PROGRESS UPDATE: OPTIMIZATION OF ENERGY LIMITED RESOURCES

Stakeholder Engagement Session 7

July 19, 2018

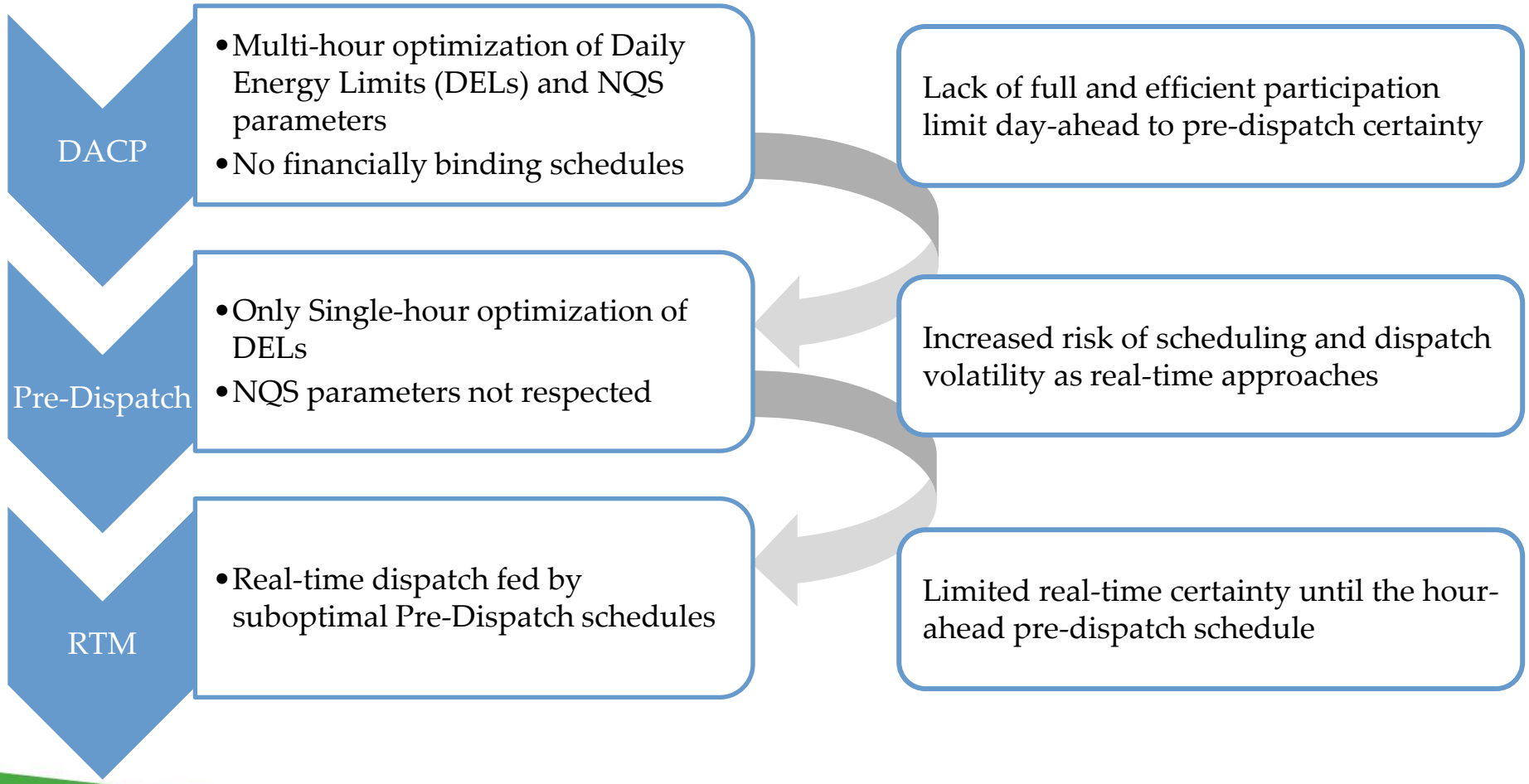
ieso
Connecting Today.
Powering Tomorrow.

