21st Century Power Partnership

An Initiative of the Clean Energy Ministerial

Dr. Douglas Arent
National Renewable Energy Laboratory
Operating Agent for the 21CPP

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

21CPP Mission

Accelerating the transition to clean, efficient, reliable, and cost-effective power systems.

- **Renewable Integration**
- **Smart Grid**
- **EE & Demand Response**

→ **Cross Cutting Issues:** Operations, Transmission, Market Design

→ **Coordinated Power System Planning, Policy, and Regulation**

Elements of Power System Transformation

21CPP Activities

The Partnership aims to advance integrated policy development through four areas of activity:

Faster Learning	**Developing and sharing knowledge** on key topics related to power system transformation.
Better Tools	**Strengthening and disseminating technical tools** to accelerate policy and regulatory analysis.
Capacity Building	**Bolstering the capacity of experts** to advance the policies, programs, and practices.
Meaningful Partnerships	**Establishing applied multilateral partnership engagements** to leverage knowledge, tools, and capacity.

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

21CPP Organization

Clean Energy Ministerial

21st Century Power Partnership Steering Group (PPSG)

Membership open to both CEM- and non-CEM government participation, as well as civic society organizations and private firms. Membership implies in-kind or direct resources to craft and implement annual Program of Work.

Annual Program of Work

Operating Agent

(NREL/JISEA)

Public-Private Leadership Forum (PPLF)

Private sector participation to inform and assist in implementing the Annual Program of Work.

POWER SYSTEMS OF THE FUTURE

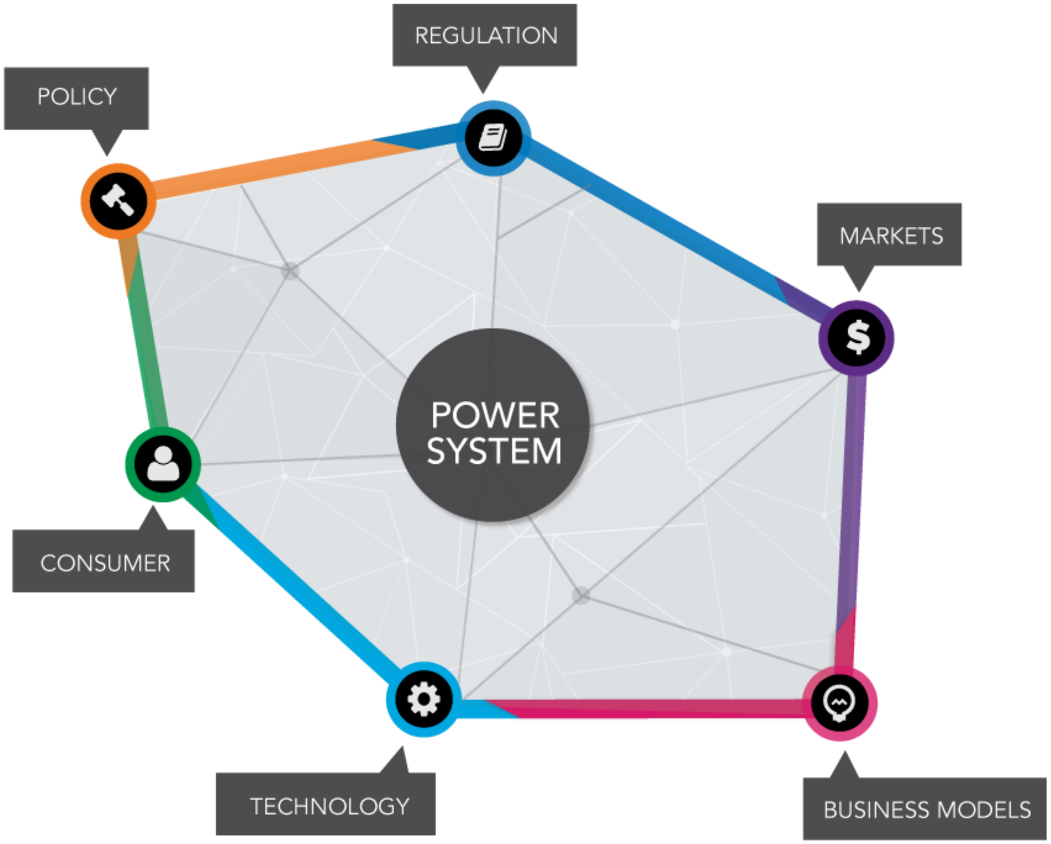
A 21ST CENTURY POWER PARTNERSHIP THOUGHT LEADERSHIP REPORT

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

21st Century POWER PARTNERSHIP
Accelerating the transformation of power systems

A Holistic Approach to Power Systems

- Power systems as *complex dynamic systems*
- Power systems are evolving around the world



