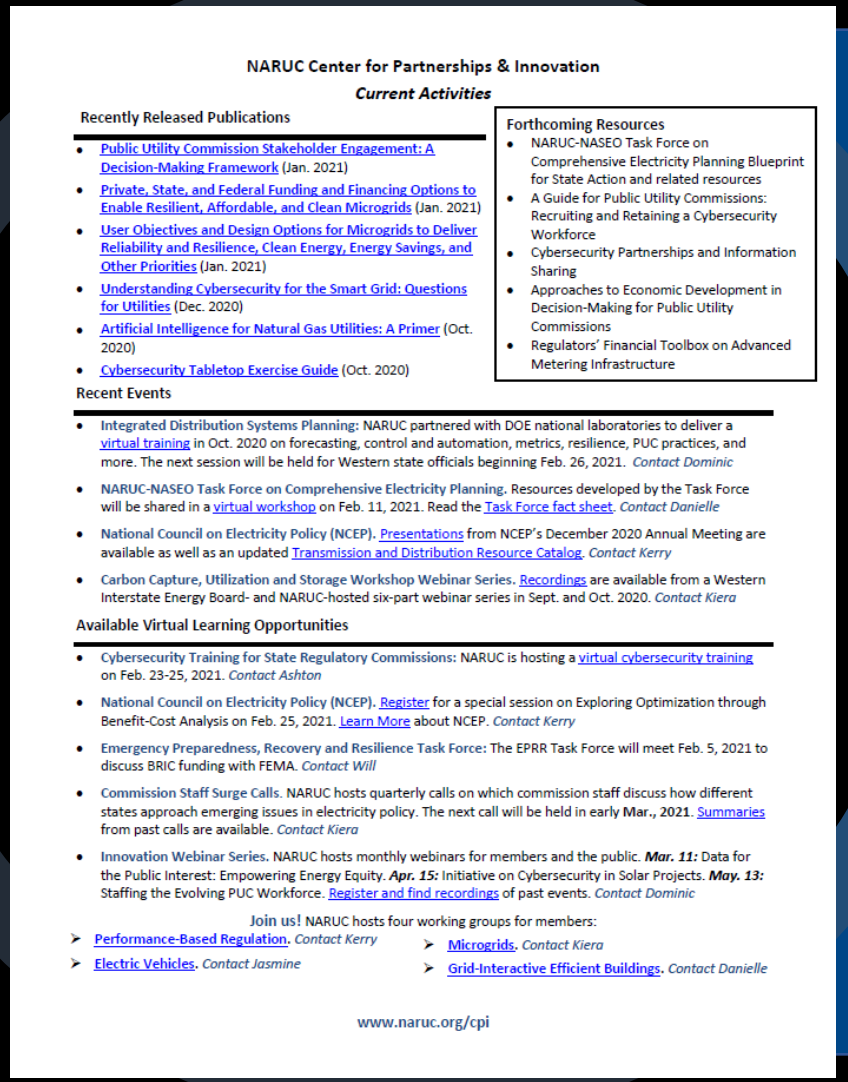
ABOUT NARUC

- The National Association of Regulatory Utility Commissioners (NARUC) is a non-profit organization founded in 1889.
- Our Members are the state utility regulatory Commissioners in all 50 states & the territories. FERC & FCC Commissioners are also members. NARUC has Associate Members in over 20 other countries.
- NARUC member agencies regulate electricity, natural gas, telecommunications, and water utilities.

ABOUT NARUC'S CENTER FOR PARTNERSHIPS & INNOVATION

- Grant-funded team dedicated to providing technical assistance to members.
- CPI identifies emerging challenges and connects state commissions with expertise and strategies to inform their decision making.
- CPI builds relationships, develops resources, and delivers trainings.



NARUC Center for Partnerships & Innovation

Current Activities

Recently Released Publications

- Public Utility Commission Stakeholder Engagement: A Decision-Making Framework (Jan. 2021)
- Private, State, and Federal Funding and Financing Options to Enable Resilient, Affordable, and Clean Microgrids (Jan. 2021)
- User Objectives and Design Options for Microgrids to Deliver Reliability and Resilience, Clean Energy, Energy Savings, and Other Priorities (Jan. 2021)
- Understanding Cybersecurity for the Smart Grid: Questions for Utilities (Dec. 2020)
- Artificial Intelligence for Natural Gas Utilities: A Primer (Oct. 2020)
- Cybersecurity Tabletop Exercise Guide (Oct. 2020)

Forthcoming Resources

- NARUC-NASEO Task Force on Comprehensive Electricity Planning Blueprint for State Action and related resources
- A Guide for Public Utility Commissions: Recruiting and Retaining a Cybersecurity Workforce
- Cybersecurity Partnerships and Information Sharing
- Approaches to Economic Development in Decision-Making for Public Utility Commissions
- Regulators' Financial Toolbox on Advanced Metering Infrastructure

Recent Events

- **Integrated Distribution Systems Planning:** NARUC partnered with DOE national laboratories to deliver a virtual training in Oct. 2020 on forecasting, control and automation, metrics, resilience, PUC practices, and more. The next session will be held for Western state officials beginning Feb. 26, 2021. *Contact Dominic*
- **NARUC-NASEO Task Force on Comprehensive Electricity Planning.** Resources developed by the Task Force will be shared in a virtual workshop on Feb. 11, 2021. Read the Task Force fact sheet. *Contact Danielle*
- **National Council on Electricity Policy (NCEP).** Presentations from NCEP's December 2020 Annual Meeting are available as well as an updated Transmission and Distribution Resource Catalog. *Contact Kerry*
- **Carbon Capture, Utilization and Storage Workshop Webinar Series.** Recordings are available from a Western Interstate Energy Board- and NARUC-hosted six-part webinar series in Sept. and Oct. 2020. *Contact Kiera*

