U.S. DEPARTMENT OF ENERGY
Office of Electricity

Building on Indiana's Transmission, Distribution, and Storage Improvement Charge to Advance Integrated Planning

Indiana Utility Regulatory Commission – IRP Contemporary Issues Technical Conference

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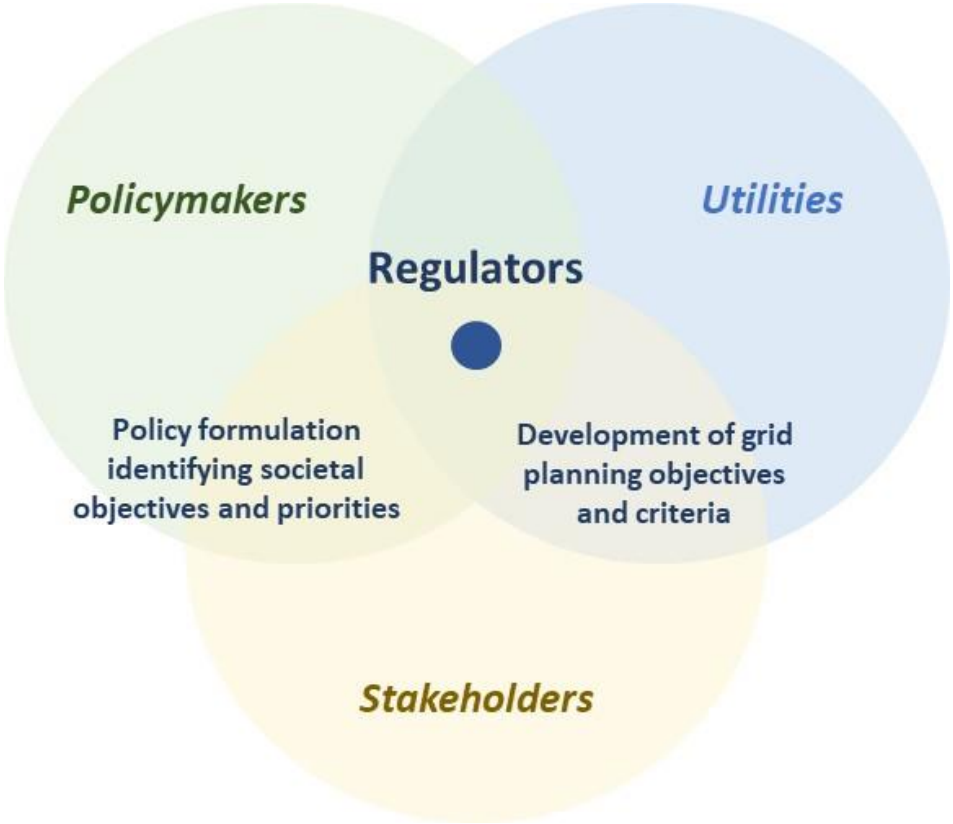
Need for Shared Understanding

Creating a shared understanding among stakeholders of strategies for grid transformation needed to meet affordability, resilience, and decarbonization objectives

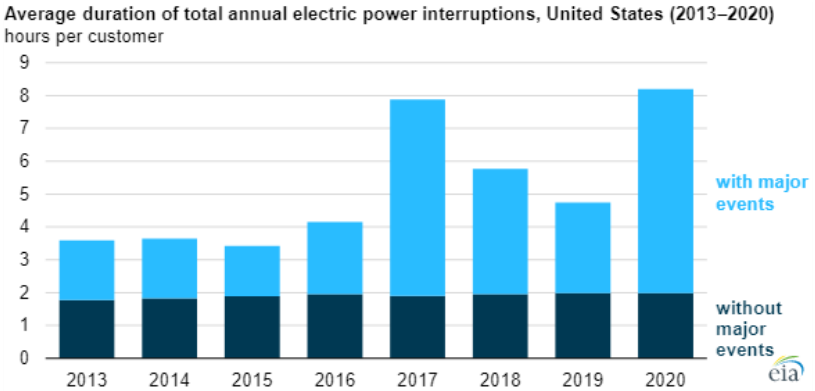


Why Care About Integrated System Planning?

Reliability and resilience are pressing concerns.

ASCE 2021 Report Card:

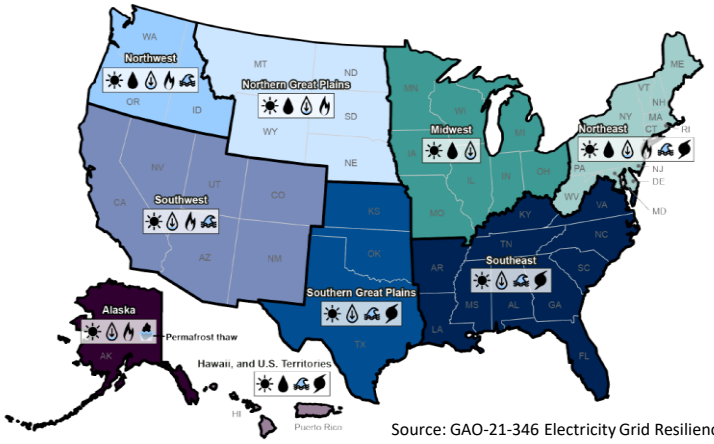
- The majority of the nation's grid is aging, with **some over a century old** — far past their 50-year life expectancy — and others, including **70% of T&D lines, are well into the second half of their lifespans.**



Associated Press (Analysis of DOE data):

- Power outages from severe weather have **doubled over the past two decades** across the US due to climate change.
- **Forty states are experiencing longer outages** — and the problem is most acute in regions seeing more extreme weather.

Figure 3: Potential Climate Change Effects by Region and Examples of Climate-Related Events on the Electricity Grid

