[Union of Concerned Scientists

CASE STUDY

Designing a Neighborhood Microgrid

Envisioning a Microgrid for the Parker Village Neighborhood in Highland Park, Michigan

Communities across the country are increasingly interested in greater local control over their energy needs. In the fall of 2021, the Union of Concerned Scientists (UCS) and Soulardarity teamed up to release a report, *Let Communities Choose: Clean Energy Sovereignty in Highland Park, Michigan*, showing how solar power, energy efficiency, and other local resources can meet 100 percent of Highland Park's electricity demand (Gignac et al. 2021).

Parker Village, a neighborhood within Highland Park, envisions creating a smart neighborhood development[1] powered by a solar-plus-storage microgrid. As a follow-up to *Let Communities Choose*, UCS partnered with Parker Village developers to explore options for designing such a microgrid and to consider what factors are involved in that effort.

Figure 1. Parker Village Comprehensive Plan

SOURCE: Paul Bierman-Lytle, Sustainable Environment Associates Corporation (SEAS).

Neighborhood microgrids can connect with one another to form a network of clean energy resources having greater resilience and flexibility and assisting communities desiring energy sovereignty and greater local control of their energy needs. Using an energy system model and an estimate of local electricity use, we present this case study as an example for other neighborhoods and communities to consider when exploring their own microgrid options.

Parker Village: A Smart Neighborhood Development

Parker Village is a neighborhood located within Highland Park, a southeastern Michigan city of about 10,000 people. The Parker Village development envisions occupying about eight acres and accommodating more than 100 potential residents. The project includes redeveloping a former elementary school into a community center featuring commercial and office space, renovating some existing residential structures, and building several new homes and other features. The plan also includes the installation of rooftop solar throughout the neighborhood, a centralized battery storage system, several electric vehicle charging stations, an aquaponics garden, and hoop greenhouses. A solar-powered café has already been established on the site.

Microgrids: Power Systems in Miniature

In many communities, power is delivered through a local distribution system connected to the broader electric grid that spans across large regions, all linked with power lines of various sizes. While this system yields many benefits, it also means that the power can go out at people's homes and businesses from distant problems—and stay out until the electric utility can resolve the issues. This centralized system can also make it difficult for some communities to choose how their power is generated, instead holding residents subject to the choices made by utilities and regulators. Enter microgrids.

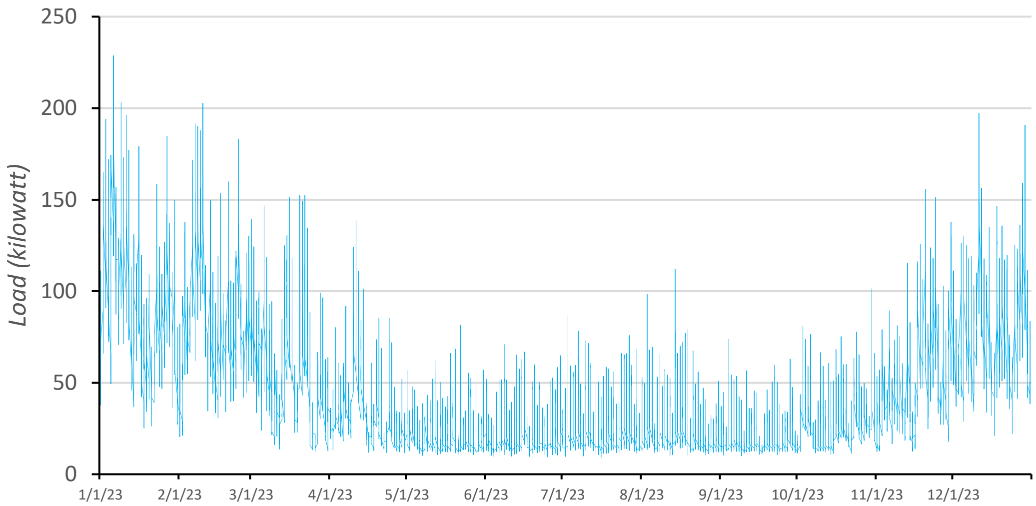
Microgrids are local energy grids either *islanded*—entirely separated—or *islandable*—capable of operating independently—from the larger grid (McNamara 2018). Microgrids can serve single facilities or power larger areas, such as campuses, neighborhoods, and small towns (Department of Energy 2014). Depending on how they are powered, microgrids have the potential to be much cleaner than the current centralized power supply. Also, they can increase resilience by continuing to supply power locally when the larger grid fails.

