Transmission-Distribution Coordination Protocols

Prepared for the Transmission-Distribution Coordination Working Group (TDWG)

Deliverable A
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Executive Summary

This report addresses operational transmission-distribution (T-D) coordination to enable distributed energy resources (DERs), individually or in aggregation (DER/A), to provide energy services across both the transmission and distribution grids. It serves as the final report for 'Deliverable A' of the Transmission-Distribution Coordination Working Group (TDWG). This work reflects input from the diverse stakeholder members of the TDWG.

Three distribution system operator (DSO) coordination models are examined: Dual Participation DSO (DP-DSO), Total DSO (T-DSO), and Market Facilitator DSO (MF-DSO), detailing key potential approaches for organizing the coordination among parties. Protocols have been developed and are presented in the form of swim lane diagrams for each model. These protocols outline operational actions, data exchanges, and associated timelines necessary to facilitate effective coordination among DER/A participants, Distribution System Operators, and the Independent Electricity System Operator (IESO). Four key service cases are addressed: (1) DERs not actively participating in any services, (2) DER/A providing only distribution energy services, (3) DER/A providing only wholesale (transmission-level) energy services, and (4) DER/A providing energy services at both the distribution and wholesale levels of the grid.

Enabling 'service stacking' allows DER/A to provide services to both the IESO and DSOs, increasing their value to both the electricity system and DER/A participants. Key challenges in achieving effective T-D coordination are outlined in the report, particularly aligning the timing and processes between DSOs and the IESO. The importance of pre-operational coordination to ensure all parties have the necessary data to model DER/A for operational assessments is emphasized. The report considers DER/A participation in the IESO's day-ahead and real-time markets in the renewed wholesale market (i.e., a post-Market Renewal Program (MRP) implementation environment). Detailed protocols are provided for five key processes: (a) day-ahead scheduling, (b) real-time dispatch, (c) DER/A outage management, (d) distribution system outages, and (e) DER/A resource plan changes.

Several potential next steps are identified to advance towards the implementation of the T-D coordination protocols, including conducting in-depth analyses of critical topics and exploring opportunities to pilot the protocols in real-world conditions.

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1. Introduction

Distributed energy resources (DERs)[1] can play an important role in the electricity system by providing services to the wholesale market, while also potentially providing services to the distribution system. These resources can be co-located with or sited close to load, offering a potential alternative to upstream infrastructure, including distribution, transmission, and centralized generation. Additionally, DERs can offer other benefits, such as improving resilience, helping customers manage their bills, and providing greater customer and community choice. The adoption of DERs is expected to continue in coming years due to decreasing technology costs, increasing electrification of transportation and heating, and growing interest in solar panels and battery storage. In fact, a significant uptake of DERs is anticipated to occur regardless of incentives aimed at promoting grid services. From the perspective of grid planners and operators, there is an opportunity to maximize the value that DERs provide to the whole grid while customers with DERs also benefit.

Enabling DERs and DER aggregations (DER/A) to participate in services across the transmission and distribution grids requires careful coordination among DER/A participants[2], Distribution System Operators (DSOs)[3], and the Independent Electricity System Operator (IESO). This report considers DER/A participation in the wholesale energy market[4] administered by the IESO, DER/A provision of distribution system services to a DSO, and the possibility of a DER/A 'stacking' both types of services. A key area of focus is the coordination of dispatchable DER/A[5], which are subject to five-minute dispatch instructions from the IESO. Additionally, the report outlines a process for DSOs to 'override' dispatch instructions to DER/A, allowing them to curtail operations for safe and reliable grid management.

The objective of this report is to detail the operational actions and data exchanges required among the relevant parties to ensure effective participation of DER/A in providing grid services and reliable

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1 DERs are resources that generate electrical energy, store and discharge electrical energy, or dynamically modify load, and that are connected directly to a distribution system or to an end-use customer's premises within a distribution system. They include, but are not limited to, solar photovoltaics (PV), combined heat and power plants, backup generators, energy storage, electric vehicles, and consumer devices that can reduce or increase electricity use on demand. Energy efficiency measures are excluded from the definition of DER for the purposes of TDWG.

2 This report uses the term 'DER/A participant' to refer to a participant with an individual DER or a DER aggregation that (a) is only registered to provide distribution-level services to the DSO, (b) is only a registered market participant with the IESO and submits bids or offers (i.e., dispatch data) for a DER/A resource in the IESO-Administered Markets, or (c) is registered to provide services to both the DSO and the IESO.

3 For the purposes of this report, DSO refers to the entity responsible for operation of the electric distribution system and operational coordination with the IESO at the transmission-distribution (T-D) interfaces. The DSO's capabilities may include advanced operational functions, such as operational planning, active management of DER/A to ensure distribution system reliability, and procurement and activation of DER/A for the provision of distribution services.

4 Only energy services in the wholesale market are considered within the scope of this report. Provision of operating reserve and other ancillary services such as frequency regulation, black start capability, voltage control, and reactive power are outside the scope of the operational actions and data exchanges addressed here.

5 Dispatchable DERs are a highly responsive subset of dynamic DERs that can quickly respond to grid needs, instructions, and market signals. In contrast, passive DERs, such as rooftop solar panels, generally operate autonomously, producing energy without active management.

operation of the power system. As agreed upon in the IESO-hosted Transmission-Distribution Coordination Working Group (TDWG), three specific DSO models, namely the Dual Participation DSO (DP-DSO), Total DSO (T-DSO), and the Market Facilitator DSO (MF-DSO) models, will be examined. Additionally, the coordination for cases involving both a host and an embedded distributor[6], which is a common occurrence in Ontario, is addressed in supplemental document *T-D Coordination Protocols with Embedded DSO and Host LDC*[7].

Complementing this report, the working group has developed three additional deliverables addressing requirements and considerations for T-D coordination from several vantage points. Together, these reports aim to provide detailed analyses and present methods, options, and potential next steps for implementing improved T-D coordination in Ontario. These deliverables are summarized in Table 1.

Table 1 | Overview of the TDWG Deliverables

Deliverable	Description
A - Coordination Protocols	Describes how DER/A participants, DSOs, and the IESO coordinate to enable DER/A participation in both distribution-level and wholesale services. Details required actions, data exchanges, and timelines.
B1 - Functional Assessment	Identifies operational and functional requirements, internal resourcing and capability development, and the associated costs incurred by LDCs as they transition to DSOs.
B2 - Communication Assessment	Identifies and maps the communication interfaces among DER/A, LDCs, and the IESO, detailing data exchanges, existing communication methods, and potential future options.
B3 - Shared Platform Concept	Explores a shared platform for T-D coordination, highlighting key features of using a shared platform and detailing data exchanges among LDCs, DER/A participants, and the IESO.

This report focuses on operational coordination in the day-ahead and real-time timeframes, both from system operation and market administration perspectives. Exploration of planning and capacity investment timeframes and processes is out of scope. Additionally, settlement and other commercial issues will not be considered in this report. The presented protocols consider the wholesale market processes implemented as part of the IESO's Market Renewal Program, which went 'live' in May

6 An embedded distributor is a local distribution company (LDC) that operates its distribution system within the service area of a host distributor. The host is connected to the transmission system at the transmission-distribution interface (T-D), while the embedded LDC has a distribution-distribution (D-D) interface. The report will consider and address cases where there is a host and an embedded distributor for the purposes of visibility and reliability. It will also consider DER/A providing services to an LDC (either embedded or host) and the IESO. However, the report will not address 'tri-participation', where DER/A would provide services to the embedded LDC, host LDC, and IESO, due to the significant complexity involved.

7 The supplemental document can be found on the TDWG engagement page.

2025[8]. The TDWG was initiated to support the IESO's Enabling Resources Program (ERP), which is a major IESO initiative aimed at enabling emerging electricity resources in Ontario's wholesale market[9].

The report is organized as follows: The introduction has outlined the need for T-D coordination and the objective of the report. Section 2 discusses grid services at the wholesale and distribution levels in the operational timeframe. Section 3 introduces the three DSO coordination models. The importance of pre-operational coordination to prepare parties for operations is emphasized in Section 4. Section 5 highlights key features of the T-D protocols, explaining their structure and functionality. In Section 6, swim lane diagrams presented detailed protocols for five different processes for each of the DSO coordination models. Section 7 briefly outlines potential next steps and concludes the report.

8 For more information, please visit the Market Renewal webpage.

9 As part of ERP, enabling participation of DER and DER aggregation in the wholesale market will be further explored. However, additional market and sector evolution may be necessary for a fully integrated ecosystem for DER/A in Ontario.

2. Operational Grid Services

The spectrum of grid services is constantly evolving, adapting to new challenges and opportunities, for instance due to emerging technologies. A key aspect of this evolution involves enabling DERs such as electric vehicles, smart thermostats, heat pumps, battery storage, and solar panels to provide grid services. Grid services include a suite of capabilities that electricity resources can potentially offer to manage the electricity system and ensure it is built and operated effectively and reliably. This includes services provided at both the transmission level to the IESO and at the distribution level to a DSO. These services are critical to balancing supply and demand in real time, maintaining power quality, managing emergency situations, and facilitating recovery from outages. For instance, the IESO procures energy, ancillary services, and capacity services to reliably balance the system in real time and to ensure adequate resources are available. In parallel, DSOs may use DERs locally for distribution services - for example, as non-wires alternatives to traditional distribution infrastructure. Doing so can similarly involve energy provision, capacity support, and potentially other services[10].

Traditionally, distribution operations have mainly focused on managing network infrastructure (e.g., transformers, feeders) to deliver electricity to end-use customers. These activities have historically had minimal impact on transmission-level operations, such as system balancing. However, with the increasing deployment of DERs and their growing participation in grid services, distribution-level operations are expected to have a progressively greater impact on transmission-level operations. Given this increasing impact, effective coordination between distribution and transmission operations is required to ensure that DERs reliably and cost-effectively support both levels of the grid. To implement these coordination-related actions, the IESO, DSOs, and DER/A participants will need incorporate them in their respective operational procedures. This report focuses on the operational timeframe - from day-ahead to real time - including the schedules and dispatches in the wholesale market as well as schedules and activations to operate DER/A for distribution system needs.

The use of DERs for distribution-level services represents an emerging opportunity, with pilot projects currently underway. Several pilots are supported by the collaborative efforts between the Ontario Energy Board (OEB) and IESO through the DER Integration Joint Targeted Call[11]. In particular, these distribution-level services include using DERs as non-wires alternatives (NWAs) to traditional distribution infrastructure, such as wires, poles, and transformers[12]. In the 2023 Framework for Energy Innovation Report, the OEB set out its policies for integrating DERs in distribution system planning and operations, including the use of DERs by distributors as NWAs. The OEB subsequently developed a Benefit-Cost Analysis (BCA) framework and issued the Non-Wires Solutions (NWS)

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10 Distribution services from DER/A can be secured and compensated through a variety of means, including programs, procurements, bilateral contracts, or distribution-level markets. This report remains approach-agnostic and focuses on the general actions a DSO would take once it determines that a DER/A should operate.

11 For more information, please refer to the November 2023 OEB/IESO Joint Targeted Call Interim Report.

12 DER/A can also serve as NWAs to traditional transmission infrastructure. For such projects, the IESO's wholesale market could capture the operational needs and instructions required to operate the DER/A. Although this document does not explicitly address transmission NWAs, the coordination discussed with the IESO's wholesale market inherently includes considerations for these applications.

Guidelines for Electricity Distributors to provide guidance for distributors[13]. In alignment with these key developments, a focus area of the TDWG and this report is the coordination of DER/A as they provide services as NWAs to distribution infrastructure and also participate in the wholesale energy market.

Although the term 'distribution services' broadly includes various services, in this document it specifically refers to dispatchable DERs providing real (active) energy as part of operationalizing non-wires alternatives (NWAs) to address distribution constraints. The protocols presented here are designed exclusively for this specific meaning and do not address other distribution-level services (e.g., reactive energy). To align with recognized industry terminology and to maintain flexibility for future updates or additional use cases, the term 'distribution services' consistently refers to this specific use case throughout the document. If additional use cases are considered in the future, the protocols will need to be revisited and adjusted accordingly.

Ontario's wholesale market, which is designed and administered by the IESO, was first introduced in 2002 and was recently modernized. In May 2025, the Market Renewal Program (MRP) implemented significant enhancements focused on electricity pricing and scheduling, aiming to improve market efficiency and ensure the wholesale market is well-equipped to support the grid of the future. Specifically, MRP introduced (a) a new Day-Ahead Market (DAM), (b) locational marginal prices (LMPs) in the Real-Time Market (RTM) and DAM, and (c) an enhanced real-time unit commitment (ERUC) process. Additionally, through the Enabling Resources Program, the IESO seeks to introduce new participation models to integrate DER/A into the wholesale energy market.

2.1 Coordination Problem

The essence of the T-D coordination problem in the operational timeframe lies in ensuring DSOs and the IESO maintain visibility into the real-time status and expected operation of DER/A. This must account for dynamically changing grid conditions that could impact and limit DER/A operations. Visibility allows both the IESO and DSOs to understand the operational capabilities of DER/A and their availability to provide grid services. Effective coordination ensures that DER/A status information is captured in DSO and IESO systems and processes, and that DER/A are not subjected to conflicting instructions.

The real-time status of DER/A is informed by telemetry from DER/A themselves, as well as from the configuration and outages of the distribution system, which can affect DER/A availability and connectivity[14]. The IESO receives detailed telemetry data at the transmission level; however, telemetry from the distribution system is expected to be more limited. This makes effective coordination among all parties - DSOs, DER/A participants, and the IESO - even more critical to ensure reliable operations, as outlined in this document. Note that this report will not examine

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13 For more information, please refer to the OEB's BCA Framework webpage as well as the OEB's NWS Guidelines webpage.

14 It is not expected that the IESO will require the same level of telemetry from the distribution system as it does from the transmission system. For DER/A participating in the wholesale market, the IESO will need telemetry from both the DER/A and potentially limited and strategic telemetry from the distribution network to complement the DER/A data and inform its connectivity to the system. Additionally, telemetry data can be aggregated and simplified for the IESO, as detailed telemetry may not be necessary. An area for further exploration is the potential and benefits of distributors taking on a larger role in providing telemetry for smaller DERs. For further information, refer to the March 28, 2024, B3 Deliverable presentation on Telemetry Requirements for Distributed Energy Resources.

telemetry requirements, as these are covered by other TDWG deliverables. Additionally, the Enabling Resources Program will separately explore telemetry requirements associated with wholesale market participation.

In addition to telemetry, outage reporting processes are needed to communicate any DER/A unavailability (or reduced availability) among DER/A participants, DSOs, and the IESO. Outages occur when DER/A are fully or partially out of service due to issues within DER/A systems or the broader distribution network. For DER/A participating in the wholesale market, IESO market rules and manuals require participants to notify the IESO of outages. Even when DER/A do not participate in the wholesale market, the IESO requires information from distributors about material distribution outages and demand management actions that impact DER/A operation. Further details on existing outage reporting processes are provided in Section 6.1.

The real-time and expected operational conditions of DER/A are also informed by schedules and dispatches in the wholesale energy market, as well as schedules and activations when DER/A provide distribution services[15]. Regardless of the DSO coordination model, the IESO is expected to need visibility into schedules and activations of DER/A providing distribution services. The data helps the IESO determine the availability of additional DER/A output for meeting transmission-level needs. This information also supports the IESO's system balancing activities, improves visibility into overall system demand, and enhances the accuracy of demand forecasting.

Similarly, DSOs may need to have visibility into wholesale market schedules and dispatch instructions issued by the IESO to DER/A. This information equips DSOs with data on anticipated DER/A operation in response to the IESO's instructions, improving their visibility and enabling them to better manage the distribution system. DSOs can more accurately assess gross demand on their system and the availability of additional DER/A output. Additionally, DSOs are positioned to manage emergencies and limit DER, overriding the IESO's dispatch of the DER/A due to unexpected distribution system conditions.

2.2 Service Stacking

Service stacking enables the more efficient use of DER/A by allowing them to offer services at both the transmission and distribution levels of the electricity system. Achieving this requires coordination among DER/A participants, DSOs, and the IESO to ensure reliable operation across the DER/A, distribution systems, and the transmission system. This approach enables DER/A participants to access multiple revenue streams[16], encouraging greater deployment and availability of DER/A for grid services and helping to meet the growing energy demands associated with the energy transition.

T-D coordination in the operational timeframe, specifically for DER/A providing energy services, is key to allowing DER/A participation in additional grid services. For example, while not addressed in this document, effective operational T-D coordination could potentially enable DER/A to deliver capacity

15 DERs may at times also be used by their owners for personal needs. During these periods, DER/A that participate in the wholesale energy market can submit price-taking bids/offers, ensuring that dispatch instructions are consistent with the actual operation of the DERs. DSOs that receive services from DER/A may similarly require notice and details of customer-driven use of DER/A.

16 The alternative to service stacking is 'single-service contracts', which restrict DER/A to providing only one service. This approach limits the potential for DER/A to offer an alternative to all upstream distribution, transmission, and generation infrastructure.

services as NWAs to distribution infrastructure while also participating in the IESO's capacity auctions or resource procurements. Recognizing its importance, the TDWG focused on developing operational coordination protocols that enable the stacking of energy services.

2.3 Services Timing and Processes

This section describes the key processes and timeframes for energy services in the wholesale market and defines high-level processes for energy services at the distribution-level. These elements inform the design of T-D coordination protocols for service delivery across both levels.

The wholesale energy market is described first. The IESO recently implemented the Market Renewal Program (MRP) to make improvements to the wholesale market design. The renewed market introduces new processes that the T-D coordination protocols presented in this report must align with.

