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Weather, Carbon and Microgrids:
How Resiliency and Renewables Integration can be achieved through Commercially Viable Design

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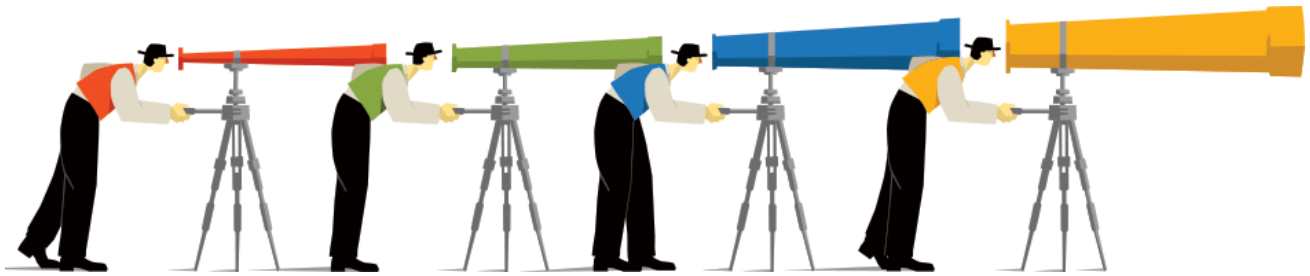

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October 13, 2015

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Abstract

Weather, Carbon and Microgrids: How Resiliency and Renewables Integration can be achieved through Commercially Viable Design.

Could microgrids be a key to decarbonizing our electricity grid while ensuring near-perfect service reliability? The presentation will first examine resilient microgrids within the larger context of microgrid investment drivers and the outlook for the future of the microgrid industry and electricity grid as a whole.

Part of this larger context is the increasing public and private investment in microgrids in the United States, especially in the Northeast. Microgrids are a modern energy delivery solution specifically designed to respond to climate change. Small grids can increase the resilience of the "smart electricity grid" and serve as one response to the increasing frequency and severity of severe weather events. Microgrids are both adaptive, since extreme weather events create long duration power outages, as well as preventative, since microgrids typically reduce the overall carbon footprint of electric energy consumption through their advantaged incorporation of renewable energy sources.

Navigant has developed a model that highlights the value streams individual microgrids provide to society, including non-monetized values (such as resiliency) that can help justify public subsidies otherwise considered necessary to finance these projects under current market conditions. This model identifies potential future revenue streams and hidden commercial risks that can enhance the microgrid value proposition and enable these projects to be financially viable.

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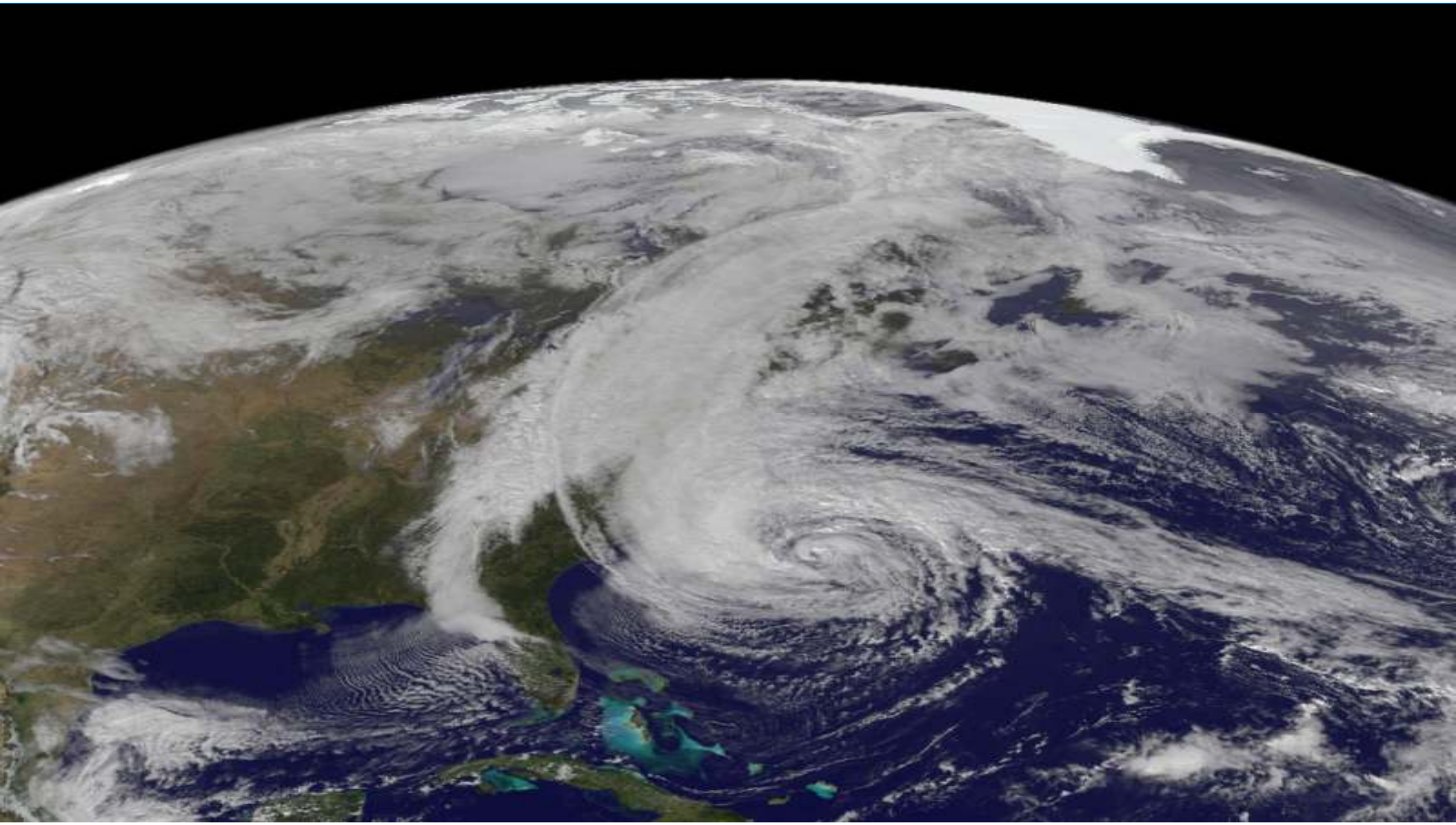


