Principle-based planning studies & full stack flexibility

Jeremiah Miller, PE

Dir. Storage
Markets & Policy

SEIA

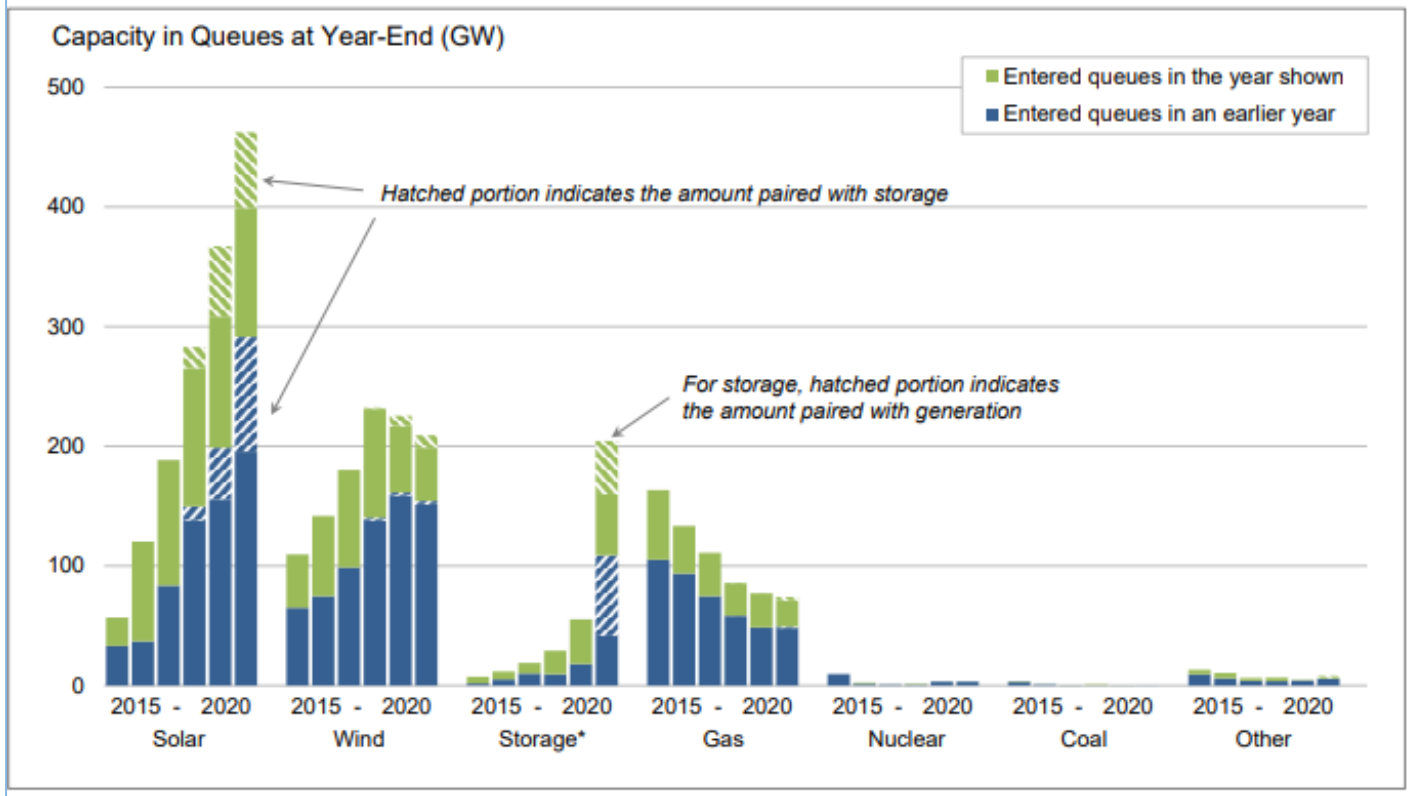
03/2022

Solar Energy Industries Association®

Powering the Solar+ Decade

Interconnection: Building Solar and Wind Grids

Interconnection queues indicate that commercial interest in solar and storage has grown, including via hybridization; wind and gas have declined