Next, key features for energy services at the distribution-level are described. In recent years, there have been a number of promising pilots and early projects that seek distribution level services from DER/A[17]. However, a standard design for using DER/A for distribution services has yet to emerge. This section defines a minimal set of features necessary for distribution services to be 'stackable' with wholesale market energy services. These features are expected to be required for the coordination protocols to be compatible with the IESO's processes. At the same time, these features provide flexibility for distributors, DER/A participants, policymakers, regulators, and other relevant stakeholders to define the distribution services further.

2.3.1 Wholesale Energy Market

The section provides a high-level overview of the IESO's day-ahead energy market (DAM) and real-time energy market (RTM) processes, focusing on the key milestones and interactions. It presents a simplified version of detailed procedural steps for clarity. Detailed operational procedures are provided in the Market Rules and Market Manuals[18].

The IESO operates both a DAM and RTM for energy and operating reserves across the transmission grid. In these markets, the IESO determines the solution that maximizes the economic gain from trade among market participants, factoring in supply offers, demand bids, the system demand forecast, and the transmission network model. This solution also respects the constraints of the transmission system and of participating resources, ensuring energy is delivered where it is needed on the transmission grid.

The DAM processes take place on the day prior to the dispatch day and will schedule resources for every hour of the dispatch day (i.e., the next day). The RTM processes take place throughout every hour of the dispatch day, during which dispatch instructions will be determined and issued every five minutes. In addition, energy prices in both the RTM and DAM will be calculated for all pricing nodes across the transmission grid, including T-D interfaces. An objective of the DAM is to schedule and

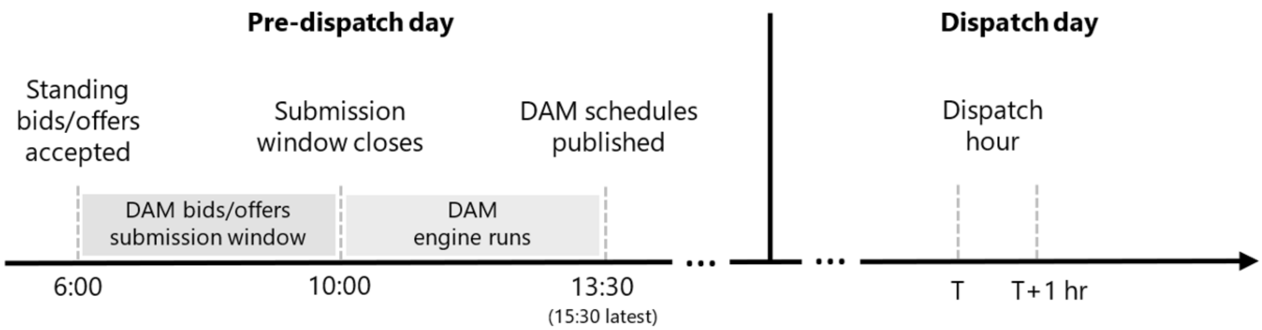
17 For some examples, please refer to the November 2023 OEB/IESO Joint Targeted Call Interim Report.

18 For more precise timing, rules, and details, refer to the documentation posted on the Renewed Market Rules & Manuals Library webpage.

commit resources to meet the dispatch day's forecasted demand. It is expected that most of the electricity supply will be scheduled in the DAM and the RTM will be used to balance any deviations that occur between day-ahead and real-time.

As shown in Figure 1 the DAM submission window opens at 06:00 Eastern Prevailing Time (EPT). Of note, the DAM operates in EPT, while the RTM operates in Eastern Standard Time (EST)[19]. When the submission window opens, standing bids/offers will be converted to bids/offers for the dispatch day (i.e., next day)[20]. DER/A participants can submit and revise daily and hourly bids/offers for the dispatch day prior to the DAM submission window closing at 10:00 EPT. Submitting bids/offers into the DAM also sets an availability declaration envelope (ADE)[21], which limits the maximum capacity that resources can be dispatched in the RTM. The DAM calculation engine is generally expected to be completed by 13:30 EPT but may be delayed to 15:30 EPT. Once completed, the IESO will issue DAM schedules and prices to market participants.

Figure 1 | Relevant IESO Day-Ahead Market Timelines in EPT



Like the DAM schedules, the dispatch instructions in the RTM are based on bids/offers while considering transmission and other constraints. As noted previously, the RTM operates in EST, while the DAM operates in EPT. As shown in Figure 1, the deadline for market participants to submit and revise hourly bids/offers in the RTM is two hours in advance of the dispatch hour at which time the unrestricted submission window closes. Modifications to bids/offers are subject to limitations during the "Mandatory Window," a period that starts two hours prior to and ends ten minutes before the dispatch hour[22].

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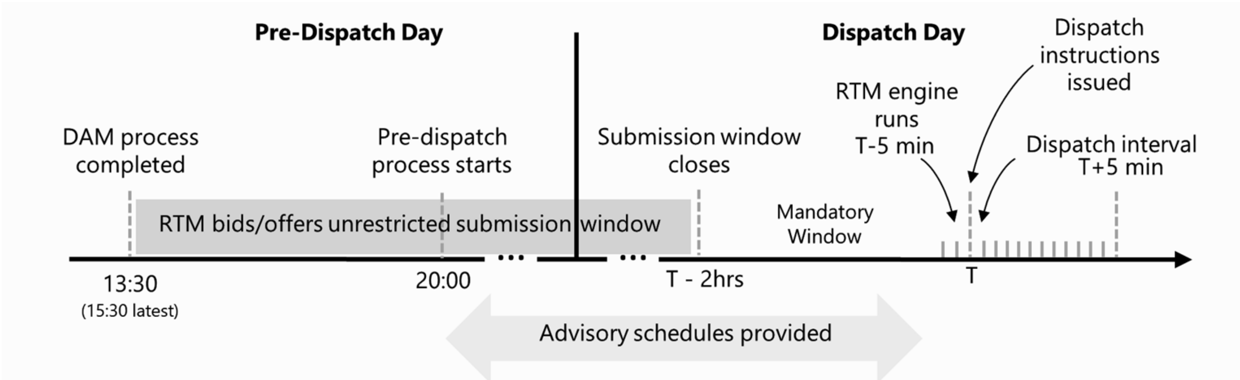
19 Eastern Standard Time (EST) in Ontario remains UTC-5 year-round and does not change for daylight savings. Eastern Prevailing Time (EPT) may be eastern standard or eastern daylight time, depending on the time of year in Ontario.

20 In the post-MRP wholesale market, standing bids/offers will be common to the DAM and RTM. Standing bids/offers remain in effect until changed, withdrawn, or reach a participant-specified expiry date. DER/A participants can submit or revise daily and hourly bids/offers until the DAM submission window (refer to Figure 1) closes. They can also submit or revise hourly bids/offers until the RTM unrestricted submission window (refer to Figure 2) closes.

21 For more details on ADE, please see section 7.5 in Market Manual 4.1 - Submitting Dispatch Data in the Physical Markets.

22 Dispatchable load and storage DER/A with bid/offer changes in the RTM that meet certain materiality thresholds and other conditions may be required to seek approval to change their bids/offers within the Mandatory Window. Currently, the threshold for this requirement is the greater of 2% of the DER/A resource or 10 MW.

Figure 2 | Relevant IESO Real-Time Market Timelines in EST



A pre-dispatch process runs hourly, projecting prices and instructions for the upcoming hours. The results also determine advisory schedules, intertie schedules, and non-quick start generator resource commitments. The RTM process takes place for each five-minute interval of the day, 24 hours a day, 365 days a year, determining prices and instructions for the next five-minute dispatch interval. The IESO sends instructions at the start of the next interval, indicating the operating point that needs to be reached by the end of the interval. Upon receiving a dispatch instruction from the IESO, the DER/A participant must confirm within 60 seconds whether it will accept or reject the instruction[23]. Additionally, when dispatch instructions for an interval are issued, dispatch advisories are also provided for the following 10 intervals.

One of the major challenges to real-time coordination among DER/A, DSOs, and the IESO lies in the rapid pace of the RTM processes, where communication latency or delays in execution may impact reliability.

2.3.2 DERs Limits and Distribution Service

This report defines a minimal set of features associated with DER/A offering distribution services, focusing primarily on timing considerations. These features give DSOs, DER/A participants, policymakers, regulators, and other relevant stakeholders the flexibility to shape the design of the distribution services. The timing features introduced in this section of the report are intended to enable 'sequential' coordination with the IESO's post-MRP processes, a concept that will also be discussed in more detail in later sections. The sequential approach involves DSOs first considering DER/A for meeting distribution system needs before the DER/A are bid/offered into the wholesale market and considered for services by the IESO. This ensures the wholesale market processes use the best available and most complete information about the expected DER/A operation.

23 For more details, please see Table 5-1 in Market Manual 4.3 - Operation of the Real-Time Markets.

The DER/A Resource Plan

The distribution service processes, detailed in Figure 3 and Figure 4 below for day-ahead and real-time timelines respectively, are initiated with DER/A participants submitting a DER/A resource plan to the DSO. The exact contents of the resource plan can be established when the distribution services are more clearly designed and defined. The information required in the resource plan will also vary depending on the specific DSO model under consideration.

The resource plan is expected to provide DSOs with data to:

- Assess and determine operating limits[24] for DERs
- Determine instructions for distribution services
- Formulate wholesale market bids/offers, as applicable

The data provided by the DER/A participants in the resource plan may include:

- Capacity/availability of DER/A for distribution and/or wholesale services
- For aggregators, the specific DER contributors planned to operate
- Pricing information for providing distribution services
- Pricing information for wholesale market bids/offers

The scope of information within the resource plan can be flexible, allowing for adjustments over time. When introduced, the data requested about the DER/A in the resource plan can be targeted and limited but then expand as requirements evolve.

DSO Operational Timelines

Figure 3 and Figure 4 show the relevant timelines considering both DSO and IESO processes in day-ahead and real-time timeframes. For the distribution and wholesale level services to be 'stackable', the DSO must strategically perform key DER/A-related processes in advance of the IESO's DAM and RTM processes.

First, DER/A participants are required to submit their resource plans to the DSO by a specified deadline. Following this submission, the DSO conducts assessments to determine operating limits on DERs when necessary[25] and to determine distribution service instructions, releasing this information to the DER/A participants by a defined timeframe. These activities need to be completed sufficiently in advance of the deadlines in the DAM and RTM, allowing for the preparation and submission of bids/offers to the IESO. Depending on the DSO model, either the DER/A participants or the DSO may be responsible for submitting the bids/offers. Note that the deadlines for the DER/A participants to

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24 As described further in following sections, operating limits refer to the maximum output at which DERs can operate without exceeding system constraints. These limits reflect both the physical capabilities of the DERs and the operational constraints imposed by the DSO to ensure distribution system reliability.

25 This approach would need to align with connection agreements to enable the DSO to dynamically set operating limits for DERs based on current network configurations and loading conditions.

submit their resource plans and for the DSO to issue DER limits and distribution service schedules are not defined in Figure 3 and Figure 4. Standardizing these processes and deadlines across the province would help streamline DER/A participation.

Figure 3 | Relevant Day-Ahead DSO and IESO Timelines

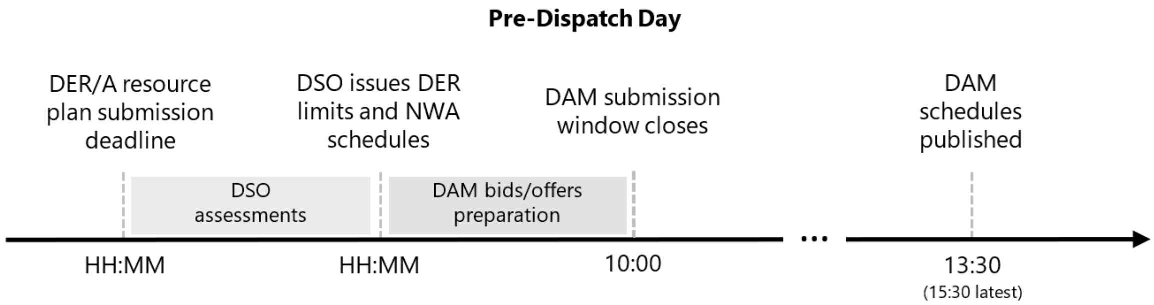
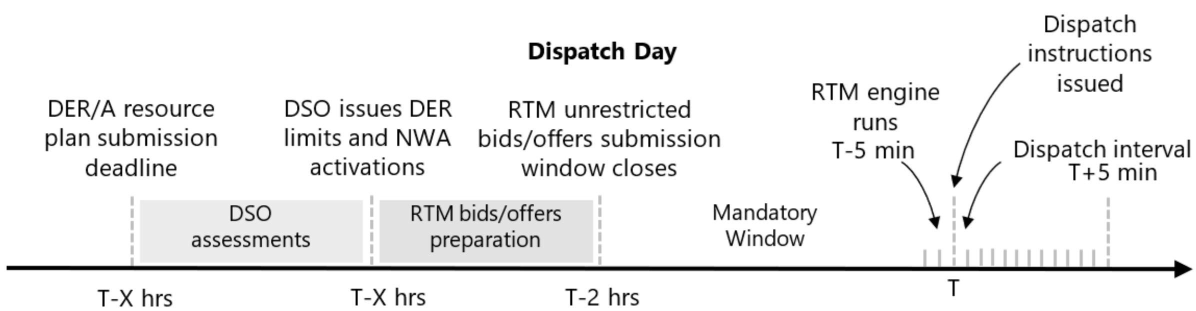


Figure 4 | Relevant Real-Time DSO and IESO Timelines



3. DSO Models for Market Participation

This report addresses three specific DSO models: (1) the Dual Participation DSO (DP-DSO) model, (2) the Total DSO (T-DSO) model, and (3) the Market Facilitator DSO (MF-DSO) model[26]. These models are particularly relevant when DER/A participate in the wholesale market, as they define the frameworks for how coordination among DER/A participants, DSOs, and the IESO is managed. Each DSO model involves different coordination processes across the parties, which will be detailed in later sections[27]. Additionally, these models represent different commercial relationships among the parties and may provide varying degrees of flexibility for DSOs in managing DER/A participation.

Dual Participation DSO Model

In the DP-DSO model, the DER/A directly participate in the IESO's wholesale energy market and directly provide distribution services to the DSO, with T-D coordination among the DER/A, DSO, and IESO to facilitate service stacking. With the DER/A directly participating in the wholesale market, the IESO clears the market and dispatches the DER/A participants directly. The IESO models participating DER/A in its systems and processes as though they are connected at the T-D interface[28].

The DP-DSO model is generally consistent with today's roles and responsibilities for DER/A participants, distributors, and the IESO, making it easier to implement in the near term from this perspective compared to the other DSO models. However, the model involves the DER/A participant managing two interfaces for providing grid services - one with the DSO and one with the IESO - and taking on several tasks to facilitate the coordination among the parties. This approach of managing two interfaces may make service stacking more operationally and administratively challenging for DER/A participants. The complexity may represent a barrier to market participation and may limit the full value of DER/A from being realized. However, the Shared Platform concept, which is the topic of one of the other TDWG Deliverables, has potential to mitigate some of these communication barriers and enable the DP-DSO model in a more streamlined manner[29].

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26 The descriptions of the three models presented in this section of the report align with the definitions outlined in the revised draft definition document prepared with input from the TDWG in May 2024.

27 For a deeper examination of the functions and processes internal to DSOs under the three different DSO models, see Deliverable B1 – Functional Assessment.

28 T-D interface can refer to both the physical and conceptual junctions where the IESO-controlled grid (ICG) meets the distribution systems. Physically, the T-D interface represents the specific locations where transmission and distribution systems interconnect. Conceptually, it represents the operational and administrative boundary where the responsibilities for system management transition among entities. T-D coordination effectively takes place across the T-D interface, underscoring its importance as the focal point for aligning transmission and distribution activities. Specifically, ICG means the transmission facilities with respect to which, pursuant to operating agreements, the IESO has authority to direct operations. Transmission facilities are all lines, structures, equipment, auxiliary equipment, and facilities operated at greater than 50 kilovolts (kV) and facilities operated at less than 50 kV at the step-down transformer stations down to the load side of the feeder breaker. Operating agreements may have additional exclusions from or inclusions in the definition of ICG.

29 If a comprehensive "Shared Platform" is implemented to support service stacking and facilitate T-D coordination, the primary distinction between the DSO models would be commercial responsibility, as many operational differences would no longer be relevant.

Total DSO Model

The Total DSO model represents a possible approach where the DSO manages all wholesale market services provided by DER/A and eliminates the need for their direct participation in the wholesale market[30]. The DSO also manages all distribution-level services provided by DER/A. The DER/A participants have a single interface - with the DSO - for everything related to all grid services, which simplifies their participation. The DSO operates as the exclusive market participant in the wholesale market within its service territory and is subject to wholesale market rules. It assumes all obligations of a market participant with resources, including commercial responsibilities related to the performance of the DER/A that it represents.

The DSO submits a consolidated wholesale market bid/offer that reflects the combined bids and offers of the participating DER/A downstream of a T-D node (or multiple nodes, if permitted) in the DSO's service territory[31]. In submitting the consolidated bid/offer, the DSO also reflects any potential operational limits on DERs due to distribution reliability. The DSO receives wholesale market schedules and dispatches that result from the wholesale market clearing. It subsequently issues granular instructions to the DER/A.

