Procuring Services from DERs

DER Scenarios and Modelling Study
Conducted by EPRI for IESO and Alectra Utilities

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Today's Agenda: Three-Part Session

- **Part 1: Foundational Topics (30')**
  - Grid services
  - Value stacking scenarios
  - Coordination models: "Total DSO" and "Dual Participation"
  - Q&A

- **Part 2: ISO-DSO-DER Coordination (30')**
  - Selection of Coordination Diagrams
  - Q&A

- **Part 3: Key Takeaways from Modeling Studies (30')**
  - Distribution Feeders Modeled
  - Summary of Findings
  - Wholesale Market Offers
  - Q&A

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<u>Part 1</u>: Foundational Topics

Grid services, value stacking scenarios, Coordination models

Project Background & Motivations

- **DERs (or DERAs) considered for *distribution* and *wholesale* services**
  - Regulatory/policy interest (objective: harness DER flexibility)
  - Economic potentials (new DER value streams, market efficiencies)
  - Services are always voluntarily provided, and financially compensated

- **Key areas of interest**
  - Foundational concepts
  - Technical feasibility of DER-provided services
  - Potential impacts at the T-D interface
  - Coordination needs between ISO and LDCs: *models, practical steps, compatibility with existing ISO processes*
  - Evaluation on real-world circuits

DERA: DER aggregation

DER-Provided Grid Services

Distribution Services (to LDC*)

- **Capacity Deferral**
  - provided under planned distribution conditions
  - purpose: investment deferral
- **Local Reserve**:
  - provided under unplanned distribution conditions
  - purpose: address network abnormality

Wholesale Services (to ISO)

- **Energy**
  - scheduled energy export on day-ahead or real-time basis
- **Capacity**
  - committed energy capacity (well in advance), creates obligation to submit energy offers
- **Reserve**
  - for bulk system needs/contingencies

**This presentation uses Local Distribution Company (LDC) and Distribution System Operator (DSO) interchangeably.*

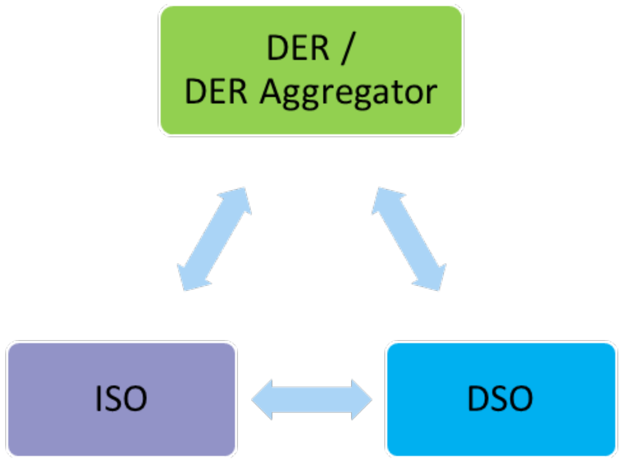
ISO-DSO Coordination Models

Are DERs submitting **wholesale market offers** through the LDC, or directly to the ISO?

Option 1: "Total DSO"

- DERs submit wholesale offers through the LDC
- LDC submits aggregated offer to IESO
- DER submits distribution offers to LDC
- DER is settled for energy by LDC

*This project focused on coordination for wholesale offers on energy/reserve. Similar models can be used for coordination on wholesale capacity offers.



Option 2: "Dual Participation"

- DERs submit wholesale offers to the ISO directly
- LDC not involved in wholesale offer process
- DER submits distribution offers to LDC
- DER is settled for energy by ISO

Scenarios Combining Multiple Services

- **Value stacking**
  - A given DER (or DERA) may have the capability to provide multiple services to the ISO and/or the LDC

- **Potential benefits of value stacking**
  - DER: additional revenue streams
  - System: more service providers, increased market competition, potential for reduced investments and fixed costs

- **Commitment sequence & Service compatibility**
  - Service requesting entities (ISO, LDC) expect service providers to perform according to service requirements
  - Before possibly committing to deliver a new service, providers are expected to ensure compatibility with all prior service commitments

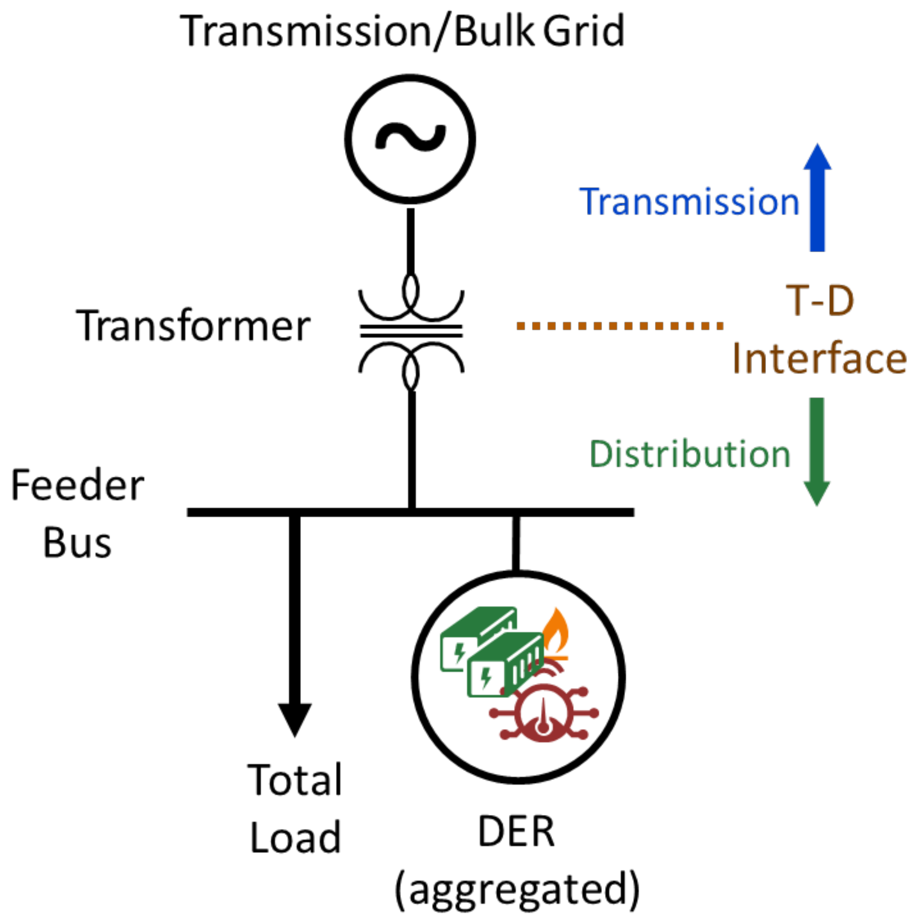
Five Families of Scenarios Considered in this Analysis

Scenarios		DER-Provided Services: Wholesale Domain – Energy	Wholesale Domain – Capacity	Wholesale Domain – Reserve	Distribution Domain – Capacity deferral	Distribution Domain – Local reserve	Value Stacking
"Transmission Energy Dispatch"	1	●					
"Distribution Override"	2	●					
"Distribution Import-Congestion"	3a				●		
	3b	●			●		♦
"Distribution Operating Reserves"	4a					●	
	4b	○		●		●	♦
"Capacity Service"	5	○	●		●		♦

Notes:
- ● primary service
- ○ service implicitly required by participation in a primary service
- ♦ scenarios considering value stacking strategies

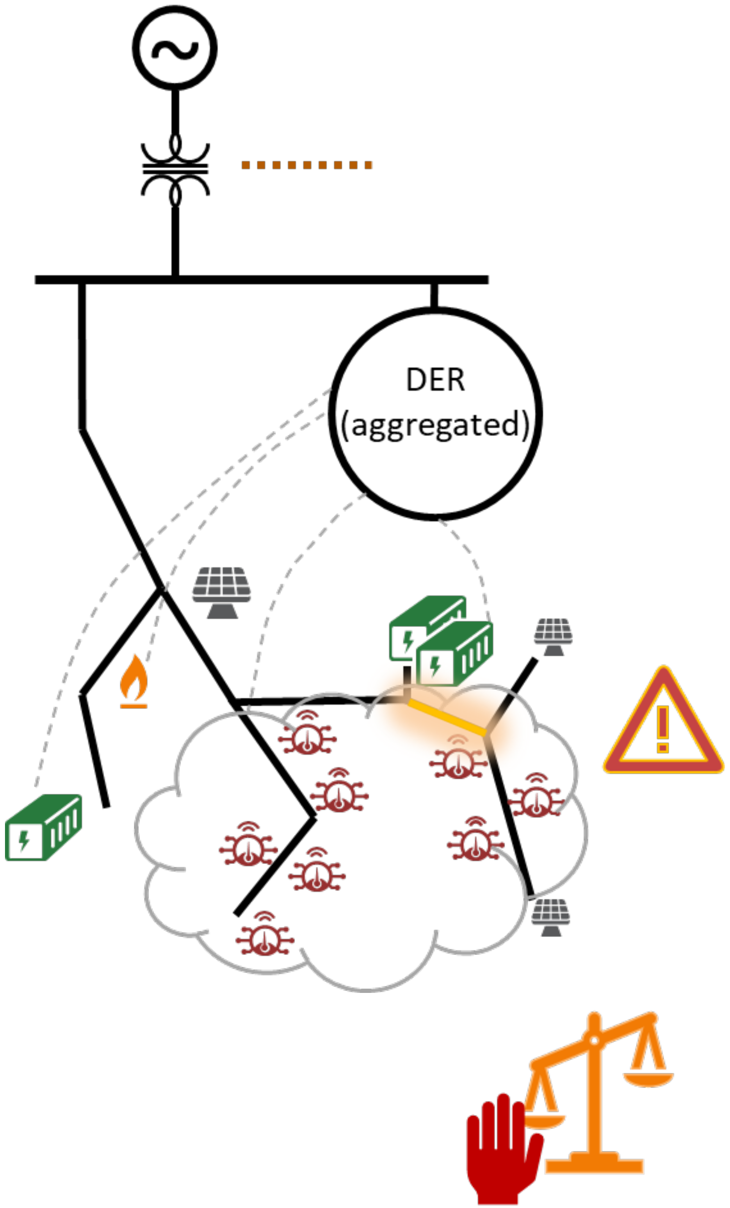
Scenario 1 – Transmission Energy Dispatch

- Strictly focused on participation of DERs in the wholesale energy market
- No distribution congestion considered
- Evaluate the impact of the DER market participation on the T-D interface (including losses).