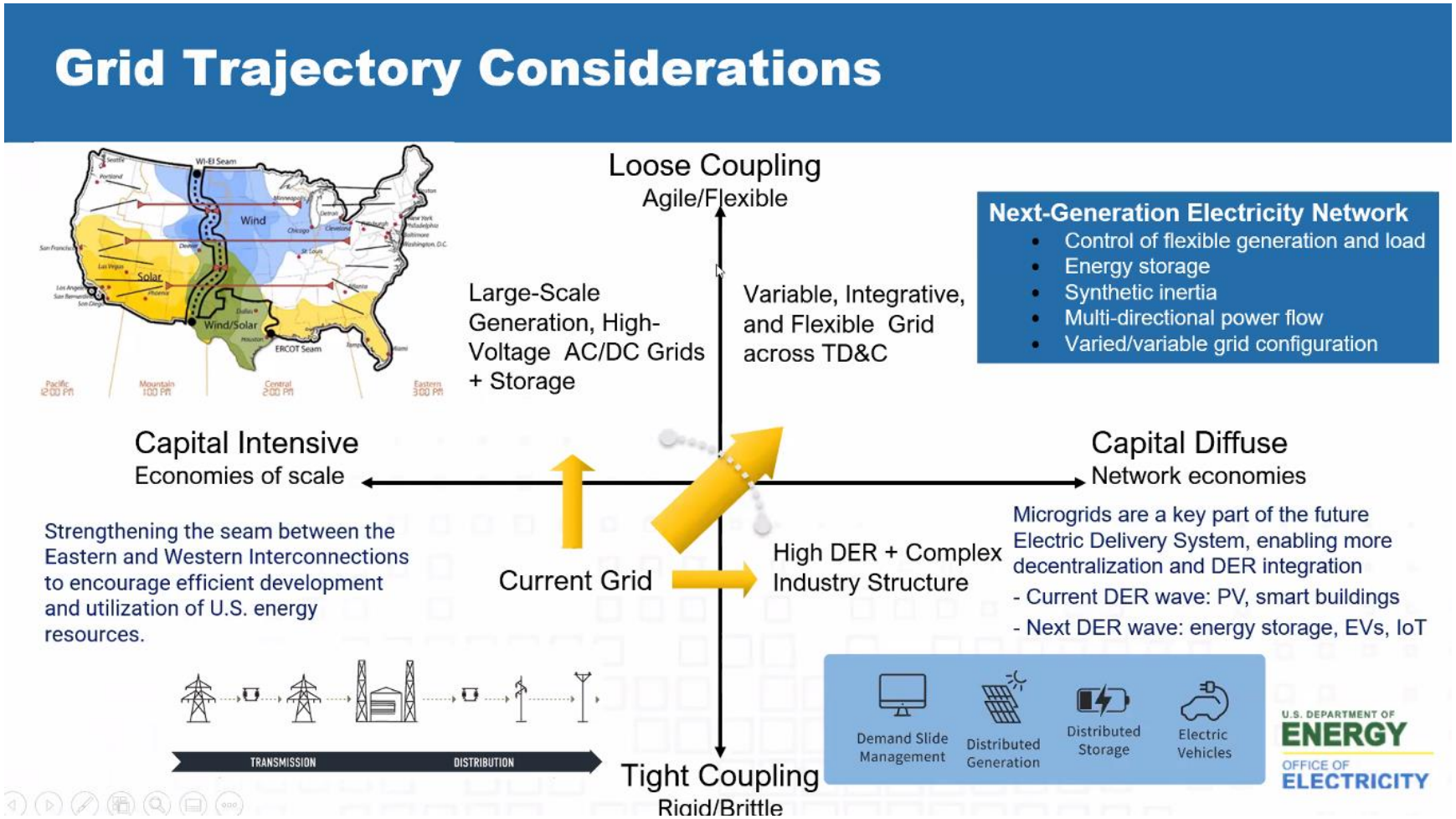
*Hybrid storage capacity is estimated using storage:generator ratios from projects that provide separate capacity data
Storage capacity in hybrids was not estimated for years prior to 2020.
Note: Not all of this capacity will be built

- "**Wind**" includes both onshore and offshore.
- "**Other**" includes
  - Hydropower
  - Geothermal
  - Biomass/biofuel
  - Landfill gas
  - Solar thermal
  - Oil/diesel
- "**Storage**" is primarily (98%) battery, but also includes pumped storage hydro, compressed air, gravity rail, and fuel cell projects.

11

https://eta-publications.lbl.gov/sites/default/files/queued_up_may_2021.pdf

Variable, Integrative, and Flexible Grid



- Uncertainty under grid transformation: changing resource mix and rapidly maturing technology that will significantly alter use (storage, electrification, etc.)
- And more complex planning than reliability through build more transmission vs distribution vs DER
- Many market services still underdeveloped for embedded storage

Source: DOE Energy Storage Financing Summit 1/20/2022

Load served by solar and wind (DER included)

