Energy Independent Cooperative Housing with DC Microgrids

Living Energy Farm is a sustainable technology development organization based in Louisa, Virginia. Our team has built three affordable housing projects in central Virginia that incorporate green building, active (pumped) solar thermal, and direct drive DC electrical systems. We have also installed direct drive DC electrical systems in several more homes in Virginia and Puerto Rico in cooperation with El Departamento de la Comida and Serenity Solidarity. Technical and financial details about our projects are provided at the end of this document.

We call our energy system design a DC Microgrid. **We are looking for partners to build and retrofit more energy independent (off grid) cooperative housing projects.** DC Microgrids have proven performance and affordability and can be a powerful tool for sustainable energy resilience in low-income communities.

What is a Direct Drive DC Microgrid?

A direct drive DC Microgrid is a multifaceted renewable energy system design that is suitable for many housing arrangements wishing to transition from fossil fuels, including housing coops, apartments, row houses and condominiums. DC Microgrids use the following strategies to harvest and store on site all the energy that is required for domestic use.

-**Robust solar thermal systems for space and water heating**. For thermal loads, direct solar thermal collection is three times more space efficient per square foot than PV, and significantly more durable. Cooperative use of solar thermal systems by several families adds to their affordability and performance.
-**Non-electric energy storage to minimize demand on batteries and maximize energy storage capacity.** Storage mediums include thermal mass and pressurized water. These energy storage methods are much cheaper and more durable than batteries, therefore storage capacity can be higher than battery-based systems, and last for many decades.
-**Demand management to encourage energy consumption when solar resources are available.** This is accomplished mainly with direct use of solar electricity for heavy loads (also known as direct drive). Residents learn to use heavy loads during the day, further decreasing demand on batteries.
-**12VDC battery kits for lights and electronics.** The efficiency of low voltage DC appliances allows for improved system performance even when small batteries are used. For these kits we recommend nickel iron, an old battery technology that can last for decades, and is not damaged by deep cycling.
-**Biogas digesters** for supplemental cooking fuel.

Benefits of DC Microgrids over Utility-scale Renewable Energy

Resilience

A 100% renewable electrical grid would need to transmit energy at unprecedented levels and distances from generation and storage sites to population centers. In this age of climate chaos, reliance on long distance transmission for essential services is extremely risky. Already weather related outages are more common, and this trend will only worsen in the future. Low income communities are at particular risk for outages.

A resilient energy future demands local generation and storage of energy. With a DC Microgrid, all energy required for domestic use is harvested and stored on site. In the event of a natural disaster, services can be restored quickly and easily, protecting the health and safety of residents.

Durability and Economy

Currently, the most active market for DC Microgrid technology is in Puerto Rico, largely because of the lessons of Hurricane Maria. In the aftermath of this 2017 hurricane, which caused the longest power outage in American history, many Puerto Ricans invested in solar and storage systems for their homes. Seven years later, very few of these systems are still operational. Solar and storage systems that include no **demand management or non-electric storage are inherently unreliable, short-lived, and expensive**. Most families simply cannot afford to replace their batteries as they age and decline in capacity. Incremental improvements in battery technology are insufficient to overcome the inherent inefficiencies of this design.

The DC Microgrid design is much more robust and durable. The DC Microgrid at our research center has seen 13 years of service, and we have experienced no decline in its performance during that time. DC Microgrids at other sites are going strong as well, years after implementation. The main components of the system last for decades.

A Model for Global Climate Justice

The DC Microgrid is a solution that can achieve zero carbon emissions with a 90% reduction in materials footprint (including collectors, batteries and wiring), when compared to industrial solar and battery storage. The Microgrid at Living Energy Farm operates with a per-capita PV capacity of 200W, which is similar to the per capita global PV capacity that already exists today.

This is crucial, when supply-side strategies to achieve net-zero are predicated on extraction of materials from exploited territories, including Indigenous lands in the U.S. and Canada.

