Commitment Cost Enhancements Phase 3 (CCE3)

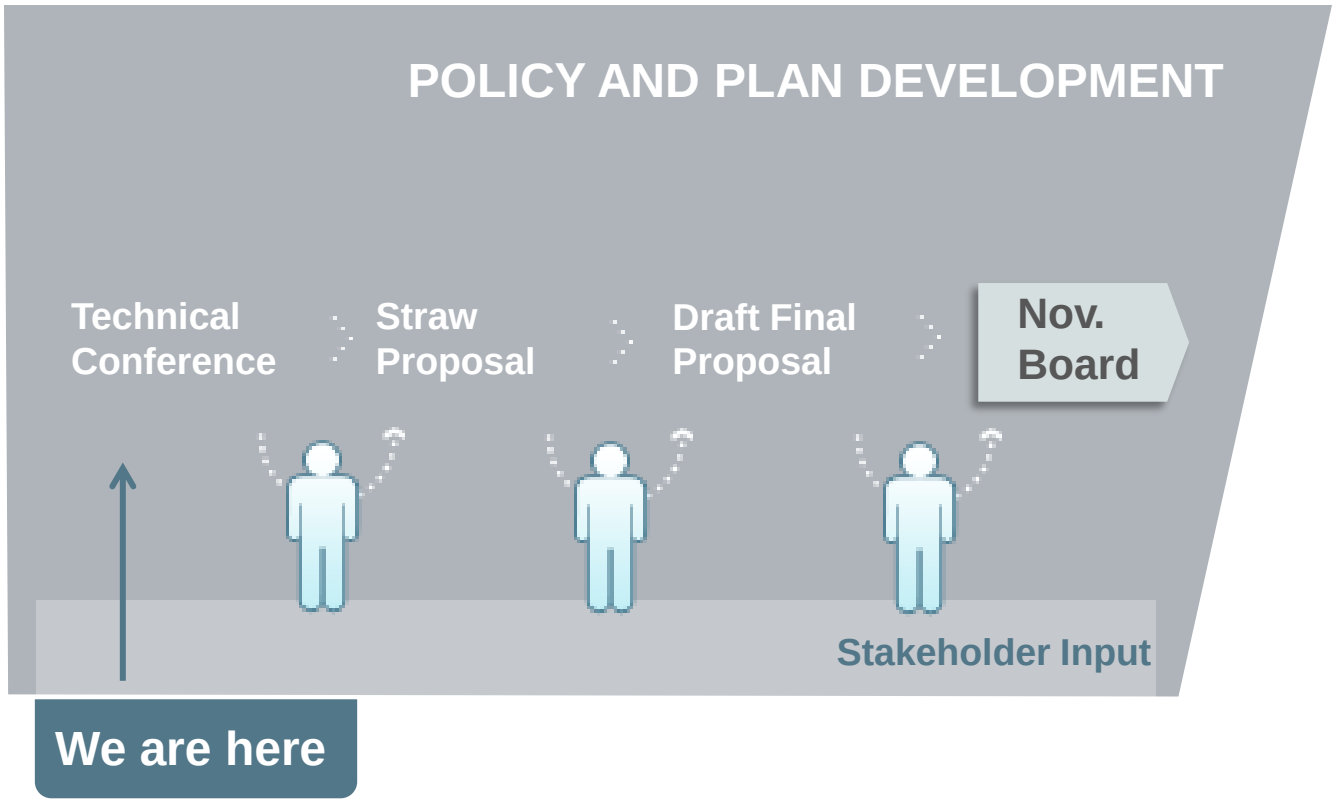
Technical Workshop
July 20, 2015

Kallie Wells
Market Design and Infrastructure Policy

Agenda

Time	Topic	Presenter
9:00 - 9:10	Introduction	Kristina Osborne
9:10 – 12:00	• Background on CCE3 • Overview of modeling process • Model Inputs	Kallie Wells
12:00 – 1:00	Lunch Break	
1:00 – 3:50	• Description of two Opportunity Cost models • Model results • Policy Issues • Negotiated Opportunity Cost	Kallie Wells
3:50 – 4:00	Wrap-Up and Next Steps	Kristina Osborne

ISO Policy Initiative Stakeholder Process



BACKGROUND

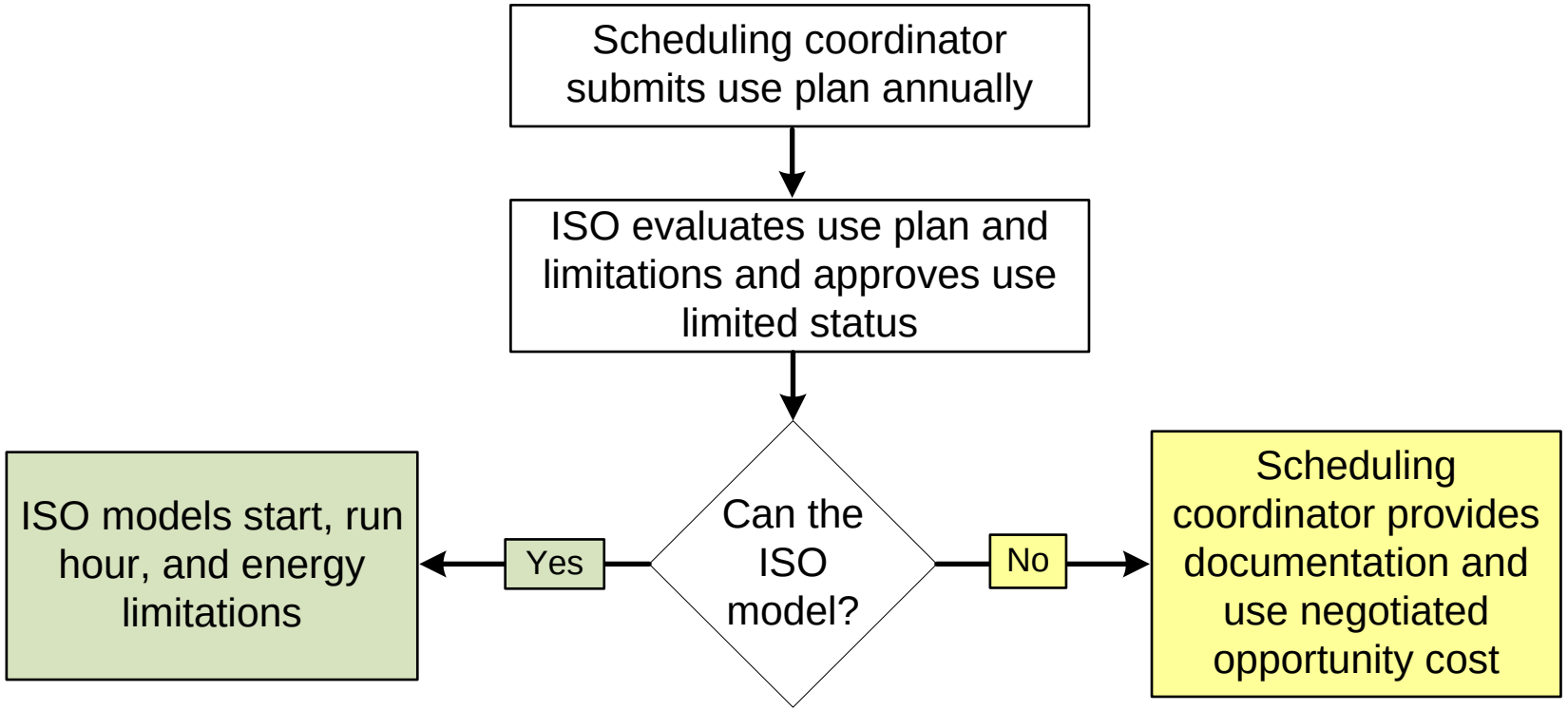
Background on the opportunity cost model

