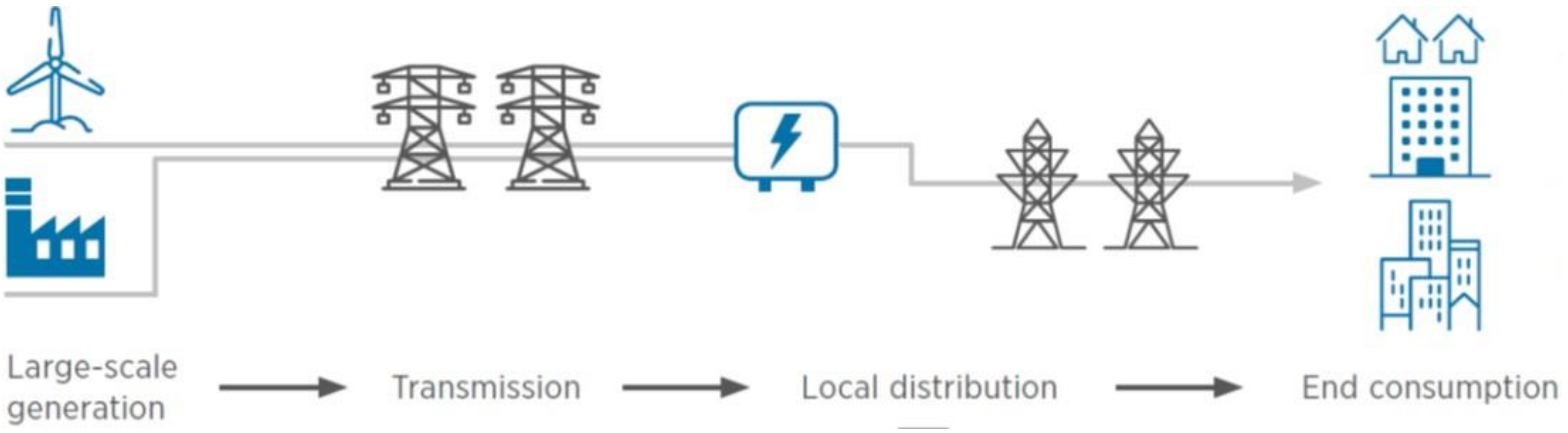
Energy Transition, Lead Jurisdictions & Navigating Whole-system Change

25 October 2021

Our 20th century legacy architecture was designed for this…



• Large synchronous generation • One-way flow • Negligible VRE and energy storage • Passive consumers

Image: IRENA System Operation Collection (2020)

But 21st century power system architecture must enable ever-increasing amounts of this…