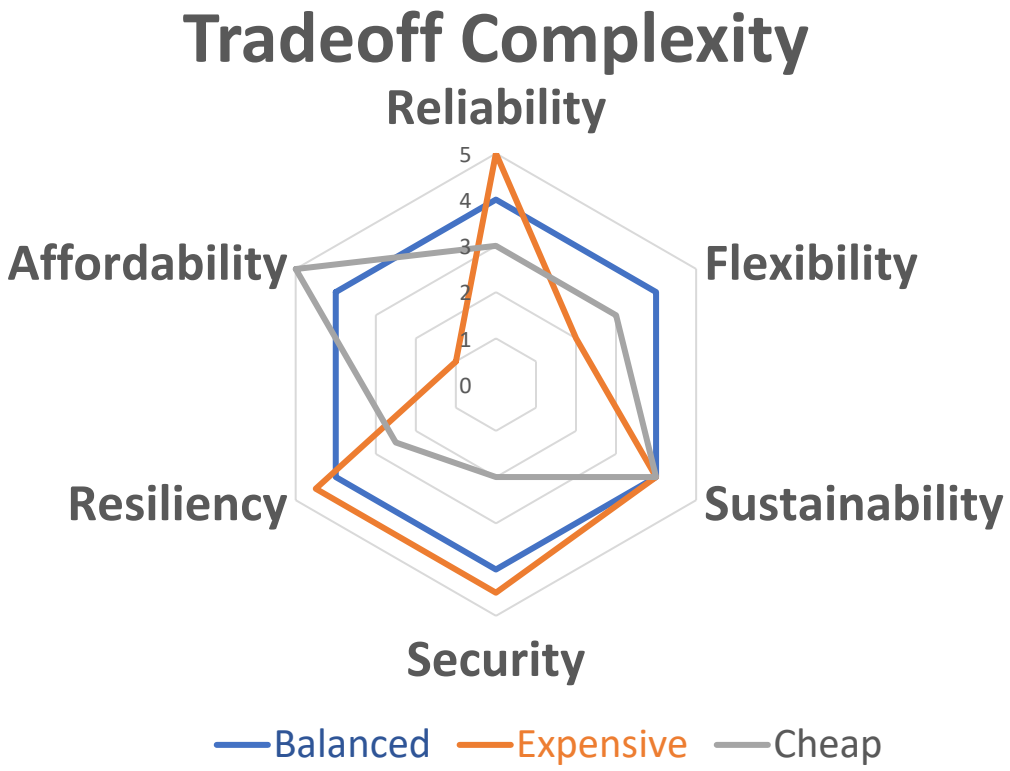
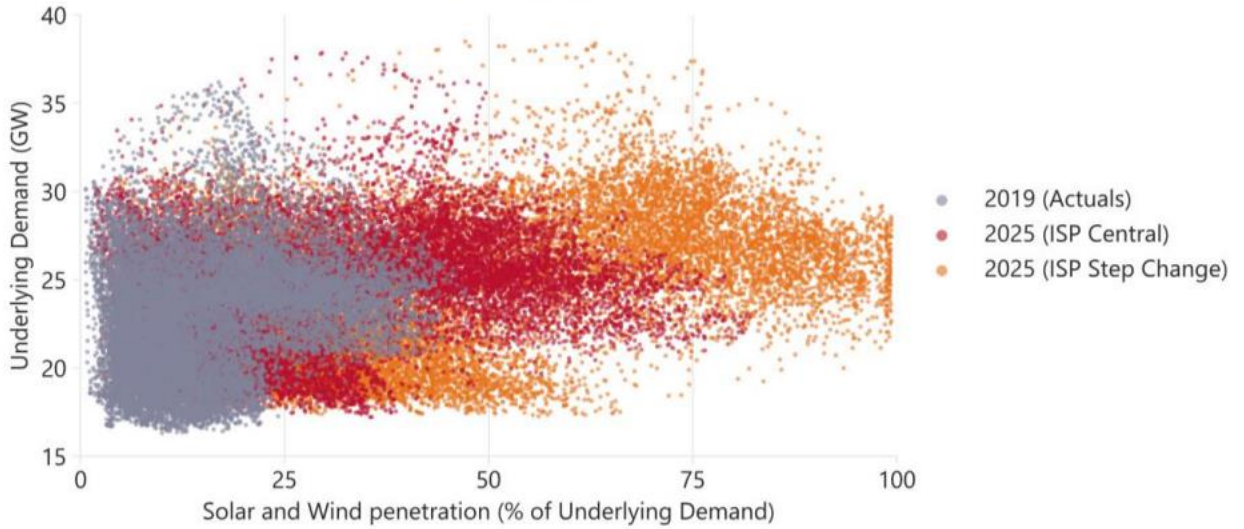


Figure 1 **Instantaneous penetration of wind and solar generation, actual in 2019 and forecast for 2025 under ISP Central and Step Change generation builds**

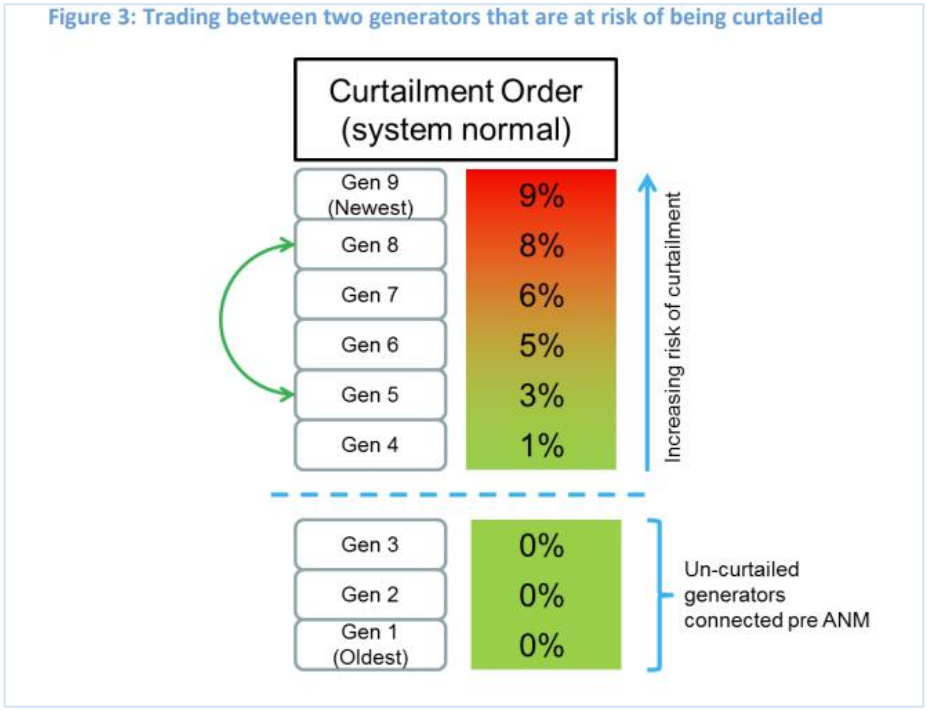


Note: Penetration on this graph represent NEM half-hourly wind and solar generation divided by the underlying demand which includes demand response, energy storage, and coupled sectors such as gas and the electrification of transport.

https://www.aemo.com.au/-/media/files/major-publications/ris/2020/renewable-integration-study-stage-1.pdf

- Variable solar and wind will increasingly serve load
- There will be periods when rooftop solar and DER will be a major generation source

