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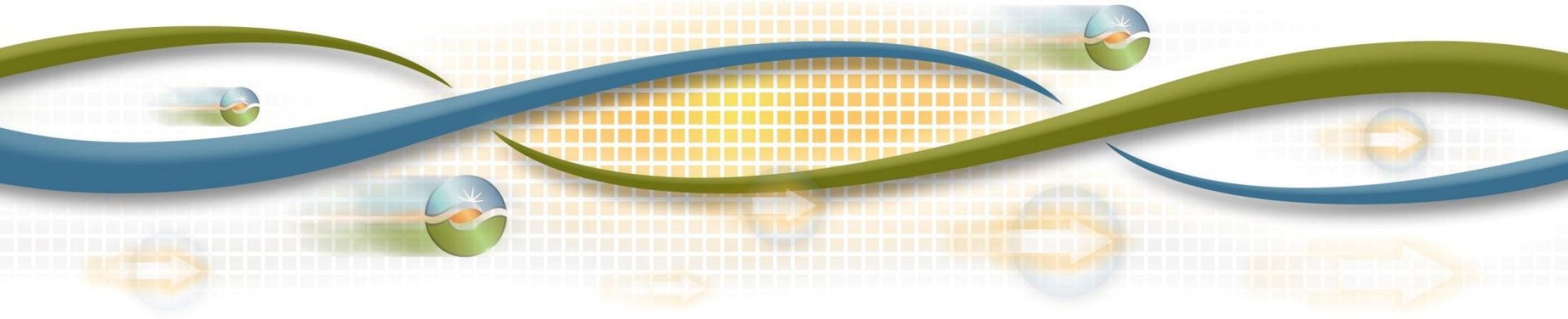
Flexible Resource Adequacy Criteria and Must-Offer Obligation

November 13, 2013

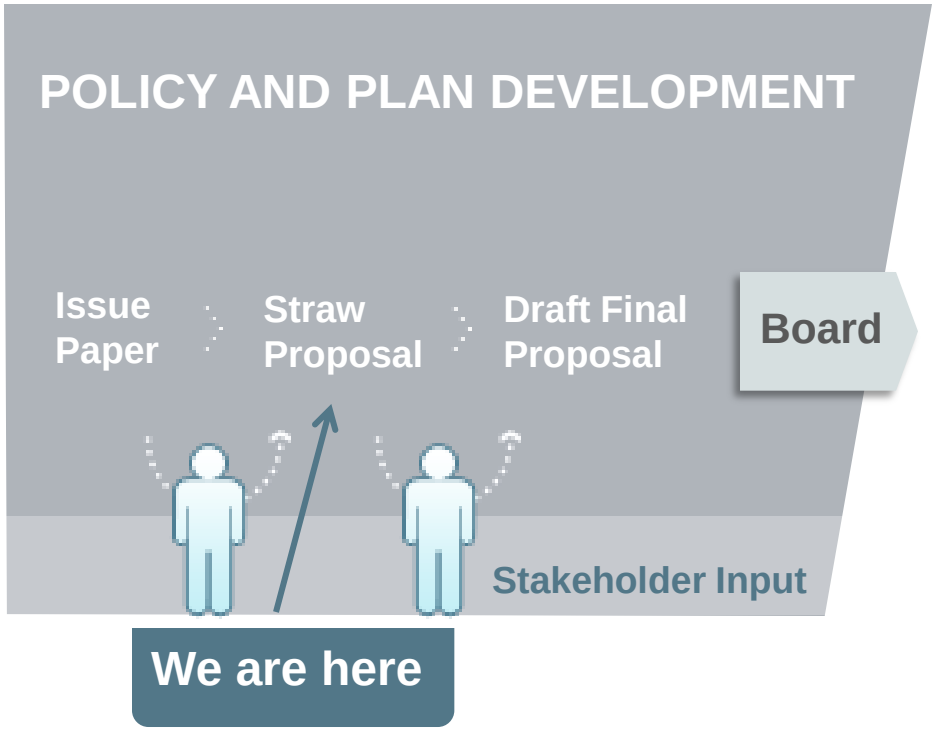
Karl Meeusen, Ph.D.
Market Design and Regulatory Policy Lead