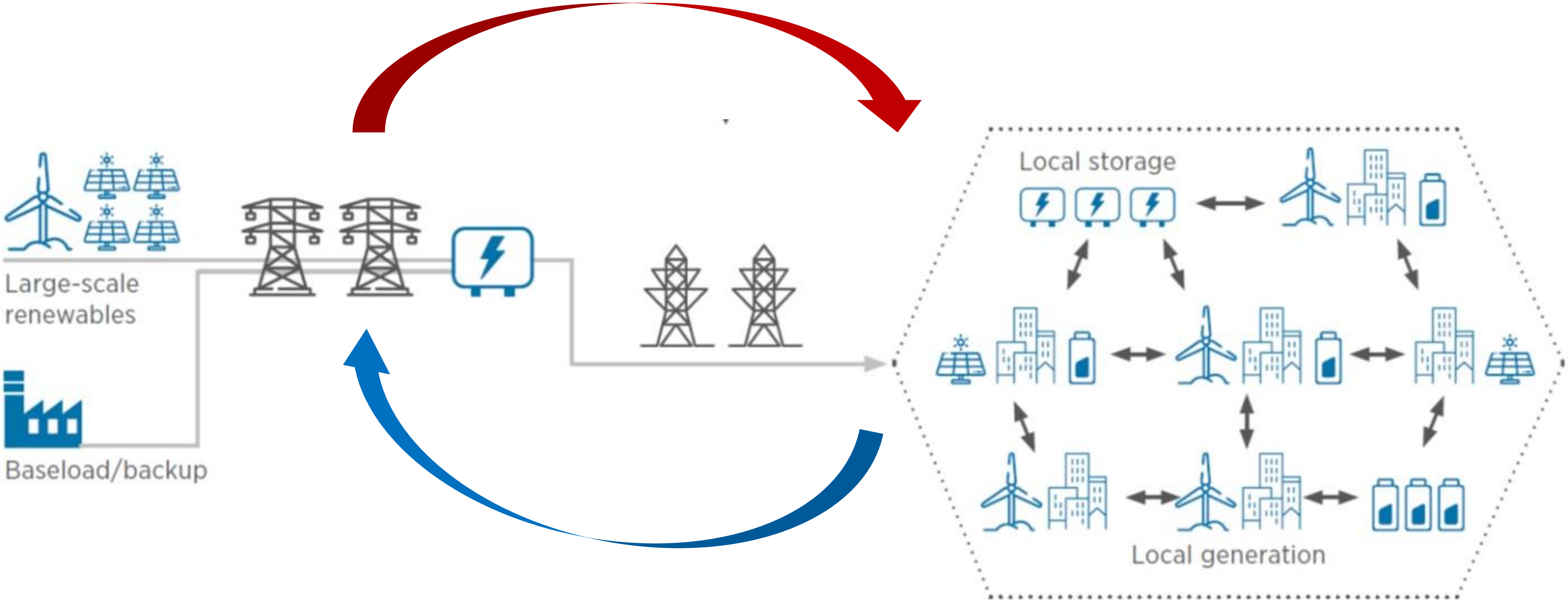


Image: IRENA System Operation Collection (2020)

What does the future look like…?

+ Deeply hybridized and decarbonised power system
+ Increasing periods where >100% of demand is served by VRE
+ Up to 50% of annual volume served by DER (GWh) at the polar opposite end of the grid
+ Massive demand-side flexibility is required
+ Huge volumes of energy storage
+ Rich diversity of customer needs and aspirations

In this increasingly dynamic future, bulk energy, transmission and distribution systems – together with deep demand-side flexibility – will need to function holistically to enable reliable and efficient operation, including during periods where >100% of instantaneous demand is served by centralised and distributed VRE.

