Day-Ahead Ancillary Services Initiative

Overview of key design features

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Overview

- With DASI, the ISO seeks to procure and transparently price the ancillary service capabilities needed for a reliable, next-day operating plan with an evolving generation fleet
  - **Currently**, the ISO relies on out-of-market means to meet key day-ahead reliability requirements
  - **With DASI**, these reliability requirements will be satisfied within the clearing of the day-ahead market (DAM)
  - DASI is scheduled to “go-live” on March 1, 2025

Outline

- Overview of current DAM and rationale for the DASI changes
- Overview of DASI design
- FER/EIR and FRS: Fundamentals, clearing and pricing logic
- Call option settlement framework and incentives
- DA A/S offer framework

OVERVIEW OF CURRENT PRACTICE FOR MEETING DAY-AHEAD RELIABILITY REQUIREMENTS

Today's day-ahead practice – Operating Reserves

- The DAM is cleared in two sequential optimizations
  - First, a unit commitment process
  - Second, a dispatch and pricing process
- Operating reserve requirements are applied during the DA commitment process, but are not applied during the DA dispatch and pricing process
  - This ensures that sufficient unloaded ramp-up capability on committed units DA, and sufficient offline fast-start capability, is available to meet expected real-time reserve requirements
  - This does not provide information, settlement obligations, prices, or compensation to the resources that the ISO counts on to meet the operating reserve requirements for the next-day operating plan

Today’s day-ahead practice – Load Forecast

- The load forecast is satisfied through the out-of-market Reserve Adequacy Analysis (RAA) process, following the clearing of the DAM
- The RAA addresses any ‘energy gap’ between (1) DAM committed physical supply, and (2) the load forecast and operating reserve requirements
  - RAA may rely upon a DAM committed resource above its DAM energy schedule
  - RAA may commit additional resources (supplemental commitments), or extend the commitment duration of a DAM-committed resource
- The RAA <u>does not</u> provide settlement obligations, prices, or compensation to the resources (or portions thereof) that the ISO counts on to meet the load forecast requirement of the next-day operating plan

THE IMPACTS OF THE EXISTING DAM DESIGN

Context: Setting up the system today

- To meet key day ahead reliability requirements, the ISO must set up the system to have sufficient capability to meet the load forecast and expected real-time reserve requirements
- At present, the only product that resources sell in the DAM is energy, where the quantity sold depends on participant DA energy offers and demand bids
- Thus, there are two potential gaps between what the DAM clears and the key DA reliability requirements
  - Energy gap when the market clears less physical energy supply than the load forecast
  - Reserves to cover any system ("source-loss") contingencies

DASI addresses missing market for reliability services

- At present, there are not well-defined products corresponding with these key reliability services in the DAM that participants can offer or sell
- Instead, ISO relies upon unloaded online fast-ramping capability and offline fast-start capability to meet these requirements for a reliable next-day operating plan
- Without market products, there are no settlement obligations, prices, or compensation provided to the resources the ISO counts on to provide these services

These missing DA markets can have several adverse impacts on system reliability and efficiency

1. **Information**: Resources that are being counted on to provide reliability services may not know ISO is relying upon them to be able to provide energy, during the next operating day
2. **Inefficient DA awards**: Without offer prices for these services, the DAM optimization cannot efficiently select the resources to provide them
3. **Poor price signals**: Current practices to satisfy reliability requirements are unpriced; may reduce energy prices below resources' costs, contrary to sound economic principles
4. **Inefficient incentives**: Because resources are not compensated for providing these services in the DAM, their incentives to invest in their ability to reliably provide energy in RT are inefficiently low

OVERVIEW OF DASI DESIGN

Day-Ahead Market with DASI: the big picture

- Familiar design elements:
  - Co-optimized procurement of energy and ancillary services
  - Determination of all clearing prices based on marginal-cost pricing principles
  - DA operating reserve constraints, products, and requirements are similar to those that exist in real-time today

- Novel design elements:
  - **Forecast Energy Requirement (FER)/Energy Imbalance Reserves (EIR)**:
    - Incorporation of load forecast into the clearing of the DAM via a new constraint, the FER
    - Procurement of a new ancillary service product, EIR, that can help to satisfy the FER
  - **Call option settlement design** will be used to settle DA ancillary service (DA A/S) awards, reflecting incremental replacement cost of real-time energy

DASI Adds New Constraints to the DAM

- Under DASI, priced constraints will be added to the DAM that reflect next-day reliability needs
- FER ensures that the operating plan resulting from the DAM will meet the load forecast
  - The load forecast is the demand quantity for the FER
- Flexible Response Services (FRS) constraints reflect the same four operating reserve requirements applied in real-time today
  - Ten-Minute Spinning Reserve requirement
  - Total Ten-Minute Reserve requirement
  - Minimum Total Reserve requirement
  - Total Reserve requirement

