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Prosumer-Based Grids for the South Fork

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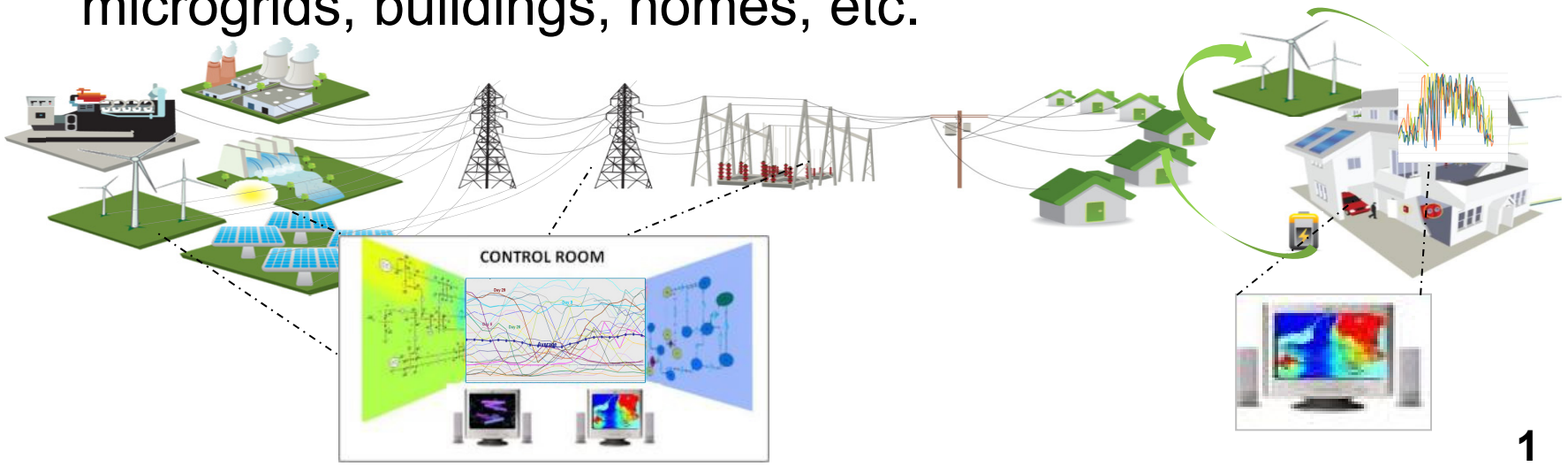
Motivation

- In order to realize resilient and sustainable energy systems and to empower the consumer, we need to:
  - Integrate vast amounts of distributed renewable energy, which is, highly variable, and less predictable.
  - Deploy smart technologies and platforms that provide choice, value, and opportunities for customer participation and innovation.
- Much faster and better ***coordination*** based on services and market transactions is needed across subsystems: utilities, microgrids, buildings, homes, etc.



Key Concept: Prosumers

- Entities that not only consume, but can produce and store energy and offer services to the rest of the grid.
- Intelligent (equipped with sensors and computing)
- Enabled with physical energy control.
- Microgrids, buildings, homes, EVs, etc.

- **Technical Challenge**

  *How can we **coordinate** and manage one billion devices and millions of connected subsystems (prosumers) to achieve grid objectives of resilience, economic optimization, sustainability, and consumer empowerment?*