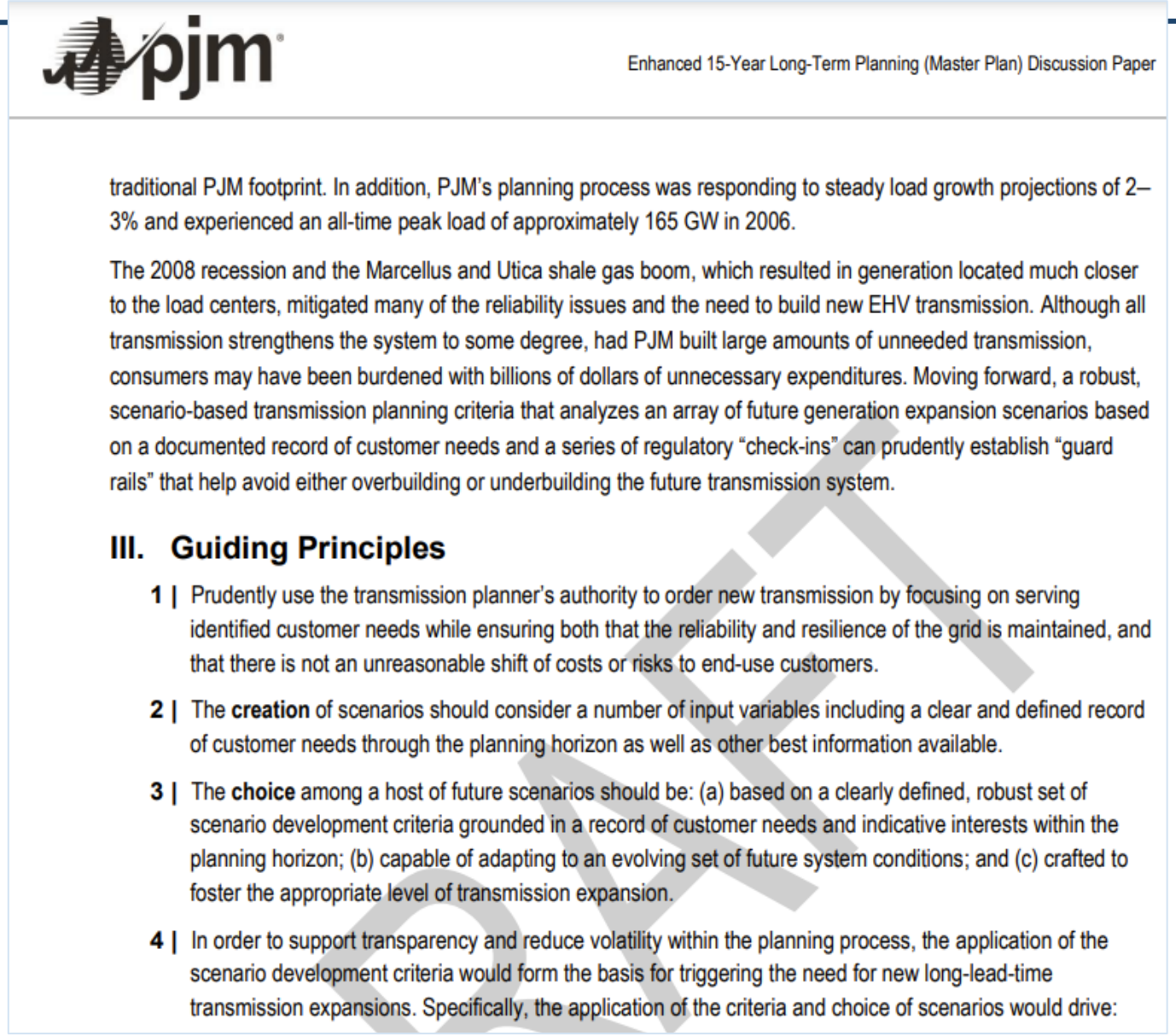
Curtailment: One Half of Bi-directionality Markets



- Curtailment doors should swing both ways – this is essential for affordable grid modernization
- The US needs a national standard for bi-directionality power control systems. Applicable at the key interfaces:
  - T-to-T interties (HVDC); large power transfers
  - T-to-flexIPP
  - T-to-D
  - D-to-flexDG (FTM)
  - D-to-flexDER (BTM)
- And we need to look holistically at market processes
  - Flexible interconnection is a mature market offering in Europe
  - Tradable curtailment rights?
  - Increased curtailment risk triggers cluster upgrade and market-based cost allocation?

https://www.chargingfutures.com/media/1396/product-1-and-product-2-combined-report_version-10.pdf

Principle-based planning and market signals



pjm

Enhanced 15-Year Long-Term Planning (Master Plan) Discussion Paper

traditional PJM footprint. In addition, PJM's planning process was responding to steady load growth projections of 2–3% and experienced an all-time peak load of approximately 165 GW in 2006.

The 2008 recession and the Marcellus and Utica shale gas boom, which resulted in generation located much closer to the load centers, mitigated many of the reliability issues and the need to build new EHV transmission. Although all transmission strengthens the system to some degree, had PJM built large amounts of unneeded transmission, consumers may have been burdened with billions of dollars of unnecessary expenditures. Moving forward, a robust, scenario-based transmission planning criteria that analyzes an array of future generation expansion scenarios based on a documented record of customer needs and a series of regulatory "check-ins" can prudently establish "guard rails" that help avoid either overbuilding or underbuilding the future transmission system.

III. Guiding Principles

1 | Prudently use the transmission planner's authority to order new transmission by focusing on serving identified customer needs while ensuring both that the reliability and resilience of the grid is maintained, and that there is not an unreasonable shift of costs or risks to end-use customers.