DASI Adds New Products to the DAM

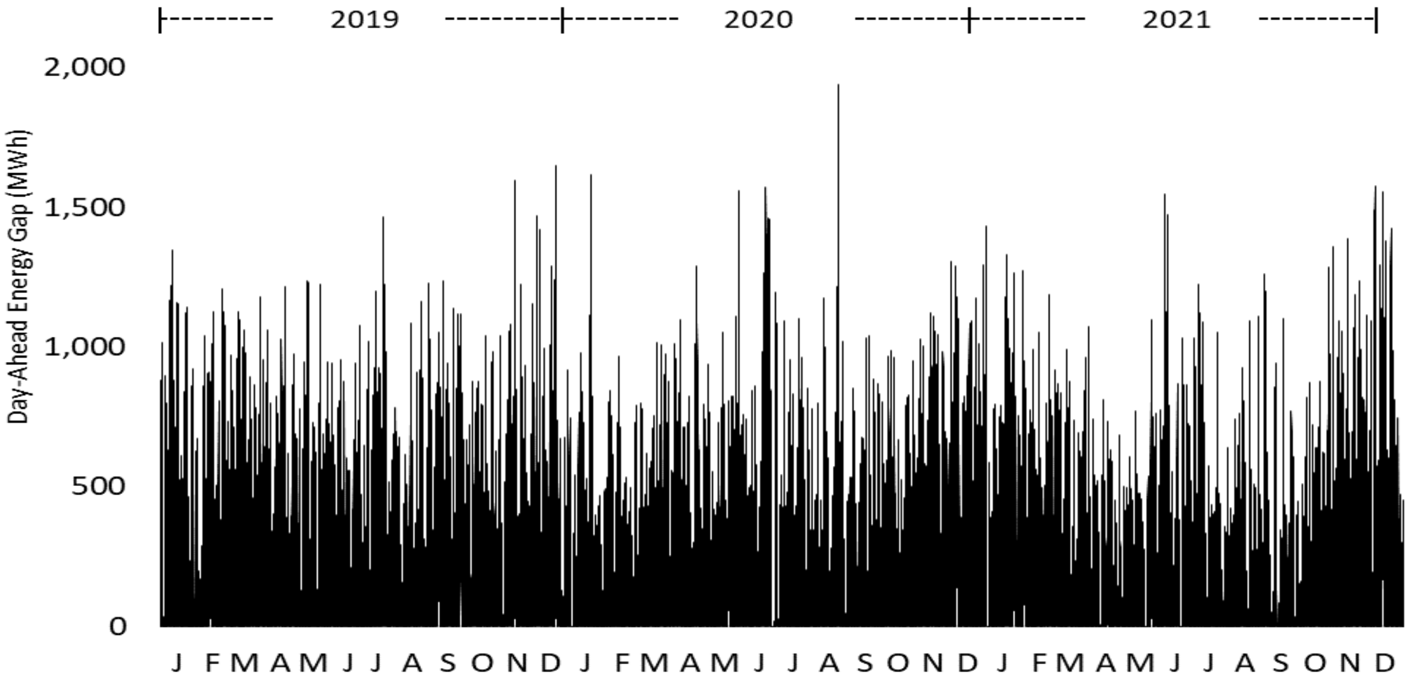
- New products will be offered by participants and procured and priced by the DAM to satisfy these reliability needs
- Day-Ahead DA EIR, along with DA energy, helps to satisfy the load forecast (reflected in FER constraint)
  - DA EIR has 60-minute ramping horizon, similar to DA energy
- Flexible Response Services are a suite of new DA A/S products that satisfy operating reserve requirements, composed of:
  - Ten-Minute Spinning Reserve (DA TMSR)
  - Ten-Minute Non-Spinning Reserve (DA TMNSR)
  - Thirty-Minute Operating Reserve (DA TMOR)

FER AND EIR FUNDAMENTALS

Today, an “energy gap” exists in the DAM

- Under current market rules, the existing DAEM results in a positive “energy gap” in ~50% of hours

Energy Gap = Load Forecast – DA Cleared Physical Energy Supply



Under DASI, the FER closes the energy gap within the DAM

- NERC reliability standard requires a DA operating plan capable of satisfying the day-ahead load forecast
- To satisfy this reliability standard <u>within</u> the DAM, DASI introduces a new constraint (FER) and a new product (EIR) to the DAM's commitment, pricing and dispatch processes
- The FER constraint ensures that the sum of cleared physical energy supply and EIR is greater than or equal to the load forecast for each hour of the operating day
- The DA energy balance constraint, which considers bid-in demand, remains part of the DAM with DASI

FER procures efficient mix of energy and EIR when an energy gap exists

- When an energy gap exists, the FER will address it through procurement of the efficient combination of additional DA energy supply from physical supply resources and EIR
  - Additional DA energy supply from physical supply resources clears against bid-in energy demand, via the energy balance constraint
- **Key point**: When an energy gap exists, we expect more physical DA energy supply (and, consequently, more DA energy demand) to clear than under current market rules
  - It may be more cost effective to clear additional energy supply (against bid-in energy demand) than to clear EIR

FER procures efficient mix of energy and EIR when an energy gap exists: simple example

- The example below illustrates that FER will:
  - Procure mix of additional DA energy and EIR to satisfy the load forecast when there is an energy gap
  - Procure no additional DA energy or EIR when there is no energy gap

Cleared Physical Energy Supply, Current Market Rules	Load Forecast	Energy Gap?	Potential ways to satisfy FER		Total DA energy and EIR ([A] +[D]+[E])
			EIR	Additional DA Energy	
[A]	[B]	[C]	[D]	[E]	[F]
18	20	Yes	1	1	20
18	20	Yes	0	2	20
21	20	No	0	0	21

Clearing and pricing with FER and energy balance constraints

- Application of a second demand constraint (the FER) in the DAM's clearing and pricing process will change cleared energy quantities and prices
  - Quantities: DA energy awards (exists today), EIR awards (new)
  - Prices: DA LMP (exists today), FER Price (FERP, new)
- Today's energy balance constraint reflects one demand curve (bid-in energy demand) and one supply curve (offered energy supply)
  - Today's DAM clears where supply and demand intersect:
    - Price: DA LMP = Marginal Cost (MC) of DA energy supply
  - Important: These dynamics will change with the addition of the FER!

Clearing and pricing with FER and energy balance constraints (cont'd)

- Clearing prices reflect the incremental cost that would be incurred to satisfy one additional MWh of demand
  - DA LMP = incremental cost of meeting another MWh of (bid-in) energy demand
  - FERP = incremental cost of meeting another MWh of the Forecast Energy Requirement
- Pricing interaction: clearing an additional MWh of physical energy supply means one less MWh of EIR is required
  - DA LMP can reflect both the marginal cost of one more MWh energy, and the marginal savings of one less MWh of EIR
  - With two demand constraints, the marginal cost of energy supply is reflected by the combination of DA LMP and FERP
- Please see the Appendix to the DASI presentation at the January 2023 NEPOOL Markets Committee for additional information on DAM clearing and pricing with the FER

DAM with FER/EIR – Who gets paid/charged these prices?

