



Free markets. Real solutions.

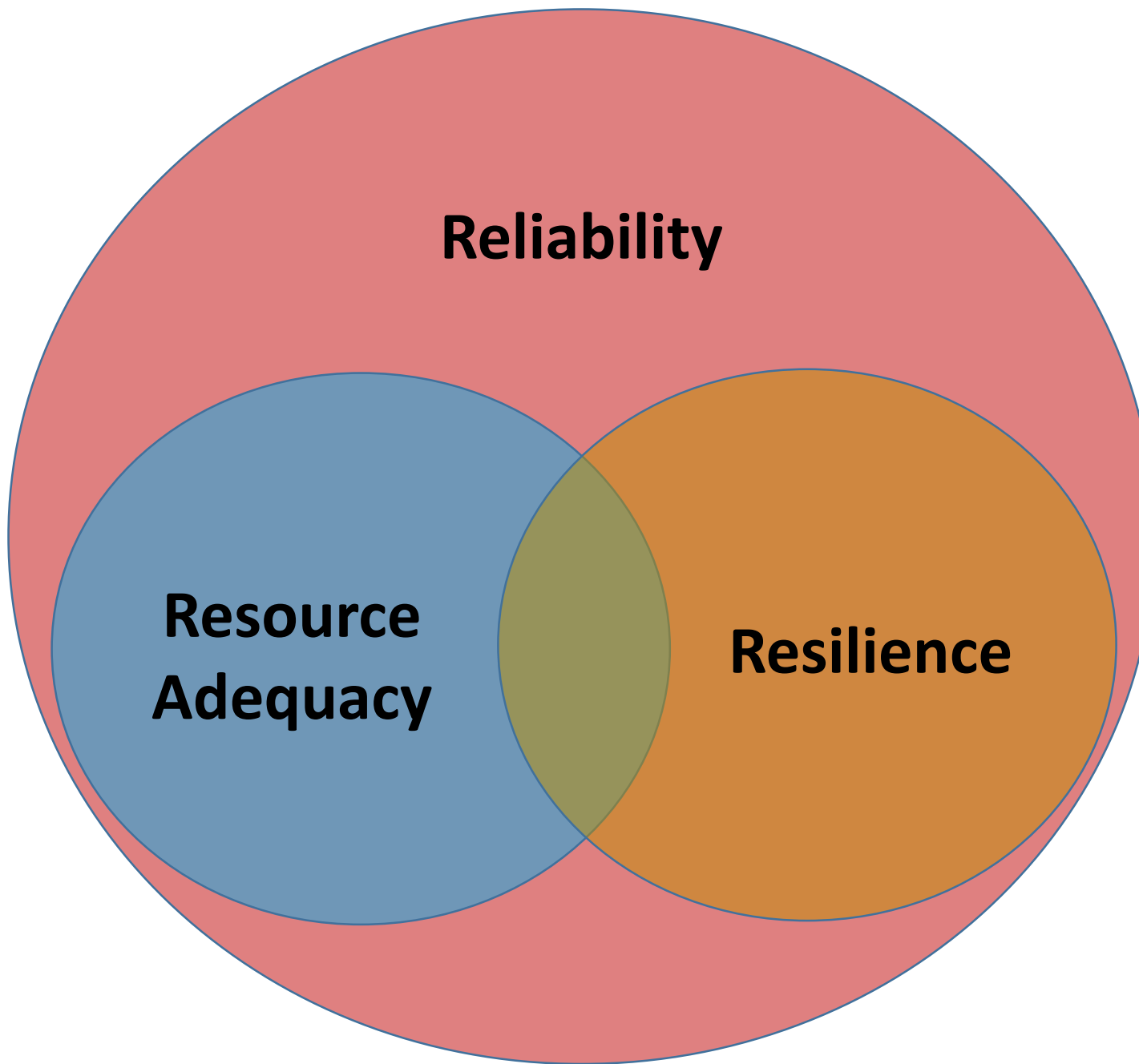
The Economics of Electricity System Resilience

