Capacity (KW) per Structure	Annual Production per Structure	Initial Investment per Structure with All Monetary Incentives Included	Effective Policy Components	Adjusted Payback Period
Single-Family Home	1,904	8.3 kW	10,908 kWh	$4,213	Eliminating size restriction; Netmeter; Residential Energy Credit; SRECs	3 years
Midrise Apartment	5	49.5 kW	62,862 kWh	$56,662	Netmeter; SRECs	3 years
Medium Office	5	86.3 kW	109,462 kWh	$98,859	SRECs	4 years
Standalone Retail	10	86.9 kW	110,468 kWh	$99,573	SRECs	4 years
Full-Service Restaurant	10	17.9 kW	22,755 kWh	$20,050	SRECs	4 years
Quick-Service Restaurant	10	10.9 kW	13,856 kWh	$12,210	SRECs	4 years
Supermarket	2	225.4 kW	286,468 kWh	$271,552	Eliminating size restriction; SRECs	8 years
Warehouse	3	245.7 kW	312,295 kWh	$296,033	Eliminating size restriction; SRECs	10 years
Primary School	1	388.2 kW	493,443 kWh	$467,749	Eliminating size restriction; SRECs	9 years

Table A-12. Full Dashboard of 100 Percent Results

Resource	Solar kWh/yr	Assumed # Structures	Total kWh/yr	Percent Total Demand	Category Contribution
Energy Efficiency					
Adjusted Achievable Potential (by 2035)			21,550,000	25%	25%
Rooftop Solar					
Single-Family Home	10,908	1,904	20,768,832	24.09%	
Standalone Retail	110,468	10	1,104,680	1.28%	
Supermarket	286,468	2	572,936	0.66%	
Full-Service Restaurant	22,755	10	227,550	0.26%	
Quick-Service Restaurant	13,856	10	138,560	0.16%	
Midrise Apartment	62,862	5	314,310	0.36%	
Warehouse	312,295	3	936,885	1.09%	
Medium Office	109,462	5	547,310	0.63%	
Primary School	493,443	1	493,443	0.57%	29.12%
Other Distributed Solar					
Solar Carport (11 KW, 4 spaces)	13,400	50	670,000	0.78%	
Solar Canopy (8 KW)	9,116	50	455,800	0.53%	
Solar Tree (2.87 KW)	3,270	100	327,000	0.38%	
Various Ground-Mounted (3,250 KW)			3,701,100	4.29%	5.98%
Community Solar Facilities					
Former Ford Highland Park Plant (50 Acres/10 MW)	14,210,000	1	14,210,000	16.48%	
Former Ecoworks Site (20 Acres/4 MW)	5,684,000	1	5,684,000	6.59%	
Land Between Johnson Controls and Coca-Cola (20 Acres/4 MW)	5,684,000	1	5,684,000	6.59%	
Land North of Nandi's Knowledge Café (10 Acres/2 MW)	2,842,000	1	2,842,000	3.30%	32.97%
Community Water Energy Resource (CWERC)					
CWERC	5,300,000	1	5,300,000	6.15%	6.15%
TOTAL					
			85,528,406	99.22%	99.22%

Assumption used for total average annual energy demand in Highland Park for residential and commercial sectors: 86,200,000 kWh/yr.

REFERENCES

Davidson, Carolyn, Pieter Gagnon, Paul Denholm, and Robert Margolis. 2015. *Nationwide Analysis of U.S. Commercial Building Solar Photovoltaic (PV) Breakeven Conditions.* Golden, CO: National Renewable Energy Laboratory. https://www.nrel.gov/docs/fy16osti/64793.pdf

Google Project Sunroof. 2018. "Estimated Rooftop Solar Potential of Highland Park, MI." Accessed July 14, 2021. https://sunroof.withgoogle.com/data-explorer/place/ChIJyQUcWerNJIgR913c7LWM_zs/#?overlay=flux

HOMER Energy LLC. 2017. "HOMER Grid 1.8 User Manual." https://www.homerenergy.com/products/grid/docs/latest/index.html

Illinois Power Agency. 2020. *Long-Term Renewable Resources Procurement Plan.* Chicago, IL: Illinois Power Agency. https://illinoisshines.com/wp-content/uploads/2020/04/Revised-LTRRPP-updated-from-ICC-Order-20-April-2020-1.pdf

Lambert, Tony, Paul Gilman, and Peter Lilienthal. 2006. "Micropower System Modeling with HOMER." In *Integration of Alternative Sources of Energy*, by Felix A. Farret and M. Godõy Simoes. New York, NY: John Wiley & Sons, Inc. https://www.homerenergy.com/documents/MicropowerSystemModelingWithHOMER.pdf

NREL (National Renewable Energy Laboratory). n.d. "2020 ATB Data." Accessed July 14, 2021. https://atb-archive.nrel.gov/electricity/2020/data.php

S&P Global Market Intelligence. 2021. "S&P Capital IQ Pro." New York, NY. Accessed July 14, 2021 (subscription required). https://www.spglobal.com/marketintelligence/en/

Spotlight Solar. n.d. "Project Overview (Alliance Energy)." Accessed July 14, 2021. https://spotlightsolar.com/alliant-content

Stanton, Ryan. 2019. "$40K Solar Carport to Be Installed in Downtown Ann Arbor by Earth Day." *MLive*, January 30, 2019. https://www.mlive.com/news/ann-arbor/2018/01/40k_solar_carport_to_be_instal.html

Testa, Diana. 2021. "Suncommon's Solar Canopy: A Carport that Does More." *Upstate House,* Summer 2021. https://upstatehouse.com/suncommons-solar-canopy-a-carport-that-does-more

US Census Bureau. 2019. *American Community Survey 5-Year Estimates.* Retrieved from *Census Reporter Profile page for Highland Park, MI.* http://censusreporter.org/profiles/16000US2638180-highland-park-mi

Wilson, Eric. 2014. "Commercial and Residential Hourly Load Profiles for All TMY3 Locations in the United States on OpenEI Database." Open Energy Date Initiative. https://data.openei.org/submissions/153