- The *participation payment principle:* Offers cleared to help satisfy a constraint must be paid the shadow price of that constraint
  - Conceptually, a MWh of cleared energy or A/S is compensated for the value (system savings) it provides by avoiding the purchase of a more costly MWh at the margin
  - Certain DA awards can satisfy more than one constraint
- Following this principle, DA cleared supply offers will be paid (and DA cleared demand bids will be charged) as follows:

Concept	DA LMP	FERP
Physical Energy Supply	✓	✓
INC	✓	
EIR		✓
Energy Demand	✓	

*FERP charges will be allocated to RT load obligation and DA cleared exports, on a beneficiary pays principle

DAM with FER/EIR – Equilibrium Behavior and Price Convergence

- *Holding all participant supply offers and demand bids constant*, the DA LMP will typically be lower with the FER applied than without
  - Intuition: the more energy cleared in the DAM, the lower is the marginal benefit of serving the next MW of energy demand
  - See link at bottom of slide 21 and Appendix 2
- Expectation: buyers will respond, with load increasing the amount of energy procured DA
  - If buyers do not increase amount of energy procured DA, then there would be an arbitrage opportunity between the DA and RT markets
  - Result: increase in DA LMP, bringing it in line with expected RT LMP
- Expectation: cleared EIR will be smaller than the historical energy gap as load responds
  - As load increases the amount of energy it buys DA, additional physical energy supply will be procured, reducing the amount of cleared EIR

FRS FUNDAMENTALS

FRS products satisfy DA reliability standards related to contingency response

- Suite of three DA A/S products that have a similar purpose as real-time operating reserve
  - Purpose: prepare the system to be able to successfully respond to sudden, unanticipated losses of supply, or increases in demand, during the operating day
- DA TMSR – ten-minute response capability on committed (synchronized) resources
- DA TMNSR – ten-minute response capability on uncommitted fast-start resources
- DA TMOR – thirty-minute response capability on committed resource or uncommitted fast-start resources

DA FRS clearing and pricing logic is analogous to RT operating reserves clearing and pricing

- Many similarities exist between FRS and real-time operating reserves
  - The DA FRS reserve requirements are analogous to current RT operating reserve requirements
  - DA FRS demand quantities for these constraints are projections of what reserve requirements will be during the operating day
  - Cleared DA FRS quantities ‘cascade down’, with faster-ramping products satisfying less restrictive demand quantities
  - DA FRS clearing prices ‘cascade up’, satisfying the participation payment principle
  - DA RCPFs are the same as in RT

CALL OPTION SETTLEMENT MECHANICS

The call-option settlement design is a two-settlement system

- A standard, two-part option settlement design, like DA energy
  - DA A/S Credit
  - DA A/S Closeout
- **Settlement Part 1: DA A/S Credit**. Suppliers are paid for DA A/S awards at DA A/S clearing prices
  - DA A/S Credit = DA A/S cleared quantity x DA A/S clearing price
- **Settlement Part 2: DA A/S Closeout**. Suppliers are charged the difference between the Real-Time Locational Marginal Price (RT LMP) and a predetermined strike price (K), *if RT LMP exceeds K*
  - DA A/S Closeout Charge = DA A/S cleared quantity x [–max(0, RT LMP – K)]
  - The strike price, K, is published in advance of the DAM offer submission, and depends on the expected RT LMP

Examples that illustrate the call-option settlement

- Assumptions that hold across all examples:
  - Consider a single resource that sells 1 MWh of DA A/S
    - This is its only DA position
  - DA A/S Clearing Price = $5/MWh
  - Strike Price (K) = $50/MWh
- We’ll vary the RT LMP, illustrate the settlement mechanics, and show how sellers of DA A/S produce energy in real-time and receive a DA credit in exchange for giving up *potential* profits from real-time energy

Option Settlement Example 1: Resource Operates, High RT LMP

- RT Energy Output = 1 MWh, RT LMP = $60/MWh > marginal cost (MC)
- Net Settlement

DA A/S Credit	DA A/S Closeout	RT Energy Credit	Net Settlement
1 MWh x $5 = $5	1 MWh x -max(0,$60 - $50) = -$10	1 MWh x $60 = $60	$55

- The resource covers its DA A/S position by providing 1 MWh of energy in RT
  - On net, it is paid $5/MWh DA and then paid $50/MWh for its real-time energy
  - Here, in exchange for the $5 DA/MWh A/S credit, it 'gives up' $10/MWh in forgone RT energy revenue ($60 RT LMP - $50 strike)

Option Settlement Example 2: Resource Operates, Low RT LMP

- RT Energy Output = 1 MWh, RT LMP = $40/MWh > MC
- Net Settlement

DA A/S Credit	DA A/S Closeout	RT Energy Credit	Net Settlement
1 MWh x $5 = $5	1 MWh x -max(0,$40 - $50) = $0	1 MWh x $40 = $40	$45

- The resource covers its DA A/S position by providing 1 MWh of energy in RT
  - It is paid $5/MWh DA and then paid the RT LMP for its real-time energy
  - Here, it does not ‘give up’ any RT energy revenue because the RT LMP falls below the strike price

Discussion of Examples 1 and 2

- A resource that clears a DA A/S award and delivers energy in real-time will effectively be paid, at most, the strike price ($K) for its real-time energy
- In exchange for the certainty of the DA A/S Credit, the resource gives up the potential gain from selling energy in the real-time market at a price above $K
  - In Example 1, participating only in RT would be more profitable
  - In Example 2, participating only in RT would be less profitable
- This potential RT opportunity cost will affect seller's DA A/S offer prices (*see competitive offer module for further discussion*)

CALL OPTION SETTLEMENT INCENTIVES

Incentive issues in current DAM

- Today, the ISO relies upon resources, or portions of resources, with no DAM award as part of creating a reliable, next-day operating plan
- Because these resources aren't paid for providing these services, and face minimal or no financial consequence for nonperformance, their incentives to invest in the ability to reliably provide energy in RT are inefficiently low
- In other words, there are cases where the resource's private profit maximizing decision is not to invest, but society would be better off if it did

The call-option settlement design addresses the misaligned incentives issue

- Key concept: Sellers of DA A/S will internalize the RT replacement cost associated with non-performance
  - Sellers of DA A/S compensate the buyer (the ISO and, in turn, load) at an appropriate incremental cost to replace their energy if they do not operate in RT
  - The buyer of the option will pay, at most, $K for that MWh of energy in real-time
  - The closeout charge puts the seller 'on the hook' for the incremental cost to replace its energy <u>to the extent that that cost exceeds the strike price</u> (i.e., RT LMP – K)
  - This improves market efficiency and system reliability
- We illustrate this concept with numerical examples on the next two slides
  - For a more detailed example, please see Appendix 4

