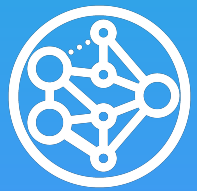
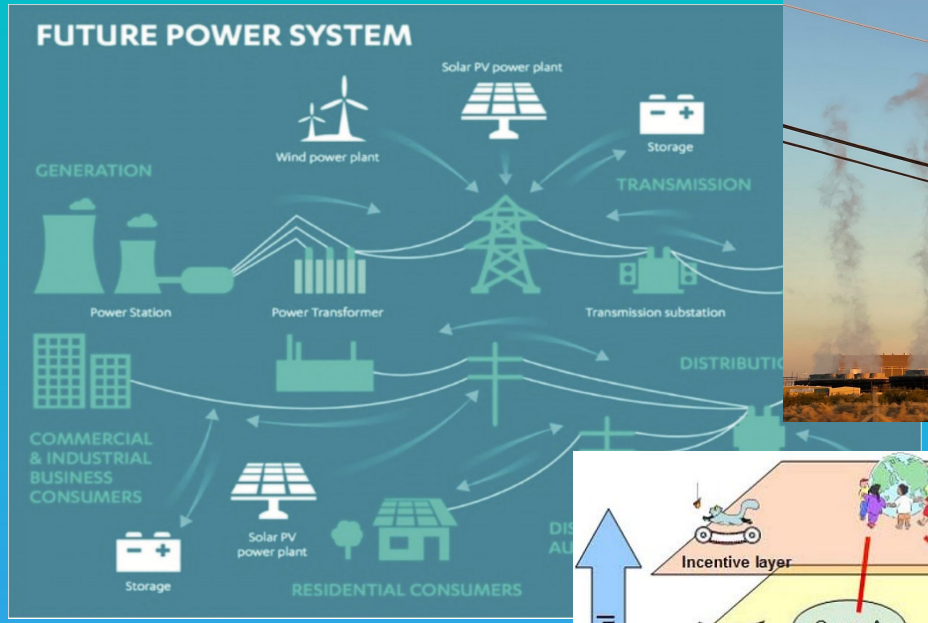
A scalable protocol for
transactive energy coordination

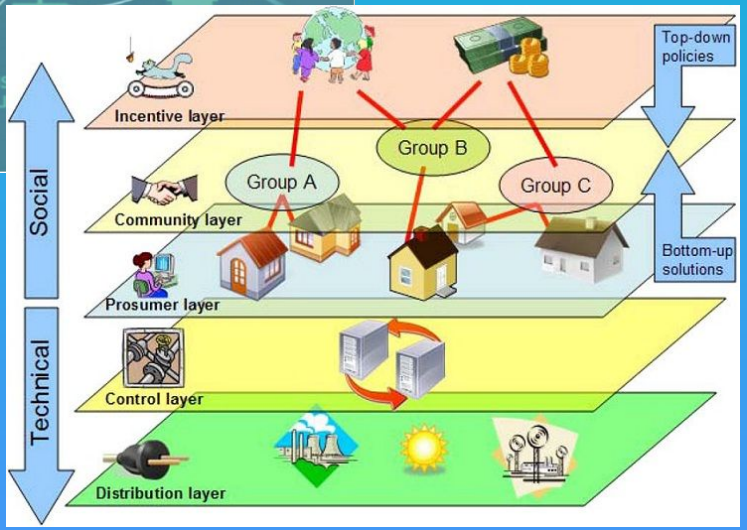


Plurigrid

plurigrid.xyz
gm@plurigrid.xyz

Energy Systems are rapidly **transitioning** from centralized resources to distributed energy resources



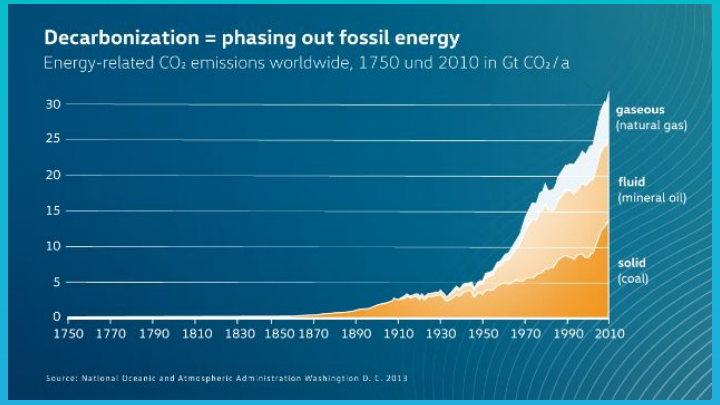


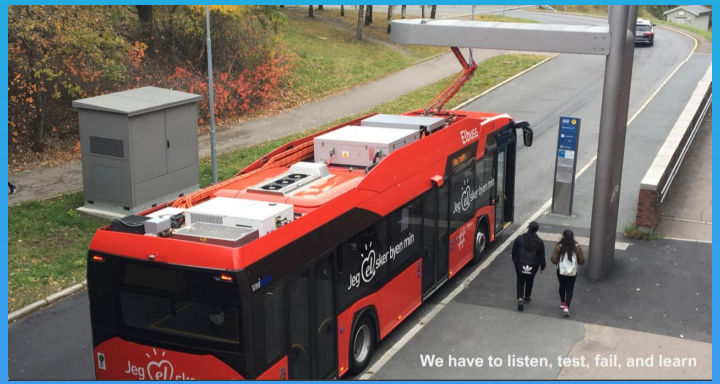
A key challenge is their **integration, coordination, as well as bidirectionality as generators and consumers** at an unprecedented scale.