Available Virtual Learning Opportunities

- **Cybersecurity Training for State Regulatory Commissions:** NARUC is hosting a virtual cybersecurity training on Feb. 23-25, 2021. *Contact Ashton*
- **National Council on Electricity Policy (NCEP).** Register for a special session on Exploring Optimization through Benefit-Cost Analysis on Feb. 25, 2021. Learn More about NCEP. *Contact Kerry*
- **Emergency Preparedness, Recovery and Resilience Task Force:** The EPRR Task Force will meet Feb. 5, 2021 to discuss BRIC funding with FEMA. *Contact Will*
- **Commission Staff Surge Calls.** NARUC hosts quarterly calls on which commission staff discuss how different states approach emerging issues in electricity policy. The next call will be held in early **Mar., 2021**. Summaries from past calls are available. *Contact Kiera*
- **Innovation Webinar Series.** NARUC hosts monthly webinars for members and the public. ***Mar. 11:*** Data for the Public Interest: Empowering Energy Equity. ***Apr. 15:*** Initiative on Cybersecurity in Solar Projects. ***May. 13:*** Staffing the Evolving PUC Workforce. Register and find recordings of past events. *Contact Dominic*

Join us! NARUC hosts four working groups for members:

- Performance-Based Regulation. *Contact Kerry*
- Electric Vehicles. *Contact Jasmine*
- Microgrids. *Contact Kiera*
- Grid-Interactive Efficient Buildings. *Contact Danielle*

www.naruc.org/cpi

Regularly updated CPI fact sheet with recent publications & upcoming events under Quick Links at:

NARUC Innovation Webinar Series

One Thursday most months

All NARUC members and stakeholders are invited

Advances in Resource Adequacy

March 16, 2023 | 3:00 – 4:00 PM EST

More webinar information will be added soon!

https://www.naruc.org/cpi-1/innovation-webinars/

NARUC Winter Policy Summit

February 12 – 15, 2023

In-person | Washington, DC

https://www.naruc.org/meetings-and-events/naruc-winter-policy-summits/2023-winter-policy-summit/

NARUC

National Association of Regulatory Utility Commissioners

Grid Architecture

Why it Matters

A panel discussion on the fundamental transformation of the electric grid and how we can effectively plan for it

Moderated by Hon. Katherine Peretick
Commissioner, Michigan Public Service Commission

The Panel

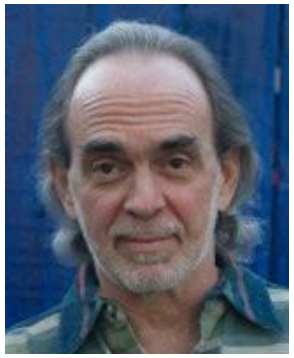
Taming runaway complexity, cost and unintended consequences

Mark Paterson, Strategen Lead Systems Architect
A globally-connected energy system transformation leader with 25-years of experience in technology strategy, power systems architecture and thermal and fluid systems. He is known for his expertise in leading the navigation of complex issues, systems thinking and co-design of transformation pathways

Transitions, networks, operational coordination and future requirements

Kay Aikin, Chief Product Officer of Dynamic Grid
A utility software company based in Portland Maine. She is a graduate of Pennsylvania State University, holding a degree in energy/sustainability engineering. Kay is a recognized Transactive Energy expert as well as distributed intelligence in the electrical grid. She is on the Board of the Grid Wise Architecture Council (GWAC), working on architecture and interoperability in grid modernization and smart grid

Applying grid architecture in the regulatory process



Lorenzo Kristov, Principal Market Architect
Independent consultant focusing on power system transition to integrate high levels of distributed energy resources (DER). His expertise includes wholesale power market design; DER participation in wholesale markets; distribution system operator (DSO) models; whole-system grid architecture. Lorenzo worked at California ISO as a principal in market design and infrastructure policy,

Mark Paterson

Taming runaway complexity, cost and unintended consequences

Grid Architecture Why it Matters

Center for Partnerships and Innovation
Innovation Webinar 1/19/23

The Grid is in the Middle of Fundamental Transformation

Driven by Decarbonization, Decentralization, Digitization, and Democratization – 4 D's

- Transition **from hundreds** to **tens of millions** of participating energy resources (generation and loads)
- **Affordability and equity** requirements are growing
- Prosumers are increasingly looking to participate and **beneficially interact** with the grid to access additional savings
- Mass electrification risks **burdening the grid** at some times while **minimum demand** occurs at other times
- The historically dominant 'Supply-side / Demand-side' bifurcation is **eroding with profound implications**
- **System load nearly 2X** and **peak demand 2 – 3X**

New system capabilities will be need to be layered over the legacy system while still operating efficiently and reliably

The Grid Transition

FROM centralized generation and passive loads…

TO both centralized and distributed generation and vastly more active participatory loads / flexibility