SPECIAL SANDY EDITION
The Star-Ledger
HISTORIC
DEVASTATION


medstar
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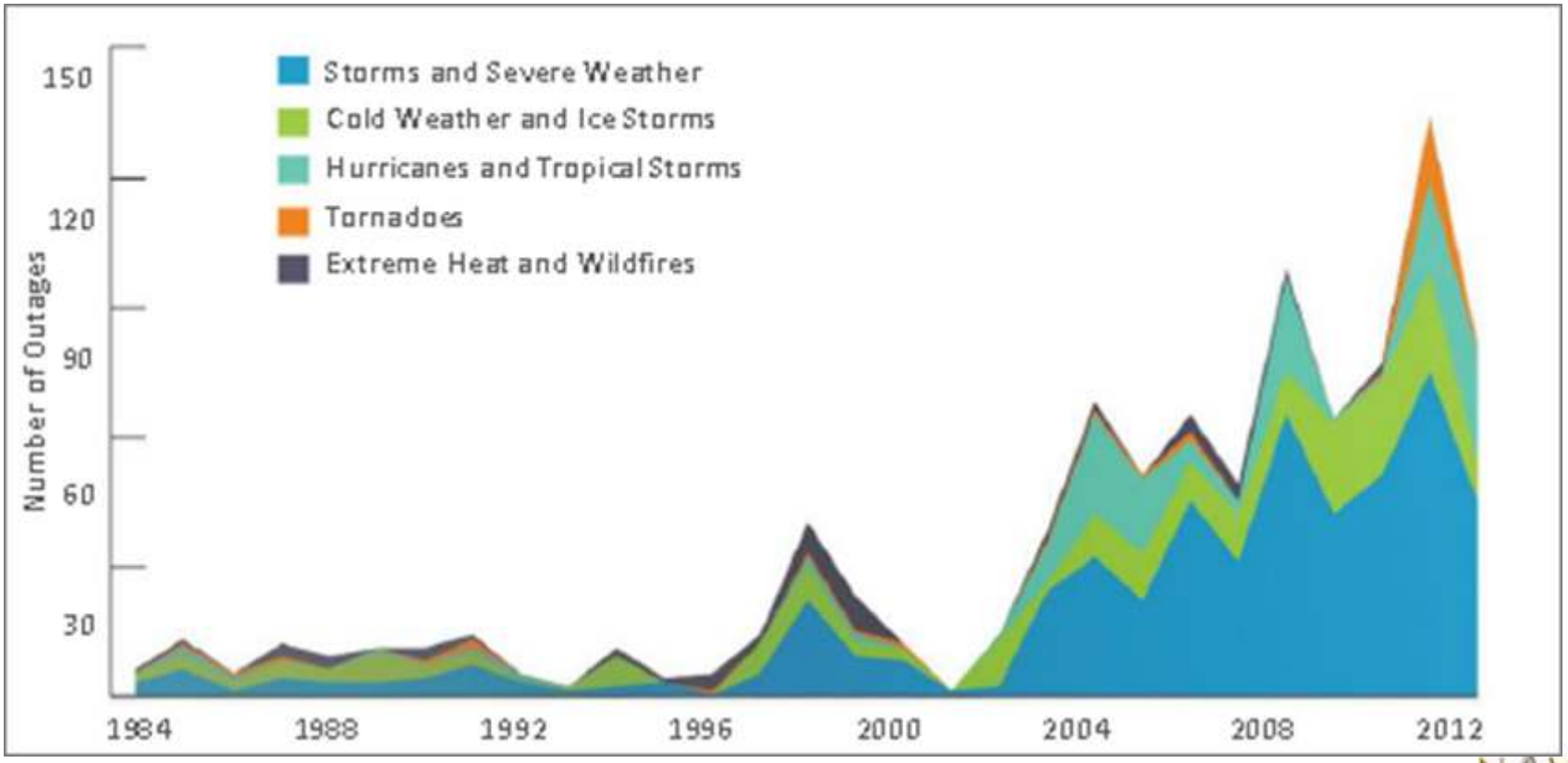
NEW YORK POST
Page Six
ABUSE OF
POWER
These massive generators are providing electricity to the marathon's tent in Central Park ... while NYers suffer!