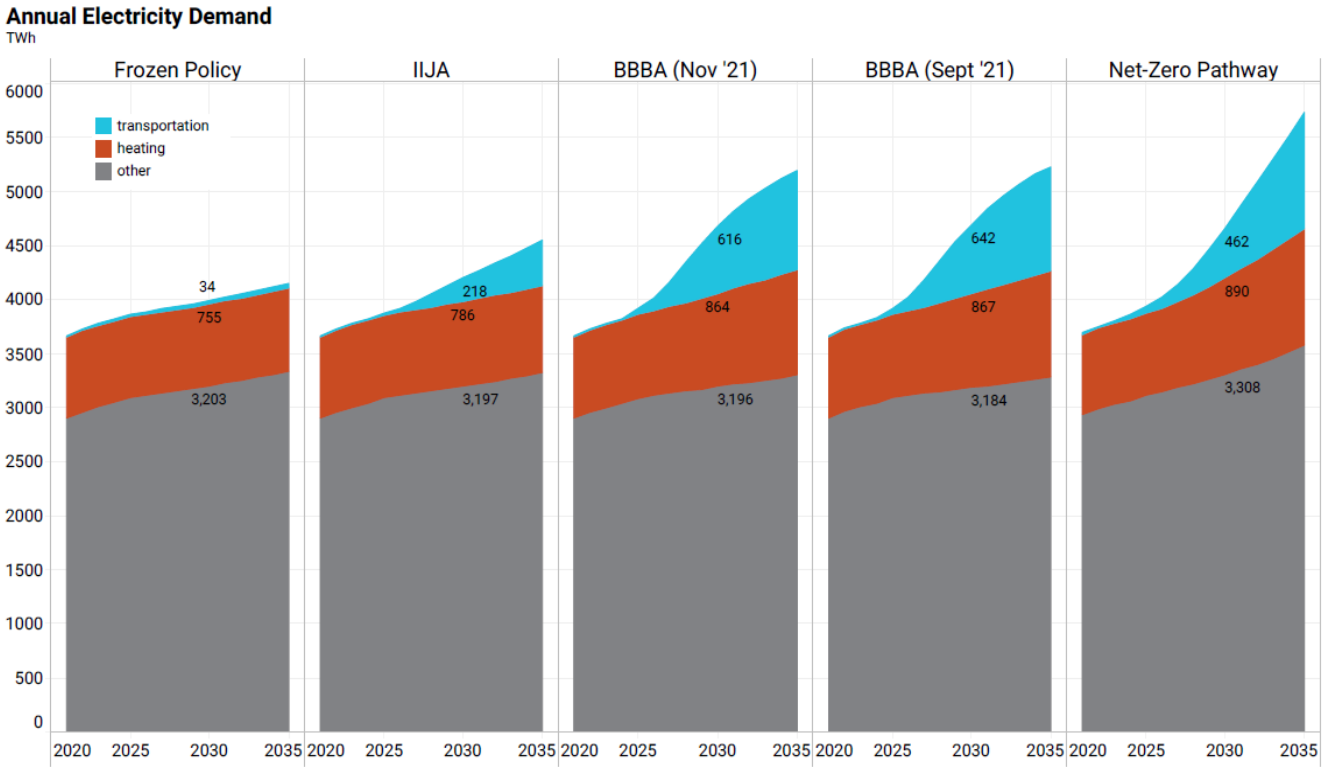


Source: GAO-21-346 Electricity Grid Resilience

Why Care About Integrated System Planning?

Electrification poses significant grid challenges.

Without mitigation, electricity demand may increase up to 18% by 2030 and 38% by 2035 compared to 2022.
Incremental distribution capacity upgrade cost is estimated at US$116 billion to US$200 billion.[1]



Source: Princeton University Zero Lab

1. Energy+Environmental Economics https://www.ethree.com/wp-content/uploads/2021/06/GridLab_2035-Transportation-Dist-Cost.pdf

Why Care About Integrated System Planning?

Large-scale growth of DER with export energy changes use of the distribution system.

- US Federal & State policies are driving greater distributed (community and customer) solar & storage adoption to achieve clean energy goals
  - Nationally about **400 GW of installed distributed solar** projected through 2030, including 100 million homes with rooftop PV*
  - DER may be **~25+% of RE portfolio** in a state by 2040**
  - Flexible DER for needed grid flexibility
- Electric distribution grid may need to deliver energy from the edge across distribution and into transmission networks
- Distribution systems in several states will become gathering systems for distributed generation and storage by 2040

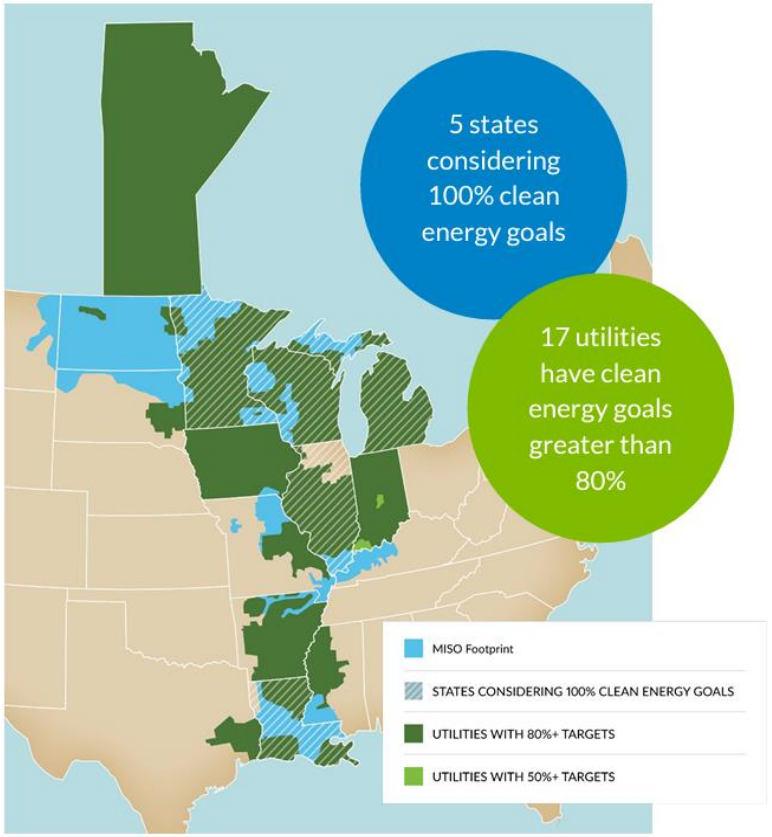


Figure 4: Clean Energy Goals above 50% Across Footprint[3]

Source: MISO Futures Report - 2021

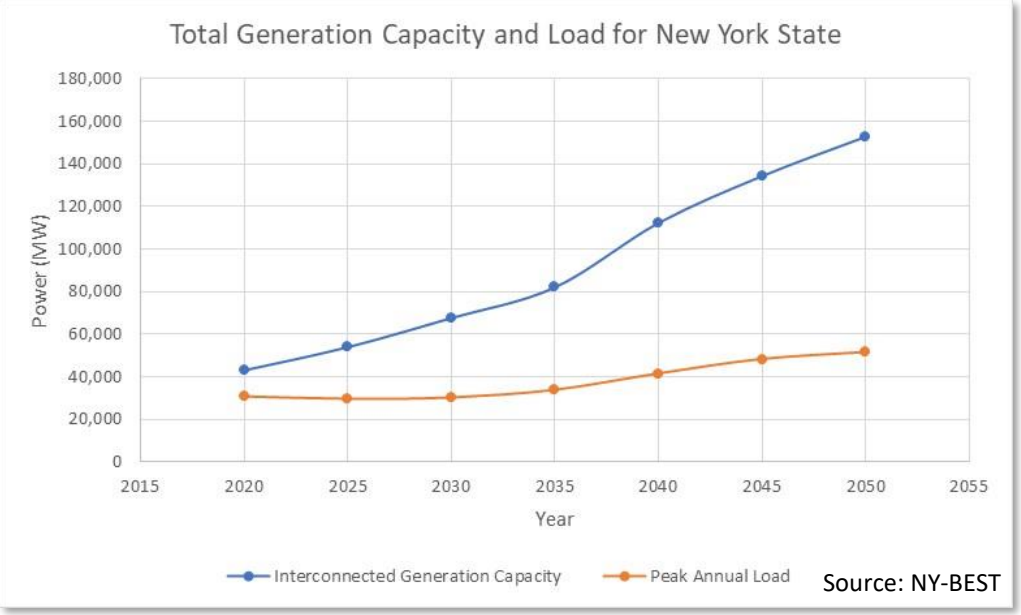
* IEA, Technology and innovation pathways for zero-carbon-ready buildings by 2030, 2022

** Several states, such as California and Hawaii will have DER contributing as much as 40-50%

Why Care About Integrated System Planning?

