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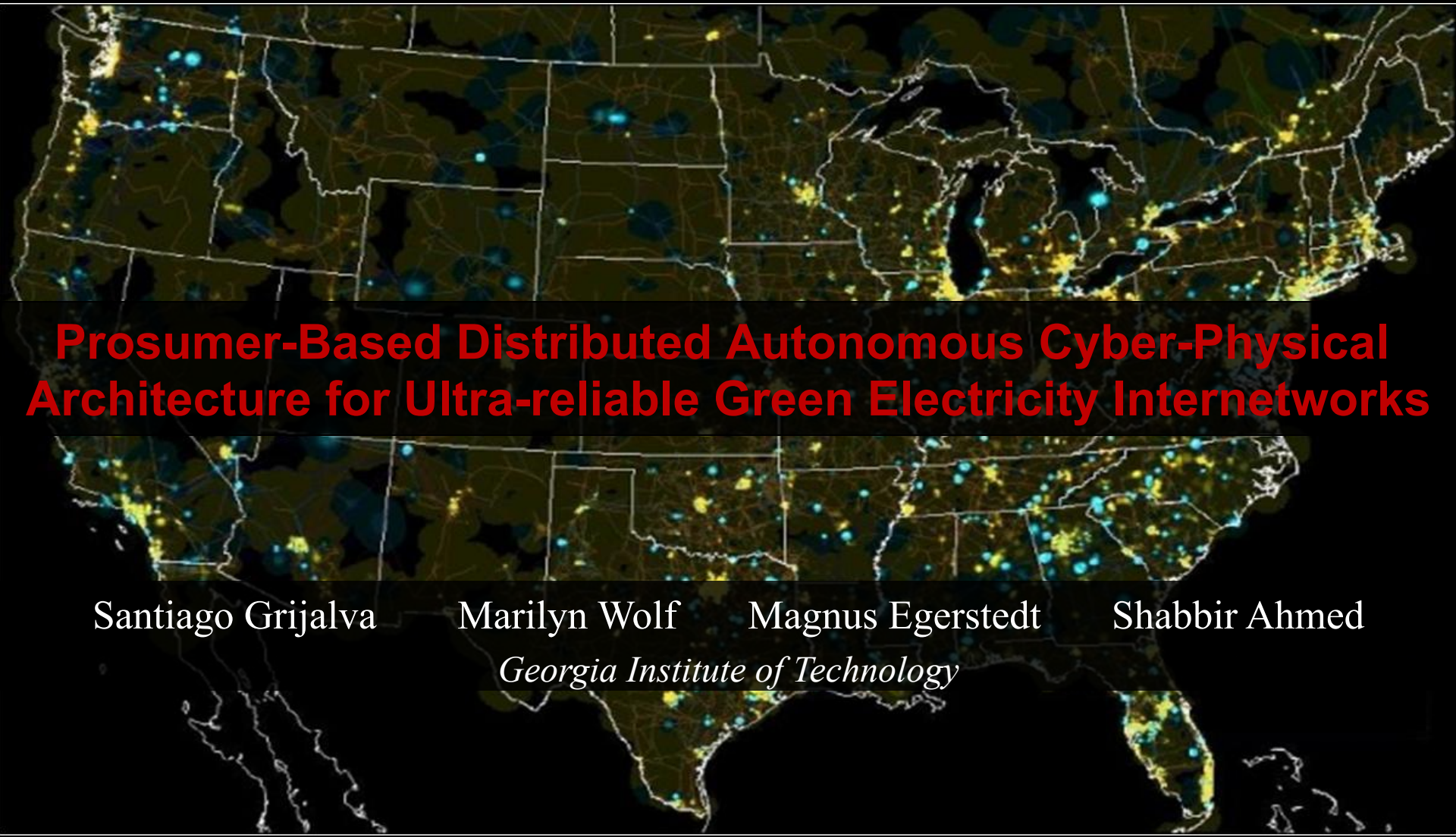
Georgia Tech ARPA-E: Energy Internet



Prosumer-Based Distributed Autonomous Cyber-Physical Architecture for Ultra-reliable Green Electricity Internetworks