And this involves transformational (not just incremental) shifts

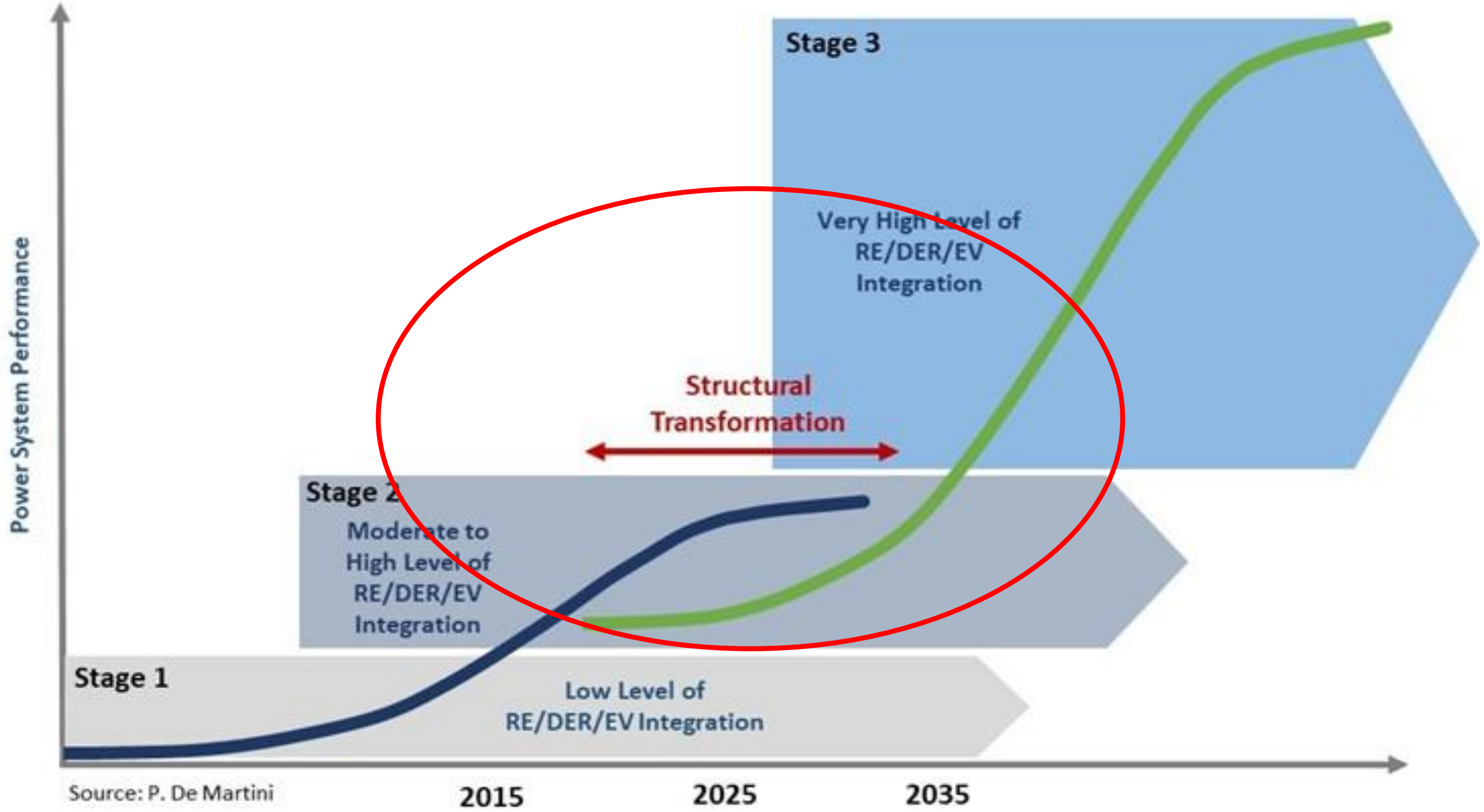
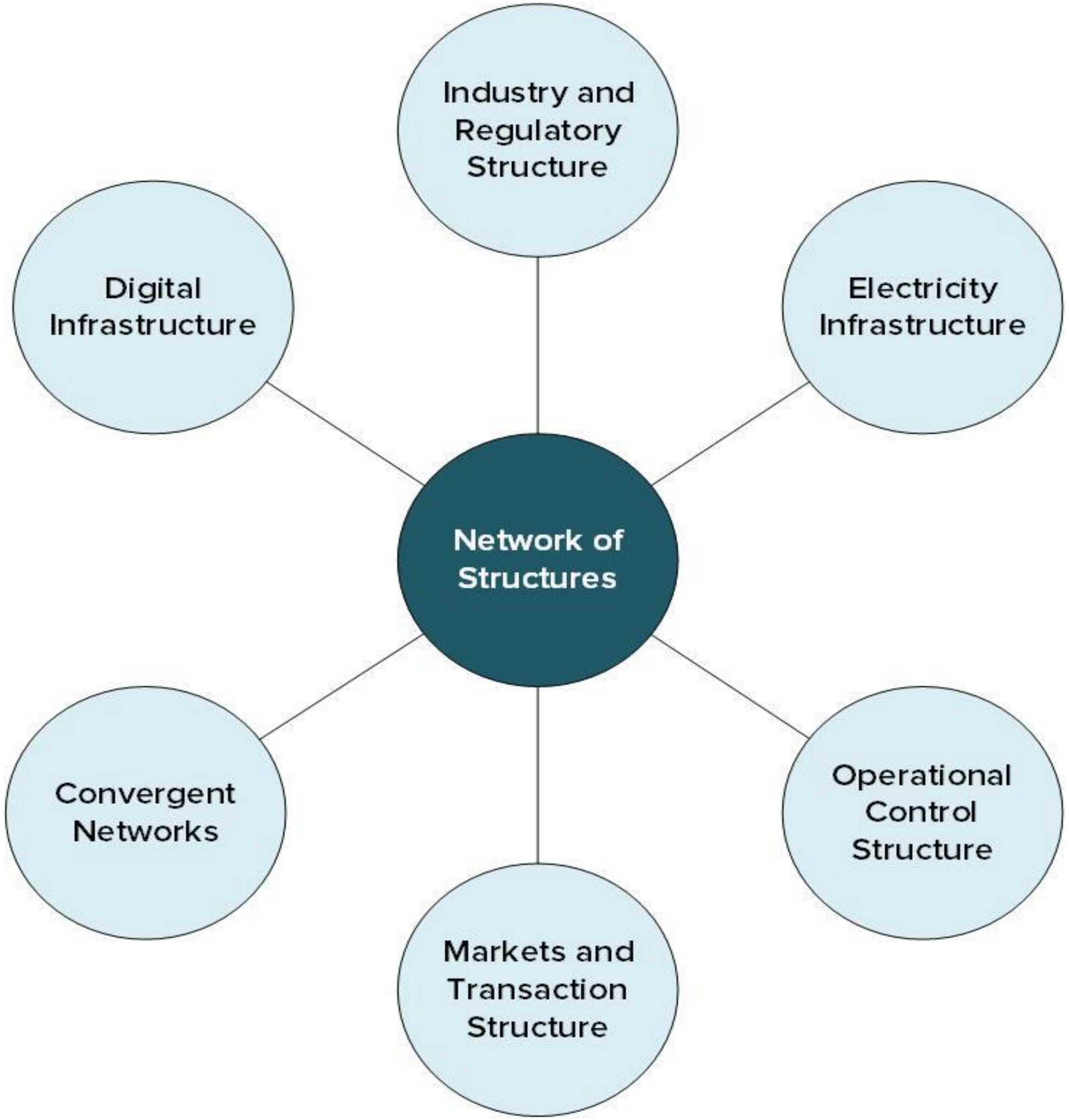