Right now

Coordination of grid-edge resources can make a major contribution to **power system decarbonisation** (critical for keeping anthropogenic warming below 1.5 °C above pre-industrial levels).

Example: Oslo, leading in decarbonization currently 60% to their 2030 goal of 95% carbon neutral due to coordination at several scales

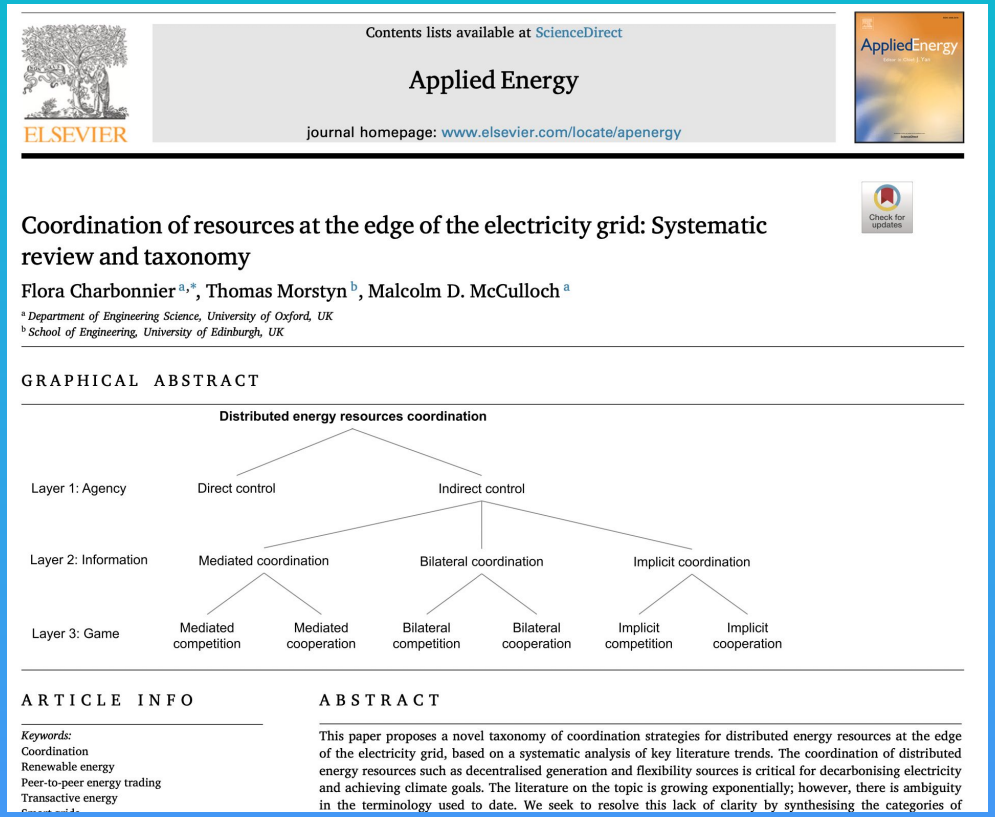




Decentralized DERMS are missing "parts"

A review of thousands of papers on this subject revealed acute gaps in

- **Privacy**
- **Demand side coordination** specifically on the retail side
- **Interoperability** and
- **Data availability** throughout grid networks
- **Assurance mechanisms** to faithfully execute the scientific planning of the grid



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journal homepage: www.elsevier.com/locate/apenergy

Coordination of resources at the edge of the electricity grid: Systematic review and taxonomy

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GRAPHICAL ABSTRACT

ARTICLE INFO

Keywords:
Coordination
Renewable energy
Peer-to-peer energy trading
Transactive energy

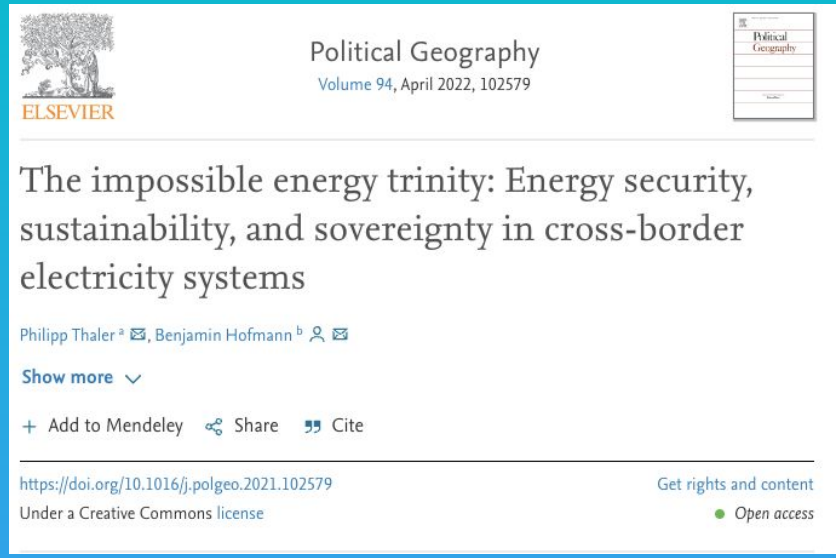
ABSTRACT

This paper proposes a novel taxonomy of coordination strategies for distributed energy resources at the edge of the electricity grid, based on a systematic analysis of key literature trends. The coordination of distributed energy resources such as decentralised generation and flexibility sources is critical for decarbonising electricity and achieving climate goals. The literature on the topic is growing exponentially; however, there is ambiguity in the terminology used to date. We seek to resolve this lack of clarity by synthesising the categories of

We strongly believe that Digital Public Goods for bootstrapping, expanding and operating systems of distributed renewable energy resources ☀️🌬️ cannot be proprietary or opaque.