Option Settlement Example 3: Resource doesn't operate, High RT LMP

- RT Energy Output = 0 MWh, RT LMP = $60/MWh
  - RT LMP could be below MC, or above MC (unit fails to run)

- Net Settlement

DA A/S Credit	DA A/S Closeout	RT Energy Credit	Net Settlement
1 MWh x $5 = $5	1 MWh x -max(0,$60 - $50) = -$10	0 MWh x $60 = $0	-$5

- The resource does not provide energy in real-time
  - Because RT LMP > K, the resource receives a closeout charge of $10/MWh
  - This charge reflects the cost the system incurred to replace the resource's energy in RT, but only to the extent that cost exceeds $K
  - In effect, it is 'buying out' its DA position at RT LMP – K = $10/MWh

Option Settlement Example 4: Resource doesn’t operate, Low RT LMP

- RT Energy Output = 0 MWh, RT LMP = $40/MWh < MC
- Net Settlement

DA A/S Credit	DA A/S Closeout	RT Energy Credit	Net Settlement
1 MWh x $5 = $5	1 MWh x -max(0,$40 - $50) = $0	0 MWh x $40 = $0	$5

- The resource does not provide energy in real-time
  - Because RT LMP <= K, the resource receives closeout charge of $0
  - No cost (above K) was incurred to replace the resource’s energy

COMPETITIVE DA A/S OFFERS

Competitive DA A/S offer includes competitive costs and (potentially) a risk premium

- In simple terms, we can think of a resource's competitive day-ahead ancillary service offer as having a competitive cost component and a risk premium component:
  - *Competitive DA A/S offer price = Competitive DA A/S Costs + Risk Premium*
- Two economic principles guide our thinking on determining competitive costs:
  - Competitive offer should allow a resource to recoup the expected costs of selling DA A/S
  - A resource would not offer to sell DA A/S at a price that makes them worse off, in expectation, than their next best alternative
- The volatility of a resource's net revenues depends on whether it sells DA A/S or not
  - For some, selling DA A/S may *reduce* risk

Competitive DA A/S costs and the avoidable cost framework

- The costs that a resource incurs *because* it clears for DA A/S (avoidable costs) are those that are included in the competitive DA A/S offer
  - The expected cost to close the DA A/S position is an avoidable cost for all resources that offer to sell DA A/S
  - Some resource types may incur fuel or input-energy related costs because they clear for DA A/S
- If a resource was not allowed to include avoidable costs in its competitive DA A/S offer, then selling its output in RT only could be more profitable than selling in both DA and RT
  - This could reduce the competitiveness of the DAM, and clearing prices would not reflect the true cost of meeting DA reliability needs

Risk premiums and competitive DA A/S offers

- By selling DA A/S, a resource receives a total profit that depends primarily on four factors: (i) revenue it earns from selling day-ahead ancillary services (ii) cost to settle the DA A/S position (iii) revenue from the selling energy in real time (iv) real-time production costs
- When a resource submits its DA A/S offer, there is uncertainty about what value the DA A/S closeout charge, will take
  – This uncertainty means that resource may face some (financial) risk when they sell day-ahead ancillary services
  – This risk is typically less than the financial risk from selling DA energy
- Risk premium can be viewed as additional compensation, in addition to avoidable costs, that resource needs to be willing to sell DA A/S
  – Whether DA A/S position reduces or increases volatility of total profits, relative to selling energy in RT only, depends on resource characteristics like marginal cost and likelihood of forced outage

Links to additional information on competitive DA A/S offer formulation

- See the following appendices for numerical examples that illustrate this concepts:
  - Appendix 4 provides illustration of why the expected closeout charge and avoidable input energy costs are included in a competitive offer
  - Appendix 5 provides an illustration of how a DA A/S position could reduce risk
- In general, please see the memo on Competitive Offer Price Formulations for Day-Ahead Ancillary Services as Options for detailed discussion of all topics related to competitive DA A/S offers

SUMMARY

DASI efficiently procures and prices new DA A/S products to meet DA reliability needs in-market

- DASI procures and transparently prices new DA A/S products to meet reliability needs in the DAM
  - New constraints: FER, FRS
  - New products: DA EIR, DA TMSR, DA TMNSR, DA TMOR
- DASI addresses four adverse consequences of current DAM
  - Information: resources know when they are being relied upon to satisfy DA reliability needs, because they now receive DA A/S awards
  - Inefficient DA awards: With priced DA A/S offers, both DA energy and A/S awards efficiently reflect the as-bid cost of providing each service
  - Poor price signals: clearing prices reflect the cost of meeting DA reliability needs, and reduce the need for DA uplift payments
  - Incentives: call-option settlement design provides incentives for resources to take cost-effective, reliability-improving actions

APPENDICES

Appendix outline

- Appendix 1: Additional context on adverse impacts of current DAM design
- Appendix 2: Additional context on FER/EIR clearing and pricing
- Appendix 3: Additional context on FRS clearing and pricing
- Appendix 4: Numerical example illustrating (i) incentive properties of call-option settlement design (ii) why avoidable costs are included in competitive DA A/S offer
- Appendix 5: Example illustrating how a DA A/S position could reduce risk

APPENDIX 1

Additional context on adverse impacts of current DAM

1. Information: Resources may not know when they are being counted on to provide these key reliability services

- While the ISO may rely upon a unit in its day-ahead operating plan to fill the energy gap, or for contingency response, this is not signaled to the Market Participant in a clear and transparent manner
- This lack of information may reduce efficiency and reliability if the resource would have made different arrangements with better information about its role in satisfying the DA reliability requirements

2. Inefficient DA awards due to missing DA ancillary services markets

- DAM does not consider resources’ costs associated with providing key reliability services that are (as noted earlier) required of the day-ahead operating plan
- Rather, the current practice implicitly assumes that these services can be provided **at no cost, by all resources** (or portions of resources) that have the capability to do so and that were not scheduled for DA energy
- Not including these costs in today’s DAM can produce inefficient DA awards