NREL
NATIONAL RENEWABLE ENERGY LABORATORY

TRENDS DRIVING POWER SYSTEM EVOLUTION

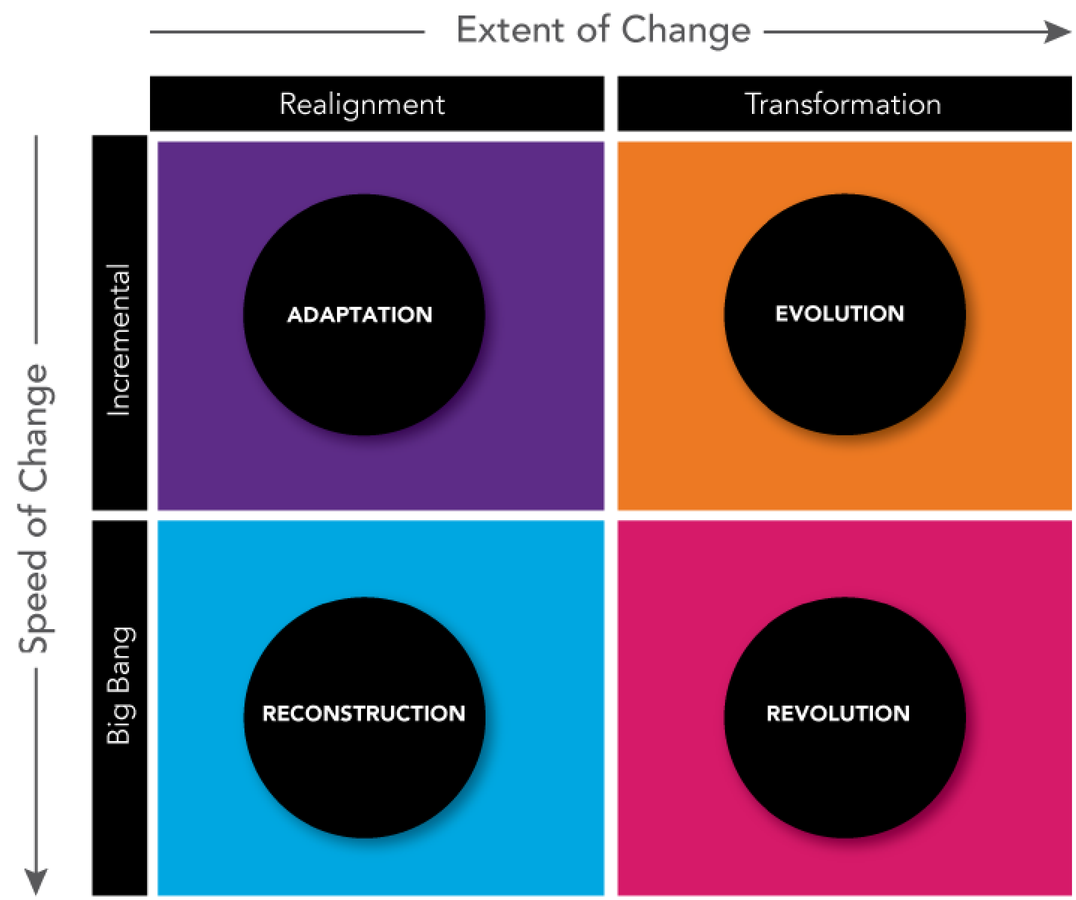
1. Renewable energy cost reductions
2. Data, intelligence, and system optimization innovations
3. Energy security, reliability, and resilience goals
4. Evolving customer engagement
5. A tale of two electricity demand forecasts
6. Increased interactions with other sectors
7. Local and global environmental concerns over air emissions
8. Energy access imperatives
9. Increasingly diverse participation in power markets
10. Revenue and investment challenges.

Deliberate and proactive collaboration is needed to encourage desired futures.