- Use limited capacity that cannot be fully optimized by the ISO's commitment processes due to operational limitations set by statutes, regulatory, ordinances, court orders, or design considerations.

- Currently:
  - Only use limited resources may remain on registered cost option. When opportunity costs are implemented, the registered cost option will be eliminated.
  - All other resources are on the proxy cost option.

- CCE3 will design a methodology to determine opportunity costs for limitations of use-limited resources.
  - Use limited resources may have a calculated or negotiated opportunity cost included in the bid caps.

Background on the opportunity cost model



Background on the opportunity cost model

- Opportunity cost model will calculate an opportunity cost for resources and limitations that are able to be modeled
- For limitations not able to be modeled, market participants will submit proper documentation and a negotiated opportunity cost.
- Calculated or negotiated opportunity cost will be added to the bid cap of the corresponding commitment cost as calculated by the proxy cost calculation.
  - Targeted implementation: Fall 2016
  - Bidding rules initiative is exploring modifications to bidding rules for commitment costs with Fall 2016 as targeted implementation date.

OVERVIEW OF MODELING PROCESS

Overview of modeling process

- The ISO will develop an opportunity cost model and model the limitations for resources that are able to be modeled.
  - Run the model, at a minimum, over the limitation horizon prior to the start of that time period.
  - Model results will calculate opportunity costs for each limitation stated in the use-limitation registration process.

- The calculated opportunity cost will be added to the bid cap as determined by the proxy cost calculation, further increasing the bid cap.
  - $1,000/hr bid cap for minimum load will be increased by the opportunity cost for run hours, i.e. becoming $1,200/hr.

- As the year progresses, there will be scheduled re-runs of the model to reflect market conditions and update opportunity costs.

Overview of modeling process

- Two models: GAMS and SAS
  - Both models use same input variables.
    - Estimated LMPs, costs, Masterfile minimum up and down times, Pmin, Pmax, and use limitation plan limits.
  - GAMS: General Algebraic Modeling System
    - Optimization program that maximizes profits over the time horizon.
    - Subject to resource characteristics and use limitation plan limits.
  - SAS: Statistical Analysis System
    - Sequential logical steps to achieve economical dispatch.
    - Respects resource characteristic.
    - Run unconstrained by use plan limitations.

Overview of modeling process: Sample resources

- Four sample resources were identified for testing.
  - Tested all resources through both models.
- Modeled each resource and estimated opportunity costs for 2014.
- Sample resources covered a wide range of limitations.
  - Starts (annual, monthly)
  - Run Hours (annual, quarterly)
  - Generation (annual)

INPUT VARIABLES

Estimated LMPs: DA vs FMM

- Estimated LMPs used in the opportunity cost model are based on 15 minute LMPs.
  - Most use limited resources are committed in the FMM.
  - FMM LMPs tend to be lower, on average, then IFM LMPs but are more volatile.

- Opportunity cost model determines optimal dispatch based on estimated 15 minute LMPs.

- Align the calculation of opportunity cost with the prices that determine unit commitment.

- For purposes of this workshop, 2013 HASP LMPs were used to estimate 2014 LMPs.
  - Once implemented, will use FMM LMPs.

Estimated LMPs: Implied heat rate

- Determine a series of implied heat rates for each resource based on prior year's nodal LMP.
  - Implied heat rates preserve the real-time volatility in the estimated LMPs.

$$\text{Im } pHR_{i,t-1} = \frac{LMP_{i,t-1}}{NatGasP_{l,t-1} + (GHGas_{t-1} * EmRate)}$$

LMPi,t-1	is the fifteen minute energy price at pnode *i* from the previous year's period, *t-1.*
GHGt-1	is the greenhouse gas allowance price from the previous year's period, *t-1*.
EmRate	is the emissions rate per MMBtu of gas, which is .0531148mtCO2e/MMBtu
NatGasPl,t-1	is the daily natural gas price from the region *l* of pnode *i* of the previous year's period, t-1