3. Poor price signals: Current practices send the wrong price signals and create uplift payments

- The current practice of committing resources to provide these reliability services in an unpriced manner can serve to reduce energy prices
  - This is not the economically correct price signal; when more capability needed for reliability, should result in increase in energy prices
- With reduced energy market prices and the commitment of higher-cost resources to meet day-ahead operating plan reliability requirements, there is an increased need for out-of-market uplift payments to ensure committed resources cover their costs

4. Current incentives can produce a less efficient and less reliable system

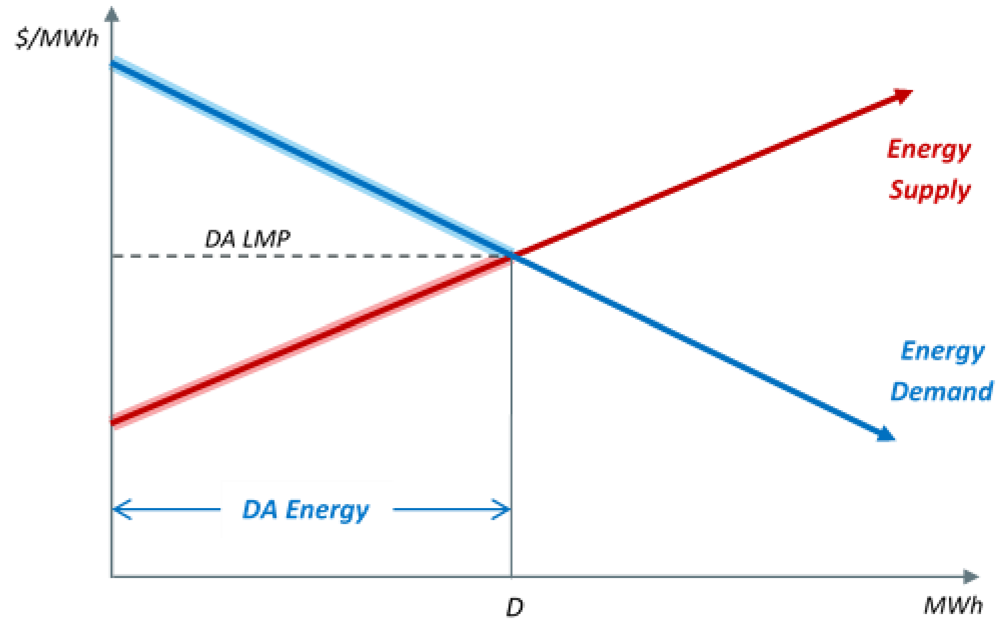
- Under current market rules, a generator that is being counted on to fill the energy gap, or to prepare for contingencies, does not fully internalize the replacement costs associated with its (potential) real-time non-performance
  - This may produce a less efficient and less reliable system due to underinvestment
- The adverse impacts of this incentive issue can extend to a broad set of resources as they undermine incentives to make a range of efficient investments in maintenance, capital expenditures, and other costly actions that improve their RT performance

APPENDIX 2:

Additional context on FER/EIR clearing and pricing

Graphical representation of DAM clearing under current market rules

- Conceptually, today's DAM clears at the point where offered supply meets bid-in demand

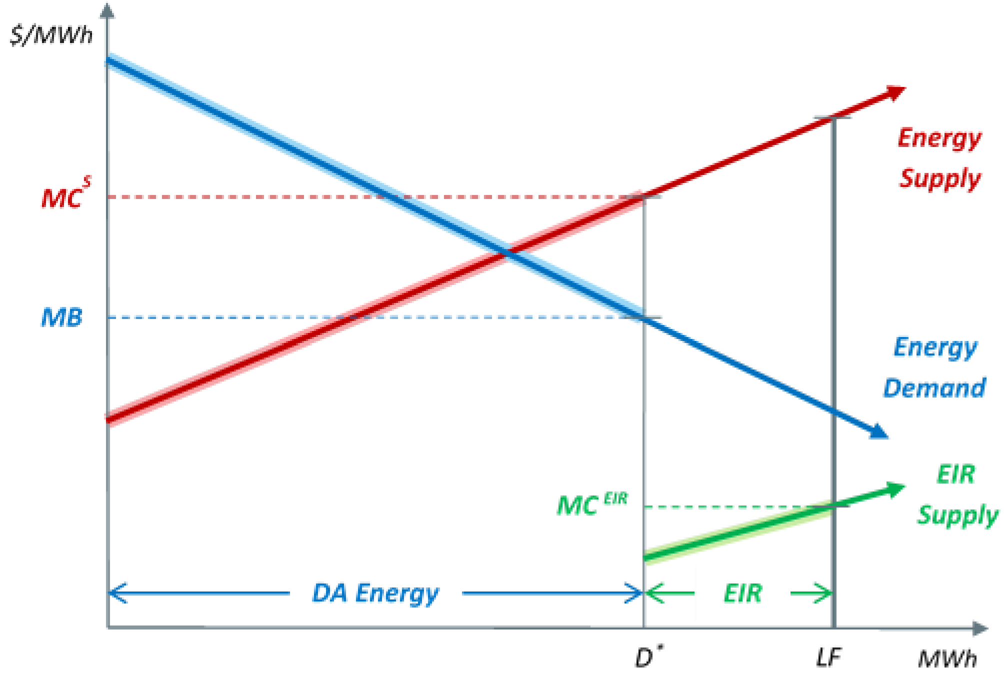


On the x axis, D represents the cleared quantity of DA energy

- The blue demand curve here is comprised of participant's demand bids
- DA LMP reflects the price at which:
  - Marginal Cost of Suppliers = Marginal Benefit of Consumers

Graphical representation of DAM clearing with FER – Cleared Quantities

- First, examine cleared quantities with two supply and two demand curves in the DAM



- (terms defined on the next slide)

Graphical representation of DAM clearing with FER – Cleared Quantities (*cont'd*)

- On the prior slide,
  - D* represents the cleared DA Energy quantity
  - EIR is cleared, beyond D*, to satisfy the load forecast (LF)
    - For convenience, the EIR supply curve is drawn starting at D*
  - MC^{S} is the marginal cost of cleared energy supply
  - MC^{EIR} is the marginal cost of cleared EIR
  - MB is the marginal benefit of serving energy demand

DAM with FER/EIR – Cleared Quantities discussion

- Cleared Physical Energy + EIR = Load Forecast
  - **More energy is cleared** with the FER applied than in the current DAM
    - D* > D
- **Note**: The DAM no longer clears where energy supply and bid-in energy demand intersect
  - The marginal cost of energy supply (MC^S) exceeds the marginal benefit of demand (MB)
  - *next slide*: How are marginal costs and marginal benefits aligned?