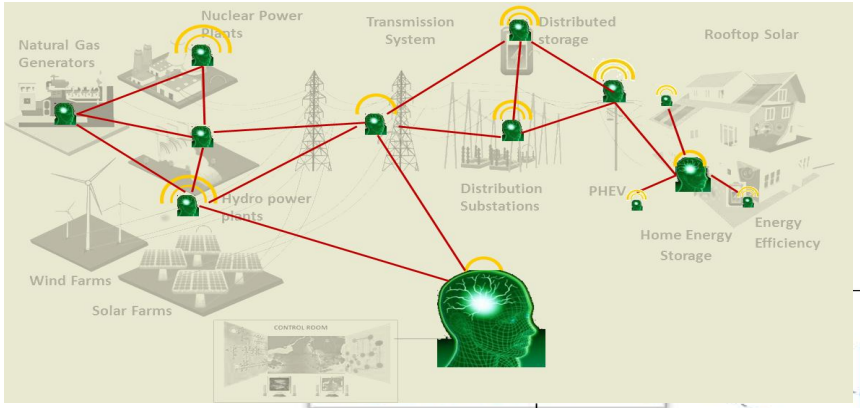
Decentralized Model

ARPA-E Distributed Controls Project

- ARPA-E: Advanced Project Research Agency for Energy
  - Transformational research arm of Department of Energy
- Georgia Tech led project (2012-2015)
  - Leveraged breakthroughs in networked control and robotics, cyber-physical systems, and decentralized optimization.
- Project developed the foundations for a massive decentralized ***Internet of Energy***:
- Outcomes:
  - Decentralized Control ***Reference Architecture***
  - ***Electricity Operating System***: cyber-infrastructure for energy services exchange.
  - ***Decentralized Applications*** including prosumer-based decentralized forms of power agreement, state estimation, frequency regulation, optimal power flow, unit commitment, transfer capability.