Interrelated T&D capacity constraints are forecast to increase

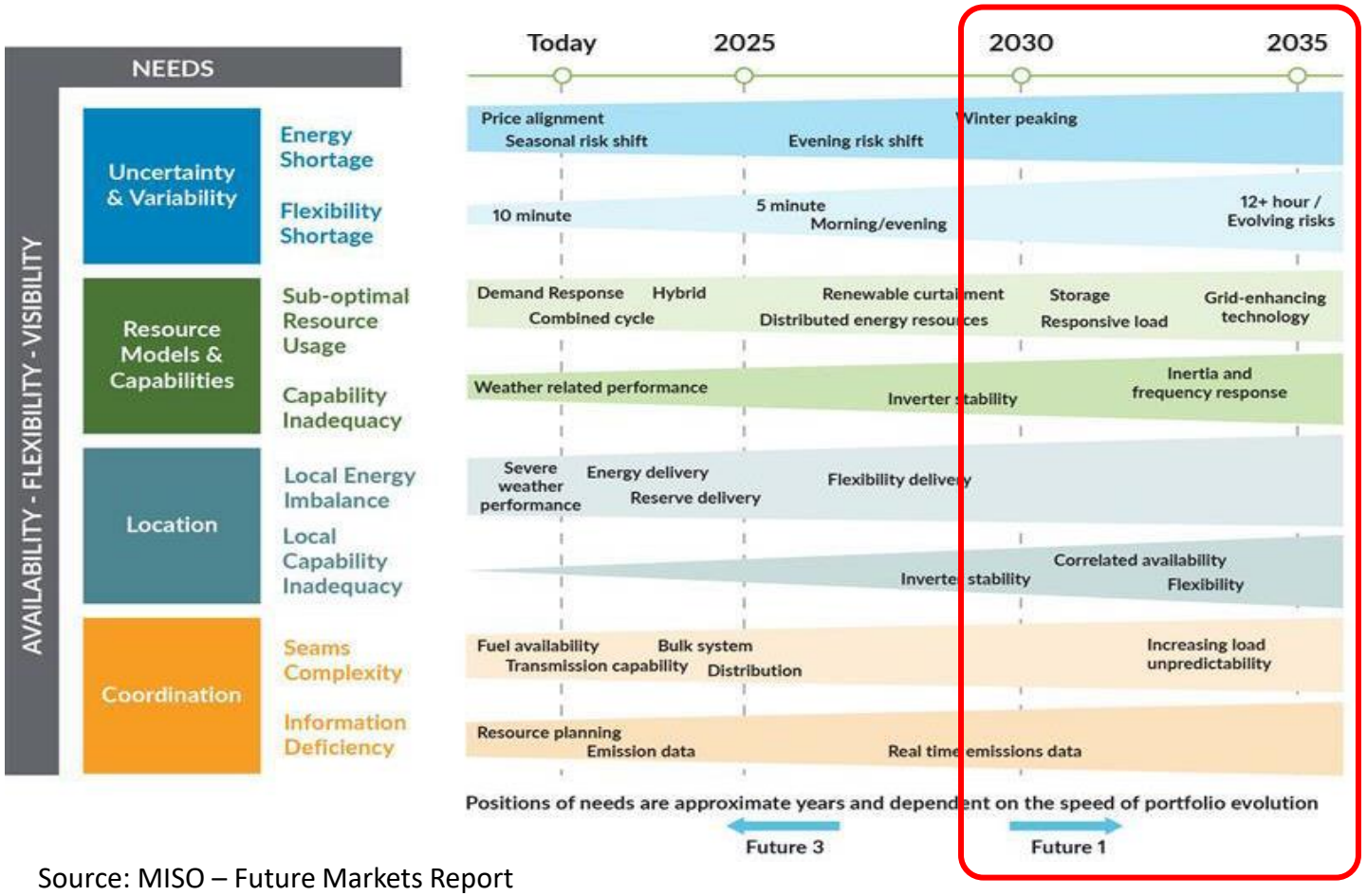
- Variable renewable energy resources with approx. 20-40% capacity factors are replacing thermal resources with ~90% capacity factor
- Increasing amount of distributed generation and storage on distribution/subtransmission also contributes to capacity issues (aka hosting capacity)
- For example, in NY, the ratio of total interconnected generation capacity to peak load is about 1.4x in 2020 and grows to about 3x by 2050 (note: 30+% of resources connected on distribution/subtransmission by 2050)



Source: NY-BEST

Why Care About Integrated System Planning?

Increasing random variability of resources and loads poses T&D operational challenges



Source: MISO – Future Markets Report
https://cdn.misoenergy.org/MISO%20Markets%20of%20the%20Future604872.pdf

Integrated System Planning Considerations

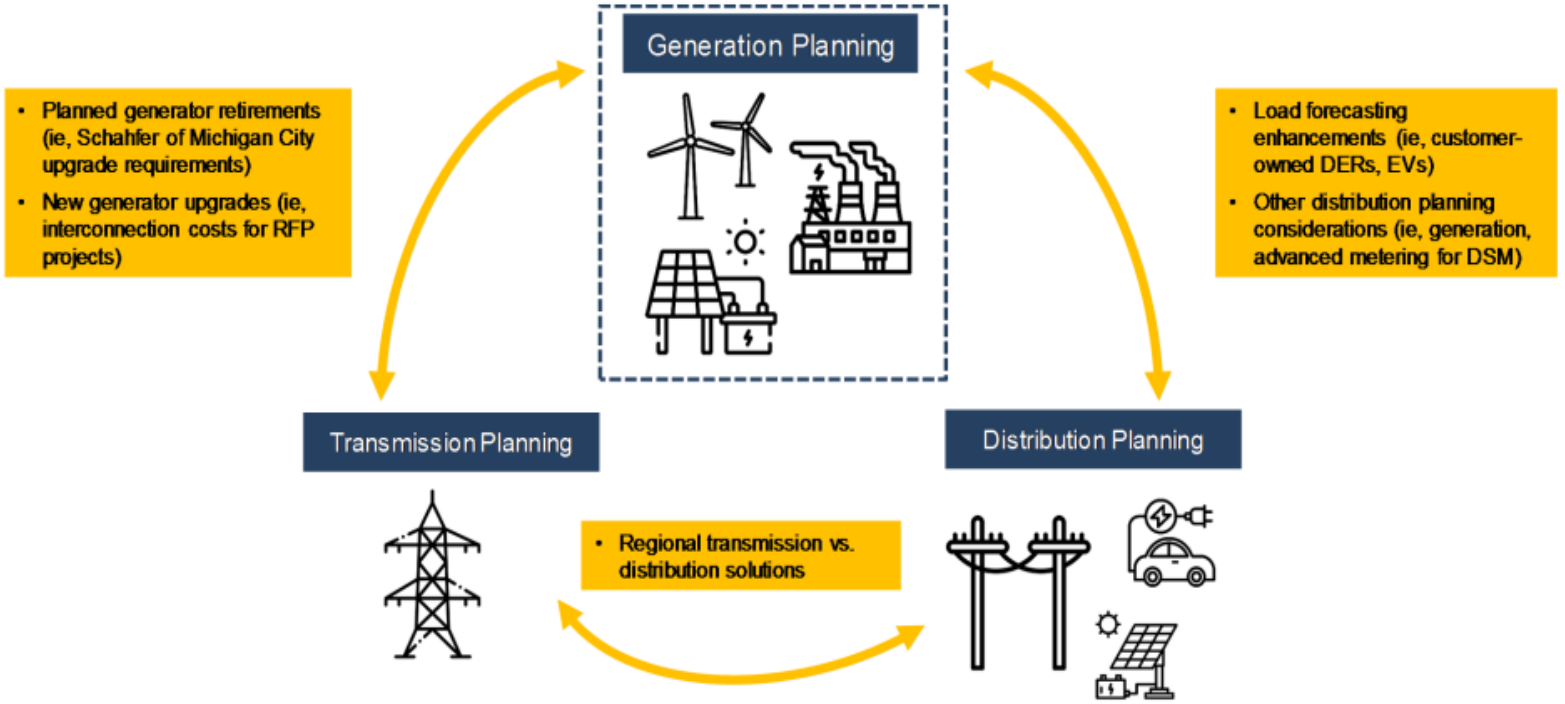
Multi-objective planning requirements & significantly different composition and uses of the grid are driving an increasingly complex planning process.

