Unlocking DER Flexibility

Grid Services, Value Stacking, and Market Integration

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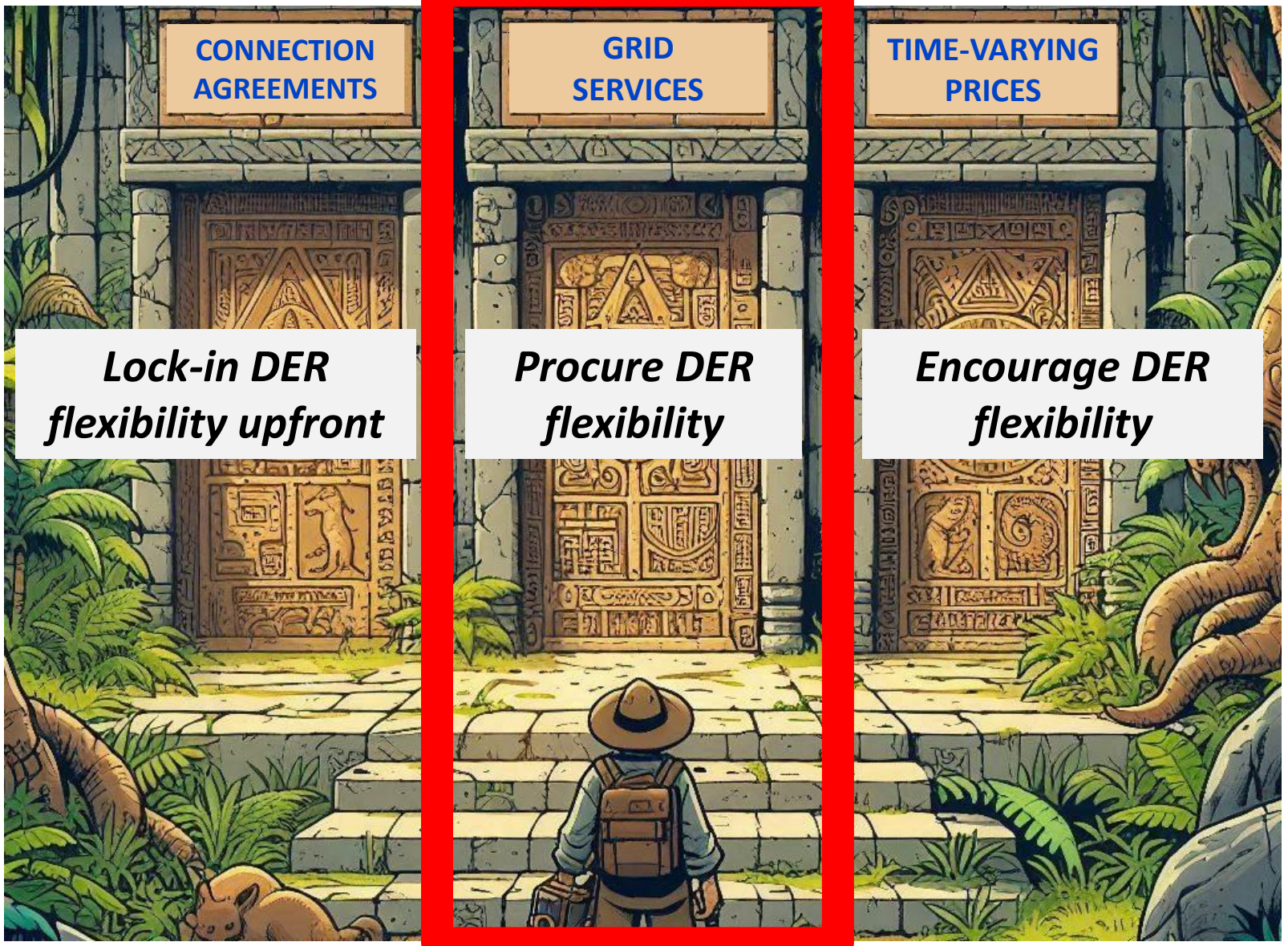
What Are DER-Provided Grid Services?