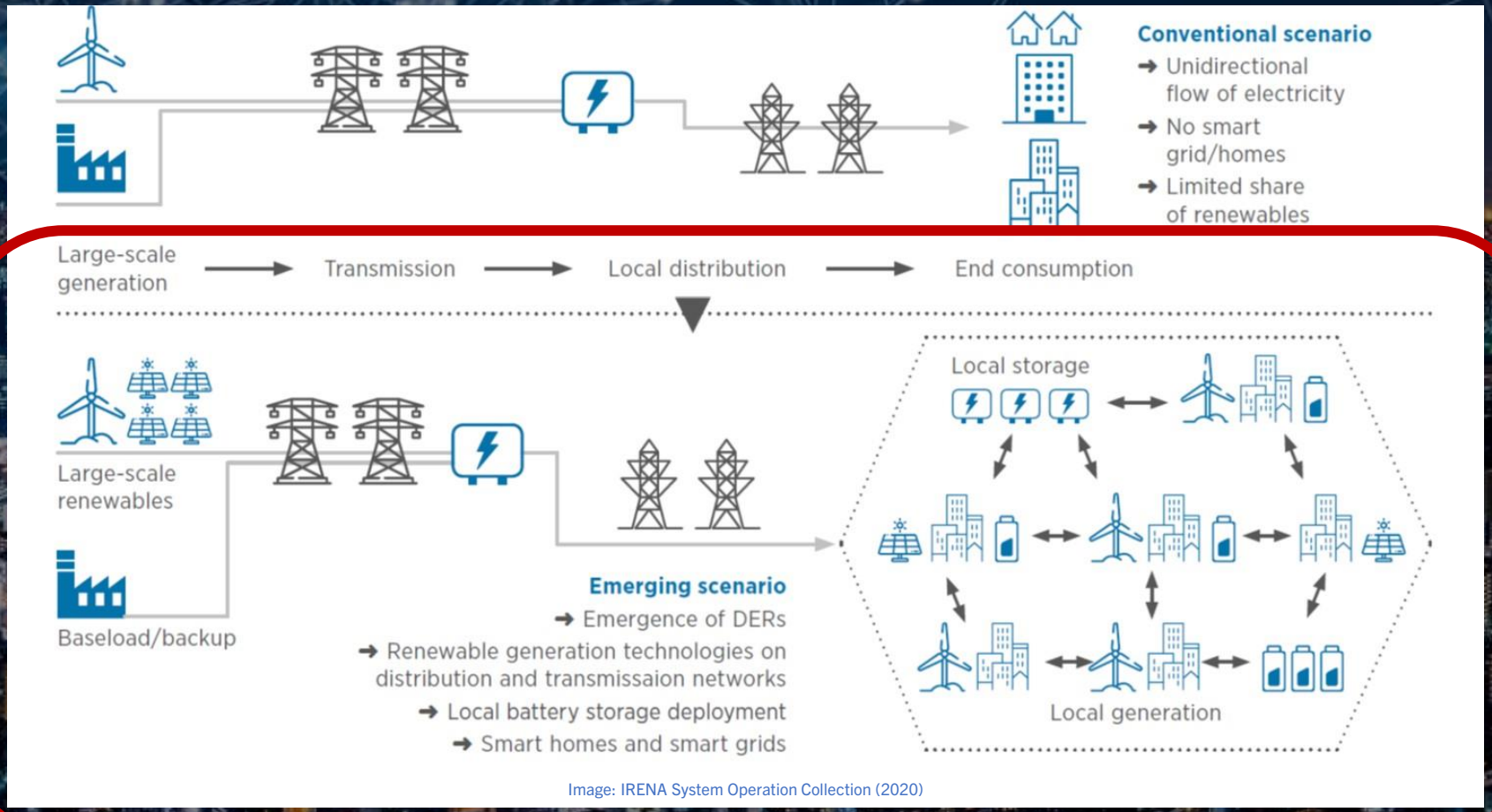


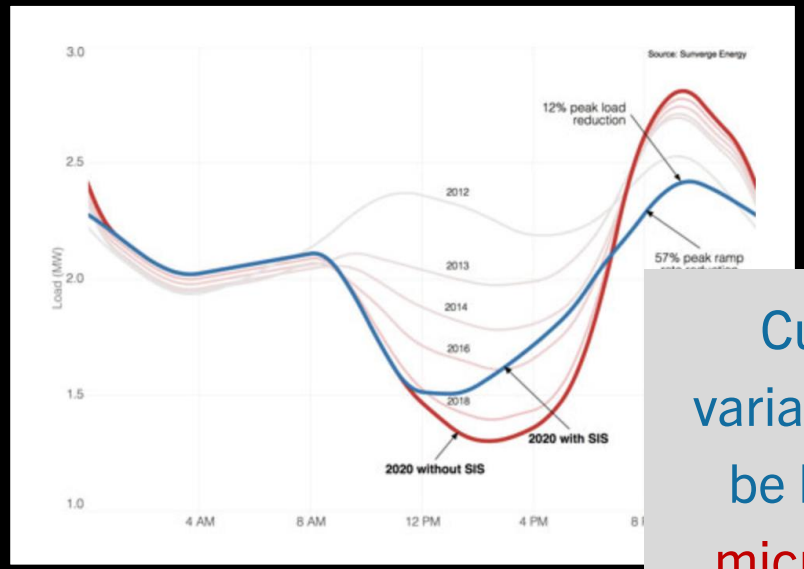
Image: IRENA System Operation Collection (2020)

Grid Architecture
Why it Matters

"Any intelligent fool can make things bigger and more complex – it takes a touch of genius – and a lot of courage to move in the opposite direction."

Albert Einstein

The Grid is becoming **vastly more dynamic** and **systemically complex**.



Customer demand and variable generation must still be kept 'in balance' every microsecond of the year as proportion of dispatchable generation declines

Similar to the modernizing aerospace sector before it, additional tools are required to **'tame' runaway complexity, cost** and **unintended consequences.**

So what? Why are 'Systems Architecture'-based methodologies so critical?

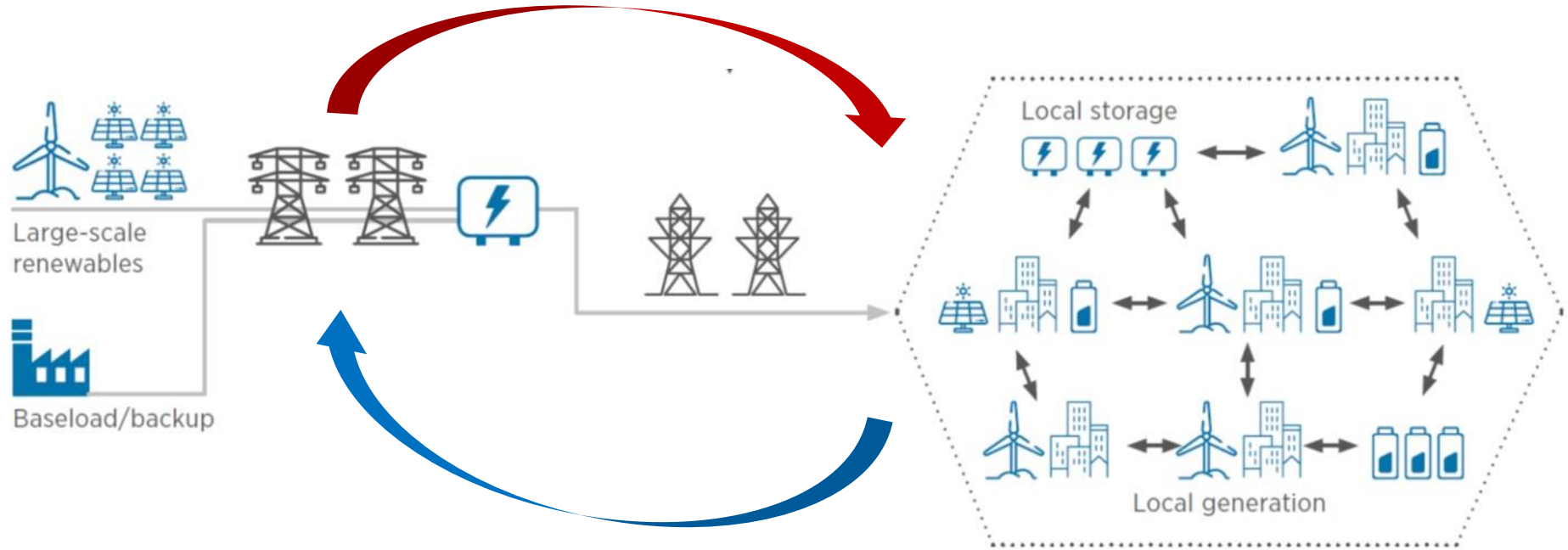
Every complex system ever created by humans has an underpinning structure or 'architecture' that is essential to its operation.