Resources for the Future Webinar

June 18th, 2018

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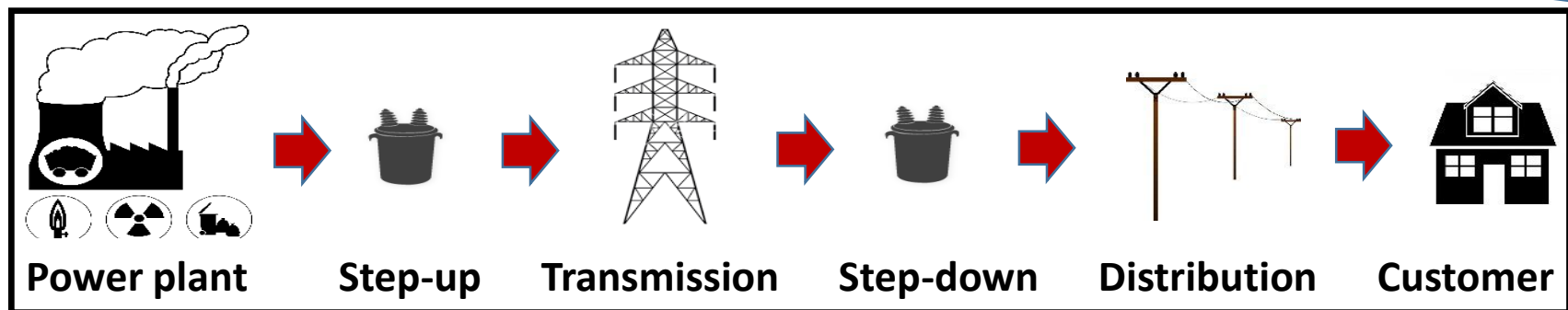
Reliability emphasis:
“think holistically”

- Resilience emphasis:
- High impact, low pr events
 - Restoration
 - Customer survivability

Resilience Threat Mitigation & Restoration

- Greater value downstream
- Myopic view of bulk resilience misses customer picture
 - Jurisdictional challenge (FERC and NERC)
 - Mostly state & local issue

Resilience Enhancement Value



Resilience Valuation

	High Value	Low Value
Grid operator, reliability coordinator	<ul style="list-style-type: none"> Interconnection rules Schedule coordination Fuel coordination Emergency planning and drills System & asset models Situational awareness 	<ul style="list-style-type: none"> Generation capacity payments
T&D, Genco Capital	<ul style="list-style-type: none"> Distribution pole hardening Additional transmission paths and loops Back-up communications Transmission automation Distribution automation 	<ul style="list-style-type: none"> T&D undergrounding Coal & nuclear subsidies Generator weatherization
T&D, Genco O&M	<ul style="list-style-type: none"> Tree trimming Cyber security & secure communications networks Physical security Mutual assistance Strategic spare equipment & mobile substations Situational awareness, system monitoring, PMUs Emergency planning and drills Outage management system 	<ul style="list-style-type: none"> Fuel supply guarantees
Customer	<ul style="list-style-type: none"> Distributed generation, back-up generators Emergency supplies More efficient building shells Community critical infrastructure hardening 	<ul style="list-style-type: none"> Insurance Distributed storage

Resilience & Regulatory Overlay

- Existing regulatory regime addresses market failures
 - Interventions substitute for competition or facilitate it
 - Current gen policies far more robust than T&D
 - Resilience threats concentrated in non-market (T&D) areas
- New instruments (unaccounted market failure)
- Enhance existing instruments (underaccounted market failure)

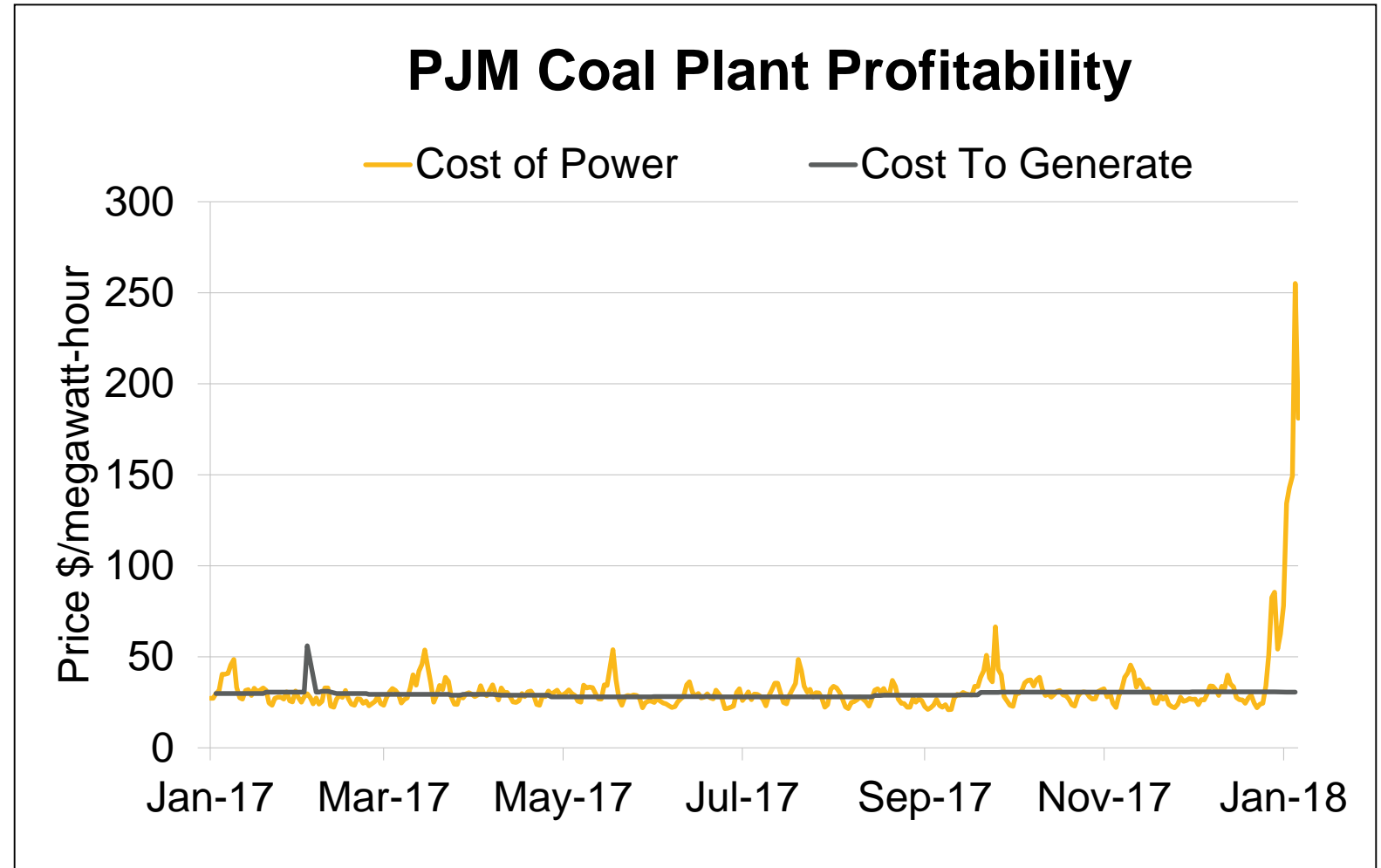
	Threat Factor	Service Procurement
Generation	Low	Market
Transmission	Medium	Competitive planning
Distribution	High	Planning