- Certain **distributed energy resources (DER)** can adjust their power imports and/or exports in support of system operations.
  - *Also… **network** **elements** can provide flexibility*

- Grid Services *(North America)* = Flexibility Services *(Europe)*

- DERs provide flexibility **voluntarily**, for a **fee**, and in response to **time- and/or location-specific needs** identified by system operator(s) in normal, alternate (e.g., due to maintenance), or emergency conditions.
  - ***distribution services*** → *distribution system operator*
  - ***Wholesale (or bulk) services*** → *wholesale market operator*

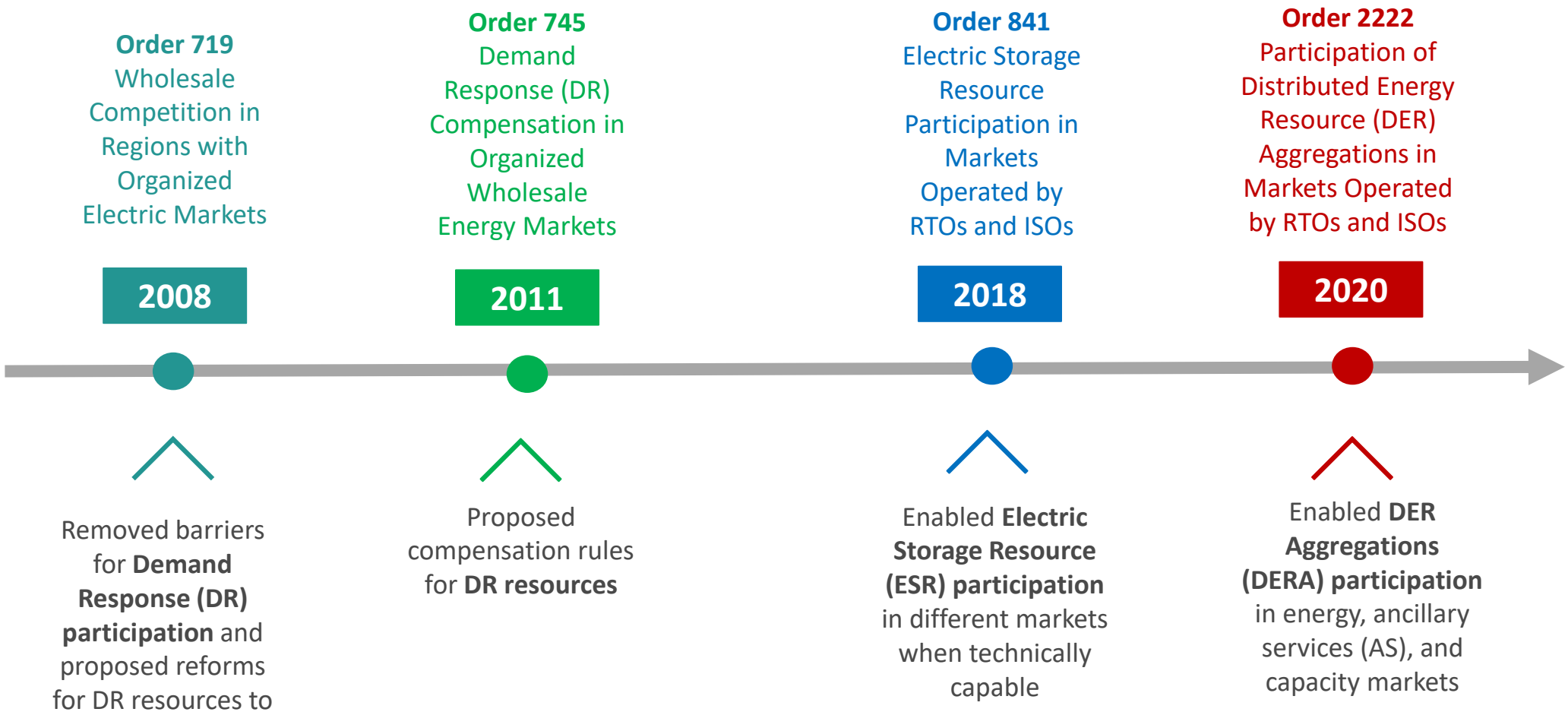
Taking A Step Back: The Three Doors To DER Flexibility



Pay-for-performance services voluntarily provided by DER to the grid are just ***one of the possible mechanisms*** to harness DER flexibility…

Wholesale Market Services

US Federal Regulation shaping DER market participation



DER Participation Models: CAISO

	Participation Model	Description
	DER Provider (DERP)	Enables *Aggregation* of DERs to meet minimum capacity requirements and act as one 'virtual' resource (homogeneous or heterogeneous)
PDR	**Proxy Demand Response (PDR)**	Enables 3rd parties to bid DR for *load curtailment* (independent of LSE)
PDR	**PDR – Load Shift Resource (PDR-LSR)**	Allows for *bi-directional* dispatch product (rewards increasing consumption during negative prices)
PDR	**Reliability Demand Response (RDRR)**	Allows reliability-based *load curtailment* triggered under certain emergency conditions
NGR	**Limited Energy Storage Resource (LESR)**	Resources with continuous *positive to negative* operating range, constrained by *state-of-charge* limits (e.g., batteries)
NGR	**Dispatchable Demand Response (DDR)**	Resources with *non-positive* operating range, constrained by curtailable *energy* limit
NGR	**Generic Non-Generating Resource (NGR)**	Resource with continuous *positive to negative* operating range
	Aggregate Capability Constraint (ACC)	Helps manage the *interconnection limits* of co-located resources