Stakeholder Meeting – Agenda – 11/13/13

Time	Topic	Presenter
9:00 – 9:05	Introduction	Tom Cuccia
9:05 – 9:15	Overview and Meeting Objective	Karl Meeusen
9:15 – 9:45	Proposal for Allocating ISO System Flexible Capacity Requirements	
9:45 – 10:30	PG&E's Alternative System Flexible Capacity Requirements Allocation Proposal	Alex Morris and Marie Fontenot
10:30 – 10:45	Break	
10:45 – 12:00	Flexible Capacity Must-Offer Obligation	Carrie Bentley
12:00 – 1:00	Lunch	
1:00 – 2:30	Flexible Capacity Availability Incentive Mechanism: Standard Flexible Capacity Product	Karl Meeusen
2:30 – 2:45	Break	
2:45 – 3:15	Proposed Flexible Capacity Backstop Procurement Authority	Karl Meeusen
3:15 – 3:30	Next Steps	Tom Cuccia

ISO Policy Initiative Stakeholder Process



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Flexible Resource Adequacy Criteria and Must-Offer Obligation: Third Revised Straw Proposal

Karl Meeusen, Ph.D.
Market Design and Regulatory Policy Lead

Overview and Meeting Objectives

Initiative scope includes ISO tariff changes to address ISO system flexible capacity requirements

- Stakeholder process targeted to be completed by February 2014 for 2015 and 2016 RA Compliance
- Initiative scope includes:
  - ISO study process to determine flexible capacity requirements (2015)
  - Allocation of flexible capacity requirements (2015)
  - RA showings of flexible capacity to the ISO (2015)
  - Flexible capacity must-offer obligation (2015)
    - (Some provisions for use-limited resources may occur in 2016)
  - Flexible capacity availability incentive mechanism and capacity substitution (2016)
  - Backstop procurement of flexible capacity (2015)

The ISO has made several changes from the Third Revised Straw Proposal

- Allocation of contribution to load change
- A more complete description to allow gas-fired use-limited resources to reflect use-limitations in their bid inputs
- Demand response resources may establish an effective flexible capacity through a test event
- Energy storage resources could elect one of two options for providing flexible capacity: Regulation Energy Management or fully flexible capacity
  - Dropped the option for energy storage resources to select one of the demand response bidding windows

The ISO has made several changes from the Third Revised Straw Proposal

- Revised the Standard Flexible Capacity product price
- Real-time economic bids weighed at 80 percent towards the SFCP calculation and day-ahead economic bids weighed at 20 percent
- Use-limited resources that reach use-limitation within a month will be required to provide substitute capacity or be subject to SFCP availability charges
  - Thresholds exempting use-limited resources from SFCP penalties have been removed

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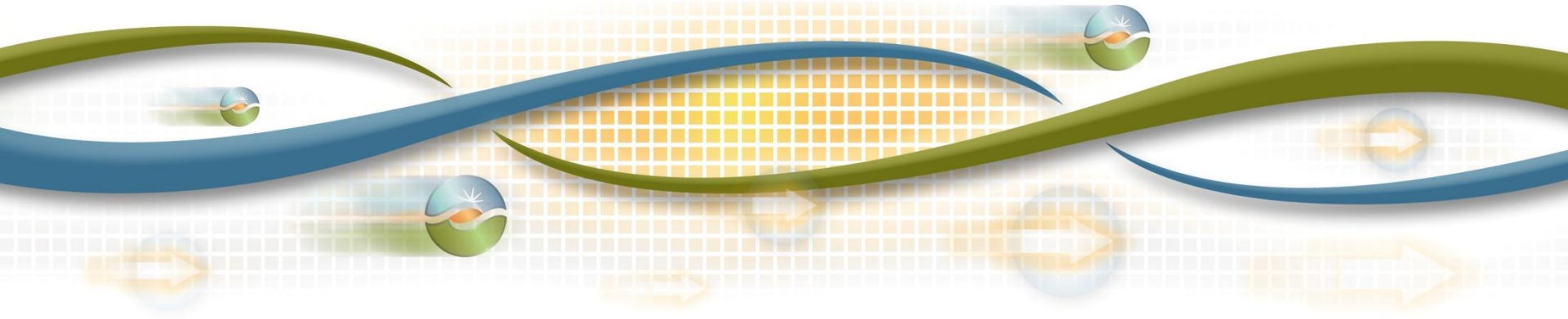
Process and Study Methodology for Determining Flexible Capacity Procurement Requirements