HURRICANE CENTRAL
SANDY POWER OUTAGES
POSSIBLE
LIKELY

Mega Driver: Climate Change and Demand for Resiliency

Power Outages Affecting 50,000 Customers Caused by Extreme Weather
United States: 1984-2012



(Source: National Oceanic and Atmospheric Administration)

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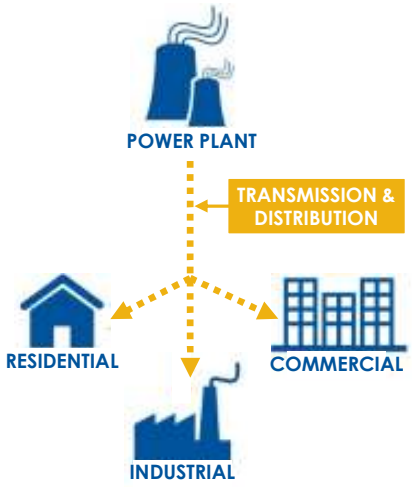
The Energy Cloud Transformation

TODAY: ONE-WAY POWER



EMERGING: THE ENERGY CLOUD

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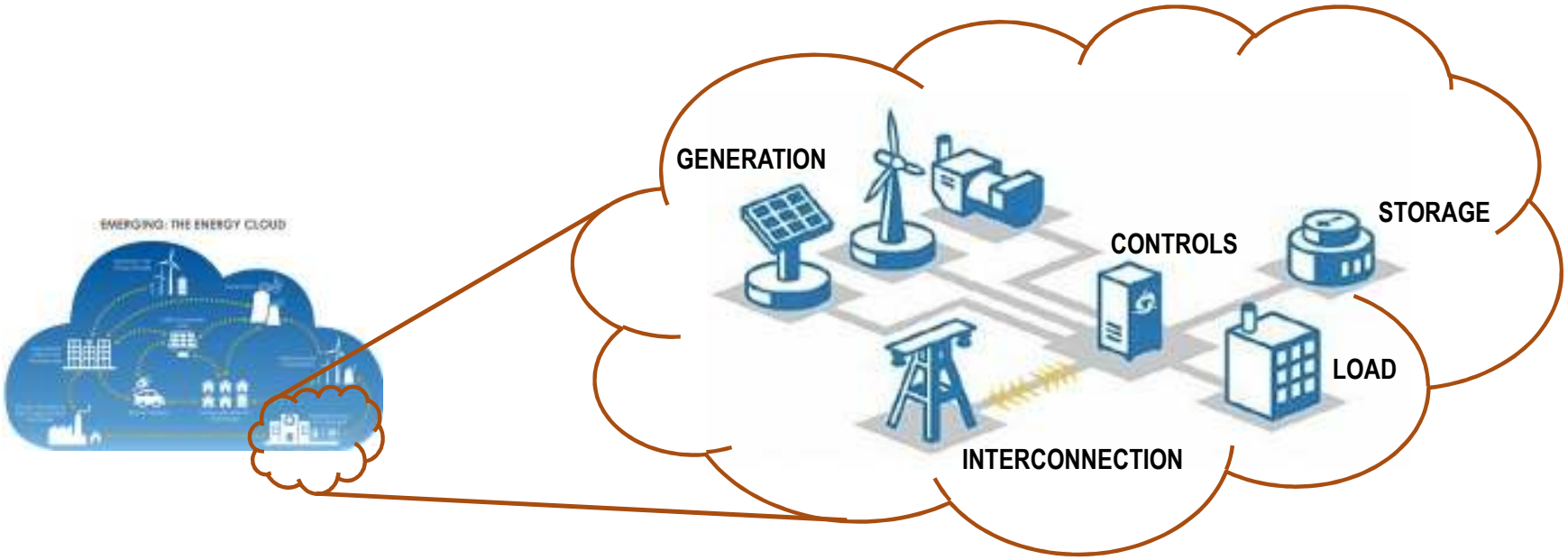
Microgrids: A Microcosm of the Energy Cloud

EMERGING: THE ENERGY CLOUD

NOW: MICROGRIDS



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Defining "Microgrid"

Market Scope

U.S. Department of Energy: *"An integrated energy system consisting of distributed energy resources (DER) and multiple energy loads operating as a single controllable entity in parallel to or islanded from the existing power grid"*