Although less visible than the system's components, its underpinning architecture has a disproportionate and irreducible influence on what the system as a whole can cost-efficiently and reliably perform.

The established Systems Architecture discipline provides formal tools for examining the elements and actors of a complex system, the critical linkages and relationships between them, and the 'emergent' behaviours of the system that arise as system changes over time.

* Refer Appendix A for simple definitions of System and Complexity

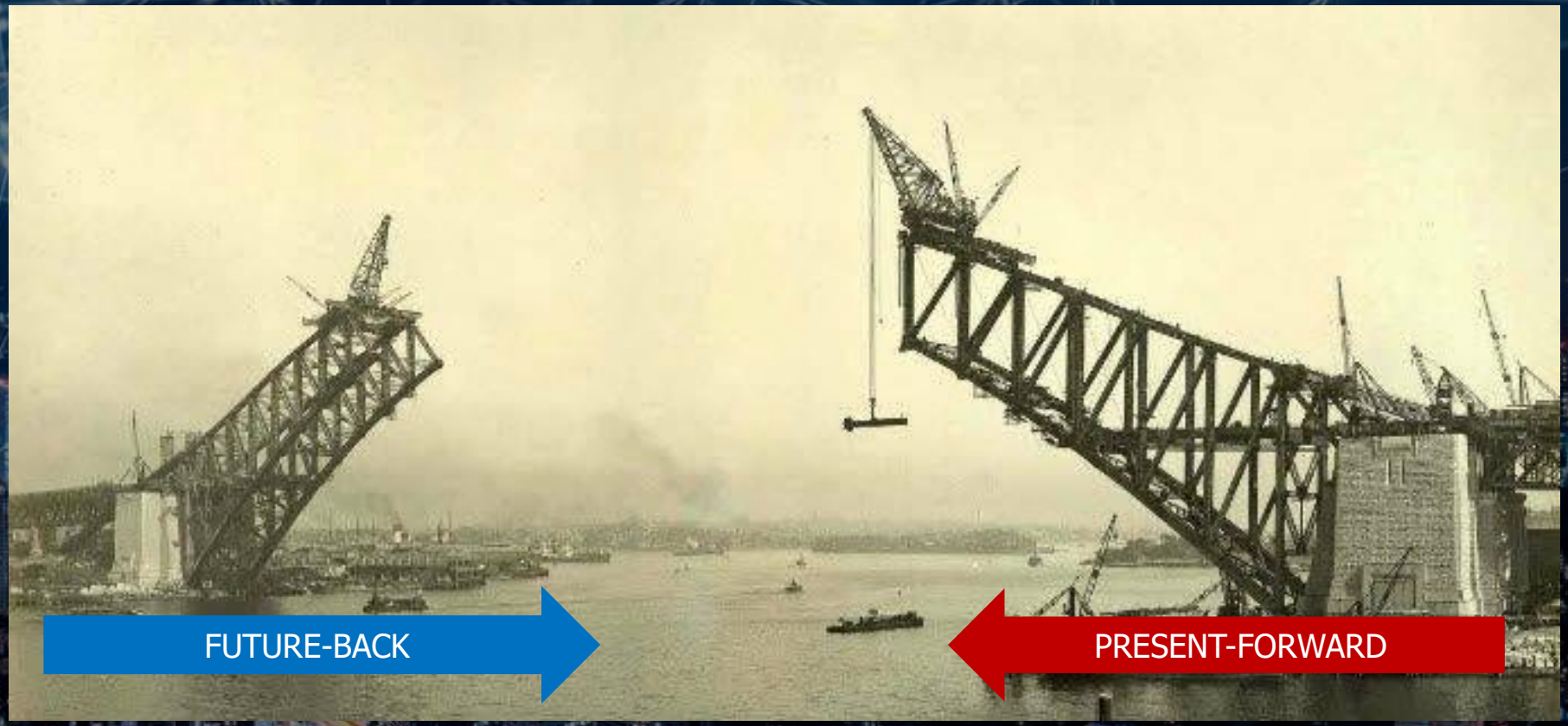
Applies to every decarbonizing grid requiring more flexibility



