Day-Ahead Market discussion

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Sr. Market Design Policy Developer

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Market Surveillance Committee Meeting
General Session
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Agenda

Item	Time	Presenter
Defining the Problem Statement	10:10 – 10:30	Megan Poage
Market Formulations	10:30 – 11:15	George Angelidis
Deliverability	11:15 – 11:30	George Angelidis
Discussion	11:30 – 12:00	MSC

Day-Ahead Market Enhancements

DEFINING THE PROBLEM STATEMENT

Megan Poage
Sr. Market Design Policy Developer
Market Design Policy

Previous stakeholder call announced cancellation of 15-minute scheduling

- ISO has ceased work on 15-minute scheduling granularity
  - Cost/benefit ratio minimized due to:
    - hourly unit commitment, and
    - uncertainty of scheduling 15-minute external resources
- DAME will proceed (without phases) for implementation in Fall 2021

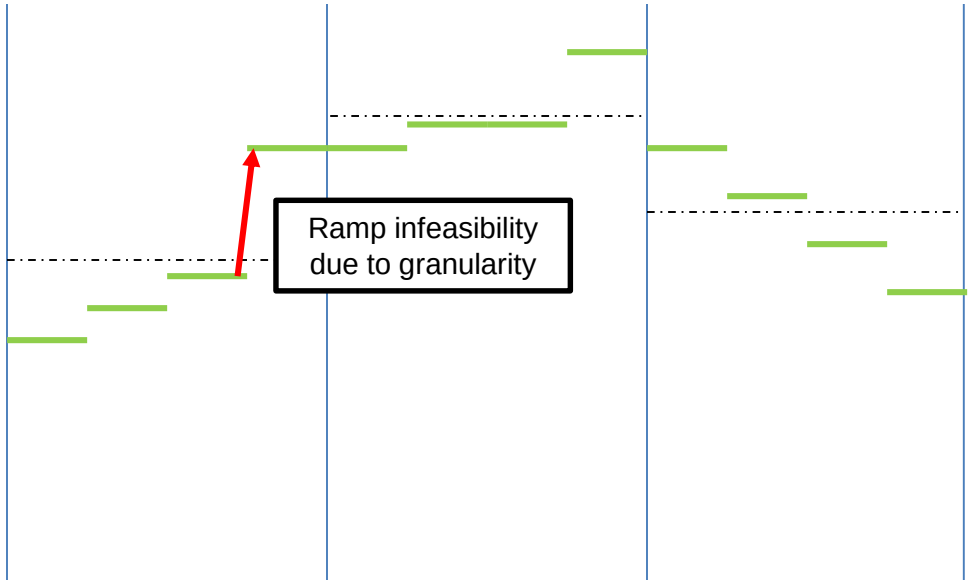
DAME solution needs to address the following operational needs

1. RAMPING NEEDS - Steep differences between 15-minute intervals (granularity differences) may result in 15-minute ramp infeasibilities due to mid-point to mid-point hourly schedules

2. NET LOAD UNCERTAINTY – The need for dispatchable generation to meet changes in the net load forecast (deviations due to load and renewables)

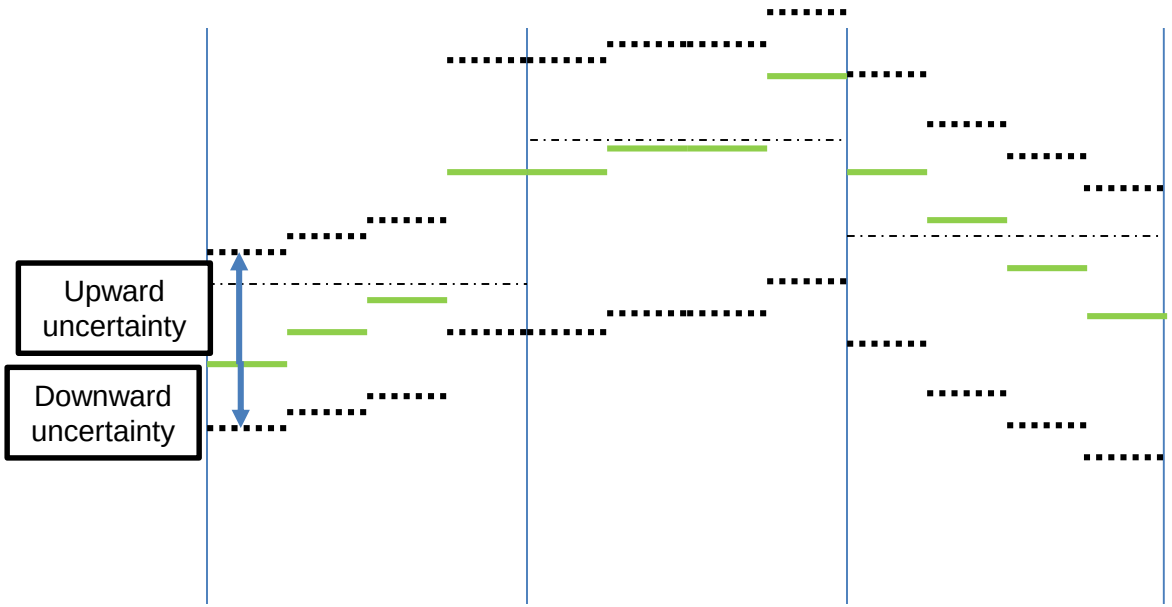
3. DELIVERABILITY – New product must be deliverable where it is needed