From the IESO's perspective, interfacing with fewer T-DSO market participants may be more streamlined and manageable than interfacing with numerous individual DER/A participants. The T-DSO model may facilitate the bundling, optimizing, and streamlining of distribution and wholesale services, potentially enabling greater DER/A participation in grid services. However, adopting the T-DSO would pose new commercial risks for the DSO and involve new potential incentive mechanisms, adding complexity to its implementation.

Market Facilitator DSO Model

In the MF-DSO model, the DSO facilitates all operational aspects of wholesale market services provided by DER/A. However, the DER/A participants continue to be market participants in the wholesale market; they are directly subject to the IESO's market rules and would individually settle directly with the IESO. Unlike in the T-DSO model, the DSO does not assume commercial responsibilities for DER performance in the RTM and DAM[32]. The DSO also manages all distribution level services provided by DER/A.

Some features of the MF-DSO model resemble the T-DSO model and others resemble the DP-DSO model. Similar to the T-DSO model, the MF-DSO model streamlines the operational aspect of DER/A participation in grid services, as the DER/A participants submits wholesale market bids/offers and distribution service information to the DSO and only needs to manage this one interface. This means DER/A participants send their information and receive instructions via the MF-DSO, which then relays

30 This report considers a specific T-DSO model where the DSO only manages the participation of DER/A in the wholesale market, as opposed to managing the net exchange at the T-D interface, which would involve a type of balancing of DER/A and load at the distribution level.

31 The consolidated bid/offer is envisioned to encompass multiple price-quantity (PQ) pairs, reflecting the diverse availability and prices of the DER/A it represents.

32 While the MF-DSO model does not assign commercial obligations to the DSO, it does impose new operational responsibilities as the facilitator of information flows among the IESO, DER/A participants, and other DSOs. For example, if the DSO's systems fail or become unavailable, it could disrupt the entire coordination process and impact all parties.

the DER/A information into the wholesale market, simplifying communication and processes for the participants. However, DER/A participants continue to interface directly with the IESO regarding other aspects wholesale market participation, such as meeting performance obligations, managing settlements, and adhering to other market rules.

Similar to the DP-DSO model, the IESO would model each participating DER/A in its systems at the T-D interface under the MF-DSO model (as opposed to a consolidated resource and bids/offers at the T-D interface under the T-DSO model).

4. Pre-Operations Coordination

Reliable operation of power systems with significant DER penetration requires detailed computer modelling of DERs by system operators. This modelling, which could include steady state and dynamic models, as well as forecasting models, assesses both individual and aggregated effects of DERs on the system. Adequate data collection is needed to ensure that DERs are appropriately accounted for and represented in these models and the assessments that use them. The models are not only employed for real-time operations but also form a part of planning and connection assessment processes. Both DSOs and the IESO need to capture DERs in their respective system models, though their needs and modelling approaches may differ. Detailed data on DERs, including technology type, capacity, location, and operational characteristics such as ride-through settings[33], and ramp rates are essential.

From an IESO perspective, DERs need to be modelled in sufficient detail at the transmission-distribution interface to effectively assess their aggregated response to grid events and their impact on Bulk Power System (BPS) voltage, frequency, and overall security[34]. Similarly, from a DSO perspective, DER/A need to be modelled with sufficient detail to evaluate their individual and aggregated impacts on distribution system reliability, power quality, voltage control, and thermal loading of equipment. This detailed modelling supports the safe and reliable operation of DER/A and facilitates their effective integration into electricity system and market operations.

Accurate forecasting models for DER output are essential for both long-term system planning and short-term operations of the power system. These models heavily rely on historical data, in addition to relevant information about existing and planned DERs, such as previously noted technology type, location, and capacity data. Generally, data shared among parties may need to include historical meter data, parameters for predictive models, and data on past participation in grid services. Forecasting models also employ telemetry data from DER/A and from across the power system[35]. Importantly, forecast models must accurately predict the output of renewable DERs based on varying weather conditions. Data on DERs are collected as part of long-term planning, connection assessment, and market, service, or program registration processes.

At present, the data that is shared with the IESO is based on certain thresholds and other criteria of these planning, connection, and registration processes. For example, for DERs that are larger than 10 MW, distributors initiate the connection assessment processes with IESO and the transmitter, where detailed data is shared. Data is collected on DER/A participating in the IESO's wholesale market, for

33 During the connection process, collaboration among IESO, distributor, and DER providers may be necessary to set certain settings for DERs, such as for under-voltage ride-through, to align with both distribution and bulk system requirements.

34 Security refers to the ability of the bulk power system to withstand sudden disturbances, such as electric short circuits or the unanticipated loss of system elements from credible contingencies, while avoiding uncontrolled cascading blackouts or damage to equipment.

35 Deliverable B2 – Communication Assessment addresses the coordination of telemetry among the IESO, DSOs, and DER/A. The IESO's Enabling Resources Program is expected to address telemetry requirements for wholesale market participation of DER/A.

which the current eligibility threshold is 1 MW. Additionally, data on DERs is collected and shared as part of regional planning processes that follow a minimum five-year cycle.

At present, distributors collect data that can be used for modelling purposes primarily through connection impact assessments (CIA), distribution system planning processes, and DER registration and monitoring activities as part of distributor programs. Additionally, distributors can use advanced metering infrastructure (AMI) data to identify behind-the-meter (BTM) DERs by analyzing consumption patterns and voltage profiles from smart meters. The data shared must be updated regularly to accurately reflect any changes in the distribution system and DERs. This ensures that the models used at both the distribution and transmission system levels are based on the most current information.

Requirements and processes for data sharing are being refined and updated. As a notable example, NERC is reviewing reliability standards to ensure their applicability and effectiveness to remain relevant with increasing levels of DERs across North America[36]. NERC seeks to address improved aggregated and/or equivalent modelling of DERs as well as data requirements and reporting procedures for accurate model development. In addition, in a recent Letter of Direction to the OEB, the Minister called for improving collection and sharing of DER data where it has clear benefits[37]. It is important to continue to enhance the data collection and modelling of DERs to ensure they are sufficiently accurate for real-time operations and reliability[38].

36 The planning and operation of the Bulk Electric System (BES) must follow the reliability standards and criteria set forth by the North American Electric Reliability Corporation (NERC). These standards are designed to meet the reliability needs of the interconnected electric system. Traditionally, NERC standards have not been applied to the components of the distribution system unless they have direct impact on BES reliability. However, the evolving landscape of DER integration necessitates adjustments to current NERC standards.

37 For a copy of the Letter of Direction from the Minister to the OEB, please visit the OEB's webpage.

38 For more information, please refer to the TDWG presentation on T-D Coordination to Support Reliable Performance of BPS with DER Integration.

5. Key Features of Operational Coordination

This section discusses the key features of the operational coordination protocols that will be detailed in the next section of the report. Specifically, four coordination strategies will be discussed here:

1. DSO overrides of DER/A dispatch instructions, which allow DSOs to curtail the output of DERs to ensure safe and reliable operation of the distribution system.
2. Sequential coordination of stacked grid services, which envisions DER/A being considered for distribution services first and then for wholesale market services.
3. Ongoing DSO limits on DER operation, which enable DSOs to establish advance operational limits on DERs to maintain distribution system reliability.
4. Floor price bids/offers for distribution services, which propose that DERs providing stacked services use floor prices in their bids/offers to the wholesale market when providing distribution services.

Each strategy plays an important role in ensuring the protocols are practical, support coordination, and enhance system reliability.

5.1 DSO Override of DER/A Dispatch Instruction

The coordination protocols outlined in this report are intended to enhance reliability and DER/A participation in grid services. The protocols for all three DSO models include a process for DSOs to identify anticipated impacts of DERs operating within established limits (described below), and to override the IESO's dispatch of DER/A as soon as needed. The override process gives DSOs the ability to limit or curtail DER/A response to IESO dispatch instructions when needed to maintain safe and reliable distribution system operation.

When a DSO identifies an outage on the distribution system or other unexpected conditions under which DER operation would pose safety and reliability risks, it can initiate the override process and update the operational limits on the DERs. This action is responsive to changing grid conditions and is not limited to specific timeframes, as it is executed promptly after such conditions are identified. Depending on the DSO model, the process may result in an outage notification about the affected DER/A to the IESO. The process also involves updating the availability and bids/offers associated with the DER/A for inclusion in upcoming market processes. However, the three different DSO models have different lines of communication among the parties, which may affect the speed with which the override process takes place (i.e., latency).

5.2 Sequential Coordination of Stacked Grid Services

For DER/A that provide both distribution and wholesale energy services, the coordination protocols presented in this report utilize a sequential process. It is envisioned that for the scheduling, activation, and dispatch[39], DERs are first considered for distribution system needs by the DSO, and subsequently considered for wholesale market services by the IESO. This ensures the wholesale market processes incorporate the most accurate and complete information about expected DER/A operation.

The sequential coordination is critical because the wholesale market processes are not designed for iterative adjustments. Specifically, they do not accommodate changes based on DSO instructions to DER/A after the bid/offer submission windows associated with the wholesale DAM and RTM processes close[40]. Furthermore, as the RTM process provides five-minute instructions to market participants, it does not leave sufficient time for DSOs to subsequently provide instructions to DER/A. The sequential coordination strategy for grid services proposed in this report is logically structured, facilitating an initial focus on local needs by prioritizing DER/A solutions where options may be limited. Following this, the DER/A are considered for addressing more system-wide needs, alongside other DER/A and transmission-connected resources.

5.3 Ongoing DSO Limits on DERs Operation

A key aspect of the coordination protocols detailed in this report is ensuring that the best available information is used when DER/A participate in the IESO's DAM and RTM processes. This includes any de-rating or operational limits - restrictions on the amount of output a DER can provide - due to current or expected distribution system conditions or outages. Each of the three DSO models addressed in this report includes a process for the DSO to set ongoing operational limits on DERs, which impacts their availability to provide both distribution and wholesale services[41]. Operational limits set by DSOs primarily apply to DERs that inject power into the grid. Non-injecting, load-modifying DERs, which adjust load rather than inject energy, generally do not require the same type of operational limit setting. However, they can still impact system conditions and should be factored into overall system forecasting and demand management.

A particular challenge may arise when DSOs assess operational limits for contributor DERs within aggregations. Often, aggregations include multiple contributor DERs whose combined output may exceed what the aggregator plans to offer and operate for grid services. If the DSO considers the output of all contributor DERs when setting limits, it may overestimate the impact and potentially impose unnecessary limits. To address this challenge, DSOs may need visibility into which specific contributor DERs the aggregator plans to operate to provide grid services as well as 'reserve' contributor DERs that are available if the DERs planned for operation unexpectedly become

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39 The terminology in this report distinguishes between 'scheduling,' 'activation,' and 'dispatch.' 'Scheduling' refers to the schedules issued by the DSO or IESO in advance of the real-time timeframe (i.e., day-ahead). 'Activation' is used for DSO instructions for the DER/A to operate for distribution level services on the dispatch day. 'Dispatch' means the process by which the IESO directs the real-time operation of a resource.

40 It should be noted that DERs are ineligible to participate in the wholesale energy market when they are subject to very short notice instructions from a DSO for distribution services, such as local reserve in case of unexpected events.

41 Operational limits on DERs set by DSOs would be based on distribution system safety and reliability considerations and aligned with the terms of connection agreements, as well as other applicable codes and requirements. Moreover, in scenarios involving a host distributor and an embedded distributor, the embedded DSO must adhere to any constraints specified by the host distributor at the host-embedded interface when calculating operational limits for DERs. For instance, if there is a limit on the reverse power flow that can be injected into the host distribution system, the embedded DSO must set DER limits accordingly.

unavailable[42]. The DSO would use this information to effectively set limits and minimize unnecessary curtailment of DERs.

To facilitate this process, and to share other potential data that can support the DSO's assessment of the DER/A, the coordination protocols presented here contemplate DER/A providing a resource plan to the DSO. Based on the resource plan data, the DSO would conduct assessments to identify operating limits for DERs and to determine distribution service instructions. The resource plan can include different types of information and evolve over time. When first implementing T-D coordination protocols, the resource plan could be limited to DER/A that meet specific conditions, e.g., if contributor DERs involve flexible connection agreements[43].

5.4 Floor Price Bid/Offer for Distribution Services

The floor price concept outlined in this section applies specifically to DER/A that participate in both the wholesale market and provide services to the distribution system. A key aspect of the coordination protocols is to ensure the DSO and the IESO have visibility into each other's instructions to the DER/A to operate and provide grid services. The sequential process for grid services described above involves the DSO identifying its needs and selecting DER/A for distribution services in advance of the IESO's DAM and RTM processes. To provide the IESO with visibility into the DSO's distribution service schedules for DER/A in the day-ahead process and its activations in the real-time process, it is recommended that a floor price be used for bids/offers. By bidding/offering at this floor price (which could, for example, be zero or a negative value) the participants signal to the wholesale market their commitment to providing distribution services. This ensures that its distribution service instructions are captured in the IESO's wholesale market processes. The bids/offers submitted to the wholesale market would reflect this floor price for a DER/A, or a portion thereof, when providing services at the distribution level. DER/A output that is available beyond what the DER/A is providing for distribution services would be bid/offered at prices set by the DER/A participant, indicating additional availability to provide wholesale energy services[44]. The floor price approach will ensure that the IESO's DAM schedules and RTM dispatches align with DSOs' instructions for distribution services, preventing conflicting instructions[45].

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42 This report assumes that DSOs assess and approve the contributor DERs that an aggregator plans to use but does not approve 'reserve' contributor DERs unless a 'Resource Plan Change Request' is made, as discussed further in the next section of the report. However, an alternative approach could involve DSOs pre-approving a defined level of 'reserve' contributor DERs to be used by the DER/A participants as needed. In this case, if reserve contributor DERs are approved, they will likely occupy a portion of the distribution network's capacity, limiting capacity available for other DERs to operate. It is important that the specifics of these processes are investigated and defined, particularly for managing contributor and reserve DERs, to avoid capacity conflicts. However, these details do not change the major concepts in this report, such as the need for a resource plan and a resource plan change request when necessary.

43 Flexible connection agreements are contractual arrangements between a DSO and a DER/A participant that allow the DSO to set or adjust operational limits (e.g., maximum active/reactive power) either in advance or in real time to ensure safe, reliable performance under varying distribution conditions.

44 Assuming a floor price of $0/MWh, consider a 3 MW DER/A where 2 MW is selected for distribution services. The 2 MW would be offered at $0/MWh to prioritize distribution needs, while the remaining 1 MW would be offered at a higher price set by the participant to reflect the availability of the DER/A to the wholesale energy market.

45 An alternative would be to use a code or a tag to indicate that a portion of the bid/offer has been selected by the DSO. In fact, the two approaches can be combined, such that a floor price bid/offer is submitted with a code. The code could for instance represent what specific distribution service the DER/A has been selected for.

6. Coordination Protocols

The protocols outlined in this section detail the actions to be taken and data to be exchanged among the parties, with a focus on ensuring effective and reliable system operation as DER/A:

- participate in the IESO's wholesale energy market (i.e., DAM and RTM), and
- may provide energy services to the distribution system as scheduled and activated by a DSO[46].

To comprehensively address coordination among the DER/A participants, DSOs, and the IESO, , the four cases listed in Figure 5 must be considered.

Figure 5 | Four DER service cases

1. DERs that are **not participating** in any services	2. DER/A providing **distribution services**	3. DER/A providing **wholesale services**	4. DER/A providing **both** wholesale and distribution **services**

Subsection 6.1 - DSO Services Only or No Services will address cases 1 and 2. Subsection 6.2 - Wholesale and Stacked Services will cover cases 3 and 4 across the three DSO models.

6.1 DSO Services Only or No Services

This section focuses on the cases where DERs are either: a) engaged solely in providing services to the DSO, or b) not actively participating in any services. In these instances, the DSO is anticipated to have access to the data it needs, as the DERs directly interface with and operates within the distribution system. To enable the IESO to maintain an acceptable level of situational awareness, even for DERs that are not registered with the IESO and do not participate in the wholesale market, the provision of certain information and actions at the distribution system level is necessary. This awareness is achieved through modelling of DERs, notices communicated between the IESO and DSOs, and telemetry from DERs and from across the system. The requirements described in this section are applicable under all three DSO models under consideration[47].

As discussed in Section 4 – Pre-Operation Coordination, the IESO employs load flow models, dynamic models, and forecasting models as part of operational processes. These models must adequately represent DERs, including those not registered with the IESO, to support reliable market and system

46 For in-depth information on the internal functions and processes DSOs would undertake aligned with the T-D coordination protocols outlined in this report, see Deliverable B1 – Functional Assessment.

47 The specific DSO models are not directly relevant as they pertain more to DER/A participation in the wholesale market. The upcoming section on 'Wholesale and Stacked Services' will delve into how the DSO models apply specifically to scenarios where DER/A participate in the wholesale energy market.

operations. It is important to continue to improve the pre-operations coordination and share data ahead of time in order to support operations. Going forward, new processes for sharing data on DER enrollment in distribution-level programs or markets are expected to be needed. Similarly, it is anticipated that the IESO will need to share DER/A registration in IESO wholesale market services.

Notices communicated between the IESO and DSOs support operational coordination of DER/A engaged solely in providing services to the DSO or not participating in any services. The requirements for these notices are outlined in the Market Rules and Market Manuals[48]. Two types of notices are particularly relevant: notices related to outage management and notices related to demand management actions.