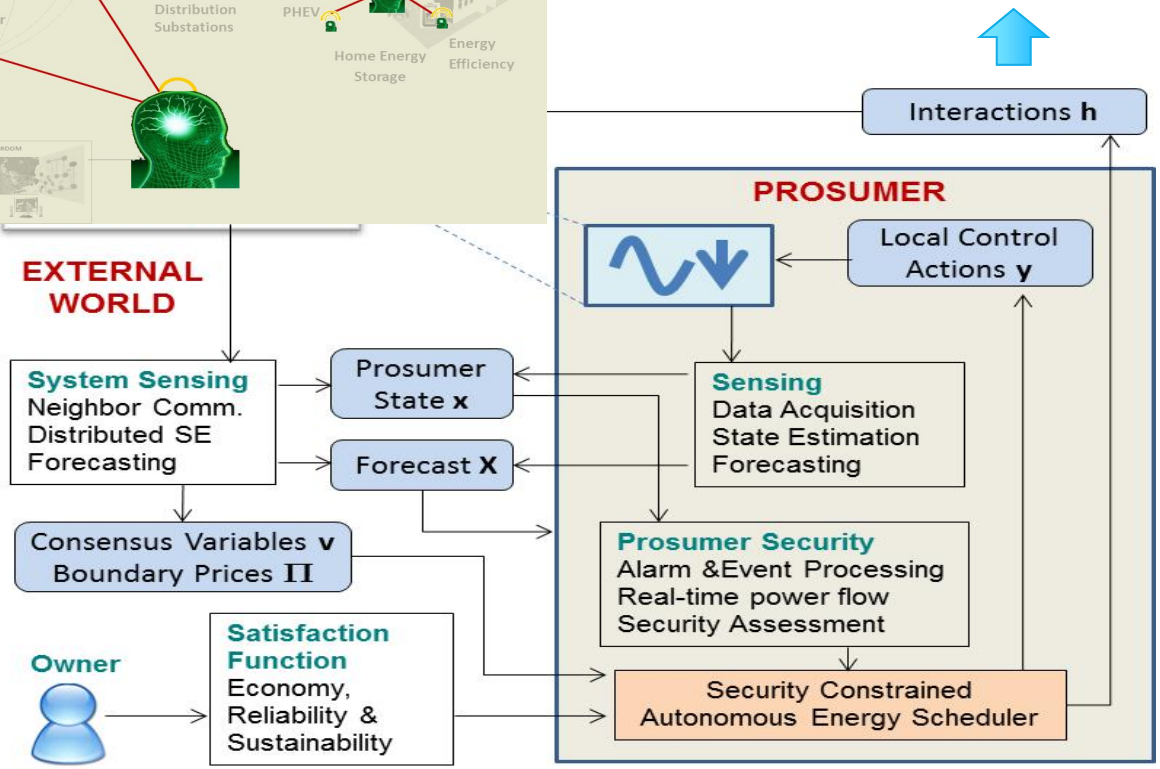
ARPA-E Distributed Controls Project

- Prosumers have:
  - Local sensing and control
  - Sparse data exchange



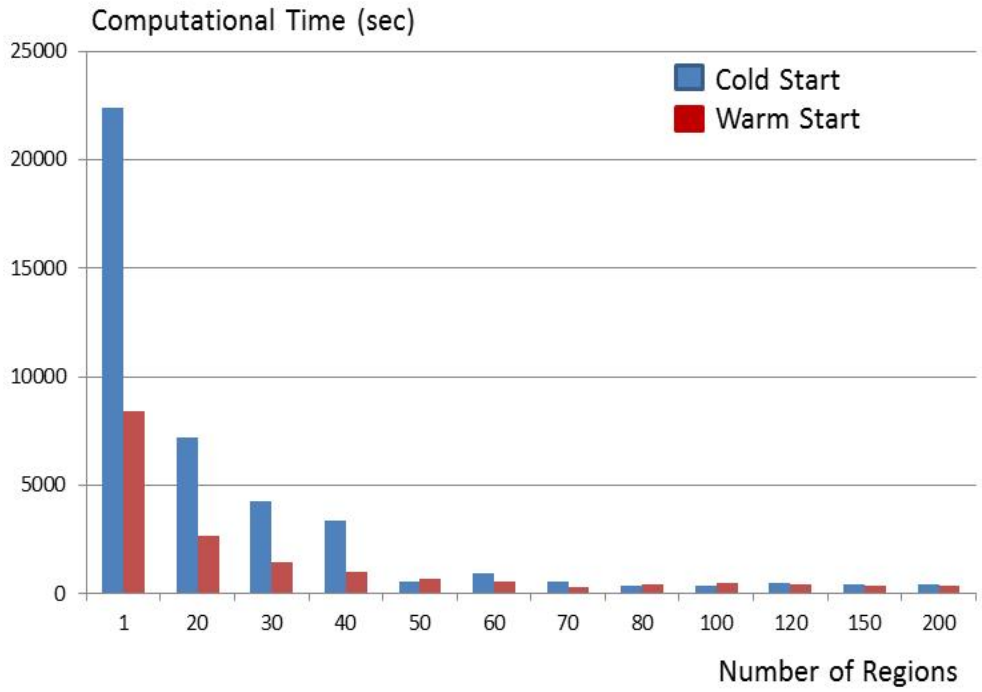
Prosumer Exposes Standardized Services

• Energy balancing	• Security
• Frequency regulation	• Self-identification
• Reserve	• Voltage control
• Sensing / Information	• Black Start
• Forecasting	• Etc.



ARPA-E Distributed Controls Project

- Example: Decentralized Unit-Commitment and Dispatch:
  - Large-scale, realistic, security constrained ISO model
  - 12,000 nodes, 17,000 constraints
  - Power/Communications co-simulation
  - **Outcome**: Same global solution (commitment, dispatch, duality gap and prices) but orders of magnitude faster.



Much faster solution to centralized problem

Smaller entities can solve the problem in a decentralized manner.

ProsumerGrid, Inc.

- ProsumerGrid, Inc. formed in 2014 to develop and commercialize ***next generation software to simulate and coordinate decentralized energy systems with potentially billions of DERs and millions of decision-makers.***

Smart Grid Elements

- Microgrids
- Demand Response
- Building Management
- Home Energy Systems
- Building, Home, Vehicle to Grid
- Transmission/distribution effects
- Consumer Empowerment
- Prosumers
- Imbalance Markets
- Distribution System Operators (DSO)
- ISO Seams Issues
- Wide-Area Control
- . . . .