Karl Meeusen
Market Design and Regulatory Policy Lead



Flexible capacity requirement assessment process including the error term

January

- Receive CEC load forecast used for TPP expansion plan
- Receive updated RPS build-out data from the LSEs
- Publish annual FCR assumptions paper

February

- ISO stakeholder meeting to discuss assumptions Stakeholder comments, and posting of comments with ISO response

March

- Draft LCR and FCR study completed followed by Local & flexible capacity needs stakeholder meeting
- Publish draft final LCR & FCR needs study (including the error term)

April

- ISO stakeholder meeting to discuss LCR / FCR results followed by stakeholders comments

May/June

- Final 2014 LCR & FCR study posted
- CPUC proposed and final annual RA decision incorporating LCR and FCR procurement obligations

July

- LSEs receive Year-Ahead obligation

August

- Revised load forecasts and renewable build-outs for following RA compliance year

September

- LSEs receive revised RA and flexible capacity obligation
- Final NQC and EFC Lists issued by the ISO

October

- Year-ahead showing of system, local, and flexible capacity (show 100% local and 90% system and flexible)

Monthly Showings

- T-45 days: Month-ahead showings, including local and flexible true-up
- T-25 days: ISO notifies LSEs and suppliers of any deficiencies of system, local, and or flexible capacity
- T-11 days: Final opportunity for LSEs to demonstrate to the ISO that any identified deficiencies have been cured

The specific study assumption will be considered in the ISO's annual flexible capacity requirement assessment

- The flexible capacity requirement assessment will consider:
  - Load forecasts
  - Renewable portfolio build-outs
  - Production profiles for intermittent resources
  - Load modifying demand side programs (i.e. DR not bid into the ISO and impacts of dynamic rates)
- Initial stakeholder call to discuss the assumptions and methodology scheduled for November 18

ISO flexible capacity requirement calculation

- Methodology

$$\text{Flexibility Requirement}_{MTHy} = \text{Max}[(3RR_{HRx})_{MTHy}] + \text{Max}(MSSC, 3.5\% * E(PL_{MTHy})) + \varepsilon$$

Where:

$\text{Max}[(3RR_{HRx})_{MTHy}]$ = Largest three hour contiguous ramp starting in hour x for month y

E(PL) = Expected peak load

MTHy = Month y

MSSC = Most Severe Single Contingency

ε = Annually adjustable error term to account for load forecast errors and variability

Flexible capacity counting rules

Start-up time greater than 90 minutes

EFC = Minimum of (NQC-Pmin) or (180 min * RRavg)

Start-up time less than 90 minutes

EFC = Minimum of (NQC) or (Pmin + (180 min – SUT) * RRavg)

Where:

EFC: Effective Flexible Capacity

NQC: Net Qualifying Capacity

SUT: Start up Time

RRavg: Average Ramp Rate

Demand response resources could have their EFC set based on a test event

- Test event would occur during the demand response resource's selected flexible capacity must-offer obligation window. The CPUC foresaw the possibility of the need for such an option in D.10-06-036.
- The test event could occur randomly
  - Would use the previous ten days load data for the PDR resource to measure the load reduction.
- Additional coordination with the CPUC and other LRAs to align this "generic" RA counting rules