1. Outage Management: Distributors must report outages to the IESO in accordance with Market Rules Chapter 5 - Power System Reliability, Section 3.7 Obligations of Distributors. The requirements for distributors include:

> "3.7.1.2 promptly informing the IESO of any change or anticipated change in the capability of its equipment or distribution facilities connected to the IESO-controlled grid that could have a material effect on the reliable operation of the IESO-controlled grid or the operation of the IESO-administered markets;
>
> 3.7.1.3 promptly informing the IESO of any event or circumstance in its service territory that could have a material effect on the reliability of the IESO-controlled grid;"

Additionally, Market Manual 7.3 - Outage Management, Section 5.2.3 Distributors and Transmitters, clarified that:

> "... the outage reporting obligations under MR Ch.5 s.3.7.1 include distributors with embedded loads or generation that are not registered with the IESO."

In Market Manual 7.3 - Outage Management, Appendix A - Outage Reporting Requirements, it is noted that distributors and transmitters must report outages that:

> "Result in changes of more than 20 MW in demand or supply in an hour from what is typical for that hour."

Additionally, Market Rules Chapter 5 - Power System Reliability, Section 6.4.12 notes:

> "Each distributor shall, in reporting to the IESO pursuant to sections 6.2 and 6.3, identify to the IESO any outages that potentially constrain an embedded generator or an embedded electricity storage facility that is connected to its distribution system."

48 This documentation is posted on the Renewed Market Rules & Manuals Library webpage.

2. Demand Management Actions: Distributors must report demand management actions that they undertake, such as scheduling or activating DERs to operate, to the IESO by telephone. According to Market Rules Chapter 5 - Power System Reliability, Section 10.2 Demand Control Initiated by a Market Participant, the requirements are as follows:

It is important to note that the 10 AM EPT deadline noted in 10.2.4.1 aligns with when the IESO's DAM bid/offer submission window closes in the pre-dispatch day timeframe shown in Figure 1.

The Market Rules and Market Manuals provide further details, including the specific information that distributors need to provide to the IESO, further communication steps required, and example codes for submitting notices.

> "10.2.4 Each distributor or transmitter that intends to initiate a disconnection in load (including, but not limited to, interruptible loads and demand management activities) shall:
>
> 10.2.4.1 by 10:00 EPT each day, notify the IESO of all such planned disconnections in load and consequent reduction in loads for the following day;
>
> 10.2.4.2 immediately notify the IESO of a disconnection in load that is planned after 10:00 EPT for the following day;
>
> 10.2.4.3 the proposed date, time, and duration of the disconnection in load by connection point on the IESO-controlled grid, by hour;
>
> 10.2.4.4 the proposed reduction, in MWs, of loads by connection point on the IESO-controlled grid, by hour; and
>
> 10.2.4.5 details of the actual reduction in loads achieved, in MWs."

6.2 Wholesale and Stacked Services

This section focuses on the cases where DER/A are either:

- exclusively engaged in services provided to the wholesale market, or
- involved in the stacking of services at both the wholesale and distribution levels.

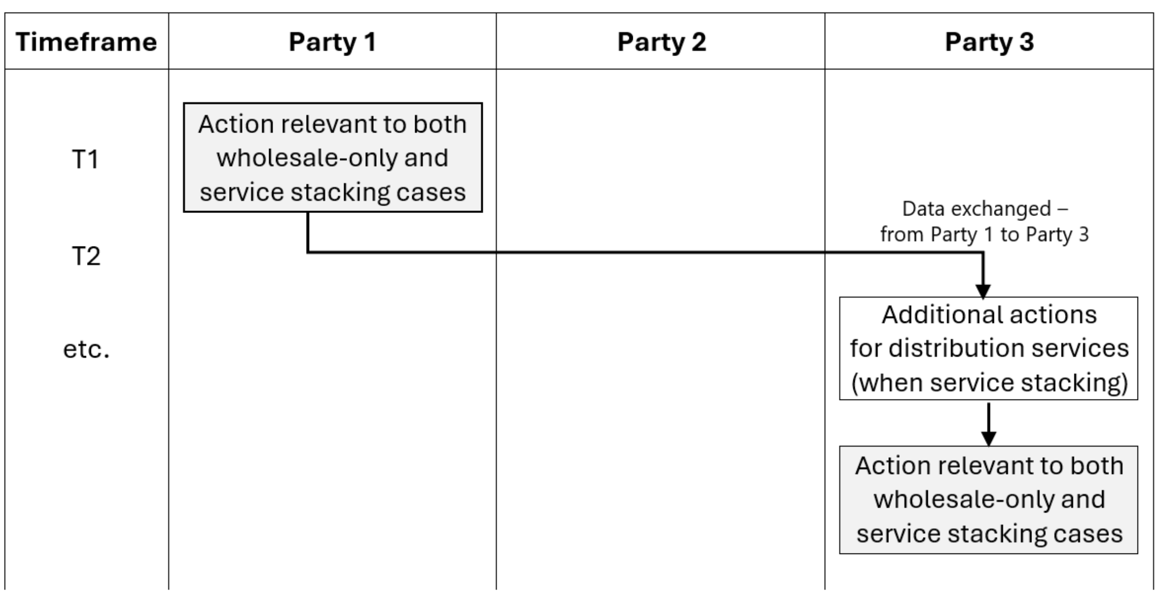
These DER/A would be registered in the wholesale market and may participate either individually or as part of an aggregation.

The upcoming subsections present the coordination protocols using swim lane diagrams to visually illustrate the processes and interactions. As shown in Figure 6, the swim lane diagrams follow this layout:

- Columns represent the coordinating parties involved.
- Rows indicate specific time periods for actions.
- Boxes show the actions that each party takes.
- Lines between boxes represent data exchanges.

The swim lanes depicted in this section cover both cases mentioned above: wholesale-only participation and stacking of services. Light grey boxes represent activities that are common to both wholesale-only participation and service stacking. White boxes indicate additional activities required for the service stacking case, where distribution services are also involved. When viewing the diagram, focusing only on the light grey boxes reflects the version of the protocols for wholesale-only participation. Including both the light grey and white boxes together provides the full version of the protocols for the service stacking case. Furthermore, the data exchange arrows in the diagrams indicate when the data is applicable to the provision of distribution services. Figure 6 provides an example of a swim lane diagram to illustrate this structure.

Figure 6 | General layout of swim lane diagrams that outline the protocols



The flowchart in Figure 7 below illustrates a general sequence of activities in the protocols that is common across all three DSO models under consideration in this report. The steps outlined in the flowchart are relevant to both the day-ahead and real-time market processes.

Note that two boxes in the diagram omit the specific entity responsible for the actions, because the responsible party varies depending on the DSO model. In the DP-DSO model, the action in the third box in Figure 7 is carried out by the DER/A participant; in the T-DSO model, it is carried out by the DSO; and in the MF-DSO model, it is carried out by the DER/A participant with facilitation from the DSO. Similarly, in the fifth box, the process varies by model: in the DP-DSO model, the DER/A receives instructions directly from the IESO; in the T-DSO model, the IESO dispatches the DSO, which then dispatches the DER/A with a degree of flexibility; and in the MF-DSO model, the DSO relays the IESO's dispatch instructions to the DER/A participant.

Figure 7 | General activities in the protocols for all three DSO models

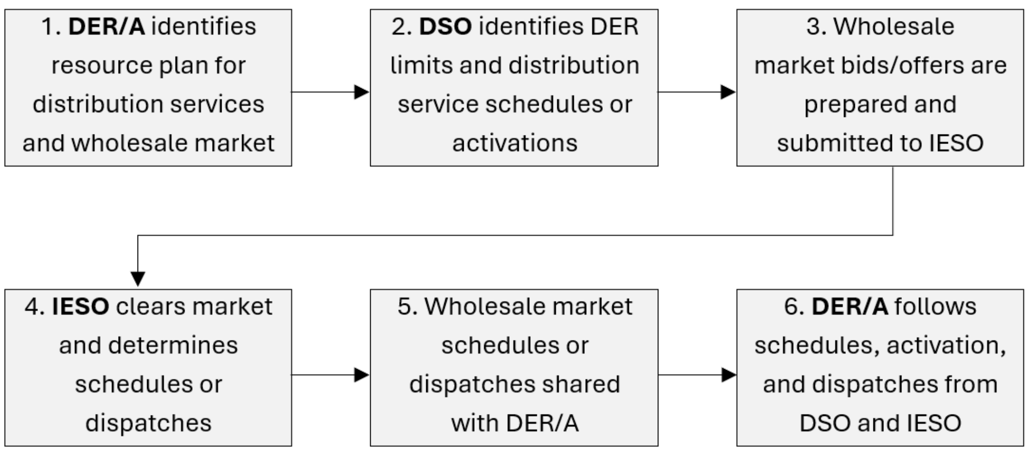


Figure 7 provides an overview of the primary steps for DAM and RTM processes, capturing operations under 'normal' conditions. It does not, however, include actions addressing abnormal conditions related to DER/A outages, DSO overrides, or changes to DER/A resource plans. These operational processes, broken down by each DSO model, will be outlined in the next subsections.

6.2.1 Dual Participation DSO

The following details the protocols for the DP-DSO model as part of five processes: (A) Day-Ahead Scheduling, (B) Real-Time Activation & Dispatch, (C) DER/A Outage Management, (D) Distribution System Override, and (E) DER/A Resource Plan Changes.

A. Day-Ahead Scheduling

Figure 8 outlines the timeframes, activities, and data exchanges in the day-ahead process for coordinating distribution services and wholesale energy services under the DP-DSO model[49].

Below are the key steps in this process:

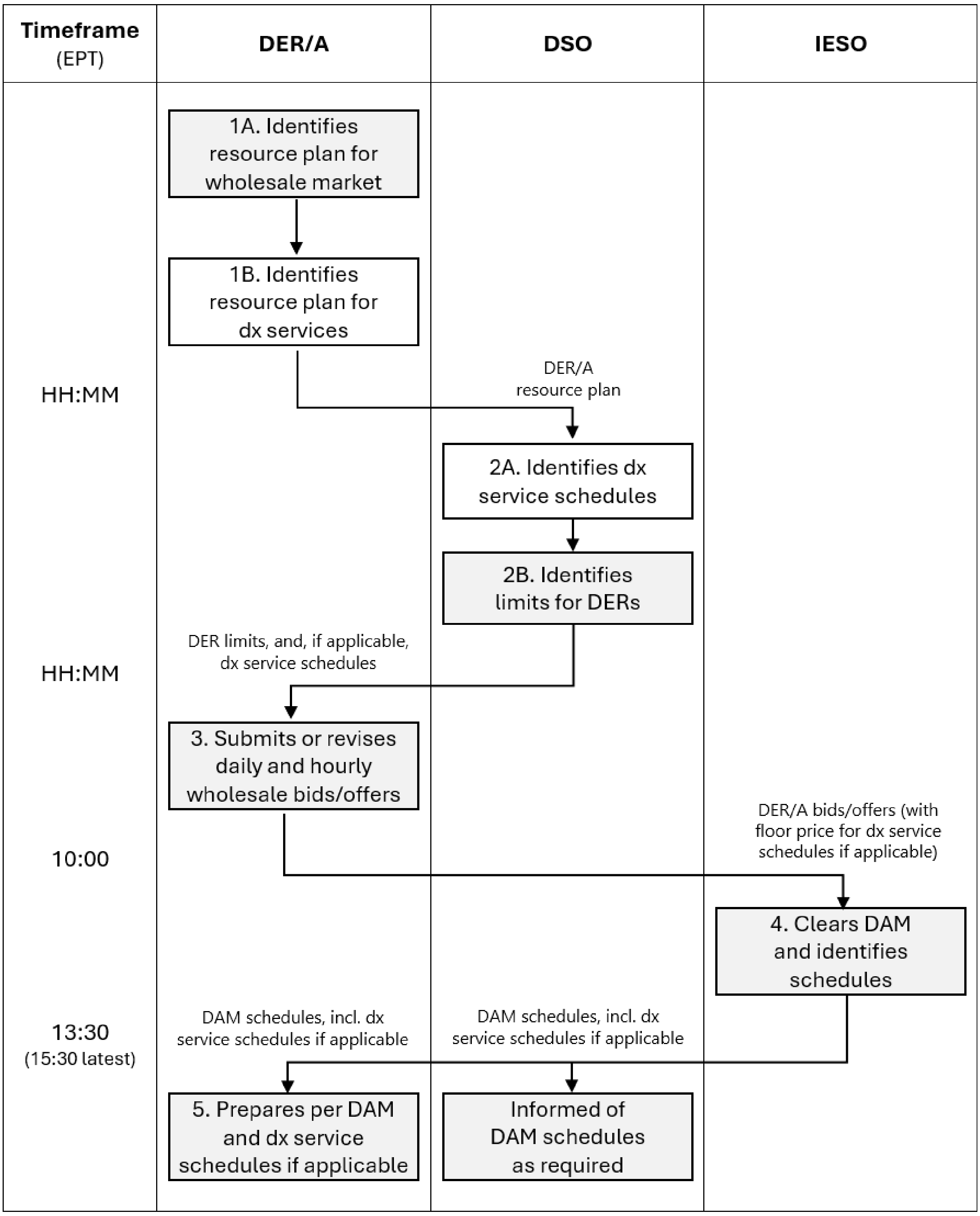
- In Step 1A, the DER/A participant identifies the wholesale market information in the resource plan, and in Step 1B, it identifies the information related to distribution (dx) services, if applicable.
- In Step 2A, the DSO uses the resource plan to identify distribution service schedules, if applicable, and in Step 2B, the DSO assesses and sets ongoing operational limits on DERs.
- In Step 3, the DER/A participant submits or revises bids/offers for the wholesale market based on any operational limits and distribution service schedules identified by the DSO.
    - The bids/offers in the wholesale market incorporate the floor price approach described in Section 5 to capture the distribution service schedules determined by the DSO.
    - This coordination allows the DAM schedules to include and reflect both wholesale and distribution level services, helping avoid conflicting instructions.
- In Step 4, the IESO clears the DAM, identifies day-ahead schedules, and sends the schedules to DER/A participants directly as well as the DSO.
- In Step 5, the final step of the day-ahead process, the DER/A prepares for operation based on the DAM schedules and distribution service schedules.

In the DP-DSO model, the DER/A participant separately manages an interface with the DSO and an interface with the IESO. The DER/A participant and DSO communicate about the resource plan, operational DER limits and distribution service schedules. The DER/A participant and IESO communicate about wholesale market bids/offers and DAM schedules.

After the day-ahead process, any changes to distribution or DER/A conditions can be managed through the real-time, DER/A outage, and DSO override processes detailed in subsequent sections.

[49] Market Manual 4.1 - Submission of Dispatch Data and Market Manual 4.2 - Operation of the Day Ahead Market are helpful references that outline detailed timing and requirements for submitting bids/offers and for DAM processes. This documentation is posted on the Renewed Market Rules & Manuals Library webpage.

Figure 8 | Protocol swim lanes for day-ahead process under DP-DSO model in EPT



B. Real-Time Activation & Dispatch

Figure 9 presents the real-time process for coordinating distribution services and wholesale market services[50]. Most of the considerations noted for the day-ahead process generally apply to the real-time process as well. For example, with the floor price approach, the wholesale market dispatch will also include activations for distribution service.

In Step 2A, if applicable, DSOs identify distribution service activations, which may differ from distribution service schedules in the day-ahead process. These activations may involve calling on the DER/A to provide additional or reduced energy.

In Step 2B of the real-time process, DSOs update operational limits on DERs, considering any changes in distribution system conditions or operational plans that have occurred since the day-ahead process. This step is intended for routine use, for example, for DERs connected under flexible connection agreements, allowing the DSO to set limits in advance of real-time as needed.

The limits identified in Step 2B are assumed to *not* represent a forced outage or trigger the override process - both of which are discussed in the following sections. Instead, these limits reflect standard operating constraints on DER output (for example, defined in a flexible connection agreement) to ensure reliable operation under known distribution conditions. However, if a DSO imposes a limit in real time because of an unplanned distribution event or an emergency condition, the forced outage or override protocols would apply. The precise distinction between a routine 'flexible connection limit' and an 'outage' or 'override' scenario warrants further investigation.

In both the day-ahead and real-time processes, it is proposed that DSOs are informed of wholesale market results directly by the IESO. Currently, the IESO and LDCs do not exchange information on wholesale market results for DER/A. The DP-DSO model could initially be implemented with a communication approach where the IESO provides wholesale schedules and dispatches directly to the DER/A participant, who would then relay this information to the DSO. However, given the importance of this information and the need for timely and robust communication, a process should be developed for direct IESO-DSO communication under the DP-DSO model[51].

