Plurigrid 🌐

https://plurigrid.xyz
https://twitter.com/Plurigrid
https://github.com/Plurigrid
https://www.energy.gov/gdo/grid-resilience-and-innovation-partnerships-grip-program

Overview: The Energy Transition

Energy Systems are rapidly transitioning from centralized resources and utilities that generate electricity to a much more dynamic world of distributed renewable energy resources, where microgrids can both import and export electricity.

Most renewable potential is in underdeveloped parts of the planet, whereas AC transmission from Africa to Europe is not efficient, and HVDC is out of reach of smaller and medium size microgrids as of yet.

For the first time ever, **IEA 2022** electricity access report for the first time in decades shows that a greater number of people lack access to Universal Basic Electricity than a year before, an estimated **~774 million** people. With growing instability due to climate change, war, and economic winds,now more than ever off-grid, sovereign energy coordination is a necessity.

This energy transition assigns new, smaller, renewable sources the duties of a central power plant, and these new systems require coordination at an unprecedented scale. Plurigrid's protocol helps accelerate this transition.

When managing distributed energy resources today, especially at the edge, many gaps exist that prevent rapid expansion of DERs (distributed energy resources) where they are needed most:

- Access to Funding is difficult to come by as industrial development levels do not warrant grid expansion in their own right
- Demand side coordination
- Interoperability
- Privacy
- Data availability throughout grid networks

- Assurance mechanisms to faithfully execute the scientific planning of the grid

What is Plurigrid Protocol?

Plurigrid Protocol is a decentralized virtual power plant and DER expansion, maintenance, and resilience protocol for microgrids everywhere, at any scale. An instance of the protocol managing DERs is simply called a **Plurigrid**, and our stack exists to allow any e-gen anywhere to participate in p2p transactive energy.

Plurigrids everywhere will curate existing and develop new Digital Public Goods that can be thought of as Civilization Starter Kit (when it comes to electricity), to include everything required for execution of decentralized planning of microgrid itself, as well as affordances for faithful execution of mechanisms that prosumers, energy product developers, and other participants in the transactive energy markets established by the plurality of Plurigrids will use to de-risk deployment of capital. The underlying consensus, execution, and data availability layers (both public and permissionless - DeFi / CoFi, as well as private, permissioned critical infrastructure) are used to faithfully record the data and carry out the exchange and discovery of smart energy assets that then serve to incentivize participants in the energy markets (e.g. with off-peak rate) to play a better game.

What is Plurigrid Inc?

Plurigrid Inc is a pre-seed stage startup (Delaware C-Corp) focused on commercializing Interblockchain Communication protocol (first developed for Cosmos Ecosystem) and generalized message-passing standards (e.g. IEEE for microgrids + politics) to critical infrastructure in the US and around the world, as well as providing for simulation products and services pertinent to the task of transactive energy market design.