Considerations for Participation Models

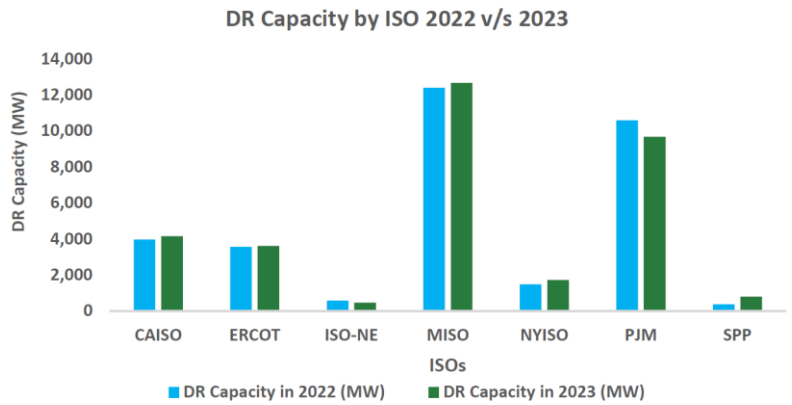
- Technology Type
- Size Limits
- Eligible Services
- Interconnection Requirements
- Metering and Telemetry Requirements
- Compensation and/or Mitigation
- Homogeneous vs Heterogeneous Aggregation

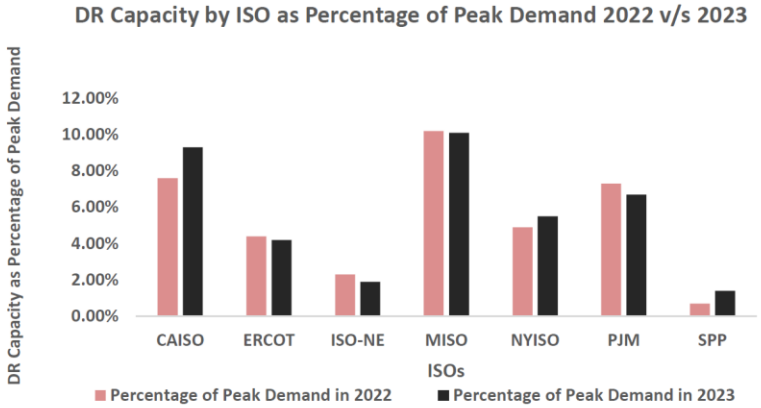
FERC Order No. 2222: DERA Market Participation

FERC Order 2222 Aspect	NYISO	CAISO
Participation Model	DER and Aggregation	DER Provider (DERP)
Eligible Wholesale Market Services	Energy, Ancillary Services (AS), Installed Capacity Market (ICAP)	Energy, AS, Flexible Ramping Product
Locational Requirements	Single Transmission Pricing Node	Multiple Transmission Pricing Nodes (but within a sub-LAP, 23 sub-LAPs in CAISO)
Metering Requirements	Aggregated Revenue Quality, Individual DER data could be measured or calculated	Aggregated Settlement Quality, Individual DER data must be directly metered
Telemetry Requirements	Aggregated Real-Time Telemetry, 6 seconds scan rate	Aggregated Real-Time Telemetry, 4 seconds scan rate
Maximum Size (individual)	20 MW	1 MW
Maximum Size (DERA)	-	20 MW (if aggregated across multiple pricing nodes)
Net Benefits Test	Settlement Adjustment	Bid-Floor Approach