Estimated LMPs: Forecasting

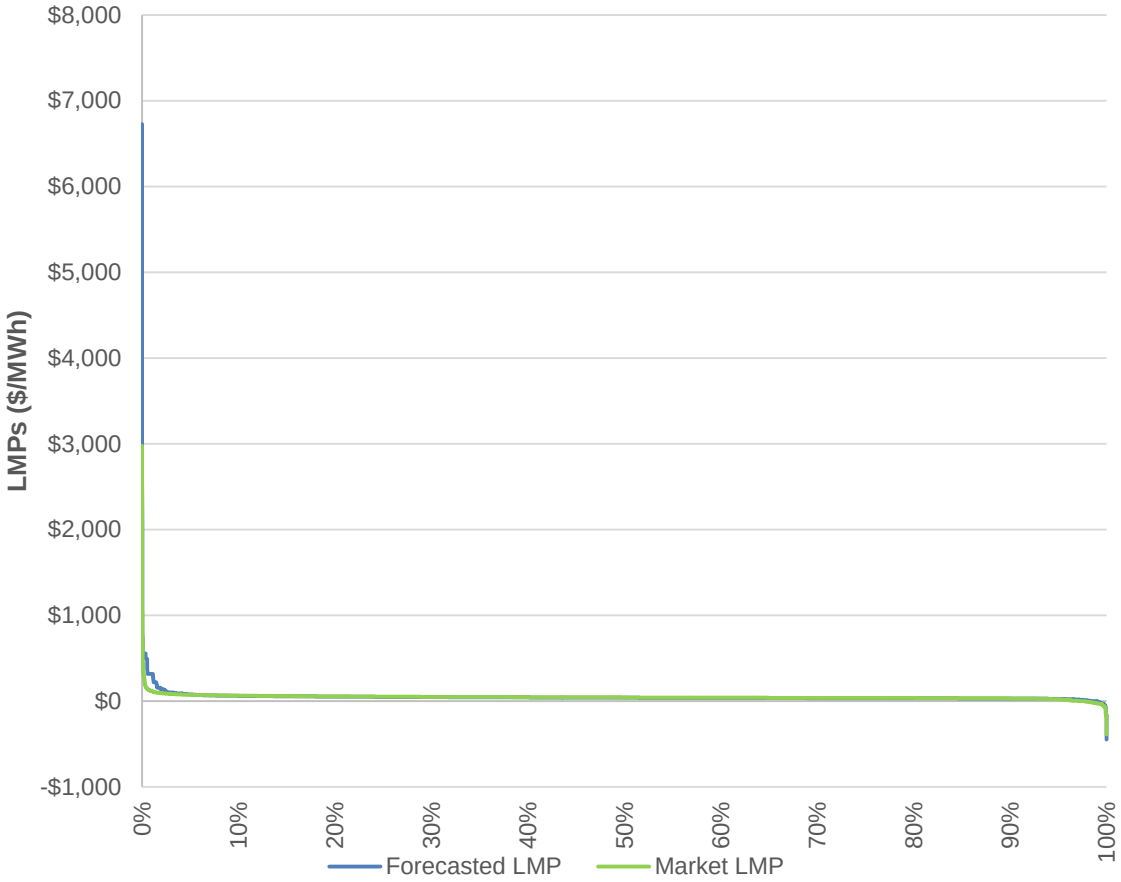
- Future gas and greenhouse gas prices will be applied to the implied heat rates to estimate 15 minute nodal LMPs for each use-limited resource as follows:

$$LMPi,t = ImpHR_{i,t-1} * \left(NatGasF_{\ l,t} + (GHGasF_t * EmRate)\right)$$

Where:

$LMP_{i,t}$	is the forecasted real time price at pnode *i* for interval *t*
$ImpHR_{i,t-1}$	is the calculated implied heat rate at pnode *i* from the previous year's period, *t-1*
$NatGasF_{l,m}$	is futures gas price from the region *l* of pnode *i* for the estimated month
$GHGasF_{t,m}$	is the average greenhouse gas allowance price of the preceding month.
$EmRate$	is the emissions rate per MMBtu of gas, which is $.0531148\ mtCO_2e/MMBtu$

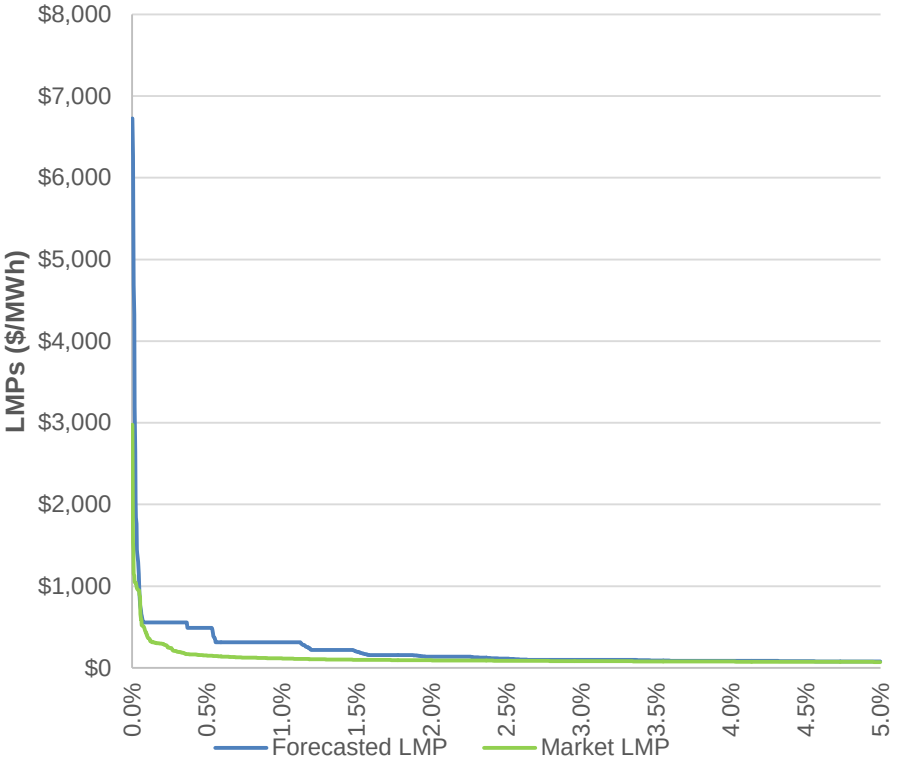
Estimated LMPs: Northern resource 2014 price distribution curve