RAMPING NEEDS - Steep differences between 15-minute intervals (granularity differences) may result in 15-minute ramp infeasibility due to mid-point to mid-point hourly scheduling



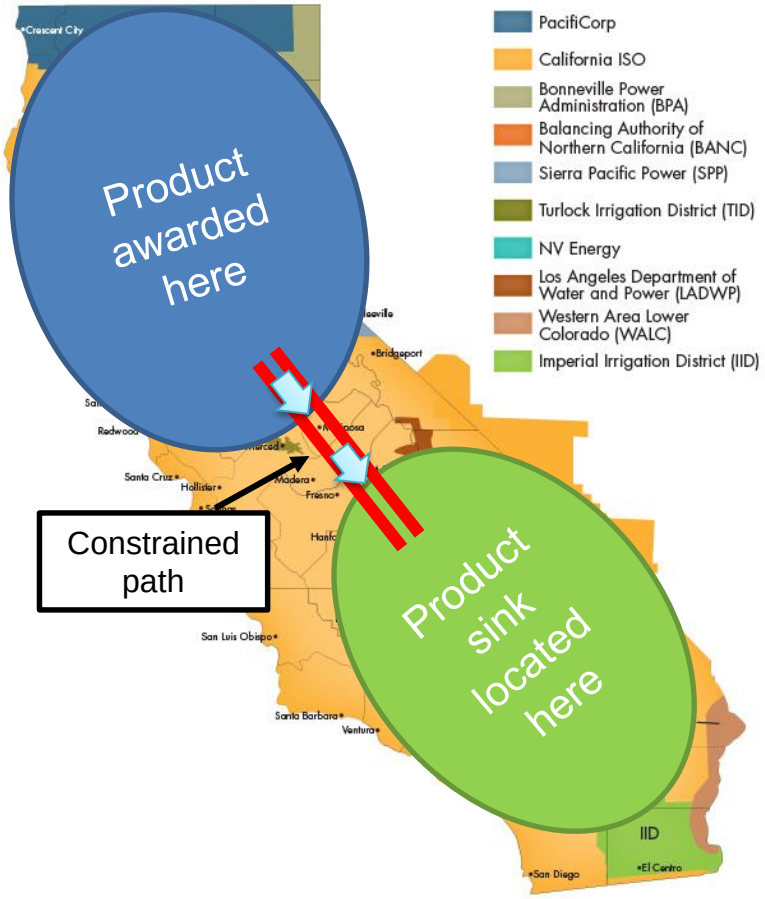
Even assuming we have perfect knowledge, the market still produces a schedule that cannot meet a single 15-minute interval ramping need due to hourly scheduling granularity.

NET LOAD UNCERTAINTY – The need for dispatchable generation to meet changes in the net load forecast (deviations due to load and renewables)



Even assuming we produce a 15-minute forecast in the day-ahead timeframe, there will be uncertainty in how much dispatchable generation is needed to meet net load.