- What are the appropriate planning objectives and criteria for your power systems?
- How should the uncertainty of the pace and scope of change be addressed?
- What is the appropriate investment prioritization model?
- What level of collaboration is required to ensure we can achieve the desired objectives with a resilient, safe electric grid?
- What level of oversight & transparency is required to ensure objectives are achieved and stakeholders buy-in?

Integrated System Planning

Integrated planning concepts are well understood. Challenges arise with implementation

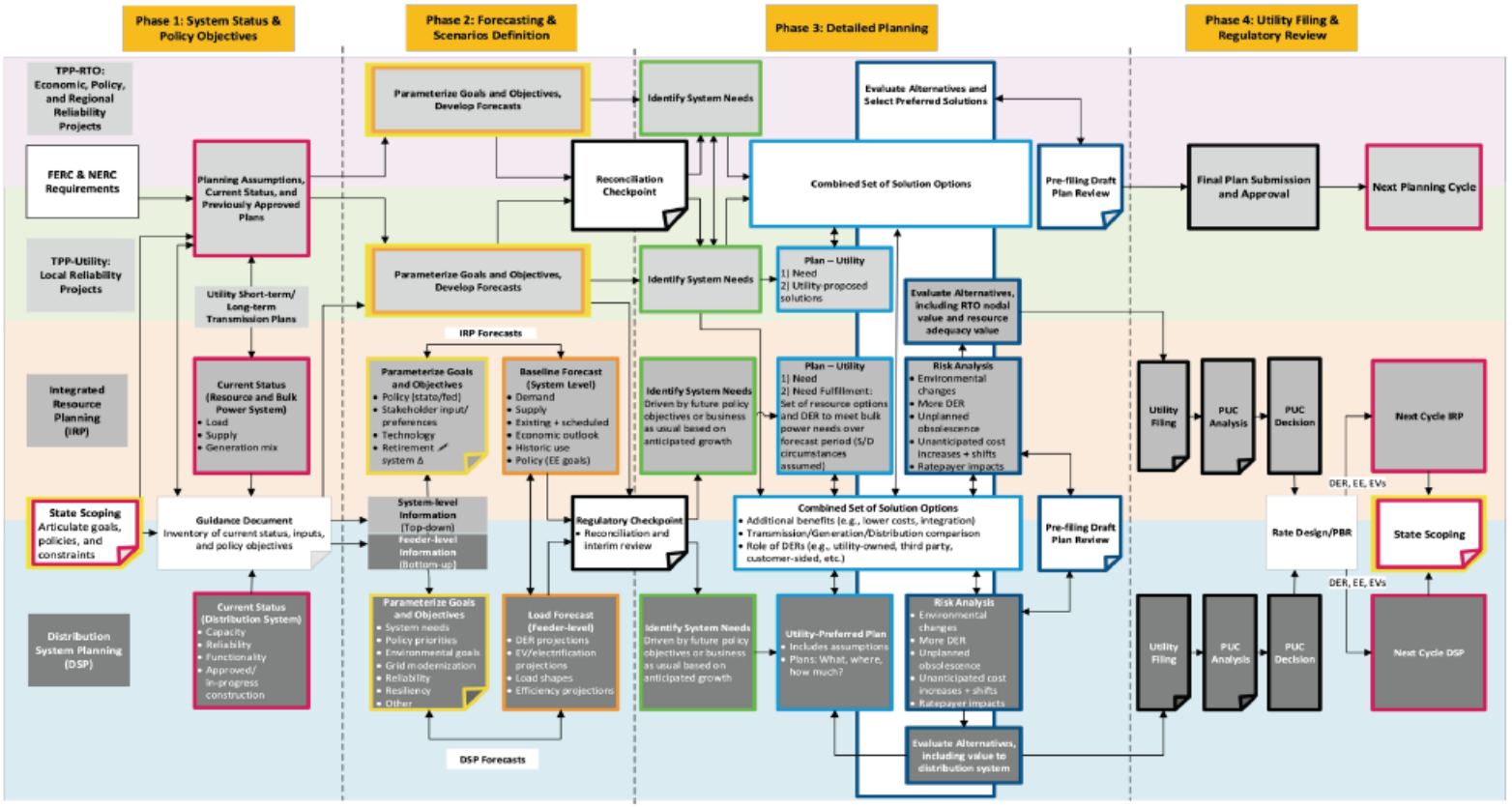
Integrated Planning Framework



Source: NIPSCO 2021 IRP

Integrated System Planning Multi-Entity Example

There is significant complexity when integrating multiple processes and entities (e.g., MISO, state energy offices, and utilities) operating on different planning cycles.