2 | The **creation** of scenarios should consider a number of input variables including a clear and defined record of customer needs through the planning horizon as well as other best information available.

3 | The **choice** among a host of future scenarios should be: (a) based on a clearly defined, robust set of scenario development criteria grounded in a record of customer needs and indicative interests within the planning horizon; (b) capable of adapting to an evolving set of future system conditions; and (c) crafted to foster the appropriate level of transmission expansion.

4 | In order to support transparency and reduce volatility within the planning process, the application of the scenario development criteria would form the basis for triggering the need for new long-lead-time transmission expansions. Specifically, the application of the criteria and choice of scenarios would drive:

DRAFT

- Prudency
- Scenario creation
- Future choice consideration & criteria
- Short- and long-lead triggers
- 15-year master plan with intermediate periods
- Scenarios based on present and future trends

Defining the Principles for Customer and System-Wide Innovations

The industry needs to define the principles for acting on innovation, for grid edge interconnection of new generation, storage (and load!), *and* system-wide clean energy infrastructure investments. We therefore need:

1. **Defined customer rights** that put customers at the center of grid modernization and that support their ability to make reliability and resiliency investments, leveraging their value for all customers.
2. **Aligned incentives** so that monopoly operators act in the interests of all consumers. Special attention should focus on mitigation and where possible removing data and customer relationship monopolies.
3. **Cost reflective** charges for monopoly services that reflect incremental costs and benefits of how consumers and other parties use the system. This includes minimizing harmful distortions arising from the recovery of fixed charges for using energy networks.
4. **A level playing field** so that all technologies and business models can compete equally, without barriers to entry to the market.
5. **Efficient allocation of risk** so that those best placed to manage the uncertainty inherent in a rapidly changing system shoulder the risks involved.
6. **Harnessing markets and competition** where it can bring benefits to consumers.
7. **Support for vulnerable communities** to address energy bill burdens and build resiliency.

Principles adapted from Ofgem, 2017

Pathways: Applying principles for full stack flexibility

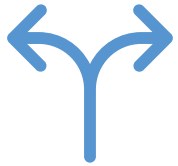
- Are there other drivers that should be considered when altering scenarios beyond the sources of information traditionally used in PJM analysis (discussion paper Scenario Drivers page 5)?
  - Principles 4 & 7: a level playing field and efficient allocation or risk
  - Market driven reinforcements | Enhanced bi-directionality opportunities | Load defection, potentially grid defection | RPS and transition to performance-based regulation | Grid enhancing technologies
- Should generation beyond what is included in the Interconnection Queue be included in Long Term Planning Studies? If yes, how should it be determined where generation is to be located?
  - Principle 6: harnessing markets and competition
  - Yes. By 2030 solar is likely to achieve $0.02/kWh, increasingly deployed as a hybrid with storage | DER diffused, enhanced bi-directionality e.g. v2g; heat pumps; etc. | More community solar | Flexible interconnection and connecting 2-3x more on 'full grids' | Grid forming solar and ad-hoc/networked microgrids
  - IPP and generation market participants should define the locational and other long term market directions
- How and when should PJM transition from probabilistic to deterministic methodologies in the scenarios?
  - Principle 2: aligned incentives, along with Principle 5: efficient allocation of risk. Least regrets transitions value based.
  - Determinism is not the right attribute. Uncertainty windows and quantified risks for least regrets should be used instead of assuming determinism. Exploring full stack flexibility opportunities should define pathways
- How do we funnel down from a multitude of potential scenarios into a subset of scenarios that are actionable (discussion paper Scenario Development Criteria page 5)?
  - ALL principles. Beside desired end-state goal identification and back casting for scenario roadmap exercises, long term plans should be based on a few extrapolated trends where different development paths indicate system-wide evolution. Tensions between stakeholders and conflict of interest mitigation methods should highlight least regret paths
  - Establish challenge committees to question long term plans and conflicts relative to foundational principles

Pathways: Applying principles for full stack flexibility

- What is the decision-making criteria to initiate a project at year 15? At year 8? (discussion paper Step Four page 7)
  - ALL principles. Enhanced bi-directionality and full stack flexibility should show least regrets pathways
  - Market driven in interconnection where participants no longer accept flexible interconnection (curtailment risk) offers.
  - While scenario pathways will always include traditional reinforcement options, these options should only be triggered after 2-3 years of attempted full stack flexibility services (except from the most extreme, immediate 1-2 years constraints)
- Who determines whether a given set of scenarios are the ones which should form the basis for ordering new projects?
  - Principle 6: harness markets and competition. Market participants must make the decision.
  - Transmission planner and especially transmission operators have a range of conflicts of interests that cause them to prefer the most capital-intensive solutions.
- How should PJM address changes to initial scenario drivers input assumptions that alter the need for projects previously set in motion?
  - Principle #5: Efficient allocation of risk. Those best placed to manage the uncertainty inherent in a rapidly changing system shoulder the risks involved.
- What is the role of FERC and the states?
  - ALL principles: Ensure good governance through principle-based regulation that incentivizes innovation throughout the energy sector.
  - Define rights, duties and obligations. Especially support vulnerable communities to address energy bill burdens and build resiliency.
- Are there any other concepts that should be incorporated within the Enhanced 15-Year Long-Term Planning (Masterplan) Discussion Paper?
  - Least regrets pathways | Bi-directionality | Full stack flexibility services | Accelerated decarbonization | Open data access

Backup

Acting on Customer Centered Solutions



- **System-wide Solutions: Full Stack Flexibility Services – Procure as a First Priority!**
  - To mention a few, flexibility services include non-wires alternatives, smart wires and enhanced grid technologies, independent connection providers, energy efficiency and conservation, demand management, and so forth.
  - Only after finding these are insufficient should the most expensive grid upgrades be approved, and increasingly even these should be competitive. For example, community and campus microgrid solutions, offshore wind connections, new substation procurement, etc.