DER participation is growing

DER participation with Demand Response Model



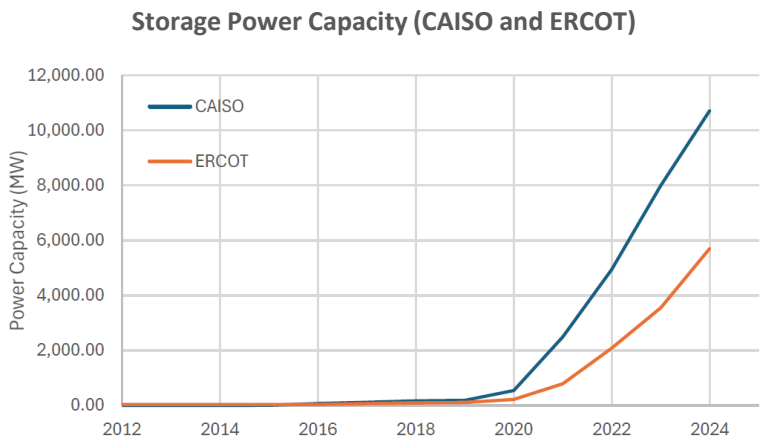


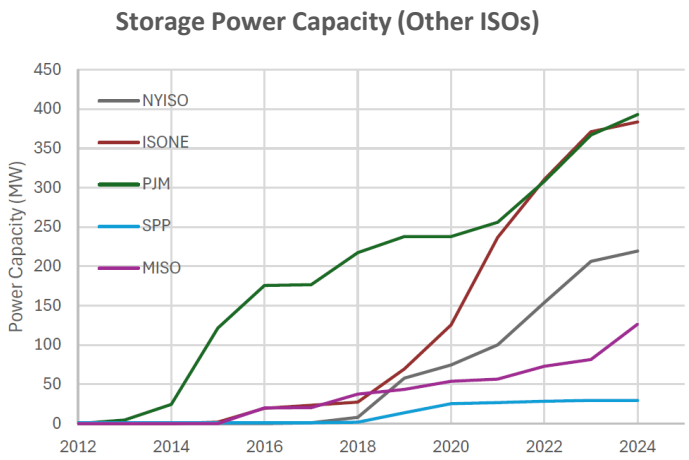
Source: FERC (data), EPRI (plots)

DER participation with Storage Model

Includes front-of-meter (FTM) numbers.

BTM storage remains small, e.g., PJM has ~ 65 MW. Similar for other ISOs.





Source: Form EIA-860 (data), EPRI (plots)

DERA model participation is currently limited

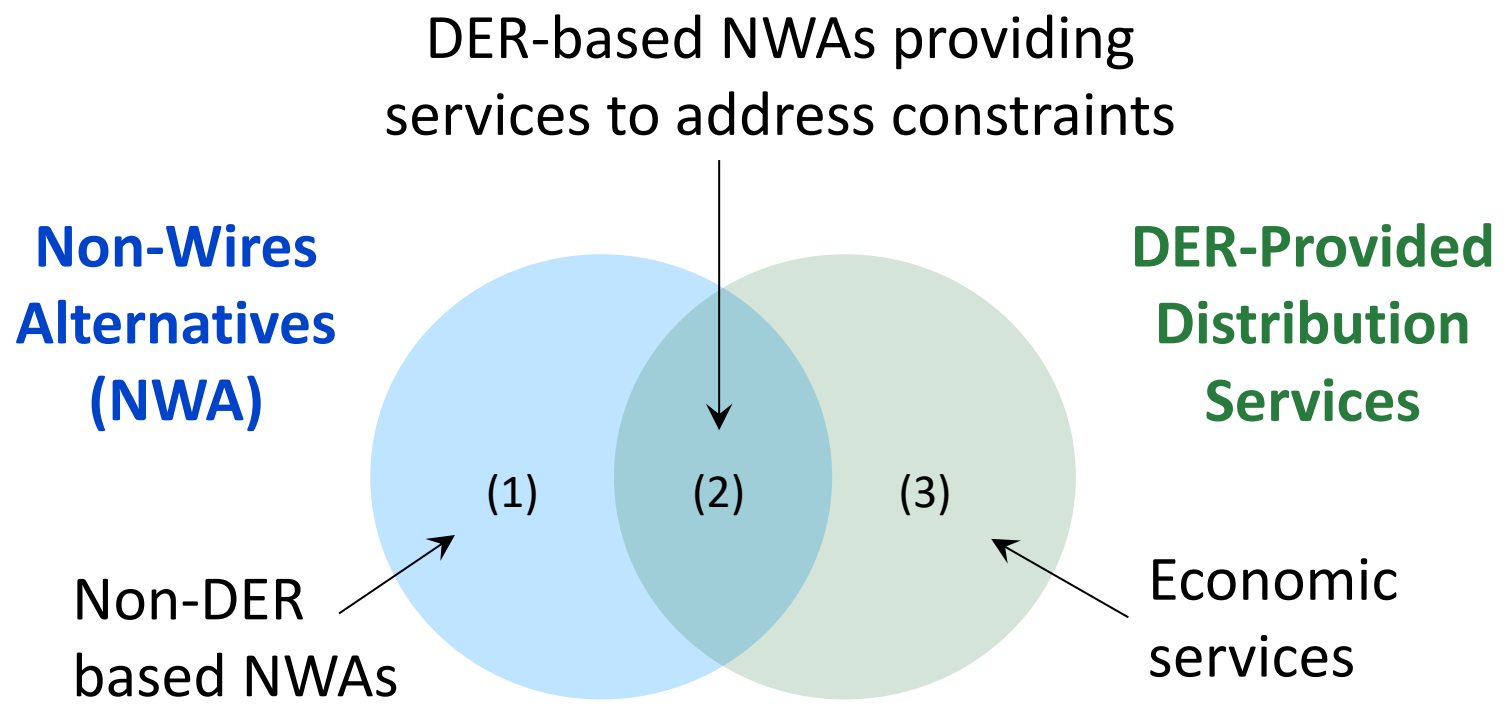
- On-going Compliance with FERC 2222
- Pilots and/or commercial procurement projects
  - Most are providing services at the distribution level
  - Plans and approval processes for wholesale market participation in the future
  - DERA data from different ISOs is not readily available
    - **ERCOT ADER**: ~9 participants (3 qualified, others at various points of registration), 15.5MW energy, 8.6MW Non-spin Reserves, 8.8MW for ERCOT Contingency Reserves
    - Other ISOs have similar participation anecdotally