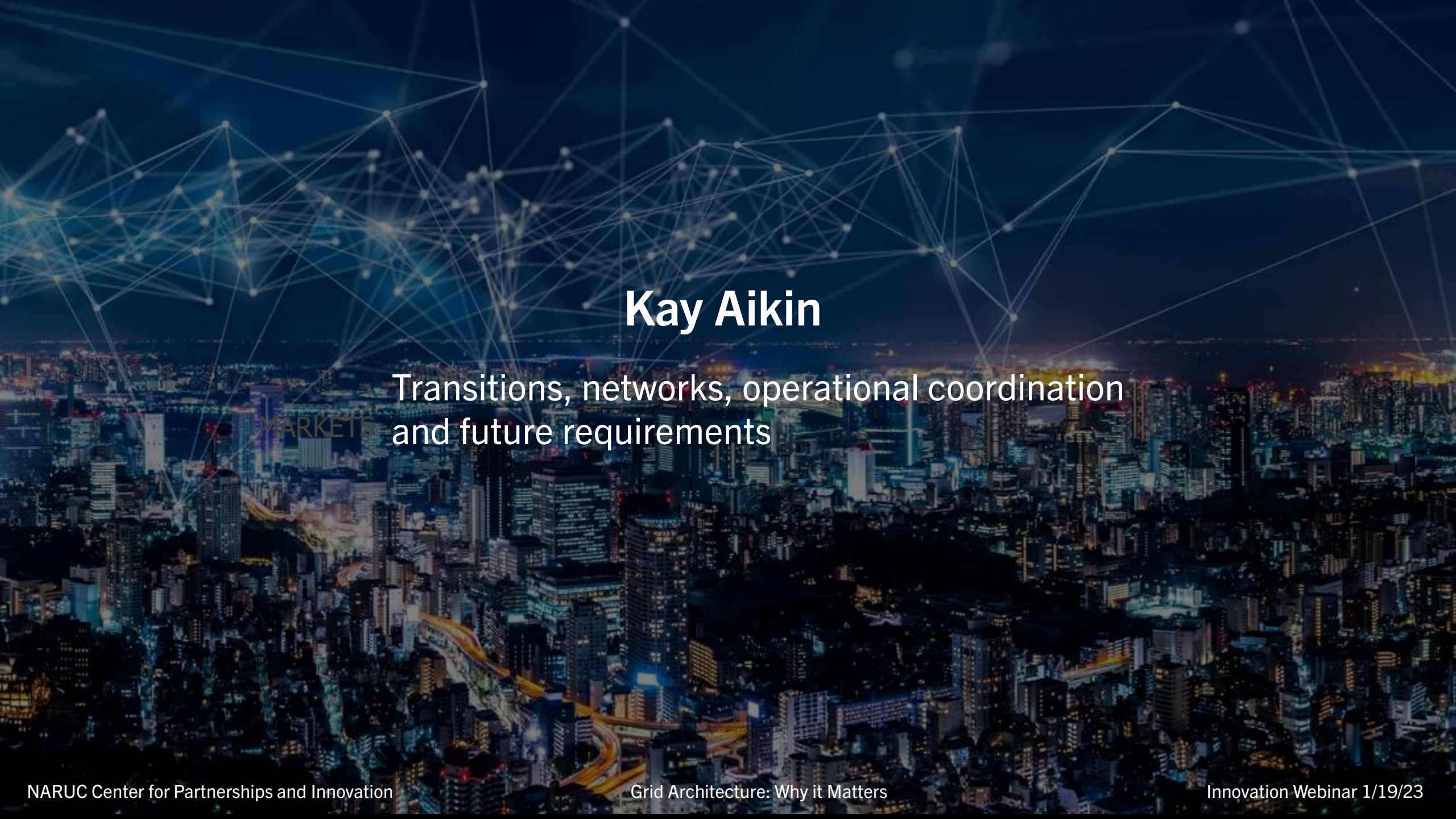
Efficient operation requires an entirely new level of whole-system interdependence

21st century grids require bulk energy, transmission and distribution systems – and deep demand-side flexibility – to **function holistically** to avoid over-build, duplication and/or stranded investments.

Grid Architecture tools empower stakeholders to better evaluate grid expansion proposals by applying both **'present forward'** + **'future-back'** thinking and analysis



For example: "How might our portfolio of $-billion projects be moderated for a future where whole-system-coordination can significantly enhance operational efficiencies?"



Kay Aikin

Transitions, networks, operational coordination and future requirements

Parallel Paths

This transition requires parallel implementation paths and whole system approaches like Grid Architecture