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

A FRAMEWORK FOR DECISION MAKING

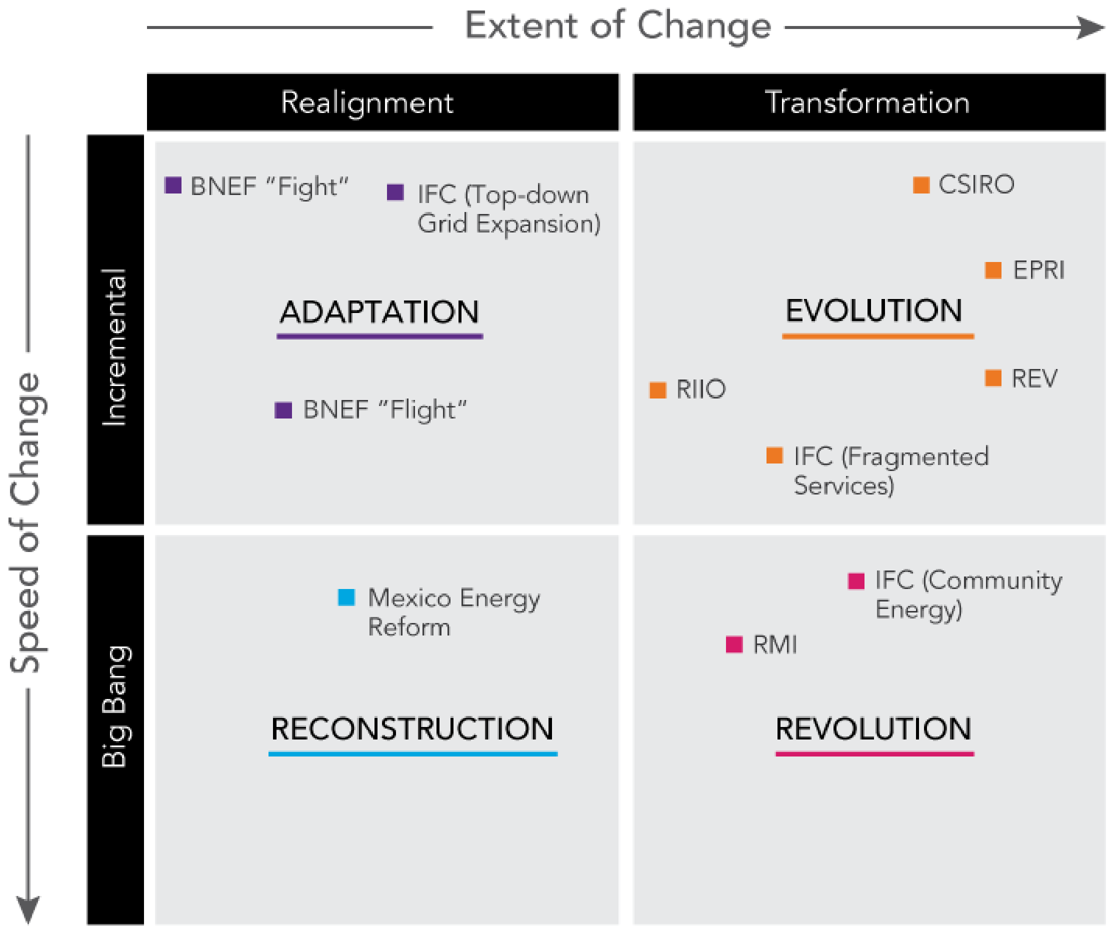
- **Evolution is path-dependent**
  - Technological, financial and institutional legacies
  - *Heavier legacies*: cautious incrementalism
  - *Lighter legacies*: more rapid change.



Types of Strategic Change*

*Adapted from Hope Hailey, V.; Balogun, J. (2002). "Devising Context Sensitive Approaches To Change: The Example of Glaxo Wellcome." *Long Range Planning* (35:2); pp. 153-178.