https://pubs.naruc.org/pub/150AB451-155D-0A36-31AD-816A88F64B67

Integrated System Planning

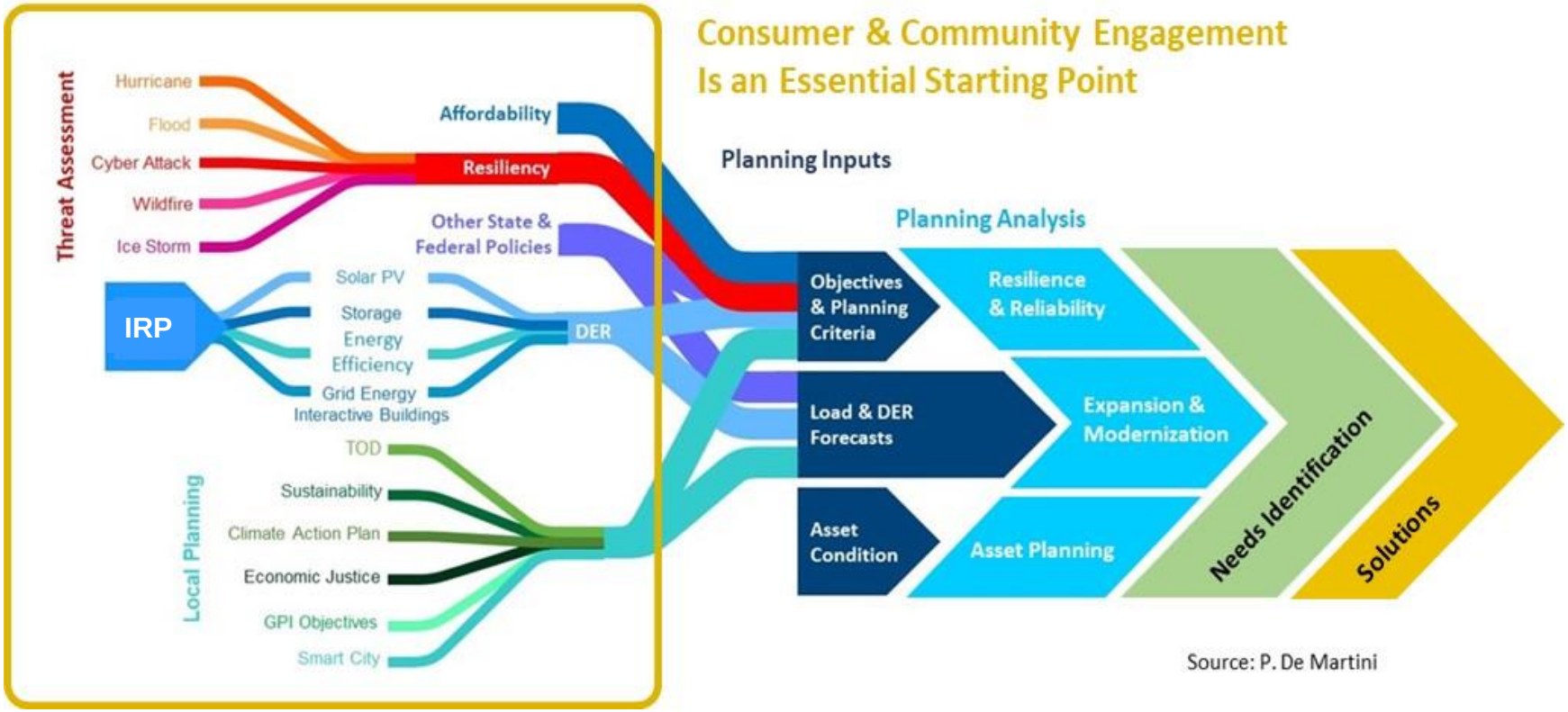
Context-setting for MISO, utility IRP and utility TDSIC

- A fully integrated system planning process for any state would be a highly complex undertaking, if at all possible.
- However, it is possible to identify key points in resource, transmission and distribution planning processes to ensure:
  - **Consistent inputs and assumptions, especially for forecasts**
  - **Transparency regarding processes and key points of interdependency and alignment**
  - **Consistent consideration of operating criteria and conditions (e.g., weather)**
  - **Optimization of solutions to potentially address a greater set of needs**
- Opportunities for state commissions to consider the interdependencies of various dockets that inform and are informed by integrated system planning.

MISO planning, utility IRP and utility TDISC should clearly and explicitly align as appropriate

Integrated Distribution Planning Inputs

Distribution planning is increasingly interdependent with IRP and bulk power use of DER, community sustainability planning, and resilience planning

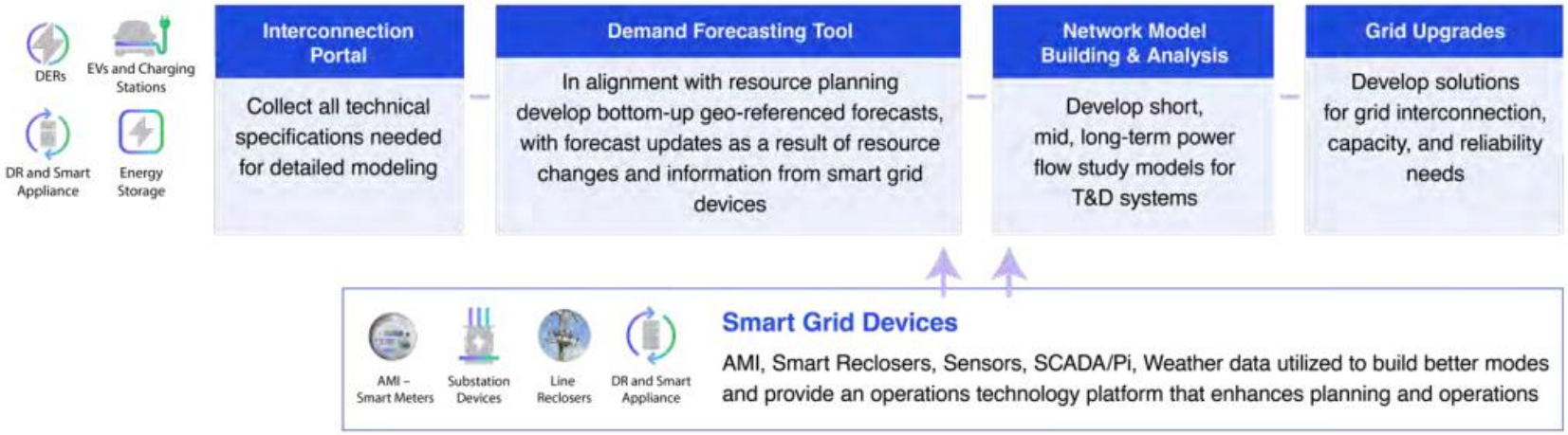


Source: P. De Martini

Indiana Distribution Planning Is Evolving

Holistic approaches are used in the IRPs to consider the changing ecosystem.

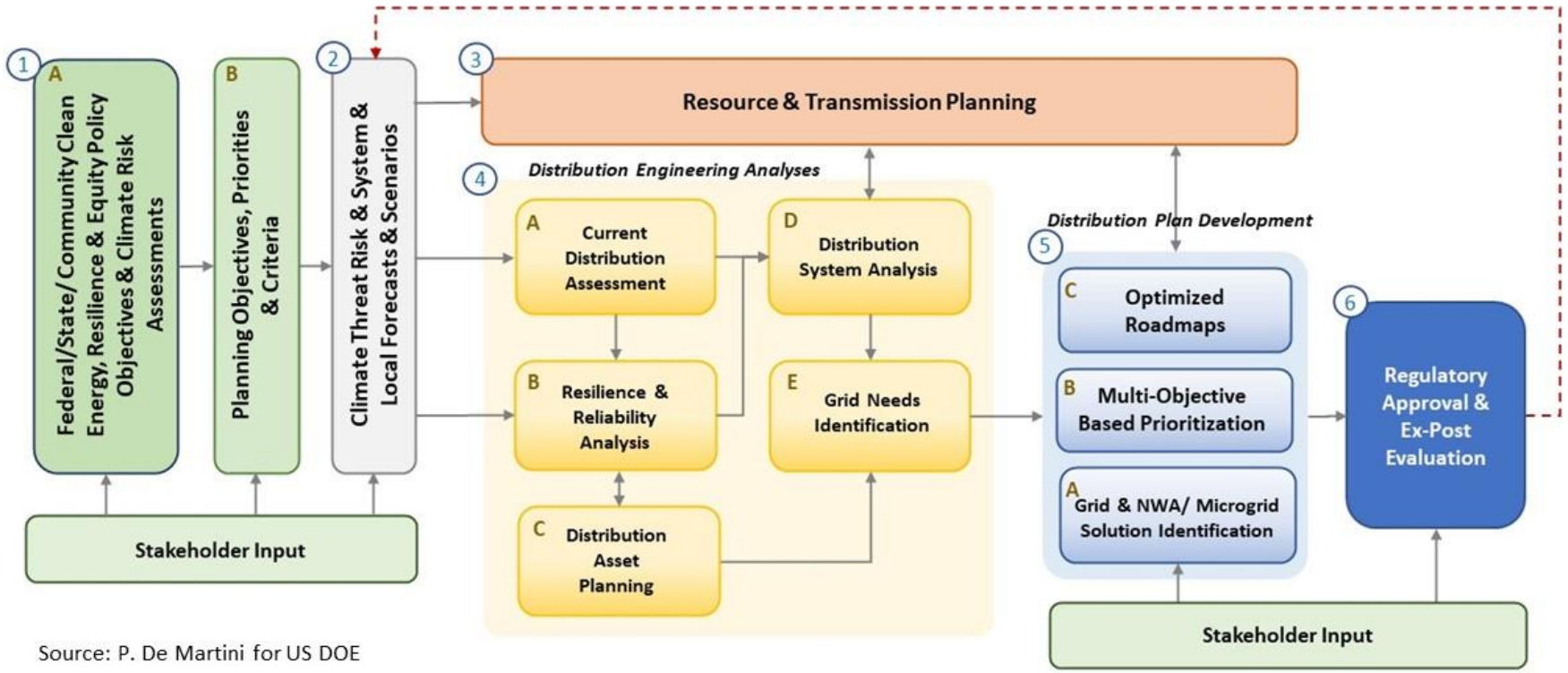
AES Indiana Distribution Planning Process