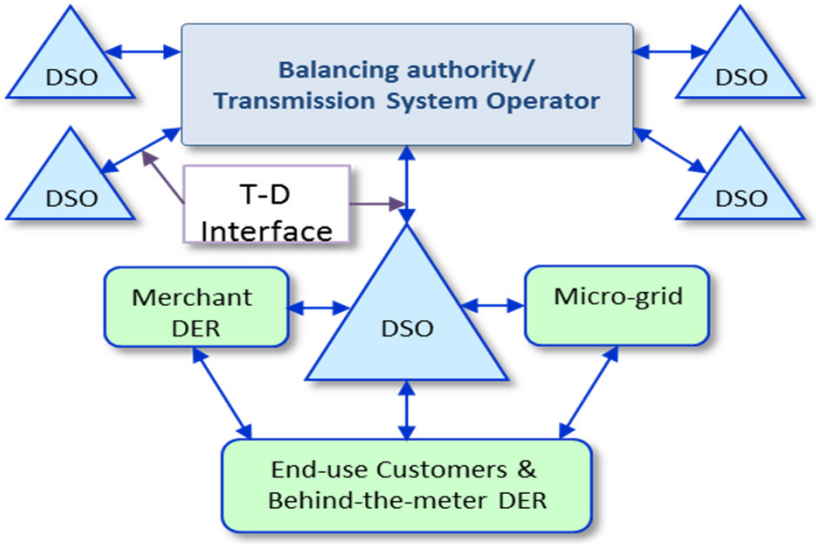
Use cases of decentralized coordination

Needs

- ***Decentralized Simulator***
- ***Decentralized Energy Controller***

Simulator

- ProsumerGrid, ARPA-E Project (2016-2018)
- **Motivation**
  - An operational platform and market place for DER and customer services is required at the distribution level.
  - ***Distribution System Operators (DSOs)*** and ***Distributed System Platforms (DSPs)*** have been identified as the missing element for future grids.



ProsumerGrid™

NYS SmartGrid Consortium

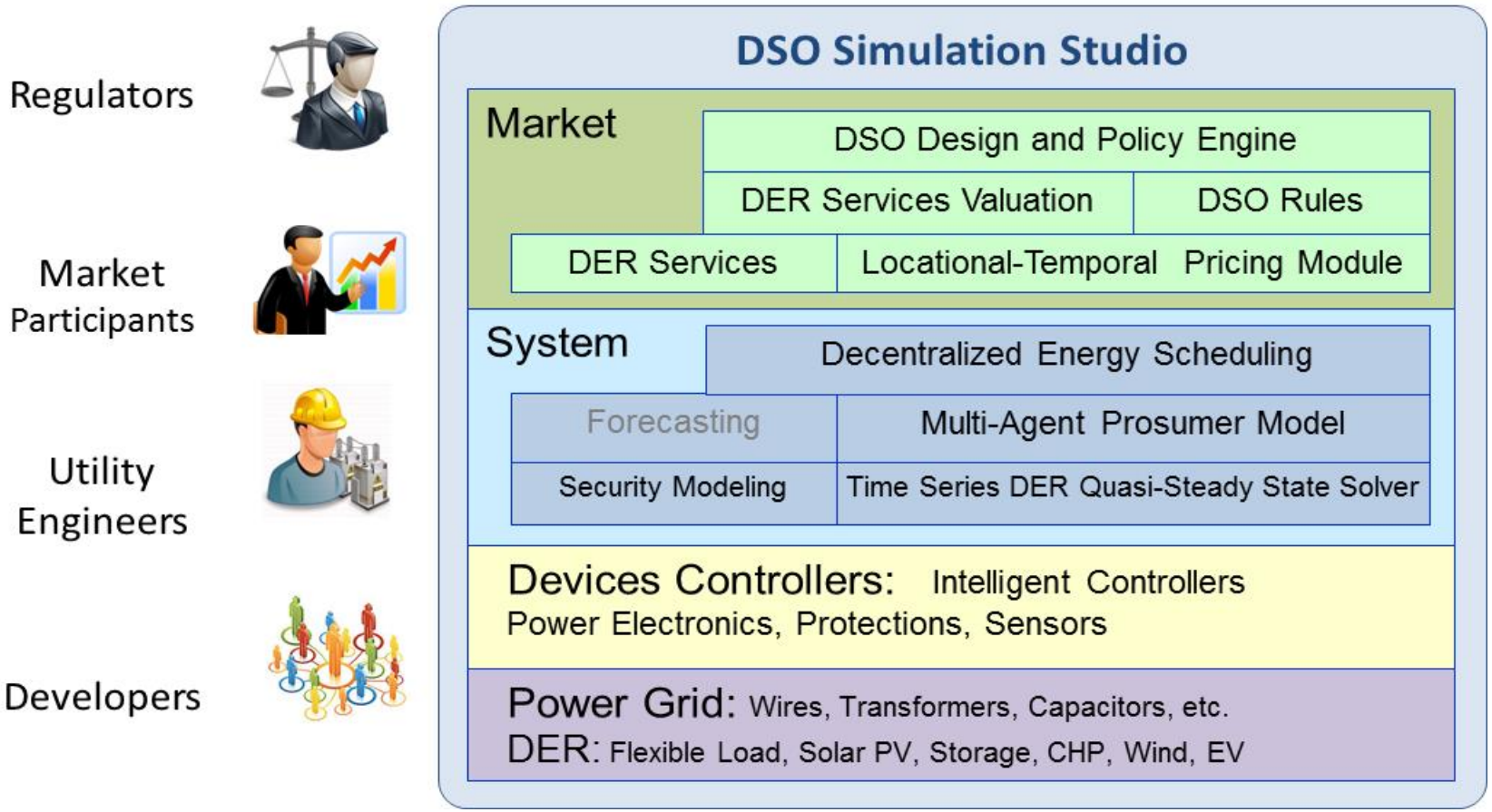
National Rural Electric Cooperative Association
A Touchstone Energy® Cooperative