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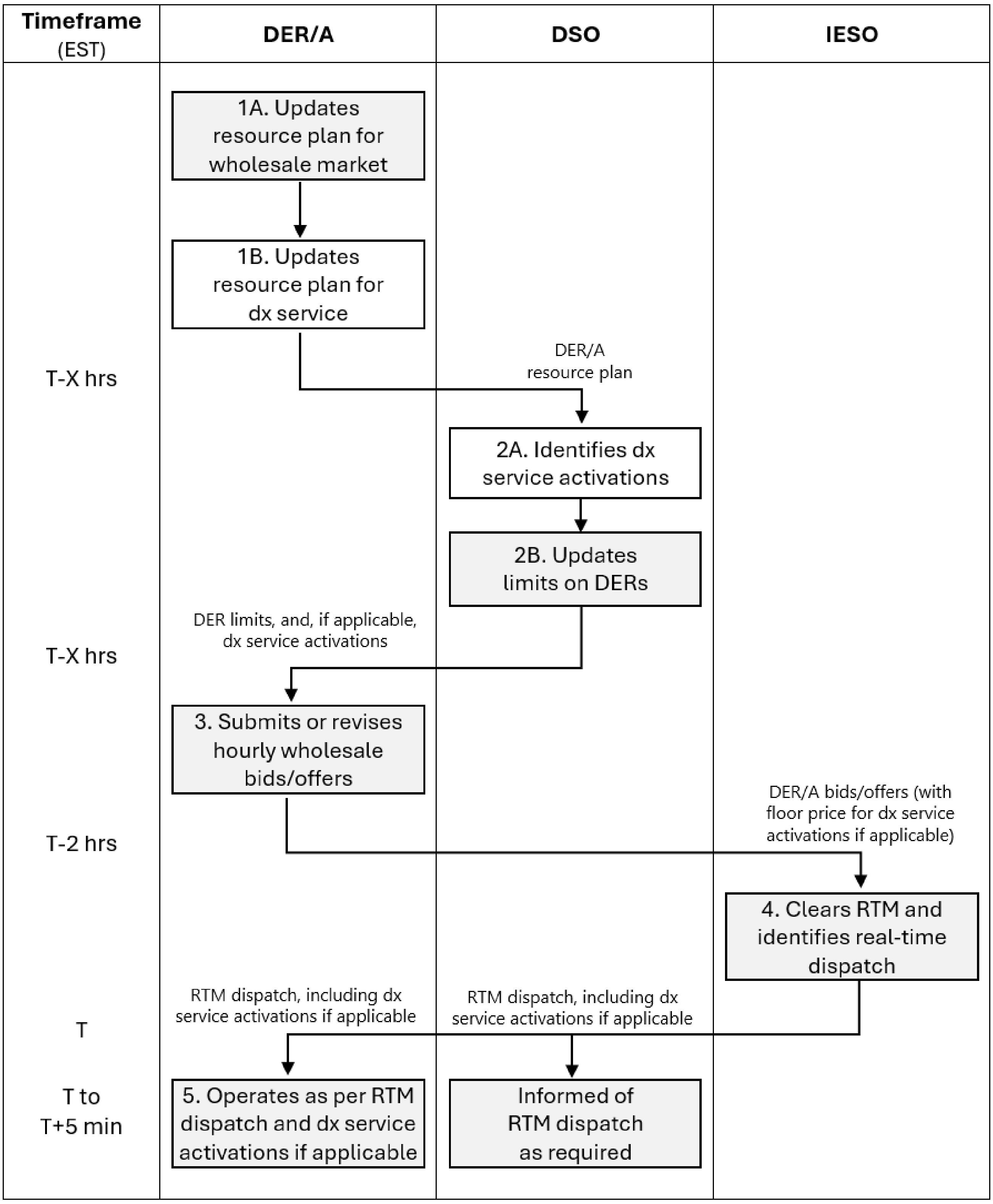
[50] Market Manual 4.1 - Submission of Dispatch Data and Market Manual 4.3 - Operation of the Real-Time Markets are helpful references that outline detailed timing and requirements for submitting bids/offers and for RTM processes. This documentation is posted on the Renewed Market Rules & Manuals Library webpage.

[51] To facilitate the exchange, several steps would be necessary, including: (a) market rule changes to enable DER/A participants' data to be shared with LDCs, (b) IESO IT solution installation to prepare and communicate the data, and (c) DSO IT solution deployment to receive, store, and make use of the data. Given that this represents a new data exchange and that interim approaches are available for the information to be shared, its rollout could be sequenced after the initial implementation of the DP-DSO model coordination.

Figure 9 | Protocol swim lanes for real-time process under DP-DSO model in EST

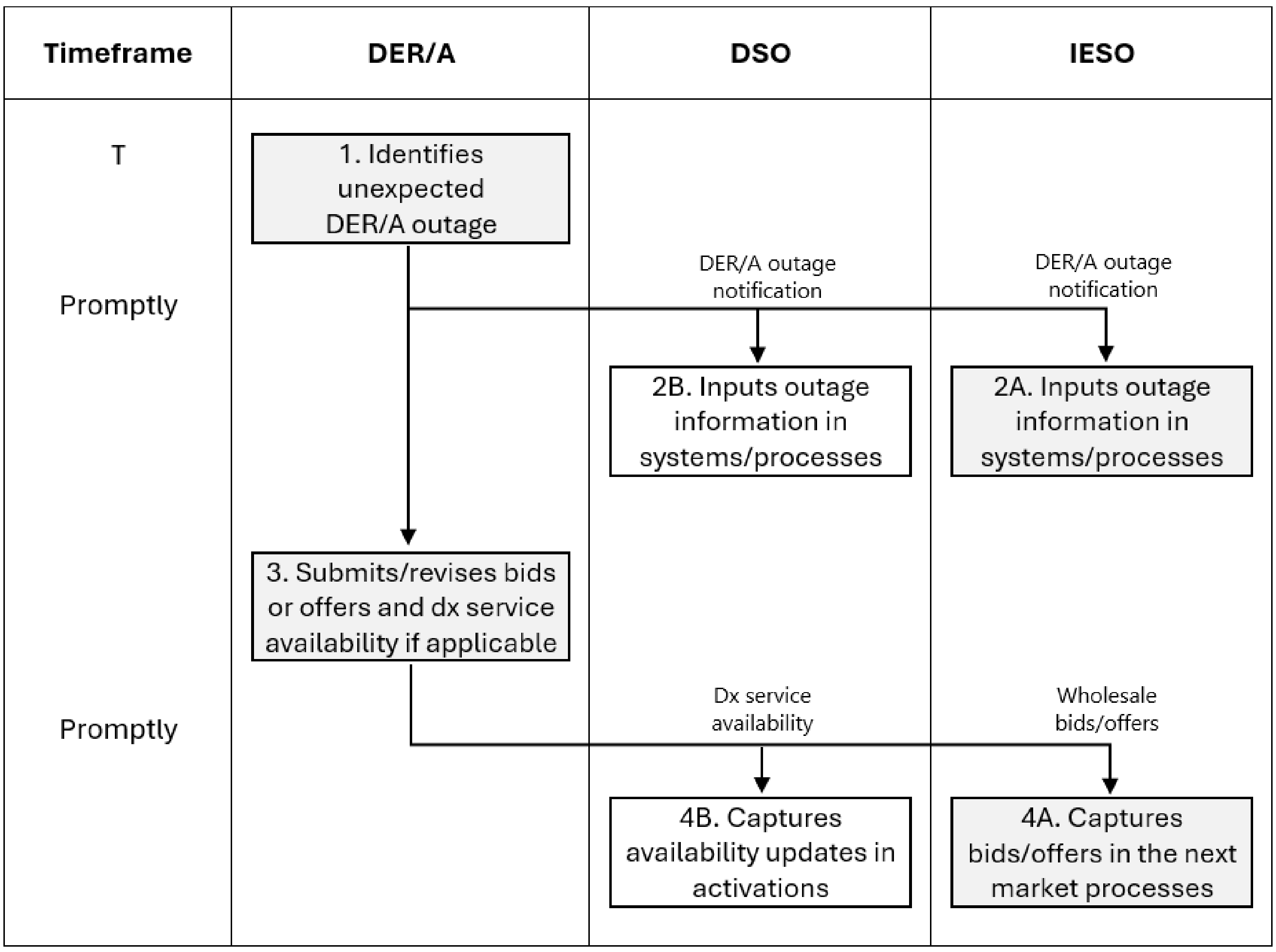


C. DER/A Outage Management

Figure 10 illustrates the process for handling forced outages to the DER/A, which could be a full or partial outage of the resource[52]. It consists of two main sub-processes: notification of outages and adjustments for market operations.

The outage notification part in Steps 2A and 2B communicates the status of DER/A that have already been selected for services or have crossed key deadlines in operational or market processes. This ensures that the availability of DER/A is promptly updated in the DSO's and IESO's systems, minimizing potential impacts to system reliability. Separately, in Step 3, the DER/A participant must also adjust distribution service availability and submit or revise wholesale market bids/offers, ensuring appropriate DER/A capacity is considered in forward-going processes.

Figure 10 | Protocol swim lanes for DER/A outages under DP-DSO model



[52] Market Manual 7.3 - Outage Management is a helpful reference that provides market participants with a summary of the steps and interfaces involved in the outage management process. This documentation is posted on the Renewed Market Rules & Manuals Library webpage.

D. Distribution System Override

Figure 11 details the override process for managing forced (i.e., unplanned) outages to the distribution system and unexpected distribution system conditions[53].

Below are the key steps in this process:

- In Step 1, the process begins upon detection of an unexpected system condition.
- In Step 2, the DSO captures these conditions in its systems and processes, and may identify new operational limits for the DERs.
    - Often, this may necessitate a DER to be fully shut down. However, there are instances where only a reduction in the output ('de-rate') in DER output is necessary.
    - As aggregations consist of individual contributor DERs, a distribution system outage affecting some of these DERs can lead to a partial outage of the aggregation.
    - Note that if a contributor DER within a DER/A is equipped with a protection mechanism, the distribution network will automatically disconnect the DER to safeguard the system.
    - At the end of Step 2, the DSO informs the DER/A participant of the expected duration of distribution conditions and the new operational limits for the DERs.
    - The DSO also notifies the IESO of the distribution outage in accordance with the distributor obligations specified in the IESO Market Rules[54].
- In Step 3, the DER/A operation is restricted due to the newly identified limits of its contributor DERs.
- In Step 4, if the distribution outage causes a material deviation in forecasted load at the T-D interface, the DSO notifies the IESO in accordance with the relevant reporting criteria in the IESO Market Rules and Manuals (including those highlighted in Section 6.1 of this report).
- In Step 5, the IESO is notified of the DER/A outage due to the distribution system outage by the DER/A participant, and this information is captured in the IESO's processes to adjust real-time market and system operations accordingly.
- In Step 6, the DER/A participant updates distribution service availability and submits or revises wholesale market bids/offers so that the appropriate DER/A capacity is considered in market processes in Steps 7 and 8.

While not depicted in Figure 11, it may be beneficial to have additional direct communication between the DSO and the IESO with respect to DSO override of DER/A participating in the wholesale market. This information would be in addition to the material forecast deviation information already required.

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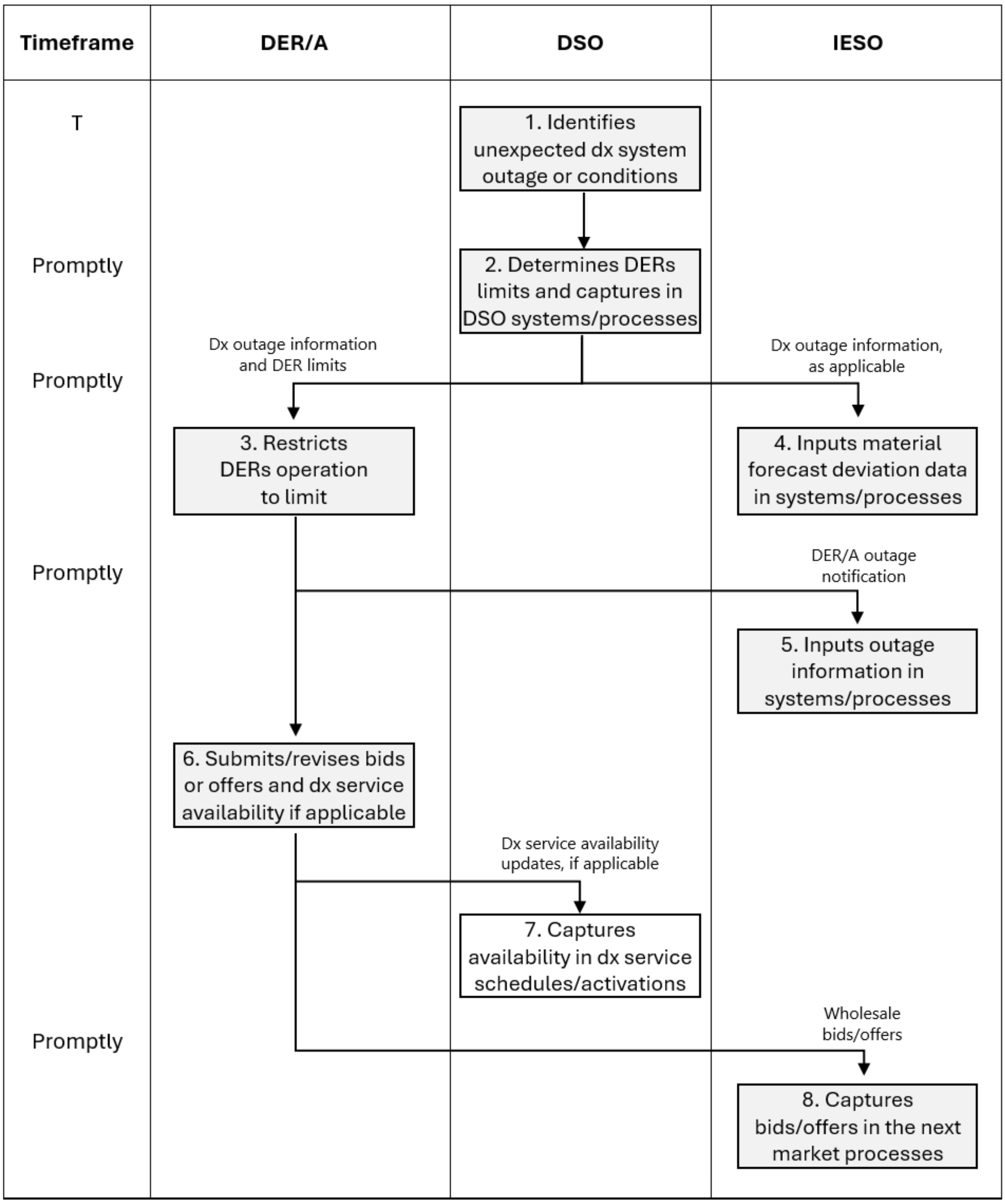
[53] Market Manual 7.3 - Outage Management is a helpful reference that provides market participants with a summary of the steps and interfaces involved in the outage management process. Of note, Market Rules Chapter 5 - Power System Reliability, section 6.4.12 describes "Each distributor shall, in reporting to the IESO pursuant to sections 6.2 and 6.3, identify to the IESO any outages that potentially constrain an embedded generator or an embedded electricity storage facility that is connected to its distribution system". This documentation is posted on the Renewed Market Rules & Manuals Library webpage.

[54] Specifically, Market Rules Chapter 5, section 6.4.12.

Figure 11 | Protocol swim lanes for distribution system override under DP-DSO model



E. DER/A Resource Plan Changes

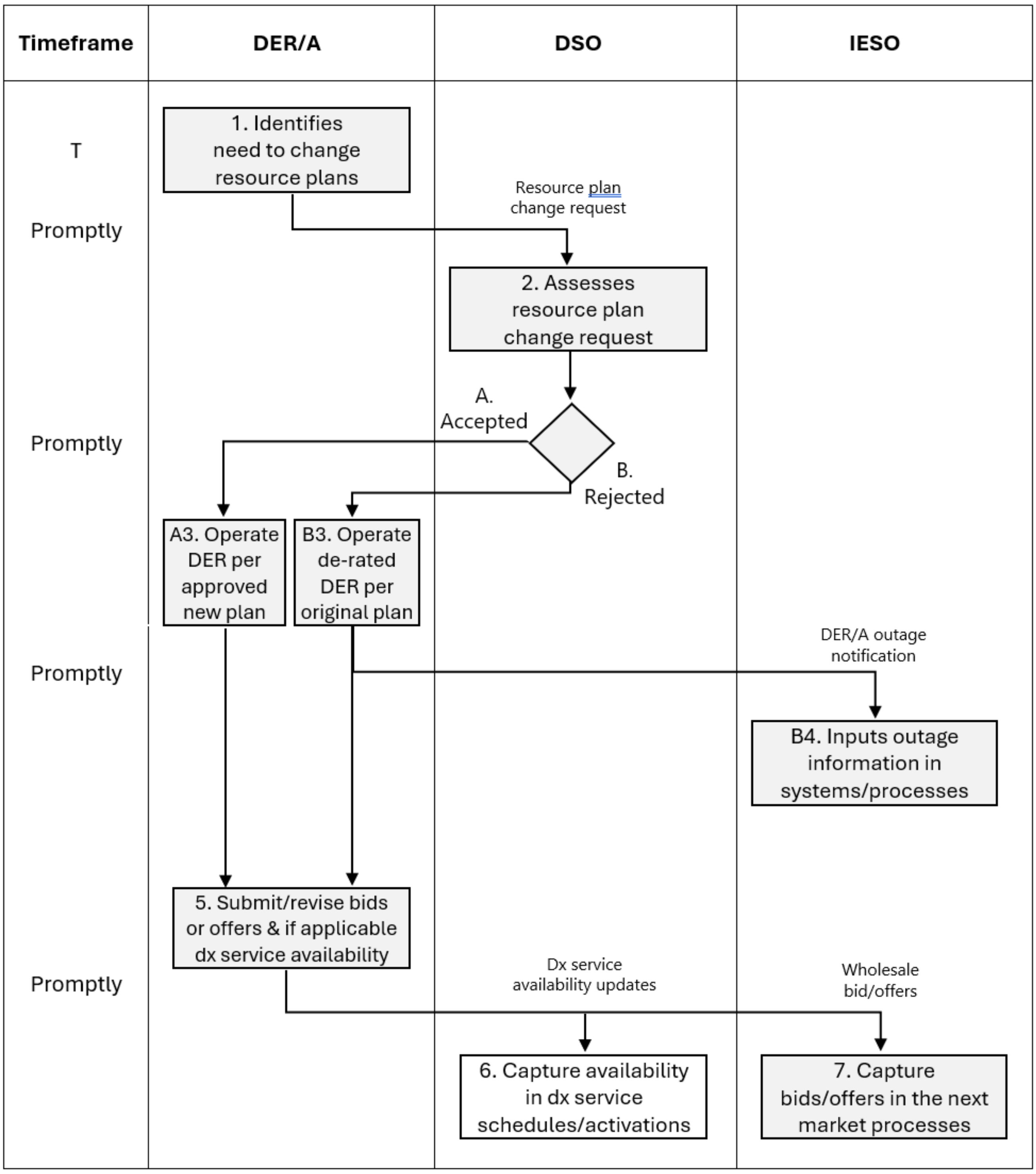
As described in section 2.3.2 DERs Limits and Distribution Service, the resource plan is envisioned as a potentially evolving tool to detail DER/A availability, the use of specific DER contributors, and pricing information for grid services.