A Survey of Literature on Power System Transformation



Illustrative Landscape of Reports on Emerging Power System Models

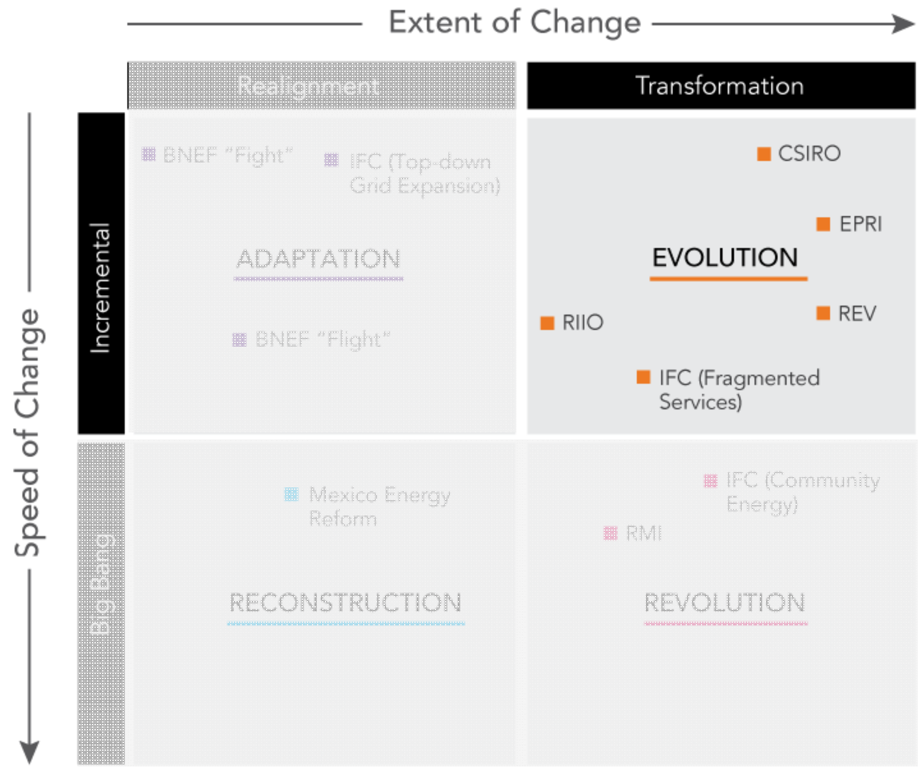
Increasingly heterogeneous landscape with high levels of context-specificity

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

EVOLUTION

Incremental yet dramatic change over 10-20 years

- *RIIO* [4]
  - Performance-based incentive and revenue cap regulation
- *IFC (Fragmented Services)* [2]
  - Reliance on small-scale energy providers
- *CSIRO* [5]
  - Large-scale “prosumer” diffusion
- *EPRI* [6]
  - Fundamental changes to the role of the central grid, and associated investment/operational frameworks
- *REV* [7]
  - NY state plan to establish retail market and technical/financial integration of DERs



4. Office of Gas and Electricity Markets (OFGEM). (2010). “RIIO –A New Way to Regulate Energy Networks.”

5. Commonwealth Scientific and Industrial Research Organisation (CSIRO). (2013). *Change and Choice: The Future Grid Forum’s analysis of Australia’s Potential Electricity Pathways to 2050.* Clayton South Victoria, Australia: CSIRO.

6. Electric Power Research Institute (EPRI). (2014). *The Integrated Grid: Realizing the Full Value of Central and Distributed Energy Resources.* Palo Alto, CA: EPRI.

7. New York Department of Public Service (NY-DPS). (2014). *Reforming the Energy Vision: NYS Department of Public Service Staff Report and Proposal*. Case 14-M-0101. Albany, NY: NY-DPS.