Nationstates have mostly failed in their legitimacy and ability to address climate change

They need to be replaced with better ontologies that have more dynamism and are better aligned with material fact of energy systems and energy markets.



ELSEVIER

Political Geography

Volume 94, April 2022, 102579

The impossible energy trinity: Energy security, sustainability, and sovereignty in cross-border electricity systems

Philipp Thaler [a], Benjamin Hofmann [b]

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https://doi.org/10.1016/j.polgeo.2021.102579

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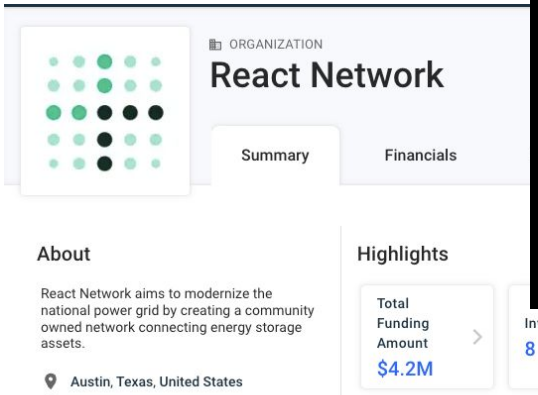
Existing Solutions

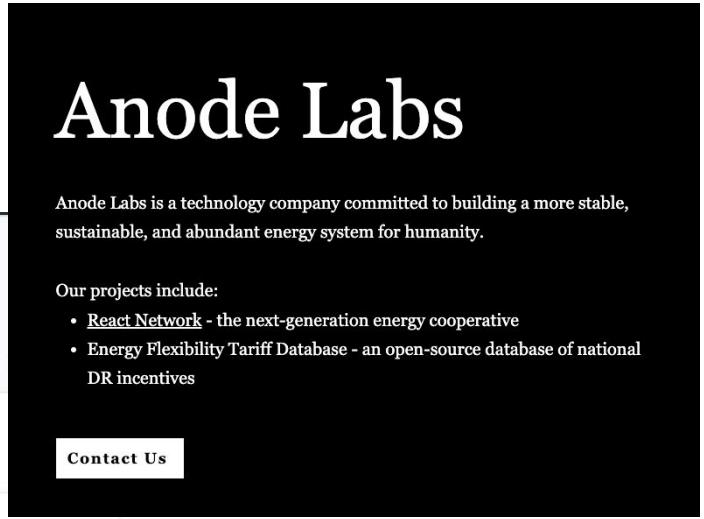
Anode Labs manages the React Network, a blockchain-based protocol that pays users to make their battery storage available to utilities during peak energy usage.

Utilities pay for access to the aggregated storage capacity available on the React Network using its tokens. The proceeds of the sale are split between Anode Labs and the battery owner.

DAVID ENERGY

Holy Cross Partnership





SolarSandy's Own Your Power initiative helps people lower their energy bills by owning their power and installing solar panels.

Open source and open model code bases exist around the world and are funded by a variety of sources

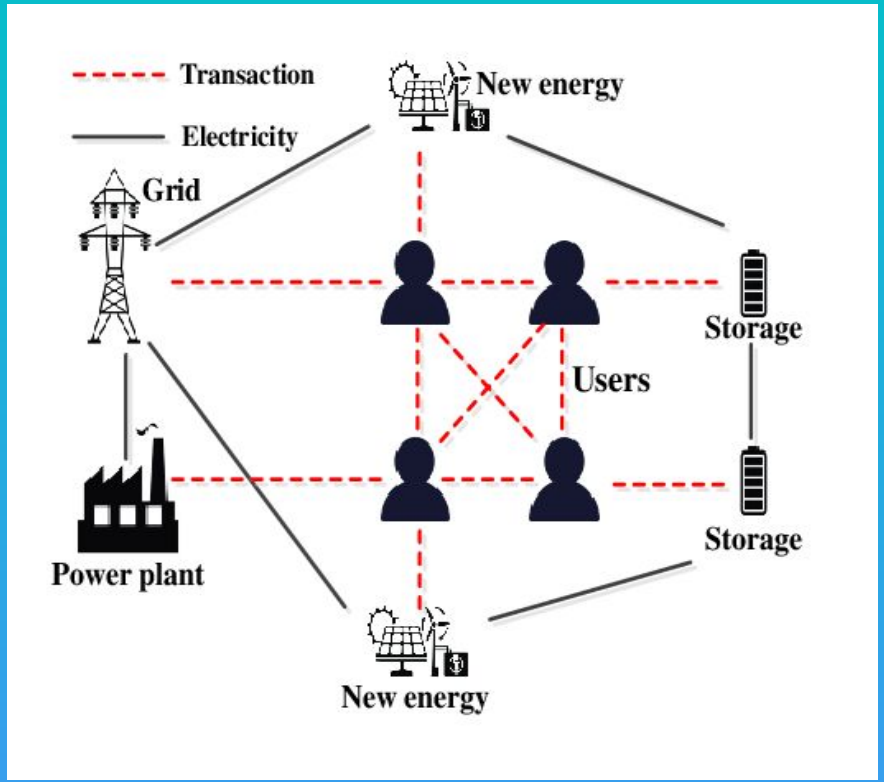
NREL SIP, GENX

Plurigrid's protocol provides for totally new opportunities for transactive energy

