Microgrids 101

This page and Wikipedia go into great detail to describe the concept of a microgrid. I would like to expand on that. During one of the weekly LF Energy Hyphae community checkin calls. When I explained that the initial phase for NFE's pilot microgrid will only include sub-metering a handful of homes. My colleague commented that "Oh, so it won't really be a microgrid yet". That statement stuck with me because I infant think it would be a microgrid. Which brings us to the question I would like to address in this article. What do I mean when I say "microgrid".

Why definitions matter

Definitions generally matter because they help us communicate more clearly about the problem and how we are solving it. If we can agree on what we when when we say "microgrid" or "battery" then it makes it simpler to have conversations about which use-cases make sense for Hyphae's autonomous microgrid idea to address.

First principles

The term *microgrid* is a compound term. It consists of two terms *micro* and *grid*. I will start with the assertion that a microgrid is first a *grid*. If we are agreed there (pun not intended), then let's move on to define what we mean by *grid*.

A grid, in it's most primitive form, is really a set of at least two energy assets, connected, usually by physical energy conducting medium like a wire for a purpose. Let's look at the picture below.



The energy asset on the left (battery) is producing energy and the asset to the right is consuming energy. The two assets have been connected for a purpose and I think that's actually an a very simple example of a grid. Now this grid can include more than 2 assets and in the real world, there's often 100s of assets connected to a grid but for the sake of defining the term, I think this example will serve us well.

If you are still with me, let's move on to the preceding term, the *micro* term. This term adds a layer of meaning to the Grid term. I propose that the distiction between Micro and Macro is really about scope of monitoring and steering for the "owner(s)" of the grid. If the scope is considered small by

the owner and exists within the context of a larger grid, then we have ourselves a *microgrid*.

Energy Assets

These exist in various forms but here's an oversimplified list Energy_Asset_Taxonomy.csv. I share it here to example one's imagination on the kind of things that can exist on a microgrid.

Supply-Side Assets (Energy Producers)

These generate or inject energy into the system.

Subtype	Example Assets	Notes
Renewable Generators	Solar panels, wind turbines	Often variable in output
Non-renewable Generators	Diesel gensets, gas turbines	Firm or dispatchable supply
Co-generation Units	CHP systems	Produce electricity + heat

Demand-Side Assets (Energy Consumers)

These draw energy from the system.

Subtype	Example Assets	Notes
Residential Loads	Lighting, HVAC, appliances	Often flexible for DR programs
Industrial Loads	Motors, manufacturing equipment	Usually larger and more steady
Electric Vehicles	While charging	Can also act as supply (see V2G)

Storage Assets (Bidirectional)

These can both store (consume) and release (supply) energy.

Subtype	Example Assets	Notes
Battery Storage	Lithium-ion, lead-acid	Fast response, scalable
Mechanical Storage	Flywheels, pumped hydro	Used in larger systems
Thermal Storage	Ice storage, molten salt	Stores heat, not electricity

Hybrid/Prosumer Assets

Assets that both consume and produce energy as part of normal operation.

Subtype	Example Assets	Notes
Solar + Battery Systems	Rooftop PV with integrated battery	Common in homes & businesses
EVs with V2G	Electric Vehicles (bi-directional)	Vehicle-to-grid capable
Smart Appliances	Can adjust operation dynamically	May support DR/load shifting

Monitoring & Steering Assets (Support Infrastructure)

These don’t directly consume or produce energy, but enable management.

Subtype	Example Assets	Notes
Smart Meters	Energy meters with comms	Enable billing, monitoring
IoT Sensors	Voltage, temperature, fault sensors	Support system diagnostics
Controllers/EMS	Inverters, EMS, SCADA systems	Coordinate and control flow

Monitoring and Steering the microgrid

This capabilities represent what the purpose for a microgrid can be. In the example of NFE's first phase of microgrid deployment. The purpose can be thought of as 3 part;

- for the owner (of the microgrid) to monitor energy consumptions patterns to inform additions of supply side assets like batteries in future so that energy can be more reliable for the community
- for the owner and consumers to bulk purchase electricity there by making it more affordable.
- for the owner and consumers to evolve the their experience of transacting on the grid. Prepaid vs postpaid vs credits to consumers.

The point here being that these capabilities of monitoring and steering (the assets) on the grid are a means to achieve a variety of purposes for the grid owner and other grid stakeholders.

The Autonomous Microgrid

This is what I think can be the vision for project Hyphae, to be able to simply define a start and end state for grid attributes we care about and have Hyphae monitor and steer the grid to the end state. For example, the end state could be 90% reliability for all demand side assets on the grid. Hyphae can then make sure that energy is being drawn or stored or cut off from some assets so

that we can maintain a reliability of 90%.

That's what I imagine an autonomous microgrid should be capable of doing. There may be aspects of grid operations that will require manual human intervention like replacing a malfunctioning asset or making a payment for a bill but the more you think about it, the more you recorgnize that almost every aspect has potential to be automated to make the grid completely autonomous.

Levels of Microgrid Autonomy

I am thinking about how we can borrow from the 6 levels for Self driving cars to define levels for Microgrids..

TBD

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