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

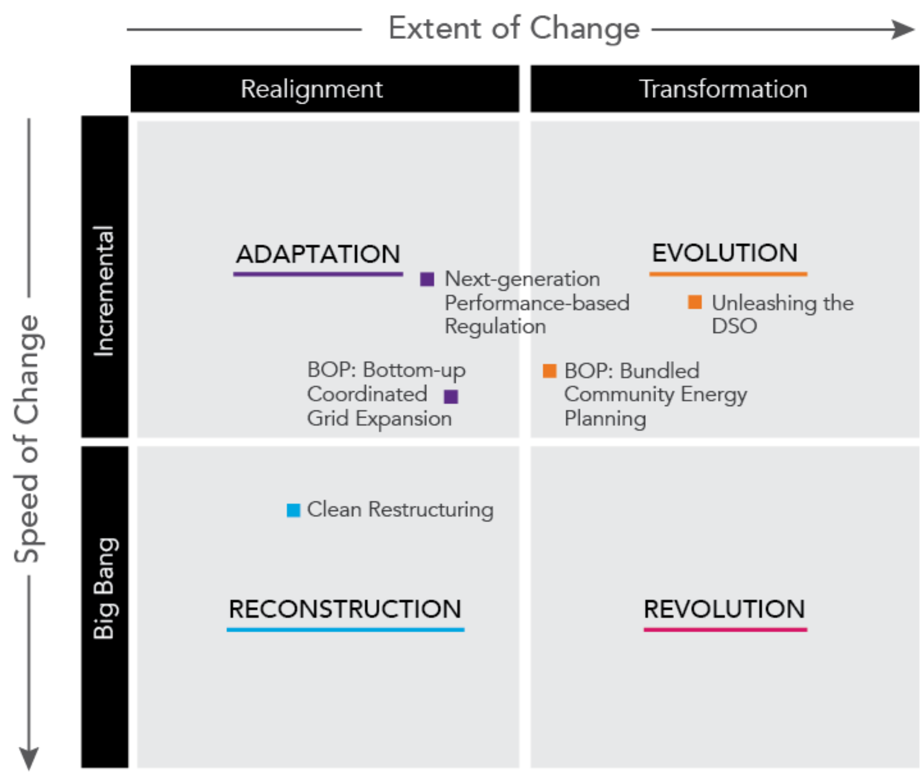
In Focus: Power Sector Finance

Nine key variables influencing the evolution of investment trends in the power sector

- *Regulations on Commercial Banking Risk*
- *Risk Premium Environments for Investment*
- *Interest Rates on Government Bonds*
- *Capital Availability from Development Authorities*
- *Tax Structures*
- *Credit Rating of Electric Utilities*
- *Price and Availability of Inputs*
- *Market Structure and Valuation Constructs*
- **Policy and Regulatory Environment.**

Five archetype pathways toward power system transformation

- Next-generation Performance-based Regulation
- Clean Restructuring
- Unleashing the DSO
- Bottom-of-the-Pyramid (BOP) Bottom-up Coordinated Grid Expansion
- BOP Bundled Community Energy Planning



STARTING POINTS

Present Status	Adjacent Pathways
VERTICAL INTEGRATION • Little or no power market restructuring • Utility as single-buyer	Next Generation Performance-based Regulation Clean Restructuring
RESTRUCTURED MARKET • Intermediate/high levels of power market restructuring • Independent system/market operator	Unleashing the DSO
LOW ENERGY ACCESS • Unreliable, limited or no access to electricity • Can occur in restructured or vertically integrated market settings	Bottom-up Coordinated Grid Expansion Bundled Community Energy Planning

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

PATHWAYS OVERVIEW

Next-generation Performance-based Regulation

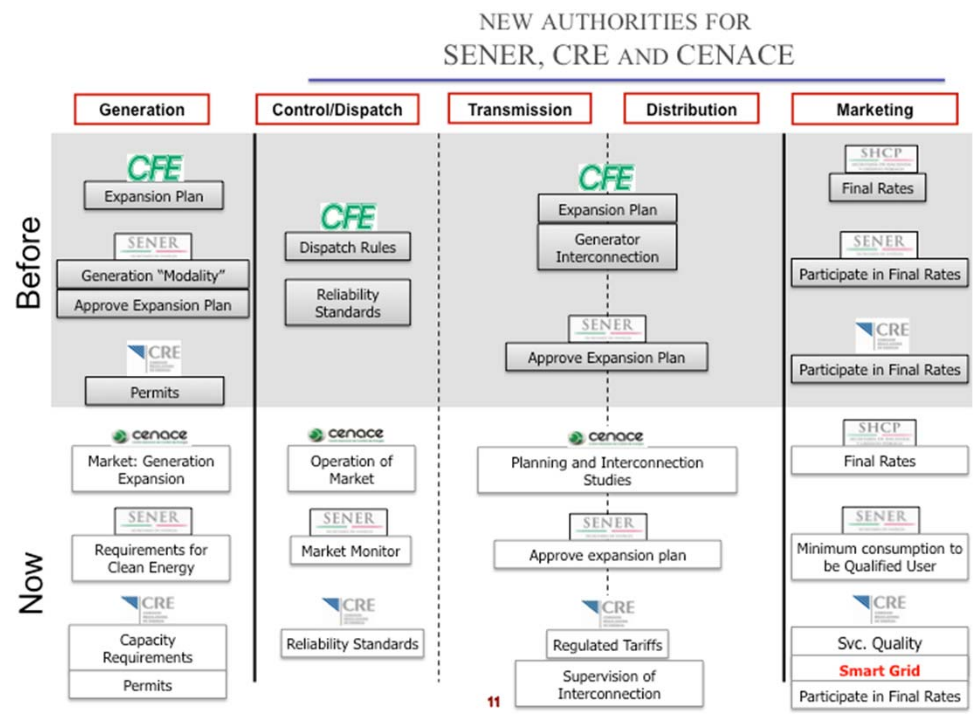
- Adaptive change dynamics
- Vertically integrated utilities remain in recognizable form
- Regulation evolves to prioritize *delivery of value* rather than prudent compensation for incurred costs
- As transitions progress, regulation and supporting policy increasingly decouple utility's revenue from costs
- Earnings increasingly linked to well-defined, quantifiable performance metrics over long performance periods