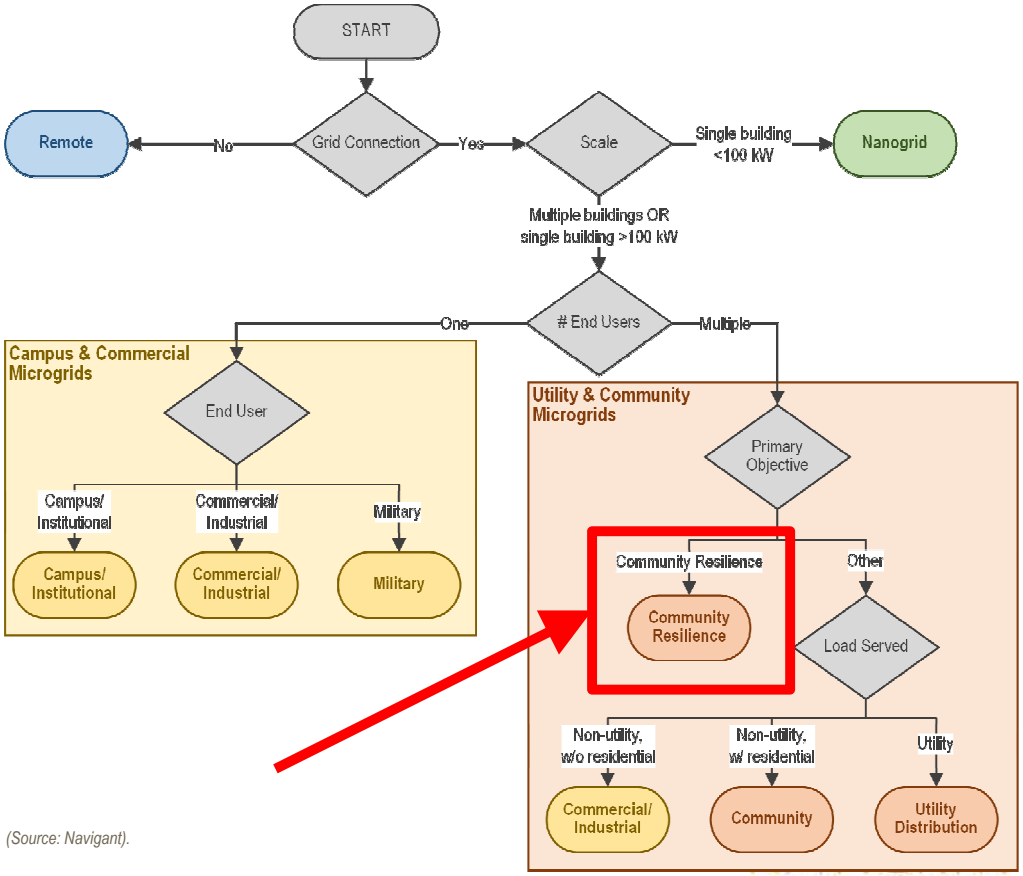
+

Off-grid / remote microgrids

+

Planned/Proposed + Operational

Classification Taxonomy

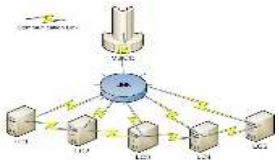


(Source: Navigant).

Community Resilience Microgrids – Drivers and Growth

Adoption Drivers

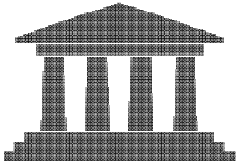
Technology



Weather

DG

Regulation

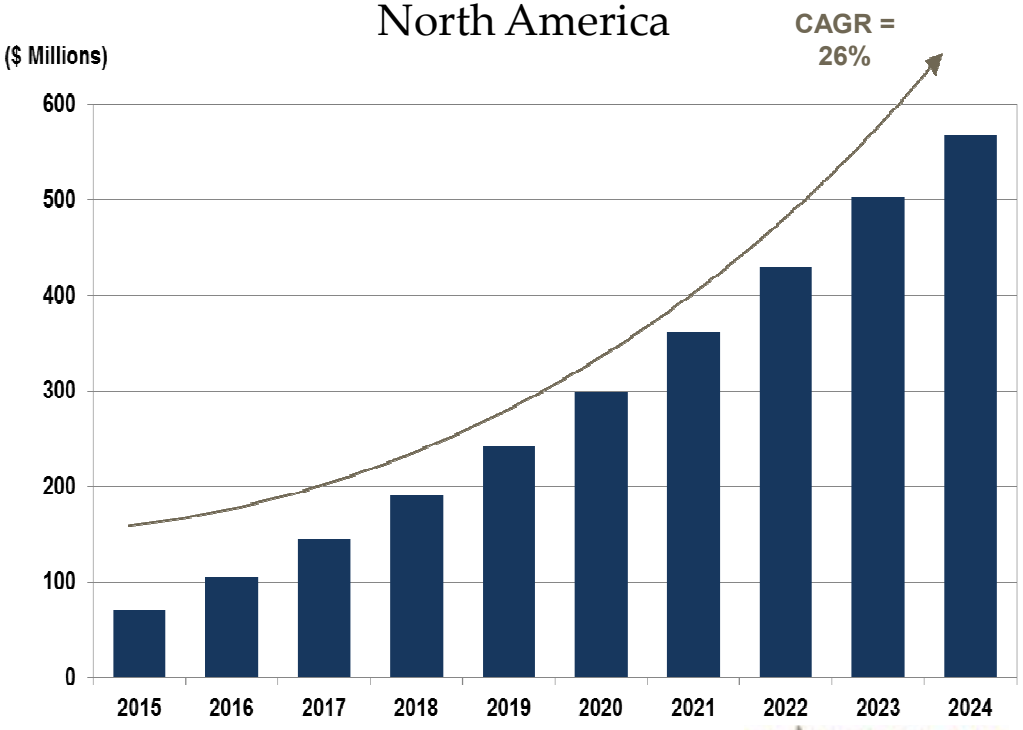


Customer Demand

Incentives

Projected Growth

Community Resilience Microgrid
Market Revenue Forecast
North America



(Source: Navigant Research)