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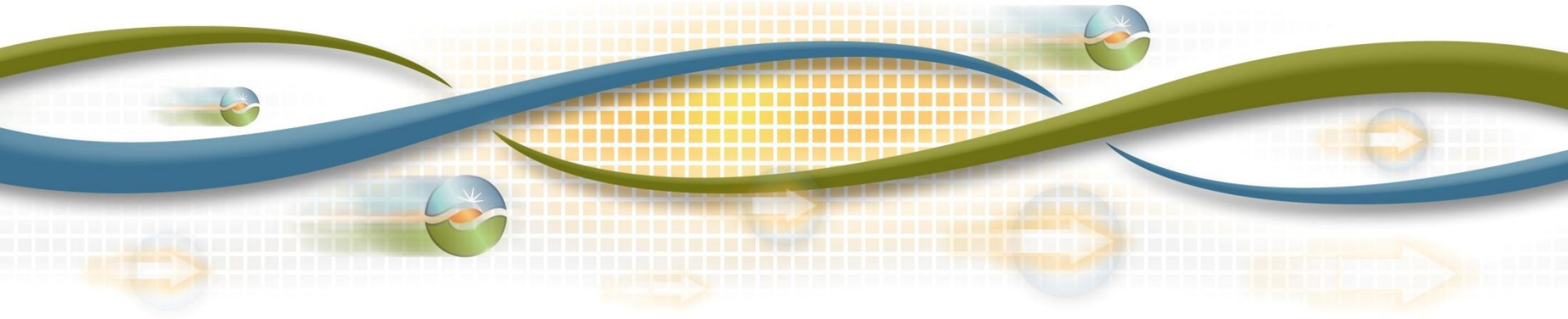
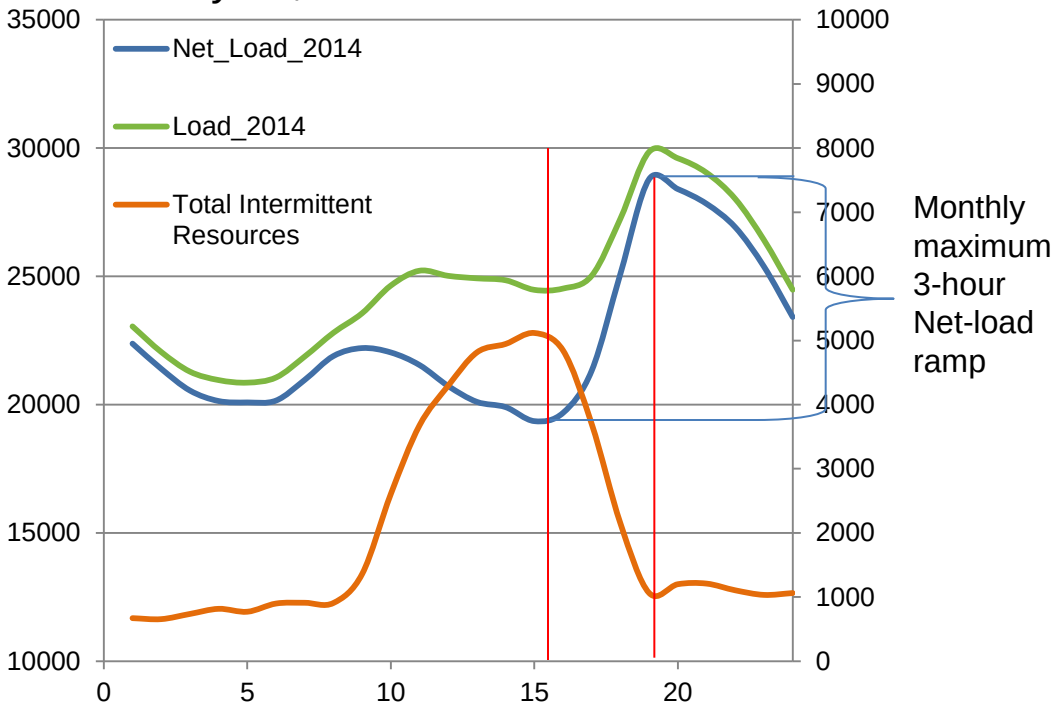
Proposal for Allocating ISO System Flexible Capacity Requirements



Allocating flexible is based on contribution to system's monthly maximum 3-hour net-load ramp

- 3-hour maximum net-load ramp used is the coincident 3-hour maximum net-load ramp
  - Not each individual LSE's or LRA's maximum 3-hour ramp
- ISO must assess the proper level of granularity to use when determining each LSE's contribution to requirement
  - Reach an equitable allocation at a reasonable cost

Forecasted Load and Net load Curves: January 15, 2014



Flexible capacity requirement is split into its two component parts to determine the allocation

- Maximum of the Most Severe Single Contingency or 3.5 percent of forecasted coincident peak
  - Allocated to LRA based on peak-load ratio share
- The largest 3-hour net-load ramp is decomposed into four components to determine the LRA's allocation