Scenario 2 – Distribution Override

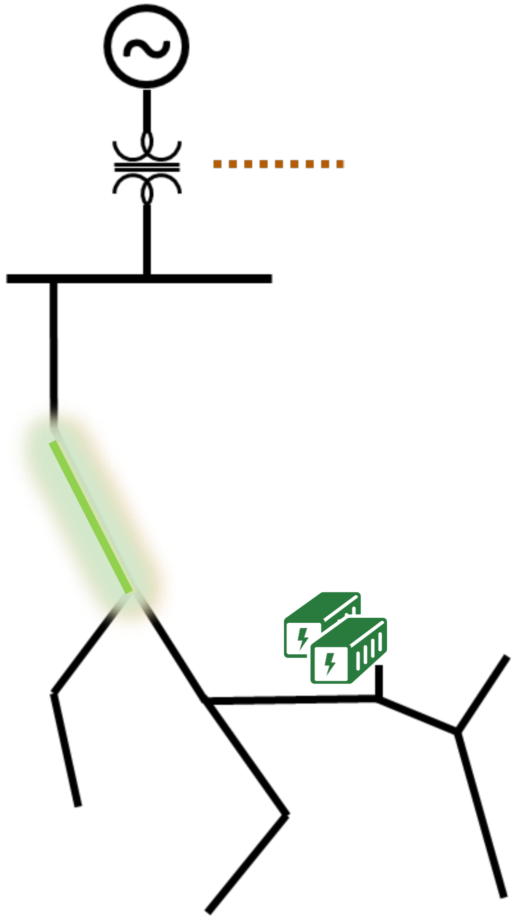
- Wholesale services (same as 1)
- Plus: recognize distribution constraints/congestion, when market dispatch override is needed
- But, no distribution services



Scenario 3 – Distribution Import-Congestion
(“Distribution Non-Wires Alternatives”)

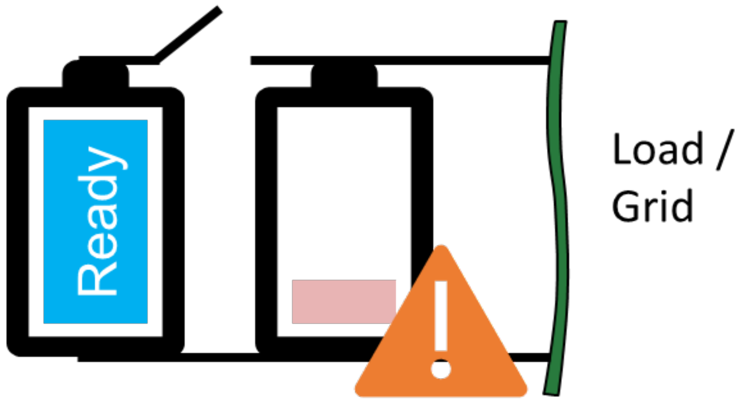
- 3a: DERs provide distribution capacity to defer conventional distribution upgrades
- 3b: scope of 3a, plus DERs participate in the wholesale energy market

- Evaluate whether DERs can
  - Avoid conventional system upgrades
  - Provide wholesale energy services
  - Maintain normal system operations, considering binding constraints and commitments for both needs



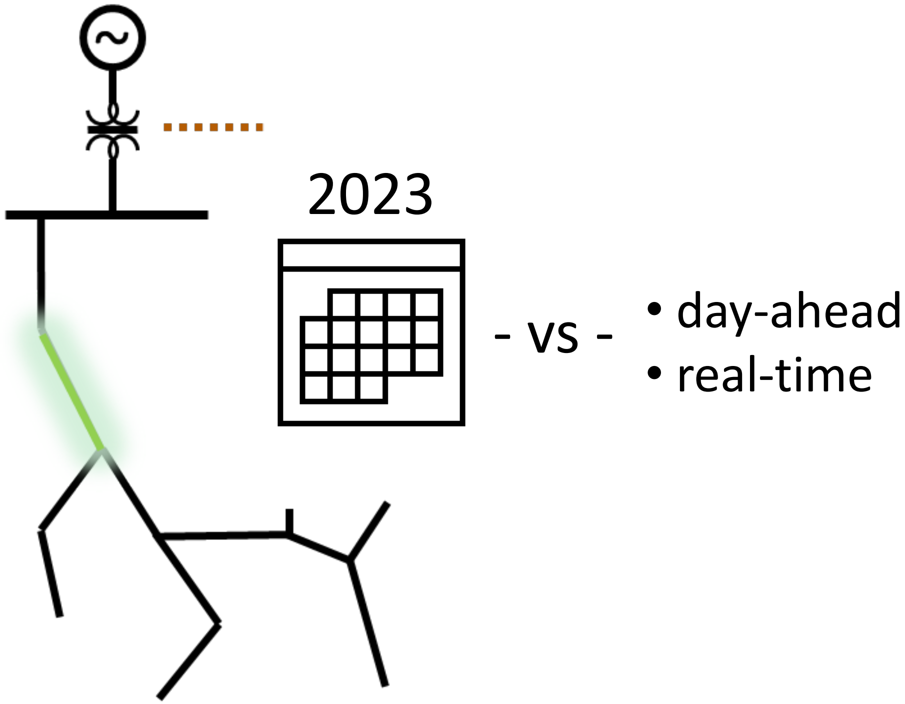
Scenario 4 – Distribution Operating Reserves

- Use DER-provided local “operating reserves” for distribution system contingencies
  - 4a: Distribution contingency applications only
  - 4b: Distribution reserve and bulk system operating reserve
- Additional communication needed for real-time conditions that call for reserves
- Address committed reserves versus prioritized reserves in both distribution and wholesale domains
- DER requirements dependent on contingency



Scenario 5 – Capacity Service

- Extension of Scenario 3a, DERs provide distribution capacity deferral AND supply capacity to the wholesale market
- Different perspectives of "capacity" for distribution and wholesale systems
- Consider both capacity auction (annual) and near-term energy offers



Summary of Scenarios Considered in this Analysis

Scenarios		DER-Provided Services					
		Wholesale Domain			*Distribution Domain*		
Scenarios		Energy	Capacity	Reserve	Capacity deferral	Local reserve	**Value Stacking**
"Transmission Energy Dispatch"	1	●					
"Distribution Override"	2	●					
"Distribution Import-Congestion"	3a				●		
	3b	●			●		♦
"Distribution Operating Reserves"	4a					●	
	4b	○		●		●	♦
"Capacity Service"	5	○	●		●		♦

Notes:
● primary service
○ service implicitly required by participation in a primary service
♦ scenarios considering value stacking strategies

Q&A on Foundational Topics

Part 2: ISO-DSO-DER Coordination

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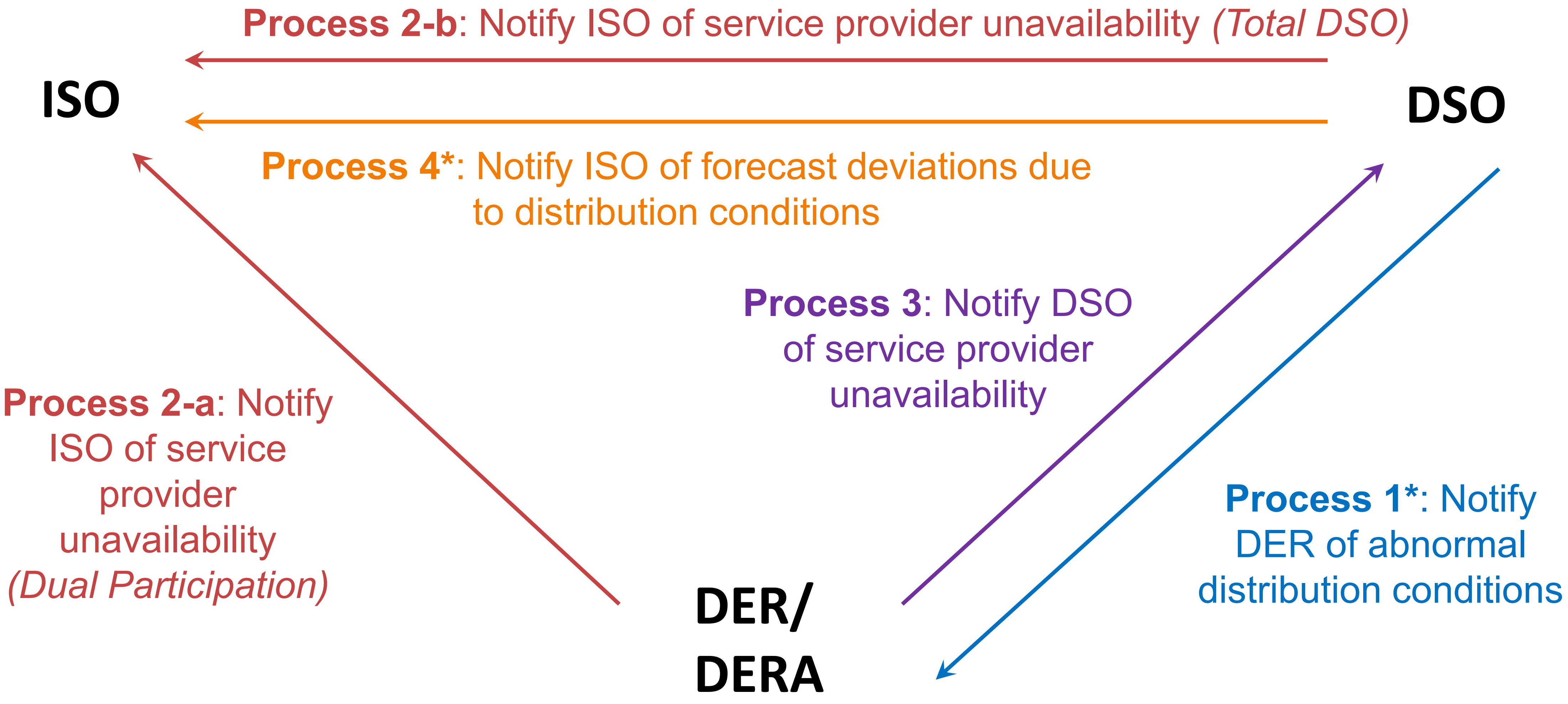
Why is “coordination” needed?

- Unplanned abnormalities can occur (whether DERs provide services, or not). Processes are needed for parties to inform each other
- Services inherently entail 1) expressing interest to participate, and 2) being dispatched if awarded
- Cross-domain impacts, especially delivery of wholesale services by DERs potentially impacting distribution operations