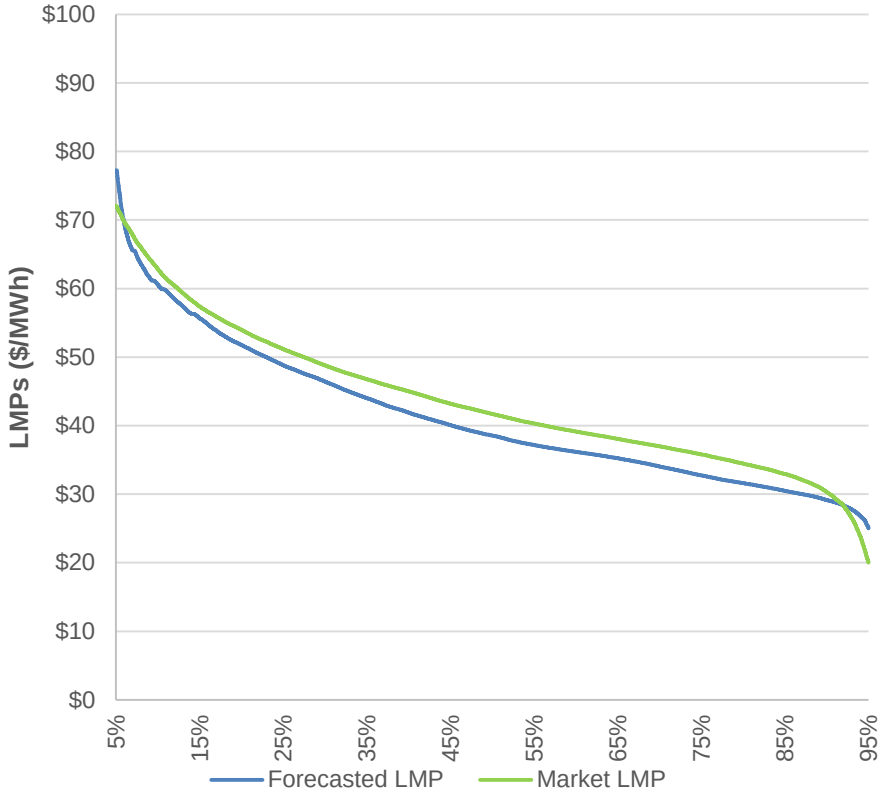
- Estimated LMPs tend to be higher than market LMPs on the tail end of the curve.

Estimated LMPs: Northern resource 2014 price distribution curve

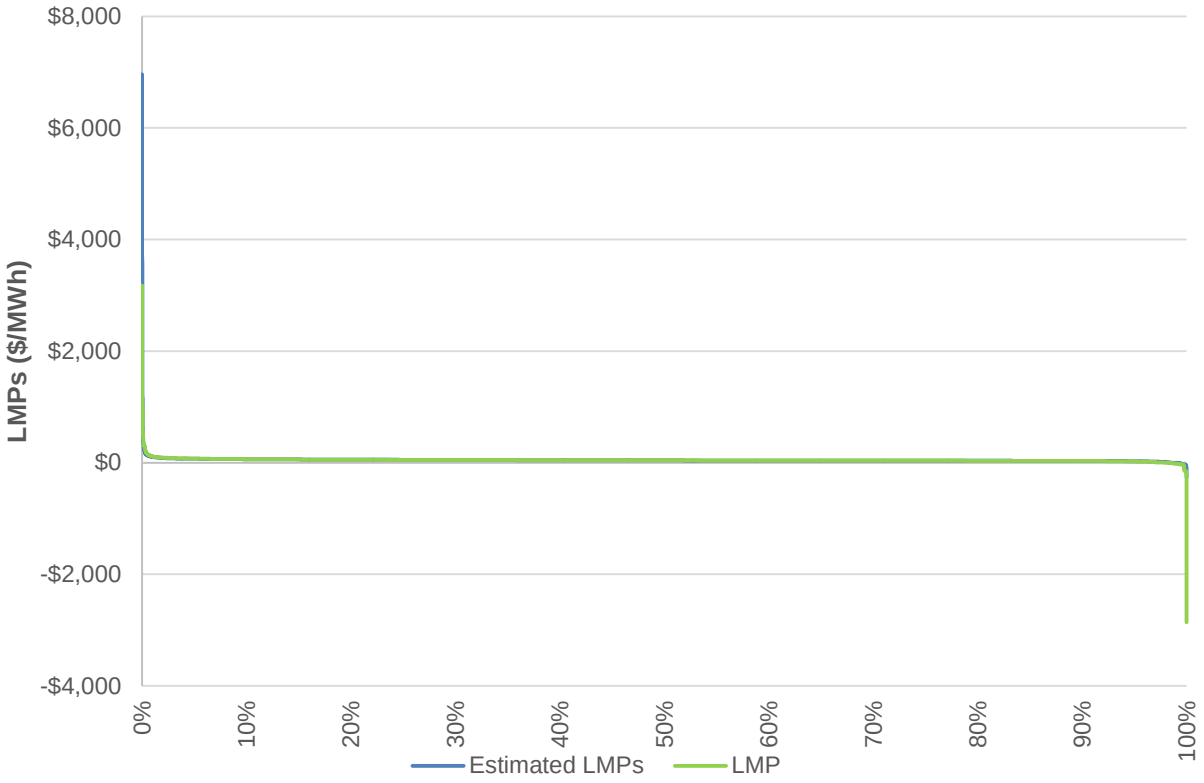
Top 5% of distribution curve



5% to 95% of distribution curve



Estimated LMPs: Southern resource 2014 price distribution curve



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Estimated LMPs: Southern resource 2014 price distribution curve