New coordination paradigms and strategies -- driven by simulation of all the layers of (social, political, economic, physics)

Compliant and certified assurance mechanisms for industrial control systems

Cyberphysical standards (NREL++)



Plurigrid Protocol provides a scalable open mechanism for **anyone in the world** to start from scratch and participate in coordinated systems, for microgrids of all sizes and maturity levels

Anyone from individuals with an e-app on their phone, vans at burning man, industrial facilities to be able to participate in **two-way markets** and systems surrounding them, sustainable, effective expansion, maintenance, and resilience of energy resources and systems surrounding them.

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

Modeling and incentive simulation

Phase 1 - Simulation

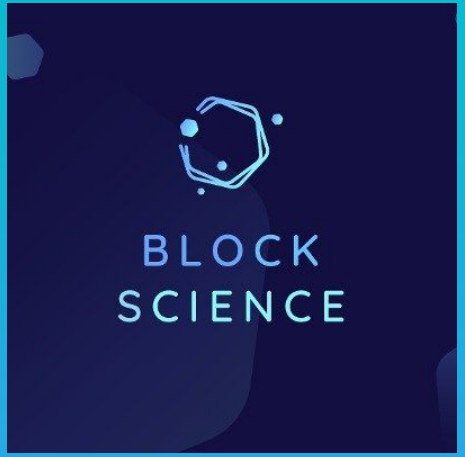
Plurigrid's superpower is the ability to model grid solutions and resources before deployment.

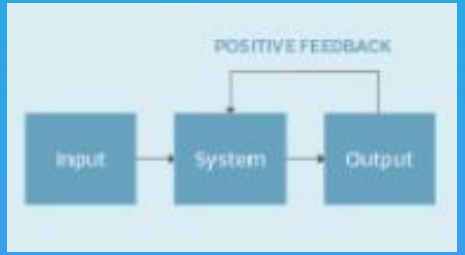
New simulation models must contain not just grid components, but politics, ecology, energy policy, physics, and incentive models.

Phase 2 - Deployment

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

In the lab, new incentive models can be safely tested before going live.





Open games that find closed loop systems

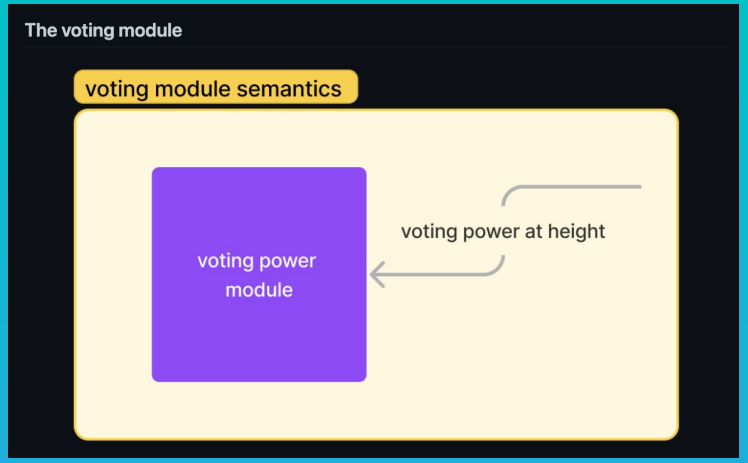
- Enabling open games and simulation models on any data and grids connected to the protocol

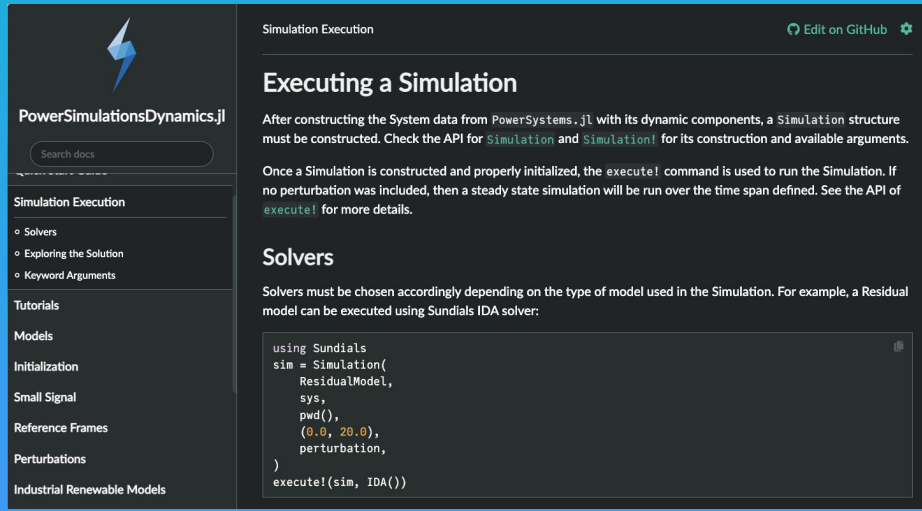
- New governance models (dao-contracts), funding and ownership models (commons-contracts