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

PATHWAYS OVERVIEW

Clean Restructuring

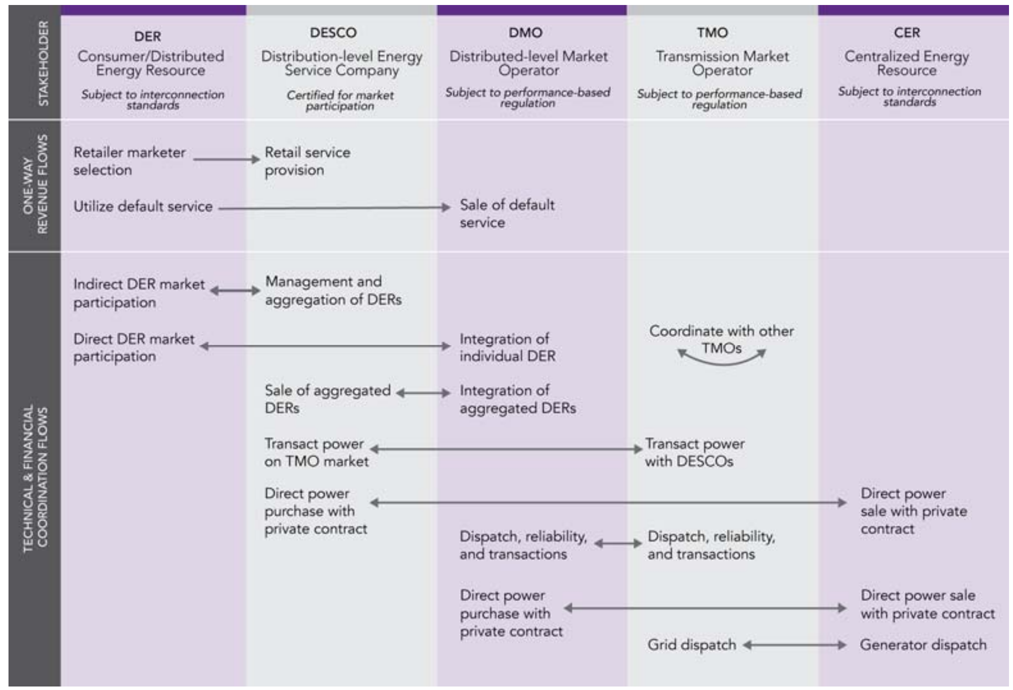
- Reconstructive change dynamics
- Bulk power market restructuring, incorporating lessons learned from the past 20 years
- Design features to facilitate clean energy integration and system optimization



PATHWAYS OVERVIEW

Unleashing the DSO

- Evolutionary change dynamics
- Distribution system operators (DSOs) facilitate retail power market restructuring
- Technical and financial integration of distributed energy resources
- Technology neutrality in policies and standards