  Allocation* =

  Δ Load** – Δ Wind Output – Δ Solar PV – Δ Solar Thermal

  * Changes in DG component captured in Δ Load

  ** The determination of Δ Load is the only changed component from the previous proposal

The Δ Load component of the flexible capacity requirement should be allocated based on an LSE contribution to historical peak 3-hour net-load ramps

- Current proposal differs from previous proposal in two ways
  - Allocation is based on each LSE's contribution to load change during the peak net-load ramps, not load ramps
    - Did not result in a significant change in the flexible requirement allocation
  - Uses the LSE's contribution during the five maximum 3-hour net-load ramps, not monthly averages
    - Helps address uncertainty in forecasting and anomalous load changes
    - Maintains focus on peak net-load ramping events
- Consistent with causation principles
  - Flexible capacity requirements set based on coincident peak ramps, allocation should also be base on the based on coincident peak ramps

The ISO will not propose seasonal allocations at this time

- Not clear that seasonal similarities will persist in the future
- Easier to move to seasonal allocations in the future if trends continue than to unwind seasonal allocations if changes are required
- The ISO may reconsider seasonal allocations of a future stakeholder initiative

Flexible Capacity Must-Offer Obligation

Carrie Bentley

Senior Market Design and Policy Specialist

Must-offer obligation topics

1. Flexible resource adequacy capacity
2. Dispatchable gas-fired use-limited resources
3. Storage resources

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Flexible resource adequacy capacity must-offer rules

Must-offer obligation for flexible capacity

- Submit economic bids for energy in day ahead and real time markets from 5:00AM - 10:00PM
  - ISO optimization will respect daily limitations
- Remain subject to generic RA must-offer obligation from 10:00PM - 5:00AM
- Specialized must-offer rules for:
  - Dispatchable gas-fired resources
  - Demand response
  - Storage
  - Variable energy resources

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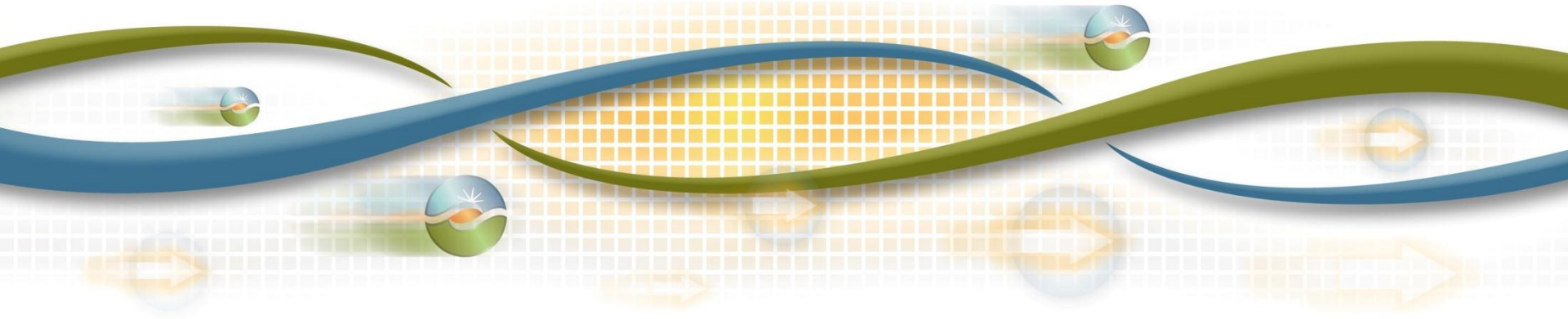
Must-offer requirements for flexible resource adequacy dispatchable gas-fired use-limited resources



Description: Use-limited, dispatchable, gas-fired resources

- Resources with monthly or annual physical limitations mandated for environmental reasons by a regulatory entity
- Have a verifiable use-plan filed with the ISO
- Monthly and annual limitations can be translated into daily limitations in the master file
  - Start, run-time, energy limits
  - Cannot be more restrictive than monthly or annual limit