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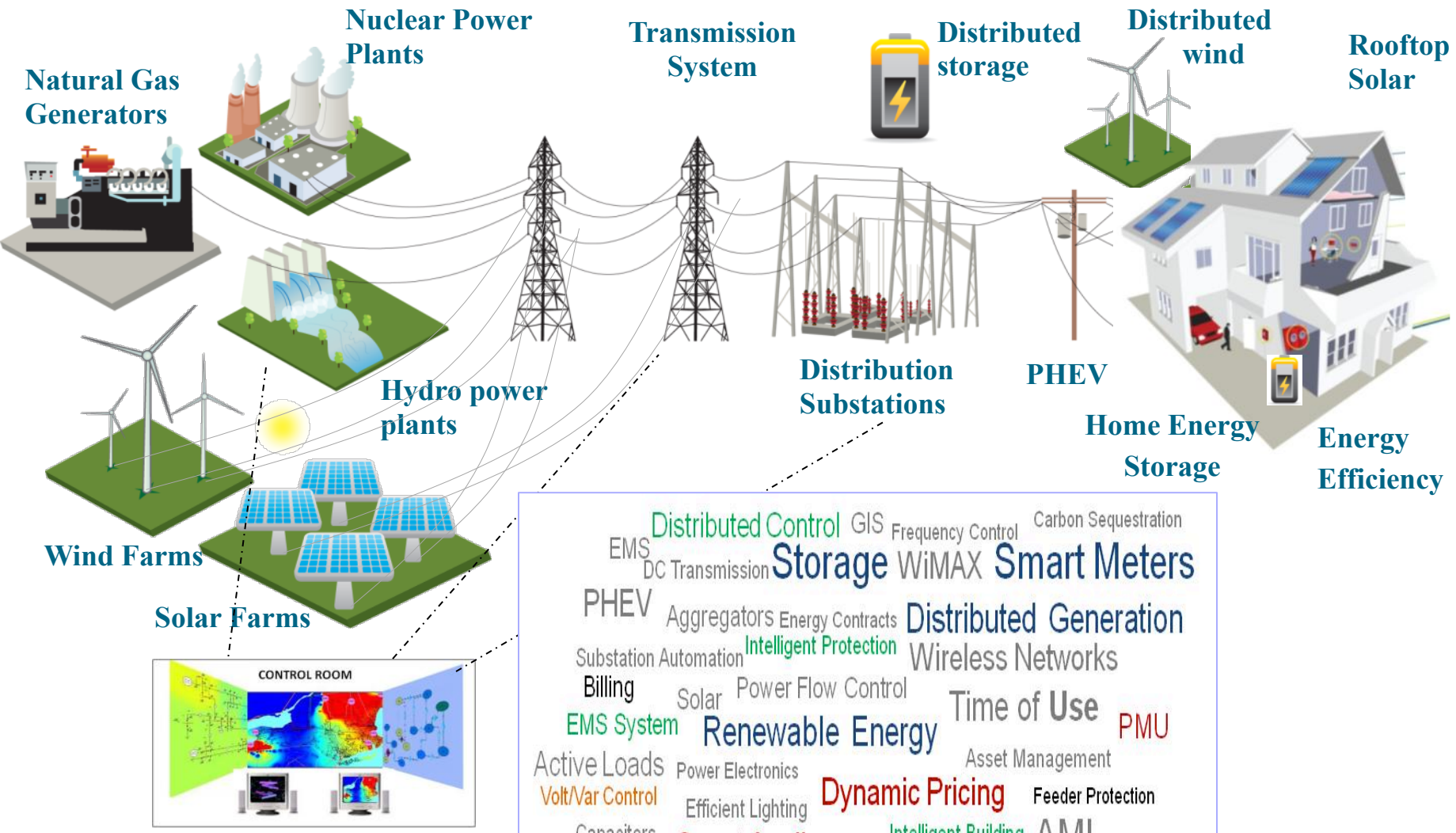
IAB Meeting 01: February 13, 2012