"With increasing penetrations of DERs (photovoltaic systems), EVs and charging stations, demand responses and smart appliances, and energy storage systems, AES Indiana is transitioning to a new distribution system planning process with ongoing adoptions of advanced tools, which can help AES Indiana proactively manage, forecast, model, and analyze system needs."

Source: AES Indiana 2021 IRP

Integrated Distribution System Planning Process



Source: P. De Martini for US DOE

1. Planning Objectives, Priorities and Criteria
2. Extreme Weather Threats and System Forecasts
3. Resource & Transmission Planning
4. Distribution Engineering Analyses
5. Solution Identification, Evaluation and Prioritization
6. Regulatory Review & Ex Post Evaluation

Source Paper: https://gridarchitecture.pnnl.gov/media/advanced/Integrated_Resilient_Distibution_Planning.pdf

IRP vs TDSIC

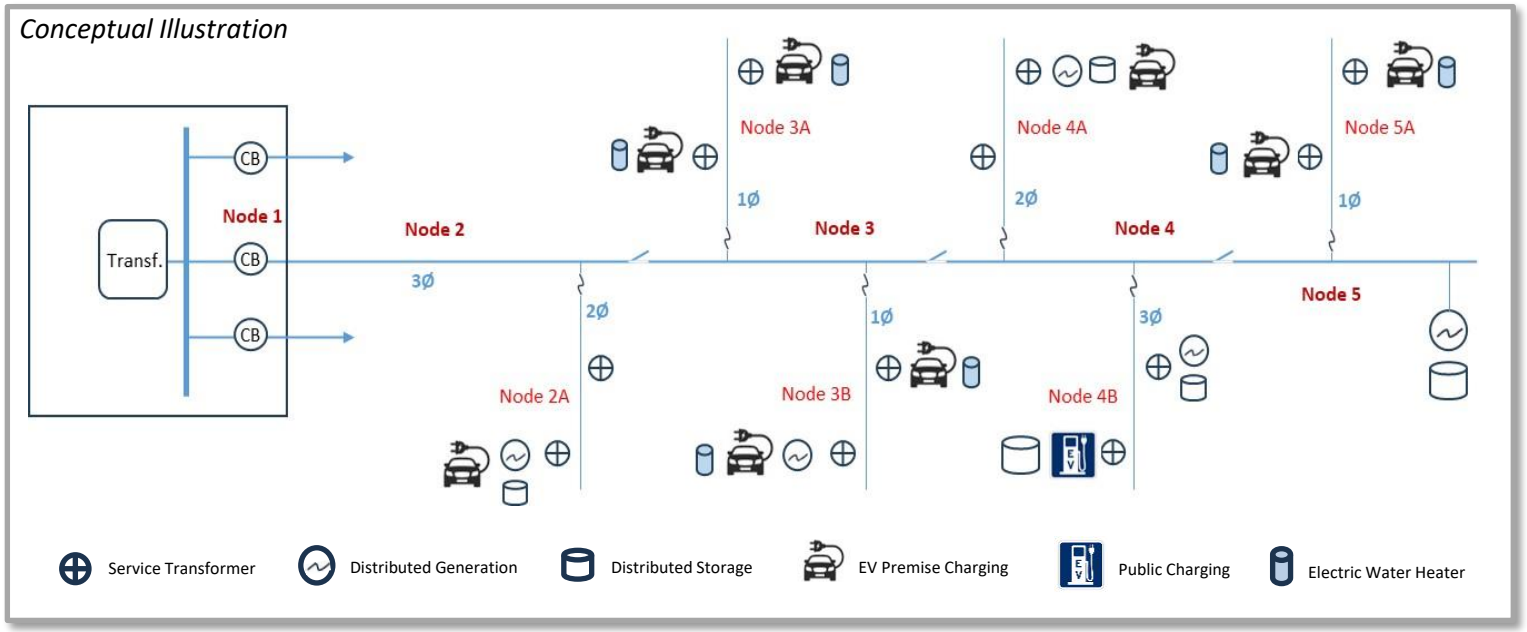
Observation: It does not appear that Indiana IRPs and TDSICs are integrated.

- Unclear how IRPs inform TDSIC analysis and proposed projects – No apparent discussion in TDSIC of the factors identified in the IRP
- Unclear if IRP and TDSIC planning processes are interrelated – industry best practice says they should be
- Unclear how state, community and customer objectives shape TDSIC analysis and prioritization of proposed projects
- Unclear how TDSIC projects tied back to IRP outcomes

Note: Observation is based on review of utility 2021 IRPs and recent TDSIC plans

New Challenges: Management of Distribution Feeder Capacity Is Getting More Complex

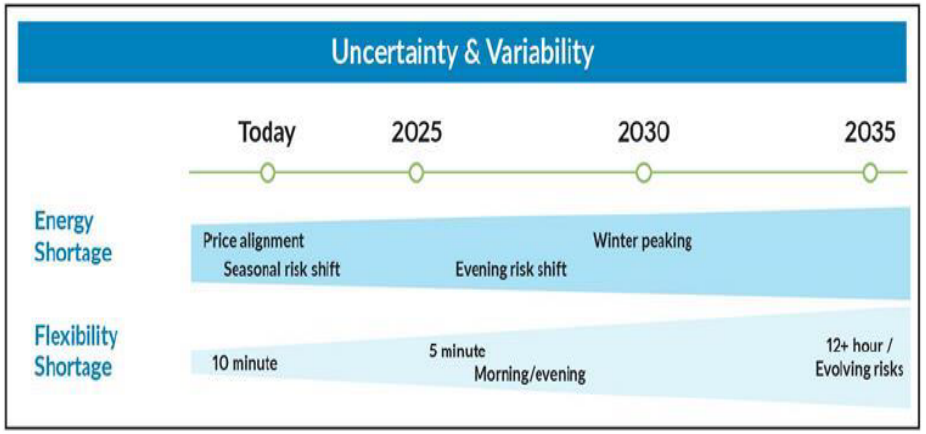
- **Managing hosting capacity** on radial distribution over the next 15 years will much **more complex involving many "nodes"**
- Power flow **constraints in any node may occur at different times with other nodes** due to the nature of the flows resulting in non-coincident peaks that also nest with one another depending on the flow directions



A Node (**dark red**) is created on a feeder between each isolation point from the feeder breaker to the end of the line. Subnodes (bright red) are created within each feeder node by each fused lateral (laterals, as illustrated, are often not 3-phase which creates additional considerations)

DER Orchestration Will Be Required

FERC Order 2222, and the need to manage distribution capacity constraints due to electrification and DER growth, will drive the need for sophisticated DER orchestration.