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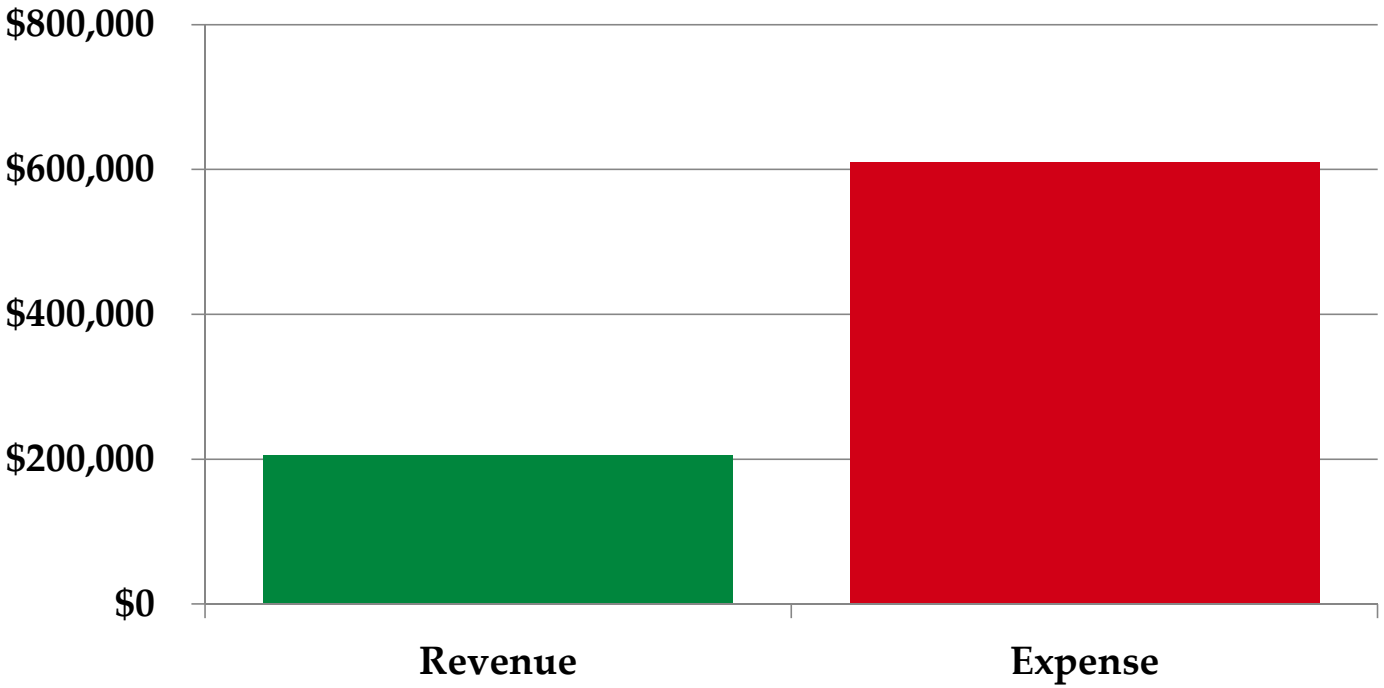
Annual Income Statement
"Typical" 2.5 MW CRM



(Source: Navigant)

Key Assumptions

- 2.5 MW – PV + NG Turbine
- PV Capacity Factor: 25%
- Islanded Op Duration: 2 weeks
- Value of Electricity: $0.15/kWh
- Value of Natural Gas: $4/MMBtu
- Capital Cost: $2MM/ MW
- Debt Finance: 100%
- Note Term: 20 years
- Interest Rate: 5.2%