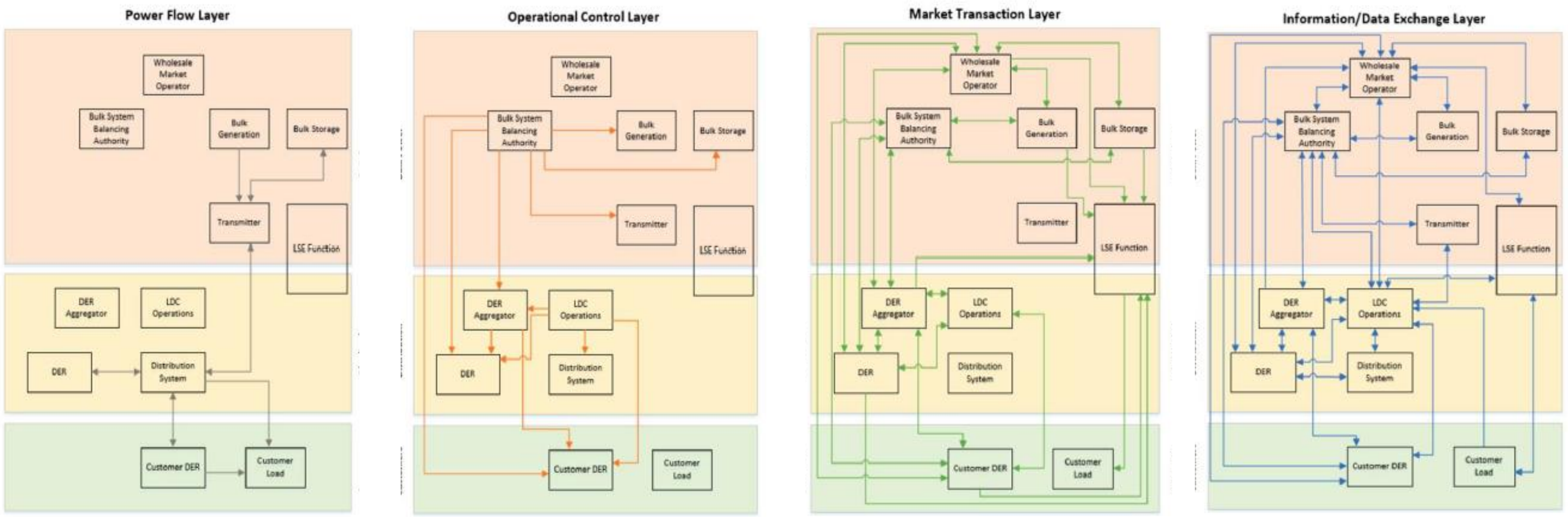
Image: https://pacificenergyinstitute.org/wp-content/uploads/2021/08/A-Gambit-for-Grid-2035-final-version.pdf