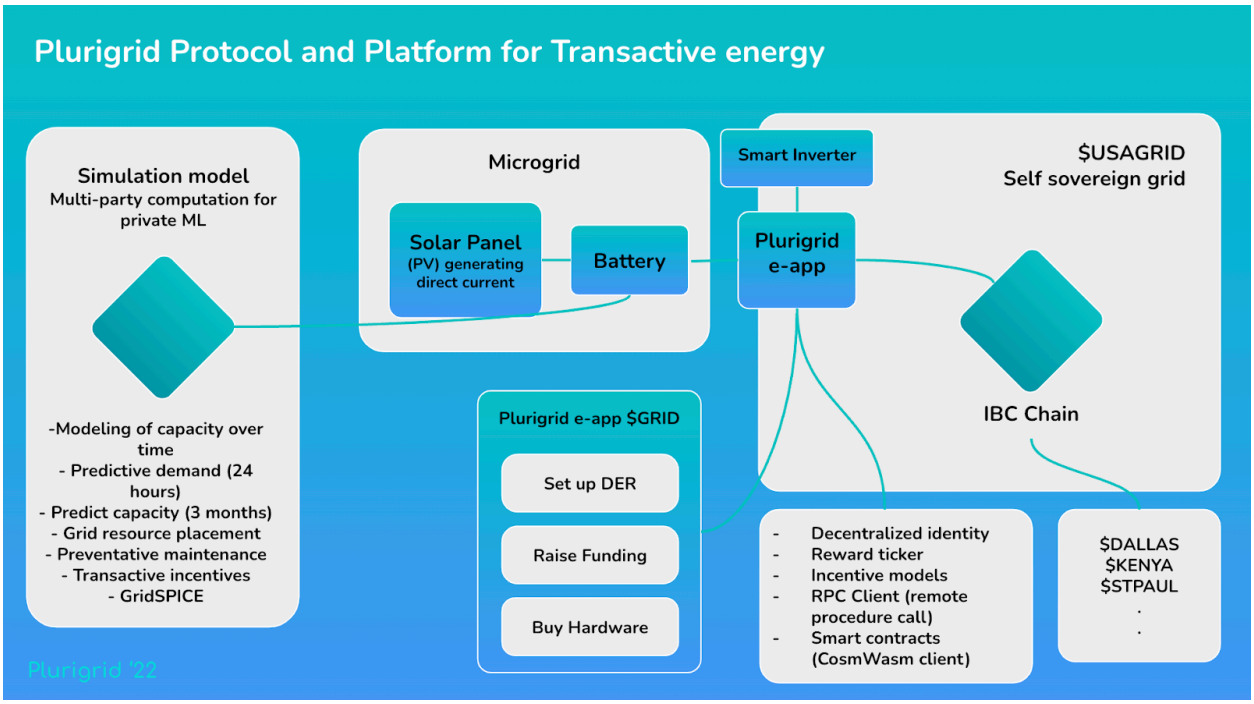
Through the legal entity, we are seeking to form partnerships with existing companies (e.g. Enode, solar panel and battery manufacturers) throughout the energy sector, as well as provide for commodified computation necessary to execute GRID simulations in time, and secure the mechanisms involved in coordination (e.g. mesh security for

any sovereign chains for large enough grids, IoT integrations, compliance).

The US entity choice is to allow for participation in **Department of Energy Grid Resilience Innovation Program** where we are currently in the process of submitting a concept paper for Plurigrid (*request separately*).

It is our expectation that by bringing Collaborative Finance and decentralized industrial assurance to the long tail, we will be able to gain efficiencies sufficient for sustainably electrifying populations lacking access per IEA access methodology, and develop brand new classes of cyberphysical assets for energy grids and serve as a launchpad for bottom-up grid innovation ideas (e.g. clever solutions to pressing needs like energy storage that otherwise would not get funded can now launch an Augmented Bonding Curve or another asset and receive funding from everyone).

By aggregating Plurigrid Protocol instances and e-gens who opt-in, the legal entity will also have leeway to enter into wholesale energy markets on behalf of everyone using the interoperable protocol and thereby form a powerful collective bargaining juggernaut. To contrast a weakened individual negotiating position for anyone who wants to sell excess electricity to the grid and / or their neighbors, or opaque Aggregator entities whose governance may not align with the constituencies being served. By bringing a Cosmos-native governance mechanism to the aggregator, a more value-aligned energy transition can take place.



Plurigrid's approach focuses on what is already recognized and validated to be the missing pieces on the frontiers of the emerging grid landscape:

- Interoperability (through IBC Inter Blockchain Communication)
- Data availability
- Privacy (through new computing techniques ZK / MPC etc.)
- P2P transactive energy incentive models

Plurgrid is applicable to the following markets:

- Emergency Services for wildfire response
- Emerging grid opportunities
- Existing centralized grids
- The 774 million people without electricity
- The next billion people and their grid needs

Go to Market

Phase 1 - Simulation

Simulation tools inform real-world deployments, creating a provable model that can be safely tested before deployment to create a smarter grid.