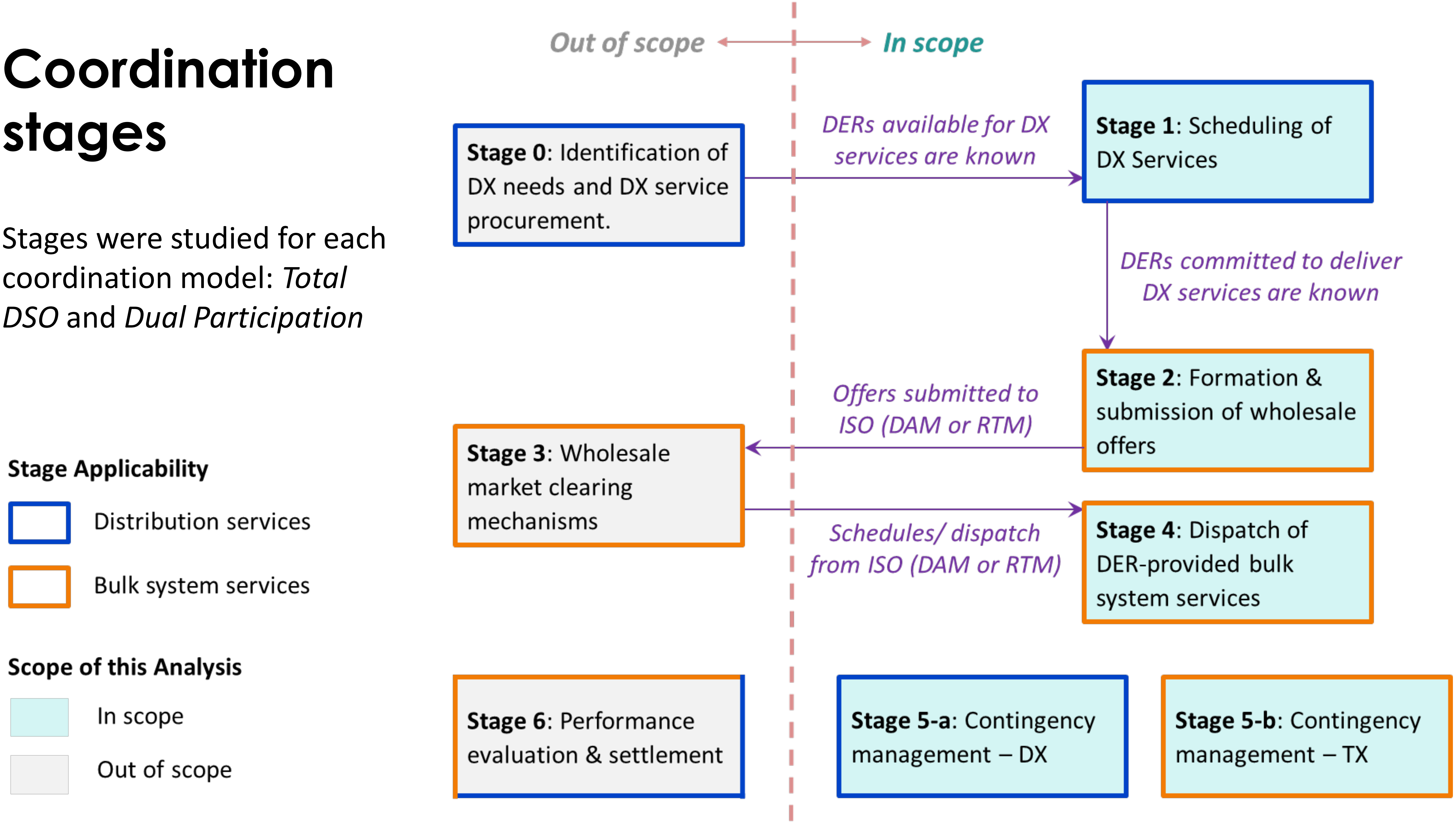
Processes to notify of abnormalities



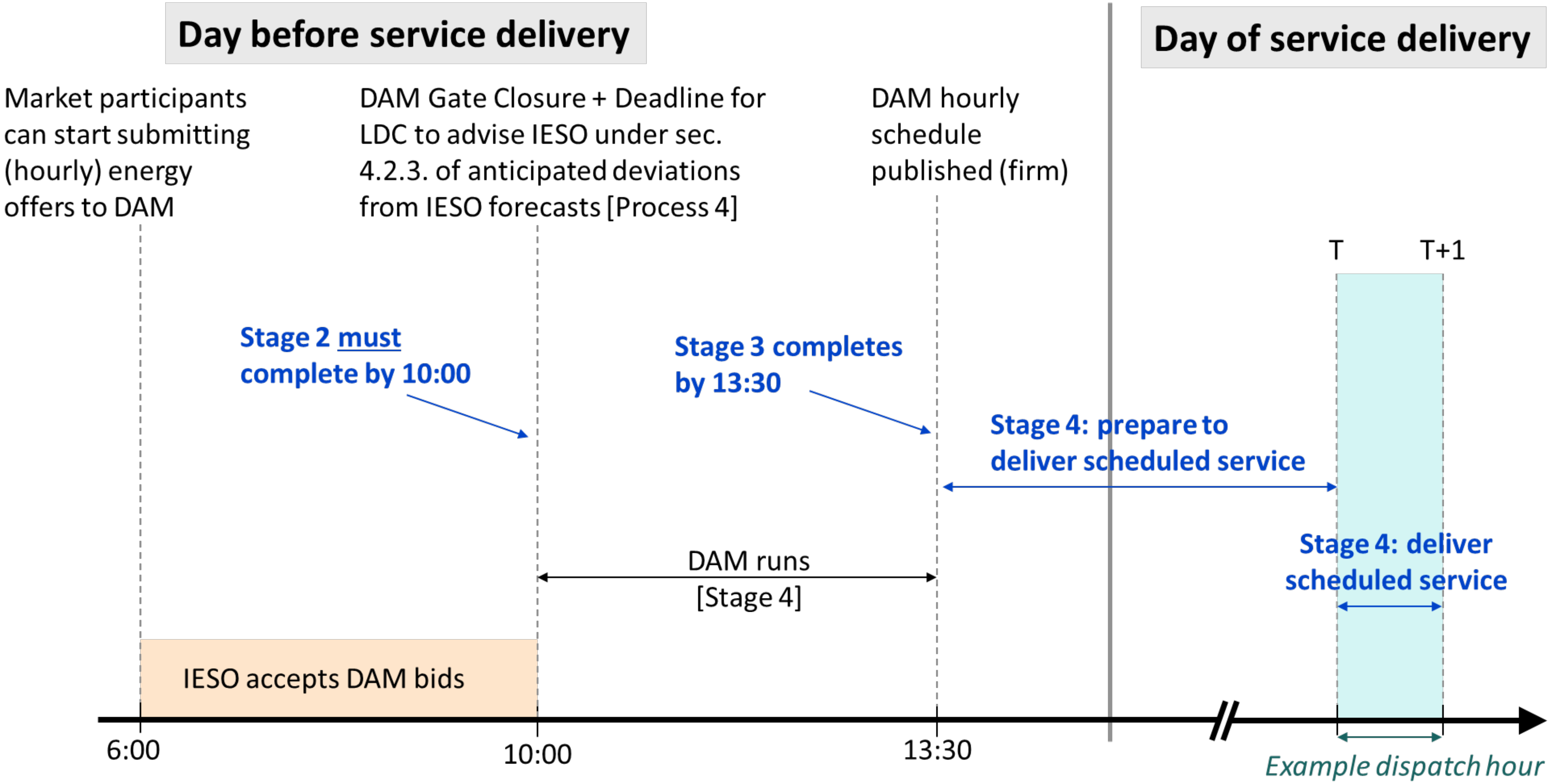
*Process applicable even when DERs do not provide grid services

Coordination stages

Stages were studied for each coordination model: *Total DSO* and *Dual Participation*



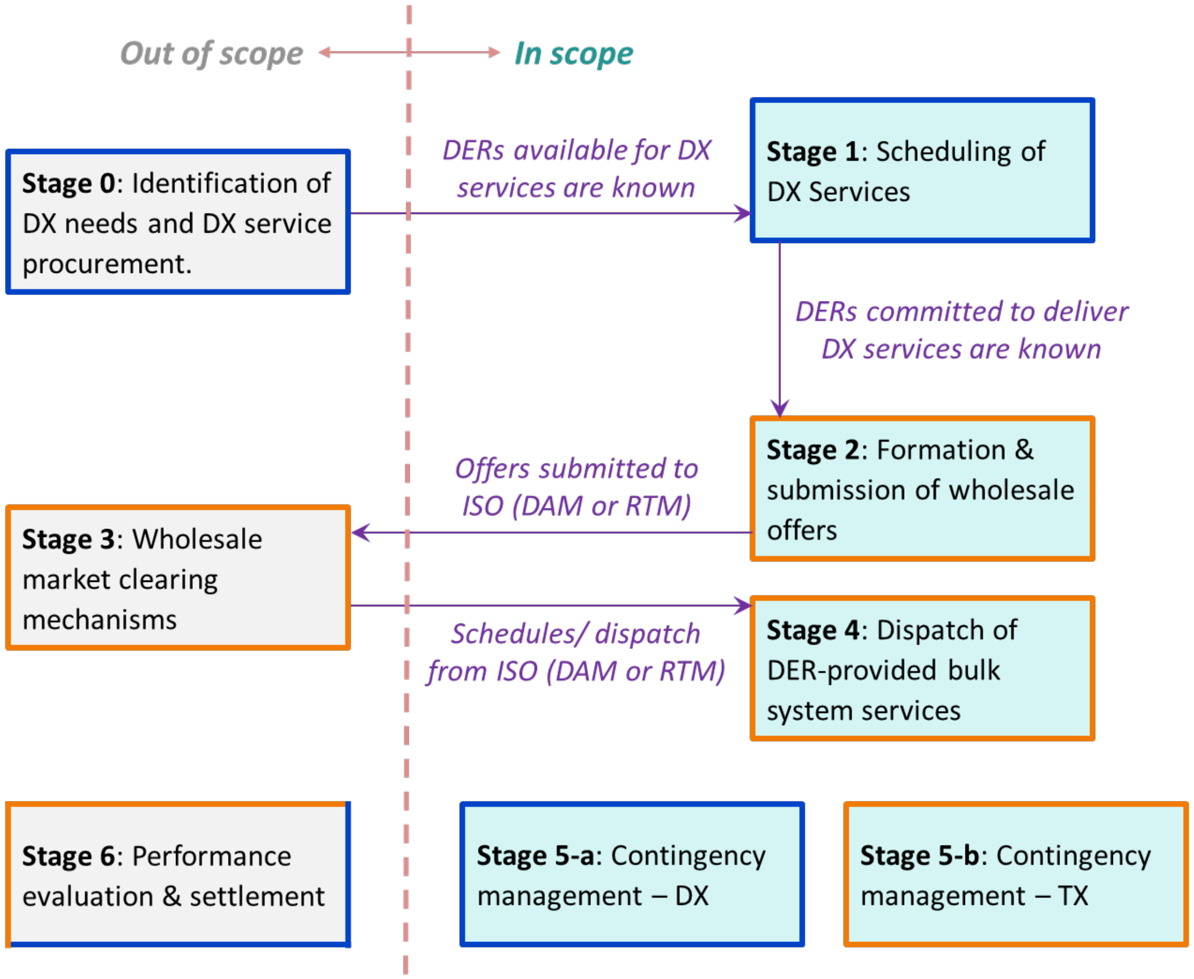
The multi-stage approach is consistent with existing IESO timelines for participation



Timeline for participation in Day Ahead Market (DAM). The report also discusses the same for Real Time Market (RTM)

For more information on IESO's Market Renewal Program (MRP): https://www.ieso.ca/en/Market-Renewal

Detailed Coordination Diagrams

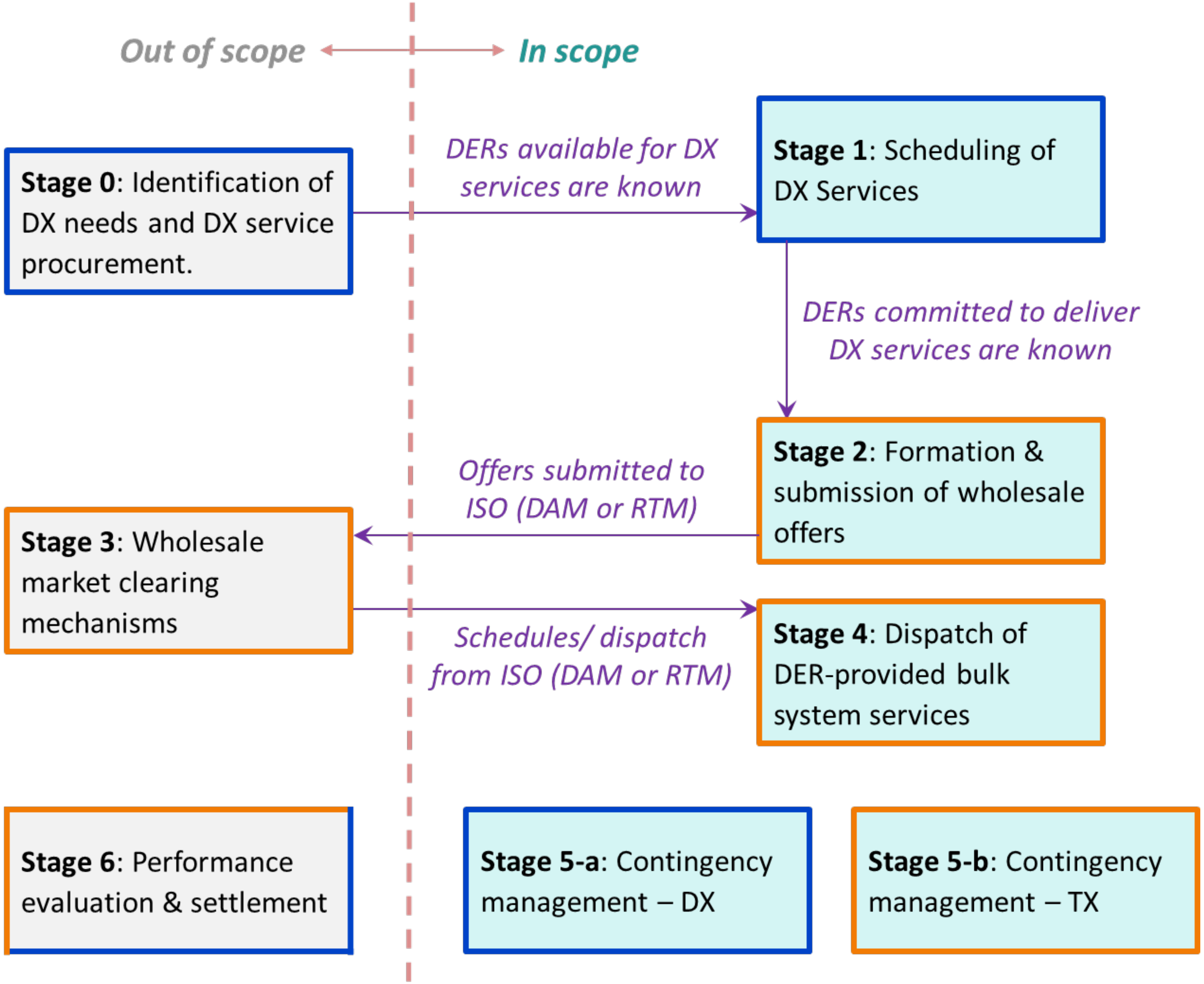


<u>Version 1</u>: Total DSO

<u>Version 2</u>: Dual Participation

Coordination stages

Stages were studied for each coordination model: *Total DSO* and *Dual Participation*