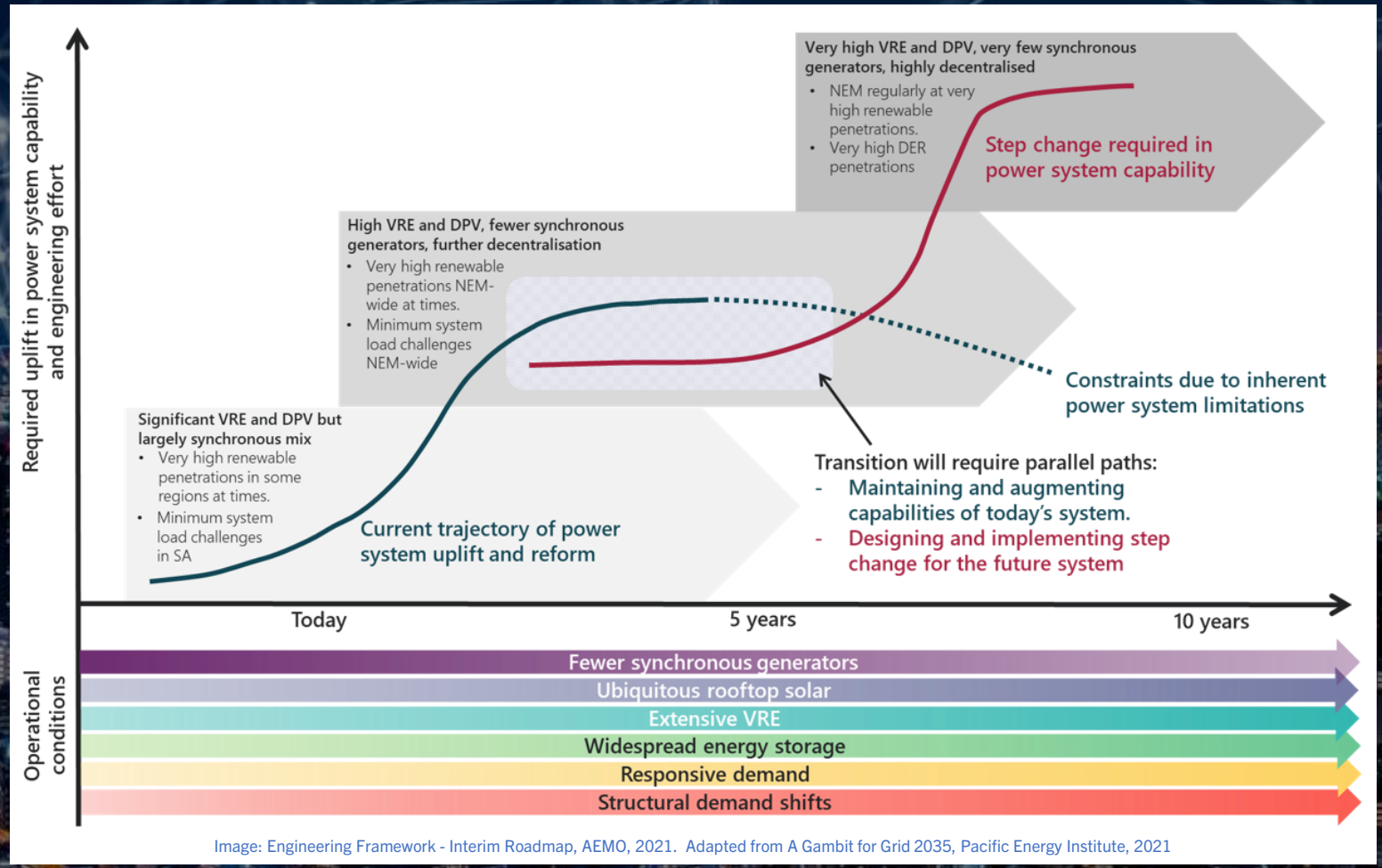


Image: Engineering Framework - Interim Roadmap, AEMO, 2021. Adapted from A Gambit for Grid 2035, Pacific Energy Institute, 2021

The Grid is a 'Network of Structures'

Systems Architecture tools are critical for 'taming grid complexity' and navigating this network of structures and provide **Operational Coordination**

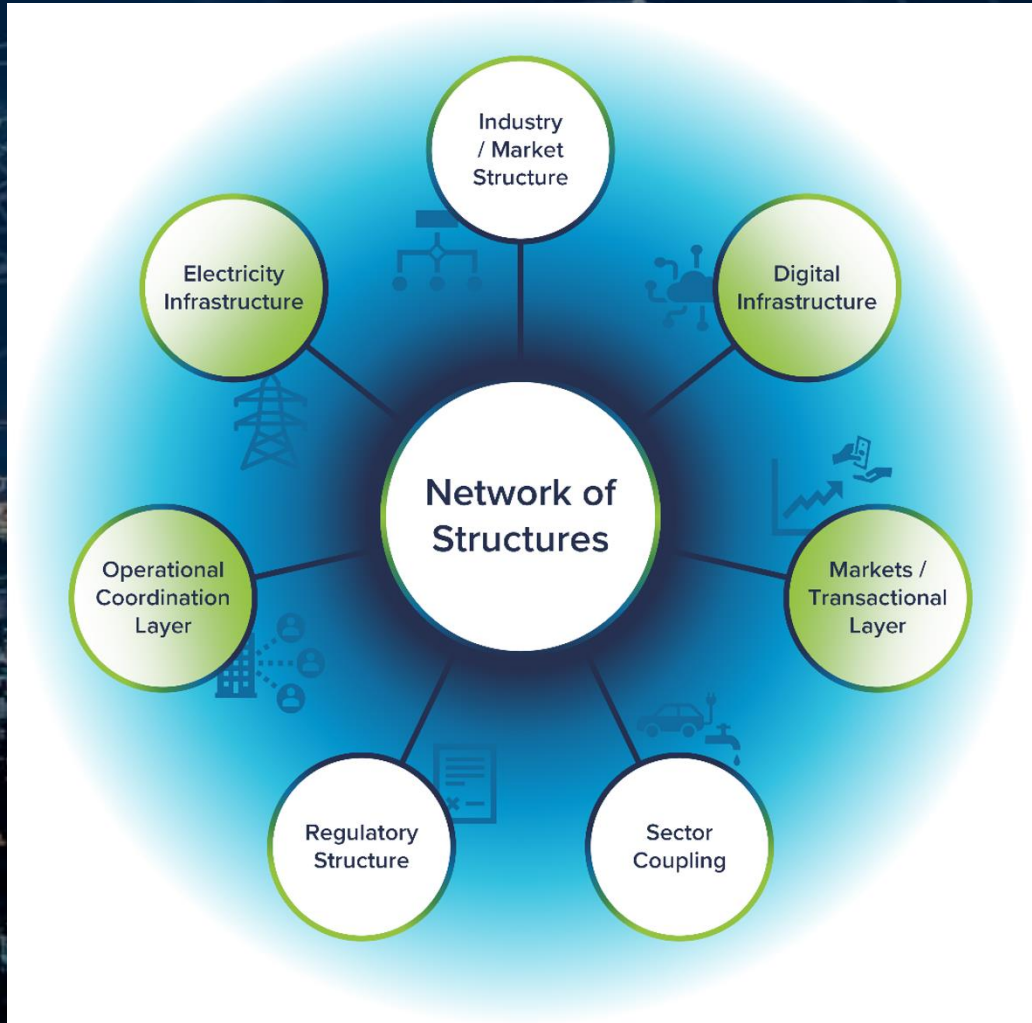


Image: Strategen Consulting, Adapted from Grid Architecture 2, Pacific Northwest National Laboratory, 2016

Operational Coordination

‘Operational Coordination requires interaction between both Markets and Control structures

Economists
“Get the market rules and prices right and everything will work fine”

✓ Solution:
An ensemble of both market and control features is required

Control Engineers
“Get the algorithms and standards right and everything will work fine”