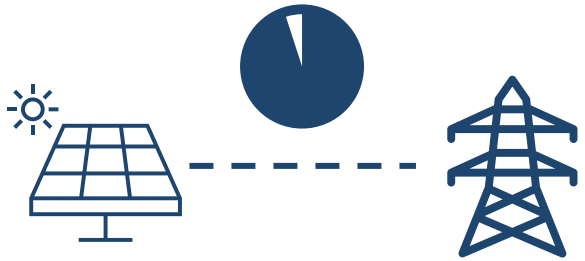
- **Customer Relationship Services – Prosumer Centered?**
  - Controllable load: how are you engaging customers to more provide load services to support grid modernization?
  - Generation: for connecting new generation, are you providing the full range of options to customers for the most affordable solutions grid edge investments?
  - Storage: are you considering how storage is both dispatchable generation and controllable load, and its further deployment will significantly alter how customers use the grid?

- **Protecting Vulnerable Populations to Energy Transformation Risks?**
  - Not all customers are able to fully participate in these new services, so how are you protecting vulnerable populations?

- **Analyzing competing system-wide and customer driven solutions requires DATA ACCESS!**
  - Customer rights to data during interconnection are critical to finding the most affordable grid edge solutions to modernize the grid

Flexible vs Firm Interconnection & Data Access

Flexible Interconnection

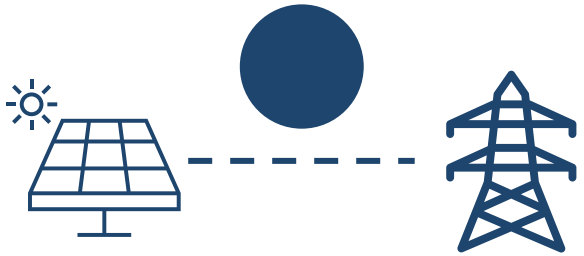


- Managed grid access during grid constraints, typically acceptable with 95-99% grid access
- Risk of curtailment provides market-based decision making for firm vs flexible interconnection; enables enhanced, dynamic hosting capacity assessments; choice is essential

DER developers & customers have the right to request grid data and the models used to analyze curtailment risks

- Can provide faster and cheaper interconnection; market-based customer relationship
- Practical pathway for future customers who may want to deploy storage

Firm Interconnection



- Firm or 100% access to the grid
- Always the best choice when grid utilization is low; lots of excess hosting capacity

Customer access to grid data necessary for long term planning horizons, like community solar or microgrid solutions

- Relies upon “static hosting capacity” that is based on snapshot, worst case conditions that are rare
- Fit and forget customer relationships

Access rights are built upon several choices

Figure 1 – Access rights are a combination of different access choices

Firmness of rights This is the extent to which a user's access to the network can be restricted (physical firmness) and their eligibility for compensation (financial firmness) if it is restricted.

Time-profiled rights This would provide choices other than continuous, year-round access rights (eg 'peak' or 'off-peak' access).

Shared access rights Users across multiple sites in the same broad area obtain access to the whole network, up to a jointly agreed level.

Other arrangements we are considering (1) Short term rights - This would provide a choice for limited duration access (eg one year) where long term access is not immediately available or where the user does not want to make a long-term commitment. (2) New access conditions - This could involve introducing conditions on access, for example 'use-it-or-lose-it' or 'use-it-or-sell-it'.

https://www.ofgem.gov.uk/sites/default/files/docs/2019/09/summer_2019_-_working_paper_-_access_right_note_final_nd.pdf

Better Flexible Interconnection Data Aligns to System-wide Digitalized Energy System Analytics