- Dynamical systems management for high availability (cadCAD.jl)

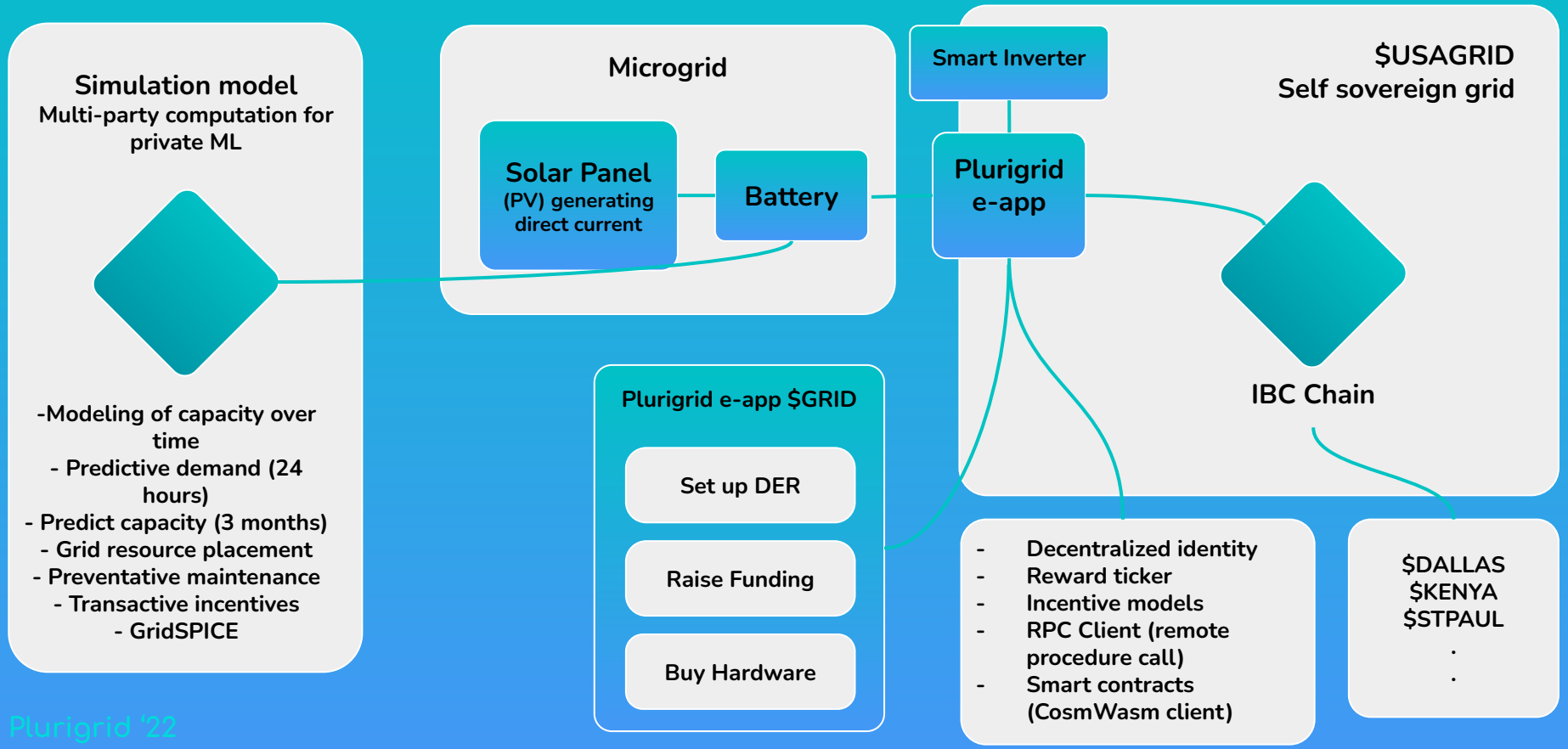
- Behavioral economic / mechanism design

- Retail demand side coordination - E-Apps show baskets of incentives available to E-Gens (prosumers)