Proposal: Incorporate market based solution

- Allow resources to incorporate an opportunity cost into their start-up, minimum load, and energy bid
  - Allow daily bidding of start-up and minimum load costs up to this amount
  - Allow a monthly registered cost of up to 150% of this amount
- An opportunity cost will be calculated each month
  - Opportunity costs will be updated, at a minimum, monthly
  - More frequent updates may occur if gas prices or energy prices vary significantly from estimated prices
- Goal is to optimize resource availability over the month or year

Opportunity cost methodology: Optimization model

- The ISO will develop a unit commitment and dispatch optimization model
  - Respect Master File and use-limitation constraints
  - Maximize gross margin (total revenues – total costs)
- Optimally commit and dispatch each resource against forecasted real time energy prices over a month
- Annual limitations will need to be converted into monthly
  - SCs provide the ISO monthly limits only for the purpose of calculating the opportunity cost
  - Do not have to be the same limit each month, but the sum of all monthly limits has to equal the annual

Opportunity cost methodology: Optimization model

- Start and run hour limitations will require the model to be run twice for each limitation
  - Once with all starts or run hours and the second with one less start or run hour
- Maximum Starts
  - The opportunity cost will be the difference between the maximized gross margin from having all starts and having one less start
  - Will be added to the resource's start-up cost for the corresponding month

Opportunity cost methodology: Optimization model

- Maximum run hours
  - The opportunity cost will be the difference between the maximized gross margin from having all run hours and having one less run hour
  - Will be added to the resource's minimum load cost for the corresponding time period
- Generation
  - The opportunity cost will be the shadow price on the generation constraint
  - Will be included in the resource's default energy bid curve as the opportunity cost portion

Estimating real time prices: Overview

- Estimate real time energy prices will be used in the model
  - Resources are dispatched and settled on real time energy prices
  - MOO requires real time economic bids
- A set of estimated prices will be generated for each pricing node associated with a dispatchable gas-fired use-limited resource
- For computational purposes, 5 minute estimated real time prices will be aggregated up to 15 minute prices

Estimating real time prices: Formulation

- Real time energy prices will be estimated using the following formula:

$$LMPi,t = ImpHR_{i,t-1} * (NatGas_{l,t} + (GHGasF_t * EmRate))$$

$LMP_{i,t}$	*is the forecasted real time price at pnode i for internal t*
$ImpHR_{i,t-1}$	*is the calculated implied heat rate at pnode I from a base period, t-1*
$NatGas_{l,t}$	*is the estimated nat gas price for region l and time period t based on the average daily more recent 30 day set of prices available*
$GHGasF_t$	*is the greenhouse gas allowance price for time period t*
EmRate	*is the emissions rate per MMBtu of gas, which is .053073 mtCO_2e/MMBtu*

Estimating real time prices: Implied heat rate calculation

- The implied heat rate used to estimate the energy prices will be calculated as follows:

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

Where

$LMP_{i,t-1}$ is the real time energy price at pnode *i* from the previous year's period, *t-1.*

$GHGas_{t-1}$ 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 $.0530731 mtCO_2e / MMBtu$

$NatGasP_{l,t}$ is the daily natural gas price from the region *l* of pnode *i* and the previous year's period, *t-1*

Estimating real time prices: Preliminary comparisons

- ISO estimated April and September 2013 LMPs
  - Two pricing nodes, one in the north one in the south
  - Two different seasons
- Estimated 5 minute real time LMPs and then aggregated up to 15 minute prices
- Compared percentage of estimated LMPs to percentage of actual LMPs within a given price range

Estimating real time prices: Preliminary comparison northern pricing node

LMP Price ($/MWh)	Apr-13		Sep-13	
	Actual LMP	Estimated LMP	Actual LMP	Estimated LMP
Less than $0/MWh	4%	7%	0%	1%
Between $0/MWh and $25/MWh	7%	13%	4%	8%
Between $25/MWh and $50/MWh	81%	67%	88%	87%
Between $50/MWh and $100/MWh	6%	12%	6%	4%
Between $100/MWh and $250/MWh	2%	1%	0%	1%
Greater than $250/MWh	1%	1%	0%	1%

- September estimations were fairly accurate
- April estimations more distributed around the $25/MWh and $50/MWh price bin
- Congestion during base year (2012) impacted the implied heat rate calculation
  - If congestion does not materialize in 2013, estimated prices vary