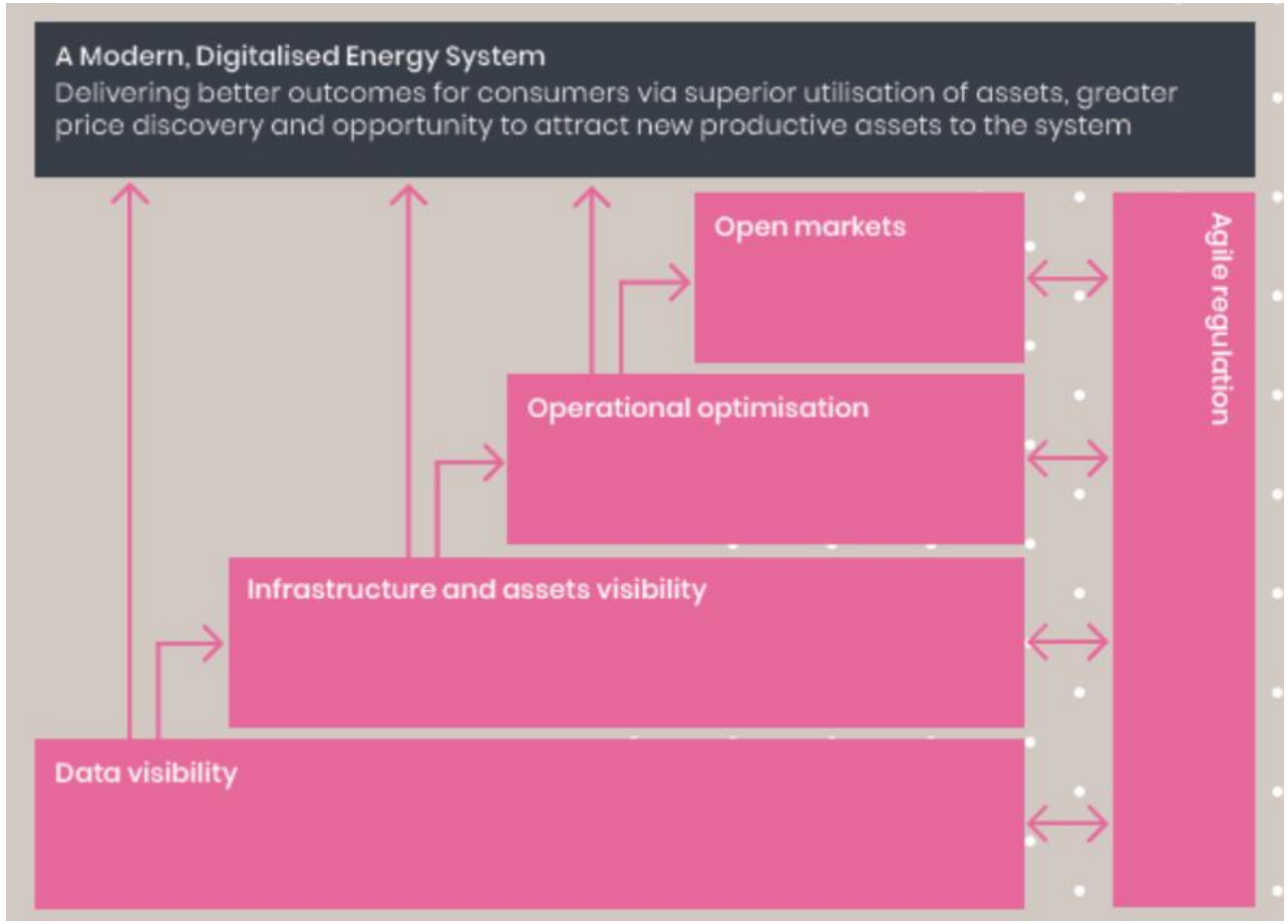
The most affordable and effective decarbonization investments need a combination of customer led and utility supported solutions.

Yet analysis is constrained by lack of data access.

And there is growing concern that digital monopolies and a range of solutions biases constrain finding the most affordable solutions.

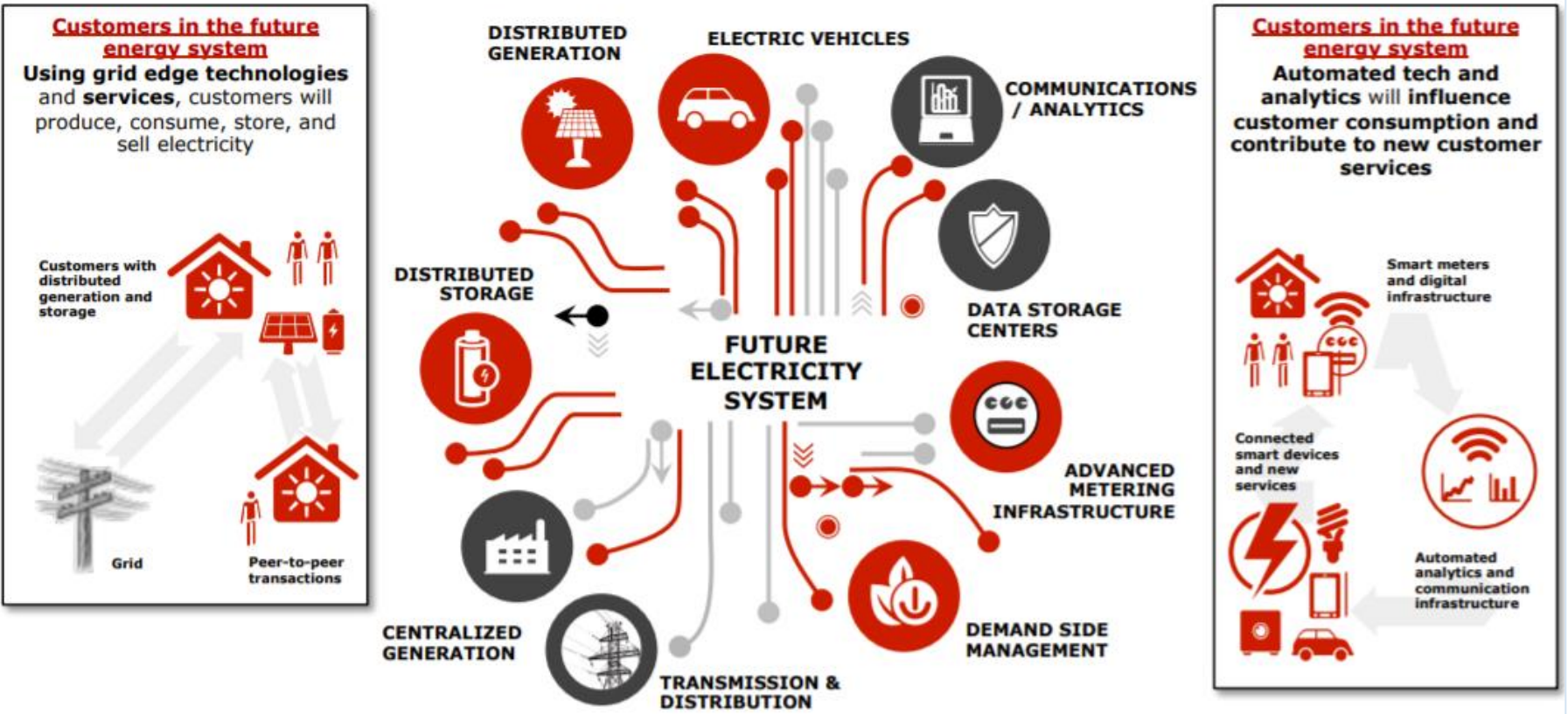
Is industry able to analyze the most cost-effective grid modernization investments? Especially when customer solutions can defer or mitigate some?