Stage Applicability

Distribution services

Bulk system services

Scope of this Analysis

In scope

Out of scope

Stage 1: Scheduling of Dx Services

Total DSO Model

Stage 1: Scheduling of DX Services

from stage 0

1.1 DSO schedules distribution services based on distribution needs

DX service to be called in **normal** configuration

1.2.a Energy for relieving DX constraint was forecasted by ISO (**normal** DX conditions). No deviation from ISO's forecast for non-dispatchable demand at the T-D interface.

DX service to be called in **planned abnormal** configuration

1.2.b Energy for relieving DX constraint was not forecasted by ISO (**planned abnormal** DX conditions). Deviation from ISO's forecast for non-dispatchable demand at the T-D interface. DSO advises ISO of deviation (Process 4).

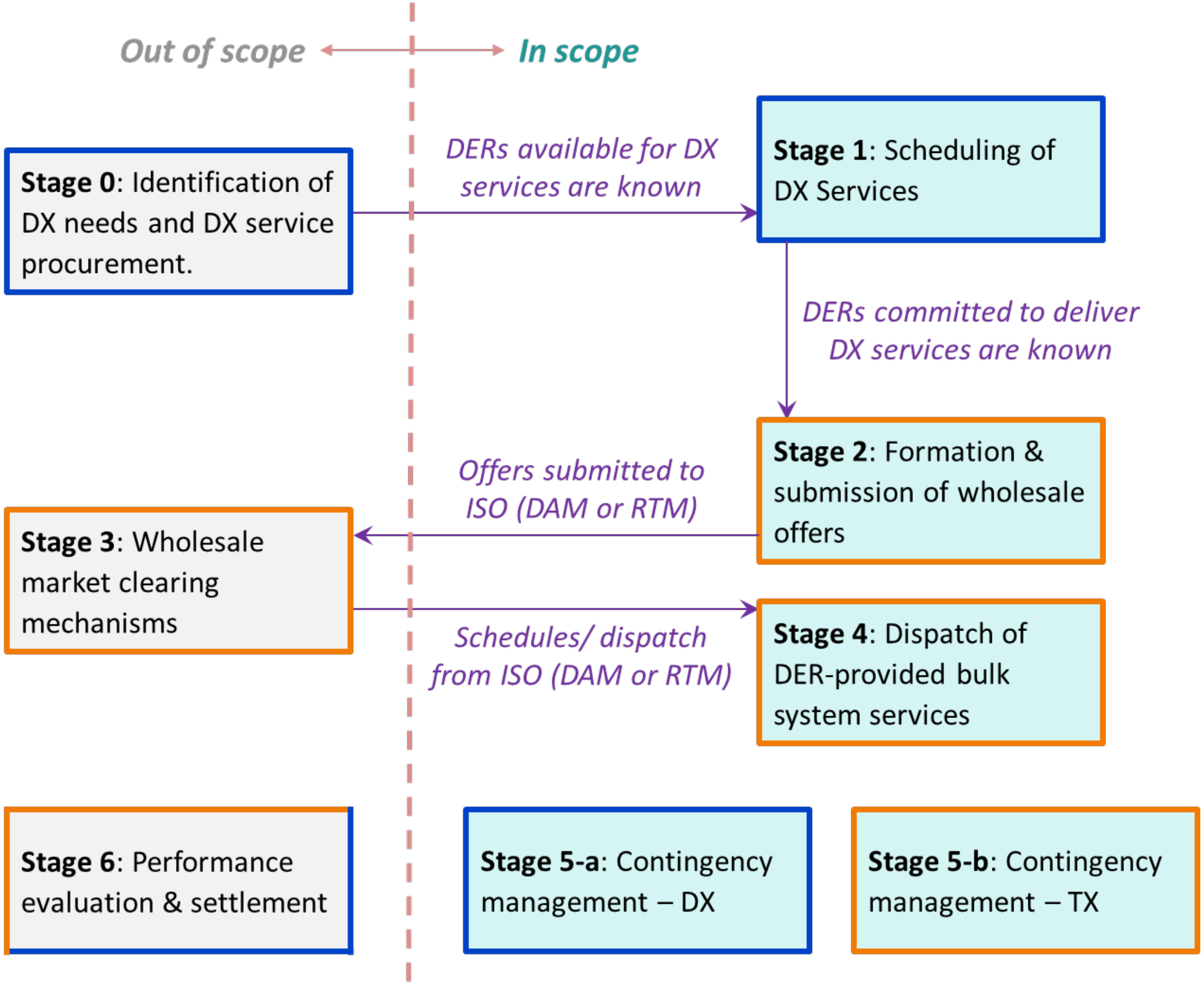
DX service to be called in **unplanned abnormal** configuration

1.2.c (N/A)
No energy is scheduled for dispatch at this stage.

to stage 2

Coordination stages

Stages were studied for each coordination model: *Total DSO* and *Dual Participation*



Stage Applicability

Distribution services

Bulk system services

Scope of this Analysis

In scope

Out of scope

Stage 2: Formation & submission of wholesale offers

Stage 2: Formation & submission of wholesale offers

Total DSO Model

from stage 1

2.1.a DER indicates to DSO intent to participate in one or several wholesale market products during a specified (future) time window with remaining DER capacity available

2.1.b (N/A)
(DER automatically considered by DSO for wholesale market participation)

DSO may want to define a gate closure here.
Purpose: collect all requests to participate before distribution feasibility analysis is run.

2.2 Based on system forecasts, offers collected from all DERs, and contingency analysis as relevant, DSO determines DER capacity that can be dispatched for wholesale market services (beyond what is already committed for DX services) according to transparent rules and procedures defined in advance.

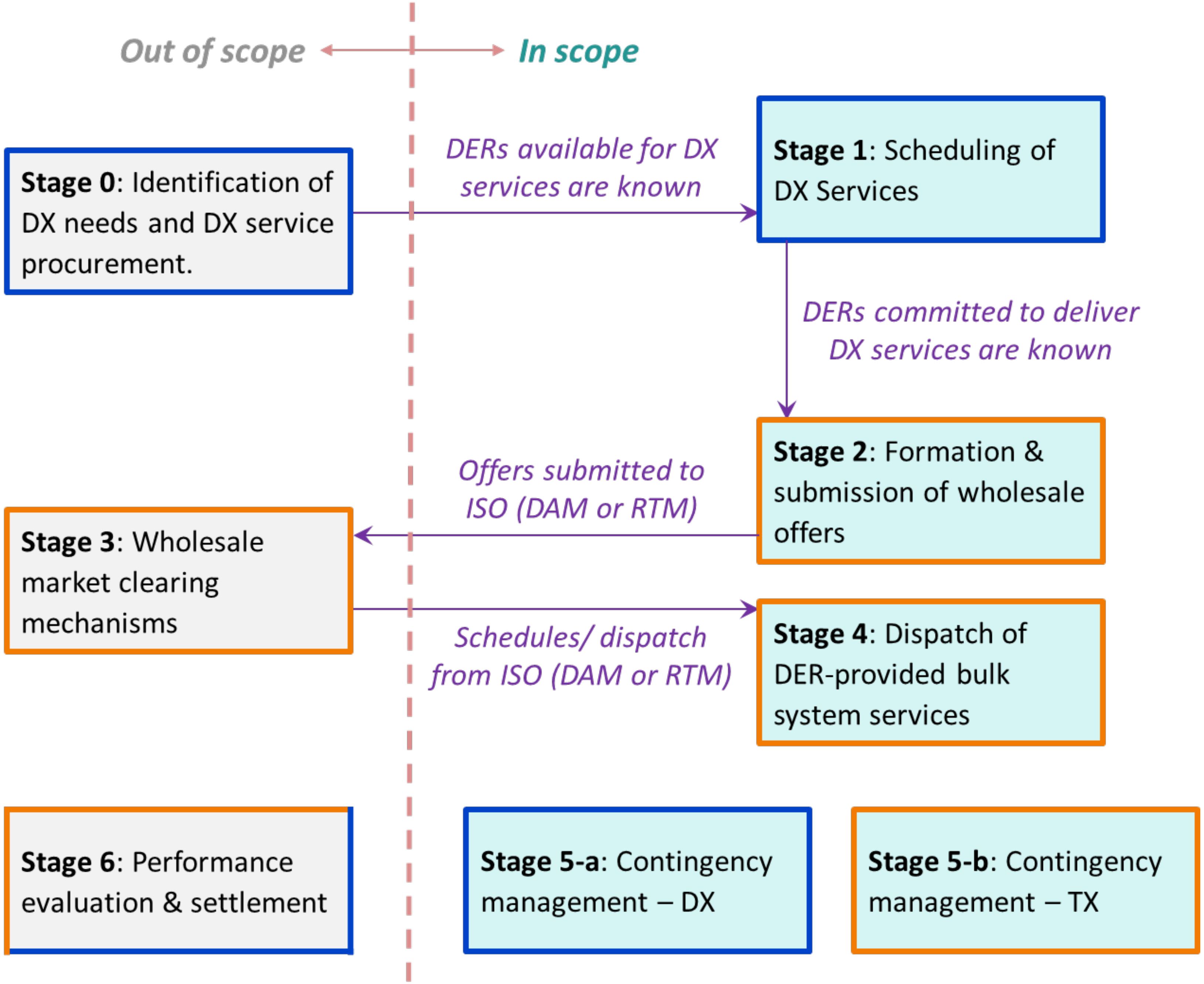
2.3 DSO aggregates all DER offers that clear distribution feasibility analysis and pass the aggregated offer to the ISO. Optional notification to DER that an offer was submitted on their behalf.

ISO gate closure

to stage 3

Coordination stages

Stages were studied for each coordination model: *Total DSO* and *Dual Participation*



Stage Applicability

Distribution services

Bulk system services

Scope of this Analysis

In scope

Out of scope

Stage 4: Delivery of DER-provided wholesale services

Total DSO Model

from stage 3

4.1 (if relevant) ISO sends advisory schedule(s) (non-firm) to DSO *(applicable to RTM)*

4.2 ISO sends dispatch schedule(s) (firm) to DSO *(applicable to DAM and RTM)*

4.3 DSO calculates DER-level setpoints. Through Process 2-b (outage slip), DSO can override aggregated ISO advisory schedules / dispatch setpoints based on expected DX system conditions, if any changes in Dx system conditions occurred since 2.2. If override occurs, DSO sends notification to ISO (outage slip via Process 2-b) with the override result, which could be a total override (zero output) or partial dispatch.