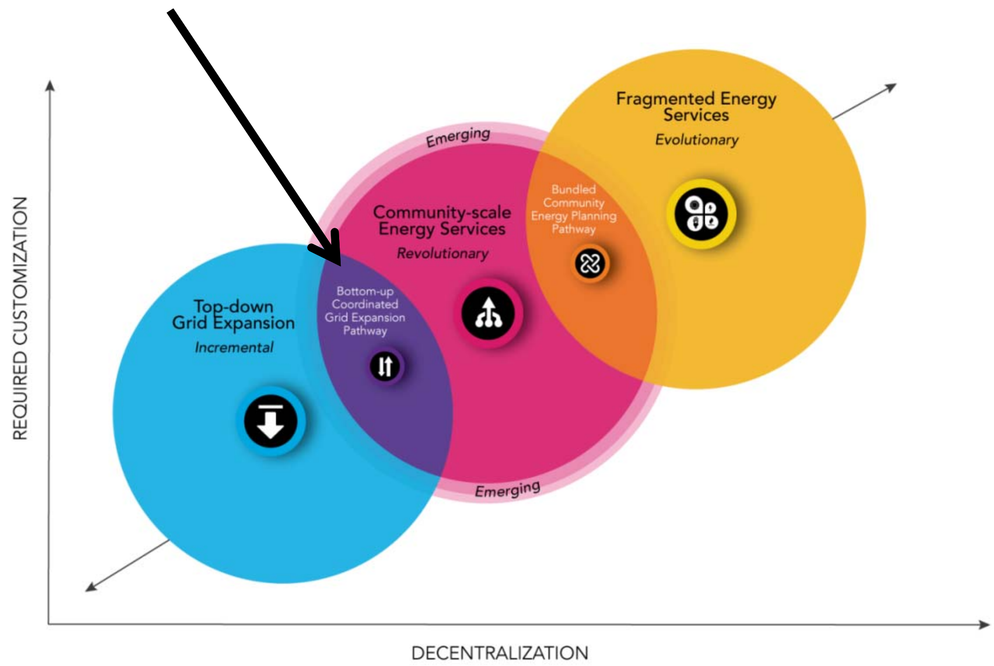


PATHWAYS OVERVIEW

Bottom-of-the-Pyramid:

Bottom-up Coordination Grid Expansion

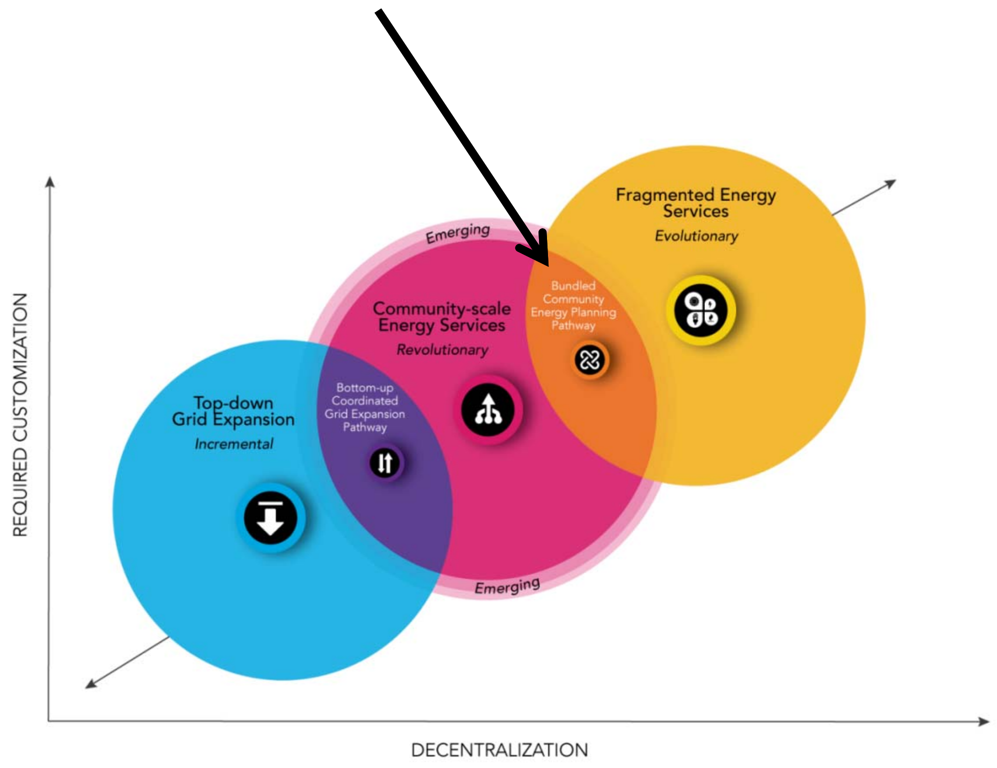
- Adaptive change dynamics
- Technical and regulatory backwards compatibility of mini-grid solutions
- Ratepayer or private financing for mini-grid
- Regulation ensures investors "made whole" upon central grid subsumption