Are customers able to analyze their most cost-effective interconnection options? Especially when customer solutions can defer or mitigate some?



https://es.catapult.org.uk/report/energy-data-taskforce-report/

Data and Interconnection



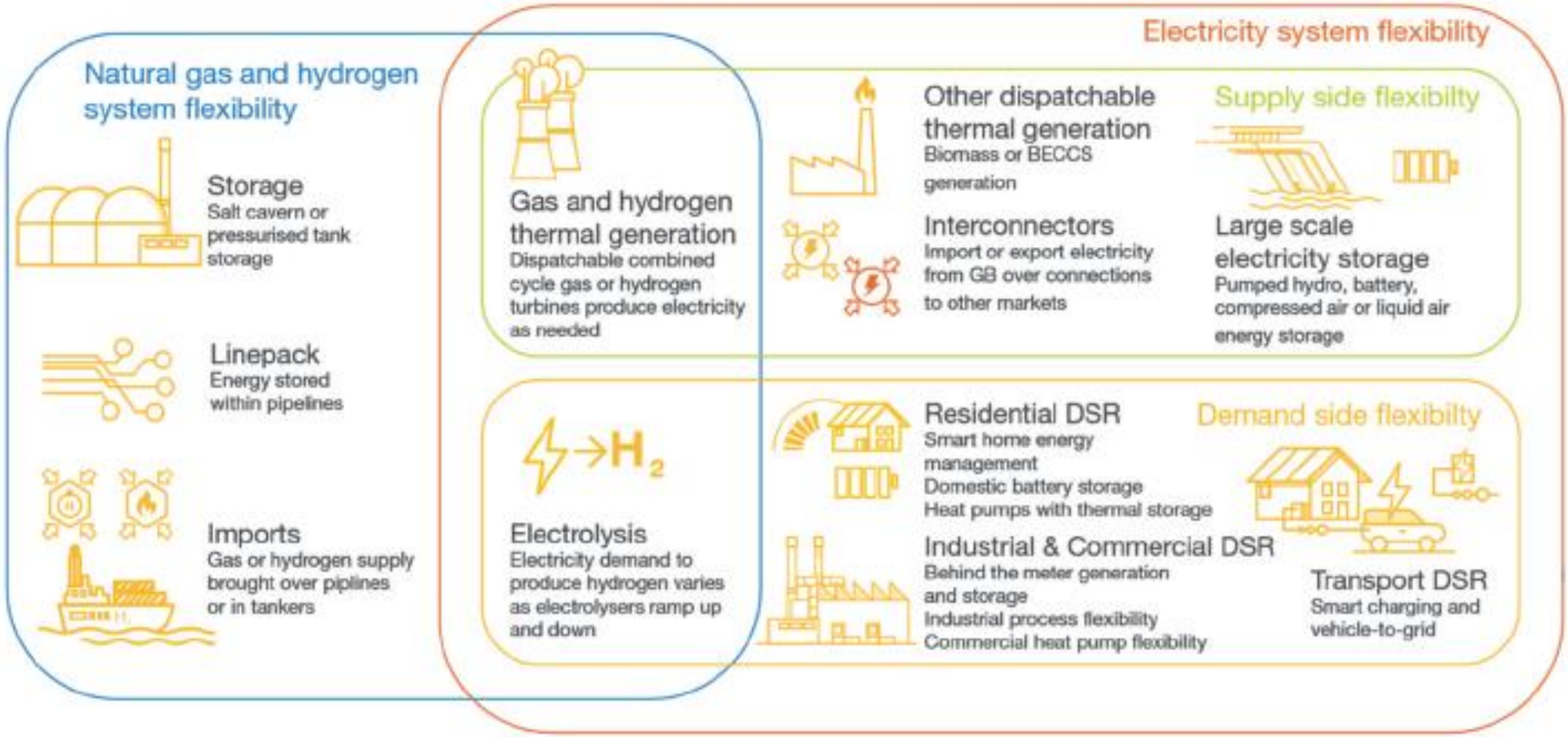
World Economic Forum: https://www3.weforum.org/docs/WEF_Future_of_Electricity_2017.pdf

Flexible interconnection is the framework to enable dynamic hosting capacity, operationalizing dynamic curtailment

WEF 2017: "In terms of connections procedures, government-funded trials in the UK have demonstrated how to *reduce connection costs by up to 90% and connection time by about seven months*. This allows for faster and cheaper connections, supporting flexible management of energy flows and utilizing data such as real-time network hosting capacity. Success at this level requires a digitized grid with active network management."

(Emphasis added)

System Flexibility is About More than Just Electrons



https://www.drax.com/wp-content/uploads/2021/03/Longer-Duration-Energy-Storage-The-missing-piece-to-a-Net-Zero-reliable-and-low-cost-energy-future.pdf