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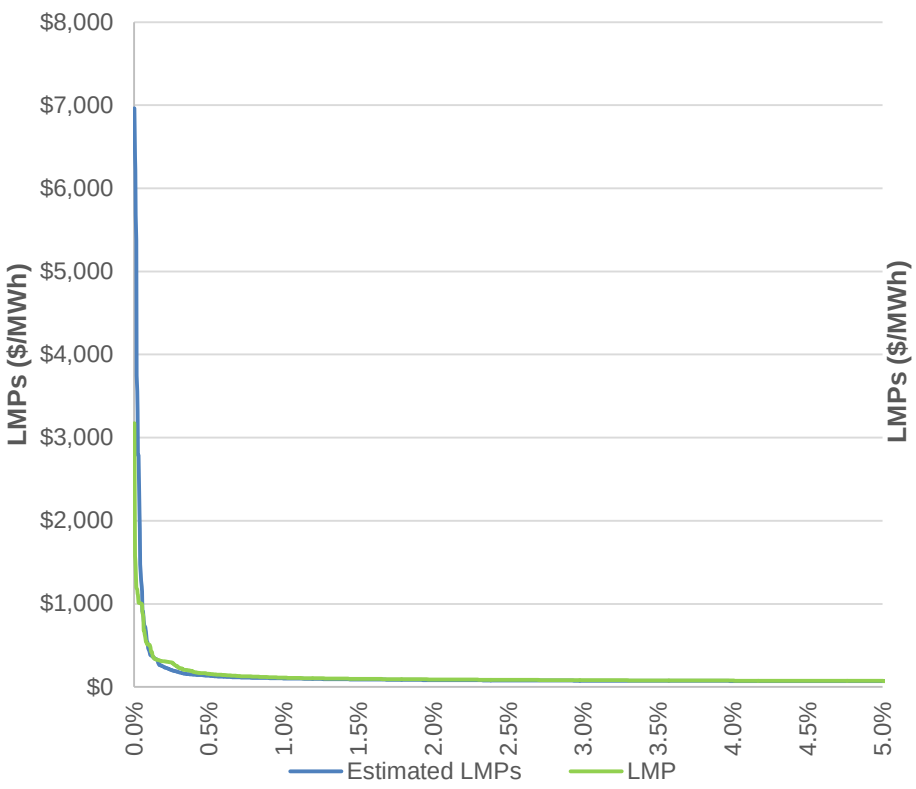
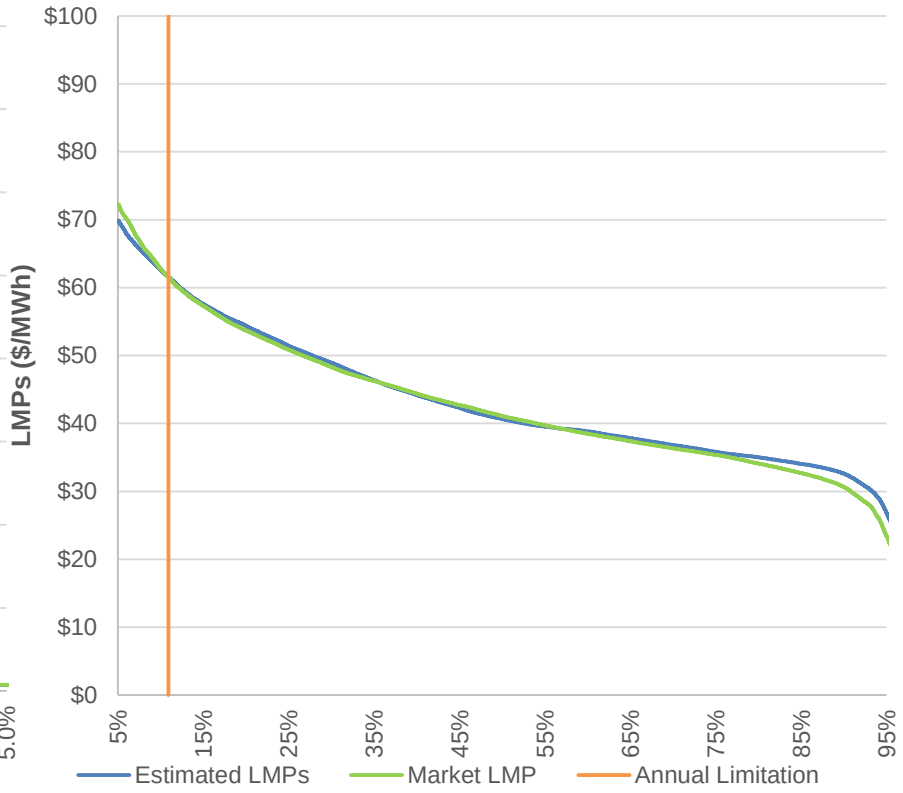


5% to 95% of distribution curve



Other input variables

- Estimated proxy start-up and minimum load costs
  - Uses future gas prices, and
  - Most recent months' costs for other costs included in the commitment cost calculation (i.e greenhouse gas, major maintenance adder, O&M, and GMC costs).
- Estimated default energy bid (DEB) curves
- Masterfile characteristics
  - Pmin, Pmax
  - Minimum up and down times
- Use plan limitations

MODELING

Modeling

- Use estimated LMPs and input variables in opportunity cost model.
- Opportunity cost model determines optimal dispatch for each use-limited resource.
- Model is run for, at a minimum, the limitation time horizon.
  - Example: Run for a year for annual, quarterly, monthly limitations.
- Determine the opportunity cost for each limitation as stated in the use-limitation registration process.
  - The profits a resource would forego if it had one less (or one more) start, run hour, or MWh.

Modeling: GAMS

- GAMS is an optimization based solver.
- Determines optimal dispatch to maximize resource profits given costs and constraints.

Objective function:
Maximize profits = revenues – costs

Subject to:

SUM(Startup) <= maximum allowed starts
SUM(Commitment) <= maximum allowed run hours
SUM(generation) <= maximum allowed generated energy
Generator output >= minimum generation level if committed
Generator output <= maximum generation level if committed
Minimum up time constraint
Minimum down time constraint

Modeling: GAMS

Start-up opportunity cost:

1. Run model with maximum starts = start limitation
2. Run model with maximum starts = start limitation – 1 start
3. Start-up opportunity cost = $Profits_1 – Profits_2$

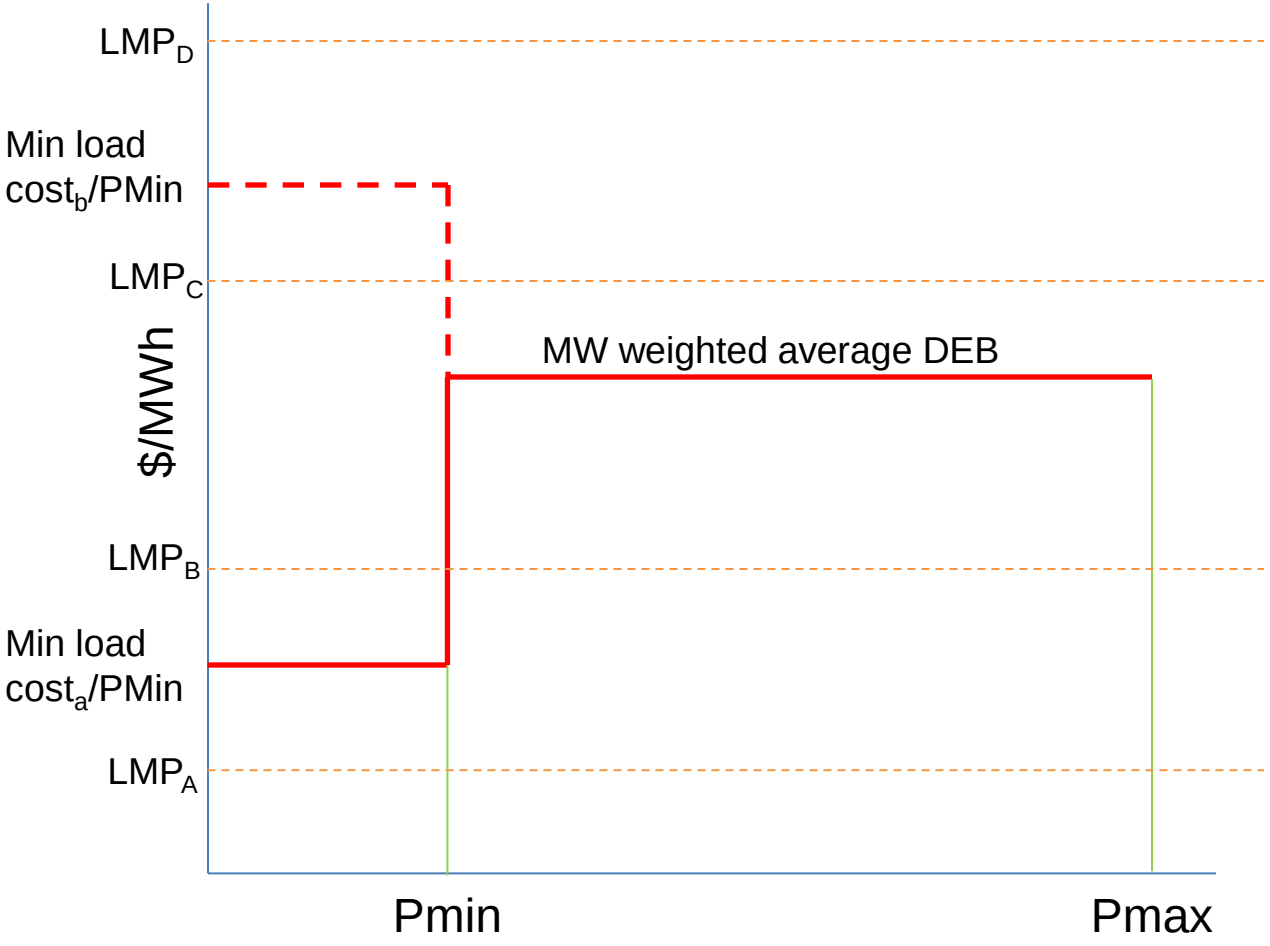
Run hours opportunity cost:

1. Run model with maximum run hours = hour limitation
2. Run model with maximum run hours = hour limitation – 1 hour
3. Run hour opportunity cost = $Profits_1 – Profits_2$

Generation opportunity cost:

1. Run model with maximum generation = energy limitation
2. Run model with maximum generation = energy limitation – 1MWh
3. Run hour opportunity cost = $Profits_1 – Profits_2$

Modeling: SAS



Solid red cost curve:

- LMP$_A$: Resource would not be committed
- LMP$_B$: Resource would be committed at Pmin
- LMP$_C$/LMP$_D$: Resource would be committed at Pmax

Dashed red cost curve:

- LMP$_A$ / LMP$_B$: Resource would not be committed
- LMP$_C$: Resource would be committed at Pmax if revenues is greater than variable energy cost at Pmax plus MLC
- LMP$_D$: Resource would be committed at Pmax

Modeling: SAS

- **Quick dispatch clean-up:**
  - One interval cycling and
  - one interval less than minimum up time.
- **Profitability check:** Keep resource on over dispatch horizon if profitable after accounting for start up cost.
- **Minimum up time:** For dispatch horizons less than minimum up time, determine if profitable to extend dispatch to meet minimum up time.
- **Minimum down time:** Determine if profitable to bridge schedules where down time not met, or forego profit of dispatch horizon.
- **Second profitability check:** Keep resource on over dispatch horizon if profitable after adjustments and accounting for start-up costs.
- **Obtain model dispatch.**

Modeling: SAS

- **Start-up limitations:**
  - Sort dispatch horizons by profitability.
  - If limited by X starts, the opportunity cost is the profit of the X^{th} dispatch horizon.
- **Run hour limitations:**
  - Calculate hourly profitability for each dispatch horizon.
  - Sort dispatch horizons by hourly profits.
  - If limited by Y run hour, the opportunity cost is the hourly profit of the Y^{th} run hour.
- **Generation limitations:**
  - Calculate average MWh profit and total generation for each dispatch horizon.
  - Sort dispatch horizons by average MWh profit.
  - If limited by Z MWhs, the opportunity cost is the average MWh profit of the Z^{th} MWh.

Modeling: SAS

Dispatch Horizon	Total profit	Run hours	Total generation
1	$10,000	5	500MWh
2	$15,000	2.5	250MWh
3	$5,000	1	75MWh
4	$24,000	8	700MWh

Starts: 3	
Dispatch	Profit
4	$24,000
2	$15,000
1	$10,000
3	$5,000

Run hours: 15		
Dispatch	Profit/hour	Cumulative hours
2	$6,000 = $15,000/2.5	2.5
3	$5,000 = $5,000/1	3.5
4	$3,000 = $24,000/8	11.5
1	$2,000 = $10,000/5	16.5

Generation: 1800MWh		
Dispatch	Avg MWh profit	Cumulative MWh
3	$67/MWh = $5,000/75MWh	75MWh
2	$60/MWh = $15,000/250MWh	325MWh
4	$34/MWh = $24,000/700MWh	1025MWh
1	$20 = $10,000/500MWh	1525MWh

MODEL RESULTS

Model Results: Annual start limited resources

Resource	SAS		GAMS	
	Percent of start limitation	Opportunity Cost ($/starts)	Percent of start limitation	Opportunity Cost ($/starts)
1	86%	$0	83%	$0
2	9%	$0	9%	$0
3*	67%	$0	46%	$0
4	83%	$0	56%	$0
*Unconstrained, GAMS model estimated 65% of start limitation				