Bottom-of-the-Pyramid:

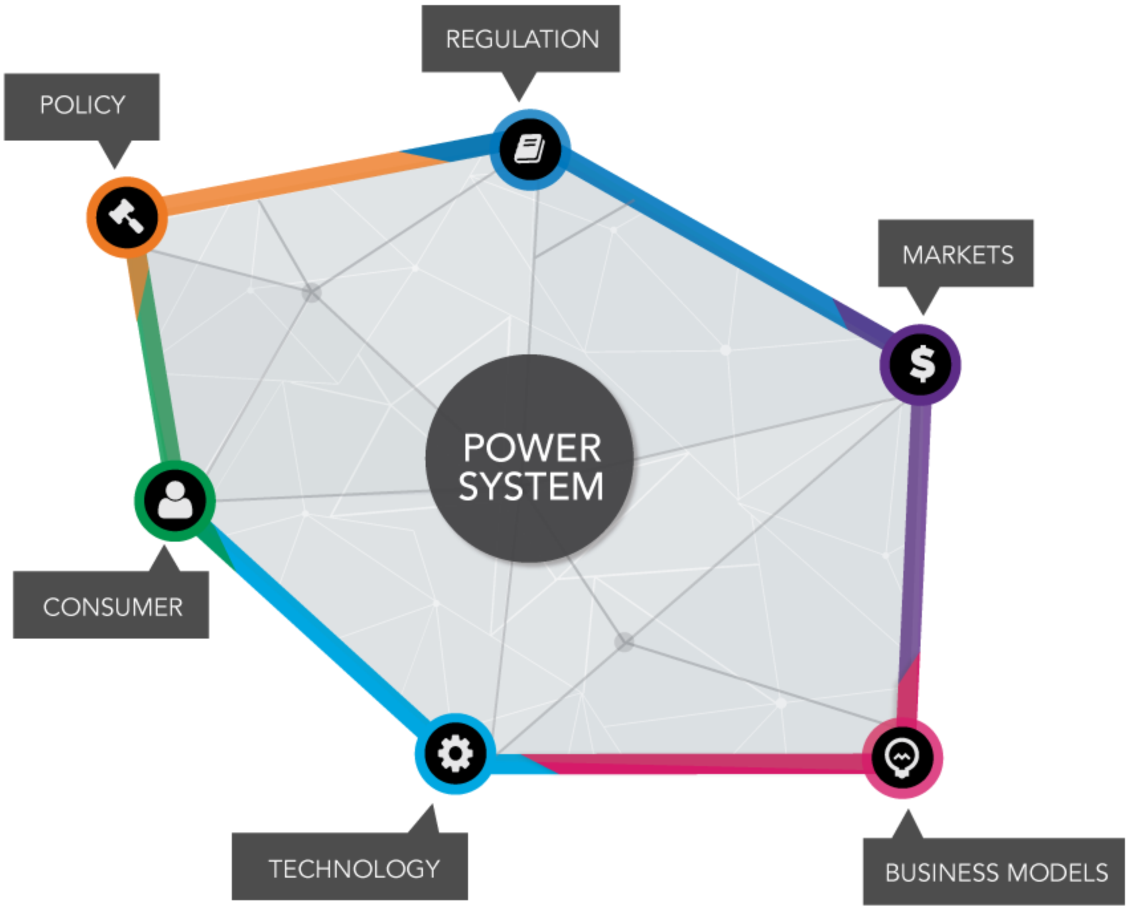
Bundled Community Energy Planning

- ❖ Evolutionary change dynamics
- ❖ Standardization of technical specifications for energy services across multiple scales
- ❖ Clear regulatory and policy signals help define market needs, unlock gaps in financing and clarify value propositions



Power System Transformation Research

The 21st Century Power Partnership provides a unique, holistic framework for approaching power system transformation.



Engaging with the 21CPP

Visit our website for more information about 21CPP publications, resources, and current activities:
http://www.21stcenturypower.org/

For questions about the 21CPP or how you can become involved, contact us at:
21stCenturyPower@nrel.gov

NREL
NATIONAL RENEWABLE ENERGY LABORATORY