Resilience Market Failure?

- May exacerbate failures of “conventional” reliability
 - Remedies:
 - Performance incentives (e.g., real-time price formation)
 - Robust demand representation (e.g., refined VOLL) & participation
 - Common mode failure a potential challenge, not resilience-unique
- Possible unaccounted failure: extreme “fat tail” events
 - Unknown probabilities, massive consequences
 - Very few scenarios for generation alone, mostly T&D vulnerability
 - Frame: uncertainty, not risk, management
 - Tool: e.g., revise credible contingency definitions
- Policy imperatives
 - Efficient contingency management in T&D?
 - Do healthy spot prices provide sufficient generation signals?

Inframarginal Rents Critical but Sufficient?

**Energy
shortage +
capacity
performance
= ~VOLL**



Source: derived from data in the Dark Spread Model of S&P Global Market Intelligence
Note: cost of power based on energy prices in the Western Hub of PJM Interconnection, LLC

Resilience Government Failure

- Concern: generation intervention costs > benefits
- Overly complex market design → unintended consequences
 - Prescriptive design undercuts procurement flexibility, risk allocation
 - Central value proposition of markets
 - E.g., capacity differentiation challenges in CAISO
- Generation poorly suited for central planning
 - Poor track record of uncertainty management for conventional reliability
 - E.g., extensive IRP errors past decade
 - “Knowledge problem” for resilience > conventional reliability
 - Many investment considerations and actors to coordinate
 - Propensity for political interference
 - Biases play out (e.g., overconfidence in contingency pr assignment)
- T&D better suited for planning process adjustments
 - Robust economic criteria imperative

“Doing the wrong thing in a panic may make us *more* vulnerable rather than less...and cost us a bundle.”

- Resilience Workshop participant

Resilience with Emerging Techs

- Advancements enhancing decentralized investments
 - Customers have more self-insurance options (phys & financial)
- Resilience decision locus: decentralized
- Advanced T&D techs isolate/limit threats
- Privatized resource adequacy → reflect massive VOLL variances
 - Policy should be more flexible, not more prescriptive
- Voluntary retail resilience products?
 - E.g., microgrid backup opt-in
- Econ characteristics of industry more conducive to competition

Next Steps

- Economically characterize resilience
 - Emphasize customer perspective, service restoration, emerging techs
 - Improve threat diagnostics, tech capabilities, extended-outage VOLL
 - Exercise: cost-value ranking of resilience measures
- Emphasize econ objectives for resilience policy
 - Focus on non-market areas
 - Especially emergency operations and T&D systems and processes
 - E.g., criteria for uncertainty treatment, cost efficient scenario planning
 - NARUC and FERC/NERC collaboration?
- Market design: stay the reliability course (i.e., incentive compatibility)
 - Essential reliability service procurement → price formation, demand participation, etc.
 - No evidence of resilience-specific instruments needed
 - Evaluate sufficiency of spot signals for fat tails
 - Must account for gov't failure!
- Prudent resilience policy = customer empowerment
 - Not expanded paternalism