Agenda

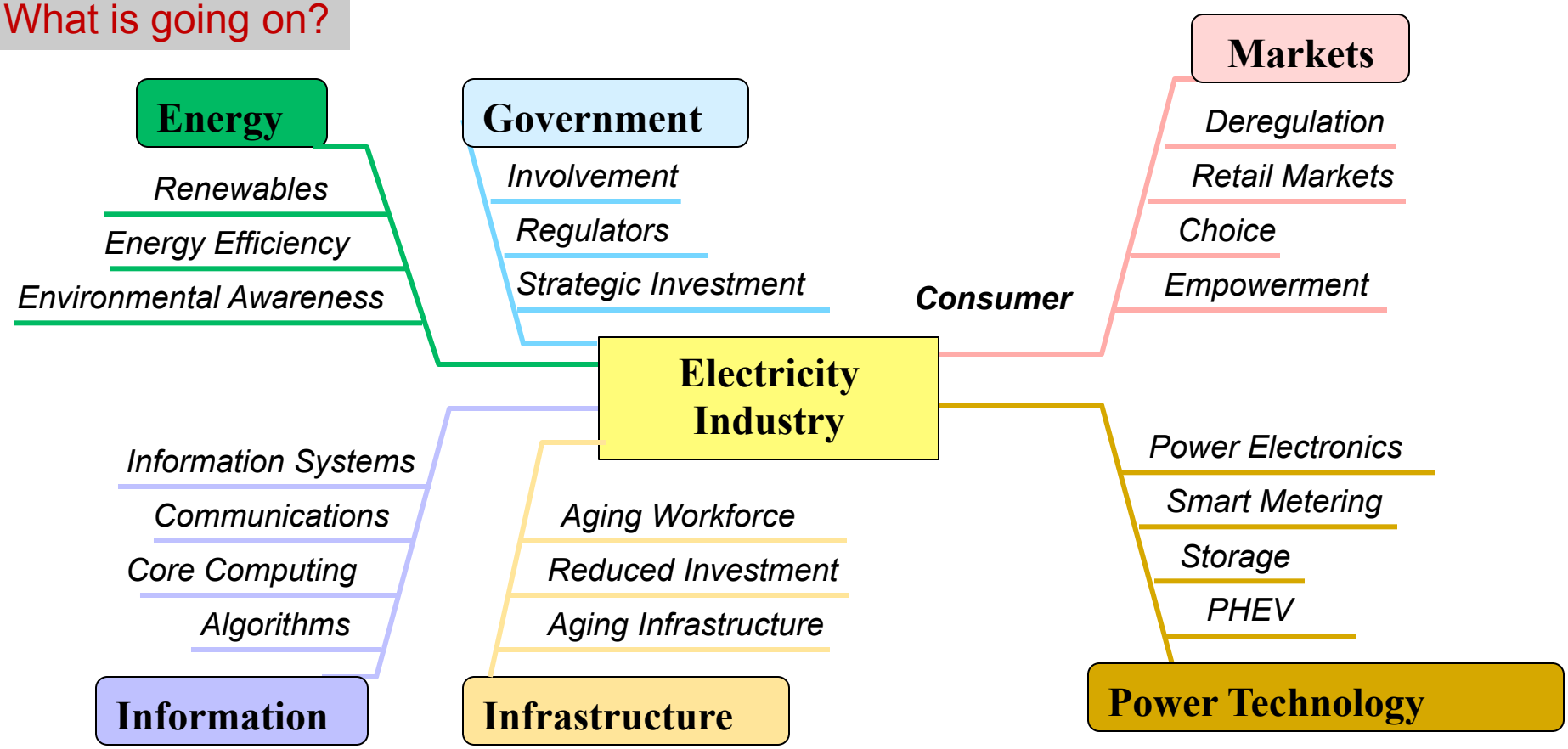
- Project Concept
- Goals:
  - Architecture
  - Interoperability
  - Grid scheduling

Emerging Grid



Smart Grid Drivers

What is going on?



There are several megatrends affecting the electricity industry. Some are game changers, some are "revolutions" on their own

Evidence of Saturation

1. Too much data is needed for operation
2. Communication bottlenecks
3. Intractable control and optimization problems
4. Some problems can't be solved even with super-computers.
5. Events can occur due to limitations of controlling large-scale renewable energy.
6. Operators complain of too much information
7. EMS, DMS system complexity continues to grow
8. Operation manuals are thousands of pages long
9. Market guides are thousands of pages long
10. Centralized infrastructure can be a security target