Estimating real time prices: Preliminary comparison southern pricing node

LMP Price ($/MWh)	Apr-13		Sep-13	
	Actual LMP	Estimated LMP	Actual LMP	Estimated LMP
Less than $0/MWh	3%	3%	2%	2%
Between $0/MWh and $25/MWh	6%	11%	7%	8%
Between $25/MWh and $50/MWh	81%	67%	82%	80%
Between $50/MWh and $100/MWh	8%	15%	8%	8%
Between $100/MWh and $250/MWh	1%	2%	1%	1%
Greater than $250/MWh	1%	2%	0%	2%

- In September, estimated 80% of LMPs to be between $25/MWh and $50/MWh, only 2% less than actual LMPs
- April estimated LMPs are more distributed around the $25/MWh and $50/MWh price range than actual LMPs

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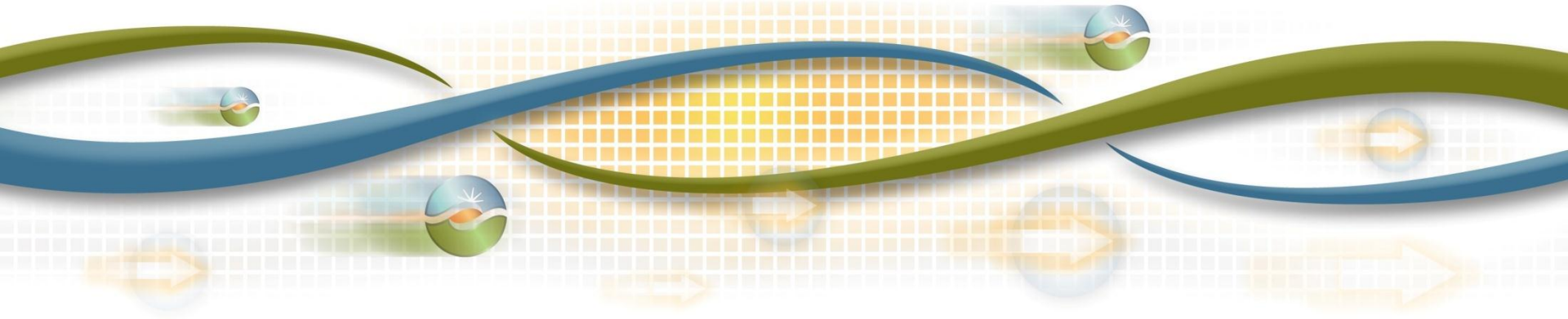
Flexible resource adequacy storage must-offer rules



Storage must-offer rules

- The ISO proposes that storage resources (excluding pump storage) that provide flexible capacity either:
  1. Submit economic regulation bids for the time period from 5:00am –10:00pm as a regulation energy management resource, or
  2. Submit economic bids from 5:00am to 10:00pm for the full EFC of resource
- Option for storage to select one of the demand response windows has been removed

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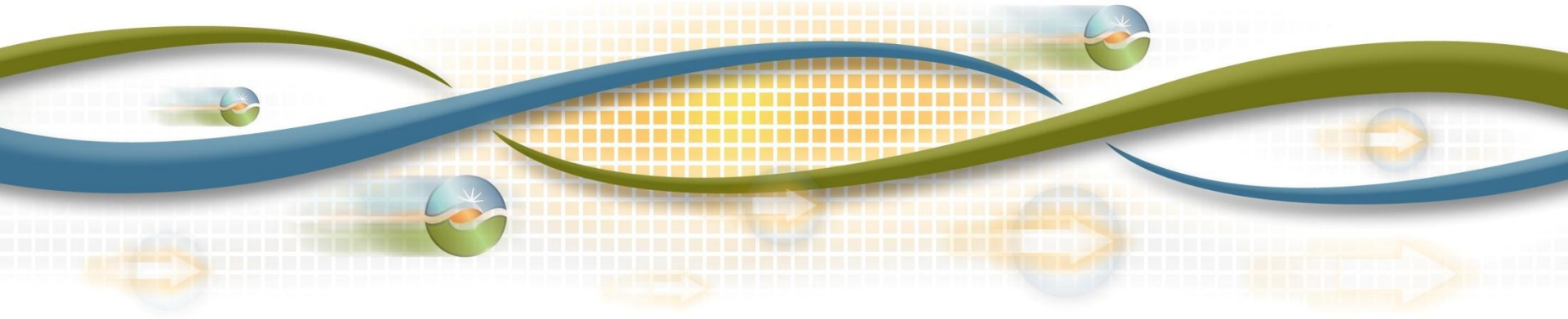
Flexible Capacity Availability Incentive Mechanism: Standard Flexible Capacity Mechanism (SFCP)