DELIVERABILITY – New product must be deliverable where it is needed



Even if the system-wide requirement is procured, product must be deliverable (export one region and import to another) where it is needed

Operations needs the ability to address the following in the day-ahead timeframe:

1. 15-minute ramp needs due to granularity differences
   – Currently not explicitly modeled
2. Uncertainty in how much dispatchable generation is needed to meet net load
   – Currently modeled approximately by RUC net short
3. Need to ensure product deliverability
   – Currently addressed at a BAA system level with net import/export constraints

Day-Ahead Market Enhancements

MARKET FORMULATIONS

George Angelidis
Principal
Power Systems Technology Development

Day-Ahead Market Enhancements Design Options

- Sequential IFM-RDA
  - 3 Passes: MPM, IFM, RDA (post-DAM tool)
  - Hourly intervals
  - Energy, AS, FRP
  - Regional deliverability constraints
  - Additional RDA unit commitment and Exceptional Dispatch
- Integrated IFM-RUC
  - 2 Passes: MPM, IFM-RUC
  - Hourly intervals
  - Energy, AS, FRP
  - Regional deliverability constraints
  - Reliability Capacity Up/Down (RCU/RCD) priced at FRP bids

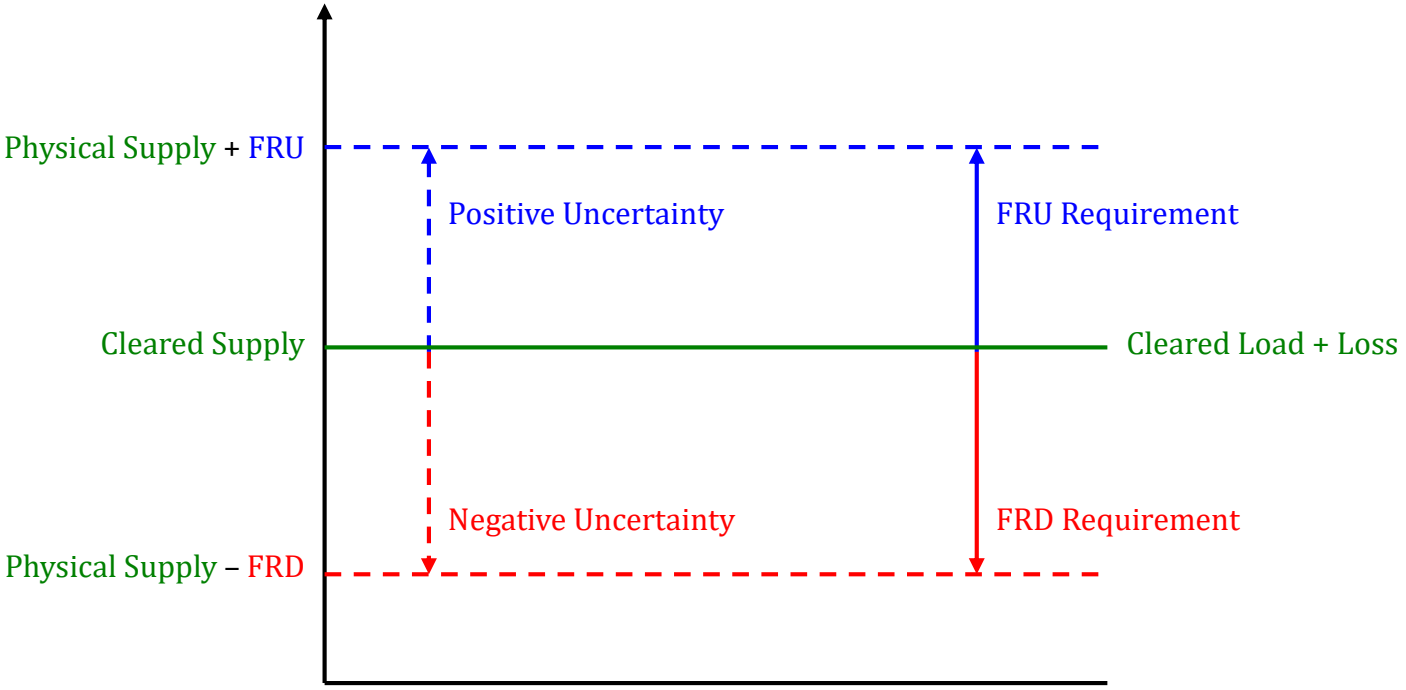
FRP in Sequential IFM-RDA

- Reserved up/down ramp capability between hourly day-ahead energy schedules
  - For granularity differences between DAME and FMM
  - For up/down uncertainty between physical/virtual supply schedules in DAME and the FMM demand forecast
- 15min product procured hourly in DAME
- Has a Must Offer Obligation for FMM
- Expires in FMM (no deviation to RTM FRP)