Why limited participation?

- Prolonged interconnection process
- Stringent metering, telemetry, data and coordination requirements
- Distribution or retail programs may offer better incentives
- Distribution reliability services take precedence over wholesale services
- Competing with various other initiatives in the list of ISO priorities

Distribution Services

Distribution Services vs. Non-Wires Alternatives (NWA)



- **NWAs** are utility-driven solutions that defer or eliminate the need for conventional system upgrades to address network constraints.
- The technical requirements for DER-based NWAs can be decomposed and packaged into one or several **distribution services**.

Defining Distribution Services – Common Attributes

Attribute categories	Question(s) being addressed	Description
Location	Where	The physical location on the distribution system where the service can be delivered. Multiple locations and/or multi-point delivery may be allowed to satisfy a given operational need.
Timing	When, how fast, for how long, how often	The specific time intervals, minimum response times and other durations characterizing the temporal aspects of the service.
Magnitude	What, how much	The real and/or reactive power capacity required, which may be time-specific.

- **Attribute values** are set by the distribution service operator based on planning and operational needs.
- The service provider has **full knowledge** of these attributes before committing to perform the service.
- Additional, "less common" attributes may be defined as **special requirements**.

These common service attributes are *agnostic* of:

- Technology (demand response, PV, storage, etc.)
- Point of connection (BTM vs. FTM)
- Ownership (utility vs. 3rd party)
- Resource portfolio (standalone vs. aggregated)
- Readiness (new vs. existing resources)
- Commitment term (hour to multi-year)
- Payment and/or penalty mechanisms
- Single vs. multi-use applications

Distribution Service Products – Examples from UK market

	Planned conditions		Unplanned conditions	
Service Product	**“Sustain”**	**“Secure”**	**“Dynamic”**	**“Restore”**
Use Case	Network forecasts indicate risk of the network going beyond capacity in normal conditions.	Network forecasts indicate risk of the network going beyond capacity in N-1 fault conditions (i.e. where resilience is compromised) **OR** Planned works which would normally involve either a power outage or the use of mobile diesel generation	Network forecasts indicate risk of the network going beyond capacity in N-2 fault conditions. (i.e. situations where power outages are likely). **OR** Planned works where there is a risk of a power outage that needs to be mitigated.	Supply restoration following unplanned power outages.
Utility's willingness to pay (WTP)	Cost of reinforcement otherwise required	Cost of reinforcement otherwise required; **OR** Cost of planned outage and/or mobile generation pre-positioned	Cost of unplanned outage and/or mobile generation (possibly pre-positioned)	Cost of unplanned outage (and any use of mobile generation)

Distribution Services: Current Status

Europe

- Close to €400M of EU research funds spent on flexibility demos since 2015.
- UK is European leader on distribution services:
  - Systematic evaluation of service-based alternatives
  - Products not requiring capacity reservation entry point with lower risk for all parties
- Other EU regions with real-world procurement experience include: Nordic countries, Netherlands (significant dx constraints), Germany, France.
- Volumes remain limited.

US

- Initial focus on long-term contracts (vs. shorter term in EU), and new resources (vs. existing resources in EU).
- NY and CA early movers.
  - CA has had DIDF program since 2018.
  - Despite multiple adjustments over the year, program effectively paused for 2024/25.
  - Limited techno-economic opportunities; interconnection delays for new resources; EV growth -> more capacity, not less.
- Multiple “layers” add complexity
  - DR programs vs. connection products vs. distribution services vs. bulk services (2222)…
- Volumes remain limited.