NEWPORT CONSULTING GROUP

SOUTHERN CALIFORNIA EDISON

Simulator

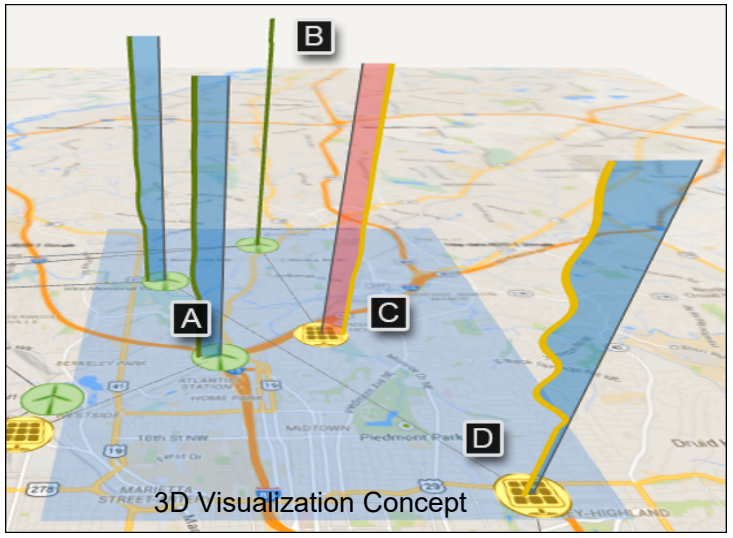
- An interactive software tool capable of simulating the operation of emerging DSOs and DSPs at the physical, information, and market levels



Simulator

Unique Features

- Decentralized energy scheduling of DER-rich systems of arbitrary size.
- Explicit modeling of energy services transacted in the DSO.
- Locational and time-vector pricing of P/Q, ancillary, and security services.
- 3D Interactive Visualization
- Analytics and valuation of DER services, DSO rules, and business models.
- Simulation of multi-scale interactions of DSO with up-stream ISO, same level DSOs, and downstream (microgrid, building, and home) prosumer subsystems.