4.4 DSO sends dispatch signals to individual DERs

to stage 5

Stage 4: Dispatch of DER-provided bulk system services

Coordination stages

Stages were studied for each coordination model: *Total DSO* and *Dual Participation*

Stage Applicability

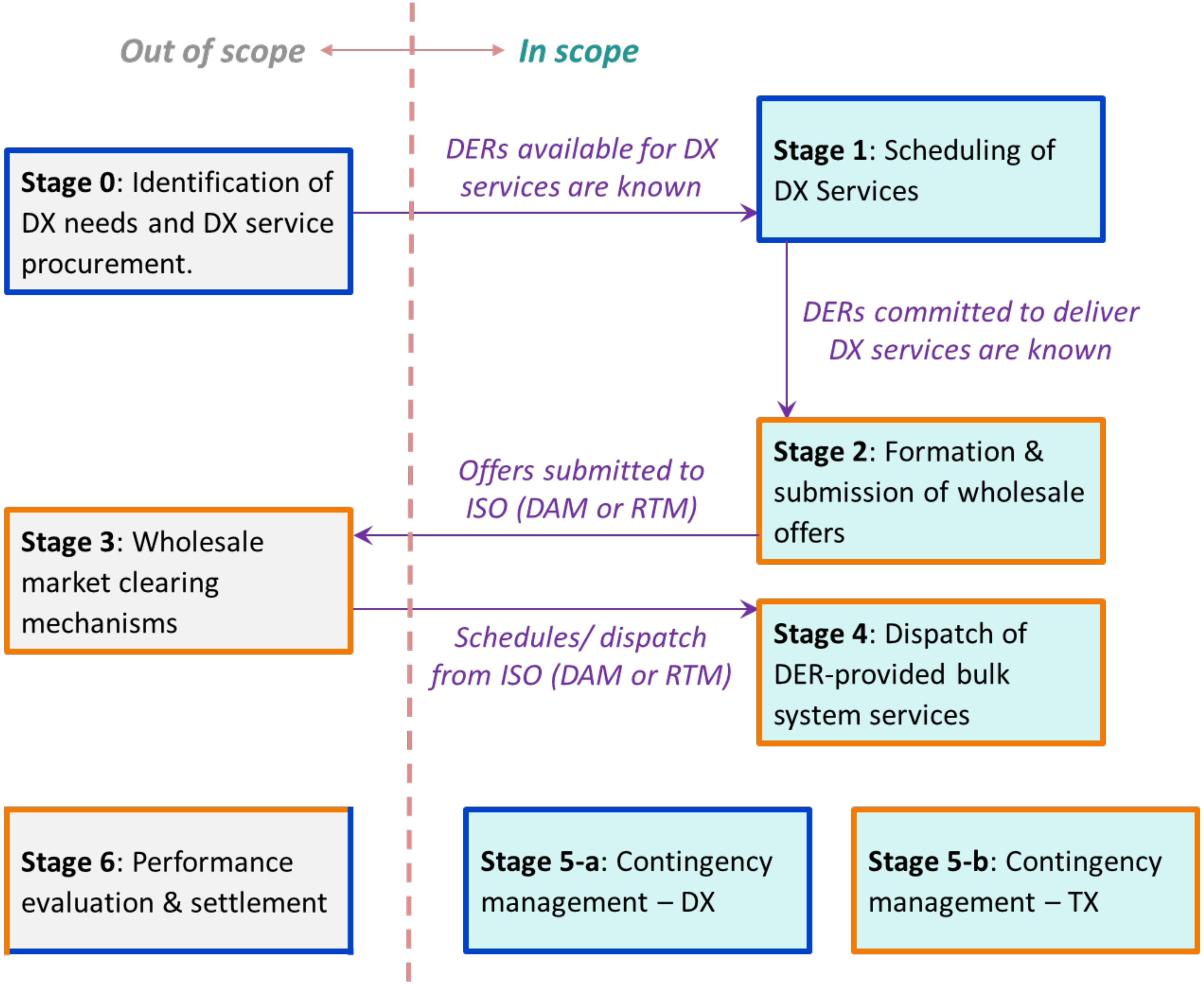
Distribution services

Bulk system services

Scope of this Analysis

In scope

Out of scope



Stage 5-a: Contingency management (Distribution incident)

Total DSO Model

Stage 5-a: Contingency management – DX

Unplanned distribution incident occurs

5.1. DSO notifies ISO if significant deviations from forecasts are observed at substations (Process 4).

DSO notifies ISO of any interruptions of wholesale service delivery, present or future (Process 2-b)

If DER derates are required, DSO notifies DERs (Process 1)

5.2 DSO dispatches distribution operating reserve if relevant to address incident

5.3 DSO recalculates available DX reserve and refills as appropriate

to stage 1

to stage 6

Coordination stages

Stages were studied for each coordination model: *Total DSO* and *Dual Participation*

Stage Applicability

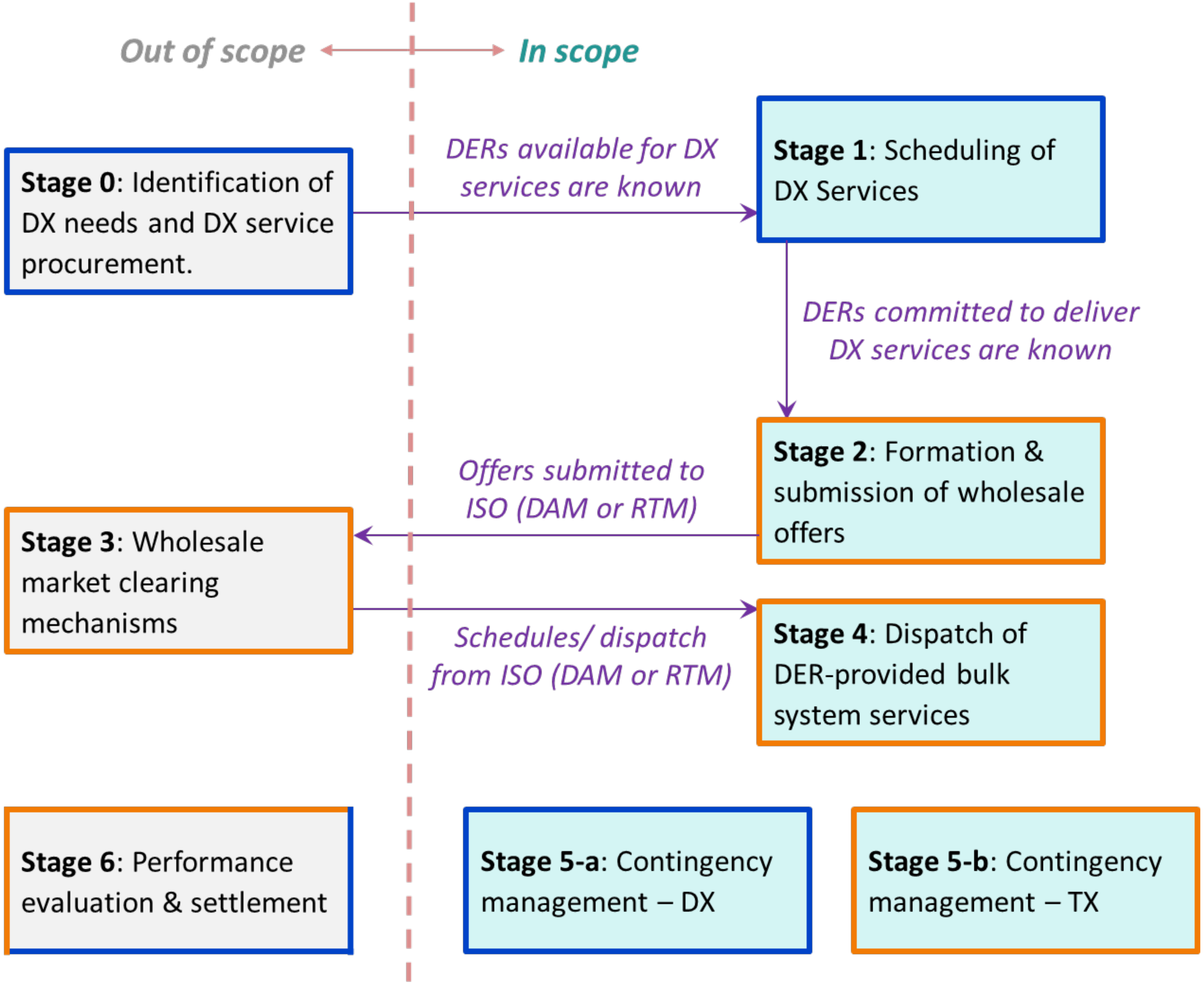
Distribution services

Bulk system services

Scope of this Analysis

In scope

Out of scope



Stage 5-b: Contingency management (Bulk-level incident)