Value Stacking:
Participating in Multiple Service Products

Value Stacking Strategies – Theory & Practice

Theory

- **"Stack" revenues by delivering multiple grid services,** either within a single domain (e.g., distribution) or across multiple domains (e.g., distribution and bulk power).
- Seen as a strategy to improve the financial viability and returns of DER projects.
- DERs may provide services simultaneously or sequentially.
- Broad agreement among stakeholders: value stacking must not compromise service performance.

Practice

- **In most areas, value stacking remains at the concept stage.**
- Some regions have begun defining value stacking frameworks.
  - Example: New York allows dual participation - projects must qualify as wholesale resources and submit NYISO offers that align with distribution-level dispatch.
- First movers are primarily standalone battery storage projects.
- Early projects generating learnings as they navigate and comply with both ISO *and* utility requirements.

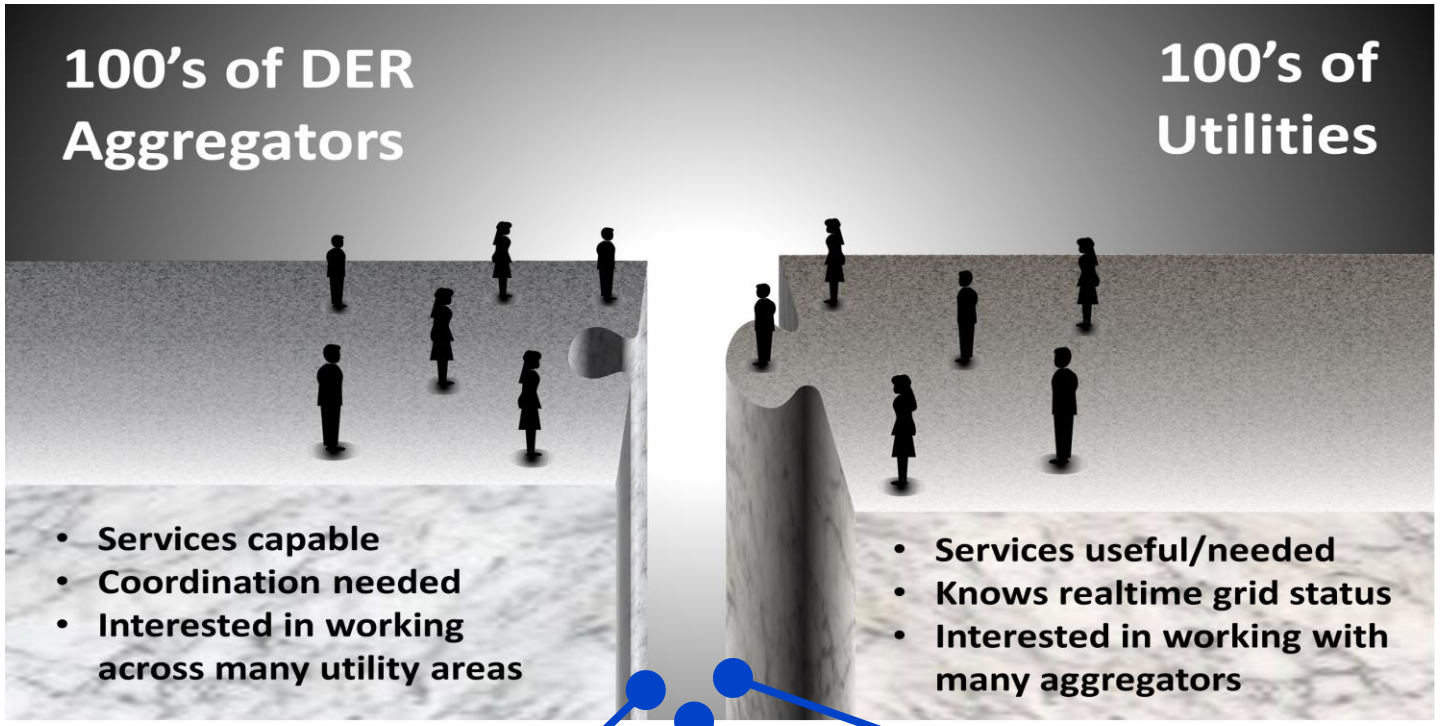
Value Stacking: Who Gets "Priority"?