Modern power systems are a massively complex 'Network of Structures'



Note: This complexity is *intrinsic* to a modern power system – Systems Architecture disciplines simply make it explicit

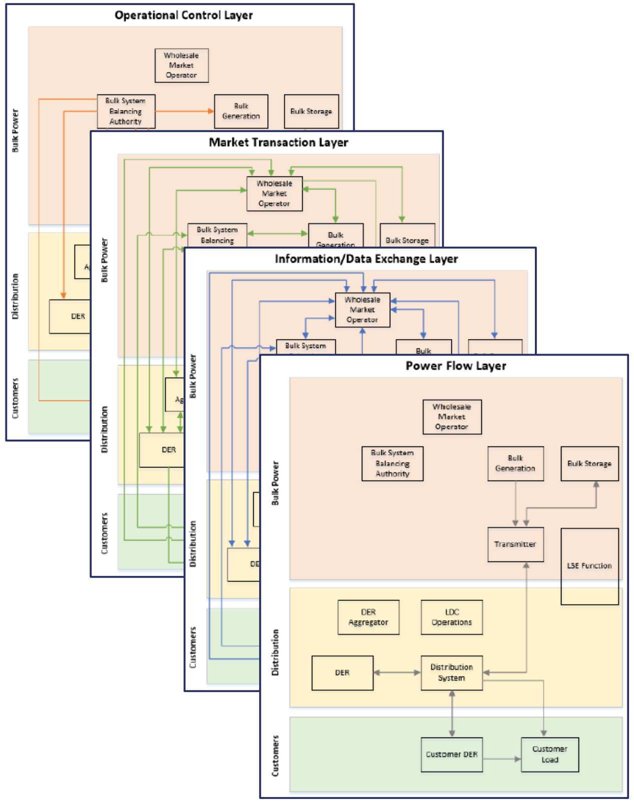
The four functional layers of the power system are shown here artificially as discrete systems