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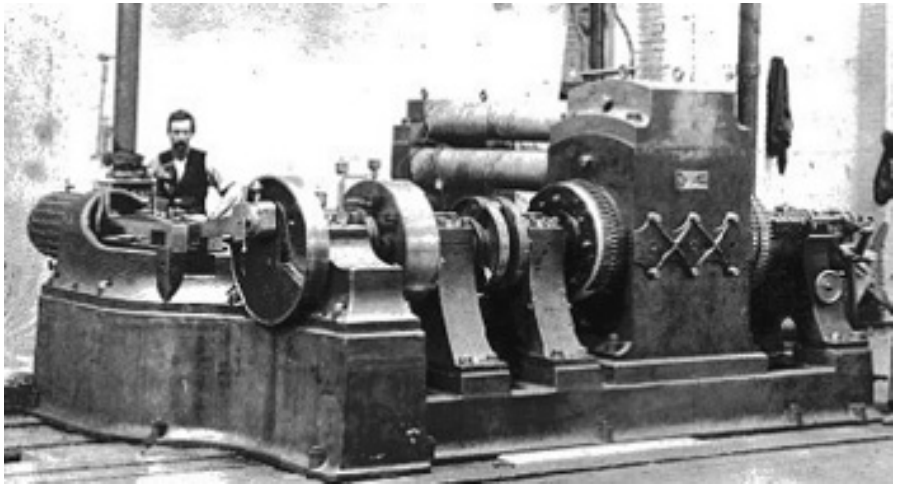
Edison's Jumbo dynamo
at Pearl Street Station



Smart Grid Components

What are we dealing with?

- Electricity infrastructure (the grid)
- Information systems including communications, cyber-security, etc
- Energy sources
- The consumer
- Specialized controls
- Electricity markets
- Policy issues
- Fringe components such as transportation, energy markets, and smart village components.

Smart Grid has several interacting elements. Smart Grid solutions must be "aware" of these elements.

Desired Smart Grid Features

What do we want to achieve?

Smart Grid Features

- Self-Healing (self-healing)
- Consumer Empowering
- 21st Century Power Quality
- Tolerant of Attack
- Variety of Generation Options
- Maturing Electricity Markets
- Optimize Assets

Consumer Needs

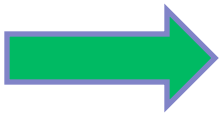
Consumer's Electricity Needs

Consumer wants:

Quantity	Enough electricity to meet its needs.
Cost	To pay as little as possible
Reliability	Reliable service
Quality	Frequency, voltage, power factor, balance, etc
Efficiency	To use electricity in an efficient manner
Sustainability	To contribute to address environmental problems
Ubiquity	Availability of power at various changing locations
Differentiation	Options and choice
Simplicity	To be hands-off

Project Key Concepts

Domain	Paradigm/Trend	Key Concept
Actors	• Consumers can also produce and store	Prosumer
Autonomy	• Consumers seek their own objectives, can be smart	Autonomous
Scope	• Devices and actors at all levels (interconnection, ISO, utility, μgrid, building, homes, appliances) can participate and "help out"	Flatness
Sources	• From fossil fuel to renewable	Green
Uncertainty	• Distributed energy is highly variable -> Source following	Stochastic
Control	• Need to control massive number of devices • Inherit limits of centralized control	Distributed
Information	• Can control entire power infrastructure through software • Increased digital control -> Cyber-physical systems • Recognition of privacy and cyber-security issues	Cyber-control
Security	• Need of increased/customized reliability	Ultra-reliable