FRP in Integrated IFM-RUC

- Reserved up/down ramp capability between hourly reliability energy schedules
  - For granularity differences between DAME and FMM
  - For up/down uncertainty between the DAME demand forecast and the FMM demand forecast
- 15min product procured hourly in DAME
- Has a Must Offer Obligation for FMM
- Expires in FMM (no deviation to RTM FRP)

Sequential IFM-RDA Targets



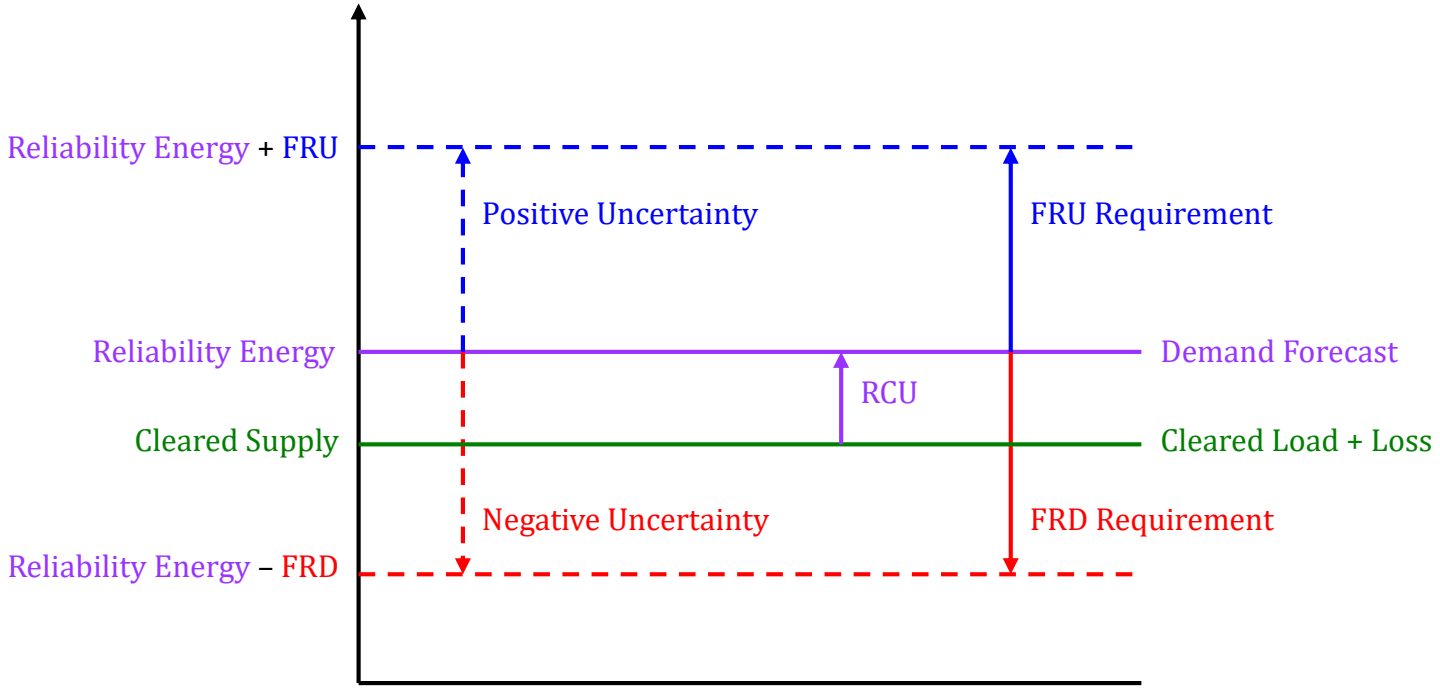
Sequential IFM-RDA Constraints

$$\sum_i EN_{i,t} + \sum_i VS_{i,t} = \sum_i VD_{i,t} + \sum_i L_{i,t} + Loss_t \quad \lambda_t$$

$$\sum_i FRU_{i,t} \geq FRUR_t \quad \rho_t$$

$$\sum_i FRD_{i,t} \geq FRDR_t \quad \sigma_t$$

Integrated IFM-RUC Targets



Integrated IFM-RUC Constraints

$$\sum_i EN_{i,t} + \sum_i VS_{i,t} = \sum_i VD_{i,t} + \sum_i L_{i,t} + Loss_t \quad \lambda_t$$