Recap from May Meeting

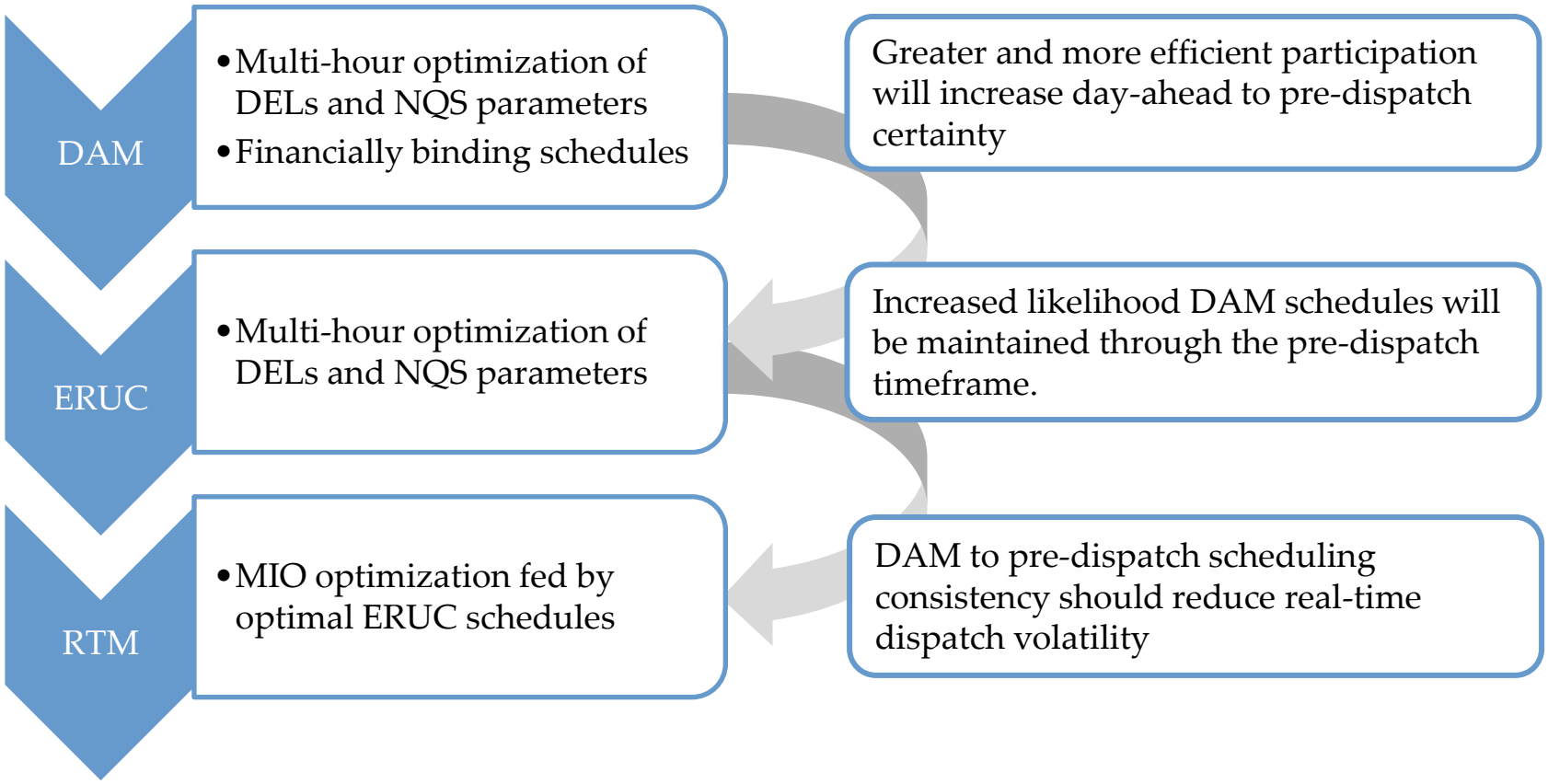
- In lieu of an ELR resubmission window in the DAM, additional operating characteristics may need to be respected in the DAM to increase the likelihood of cascade hydro resources receiving a feasible day-ahead schedule.

- Additional hydro operating characteristics would also need to be respected by the new pre-dispatch (i.e. ERUC) to maintain scheduling certainty and efficiency as real-time approaches
  - Ignoring additional operating characteristics in pre-dispatch would introduce similar issues experienced with today's pre-dispatch

Today's Scheduling



Tomorrow's Improved Scheduling



Further Improvements may be Required

If system conditions were constant → DAM Schedules = Pre-Dispatch (ERUC) Schedules = Real-Time Dispatches

Because they are not constant → Additional constraints may be required to increase the likelihood of hydro receiving optimal DAM and ERUC schedules

Objectives for Today's Session

- Today's session will update stakeholders on preliminary discussions held with hydro resources to:
  - Better understand their operating characteristics; and
  - Determine whether these characteristics could be represented by commonly used solution parameters to improve hydro-electric operational efficiency and preserve hydro-electric scheduling flexibility.