In the resource plan information submitted to support wholesale market processes, DER/A participants may need to specify the specific DER contributors within the aggregations they intend to use for delivering grid services. The DER/A Resource Plan Changes process, presented in Figure 12 manages changes to a resource plan when a DER/A participant seeks to modify the composition of DER contributors in the aggregation that it plans to use. This process enables DER/A participants to adjust for specific DER contributors that are affected by DER outages or subject to DSO overrides.

Below are the key steps in this process:

- In Step 1, a DER/A participant identifies the need to change a previously approved resource plan and submits a request to the DSO to approve an updated plan.
- In Step 2, the DSO assesses the request and either accepts or rejects it.
- In Step A3 (i.e., Step 3, Path A), if the DSO can accommodate the request and reliably operate the distribution system with the modified contributor DERs, it would approve the request, allowing the DER/A to operate according to the new resource plan.
- In Step B3, if the DSO cannot accommodate the change request, it is rejected, and the DER/A will need to operate under partial outage.
- In Step B4, the DER/A participant provides outage information to the IESO, reflecting that the resource plan change was rejected, and the DER must operate at reduced capacity.
- In Step 5, the DER participant updates its distribution service availability and wholesale market bids/offers, communicates the changes to the DSO and the IESO respectively.
- In Steps 6 and 7, the DSO and IESO capture these updates in their systems and processes.

Figure 12 | Protocol swim lanes for DER/A resource plan change process under DP-DSO model



6.2.2 Total DSO

The following details the protocols for the T-DSO model as part of five processes: (A) Day-Ahead Scheduling, (B) Real-Time Activation & Dispatch, (C) DER/A Outage Management, (D) Distribution System Override, and (E) DER/A Resource Plan Changes.

A. Day-Ahead Scheduling

Figure 13 outlines the day-ahead process for coordinating distribution services and wholesale market services under the T-DSO model. In the T-DSO model, the DSO is the single interface for DER/A, as shown in Step 1 and Step 6. The DSO in turn interfaces with the IESO and manages how DER/A are represented in the wholesale market.

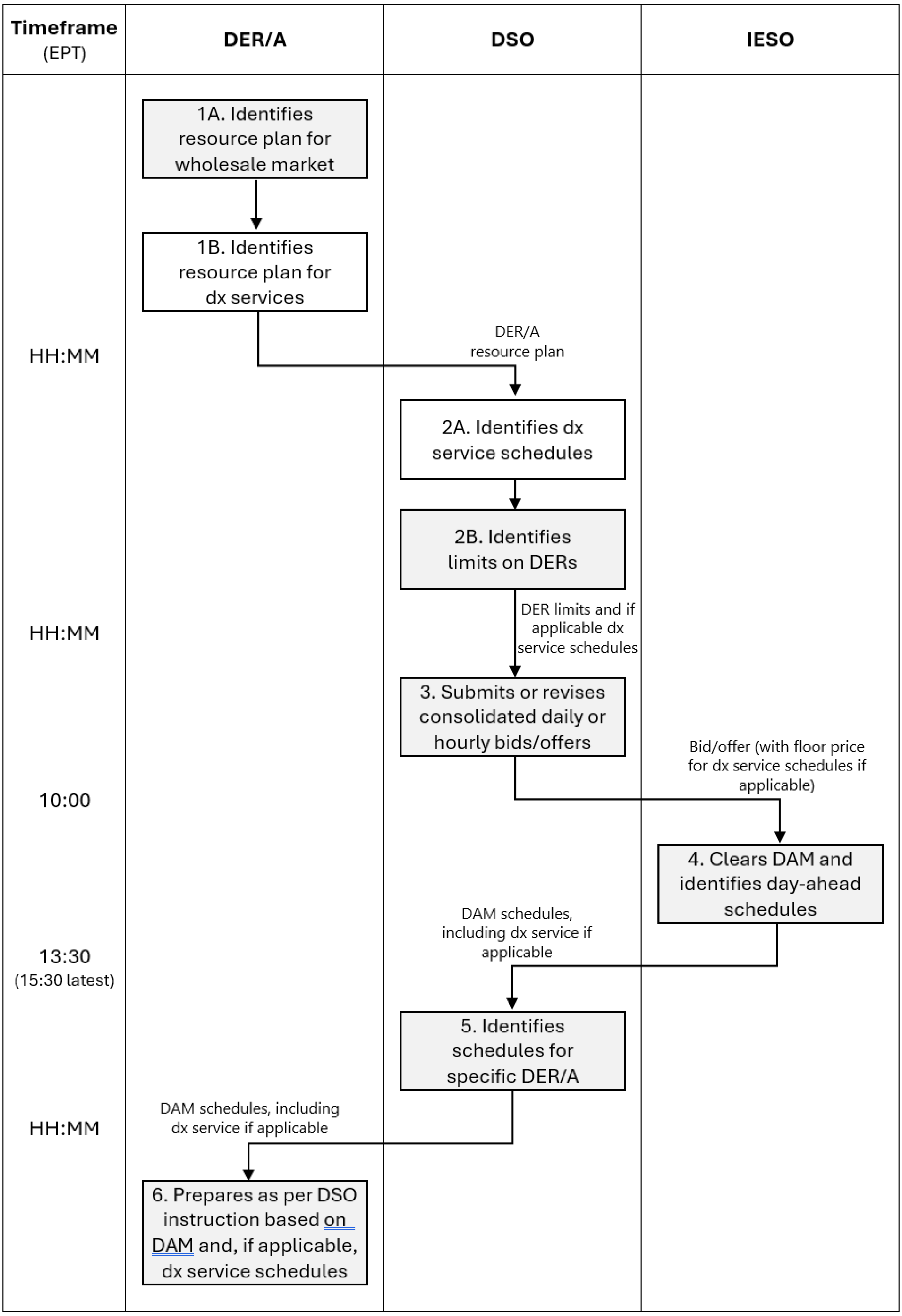
This approach simplifies the process for DER/A, since they do not need to manage two interfaces (one with the IESO and one with a DSO), as they would in the DP-DSO model. In this model, the IESO does not directly observe bids/offers from individual DER/A or which specific DERs within an aggregation will operate. The resource plan submitted by the DER/A participant to the DSO includes pricing information, potentially including bids/offers, which the DSO uses both to procure distribution services and to formulate bids/offers for the wholesale market.

As the sole wholesale market participant, the DSO prepares and submits a consolidated bid/offer in Step 3 for all DER/A within the distribution system downstream of a T-D node (or multiple nodes, if permitted). These bids/offers in the wholesale market incorporate the floor price approach described in Section 5 to capture the distribution service schedules determined by the DSO.

After receiving the DAM schedule from the IESO in Step 4, the DSO distributes the schedule to the DER/A that are providing services to the DSO, along with schedules associated with distribution services, in Step 5. This approach contrasts with the DP-DSO model, where the DER/A participant and IESO have direct interactions.

In the T-DSO model, the DSO can also determine how to meet the instructions from the IESO with participating DER/A in Step 5, as it takes on the commercial responsibilities for the DERs in the wholesale market. As outlined in the following sections, if DER/A outages occur or distribution system conditions change, DER/A schedules or dispatches specified by the DSO may become infeasible. The DSO may then substitute the DER/A on outage with other available DER/A and minimize any shortfall in meeting commitments to the IESO, instead of reporting an outage. For instance, the DSO may opt for this substitution if the non-performance charges for not meeting IESO commitments exceed the cost of using other DERs to meet the commitments. This is possible because the IESO schedules and dispatches the DSO rather than individual DER/A, which provides the DSO some flexibility to internally manage how it meets its commitments.

Figure 13 | Protocol swim lanes for day-ahead process under T-DSO model in EPT



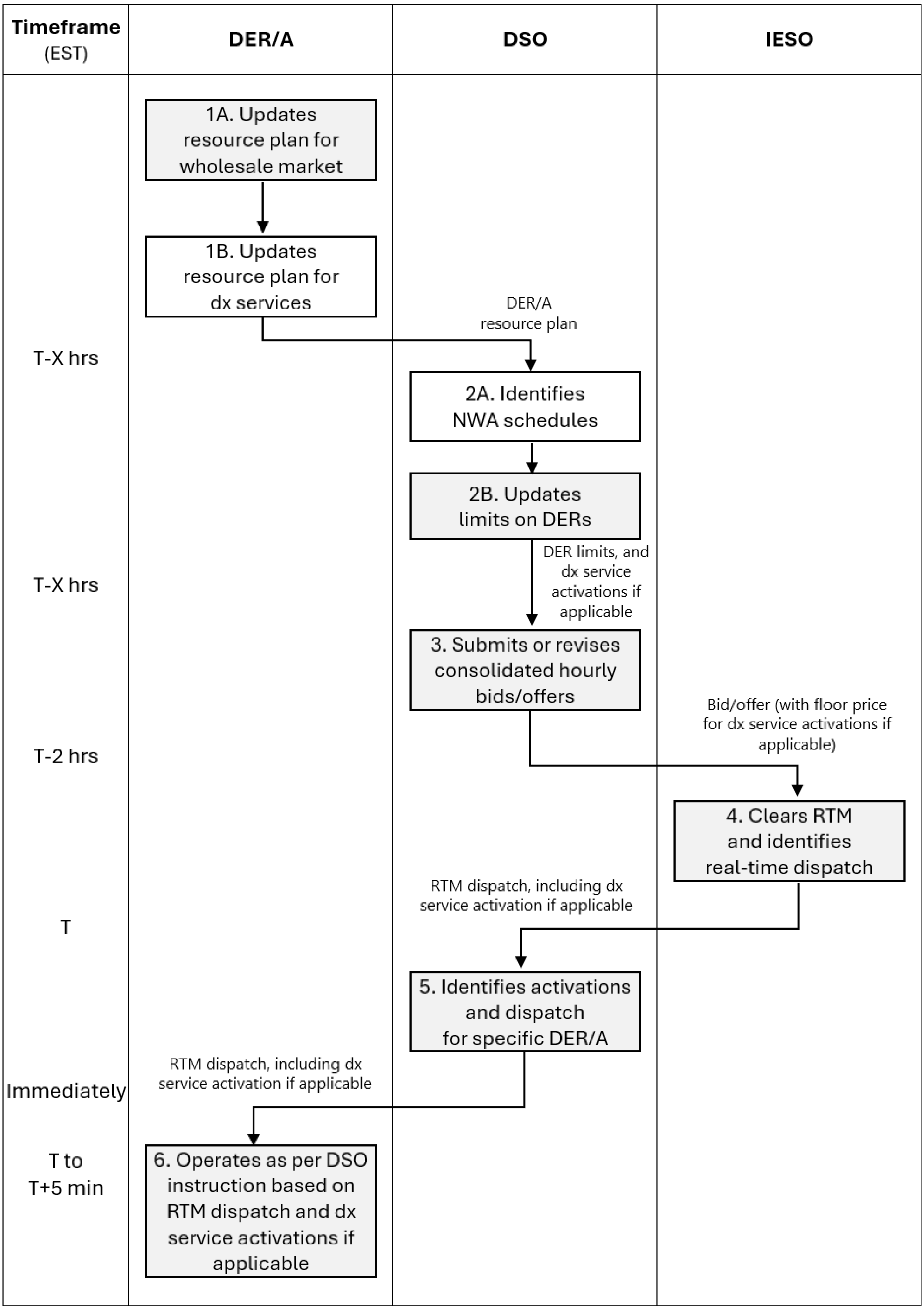
B. Real-Time Activation & Dispatch

Figure 14 describes the real-time process for coordinating distribution services and wholesale energy market services under the T-DSO model. Most considerations noted for the day-ahead process also apply to the real-time process, including the representation of all DER/A downstream of a T-D node (or multiple nodes, if permitted) by the DSO in the wholesale market, as shown in Steps 3 to 5 in Figure 14.

As discussed, in this DSO model, the DSO may have additional flexibility in selecting the specific DERs to use in Step 5 to meet the IESO's schedules and dispatches as distribution system conditions change. However, the real-time process operates within much tighter timeframes than the day-ahead process, requiring a faster sequence of steps and more immediate data exchanges.

Step 5 shows that dispatch instructions are issued continuously for every five-minute interval. The IESO sends these instructions at the start of each interval, indicating the operating point that must be reached by the end of the five-minute period. The DSO then distributes the dispatch to specific DER/A to operate and provide the energy services.

Figure 14 | Protocol swim lanes for real-time process under T-DSO model in EST

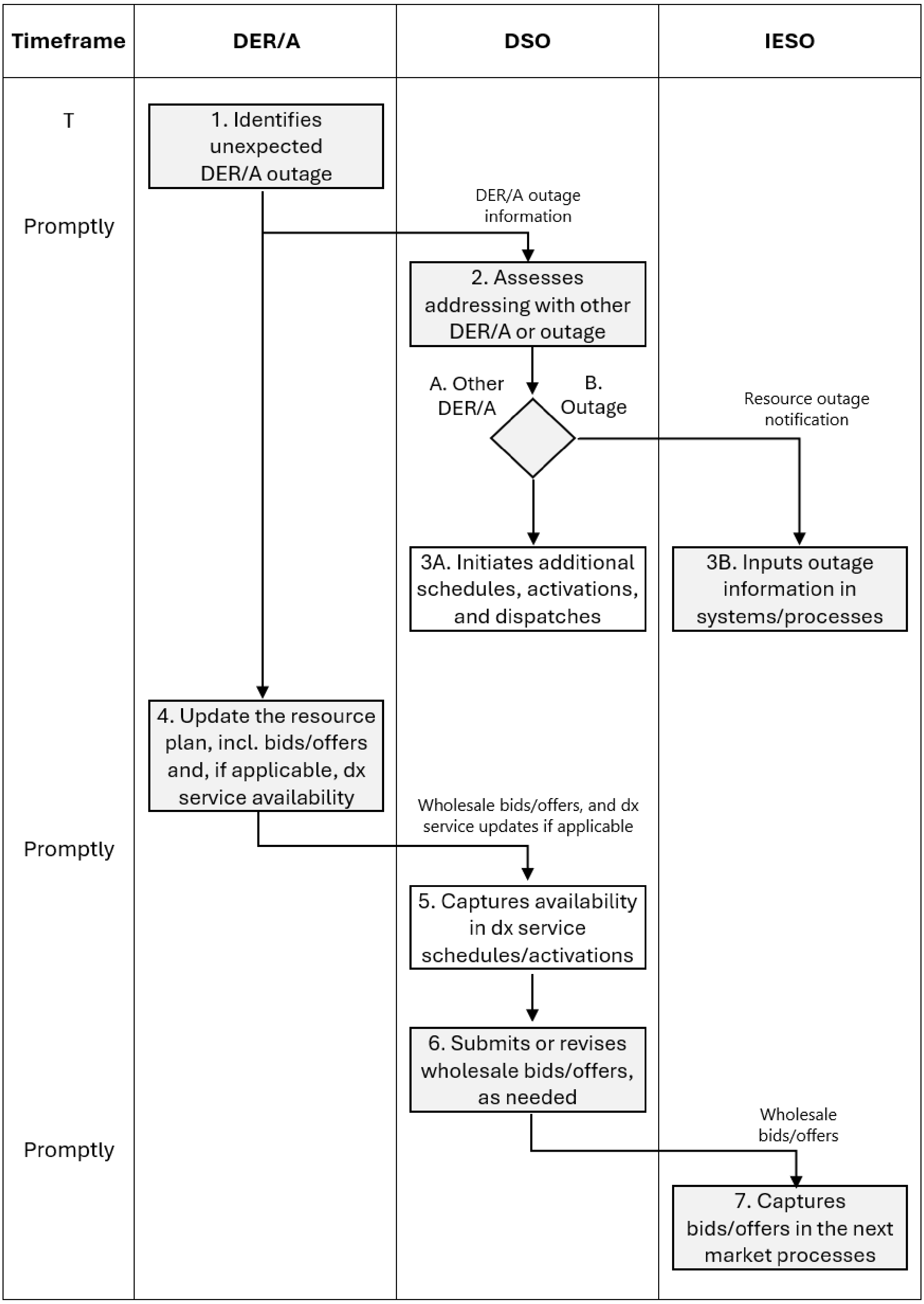


C. DER/A Outage Management

Figure 15 outlines the process for handling forced (i.e., unplanned) outages to the DER/A under the T-DSO model. In this model, the DSO represents the DER/A and is responsible for submitting outages and submitting or revising bids/offers to the IESO, as shown in Steps 3B and 6.