Total DSO Model

Stage 5-b: Contingency management – TX

Unplanned bulk level incident occurs

↓

5.1 ISO sends reserve dispatch activation (ORA) to DSO

↓

5.2 DSO dispatches operating reserve requested by ISO

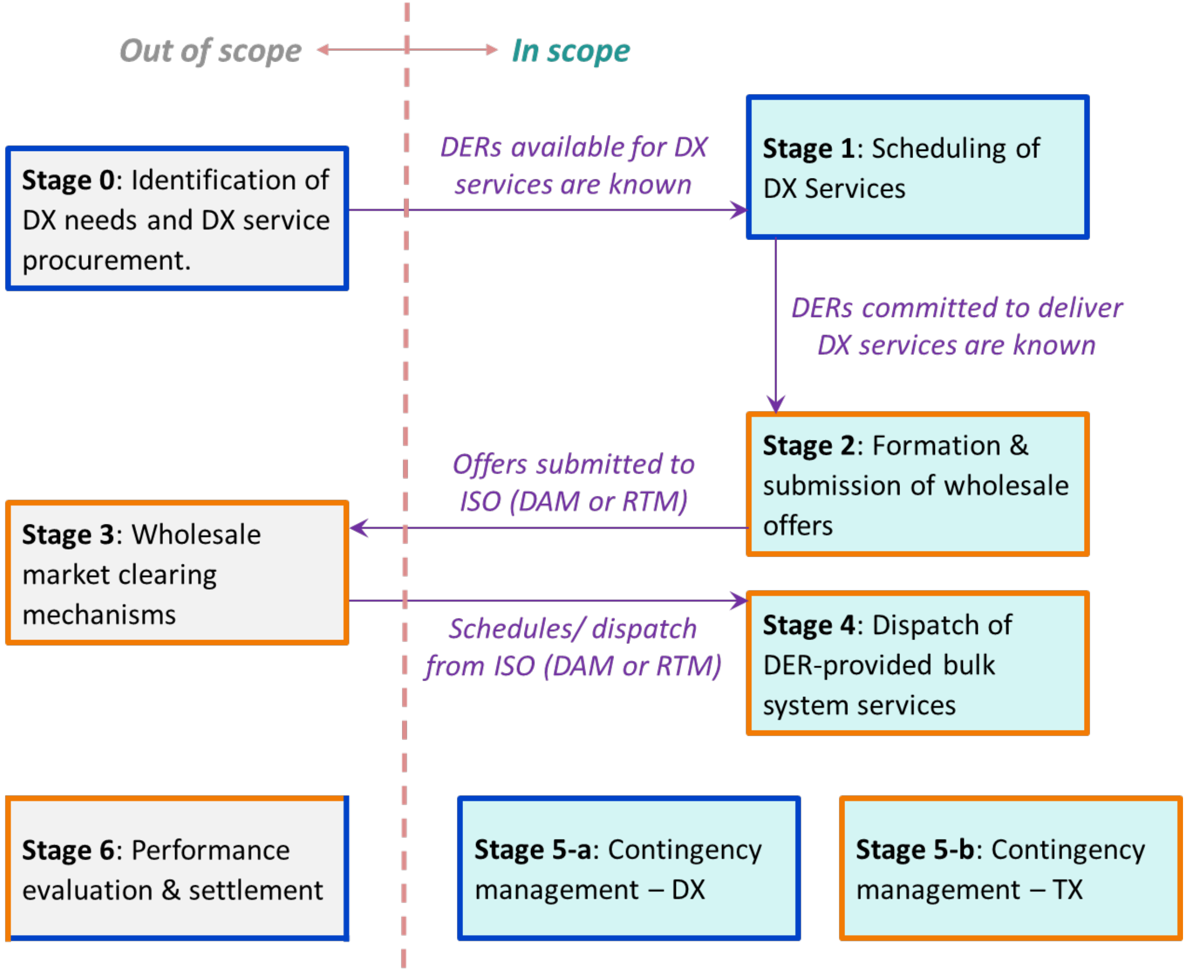
↓

5.3 ISO recalculates available reserves and refills as appropriate

↓

to stage 6

Detailed Coordination Diagrams



<u>Version 1</u>: Total DSO

<u>Version 2</u>: Dual Participation

Not covered in this session, but discussed in project report

Q&A on ISO-DSO-DER Coordination

Part 3: Key Takeaways from Modeling Studies

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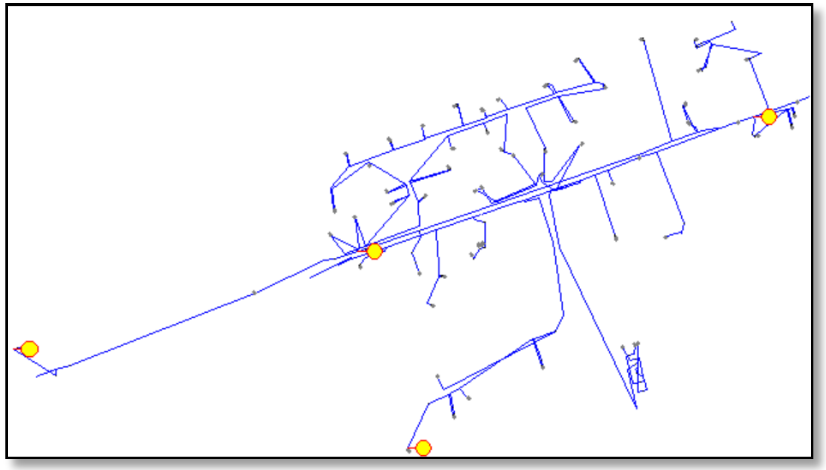
Simulation Scope / Overview

Application: Feeder Modeling and Analysis



- Power flow analysis
- Eight (8) Alectra feeders
- Two (2) IEEE test feeders
- Three (3) load demand snapshot cases
- Various DER allocations (location and size) on each feeder
- Different DER technologies
- Contingency simulation
- Evaluate impacts at T-D interface
  - Congestion relief, losses, etc.

Metrics Evaluated from Simulations

- Total MW Impact at T-D interface
  - Capturing direct impact on forecasted/expected net feeder load
- Losses Impacts from DER Injection
  - Capturing potential for enhanced value from DER injection
- Feeder Element Thermal Loading
  - Confirmation of relief offered by DER injection
- Feeder Operating Voltage
  - Ensure DER injection does not create coincident adverse conditions

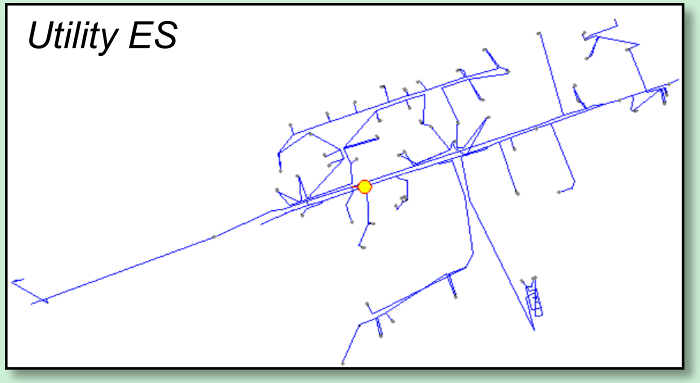
Simulation Assumptions

- DER installed downstream of constrained feeder elements

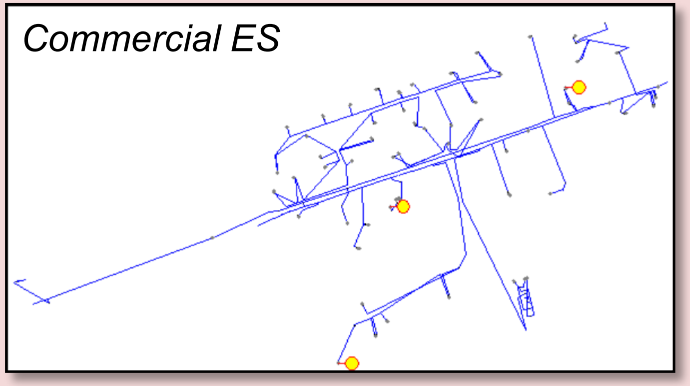
- DER size allowed to be large
  - Allows participation in both distribution and bulk grid services at appropriate times of day/year
  - Assumes flexible interconnection agreement that will limit output at times deemed necessary by DSO
    - Note: this is a known departure from current practices, needed for proving simulation cases

Sample Feeder Results

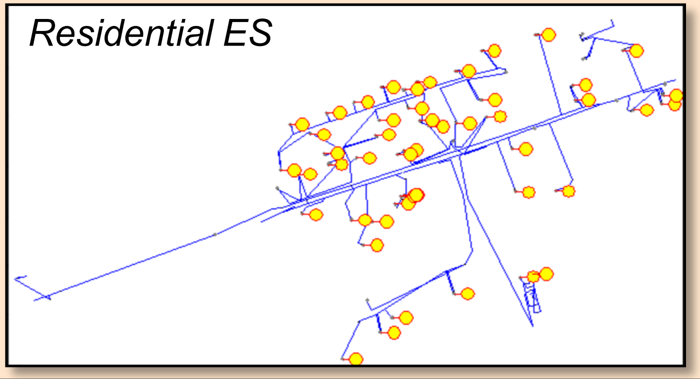
DER Allocation – 3 Classes of Energy Storage (ES)



- Manual allocation
- 1 unit per feeder



- Manual allocation
- Secondary side of service transformers
- 3 units per feeder



- Random allocation at 50% of the load buses
- Secondary side of service transformers

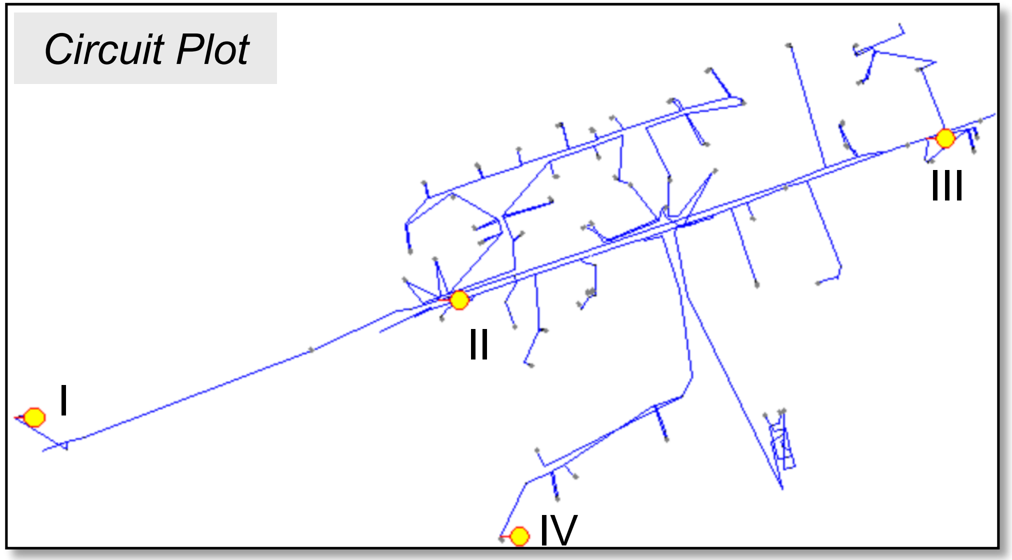
Result - Baseline Conditions

Load Case	Load Magnitude (MW)	Current (Amps)	Existing DER (MW)	% Load vs Rating (Max)
Peak	19.7	434*	0.1	82
Average	11.2	244	0.5	48
Min	7.2	156	0.5	53+

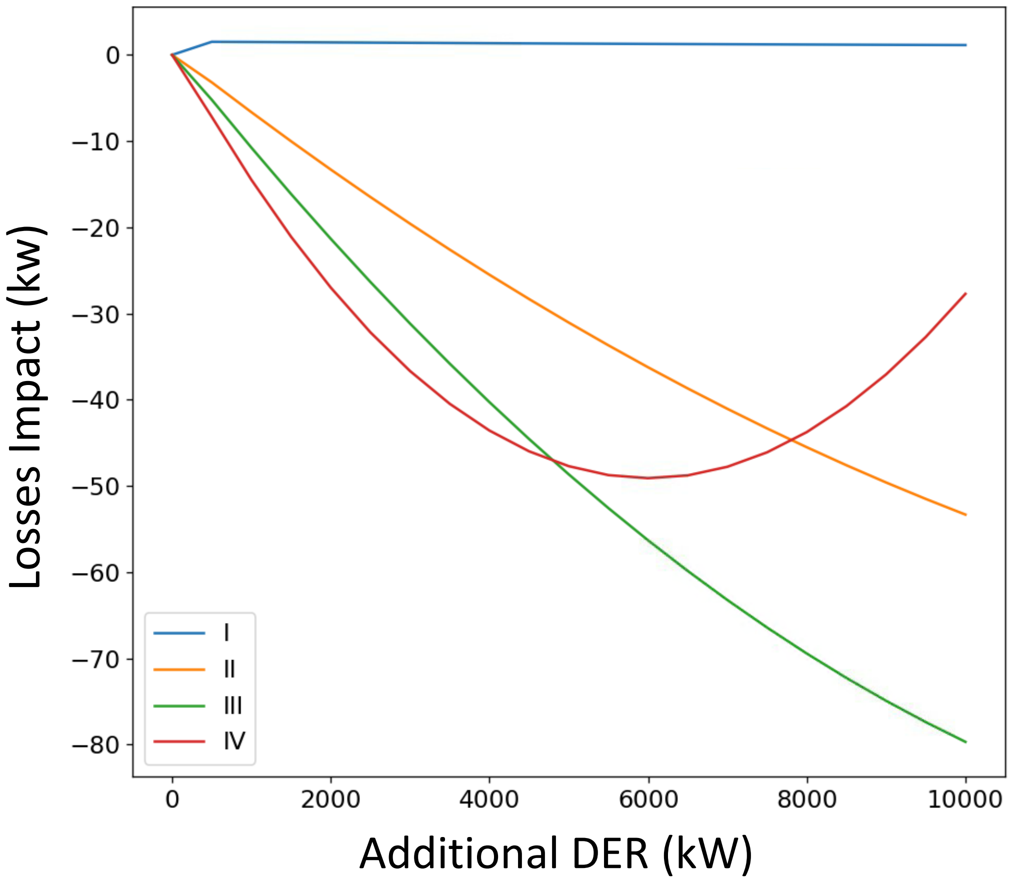
*Indicates feeder total load is above the threshold where distribution engineering would plan system upgrades.
+Caused by net reverse power flow at a customer site with low demand and high DER injection

Range of Losses Impacts (at Peak Demand, Arbitrary Locations)

- Locational impact simulation:
  - 3 MW DER added, 4 key locations (see below)
  - DER farther from the substation more notably reduces losses.
    - I: 0.15 kW, or 0.0001% reduction
    - II: 19.9 kW, or 0.1%
    - III: 31.7 kW, or 0.16%
    - IV: 37.4kW, or 0.19%