Plurigrid Protocol and Platform for Transactive energy



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

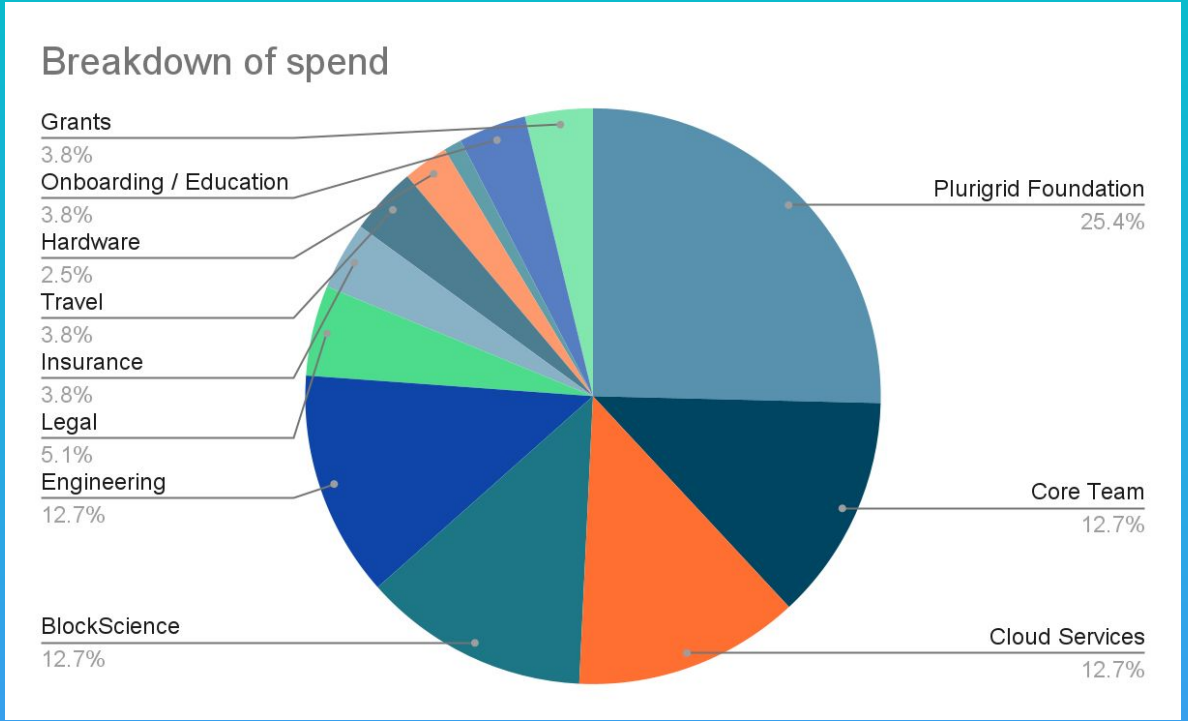
- Go to Market through press channels, trade shows, website, word of mouth, podcasts, partnerships and conference speaking
- e-app partnerships and integration into Microgrid systems
- P2P Transactive energy market model, spot market trading based on unprecedented predictive modeling
- Public Goods bootstrapping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

Where are we today?

Numerous small capital commitments.
Looking for value-aligned leads or co-leads in regenerative finance and climate change who understand our unique mission.

Raising a SAFE - 1.5-2m at 10m

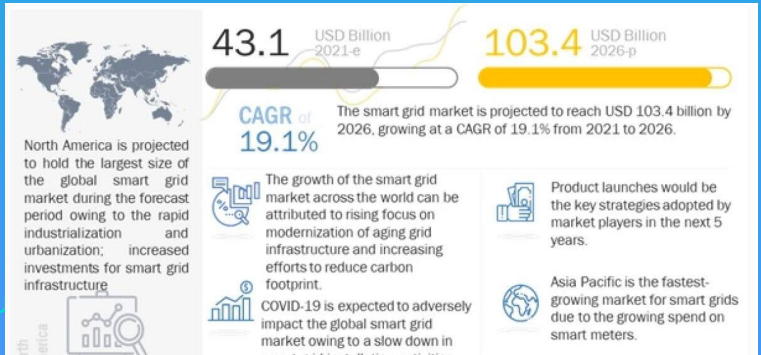
Looking for a lead or co-lead of 750K.

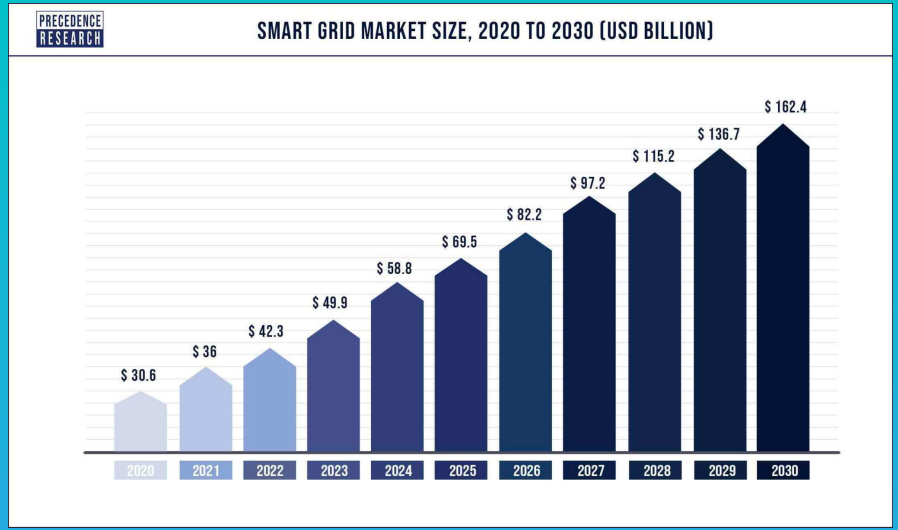


By interoperating we can create better energy systems for everyone. Create new, better games for energy markets to play.