Plurigrid's superpower is the ability to model grid solutions and resources before deployment.

New simulation models must contain not just grid components, but politics, ecology, energy policy, physics, and incentive models.

One of Plurigrid's first steps is to extend these existing grid simulation models and add capacities for even more simulation. Using machine learning and multi-party computation, Plurigrid can simulate not just the electrical grid, but also the funding possibilities for grids, incentive and policy models.

We want to show that anyone can bootstrap their grid, and that there is a public goods funding model for them. More realistic and ethical tokenomics models such as the ABC - augmented bonding curve, allows for a hatch period, a provable reserve and a way to model out tokenomics that can result in much more sustainable, longer term and healthy microeconomies.

What does a smarter grid enable?

- Automated outage management and faster restoration
- Dynamic pricing mechanisms
- Consumer incentives to alter usage during different times of day based on pricing signals
- Better energy management

Phase 2 - Deployment and Testing

In the lab, models can be safely tested before going live. This feedback loop will allow for assurance mechanisms for grid planning at different scales.

Smart Grids can deploy Plurigrid's technologies through:

- Mobile apps (e-apps)
- Simulation and visualization
- Smart inverters and batteries

To:

- Monitor the power the comes from each of the energy sources, turn on and off the power to avoid spikes
- Provide time of day energy management
- Enable P2P transactional energy markets
- Train privacy-preserving (MPC) models for spot price prediction, capacity / demand, as well as predictive maintenance

- Develop the most comprehensive supply chain catalog of parts that e-gens bring to their Plurigrids and keep growing compatibilty

The benefit of Plurigrid being able to connect so many entities is that transactional energy models at the edge can ingest way more information at the edge can actually become more powerful that what a single centralized entity has access to.

A future with Plurgrid will allow for:

- Anyone to bootstrap their grids of any size in places where it wouldn't be economically viable to do this before.
- To create and fund your own energy market in one click. And also form organic local network through that energy market
- Disintermediate the aggregators and allow individuals and communities to seize the means of coordination.

Access to more potential data than centralized grids alone puts Plurigrid in a significant position of political power. From the app, people can choose what kind of energy they'd like to use, or get more insight into when to charge their car. And with inverters, this can all be done automatically if you opt into it.

User Stories

User Story #1:

- I live in Texas and have a ranch. I want to make extra money selling electricity back to the grid.
- I am eligible for the Inflation Reduction Act incentive to install batteries.
- I get Plurigrid e-app for Dallas Cowboys Fans Microgrid that guides me through the selection of the hardware - a battery, a network-aware microinverter, and a smart charger for my phone.
- After I perform the installation and connect the battery to my solar pannels, I use the e-app to upload visual inspection photos and begin receiving $DALLAS. If I charge my phone using the smart charger I get, I get extra $DALLAS to recompense me for the charging.

User Story #2:

- As the energy stakeholder (official) of an East African (Kenya) town continuing to experience an increase in population growth, and while average electric consumption per person in the country is less than 1000 kWh each year, (USA personal average is around 11,000 kWh/year) I am aware of the strong population growth trajectory and need to start planning to sustain increases in electricity demand.
- I heard about the Plurigrid solution from a friend in the Kenyan energy department and from a section on the Plurigrid website, I found a simple web-based (with mobile native client support) app for evaluating the optimal placement of solar panels to maximize solar energy generation as well as a simulation of how converting solar energy into electricity can handle the demand curves of the town's predicted energy consumption demand depending on time of day.
- From these predictions, I was able to put together an estimated ROI for both energy production *and* understand how any surplus energy can be traded with other towns in a rebate mechanism collateralized with local currency.
- Because of this additional information, I am able to understand the full stack of both energy and economic impact this project can have and I am able to raise funding (from both government budget and banking) much more quickly and easily to purchase the solar panel(s), inverter, and (PluriCortex enabled) battery hardware to start our own microgrid.