Losses Impact – 3 MW at 4 Locations

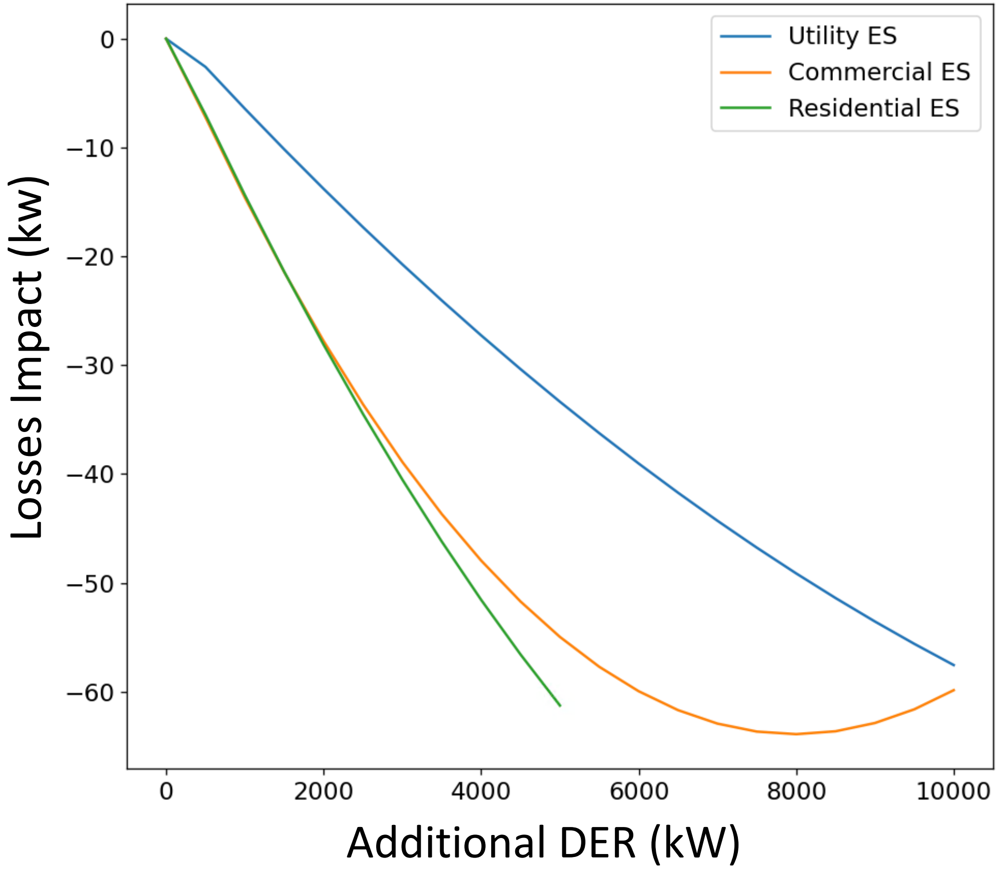


Overall, low losses relative to load demand (max 80 kW when DER is 10 MW).

Range of Losses Impacts (at Peak Demand, Storage Class Allocations)

- DER technology allocations (each 3MW aggregate):
  - Utility ES: 20 kW, or 0.1%
  - Commercial ES: 39.4 kW , or 0.19%
  - Residential ES: 40 kW or 0.20%
  - Higher loss reduction with commercial and residential ES

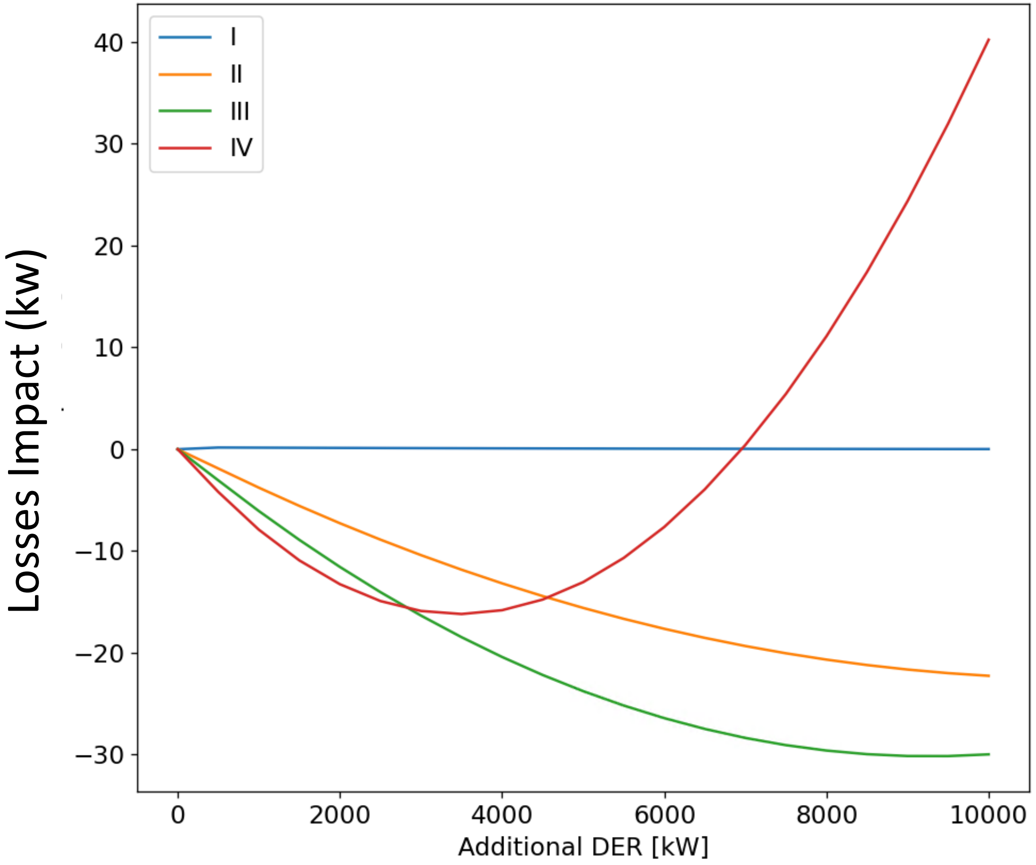
Losses Impact – DER Allocations



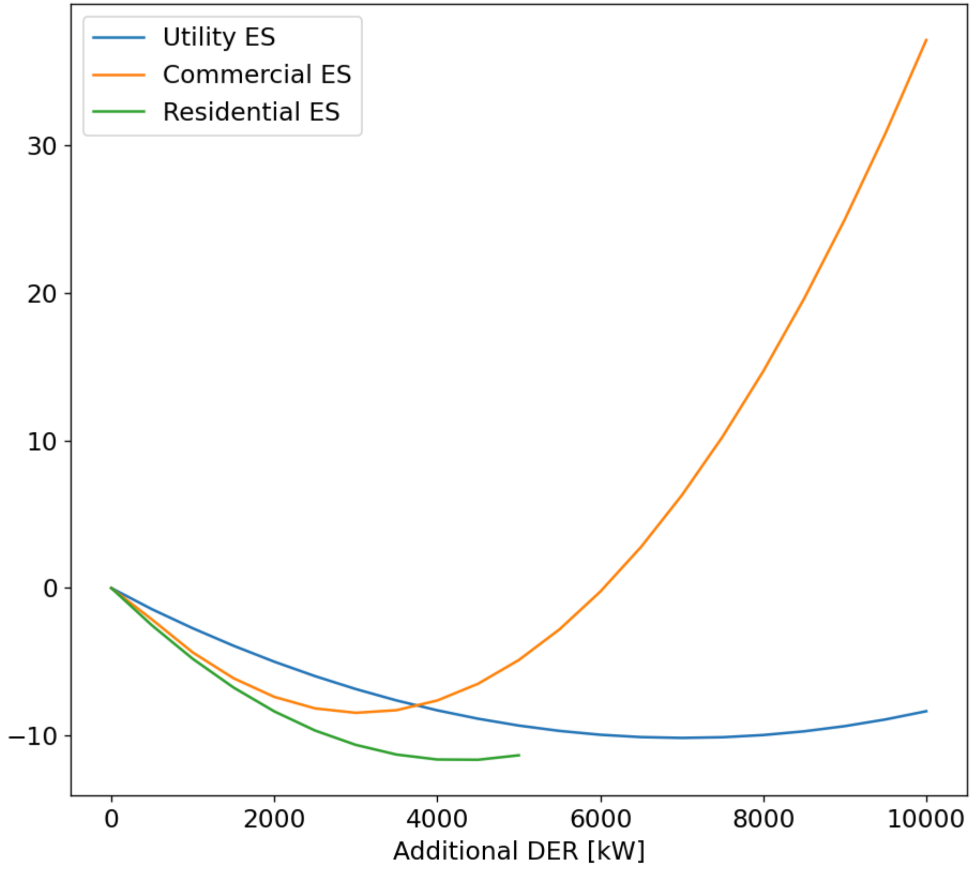
Losses still low, even with 8-10 MW DER (65 kW max).

Gradient Study (Losses at Min Load)

Losses Impact – 3 MW at 4 Locations



Losses Impact – DER Allocations



Losses variation:

-15 kW up to +40 kW

Losses variation:

-30 kW up to +40 kW

Peak Load Results of DER Additions for Congestion Relief (3a)

Feeder Conditions	DER Type	Feeder MW	Total DER MW	Feeder Losses MW	Heaviest Load vs Rating %	Vmax (pu)	Vmin (pu)
Baseline	(none)	19.7	0.1	0.189	82	1.03	0.986
Congestion Relief (3a)	Residential	15.7	4.1	0.138	67	1.03	0.987
Congestion Relief (3a)	Commercial	15.7	4.1	0.140	67	1.03	0.987
Congestion Relief (3a)	Utility-scale	15.7	4.1	0.163	67	1.03	0.987

Scenario 3a (Congestion Relief)

- 4 MW required to reduce feeder head current below planning threshold
- Improved feeder operation
  - Reduced losses
  - Reduced line loading
  - No major changes in voltage

Results for Congestion AND Market Participation (3b)

Feeder Conditions	DER Type	Feeder MW	Total DER MW	Feeder Losses MW	Heaviest Load vs Rating %	Vmax (pu)	Vmin (pu)
Baseline	(none)	19.7	0.1	0.189	82	1.03	0.986
Congestion Relief (3a)	Residential	15.7	4.1	0.138	67	1.03	0.987
Congestion Relief (3a)	Commercial	15.7	4.1	0.140	67	1.03	0.987
Congestion Relief (3a)	Utility-scale	15.7	4.1	0.163	67	1.03	0.987
Market Participation (3b)	Residential	12.7	7.1	0.113	77	1.03	0.988
Market Participation (3b)	Commercial	12.7	7.1	0.126	58	1.03	0.988
Market Participation (3b)	Utility-scale	12.7	7.1	0.147	58	1.03	0.988