DAM with FER/EIR – Aligning marginal costs and marginal benefits

- With two supply curves (energy and EIR), we have two marginal costs to consider
- With the FER in place, clearing an additional MWh of energy, at the margin, incurs both a cost and a savings
  - Cost of one **more** MWh of energy
  - Savings of one **less** MWh of EIR
- MB of serving energy demand = MC of serving energy demand
  - MC of serving energy demand = MC^S - MC^{EIR}
  - MB = MC^S - MC^{EIR}

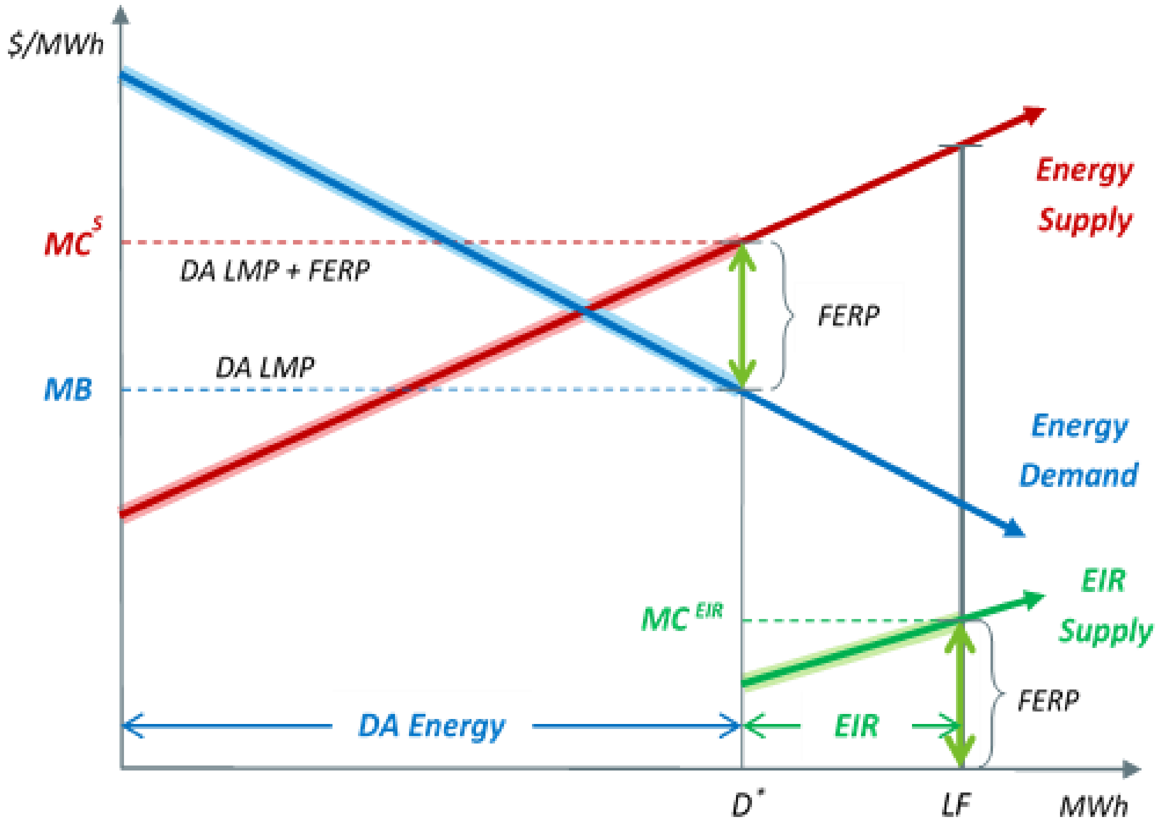
DAM with FER/EIR – Aligning marginal costs and marginal benefits (*cont'd*)

- With two supply and demand curves, efficient market clearing does not necessarily occur where supply and demand for <u>energy alone</u> intersect
  - Clearing must account for the fact that clearing one more MWh of energy means we need one less MWh of EIR
  - This occurs whenever LF is 'to the right' of the intersection of energy supply and demand
    - Under this condition, more energy will be cleared than in today's energy-only DAM (D* > D)

DAM with FER/EIR – Pricing

- As always, clearing prices reflect the incremental cost that would be incurred to satisfy one additional MWh of demand
- Bid-in Energy: clearing one more MWh of energy supply means one less MWh of EIR is needed
  - DA LMP = MC^{S} - MC^{EIR}
- Load Forecast: an additional MWh of EIR can satisfy an incremental MWh of Load Forecast
  - FER Price = MC^{EIR}
- We'll look at this pricing in the context of our clearing illustration

Graphical representation of DAM clearing with FER – Pricing



DAM with FER/EIR – Pricing Discussion

- DA LMP is the correct price for cleared DA demand
  - All cleared DA demand is willing to pay, at most, DA LMP
  - But, the DA LMP is lower than the MC of energy supply!
    - This is accounted for via the FER Price (FERP)
- When EIR is cleared, the MC of energy supply will exceed DA LMP by (precisely) the FERP
  - MC^S = DA LMP + FERP
- With the FER applied, the DAM separates the marginal cost of energy supply into two distinct price signals
  - The MC of serving DA energy demand (DA LMP)
  - The MC of satisfying the Load Forecast (FERP)

DA EIR Eligibility

- To be eligible to clear DA EIR, a resource must be a physical supply resource located within the bounds of ISO-NE
  - Virtual Supply (INCs), Imports, and Dispatchable Asset-Related Demands (DARDs) will not be able to provide EIR
- To provide DA EIR, a resource must be either committed for energy, or be a fast-start resource
  - We must be able to access its energy in real-time (RT) at the start of the hour, if the load materializes as forecast
- Resources must not be designated as constrained by transmission (as applies for reserves in RT today)