$$\sum_i REN_{i,t} = \sum_i \left(EN_{i,t} + RCU_{i,t} - RCD_{i,t}\right) = D_t \quad \xi_t$$

$$\sum_i FRU_{i,t} \geq FRUR_t \quad \rho_t$$

$$\sum_i FRD_{i,t} \geq FRDR_t \quad \sigma_t$$

Integrated IFM-RUC Objective Function

- Unit Commitment costs
  - Start-Up, Minimum Load, State Transition costs
- Incremental energy costs for Energy schedules
- Ancillary Services costs at AS bids
- Flexible Ramp Up/Down costs at FRP bids

$$\sum_t \sum_i \left(FRU_{i,t}\, FRUP_{i,t} + FRD_{i,t}\, FRDP_{i,t} \right)$$

- Reliability Capacity Up/Down costs at FRP bids

$$\sum_t \sum_i \left(RCU_{i,t}\, FRUP_{i,t} + RCD_{i,t}\, FRDP_{i,t} \right)$$

$$REN_{i,t} - EN_{i,t} \leq RCU_{i,t}$$

$$EN_{i,t} - REN_{i,t} \leq RCD_{i,t}$$

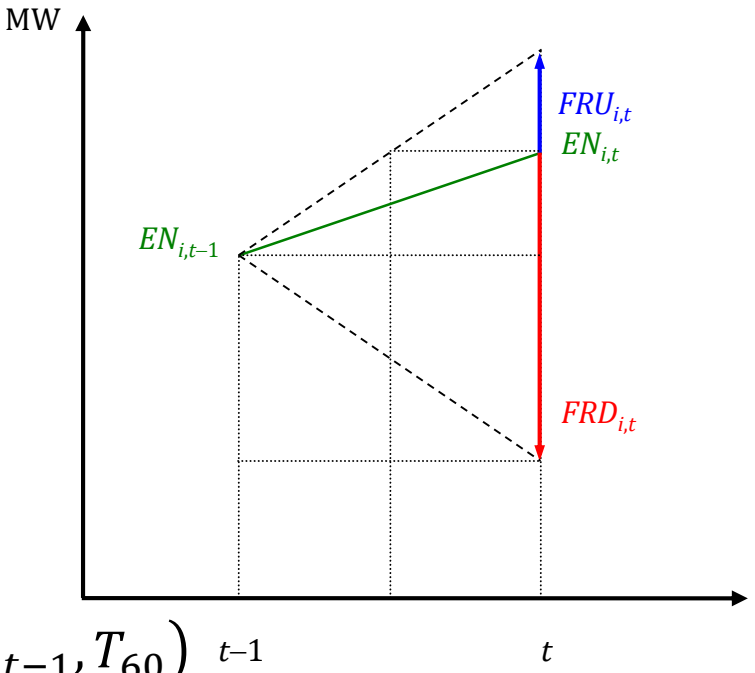
Integrated IFM-RUC
Capacity and shared ramping constraints

- FRU/FRD feasible with both Energy/Reliability schedules
- Capacity Constraints

$$EN_{i,t} + FRU_{i,t} \leq UEL_{i,t}$$
$$EN_{i,t} - FRD_{i,t} \geq LEL_{i,t}$$
$$REN_{i,t} + FRU_{i,t} \leq UEL_{i,t}$$
$$REN_{i,t} - FRD_{i,t} \geq LEL_{i,t}$$

- Shared Ramping constraints

$$EN_{i,t} + FRU_{i,t} \leq EN_{i,t-1} + RRU_i\left(EN_{i,t-1}, T_{60}\right)$$
$$EN_{i,t} - FRD_{i,t} \geq EN_{i,t-1} - RRD_i\left(EN_{i,t-1}, T_{60}\right)$$
$$REN_{i,t} + FRU_{i,t} \leq REN_{i,t-1} + RRU_i\left(REN_{i,t-1}, T_{60}\right)$$
$$REN_{i,t} - FRD_{i,t} \geq REN_{i,t-1} - RRD_i\left(REN_{i,t-1}, T_{60}\right)$$