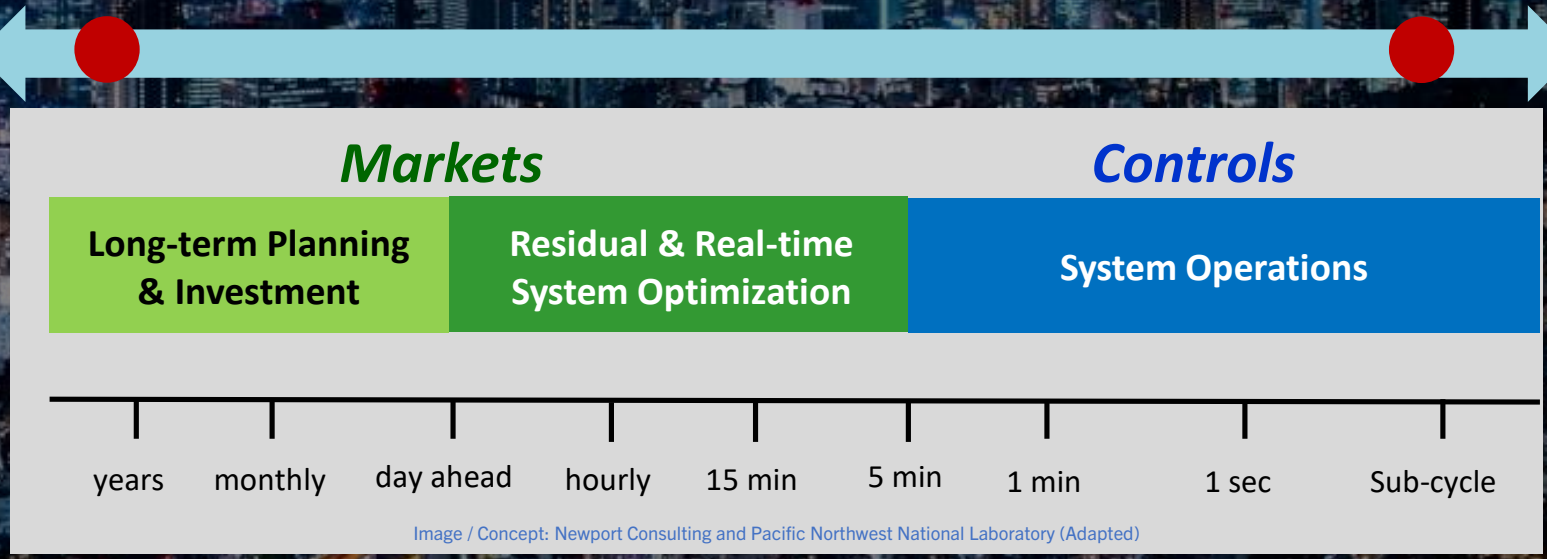


Image / Concept: Newport Consulting and Pacific Northwest National Laboratory (Adapted)

Grid Architecture

Grid Architecture is critical for making key structural choices to enable a more intelligent, self-optimising power system for the 21st century

Affordability, quality and resilience outcomes for all

VRE & DER energy and systems services rewarded

MARKETS

Coordination of desirable system behaviors

OPEX and CAPEX efficiencies

New offerings for customers

Enhanced decarbonization

Enhanced equity

Image: Strategen Consulting

Future Requirements

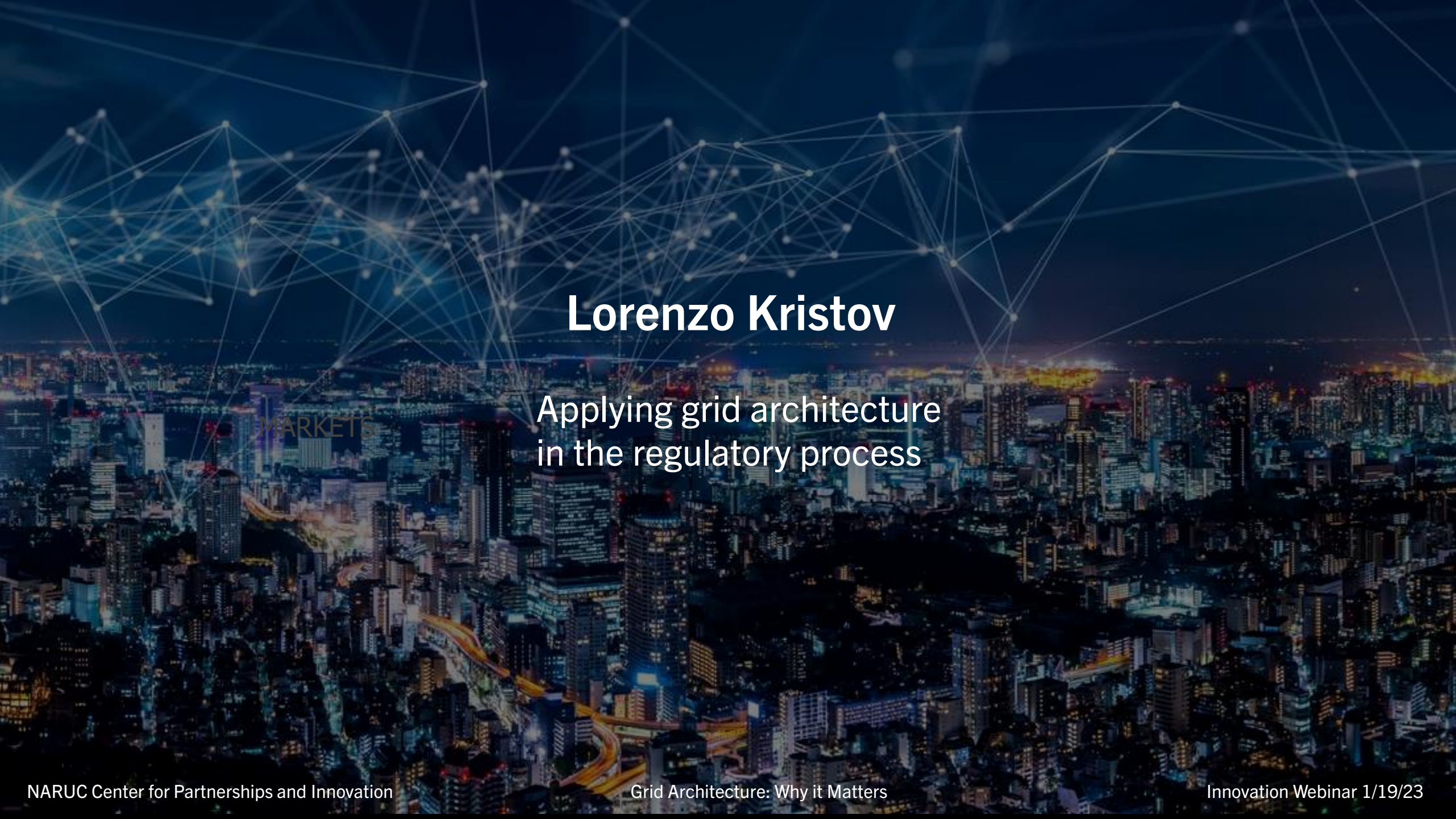
New emerging requirements that Grid Architecture can help regulators to understand, adapt and evolve the grid.