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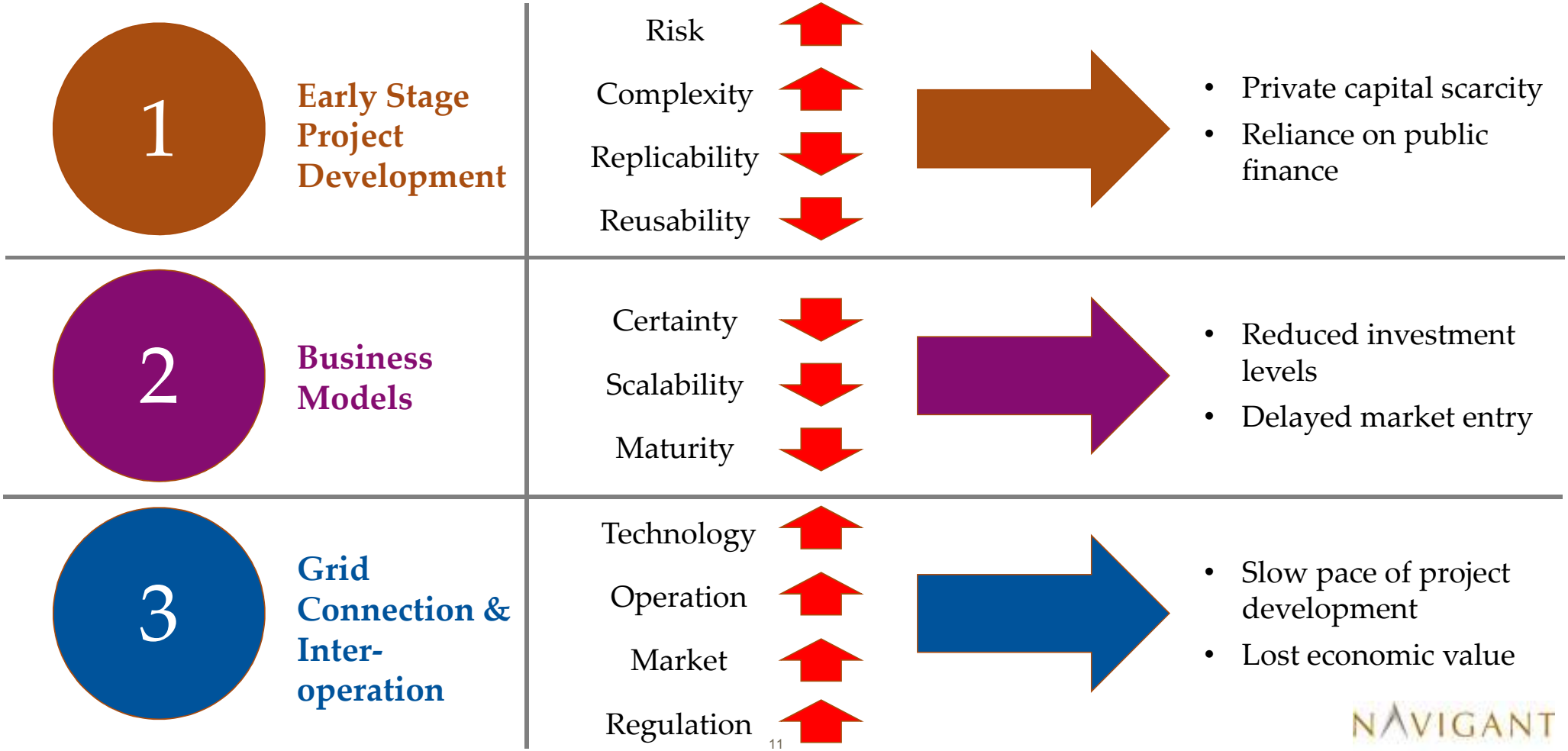
Challenges to Microgrid Market Participation



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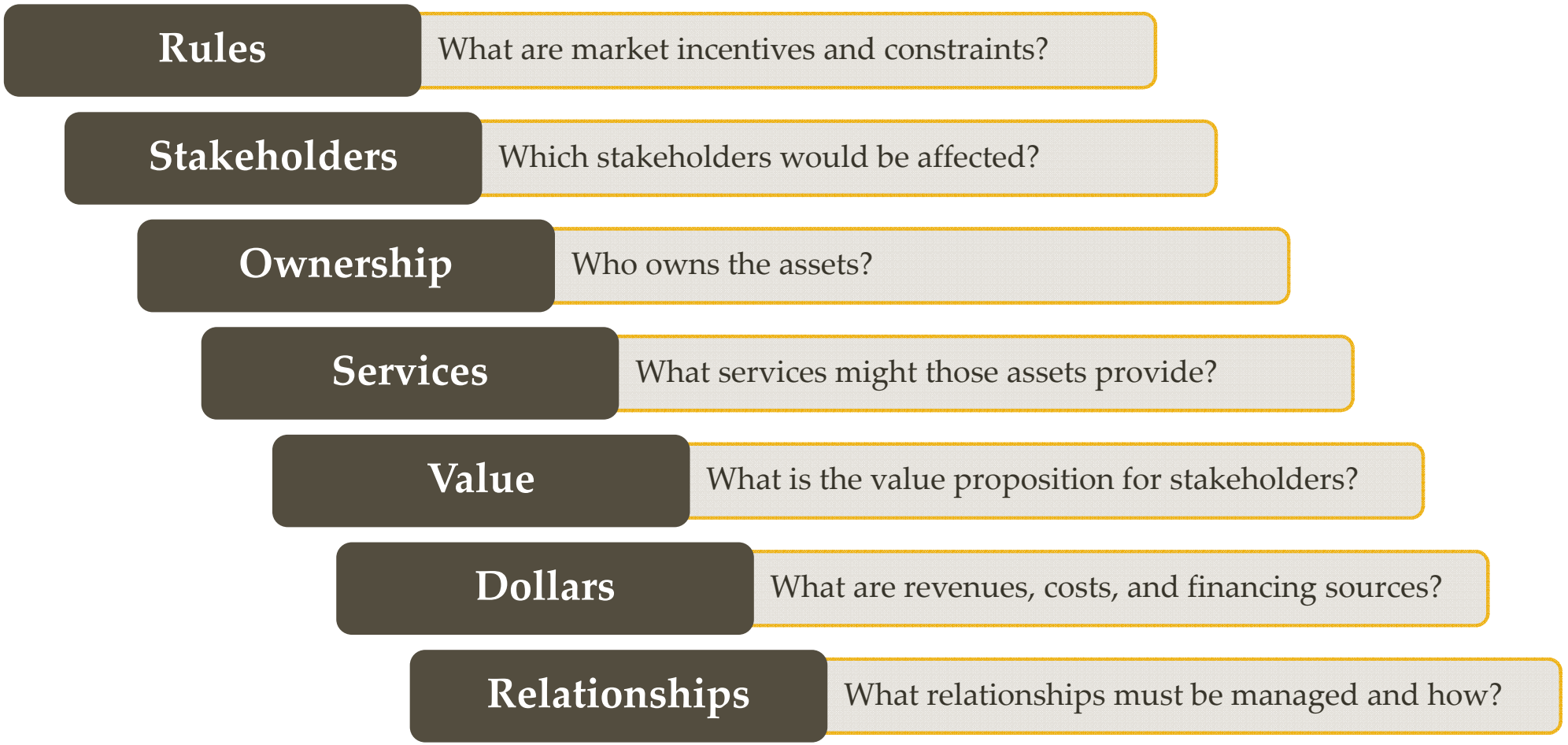
Microgrid Commercial Viability Questions