Sequential/Integrated IFM-RUC Settlement

- Supply
  - $-EN_{i,t}\ \lambda_t, t = 1,2, \dots, T_D$
  - $-VS_{i,t}\ \lambda_t, t = 1,2, \dots, T_D$
- Demand
  - $+VD_{i,t}\ \lambda_t, t = 1,2, \dots, T_D$
  - $+L_{i,t}\ \lambda_t, t = 1,2, \dots, T_D$
- FRP
  - $-FRU_{i,t}\ \rho_t, t = 1,2, \dots, T_D$
  - $-FRD_{i,t}\ \sigma_t, t = 1,2, \dots, T_D$
- Reliability Energy
  - $-REN_{i,t}\ \xi_t = -\left(EN_{i,t} + RCU_{i,t} - RCD_{i,t}\right)\xi_t, t = 1,2, \dots, T_D$
- Marginal loss over-collection (to measured demand)
- Congestion revenue (to CRRs)

Day-Ahead Market Enhancements

DELIVERABILITY CONSTRAINT

George Angelidis
Principal
Power Systems Technology Development

Regional requirements will ensure deliverability for the new day-ahead product

- Regional requirements to distribute a portion of the overall requirement across each balancing authority area
  - Similar to ancillary services, this approach will provide sufficient confidence that the new product can be dispatched in subsequent intervals

- Establish upward and downward constraints for each region to insure that day-ahead AS and the new product are deliverable
  - Includes consideration for import/export simultaneous regional transfer capability

Day-Ahead market formulation and procurement of the new day-ahead product ensures deliverability

- Day-ahead market will co-optimize procurement of energy, AS and new product
- Constraints modeled to ensure deliverability between regions
- Minimizes costs associated with procurement of the new day-ahead product

Sequential IFM-RDA
Regional Deliverability Constraints

$$\left.\begin{aligned}
&\max\left(0, \sum_{i \in S_r}\left(EN_{i,t} - L_{i,t}\right) + \sum_{j \in S_r}\left(EN_{j,t} - L_{j,t}\right) - Loss_{r,t}\right) + \\
&\qquad \max\left(0, \sum_{i \in S_r} ASU_{i,t} - ASUR_{r,t}\right) + \\
&\max\left(0, \sum_{i \in S_r} FRU_{i,t} - FRUR_{r,t}, FRDR_{r,t} - \sum_{i \in S_r} FRD_{i,t}\right) \leq NEL_{r,t} \\
&\max\left(0, \sum_{i \in S_r}\left(L_{i,t} - EN_{i,t}\right) + \sum_{j \in S_r}\left(L_{j,t} - EN_{j,t}\right) + Loss_{r,t}\right) + \\
&\qquad \max\left(0, \sum_{i \in S_r} RD_{i,t} - RDR_{r,t}\right) + \\
&\max\left(0, \sum_{i \in S_r} FRD_{i,t} - FRDR_{r,t}, FRUR_{r,t} - \sum_{i \in S_r} FRU_{i,t}\right) \leq NIL_{r,t}
\end{aligned}\right\}, \forall r > 0 \wedge t = 1, \ldots, T_D$$

Integrated IFM-RUC
Regional Deliverability Constraints

$$\left.\begin{aligned}
&\max\left(0, \sum_{i \in S_r} REN_{i,t} - D_{r,t}\right) + \\
&\max\left(0, \sum_{i \in S_r} ASU_{i,t} - ASUR_{r,t}\right) + \\
&\max\left(0, \sum_{i \in S_r} FRU_{i,t} - FRUR_{r,t}, FRDR_{r,t} - \sum_{i \in S_r} FRD_{i,t}\right) \leq NEL_{r,t} \\
&\max\left(0, D_{r,t} - \sum_{i \in S_r} REN_{i,t}\right) + \\
&\max\left(0, \sum_{i \in S_r} RD_{i,t} - RDR_{r,t}\right) + \\
&\max\left(0, \sum_{i \in S_r} FRD_{i,t} - FRDR_{r,t}, FRUR_{r,t} - \sum_{i \in S_r} FRU_{i,t}\right) \leq NIL_{r,t}
\end{aligned}\right\}, \forall r > 0 \wedge t = 1, \ldots, T_D$$

Day-Ahead Market Enhancements

DISCUSSION

The ISO is seeking input on the following:

- Sequential IFM & RDA
  - PROs
  - CONs
- Integrated IFM & RUC
  - PROs
  - CONs
- Other items for consideration