Scope of Preliminary Discussions

- Parameters commonly used in DACP and other DAMs that could be used to reflect hydro-electric operating characteristics were explored:
  - Typical NQS resource parameters (e.g. MLP, MGBRT)
  - Daily energy limits (DEL)
  - Block offers: MW blocks offered at a price for a specified number of hours (e.g. 100 MW @ $50 for 4 hours)
  - Linked offers: linking PQ pairs for two or more resources such that evaluation of one resource depends on the scheduling of others

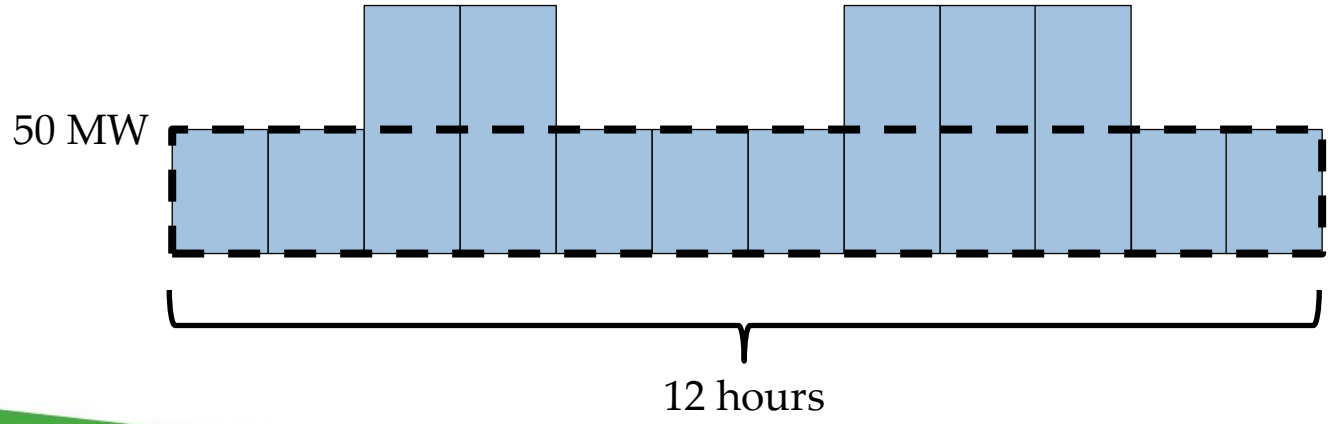
- Feasibility assessments were performed for each parameter (discussed next)

Results of Preliminary Discussions

Hydro Operating Characteristics	Commonly Used Solution Parameters	Feasibility Assessment	
• Minimum flow requirements • Maximum flow requirements • Intertemporal dependencies • Energy limitations	Minimum Loading Points	☑	Could be used to reflect must run requirements
	Minimum Run Times		
	Minimum Down Times	☑	Either can reflect physical start/stop limitations, however maximum starts per day may be more efficient
	Maximum Starts per Day		
	Daily Energy Limits (DELs)	☑	More efficient with ability to specify multiple DELs for a single resource
	Linked Offers (linking PQ pairs)	☑	Can effectively manage intertemporal dependencies
	Block Offers	⚠	• Offer structure different from existing PQ pair structure • Not proven in markets that co-optimize energy and reserve

Min Loading Points and Min Run Times

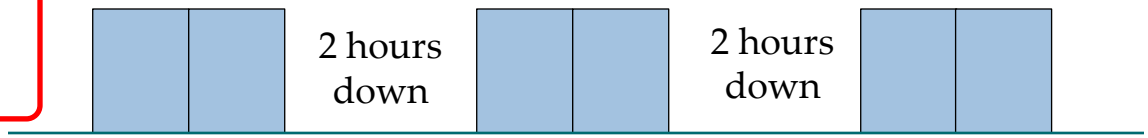
- These parameters could be used to represent minimum physical requirements
  - For example, a hydro-electric resource may need to run at a 50 MWs for 12 hours
  - Could be used to ensure the resource is not scheduled below these requirements
  - Typically enforced across all timeframes, including real-time dispatch



Max Starts/Day vs. Min Down Times

- These parameters could also be used to represent minimum physical requirements
  - For example, a hydro-electric resource may be restricted in the number of times it can cycle above and back to 0 MW
  - Specifying minimum down times could be effective if the participant wanted to ensure a specific start/stop sequence