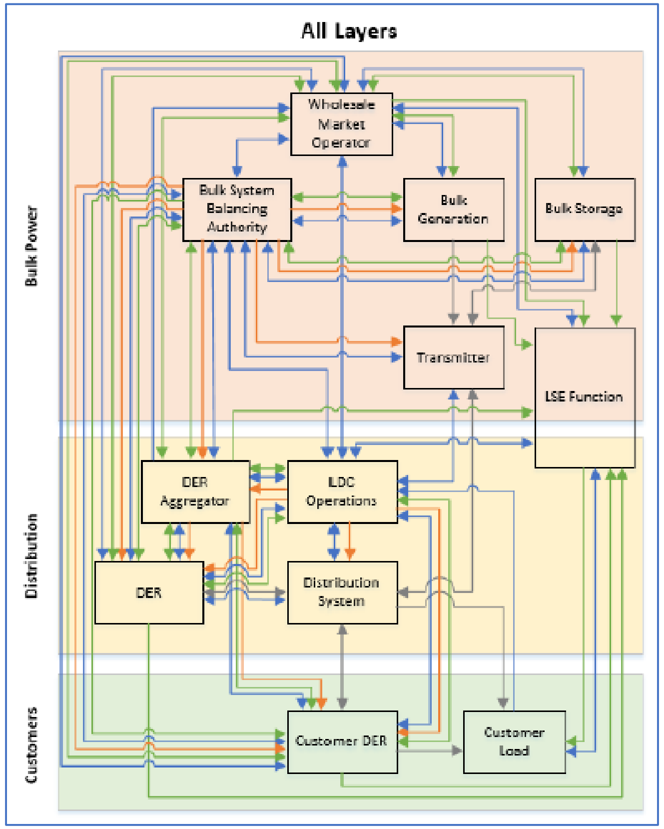


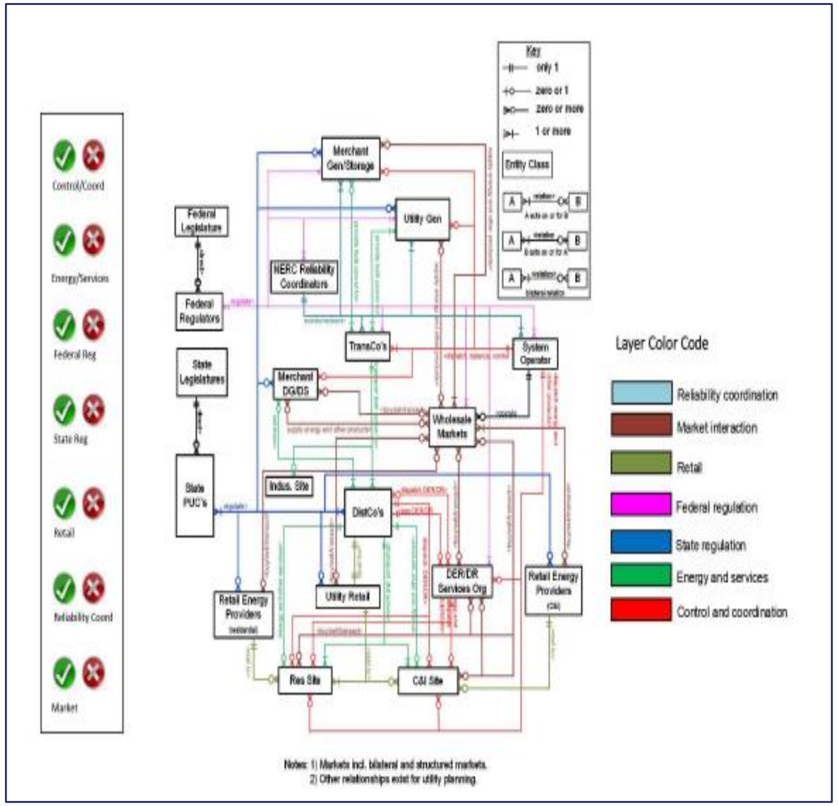
Each of these four functional layers are dynamically interdependent. It is not uncommon that changes to one layer will result in both intended and unintended impacts on other layers.

Images: Development of a Transmission-Distribution Interoperability Framework, prepared by ICF for the Independent Electricity System Operator, Ontario, Canada (2020)

These four interdependent layers as they *really* are, plus the industry and regulatory structures