- Affordability
- Equity
- Variable generation
- Dynamic load balancing
- Load Shaping
- Load following generation
- System constraints (load and DER)
- Infrastructure upgrades

Future Questions for Regulators

There are estimates that distribution grid upgrades to manage this transition is from $2 to $10 Trillion

- Distributed solar adoption rate?
- Where solar happen first?
- Impact of federal incentives?
- Impact of FERC 2222 on distribution?
- What kind of tariffs?
- What kind of future planning?
- Power quality impacts?
- Investments in grid modernization who pays and how much?



Lorenzo Kristov

Applying grid architecture in the regulatory process

Grid Architecture

MARKETS

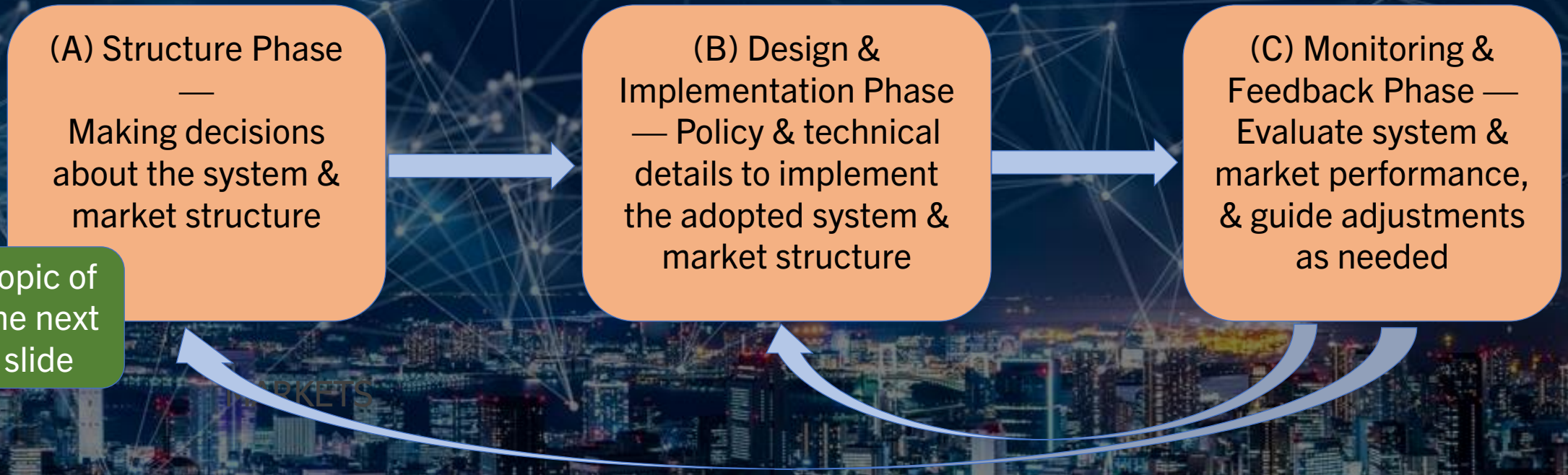
Two uses of the word ‘architecture’

1. **The “architecture” of a complex system** is the arrangement of actors who comprise the system, along with their responsibilities, functions, roles & interactions with one another.

2. **‘Grid Architecture’** (aka ‘Power Systems Architecture’) is a discipline & set of methods for representing, analyzing & understanding the electricity system as a whole system, & tracing the impacts of changes to the system.

In the regulatory process, the discipline & methods of Grid Architecture assist regulators to better align the performance of regulated entities with the public interest

The Grid Architecture Discipline — cloud level



1. Design & implementation follow structure
2. Monitoring is ongoing:
   - The electricity system is a complex adaptive living system
3. Most adjustments are within the existing structure, design & implementation
4. Major changes in conditions warrant revisiting the structure

Grid Architecture — The Structure Phase (A)

Step 1
Define the public interest: Specify the societal goals the electricity system must support

Step 2
Specify electricity system performance & outcomes required to support the goals

Step 3
Identify major Functions, Roles & Responsibilities required to achieve desired performance

Step 4
Construct system structure models **& compare them based on criteria from Steps 1-2**

Policy decisions that shape system & market structures

The policies, mandates & societal interests the system must support

Performance & external impacts of the system — the "outside-the-system" perspective

Before deciding which Actors do what, specify all required functions — the "inside-the-system" perspective

A "structure model" is an assignment of Functions, Roles & Responsibilities to Actors; + market structure (competition vs monopoly) & unbundling of functions

Takeaways

- The structure phase (A) is where system & market structure policy decisions are made, to best align system performance with the public interest.
- The electricity system has existing operating & market structures today (the *status quo* structure).
- The Grid Architecture discipline starts by mapping & understanding the existing structures.
- Major changes in conditions warrant revisiting the structure.
- A decision not to revisit structure, to skip phase (A) & make major changes in design & implementation (B), is an implicit decision to retain the *status quo* structure.

Thank you

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