Source: MISO – Future Markets Report

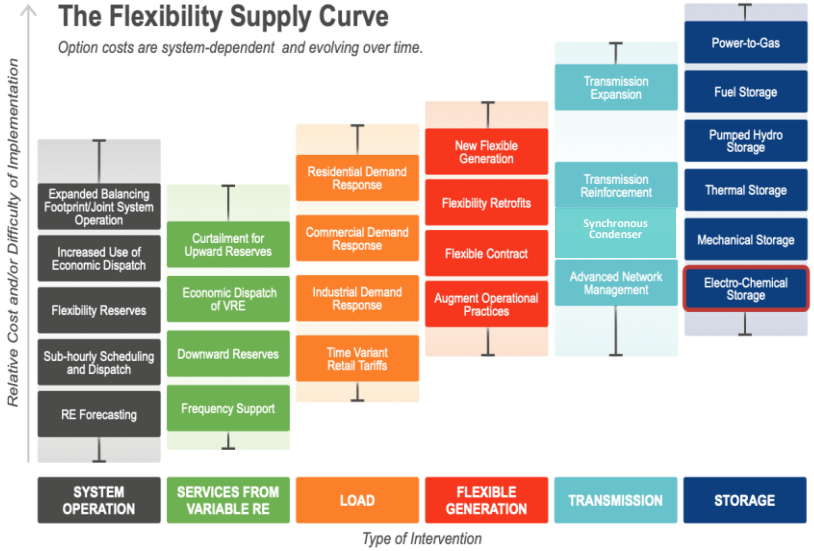


Figure 6. The flexibility supply curve

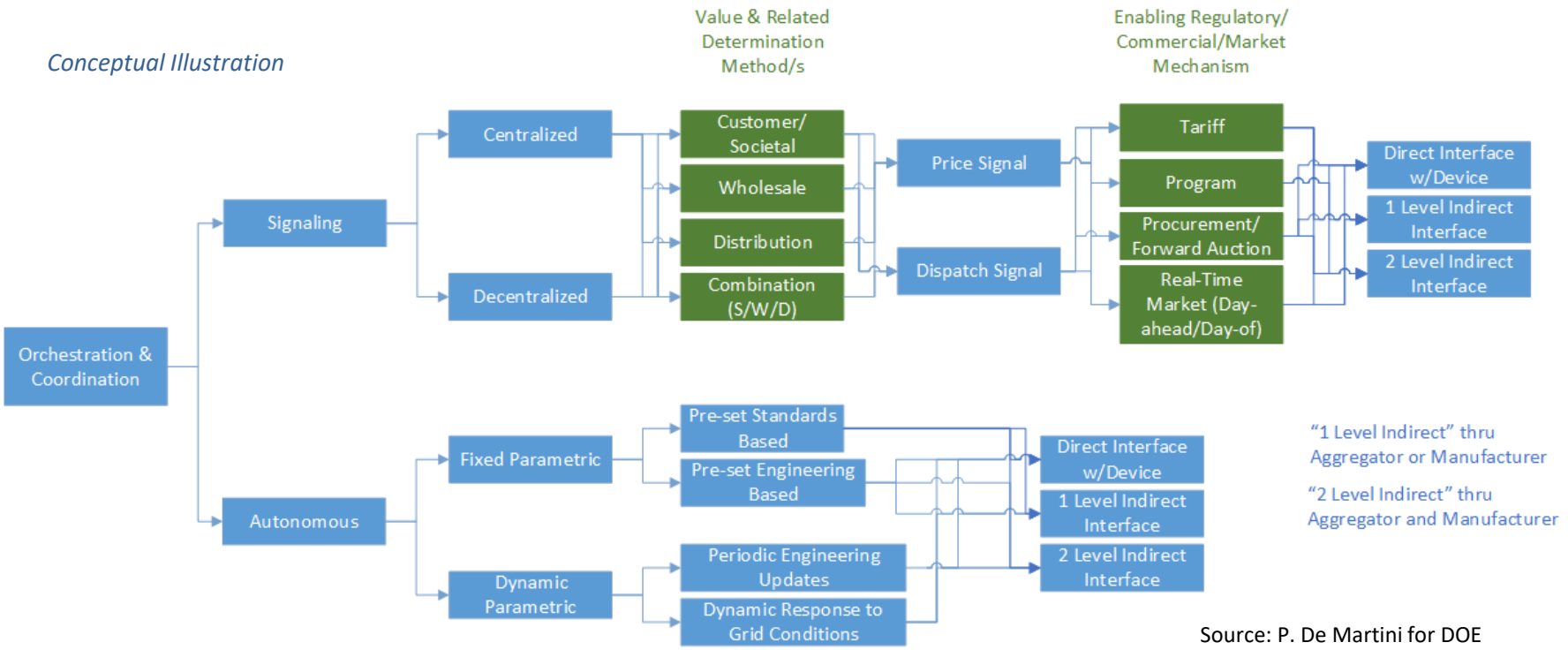
Source: NREL

- How are MISO's market plans informing utility IRPs and TDSICs?
- What operational coordination is needed between Distribution Operators and MISO?
- What operational systems and new procedures are required?

Emerging DER Orchestration Challenge

Orchestration of DER/EV charging to address MISO and distribution needs will become increasingly complex.