Our communities need a sustainable energy future that ends the cycle of extraction, and energy system designs like DC Microgrids offer a way to meet our energy needs in community, while upholding climate and environmental justice.

The Projects

Outlined below are three cooperative houses we built or retrofit with DC Microgrid design, and one community kitchen that was renovated with a DC Microgrid. (The community kitchen is located in Puerto Rico, therefore it does not include solar thermal features which are unnecessary in the tropics.)

In each of the building projects, the cost per capita is under $20,000. We are able to keep costs very low for a number of reasons. First, we are able to do much of the work ourselves, including the skilled labor involved with the construction of solar electric and thermal systems. Second, because the house is cooperative, square footage per person is significantly reduced. Third, we are able to employ quite a bit of voluntary/ unpaid trainee labor for straw and stucco. Fourth, our solar thermal systems are much simpler than historic systems that employ more complex thermal storage. And finally, because thermal systems are shared by a number of users, the cost per capita for good quality equipment is low.

1) Living Energy Farm

Nature of Construction: New construction, fully off-grid, wood frame, strawbale.
All Costs Including Upgrades: $15,000 per resident
Energy Use: All energy generated on site.

Comments: The primary residential structure at Living Energy Farm is a cooperative house with extensive solar thermal collection, strawbale walls, and a very large thermal mass. Solar hot air is collected on the roof and blown under the radiant slab floor. The only ongoing energy costs for this structure are a very small amount of firewood burned in winter for supplemental heat and depreciation of built systems.

2) Magnolia House

Nature of Construction: Strawbale retrofit around existing structure. Off-grid transition nearing completion.
All Costs Including Upgrades: $17,000 per resident
Energy Use: Not calculated, project ongoing.

Comments: Magnolia was a cinder block, “second home” completed in 1951. We purchased the property in 2014. We have wrapped a straw bale shell around the entire house. The cost of that project was $15,000. Of that sum, replacing the windows cost $10,000. Passive solar potential is poor due to the shape of the house and pecan trees on the south side. A large shed has been constructed in an area with good solar exposure next to the house for both solar thermal and solar electric collectors. We are completing the thermal systems at this time. We are building a glycol based solar heat loop which will distribute heat through the old radiator system, originally used with a fuel oil boiler.

3) Woodfolk House

Nature of Construction: Straw wrap retrofit, extensive solar thermal, currently no solar PV.
All Costs Including Upgrades: $14,500 per resident.
Energy Use: 9% of American average per resident.

Comments: This house was built with cinder blocks decades ago by a low income family in Charlottesville VA. It was abandoned in the early 1990s. We purchased it in 1999. A strawbale shell was wrapped around the existing house, and a second floor stacked over the rear part of the house with trusses. Radiant floor heating was installed. Solar thermal panels provide both water and space heat. The walls are 18 inches thick throughout. Currently the house has no solar electric, but a transition in the future from grid electricity to direct drive DC would be straightforward and affordable.

4) El Departamento de la Comida

Nature of Construction: Community kitchen in Puerto Rico.
Cost (electrical only): $10,000

Comments: This kitchen provides community meals and processing facilities for local growers in San Salvador, a small town outside of Caguas, PR. San Salvador lost power for about one year following Hurricane Maria. In response, the El Depa team invested $25K in a solar and battery system for the kitchen, but it found it could not support their loads, particularly refrigeration. In 2023 the LEF team traveled to Puerto Rico to install direct drive DC cooking and refrigeration equipment. This DC system has allowed them to serve their community without dependence on the electrical grid. Their system includes 2 direct drive refrigeration units (one operating as a fridge and one as a freezer), two insulated solar electric cookers, and two 55AH nickel iron battery kits for lights, charging electronics, and ventilation.

Consulting & Partnerships

We are interested in partnering with and offering consultation to non-profits, public authorities, and developers. Our experience with DC Microgrids and resilient housing for communities can help unlock fossil-free transitions at scale in the housing sector.

If you are interested in learning more or working together, feel free to contact us below:

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