- **System operators expect DERs to fully deliver on all committed services -** whether at the distribution level, wholesale level, or both.
  - Participation rules should discourage intentional or avoidable service defaults, reinforcing accountability.
- Before committing to an additional service, **DER providers should verify that performance requirements are compatible with existing commitments.**

- Open question: **Who is responsible for verifying service compatibility and performance?**
  - *Providers? Would require appropriate training and meaningful financial deterrents.*
  - *Service-requesting entities (e.g., utilities, ISOs)? May require new tools, processes, or coordination mechanisms.*

Ongoing Developments

Need to Standardize Utility<>Aggregator Interactions



flexit

An EPRI Collaborative Initiative with:

PG&E, Southern Company, Dominion Energy, aps, Nebraska Public Power District, Duke Energy, conEdison, SRP, Portland General Electric, Ameren, Xcel Energy, New York Power Authority, exelon, nationalgrid, Southern California Edison, SMUD, LA DWP Los Angeles Department of Water & Power, SDGE, ENMAX

Each integration is unique → large effort, high cost

Integrations are limited, some technical capabilities unrealized

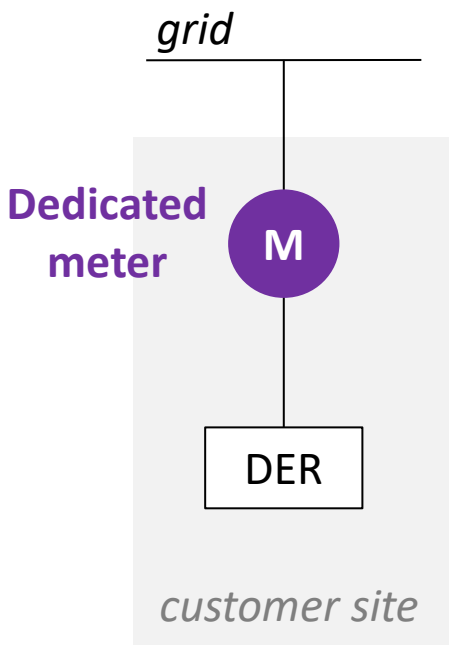
1000's of interfaces, impossible to maintain

Access Costs: Accessing Wholesale Markets Isn't Free

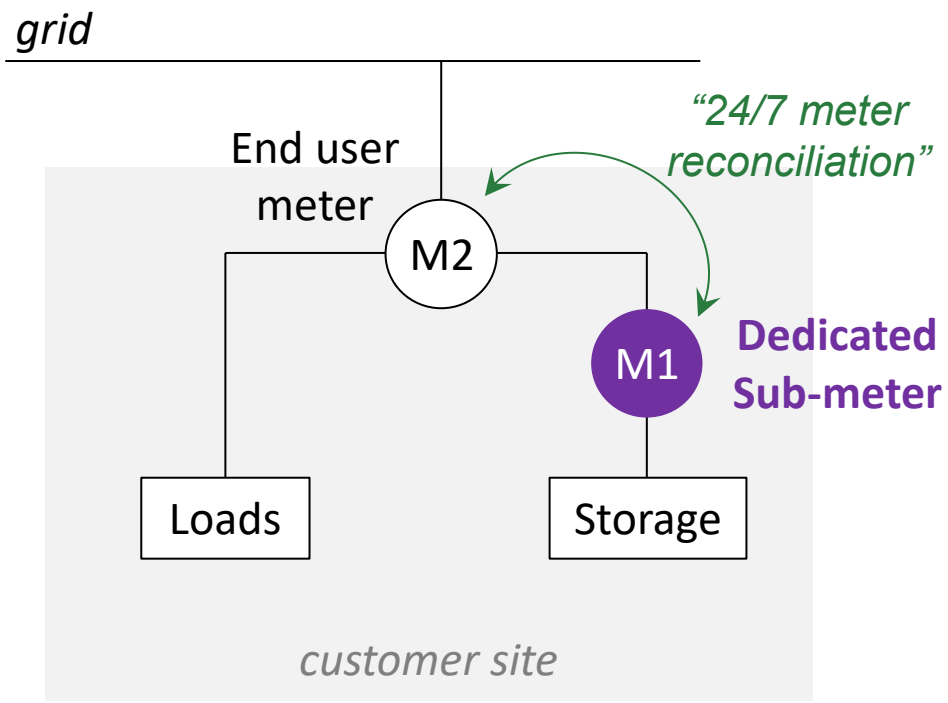
		Origin	Upfront Costs *(required before DER can start providing wholesale market services)*	Ongoing Costs *(required so DER can continue to provide wholesale market services)*
		DER owner/developer	Procurement and installation*	Operation and maintenance*
Access Costs	External	① Distribution utility	Interconnection costs** (application, study, equipment required, network upgrades, cost of ownership)	Distribution delivery charges
		② Wholesale market operator (ISO)	Onboarding, metering/telemetry, collateral/credit requirements	Communications, ISO recovery fees
		③ Entities facilitating DER participation in wholesale markets (consultants, contractors, aggregators, market intermediaries, etc.)	Upfront fees (e.g., initial due diligence; support setup enabling market participation)	Ongoing fees (e.g., fees indexed to revenues generated from market participation)
	Internal	DER owner/developer	Time (and labor costs as appropriate) required to interact with all parties involved.	