In Step 2, there is additional flexibility for the DSO to manage DER/A outages. The DSO can either make use of other DER/A to address any shortfall in meeting the IESO's instructions, as seen in Step 3A, or submit an outage to the IESO, as in Step 3B. This process links with the day-ahead and real-time processes described above, where the DSO identifies schedules, activations, and dispatches for specific DERs. This flexibility may allow the DSO to adjust which specific DERs are used as distribution conditions change. The DSO would also have the option of partially addressing the shortfall with other DER/A and partially with an outage notice. In Step 6, the DSO submits or revises its consolidated bids/offers in the wholesale energy market to reflect DER/A outages.

Figure 15 | Protocol swim lanes for DER/A outages under T-DSO model

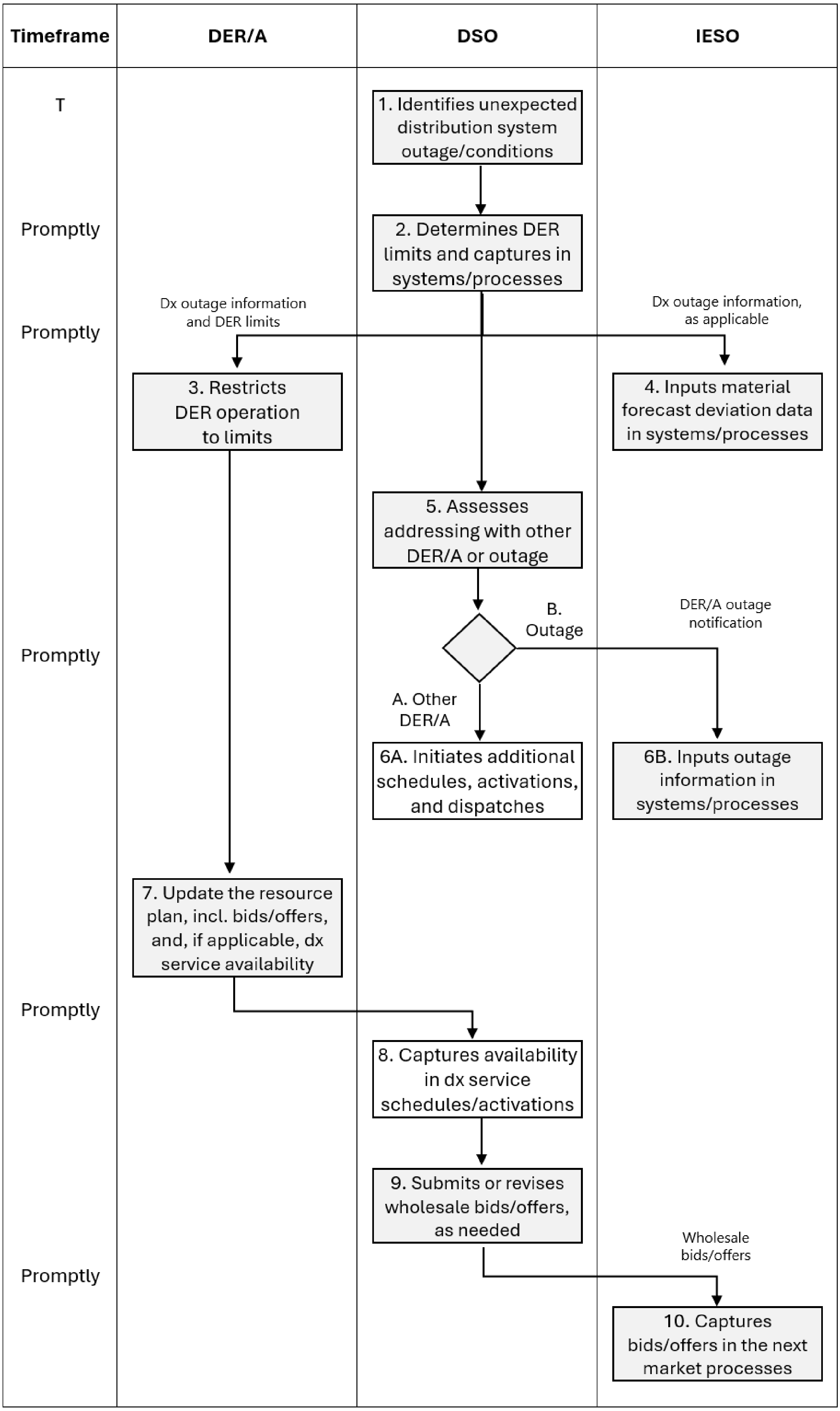


D. Distribution System Outage

Figure 16 details the process for managing forced outages to the distribution system or unexpected distribution system conditions that impact distribution safety and reliability. In the T-DSO model, the DSO represents the DER/A and is responsible for submitting outage notifications and submitting or revising wholesale bids/offers, as shown in Steps 4, 6B, and 10.

Similar to the DER/A outage process, the distribution outage process offers the DSO flexibility in Step 5 in how to address the shortfall to meet wholesale market commitments. The DSO can use other DER/A to make up for the DER/A that cannot operate due to distribution system conditions in Step 6A. Alternatively, in Step 6B, the DSO has the option to submit an outage notice to the IESO.

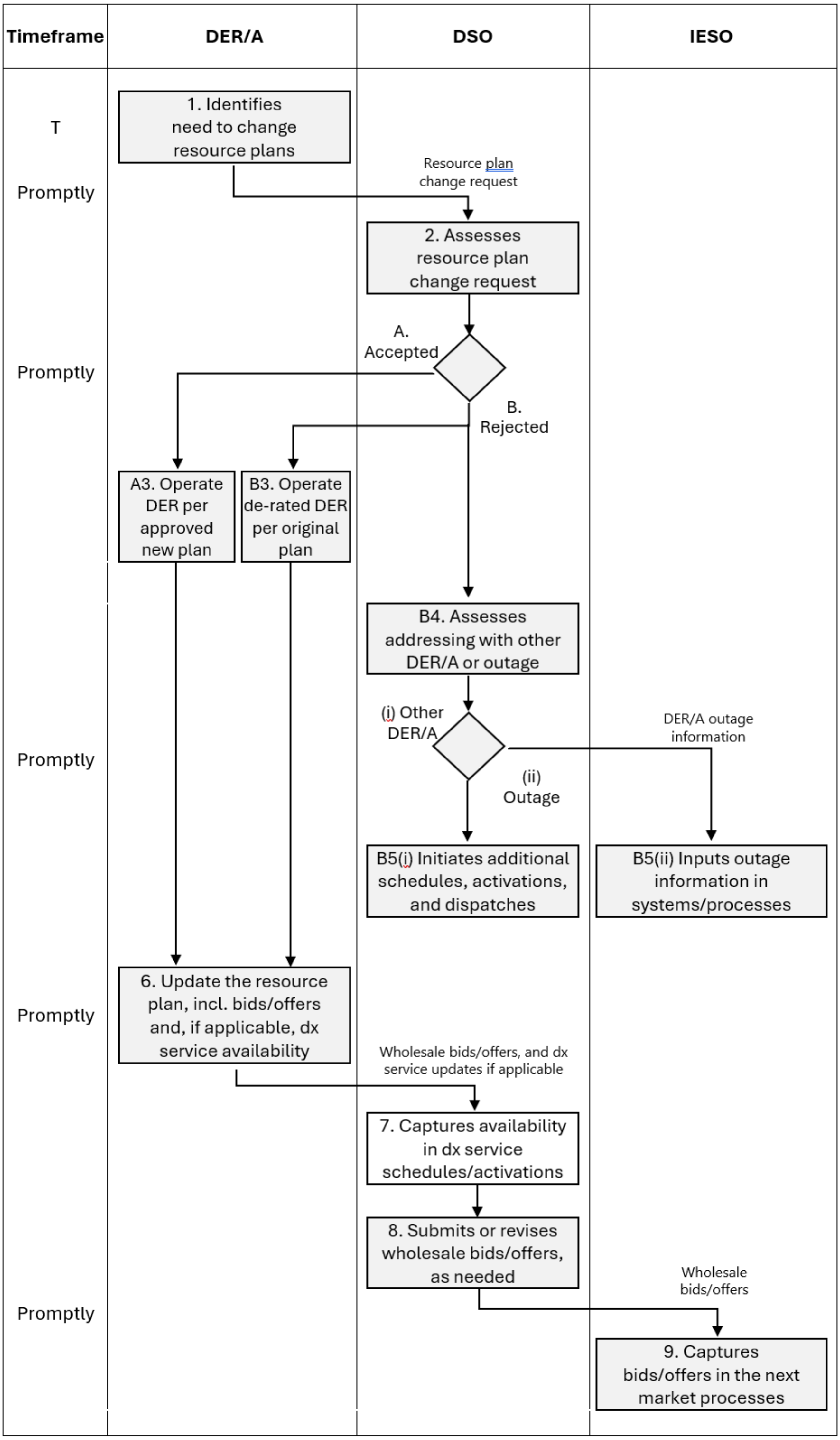
Figure 16 | Protocol swim lanes for distribution system outages under T-DSO model



E. DER/A Resource Plan Change Process

Figure 17 presents the process for handling changes to a DER/A participant's resource plan for which DERs within the aggregation it intends to make use of and operate. In the T-DSO model, the DSO is responsible for submitting outage notifications and submitting or revising wholesale bids/offers, as shown in Step B4 and Step 8. Similar to the outage processes under the T-DSO model presented above, when a resource plan change request is rejected, the DSO can choose how to proceed in Step B4. The DSO may either 'internally' substitute the DER/A on outage with other DER/A in Step 5B(i) or report an outage to the IESO in Step 5B(ii).

Figure 17 | Protocol swim lanes for DER/A resource plan changes under T-DSO model



6.2.3 Market Facilitator DSO

The following details the protocols for the MF-DSO model as part of five processes: (A) Day-Ahead Scheduling, (B) Real-Time Activation & Dispatch, (C) DER/A Outage Management, (D) Distribution System Override, and (E) DER/A Resource Plan Changes.

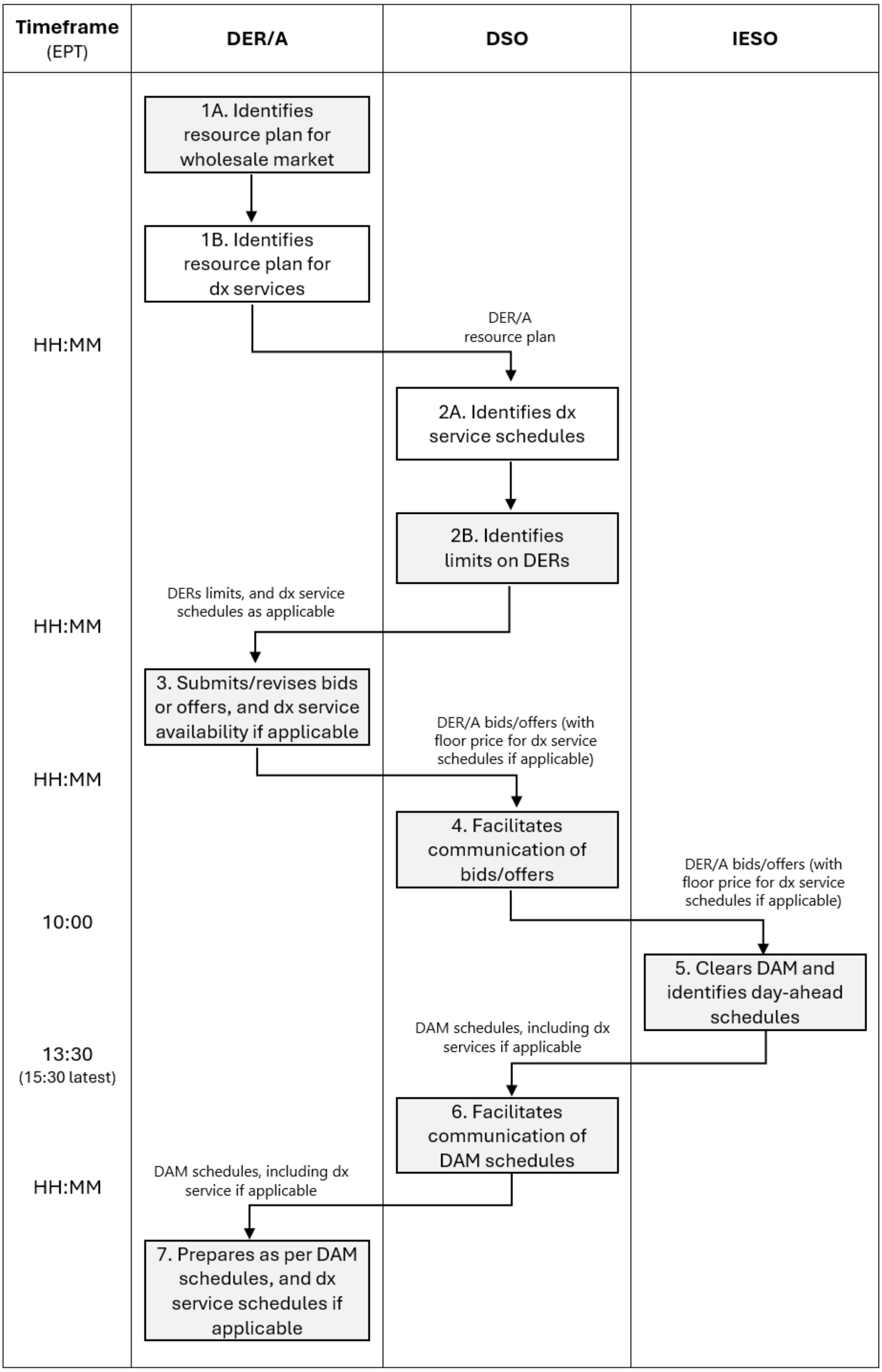
A. Day-Ahead Scheduling

Figure 18 presents the day-ahead process for coordinating distribution services and wholesale market services under the MF-DSO model.

In some ways, the MF-DSO model resembles the T-DSO model. For example, similar to the T-DSO model, the MF-DSO model involves DER/A participants managing one operational interface with the DSO, which simplifies the participation process as seen in Steps 1, 3 and 7. This contrasts with the DP-DSO model, where the DER/A participant must manage two interfaces: one with the DSO and one with the IESO.

In other ways, the MF-DSO model resembles the DP-DSO model. For example, as in the DP-DSO model, DER/A are registered market participants in the wholesale market. This contrasts with the T-DSO model, where the DSO is the market participant representing the DER/A. In Steps 4 and 6, the DSO facilitates the participation of DER/A in the wholesale market without the DSO assuming commercial obligations associated with the DER/A.

Figure 18 | Protocol swim lanes for day-ahead process under MF-DSO model in EPT

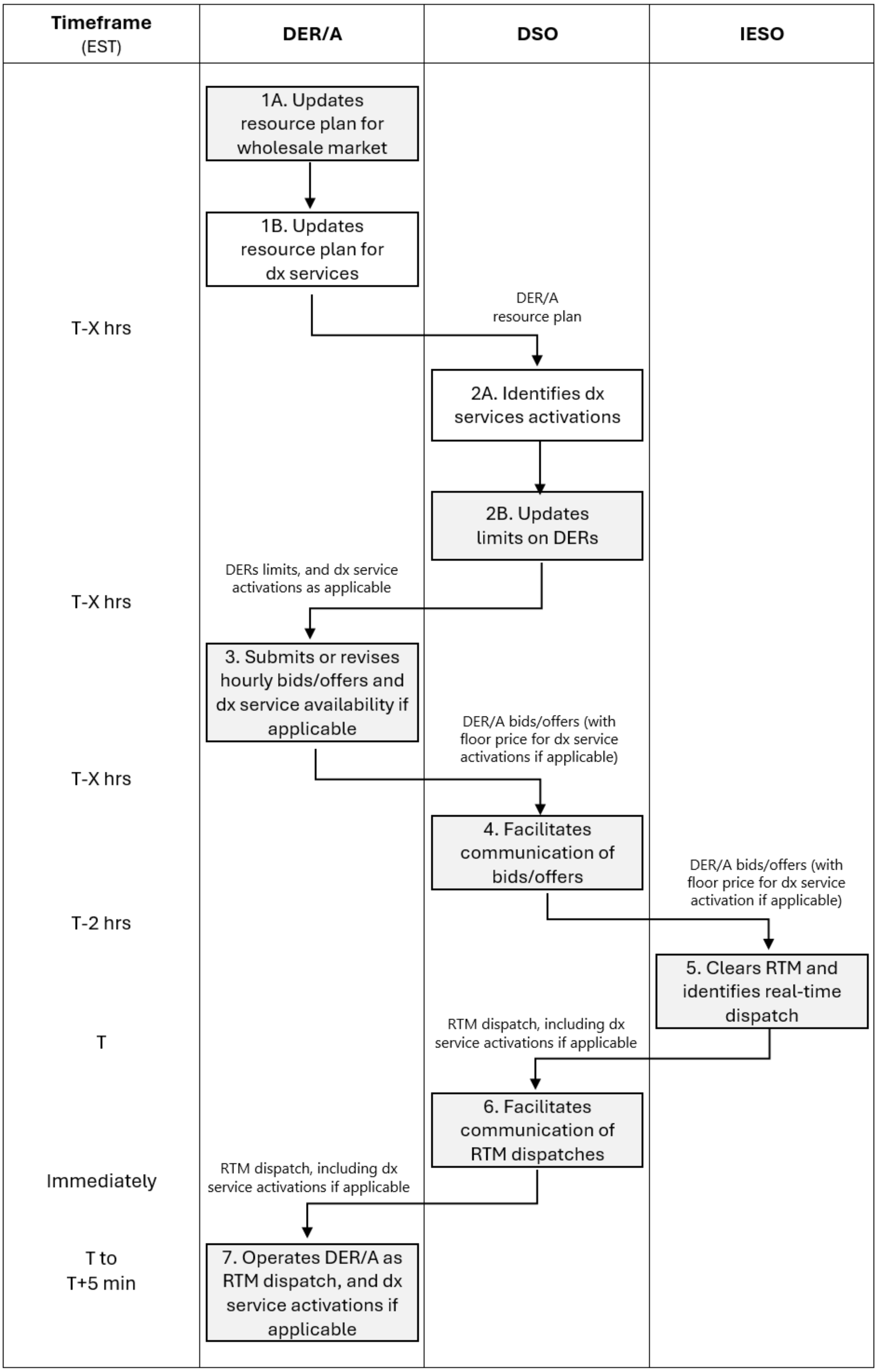


B. Real-Time Activation & Dispatch

Figure 19 illustrates the real-time process for coordinating distribution NWA and wholesale energy market services under the MF-DSO model. In the MF-DSO model, the DSO plays a central operational role in facilitating DER/A participation in grid services in a streamlined manner. For example, in Step 3 (and potentially Step 1A), the DER/A participant shares its wholesale market bids/offers with the DSO. In Step 4, the DSO facilitates the communication of bids/offers to the wholesale market that it received from the DER/A participant in Step 2. Similarly, in Step 6, the DSO relays wholesale market instructions from the IESO to the DER/A.