Exploring the Potential for a Parker Village Microgrid

We used the HOMER Grid model[2] to analyze microgrid possibilities for Parker Village. As a first step, we developed an estimate of the electricity needs the microgrid will serve based on the electric load profiles of residences and other buildings. Because the Parker Village development is not yet built, we used the comprehensive plan (Figure 1) and generic end-use load profiles from the National Renewable Energy Laboratory (NREL) for initial load profile assumptions (NREL 2021).

Specifically, we assumed that all the buildings in the neighborhood would be fully electrified and use electric heat pumps for their heating and cooling. We then selected appropriate building load profiles from the NREL database and assembled a composite annual hourly load profile for the entire neighborhood (Figure 2).

Figure 2. Composite Hourly Load Profile for Parker Village



Electric heating tends to produce winter peak demand for Parker Village. Improved efficiency designs for the neighborhood's buildings can help reduce the overall electricity demand, lower the system costs, and increase the comfort of homes and other structures. Additionally, education and incentive programs for residents can enlist their assistance with lowering peak period needs. SOURCE: UCS estimation based on data from NREL and the Parker Village comprehensive plan.

End-use load profiles are the most important input for modeling the proper amount of distributed energy resources needed to serve a microgrid. As Parker Village develops design and construction plans to make its buildings energy efficient, the initial electricity demand assumptions shown in Figure 2 can and should be adjusted.

In the next step of our microgrid analysis, we further refined the model's characteristics based on responses to several key design questions:

Microgrid Design Questions	Initial Selections for Parker Village Modeling
Will the microgrid be connected to the larger power grid? As discussed previously, microgrids can either be grid-separated (islanded) or grid-connected systems. For islanded microgrids, the system must entirely supply its own power and cannot rely on the larger grid to share electricity.	Parker Village was most interested in exploring a grid-separated microgrid to maximize community independence from the larger system.
What resources will power the microgrid? Any type of power-generating resource can serve a microgrid, considering factors such as the project preferences or goals and available land space.	Focused on clean, non-emitting resources, Parker Village envisioned a microgrid powered primarily by solar photovoltaic (PV) panels and energy storage batteries.

What backup resources can be available? Depending on the design and purpose, a grid-connected microgrid can rely on the larger power grid as its primary supply, using its own resources as backup in case of outages. The reverse occurs in which the microgrid's own resources are the primary power and the larger system is used when those resources are insufficient. However, if the microgrid is islanded, the host entity often needs to include a secondary power source as backup to help minimize outages.	Because Parker Village preferred to analyze an islanded microgrid, we allowed the model to select fossil fuel backup generation when needed; however, for comparison purposes, we also included a grid connection backup option.
What level of outages are tolerable for the microgrid's customers? While the occurrence of no outages is ideal, the willingness to tolerate some level of power interruption can help reduce the amount of resources needed to maintain the microgrid.	We modeled restricted amounts of outage tolerance.[3]

Using these initial selections, HOMER provided several feasible system configurations.[4] Table 1 shows six possible options based on the criteria described.

Table 1. Sample Feasible Configurations for Parker Village Microgrid

Solar PV (MW)	Energy Storage (Tesla Powerpack)[5]		Backup Generator			Initial Investment Cost (2021 million $)	Net Present Cost (2021 million $)
	Units	Total storage capacity	Capacity	Operating hours	Capacity factor		
Fuel type: Natural gas							
1.1	20	4.2 MWh	150 kW	216/year	2.4%	$4.57	$7.99
1.1	30	6.3 MWh	300 kW	72/year	0.8%	$6.30	$11.20
Fuel type: Diesel							
1.1	20	4.2 MWh	100 kW	312/year	3.5%	$4.35	$7.87
1.1	30	6.3 MWh	300 kW	72/year	0.8%	$5.94	$11.00
Grid connection backup							
1.1	10	2.1 MWh	3.4% of annual power supply			$2.85	$4.80
1.1	20	4.2 MWh	1.9% of annual power supply			$4.28	$7.76

Our analysis shows that a grid-separated microgrid powered primarily by solar and energy storage is possible for Parker Village. Yet, there are trade-offs. For example, in four of the configurations, Parker Village achieves its preference to be separate from the larger electric grid and to keep power outages limited. These configurations, however, require a relatively large amount of solar and battery capacity for the space available in the neighborhood. They also include fossil fuel backup generation to run during winter peak periods when solar and battery storage cannot meet the power demand of the neighborhood.