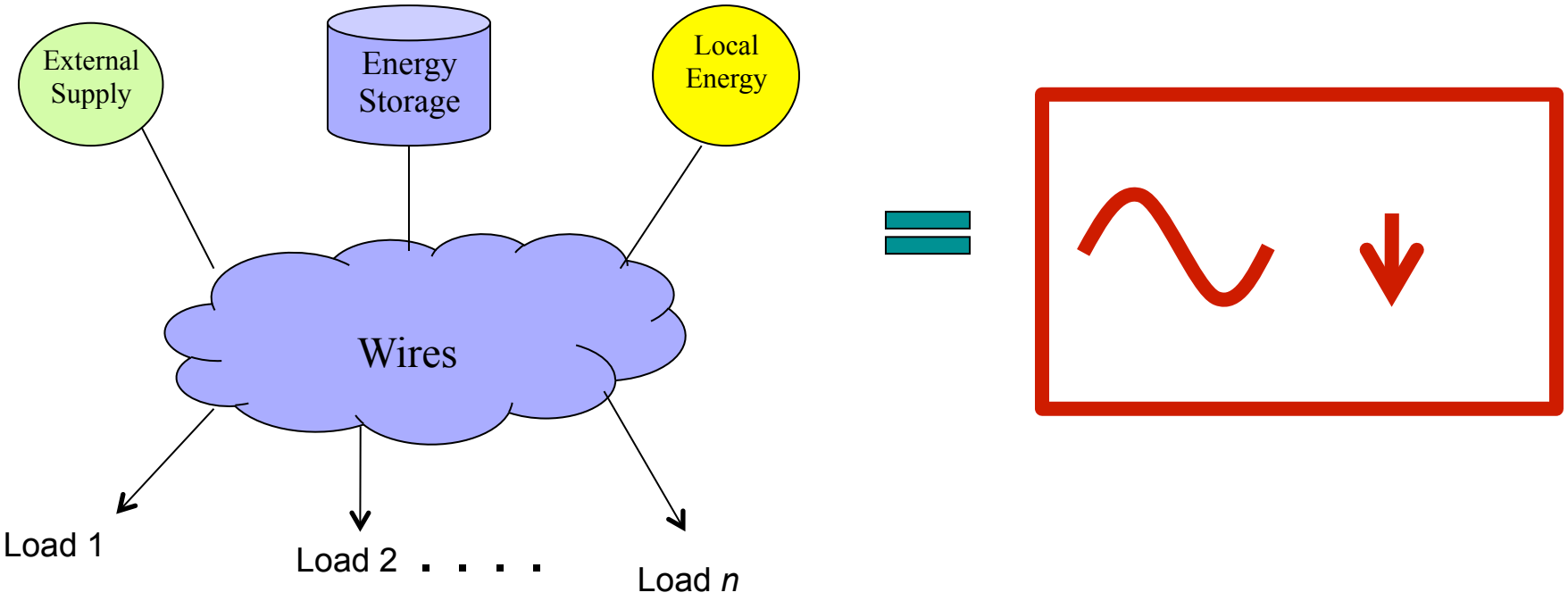
"Prosumer-Based Distributed Autonomous Cyber-Physical Architecture for Ultra-reliable Green Electricity Internetworks"

Project Objectives

- In this project we will demonstrate a distributed control architecture for resilient, reliable, and cost-optimizing utility systems, capable of integrating large-scale renewable energy up to 40%.

1. Consolidate and demonstrate *the architecture* that will allow the electricity industry to operate with characteristics similar to the internet: Distributed, Flat, Layered, Scalable
2. Develop and demonstrate in large-scale using realistic data, a *distributed services cyber- infrastructure* that supports prosumers interaction. This cyber-infrastructure can be understood as an "Electricity Grid Operating System".
3. Develop and demonstrate in large-scale, using realistic data, a stochastic *prosumer energy scheduler*

Prosumers



- A generic model that captures basic functions (produce, consume, store, etc.) can be applied to power systems at any scale.

Prosumer Needs =

Consumer's Needs

(Already discussed)

+ *Producer Needs*

Access
Cost
Grid Reliability

- Standard connection to the grid
- To be paid as much as possible
- Grid reliability

+ *Grid Operator Needs*

OP Framework
OP Models/Info
Control System
OP Intelligence

- Operational Goals and Framework
- Models, Data, and Real-Time Information
- Control System
- Analytics and Decision Making

+ *Market Operator Needs*

MK Framework
MK Models/Info
MK System
MK Intelligence

- Economic Goals, Framework, and Standards
- Models, Rates, Costs, Offers and Bids
- Market System
- Analytics and Decision Making