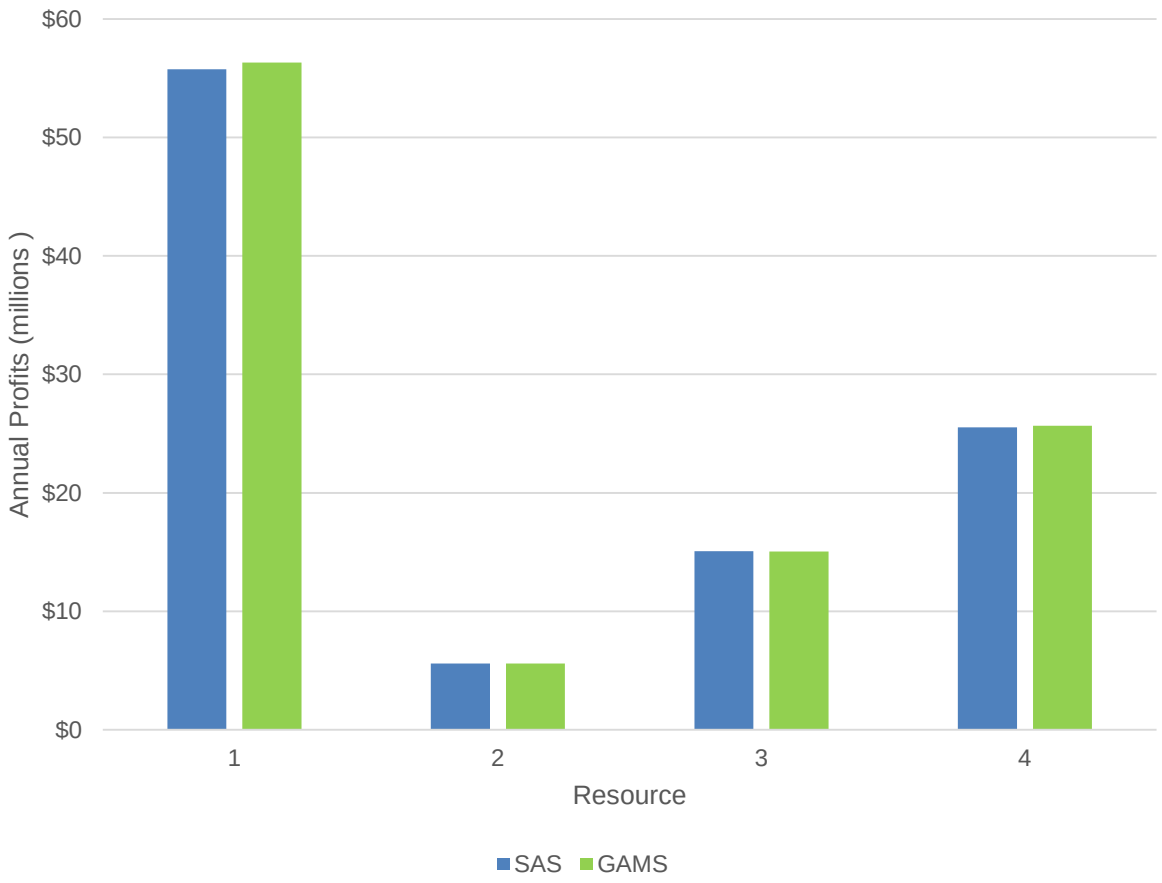
- Both models estimated $0 start up opportunity cost for all resources.
- Number of starts by resource were similar in both models.
- GAMS tends to have fewer starts.

Model Results: Other modeled limitations

Resource	SAS		GAMS	
	Modeled hours or dispatch	**Opportunity cost**	**Modeled hours or dispatch**	**Opportunity cost**
2	3% (Feb) Run hours	$0	3% (Feb) Run hours	$0
	5% Max output	$0	5% Max output	$0
3*	140% Run hours	$366/hr	100% Run hours	$310/hr
4	26% (Q4) Run hours	$0	31% (Q4) Run hours	$0
***Unconstrained, GAMS model estimated 168% run hours**				

- Both models estimated similar opportunity cost for run hour limit.
- Overall dispatch between the two models are similar in terms of run hours, starts, and dispatch.

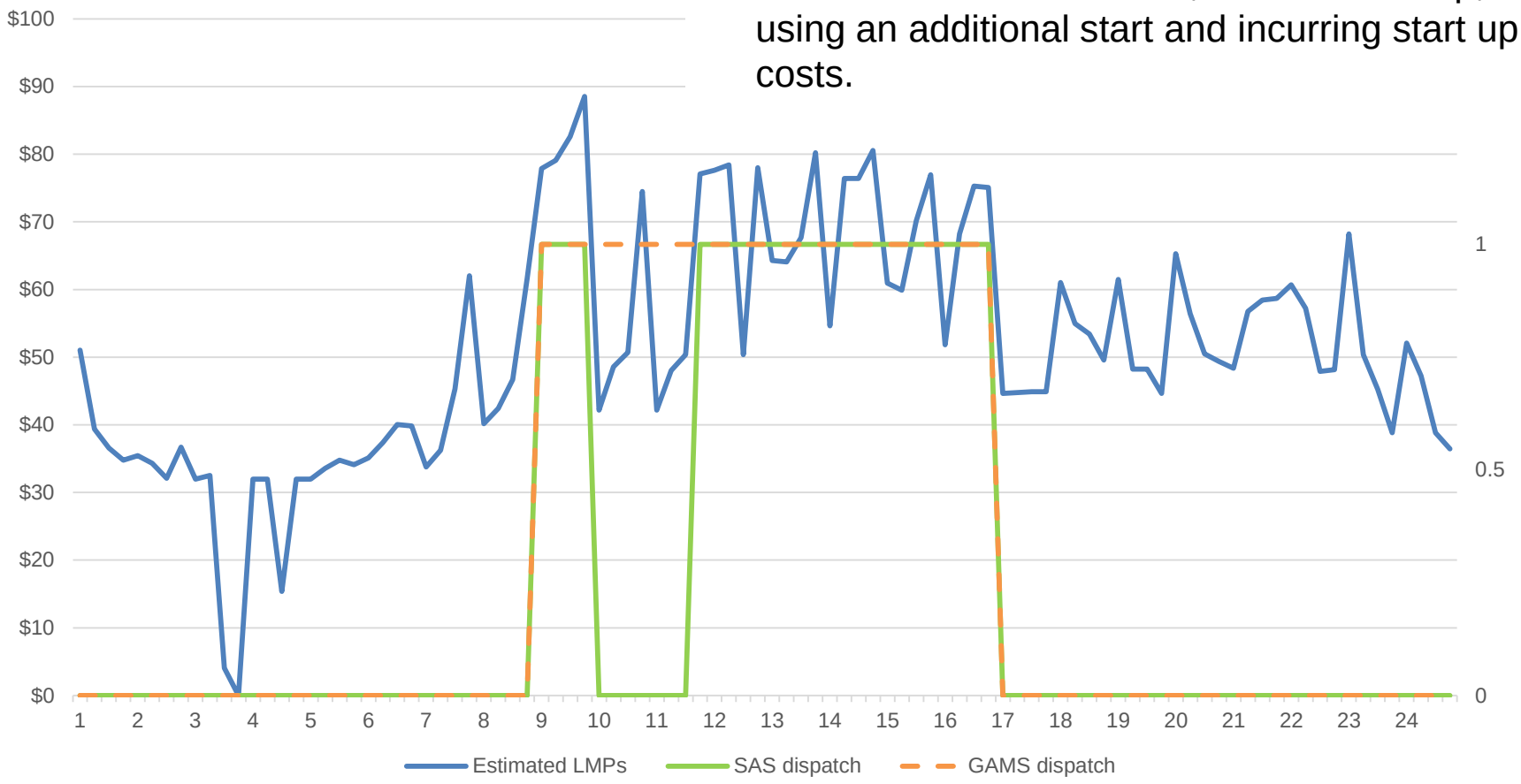
Model Results: Overall estimated profits



- Estimated profits between the two models are nearly identical.
- GAMS is slightly higher, as would be expected.
- SAS has higher profits for resource 3 due to GAMS enforcing the run hour limitation in the optimization.