Max 3 starts/day respected via down times



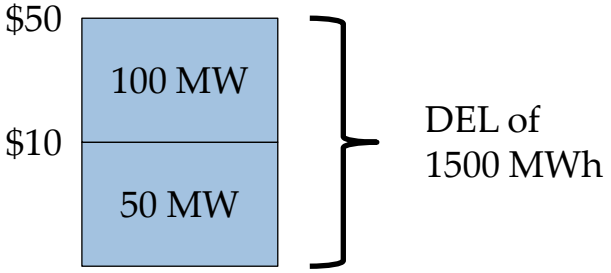
  - However, if the participant was indifferent as to when the resource was scheduled to run above 0 MW, the optimization engine could make more efficient use of the resource over the course of the day

Max 3 starts/day still respected

Multiple Daily Energy Limits per Resource

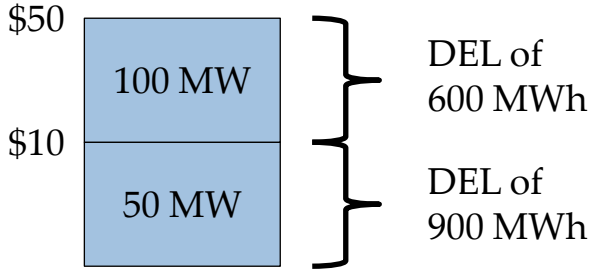
- Current DEL parameter is specified for a resource's entire offer curve
- This results in over scheduling of water priced at $10 based on the example below

OFFERED ENERGY



Hours 1 through 24

AVAILABLE ENERGY



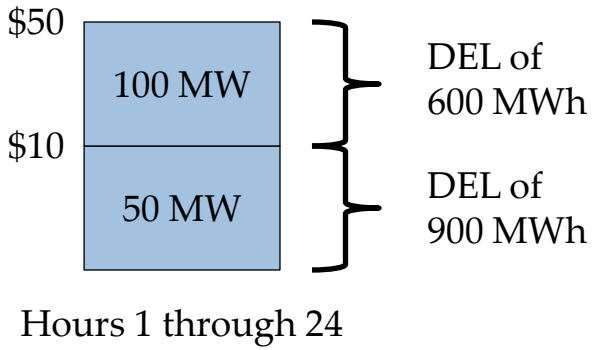
Hours 1 through 24

- Pre-Dispatch could schedule all 24 hours at 50 MW = 1200 MW which is less than the total DEL of 1500 MWh, but more than actual availability of 900 MWh of the water priced at $10

$10	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
HE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

Multiple Daily Energy Limits per Resource

- Managing multiple DELs for different opportunity costs of water will result in an accurate representation of costs and overall optimization of all resources

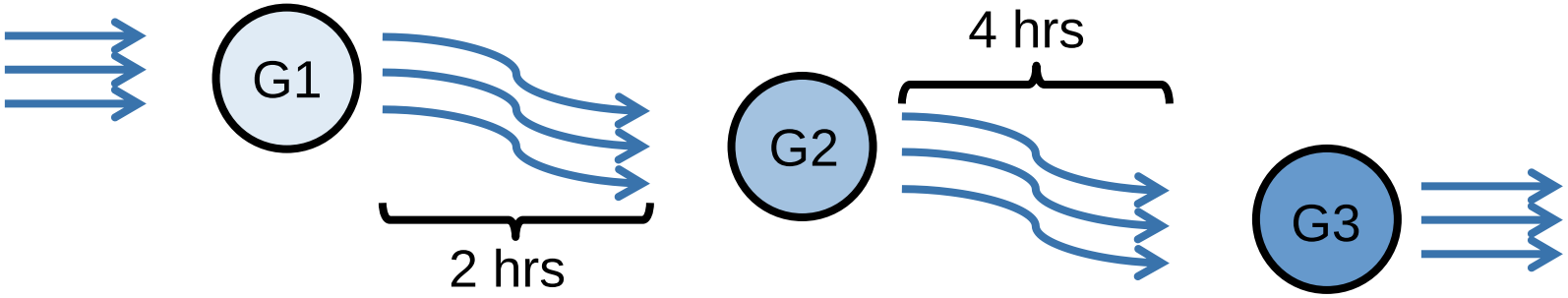


- Pre-Dispatch will only schedule the water at $10 for the 900 MWh and then optimize around all other resources to determine if $50 water is necessary or if there are other options available