Additional trade-offs exist with the various types of backup resources. Generating units cause noise and air pollution and require maintenance to ensure they are available when needed. While natural gas is not as polluting as diesel, it requires a connection to the gas distribution system unless another local source of fuel—such as carbon-neutral biogas from a community water and energy resource center (CWERC)—is available.[6] Further, adding more battery capacity or a larger gas or diesel generator significantly lessens the backup units' operating hours per year but increases the costs (see Table 1). Finally, instead of a backup generator, a slightly less costly grid connection requires Parker Village to be dependent on the utility and larger power grid for about 2 percent of its annual power demand, while installing fewer batteries increases the grid reliance but significantly reduces costs.

As Parker Village proceeds with its development planning, it can refine its choices and continue to examine the microgrid options available. For example, building more efficient homes and other structures than we assumed in our initial load profiles would allow for the neighborhood's needs to be served with smaller amounts of solar and batteries and less, or possibly no, fossil fuel generation or grid backup. Additionally, while not modeled in this analysis, natural gas fuel cells are increasingly being used in microgrid applications and could be explored as an alternative backup power source. Fuel cells have lower direct emissions and could in the future be fully carbon free, fueled by hydrogen produced by renewable electricity. Further, there may be the possibility of locating some solar and battery resources nearby—but not within—the planned development, which could allow Parker Village its preference of being grid-separated while keeping outages to a minimum.

In conclusion, this case study illustrates that microgrids offer the possibility for neighborhoods and communities to choose what matters most to them and select their own path that best maximizes their preferred combination of clean energy, resiliency, affordability, and local control.

Microgrids as Part of Local Clean Energy Transitions

In *Let Communities Choose*, UCS and Soulardarity explored what an overall clean energy future could look like for the city of Highland Park. Microgrids in Parker Village and other Highland Park neighborhoods can serve this vision by powering their own areas with clean energy or choosing to interconnect with one another and to the larger electric grid as desired.

Utilities and state and federal policymakers should continue encouraging the development of microgrids in places such as Parker Village and throughout the country through grant programs, technical resources, and policies that promote solar and battery deployment to ensure that projects can be powered by clean resources. Together, we can make microgrids a key part of a new model of supplying and consuming electricity—one that empowers communities and neighborhoods to choose clean energy, generate electricity locally, and increase resiliency.

Youngsun Baek is an energy modeler and **James Gignac** is the senior Midwest energy analyst at the Union of Concerned Scientists. **Juan Shannon** is the founder of Parker Village.

ACKNOWLEDGMENTS

This case study was made possible by the generous support of the Bezos Earth Fund, the John D. and Catherine T. MacArthur Foundation, the Heising-Simons Foundation, the Joyce Foundation, and UCS members. The authors especially thank Soulardarity staff and members, including Shimekia Nichols, Jackson Koeppel, and Gracie Wooten, for their thoughtful contributions and leadership toward exploring energy sovereignty in Highland Park and Parker Village. The authors also thank Julie McNamara, Edyta Sitko, and Jeff Deyette for their insightful review of the report and Victoria Coleman for production assistance.

ENDNOTES

1. Parker Village's "smart neighborhood" development plans for an integrated systems approach in areas including renewable energy, water usage, waste reduction, and food production.
2. For more information on the HOMER Grid model, see our technical appendix available at https://www.ucsusa.org/resources/let-communities-choose-clean-energy.
3. For our reliability assumption, we specified in the model that (1) the total capacity shortage in the system cannot be more than 1 percent of the total annual electric load of the community and (2) the system is allowed to have a capacity shortage of up to 20 hours per year.
4. A larger list of feasible system configurations provided by HOMER is available in Table 7 of the technical appendix.
5. For purposes of this analysis, we modeled Tesla's Powerpack product. The company also offers a Megapack product, designed for utilities and large-scale commercial customers, that has an energy capacity of 3 MWh (Marsh 2021). Two Megapacks provide roughly the same storage capacity as 30 Powerpacks, require less space, and potentially provide cost savings.
6. More information about CWERCs is available in the report *Let Communities Choose* (Gignac et al. 2021).

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