*The costs to procure, install, operate and maintain DER are included in this table for completeness, but are not "access costs" per se.
**New DER are subject to interconnection costs; already-connected DER not currently participating in ISO markets may be subject to additional interconnection costs.

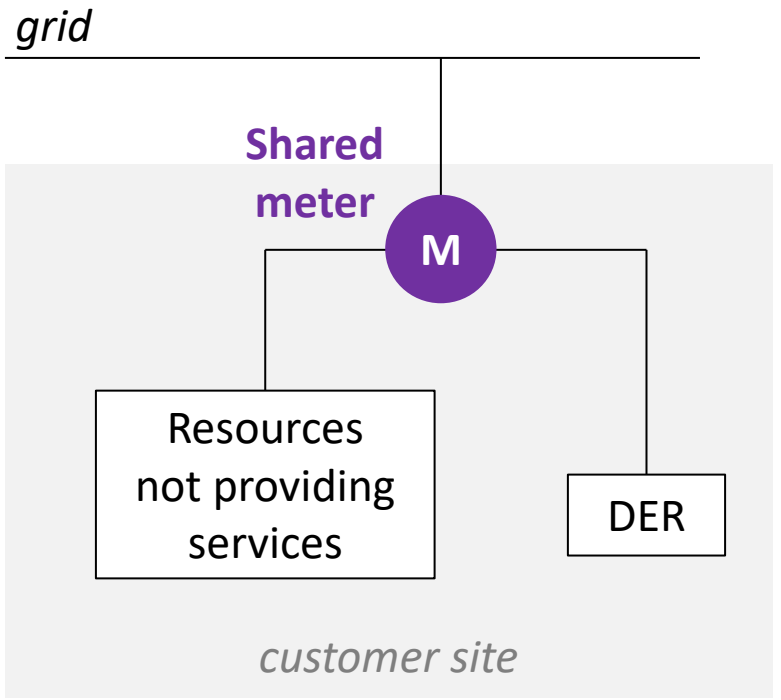
Metering Complexities For BTM DER Providing Services



- Relatively easy
- Meter cost
- Not applicable to BTM DER.



- Applicable to BTM DER.
- Requires meter reconciliation…
- … which requires significant AMI upgrades



- Requires baselines.
- Cost efficient (existing meters).
- Challenges: data accessibility + granularity (insufficient for certain services)

Settlement Complexities: Are DER Providing Services Settled by the Utility or by the ISO for the Energy Exchanged with the Grid?

RECONCILIATION APPROACH FOR **ENERGY** TRANSACTIONS	CHALLENGES ASSOCIATED TO DER-PROVIDED GRID SERVICES	
Approach 1 *Status quo*: DER invoiced by distribution utility per retail tariff.	**Challenge A** *Challenge*: Distribution services can introduce energy imbalances at T-D interface. *Potential solution*: LSE serving DER submits energy bid corresponding to energy imbalance resulting from distribution service.	**Challenge B** *Challenge*: Current ISO practices provide that wholesale participants are settled for energy by ISO; this could prevent DER participation in wholesale markets. *Potential solution*: Allow DER billed for energy transactions by distribution utility to participate in wholesale markets; requires special consideration of potential double counting issues.
Approach 2 *Alternative*: DER settled for energy by ISO.	**Challenge C** *Challenge*: Cost recovery of distribution grid costs is currently integrated in distribution billing. *Potential solution*: Maintain some form of billing from the utility to recover network costs.	**Challenge D** *Challenge*: DER settled by the ISO for the energy they exchange with the grid need to submit wholesale bids, even when dispatched for distribution needs. *Potential solution*: Following scheduling by utility, DER submits wholesale bid corresponding to energy required to perform distribution service.

Don't Forget the Big Picture: It's All About "DER Flexibility"

Adjusting timing/magnitude of DER imports/exports in support of grid objectives

Mechanism to Harness DER Flexibility	Guiding Principles
Connection Requirements	**Rule-based** (codes, rules, standards)
Flexible Connection Agreement	**Agreement-based** (DER customers agree to stricter import/export limits during grid constraints in exchange for faster/cheaper grid connections)
Pay-for-Performance Grid Services	**Market-based (**DER customers voluntarily enter contracts to adjust power output in response to system needs, receiving financial compensation)
Time-Varying Pricing	**Tariff-based** (DER customers adjust power output based on time-varying prices)

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Implicit flexibility

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