Microgrid Roles and Value Creation Streams

Microgrid Role Groups

User	Microgrid	Macrogrid
User DER assets and loads	Operation, assets & owner	Distribution, transmission and wholesale participants

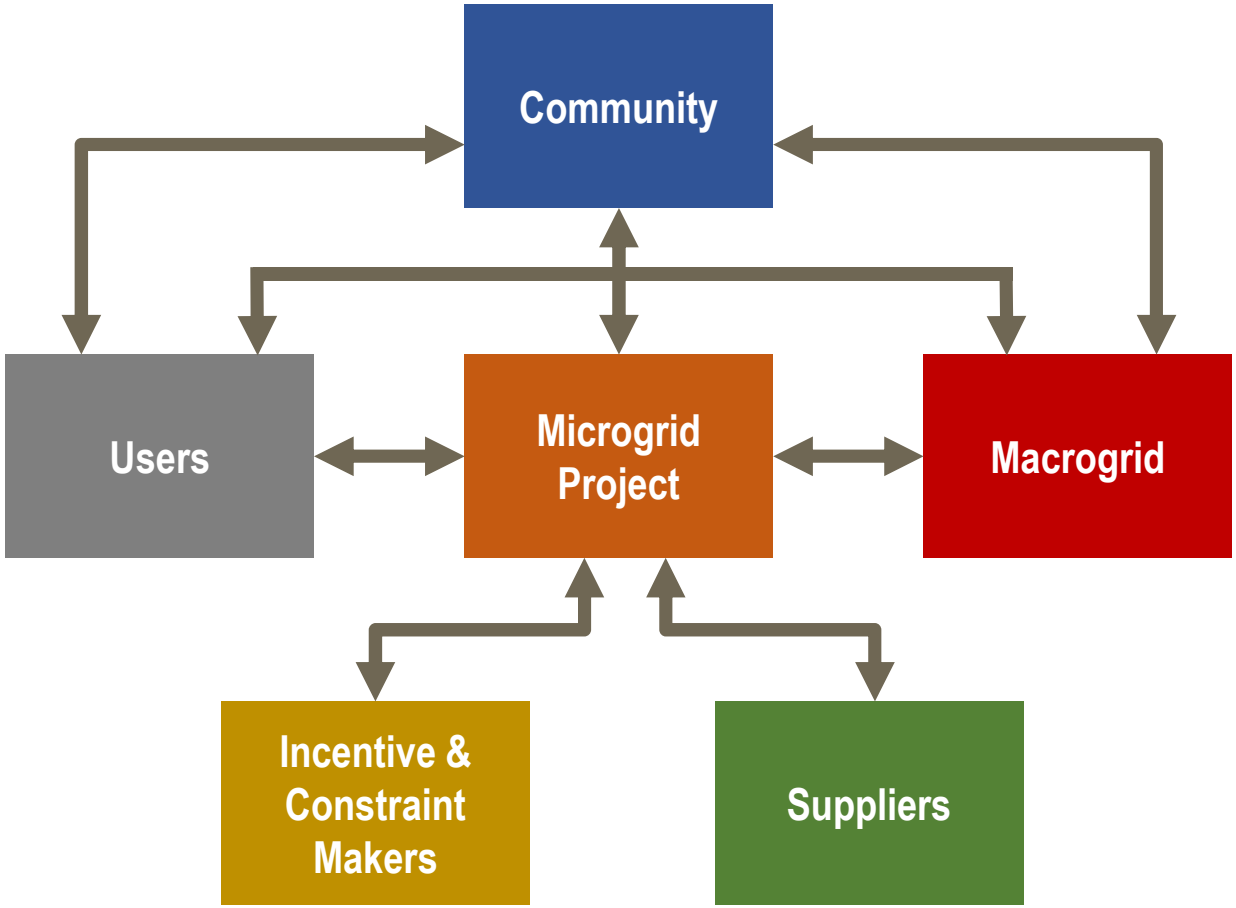
Incentives and Constraint Makers	Community	Suppliers
Government and markets	Residents, rate payers, taxpayers and voters	Capital, equipment, labor, O&M services, engineering