Pricing, programs and procurements will need to be aligned

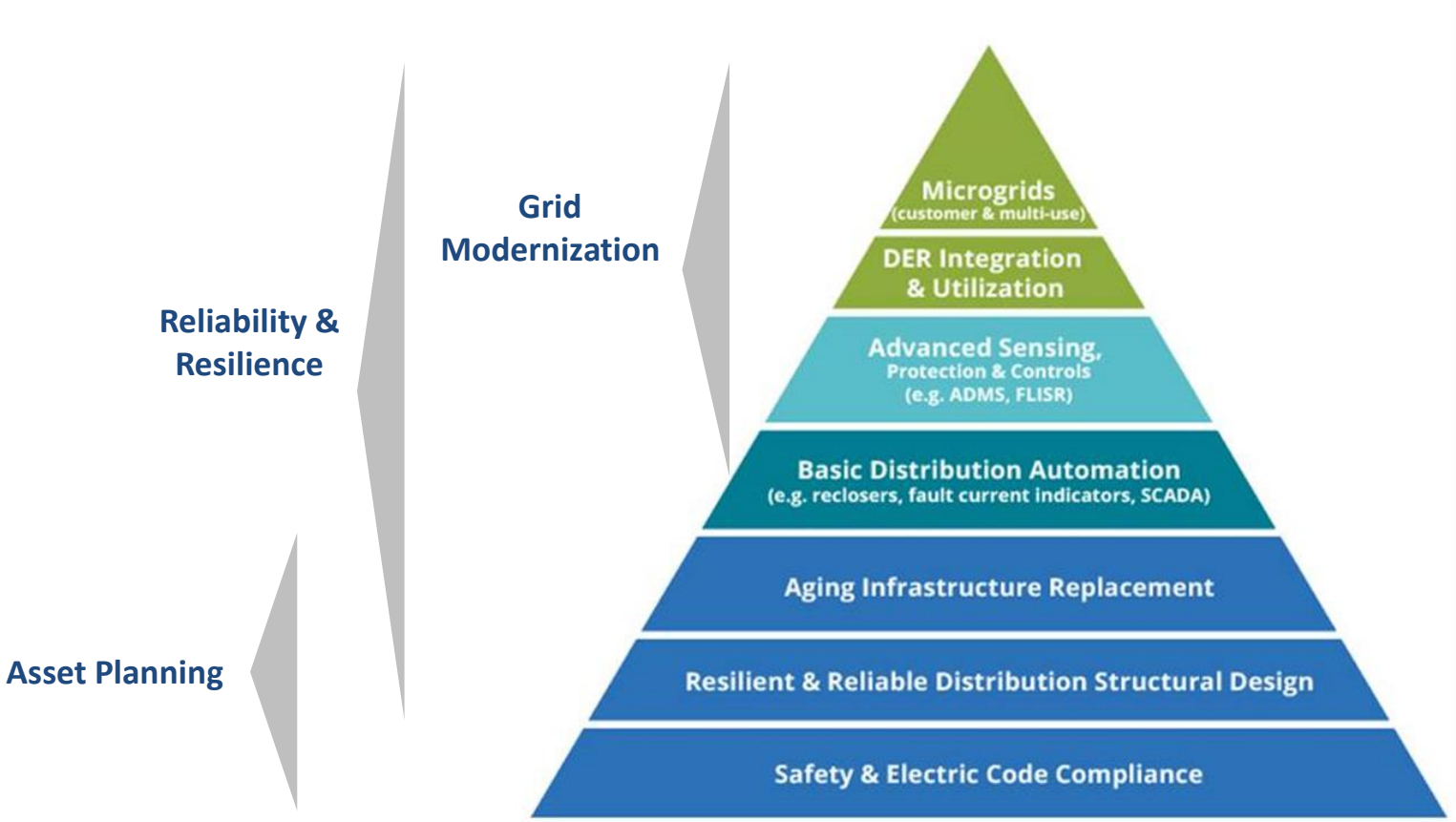


Source: P. De Martini for DOE

DER orchestration will involve both control signals and DER autonomous response

Distribution Investment Categories

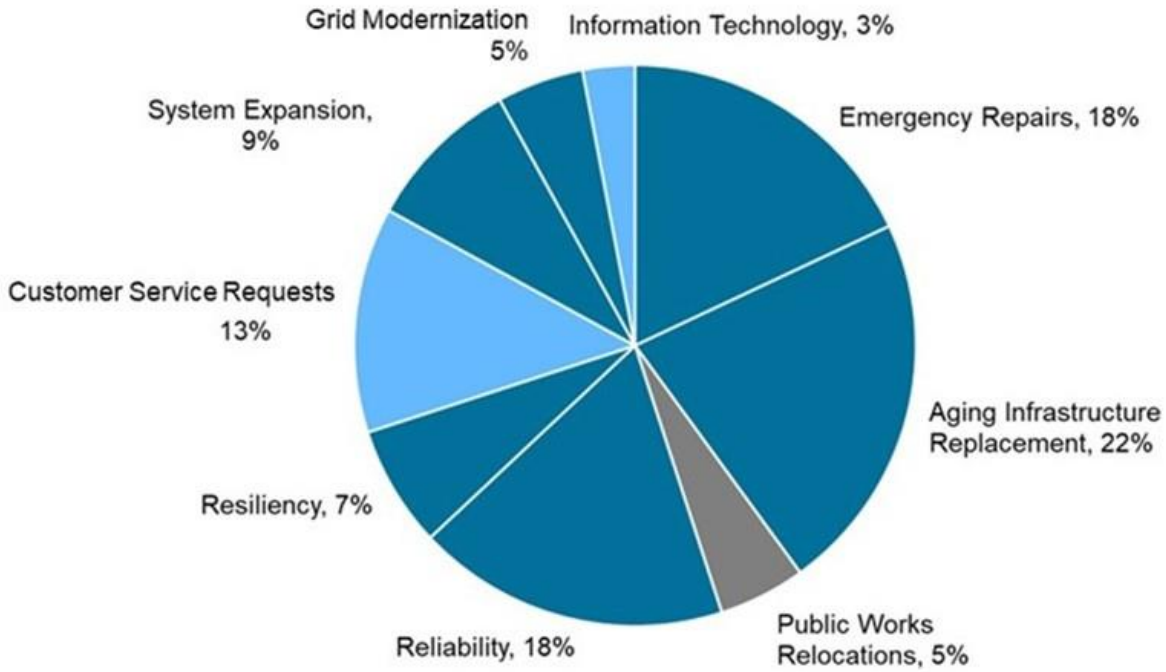
Grid modernization technologies layer on top of and integrate with foundational physical grid infrastructure.



Source: De Martini

Distribution Investments Are Interrelated

Most distribution capital investments contribute to achieving multiple objectives



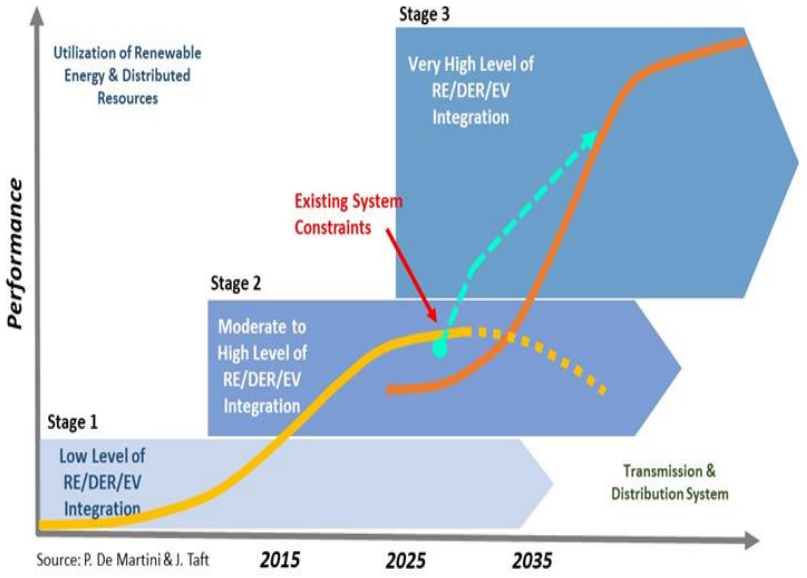
Conceptual Budget Allocation Example

For example, **blue** shaded elements directly or indirectly meet reliability and resilience objectives.

Integrated System Planning Takeaways

"What got us here, is not going to get us there" Marshall Goldsmith

- **Planning scope is expanding** – Scope of climate mitigation and adaption is growing in scale and complexity
- **Integrated planning** is needed to address balkanization of planning, investment decisions, and execution and **prioritize actions** toward outcomes that have the most significant benefits for consumers/communities
- **DER/EV orchestration** capabilities need to advance more quickly to avoid significant problems with the energy transition
- **New grid architecture** – The 19th Century Tesla-Edison architecture is not adequate for the 21st Century



IDSP Reference Material

Lawrence Berkeley National Laboratory's Integrated Distribution System Planning Website

https://emp.lbl.gov/projects/integrated-distribution-system-planning

This website has an extensive library of reference material to support deeper exploration of integrated planning.

Thank you

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