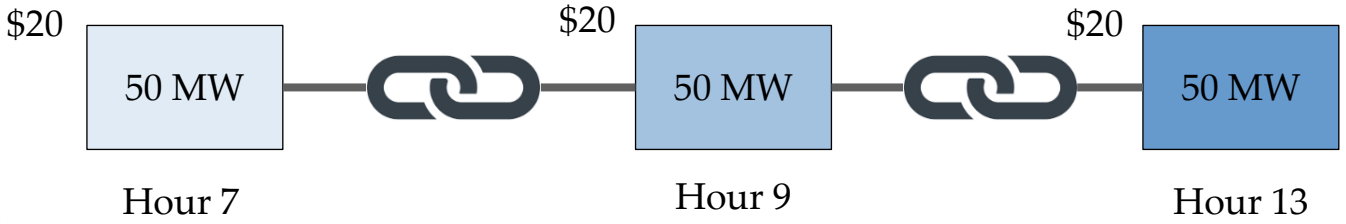
$50										50	50						50	50	50	50				
$10	0	0	0	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	0	0	0
HE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

Linked Offers

- Cascade hydro systems have intertemporal dependencies that govern output between resources on a cascade

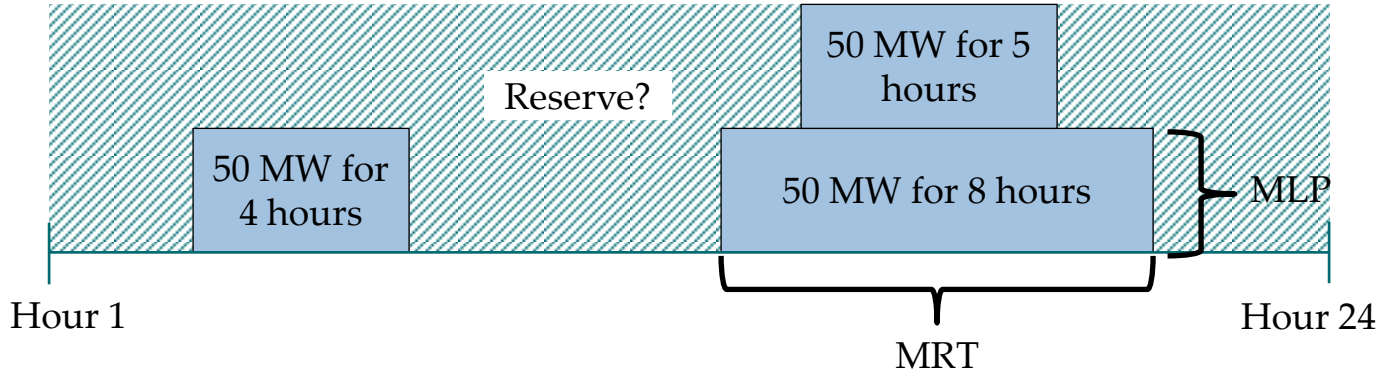


- Linked offers would provide hydro-electric participants with the ability to specify G1 must first be economic for G2 and G3 offers to be considered



Block Offer Model

- Block offers could make for very efficient scheduling
  - Offer parameters could capture minimum loading points, minimum run times, and manage multiple daily energy limits per resource



- However, because this offer structure is different from the existing PQ pair structure used today, IESO is uncertain as to:
  - How operating reserve could also be offered and co-optimized with corresponding energy offers as it is only known to be used for optimization of energy schedules in other jurisdictions; and
  - How block offers would be dispatched in real-time

Results of Preliminary Discussions

- Combining these solution parameters into a single hydro-electric optimization model could allow for a more complete representation of hydroelectric resources in DAM
  - However there is a risk that simply combining existing solutions could reduce the overall efficiency of the optimization engine

- Rather than combining solutions, IESO believes a better approach would be to establish hydro electric modelling requirements and consult with a vendor on the best way to meet those requirements

Potential Software Requirements Developed to Date

- Ability to manage must run conditions
- Ability to limit the number of resource starts
- Ability to respect intertemporal dependencies between two or more resources on a cascade system
- Ability to specify multiple daily energy limits to represent quantities of water with different opportunity costs
- Maintain ability for hydro resources to provide monotonically increasing offers (i.e. PQ pairs)
- Maintain ability for hydro-electric resources to be co-optimized for energy and operating reserve, and continue to be scheduled for reserve during 0 MW energy schedules.

Next Steps

- August meeting with the broader hydro community to:
  - Discuss the proposed requirements for DAM and add/modify as required
  - Discuss to what extent these requirements would also be modelled in pre-dispatch
  - Discuss how pre-dispatch schedules interact with real-time dispatch.

- Preliminary decisions for a complete set of requirements to be presented in September.