Self-sovereignty is critical. Plurgrid is applicable to the following markets:

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





Smart Grid Market Size to Hit USD 140.53 Billion by 2028 (CAGR of 21.9%)

Smart Grid Market Forecast Report 2021-2028

Power System Simulator Market Forecasted to Hit USD 1,461.8 Million by 2025 with 7.50% CAGR

Report by Market Research Future (MRFR)

*Utility energy storage could approach **$1 trillion** during the next 10-20 years.*

Plurigrid Team

Barton Rhodes
Machine Learning
Security DAO, Lacework, DaVita, Optfit, Hurricane Labs

Amber Case
Exits: EverCharge / Geoloqi
MIT Media Lab / Harvard Berkman

Janita Chalam
IBC+ Smart Contracts
Uber / Microsoft

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SJ Klein
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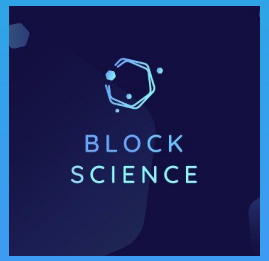
Seth Frey
MetaGov

Lynne Kiesling
Energy Economist

Scott Moore
Co-Founder, GitCoin

Jules Hedges
Applied Category Theory

Partnerships
BlockScience
cadCAD
WindscapeAI
Anoma
Metagov
NREL



Thank you!

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Appendix

Appendix A | Resources

Research

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

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

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.

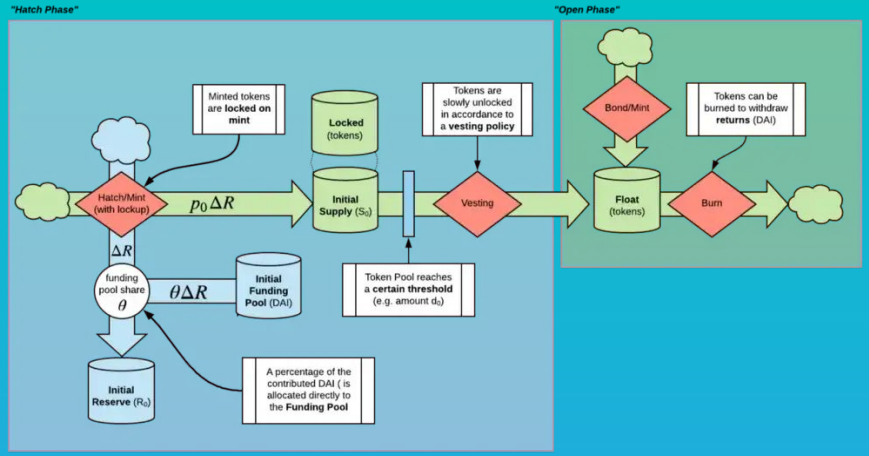
IBC and Plurigrid Protocol can allow grids to exist at any scale on sovereign blockchains. GridSPICE modeler can inform when to create a sovereign blockchain. Smart contracts, specifically commons contracts and dao-contracts are used to bootstrap smaller grids and allow for legal public funding of grid resources

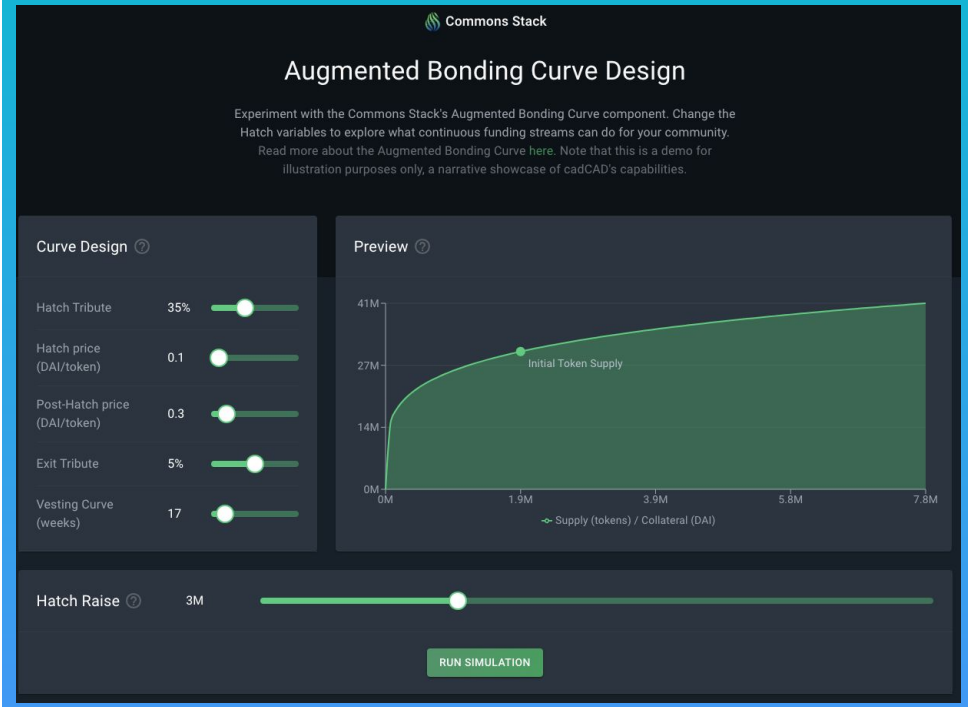
Any number of microgrids can start up as an instance of a commons on a permissioned, public Plurigrid:

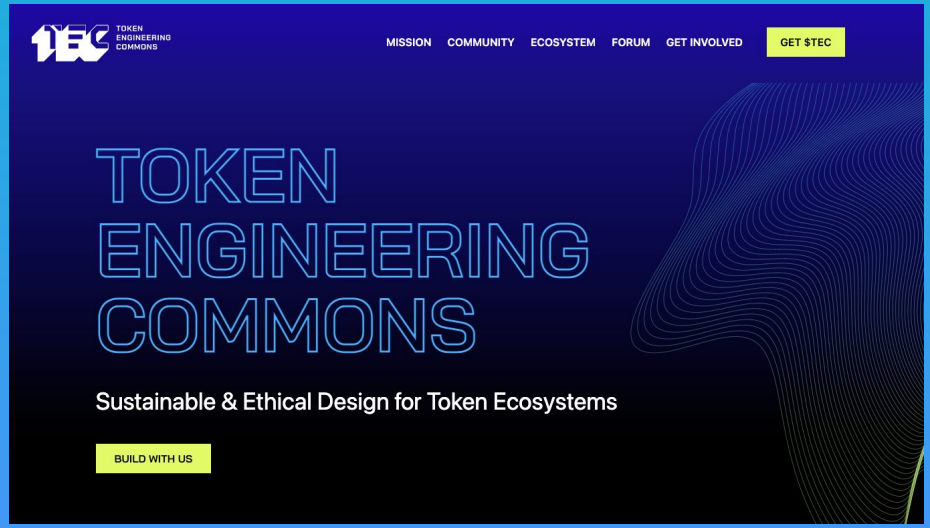
- Acquire a number of private permissions ledger instruments
- Over time, discover the value of coordination
- Evolve into sovereign blockspace across any number of chains, public and private, necessary to sustainably fulfill coordination needs of that given Plurigrid.

cadCAD and BlockScience

Configuration at the edge: Microgrids themselves set incentive structures and have sovereign blockchains and hatch events







Initial Deployment Targets

Mount Evans Outdoor Lab | Morrison CO

NREL Energy Systems Integration Facility

Kennedy Mountain Campus

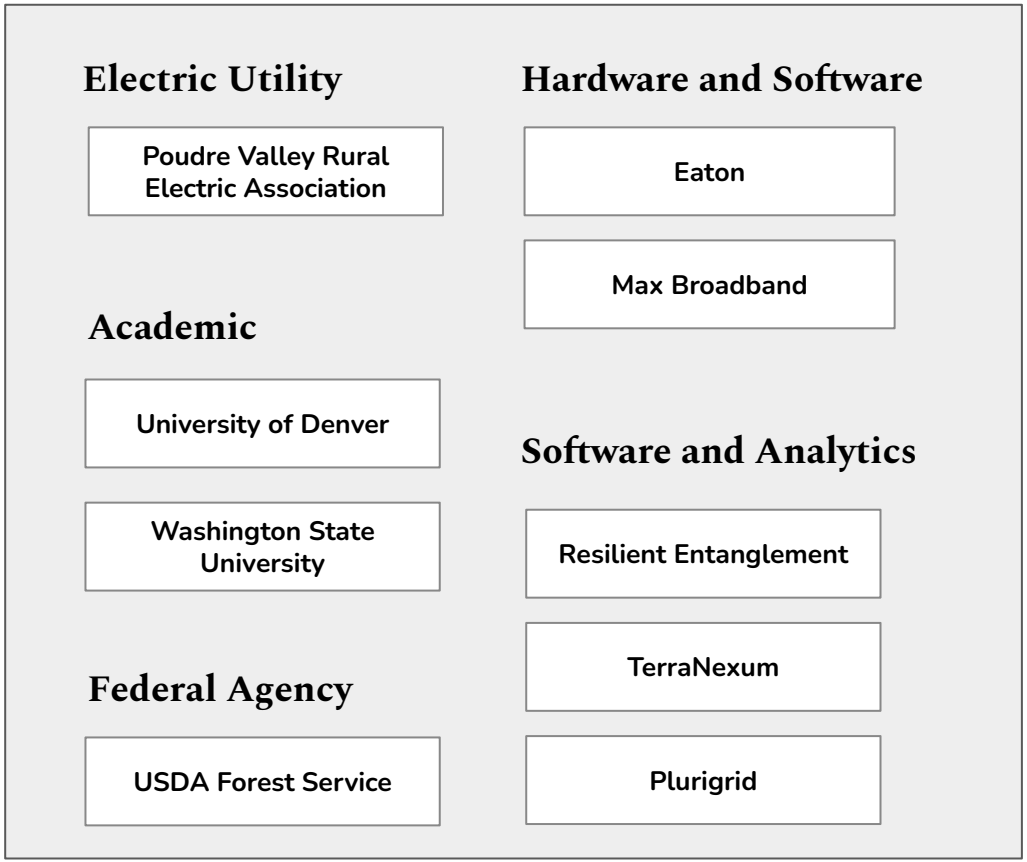
University of St. Thomas Renewable Energy Facility in Minnesota - *Partnership with Xcel Energy**

Steger Wilderness Center*

Individual small, community-owned Microgrids

Starting with an idea for a home that also functions as a microgrid, NREL collaborated with Holy Cross Energy to create this home site .

** Advised by Professor Greg Mowry, Minnesota*



Federal Grip
Grid Resiliency Grant Application
Submitted 2022-12-16