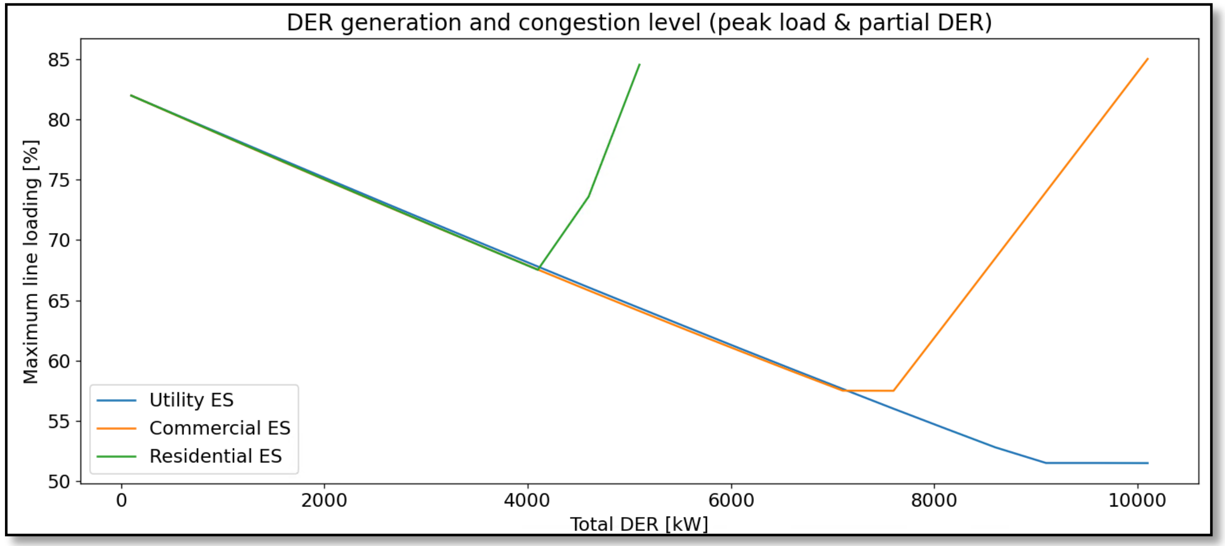
Scenario 3b (Market participation/ value stacking)

- DER is 3MW larger (7MW total) to participate in the wholesale market
- Lower losses for all DER technology and load condition
- Residential ES creates heavier loading for larger aggregate to participate in the market
  - Maximum component loading > 85%

Gradient Study

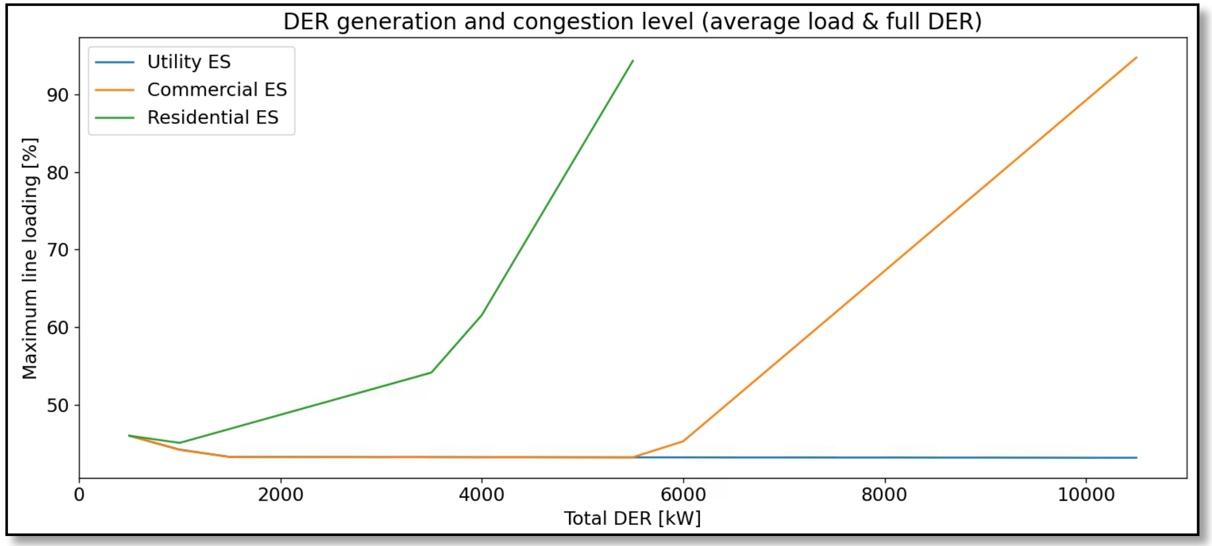
- Peak Load
  - All DER allocations work for aggregate 4 MW size
  - Residential DER creates ***heavier*** loading above 4 MW
  - Commercial DER loads elements more after 7 MW

Peak Load



- Average Load
  - Running DER at full capacity creates heavier loading
    - Residential: after 1 MW aggregate size
    - Commercial: after 5.5 MW

Average Load



All-Feeders Broader Results

Summary of All-Feeders Results

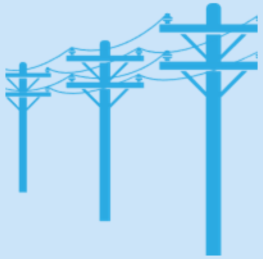
- **Alectra feeders have a robust build**
  - Losses are minimal
  - Power exchange from DER to T-D interface is nearly 1:1
  - Voltage change minimal
- **DER can successfully serve minor constraints near the planning threshold**
  - Almost any scale of energy storage can achieve distribution relief
  - Some types of DER technology are less likely to guarantee feeder relief, either due to volume or scale (e.g., residential storage lacking enough aggregate energy)

Summary of All-Feeders Results (cont.)

- **Careful coordination is needed between DER, DSO and ISO during non-peak conditions**
  - Can possibly create overloads in reverse flow (assuming flexible interconnection agreement)
- **Non-dispatchable DER would need a different approach**
  - Account for variability and less reliable output

DER-Provided Wholesale Market Offers

What makes the dispatch of a DER different from a transmission-connected resource?



Distribution Congestion

Congestion on the distribution system can alter the economic dispatch of DERs

Distribution Losses

The ability to reduce distribution losses can prioritize dispatch of DERs

Heterogenous Aggregations

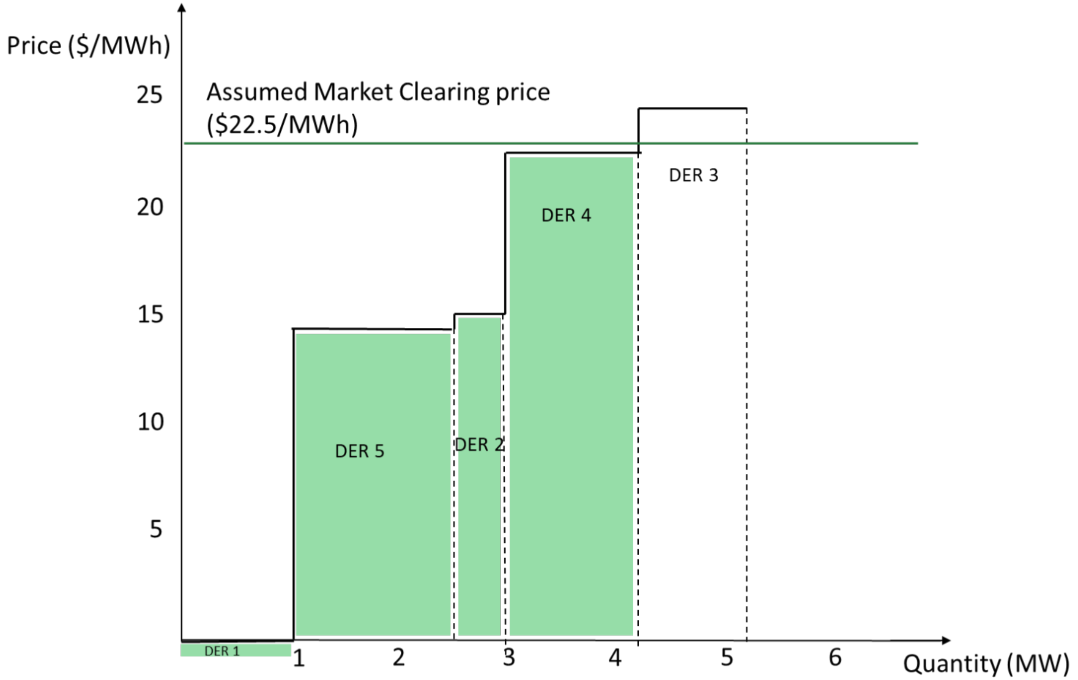
Aggregations can include multiple technologies, complicating participation models

Wholesale market offers submitted by DER/ DERA

- **Offer parameters**
  - Price-quantity pairs ($/MWh, MWh), up to 20
  - Ramp rates, Pmax, others based on participation model

- DERA *(Dual Participation)* and/or LDC *(Total DSO)* **aggregate individual DER offers** into monotonically increasing price-quantity pairs

- Reflect distribution service commitments in wholesale market *(Dual Participation)*
  - DERs submit floor price offer corresponding to energy needed

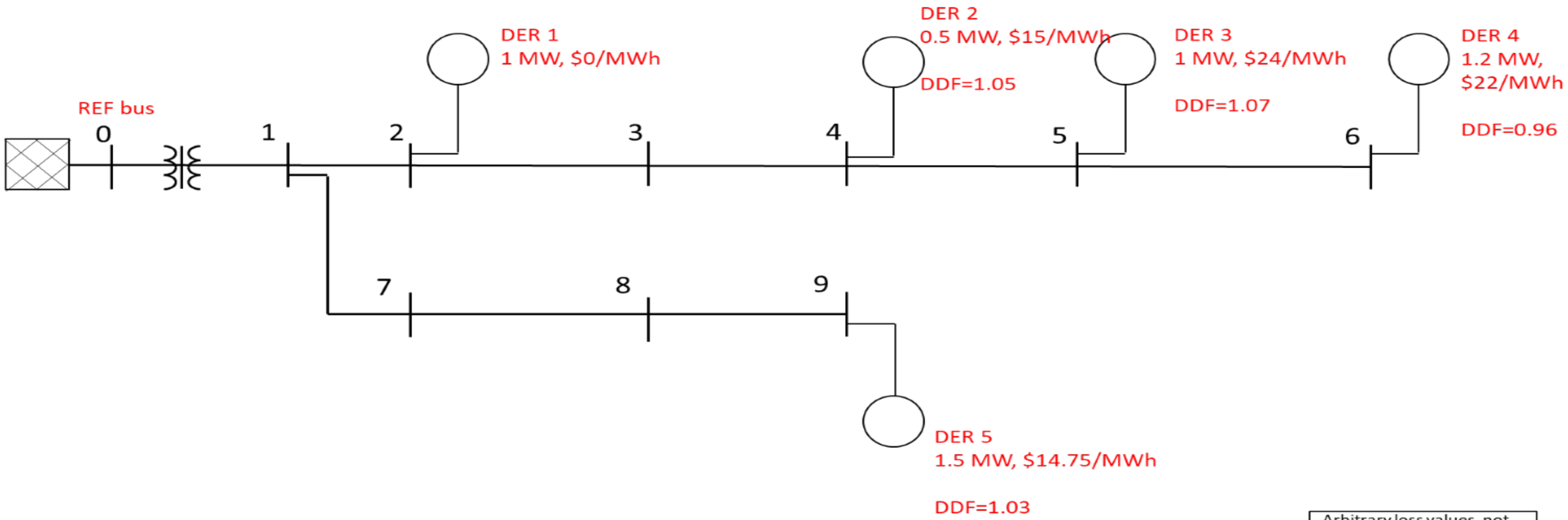


One single offer with multiple price-quantity pairs
Provided by the DER/DERA or the DSO

An aggregated DER offer can look like a traditional generator offer

EPRI

Effect of Distribution Losses: Illustrative Example



Arbitrary loss values, not representative of location

DER (Bus)	DDF_i	Distribution Loss Adjustment Factor $DLAF_i = \left(\frac{1}{DDF_i}\right)$	Original Offer \$/MWh	Adjusted Offer (AO_i) = Original offer (OO_i)* $DLAF_i$ \$/MWh
DER 1 (Bus-2)	1	1	0	0
DER 2 (Bus-4)	1.05	0.952	15	14.28
DER 3 (Bus-5)	1.07	0.935	24	22.43
DER 4 (Bus-6)	0.96	1.042	22	22.92
DER 5 (Bus-9)	1.03	0.971	14.75	14.32

Distribution Loss Adjustment Factors can be used to optimally dispatch DERs for wholesale participation (cost minimization) while taking into account distribution losses.

Q&A on Key Takeaways from Modeling Studies

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