APPENDIX 3

Additional context on FRS clearing and pricing

Flexible Response Services (FRS) Eligibility

- Existing RT operating reserve eligibility criteria apply for the DA FRS products
- Resources that can provide RT operating reserves today will be able to sell FRS
  - Generators, Demand Response Resources (DRRs), DARDs

FRS Constraints and Demand Quantities

- New FRS constraints will be enforced in each hour of the DA clearing and pricing process
- Demand quantities for each constraint will be calculated within the DAM, consistent with ISO, NERC, and NPCC standards

Constraint	DA Demand Quantity Calculation
Total 10-minute	Largest Contingency MW x Non-performance factor*
Ten-Minute Spin	Total 10 Demand Quantity x TMSR %**
Total 30-minute (*step 1*)	Total 10 Demand Quantity + ½ x Second Contingency MW
Total 30-minute (*step 2*)	+ Replacement Reserve MW***

*Non-performance factor is currently set to 120%, and is reviewed quarterly
** TMSR % can range from 25% to 100%; currently, it is generally set at 25%
*** Replacement reserve MW represent the 'second step' of the two-step Total 30-minute reserve demand curve, and is set to 160 MW or 180 MW seasonally

FRS awards ‘cascade down’ to satisfy Demand Quantities

- Faster-ramping reserve awards ‘cascade down’ to satisfy less restrictive demand quantities
- This cascading is identical to that in effect for RT reserves today

Constraint	Satisfied by Total DA Awards of:
Ten-Minute Spin	TMSR
Total 10	TMSR + TMNSR
Total 30	TMSR + TMNSR + TMOR

FRS prices 'cascade up', following the participation payment principle

- FRS clearing prices 'cascade up' from slowest-ramping products to fastest-ramping products
  - Product clearing price is equal to the sum of all shadow prices (SPs) of the constraints to which that product contributes (just as real-time reserve pricing works today)
  - This satisfies the participation payment principle

Award Quantity (MWh)	Clearing Price = sum of constraint SPs ($/MWh)
TMSR	$SP_{TenSpin} + SP_{Tot10} + SP_{Tot30}$
TMNSR	$SP_{Tot10} + SP_{Tot30}$
TMOR	SP_{Tot30}

Reserve Constraint Penalty Factors (RCPFs)

- FRS constraint RCPFs correspond with those that exist in real-time today
- FER constraint RCPF is proposed to be 101% of the sum of FRS RCPFs
  - The intent is to ensure that satisfying the FER is prioritized above satisfying FRS requirements

Constraint	**RCPF ($/MWh)**
Ten-Minute Spin	$50
Total 10	$1,500
Total 30 (*step 1*)	$1,000
Total 30 (*step 2*)	$250
FER	$2,575

APPENDIX 4

Illustration of incentive properties of call option design and why avoidable costs are included in competitive DA A/S offer

Example Overview

- In this example, Resource A is making an input energy acquisition decision in the day-ahead timeframe
  - This represents a costly decisions in advance of real-time that impact its ability to provide energy in real-time
- We'll examine four states of the world, considering two variables:
  - **Costly Action**: The resource can choose whether or not to take a costly action, in advance of real-time, that improves its ability to provide RT energy
  - **RT Energy Demand**: Demand in real-time can be high or low, which affects the RT LMP and whether the unit would be in merit for energy dispatch

Example Overview (*cont'd*)

- With regards to incentives, this example illustrates:
  - Misaligned incentives exist under the current design, as the resource prefers not to invest, even though society is better off if it does because the investment would be cost-effective from the system's standpoint
  - Incentives are aligned with the call-option settlement design, because the resource's private incentive is then to invest, and society is better off as a result
- With regards to competitive DA A/S offers, this example illustrates:
  - If the expected cost to close the energy call option and the avoidable input energy cost are not included in the offer, the resource would be better off not clearing for DA A/S

Example A – Set-up

- Resource A can procure input energy in the DA timeframe at a cost
  - If it procures input energy DA, it can operate in real-time, whereas if it does not, it cannot
  - If it is not dispatched (low demand), it will have unrecovered costs

	Advance Input Energy		No Advance Input Energy	
Concept	**High Demand**	**Low Demand**	**High Demand**	**Low Demand**
Unrecovered Input Energy Cost ($/MWh)	-	$40	-	-
Incurred Marginal Cost ($/MWh)	$80	-	-	-
RT LMP ($/MWh)	$80	$60	$180	$60
Scenario Likelihood	50%	50%	50%	50%

- **Key Point**: society is better off by $30/MWh, in expectation, if Resource A procures input energy DA (details in Appendix)
  - That is, ($180 - $80) × 50% - $40 × 50% = $30
- *Next*: Under current market rules, does Resource A want to make the investment?

Example A – Under current rules, market provides Resource A no incentive to make arrangements

Concept		Calculation	Advance Input Energy		No Advance Input Energy	
			High Demand	Low Demand	High Demand	Low Demand
Resource A's Settlement						
[1]	Day Ahead Energy Credit		-	-	-	-
[2]	Real Time Energy Credit		$80	-	-	-
[3]	Total Settlement	[1]+[2]	$80	-	-	-
Resource A's Incurred Costs						
[4]	Unrecovered Input Energy Cost ($/MWh)		-	-$40	-	-
[5]	Marginal Cost		-$80	-	-	-
[6]	Total Cost	[4]+[5]	-$80	-$40	-	-
Resource A's Net Revenue						
[7]	Scenario Net Revenue	[3]+[6]	-	-$40	-	-
[8]	Scenario Likelihood		50%	50%	50%	50%
[9]	Expected Net Revenue	sumprod([7],[8])	**-$20.00**		**$0.00**	

Example A – Under current rules, market provides Resource A no incentive to make arrangements (*cont'd*)

- Under current market rules, resource A clears no DA award (there are no DA A/S) and receives no DA revenue
- If it arranges input energy, it incurs a cost in the day-ahead timeframe
  - If demand is high and it operates in real-time, it sets RT LMP at its marginal cost of $80 and breaks even (its revenues offset its costs)
  - If demand is low, it does not operate, and has unrecovered costs of $40
  - As a result, its expected net revenue is -$20
- If it arranges no input energy, it does not operate
  - It incurs no costs, and receives no revenues
- From Resource A's perspective, its private financial interest is best served when it does not make DA input energy arrangements
  - Misaligned incentive: this is in spite of the fact that society would be better off if it did
  - *Next*: If it sells DA A/S that settle as call options, are incentives aligned?