Model Results: Sample day dispatch

- GAMS model keeps resource on through lower LMPs, using more run hours.
- SAS shuts resource down, starts it back up, using an additional start and incurring start up costs.



SAS vs GAMS

	SAS	Optimization based (such as GAMS)
Pros	- ISO already has license and a more common language within ISO. - Fast processing time allows for more frequent updates.	- Optimization based program finds optimal dispatch. - Easy to model linear constraints.
Cons	- Not an optimization solver that maximizes profits.	- Higher cost of licensing and external support. - Full integration with ISO systems. - Potentially slow processing time.

POLICY

Policy questions

- Use limitation plan registration process.
- How calculated opportunity costs are included in bid caps for minimum load costs, start up costs, and default energy bids.
- Opportunity cost updates through scheduled and impromptu re-runs.
- Modeling multi-stage generation (MSG) resources

Use limitation registration process

- Reliability Services initiative developing new use limitation registration process.

- It allows scheduling coordinators to
  1. Define the limit(s) and applicable time horizon for each limit.
  2. Upload supporting documentation, such as use-limitation plans, affidavits, and methodology of determining its opportunity cost.

- It allows the ISO to
  1. Identify the limitations and applicable time horizon.
  2. Determine if the resource's limitations can be modeled or fall under the "other" category.
- Translating emission or fuel limitations to starts, run hours, dispatch
  1. SC translates and uploads methodology used
  2. ISO translates emissions/fuel into limits

Applying opportunity costs

- Registered cost option will be eliminated with the implementation of opportunity costs.

- For both modeled and non-modeled limitations, opportunity costs will be included in the following costs:
  - Start limitations: Added to the bid cap as determined by the proxy start-up cost calculation.
  - Run hour limitations: Added to the bid cap as determined by the proxy minimum load cost calculation.
  - Generation limitation: Added to the resource's default energy bid.

- Bidding rules initiative is exploring modifications to bid caps as related to proxy cost calculations.

Opportunity cost updates: Scheduled re-runs

- As the year progresses, the ISO will have scheduled re-runs to re-calculate opportunity costs.
  - If modeled time period longer than limitation, calculated opportunity costs for limitation period(s) that will occur prior to next scheduled re-run are binging.
    - i.e. run model for calendar year to model monthly limitation

- Reflect changes in market conditions that may have resulted in resource using more/less than estimated starts, run hours, or generation.
  - Gas prices, congestion patterns, market constraints such as MOCs, resource testing, etc.

- Need to determine the most effective way to update the limits while maintaining an unbiased opportunity cost.
  - ISO has identified three potential options.

Opportunity cost updates: Scheduled re-runs

- For illustrative purposes assume:
  - Resource with 400 starts per calendar year.
  - Initial model run for full year estimated 15 starts in first three months of the year.
  - Resource actually was started 20 times in first three months of the year.

- Option #1: Re-run the model for April – December adjusting the limit by actual usage (380 starts).
  - Issue: Incentive to bid the resource in such a way to run through starts at the beginning of year and increase opportunity cost in the latter part of the year.

Opportunity cost updates: Scheduled re-runs

- Option #2: Re-run the model for April – December adjusting the limit by estimated usage (385 starts).
  - Issue: Unanticipated market conditions may have warranted starting the resource more often than the model estimated, therefore should have a higher opportunity cost.

- Option #3: Re-run the model January – December with the full limit using actual LMPs for the months past and estimated LMPs for the remaining months.
  - Issue: Assumes resources are bidding around marginal cost and resources are committed solely based on LMPs (i.e. no other market constraints/conditions commit resource).

Opportunity cost updates: Impromptu re-runs

- Metrics that trigger an impromptu re-run outside of scheduled updates.
  - Need to be persistent trends that cause resource to run through more of its limitations than model estimated.
  - More frequent scheduled updates may mitigate the need.

- Notifications from market participants of market conditions causing resource to run through limitations.
  - Resource testing, failed starts

- Incorporating future power prices to minimize need of impromptu re-rung

Modeling MSG Resources

- ISO is currently not intending to model MSG resource limitations.
- MSG resources are complicated to model in both SAS and GAMS.
  - Permits may be applicable to individual configurations or at the parent resource level.
  - Transitions may or may not count towards starts for a resource with start limitations.
- ISO is anticipating to have MSG resources fall under the “other” category and have a negotiated opportunity cost.

NEGOTIATED OPPORTUNITY COST

Negotiated opportunity cost option

- Resources with accepted use limitation plans that cannot be modeled fall under the “other” category.

- A negotiated opportunity cost for each use limitation plan limit.
  - Opportunity cost will be added to corresponding commitment cost bid caps or default energy bids.

- Market participants will upload supporting documentation, affidavits, methodology, and negotiated opportunity cost.
  - Use limitation registration process developed through Reliability Services initiative.

STAKEHOLDER ENGAGEMENT SCHEDULE AND NEXT STEPS

Stakeholder engagement schedule

Date	Stakeholder process
July 20	Technical workshop
July 30	Comments due - technical workshop
August (TBD)	Straw proposal
	Stakeholder meeting
	Comments due - straw proposal
September (TBD)	Draft final proposal
	Stakeholder call
	Comments due – draft final proposal
November 5 - 6	ISO Board of Governors meeting

Materials related to this initiative are available on the ISO website at http://www.caiso.com/informed/Pages/StakeholderProcesses/CommitmentCostEnhancementsPhase3.aspx

Next steps

- Submit written comments on the technical workshop presentation and discussion to initiativecomments@caiso.com by close of business July 30. Please use comments template available on the ISO website at

  http://www.caiso.com/informed/Pages/StakeholderProcesses/CommitmentCostEnhancementsPhase3.aspx

- Straw proposal posted early August, 2015; look for details in a forthcoming market notice

- Questions following the workshop can be submitted to email provided above.