Signup Process

- Plurigrid uses a mobile-first approach. Anyone with an interest in Microgrids (battery and a smart inverter) should be able to use a wallet and DID to verify their identity and show that they're a part of the ecosystem.
- Decentralized identifiers (DIDs) are a new type of identifier that enables verifiable, decentralized digital identity.

Partnerships

Plurigrid's success will depend on wide-ranging partnerships in order to get where we need.
What we want to build

- We want to build our own protocol and energy market model and simulation framework, but build on open source tools and existing simulation frameworks.
- We do want to allow other companies to commercialize other pieces of the puzzle.
- We do not want to build our own mobile applications, physical batteries, solar panels or inverters.

Related Reading

Coordination of resources at the edge of the electricity grid: Systematic review and taxonomy https://www.sciencedirect.com/science/article/pii/S030626192200558X

Electricity retail rate design in a decarbonizing economy: An analysis of time-of-use and critical peak pricing https://energy.mit.edu/publication/electricity-retail-rate-design-in-a-decarbonizing-economy-an-analysis-of-time-of-use-and-critical-peak-pricing

Deep Dive

Scalability: Sovereign blockchains + IBC

The Inter-Blockchain Communication Protocol (IBC) allows independent blockchains to directly communicate and trade assets.

- IBC enables independent blockchains to connect, transact, exchange tokens and other data, scale, and thrive in an interconnected network.
- IBC is what Plurigrid instances use to operate smart contracts, send and receive information from the grid to data models, and ensure information is private or public
- Because IBC is interoperable across multiple chains, each grid can have their own ledger mechanisms, and the network can achieve global scale.
- For larger grids, IBC powers the compositionality of working smaller grids.

IBC and Plurigrid Protocol can allow grids to exist at any scale on sovereign blockchains.

- Plurigrid's GridSPICE modeler can inform when to create a sovereign blockchain. Smart contracts, specifically commons contracts and dao-contracts are used to bootstrap smaller grids and allow for legal public funding of grid resources
- Any number of microgrids can start up as an instance of a commons on a permissioned, public Plurigrid:
- Acquire a number of private permissions ledger instruments
- Over time, discover the value of coordination
- Evolve into sovereign blockspace across any number of chains, public and private, necessary to sustainably fulfill coordination needs of that given Plurigrid.

Initial Deployment Opportunities

- Mount Evans Outdoor Lab | Morrison CO
- NREL Energy Systems Integration Facility
- Kennedy Mountain Campus
- University of St. Thomas Renewable Energy Facility in Minnesota - Partnership with Xcel Energy*
- Steger Wilderness Center*
- Individual small, community-owned Microgrids

** Advised by Professor Greg Mowry, Minnesota*

Roadmap

2023 Jan - Mar - Simulation Phase

- Extend cadCAD to simulate grid modeling
- Create gridSPICE (token incentive modeler)
- Create Commons Contracts (p-ABC)
- Google Cloud Anthos partnership
- Private testnet
- Public testnets
- Public goods NFT simulations

2023 Jun - Nov - Pilot Stage

- First physical Microgrid running Plurigrid protocol
- Testing and feedback
- Additional pilot projects deployed at universities and Microgrid sites

- Additional testing and feedback
- Predictive maintenance demo / private machine learning and digital twinning

2023 Nov - Jan - Growth Stage

- Smart inverter, solar and battery partnerships
- Deployment at additional sites, create case studies
- Prove scalability, privacy and security

2024 Jan - Jun - Scale Stage

- Go to Market through press channels, trade shows, website, word of mouth, podcasts, partnerships and conference speaking
- e-app partnerships and integration into Microgrid systems
- P2P Transactive energy market model, spot market trading based on unprecedented predictive modeling
- Public Goods bootstrapping for Kenya and other sites competitive with central resources