Example A – DA A/S award, settled as call option, provides the appropriate incentive

- Assume:
  - K = Expected RT LMP = $70/MWh
  - DA A/S award has some (currently unspecified) clearing price $P^o > 0$

Concept		Calculation	Advance Input Energy		No Advance Input Energy	
			High Demand	Low Demand	High Demand	Low Demand
Resource A's Settlement						
[1]	DA A/S Credit		P^o	P^o	P^o	P^o
[2]	Real Time Energy Credit		$80	-	-	-
[3]	DA A/S Closeout	max([RTLMP - K],0)	-$10	-	-$110	-
[4]	Total Settlement	[1]+[2]+[3]	P^o + $70	P^o	P^o - $110	P^o
Resource A's Cost						
[5]	Unrecovered Input Energy Cost ($/MWh)		-	-$40	-	-
[6]	Marginal Cost		-$80	-	-	-
[7]	Total Cost	[5]+[6]	-$80	-$40	-	-
Resource A's Net Revenue						
[8]	Scenario Net Revenue	[4]+[7]	P^o - $10	P^o - $40	P^o - $110	P^o
[9]	Scenario Likelihood		50%	50%	50%	50%
[10]	Expected Net Revenue	sumprod([8],[9])	P^o - $25		P^o - $55	

Example A – DA A/S award, settled as call option, provides the appropriate incentive (*cont'd*)

- Resource A faces a steep incremental replacement cost if it does not procure input energy DA and cannot operate when demand is high (recall, RT LMP in this case is $180)
- Resource A now is better off, by $30, if it makes advance arrangements for input energy
  - Note that this is precisely equal to the benefit to society of such arrangements (from slide 19)
  - This is why the call option *efficiently* addresses today's misaligned incentives
- *Next*: What value of P^o would Resource A require to break even (in expectation) from selling DA A/S?

Example A – Resource A's break-even DA A/S offer price

- Recall that, under current rules, Resource A's best possible expected net revenue was \$0
  - This occurs when it does not arrange input energy, and therefore cannot operate
- With DASI, it can achieve the same expected net revenue if it sells DA A/S and arranges input energy, so long as the clearing price satisfies: P^o - \$25 >= \$0, or P^o >= \$25
  - This "break-even" price level reflects both the expected closeout charge (\$5) in the 'advance input energy' scenario, and Resource A's expected cost of unused input energy (\$40 x 50% = \$20)
    - See slide 22, last row
  - At clearing prices below \$25, Resource A would be better off, in expectation, not clearing for DA A/S
  - For this reason, we would not expect Resource A to offer below this break-even price. In other words, we expect Resource A to include the expected closeout charge and avoidable input costs in its competitive offer.

Example A - Key Takeaways

- Society is better off if Resource A makes advance input energy arrangements, but current market rules don’t provide appropriate incentives for those arrangements
  - Society is $30 better off, in expectation, if such arrangements are made because we avoid higher replacement energy costs in the high demand state
  - Under current rules, Resource A would not make such arrangements because it does not internalize these high replacement costs
- Clearing DA A/S awards, and settling as call options, aligns these incentives
  - Resource A now internalizes these high replacement costs in the high demand state and therefore has efficient incentives to arrange input energy
  - Society is better off as a result

APPENDIX 5

Example illustrating how a DA A/S position can reduce risk

Example assumptions

- This example builds on the framework used in Examples 1 and 2 (slides 30 and 31)
- Assumptions:
  - If resource sells DA A/S, it sells 1 MWh and the clearing price is $5/MWh
    - This is its only DA position
  - Strike Price (K) = $50/MWh
  - Resource's marginal cost is $30/MWh
  - In Real-Time, demand can be high or low, with equal probability
  - If demand is high, the RT LMP = $60/MWh
  - If demand is low, the RT LMP is $30/MWh

Expected net revenues and volatility of net revenues when resource sells energy in RT only

- In each RT demand scenario, the resource's net revenue is equal to the RT LMP minus the resource's marginal cost
  - The table below summarizes the resource's expected net revenue from selling energy in RT only ($20.00) and the standard deviation of the resource's net revenues when it sells energy in RT only ($10.00)

			RT demand	
		Calculation	High	Low
[1]	Scenario likelihood		0.5	0.5
[2]	RT LMP		60	40
[3]	MC		30	30
[4]	Scenario net revenue	[2] - [3]	30	10
[5]	Expected net revenue	sumprod([1], [4])	$ 20.00	
[6]	Standard deviation	stdev.p([4])	$ 10.00	

Expected net revenues and volatility of net revenues when resource sells DA A/S and energy in RT

- In each RT demand scenario, the resource's net revenue is equal to the DA A/S revenue, plus the RT LMP minus the DA A/S closeout charge, minus the resource's marginal cost
  - The table below summarizes the resource's expected net revenue from selling DA A/S and energy in RT ($20.00) and the standard deviation of the resource's net revenues when it sells DA A/S and energy in RT ($5.00)

			RT demand	
		Calculation	High	Low
[1]	Scenario likelihood		0.5	0.5
[2]	DA A/S revenue		5	5
[3]	RT LMP		60	40
[4]	DA A/S closeout charge		10	0
[5]	MC		30	30
[6]	Scenario net revenue	[2] + [3] - [4] -[5]	25	15
[7]	Expected net revenue	sumprod([1], [6])	$ 20.00	
[8]	Standard deviation	stdev.p([6])	$ 5.00	

Discussion

- The resource has the same expected net revenue when it sells DA A/S and energy in RT as when it sells energy in RT only ($20.00)
- However, the standard deviation of the resource's net revenues drops from $10.00 when it sells energy in RT only to $5.00 when the resource sells DA A/S and energy in RT
- Selling DA A/S "smooths" the resource's net revenues (they change less as the RT LMP changes), while preserving the same expected profit
- While we expect DA A/S participation to de-risk energy and A/S market participation for many resources, a resource with a higher marginal cost or higher likelihood of forced outage (which we ignored in this example) could face higher risk from selling DA A/S
  - For additional discussion, please see the November 2022 NEPOOL Markets Committee presentation and the competitive offer memo