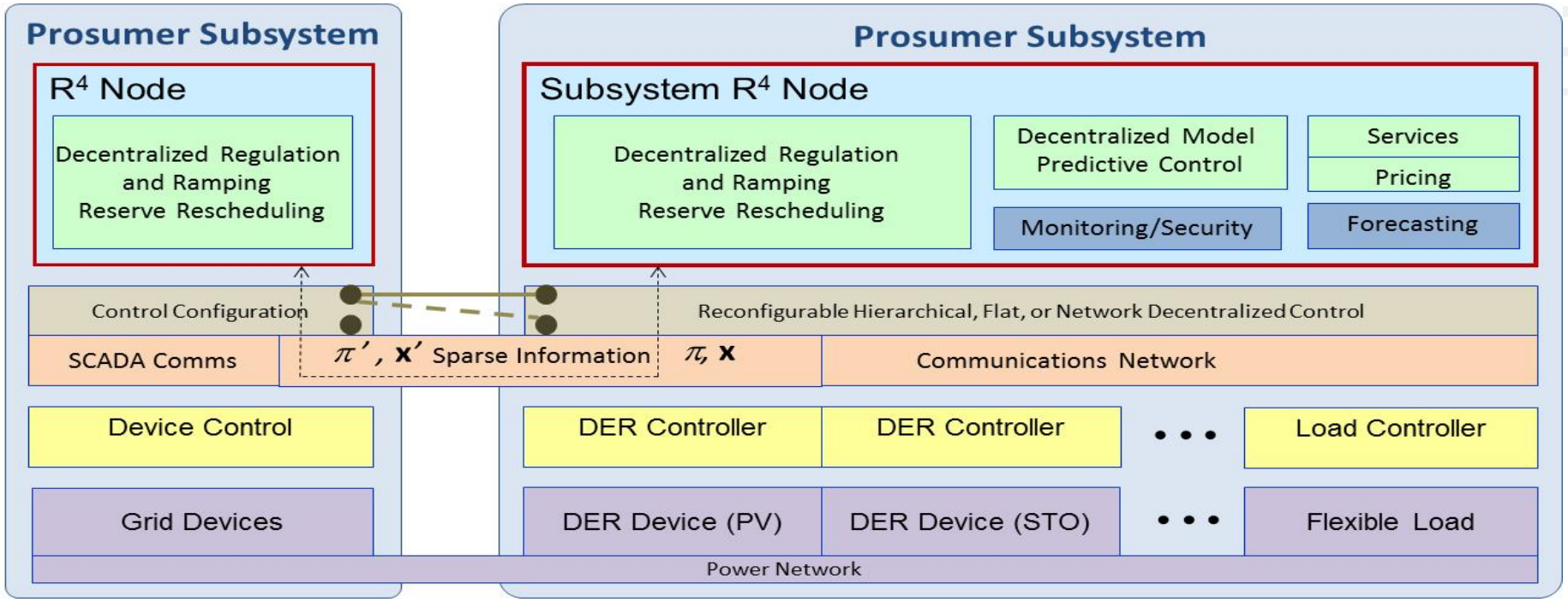


3D Visualization Concept

Decentralized Energy Controller

- Existing energy management systems have architectural limits to meet the needs and complexity of the emerging grid.
- ProsumerGrid is developing a ***Decentralized Energy Controller*** able to control and manage electricity networks using mathematically-proven, decentralized power control protocols.
  - Natively prosumer-based decentralized model.
  - Massively scalable
  - Suitable for spatially-distributed decision-making
  - Arbitrary size and complexity of subsystems (feeders, microgrids, buildings, homes, etc.)
  - Reconfigurable control structure.
  - Zero-cost-of-anarchy decentralized algorithms.

Decentralized Energy Controller



South Fork Prosumer-Based Grids

- **High Level requirements:**
  - Consumer empowerment
  - High reliability and resilience
  - High sustainability (100% renewables)
  - Further economic optimization and asset utilization
- Integrated ***Simulator*** could be used to:
  - Gain a detailed vision of how the future will look like.
  - Validate assumptions as part of complex deployments.
  - Support critical decisions on technology solutions.
  - Support analytics on operational architecture, cyber-infrastructure, and policy.
- ***Decentralized Energy Controller***
  - Is needed to realize the objectives above, enable desirable use cases and valuable propositions, using a future-proof scalable framework.

Thanks

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