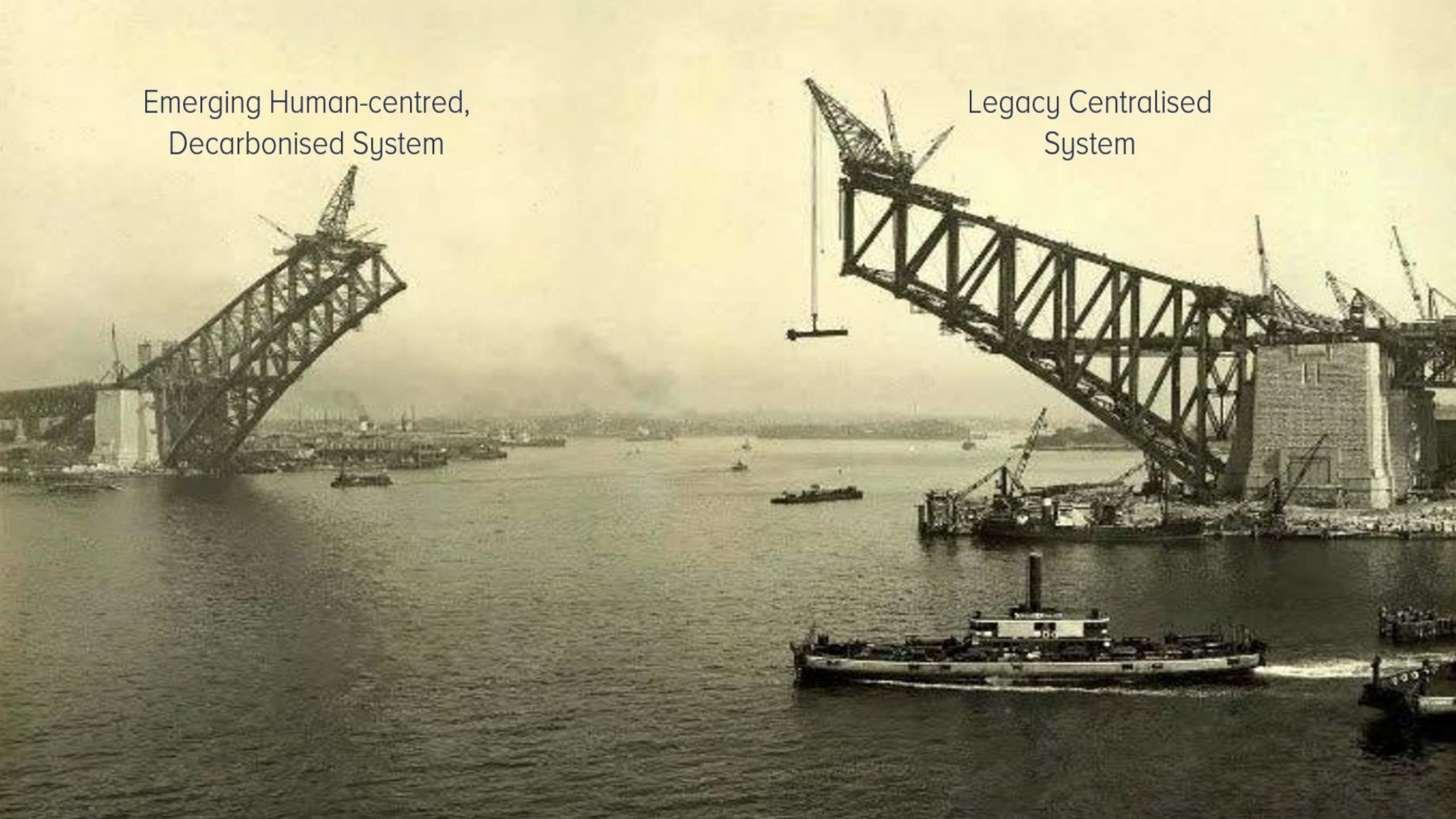




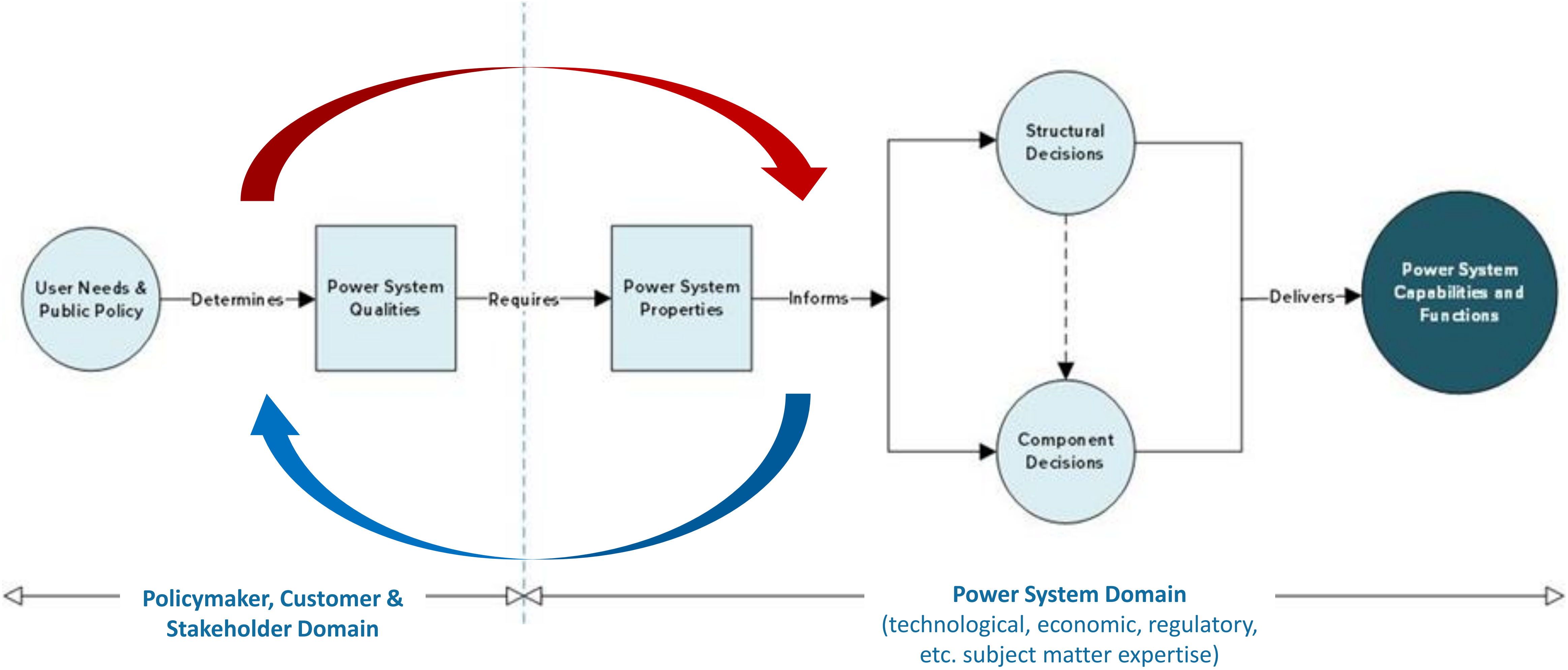


Caution: Don't 'shoot the messenger' – Systems Architecture disciplines simply reveal what is already there

Images: Development of a Transmission-Distribution Interoperability Framework, prepared by ICF for the Independent Electricity System Operator, Ontario, Canada (2020) and Pacific Northwest National Lab (2021)


Emerging Human-centred,
Decarbonised System
Legacy Centralised
System

A whole-system architectural approach provides a structure key states to lead and enable multi-stakeholder navigation of longer term transformation



Examples of contemporary practical issues that are directly impacted by whole-system longer-term architectural action (or inaction)

- Network Planning & Options Analysis
- Evolving DNSP / DSO Roles & Responsibilities
- Distribution System Operator (DSO) models and investment cases
- DER Services Valuation & Benefits Realisation
- Business Case development for Non-network Solutions (including Energy Storage)
- Ring-fencing considerations for grid-scale and community-scale energy storage
- Transmission – Distribution Interface Design
- Dynamic Operating Envelope scalability (post-trial)
- Digital Market Platform computational scalability (post-trial)
- Distributed Energy Resource Management Systems (DERMS) investment cases
- Enterprise IT Architecture investments

In summary, a whole-system approach is also required because…

Align the system architecture with 21st century needs and all the components will fit neatly into place, the 'vertical' value-stack of VRE / DER / ES unlocked, investments made more extensible and future-resilient, and the entire system more resilient and cost-efficient.

Fail to address power system architecture issues and VRE / DER / ES integration becomes increasingly costly and inefficient, investments will be duplicated and/or stranded, the system will become more brittle and less resilient and post-trial scalability issues will multiply.