As discussed previously, the real-time process operates within tight timeframes, requiring a fast sequence of steps and immediate data exchanges. Generally, the DSO does not intervene to modify the information exchanged between DER/A participants and the IESO as part of wholesale market processes. Note that, unlike the T-DSO model where the IESO dispatches a consolidated resource at each T-D interface represented by the DSO, in the MF-DSO model, the IESO dispatches individual DER/A, similar to the DP-DSO model. Unlike the DP-DSO model, in the MF-DSO model, the dispatch instructions are relayed through the DSO to the DER/A. Therefore, there is potential for the DSO to override these instructions prior to relaying them to DER/A, in case of unforeseen events in the distribution system that necessitate limiting DER operation. However, to enable this potential in the MF-DSO model thorough investigation is needed to identify the required data exchange and coordination to address both wholesale market and distribution system operational requirements.

Figure 19 | Protocol swim lanes for real-time process under MF-DSO model in EST

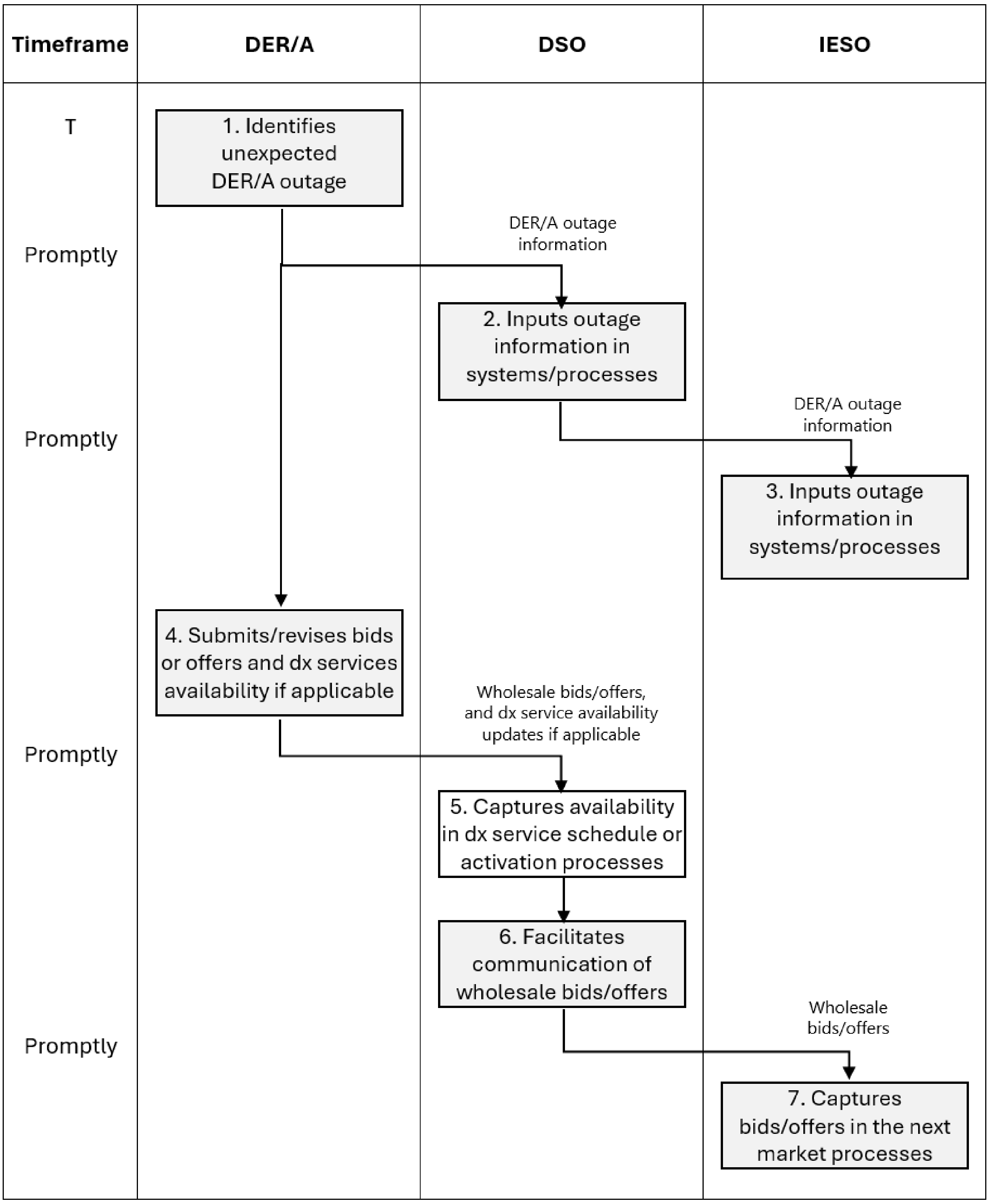


C. DER/A Outage Management

Figure 20 outlines the process for managing forced (i.e., unplanned) outages to the DER/A. In this process, the DSO serves as the single operational interface with the DER/A participant and with the IESO.

In Step 1, the DER/A participant identifies and informs the DSO of an unplanned outage. The DSO in turn relays this information to the IESO in Step 2. In Step 4, the DER/A participant updates its availability for distribution NWA services and submits or revises bids/offers in the wholesale energy market. This updated information is provided by the DER/A participant to the DSO, which in Step 6 relays the wholesale market bids/offers to the IESO.

Figure 20 | Protocol swim lanes for DER/A outages under MF-DSO model



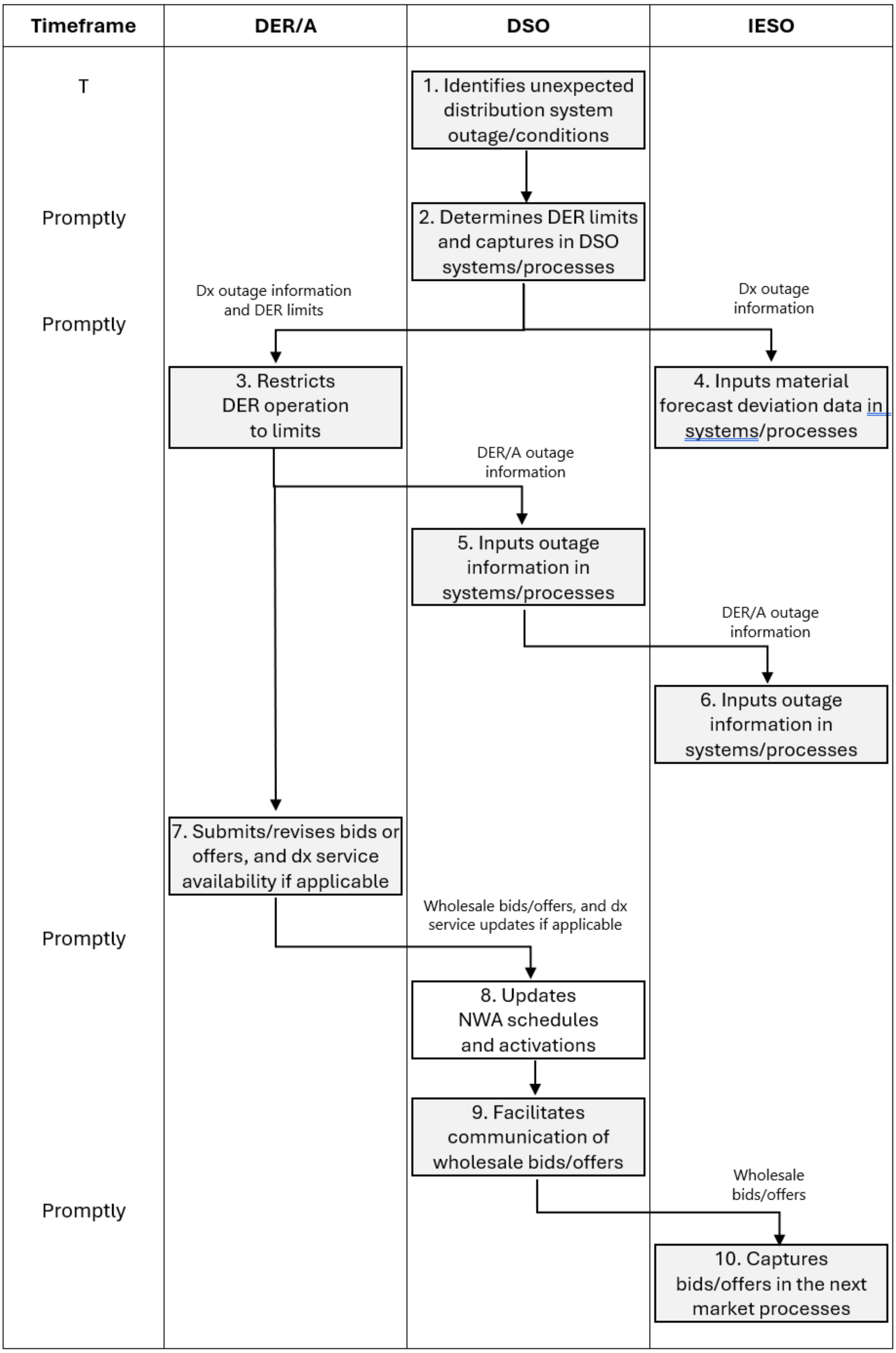
D. Distribution System Override

Figure 21 details the override process for managing forced outages to the distribution system or unexpected distribution system conditions under the MF-DSO model.

Below are the key steps in this process:

- In Step 1, the process is initiated when the DSO identifies unexpected distribution conditions that prevent the DER/A from operating.
- In Step 2, the DSO proceeds to assess the limits on the associated DERs. These limits often require the DERs to be shut down altogether but may also involve a derate (reduction in output) of the DERs.
- In Step 3, the DSO communicates about the distribution outage and the resulting operational limits on DERs to the DER/A participant.
- In Step 4, the DSO provides notification of the distribution outage to the IESO, in accordance with the relevant reporting criteria in the IESO Market Rules and Manuals.
- In Step 5, the DSO receives DER/A outage information from the DER/A participant and relays this information to the IESO.
- In Step 6, the IESO receives the DER/A outage information and captures it in its systems and processes.
- In Step 7, the DER/A participant reflects the changes to DER/A availability to provide distribution service and submits or revises wholesale market bids/offers.
- In Step 8, the DSO inputs these updates in its systems, which can also trigger new distribution service schedules and activations.
- In Step 9, the IESO receives the updated information due to the distribution override from the DSO.

Figure 21 | Protocol swim lanes for DSO overrides under MF-DSO model



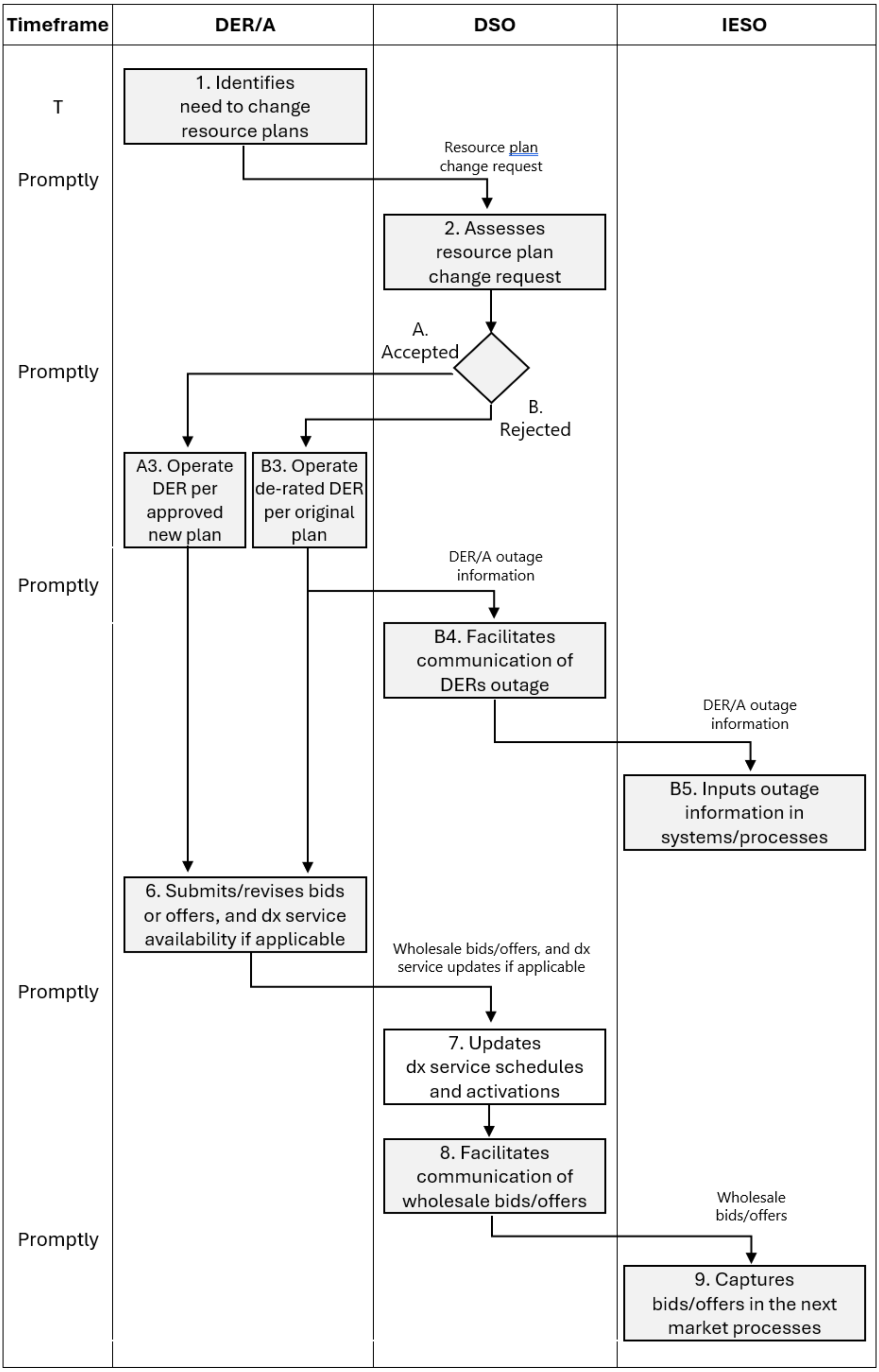
E. DER/A Resource Plan Changes

Figure 22 presents the process for handling changes to a DER/A participant's resource plan, where the DER/A participant specifies which DERs it intends to make use of to provide services.

Below are the key steps in this process:

- In Step 1, the DER/A participant can request a change to its resource plan in the MF-DSO model, similar to the other DSO models.
- In Step 2, the DSO assesses the change request and may accept or reject it.
- In Step B3, if the request is rejected, the DER/A will need to operate under de-rated capacity.
- In Step B4, the DER/A participant submits a DER/A outage notification to the DSO.
- In Step B5, the DSO relays the DER/A outage information to the IESO.
- In Step 6, the DER/A participant updates DER/A availability for distribution services and submits or revises wholesale energy market bids/offers.
- In Step 7, the DSO receives the updated information and captures it in its systems.
- In Step 8, the DSO facilitates the communication of the updated wholesale market bids/offers to the IESO.
- In Step 9, the IESO reflects the updated information in its processes.

Figure 22 | Protocol swim lanes for DER/A resource plan change process under MF-DSO model



7. Conclusions

This report has discussed the need for effective T-D coordination to better enable DER/A to provide services across the grid. The detailed protocols developed here represent a key step forward in enabling DER/A to provide stacked services across the distribution and wholesale levels. The detailed investigation of the three DSO models provides valuable information for the IESO and stakeholders as they navigate the next steps and make informed decisions. For a more comprehensive understanding of the options and considerations relevant to T-D coordination, this report should be read alongside the other three TDWG Deliverable reports. Improved coordination among DER/A participants, DSOs, and the IESO represents an opportunity to maximize the value that DERs provide to the electricity grid while also benefiting customers with DERs.

To further advance the T-D coordination protocols detailed in this report, several potential actions may be considered. For example, exploring a broader range of related topics - such as settlement and forecasting implications - could further support the design of the protocols. In addition, pursuing more opportunities to demonstrate these protocols in real-world settings may yield valuable insights. Continued stakeholder feedback can further refine the approach, and engaging in industry forums will contribute to sector collaboration and drive additional innovation in T-D coordination.

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