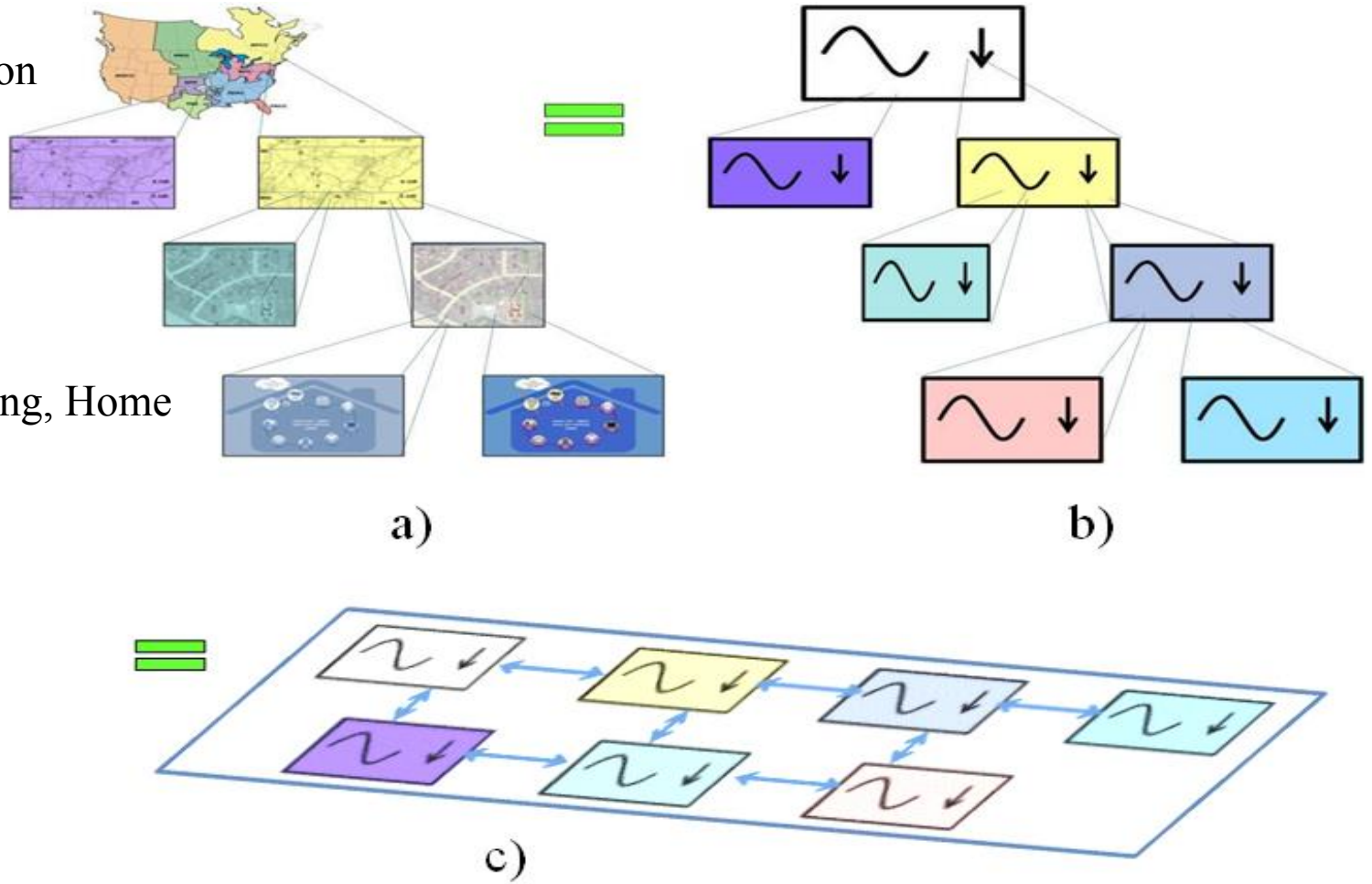
Flat Industry

Interconnection

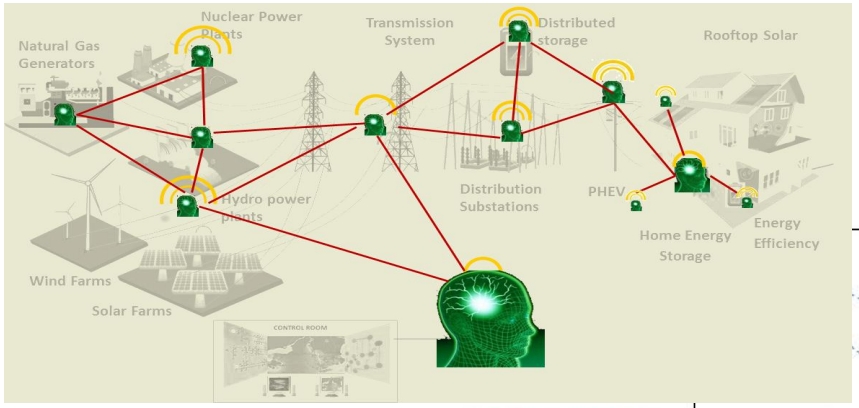
ISO

Utility

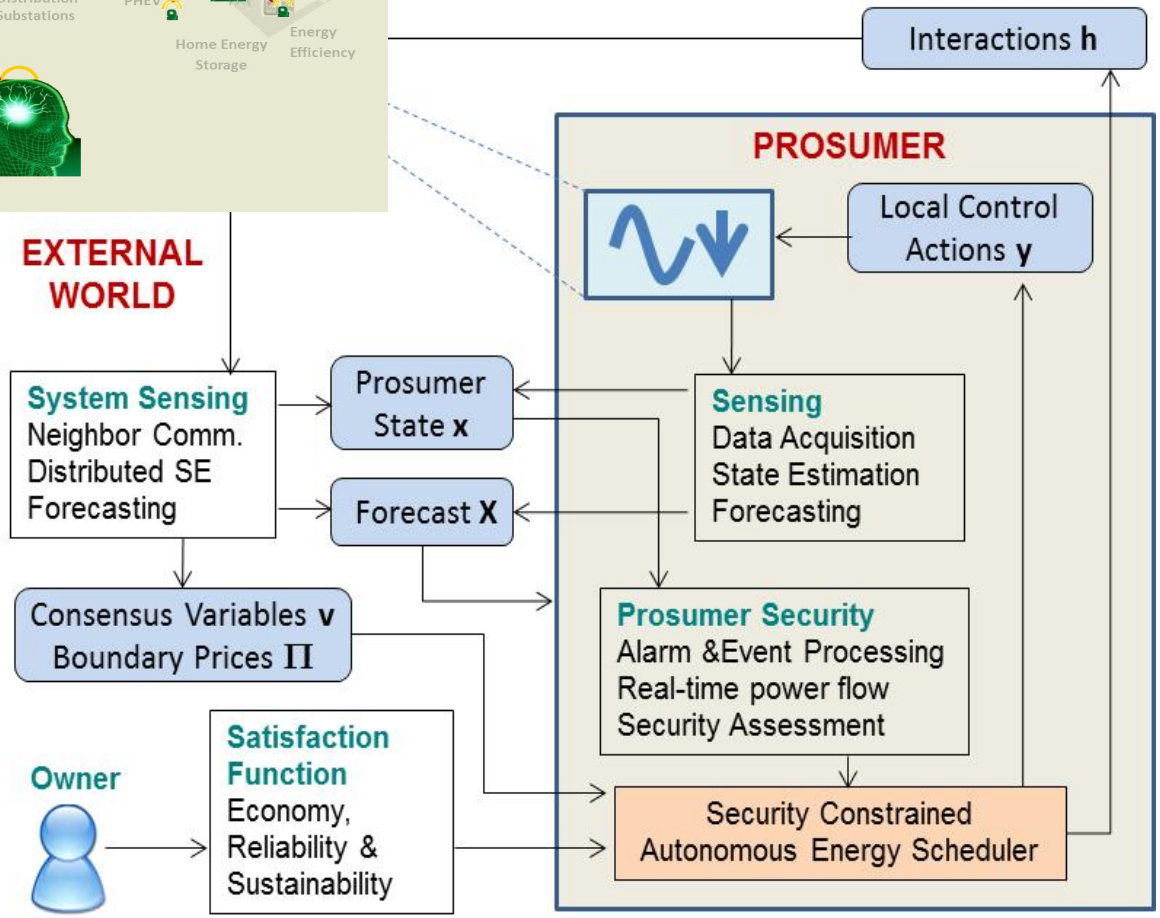
µGrid, Building, Home



Prosumer Interactions



- Interactions will leverage recent developments in networked and autonomous control.