Microgrid Value Streams

Energy	Electrical and thermal generation and consumption
Money	Monetary exchange
Services	Services to implement or resulting from the microgrid
Impacts	Other qualitative or indirect affects
Relationships	Formal or informal agreements

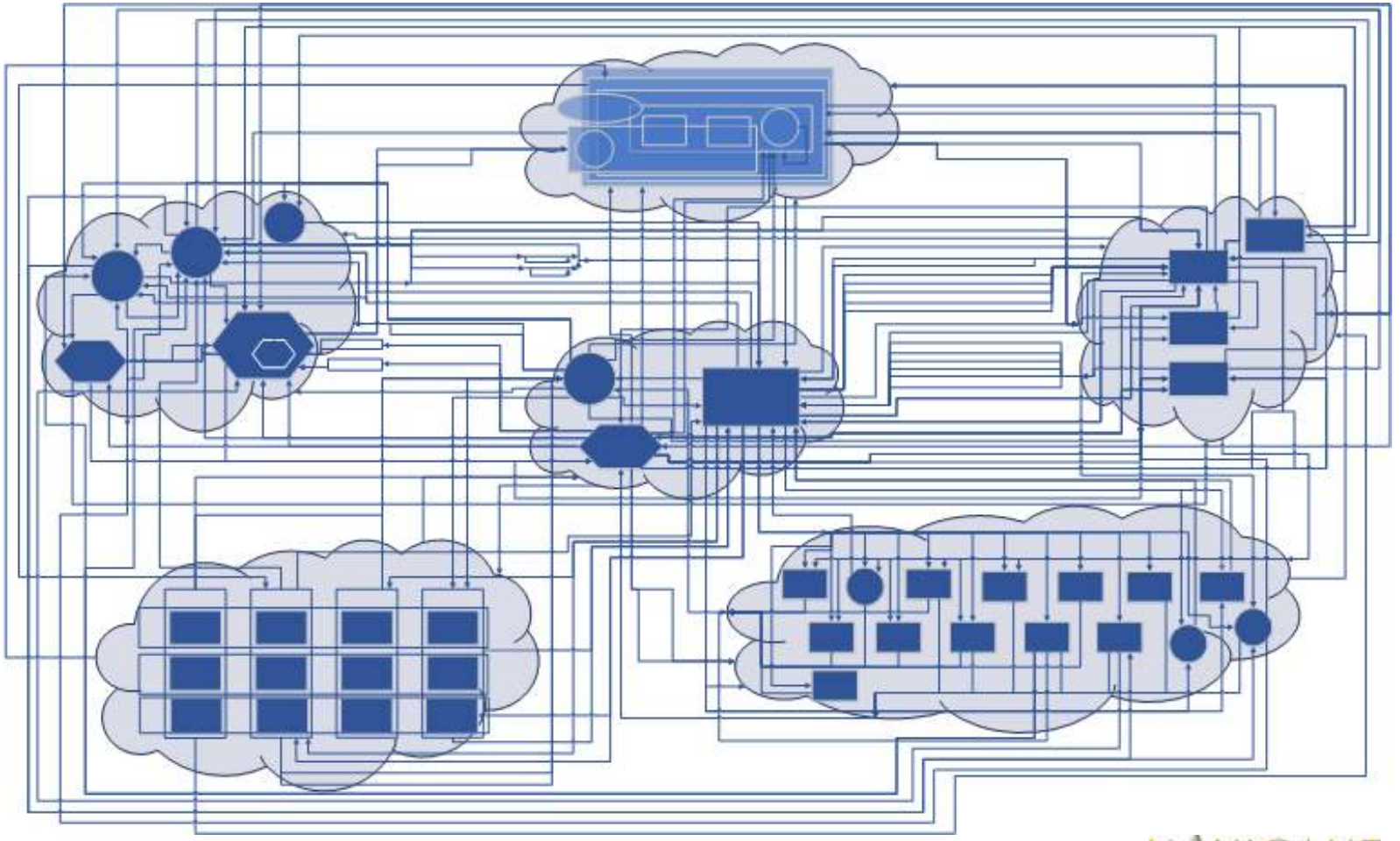
Microgrid Ecosystem Model

- This **microgrid ecosystem model** has 6 role groups and includes 5 value stream categories
- This model may be used to define a distributed energy resource **project, business or market**



Complex Choices

- The realm of microgrid product / service offering possibilities is **complex**
- There are 300+ ecosystem design element **choices**



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