Layered Control Architecture

OWNER/
OPERATOR

PROSUMER AGENT

Market
- MKT Engine
- MKT-USR Interface
- MKT-SC Interface

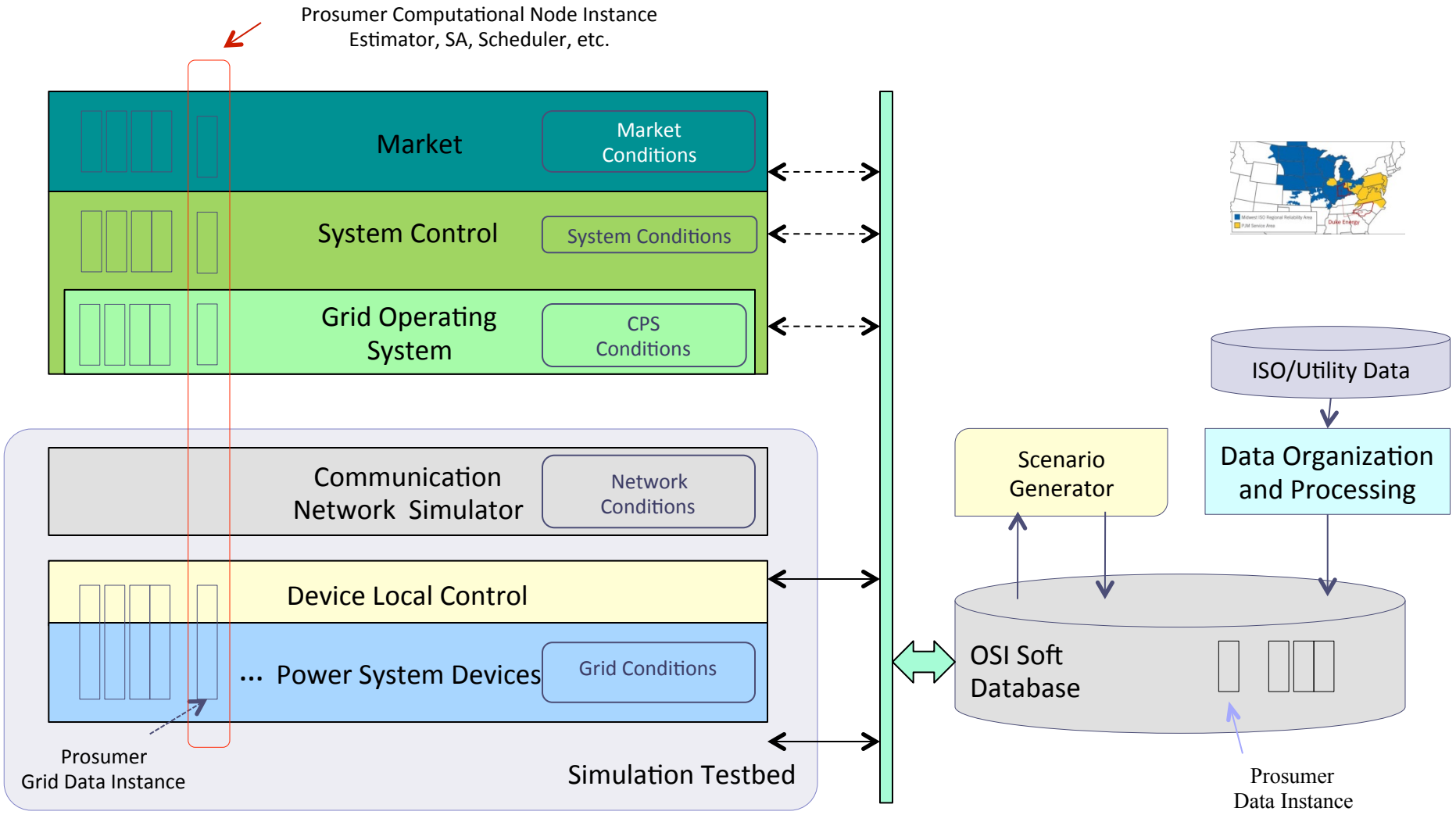
System Control
- SC
- SC-MKT Interface
- SC-COM Interface

Communication
- COMM
- COMM-SC Interface
- COMM-LCTRL Interface
- Communication Interface

Local Control
- LCTRL
- LCTRL-COM Interface
- LCTRL-DEV Interface

Power Device
- DEV
- DEV-LCTRL Interface
- Power Device Connection Interface

Demonstration System



Smart Grid Creation Process

How are we going to do it?