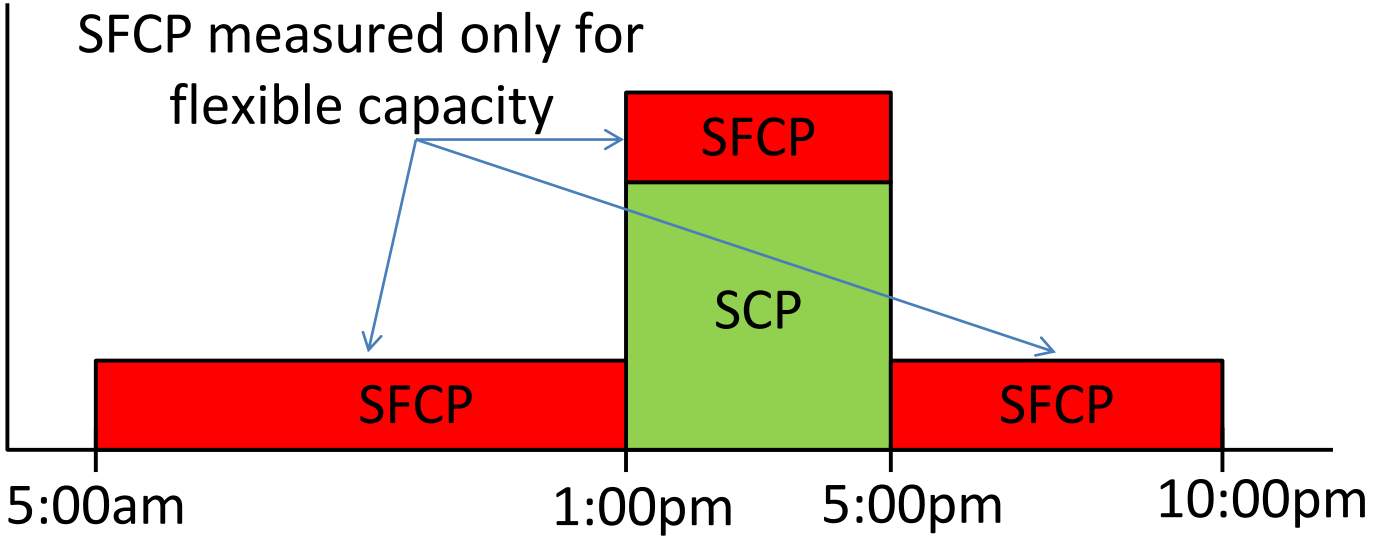
Karl Meeusen
Market Design and Regulatory Policy Lead



ISO believes an availability incentive mechanism is superior approach to bid insertion rules for flexible capacity

- Availability incentive mechanism (SFCP) based on economic bids
- Compliance with must-offer obligation can be ensured through this mechanism
  - Positive affirmation flexible capacity is available, e.g. demand response bids
  - Allows for use-limitations or need for self-scheduling that market cannot model
- Anticipate implementing no later than the 2016 RA compliance year

Example: The Adder Method



- The SCP is measured for all RA capacity and does not consider flexibility capacity availability rules
- The SFCP is measured for only flexible RA capacity and does not consider generic capacity availability rules
- A resource that self schedules would be available under SCP, but not SFCP
- A resource that is on forced outage would be considered unavailable under both the SCP and SFCP
- Resources subject to both SCP and SFC charges

Most stakeholders support the use of the adder method to price the Standard Flexible Capacity Product

- Most accurately reflects
  - Relative values of generic capacity and
  - Additional value of flexible capacity
- Subject to less overlap
- More accurate values availability
  - Considers a self-scheduled resource to be available for generic but not for flexible
  - SFCP appropriately value additional benefit of economic over self schedule

Most stakeholders support the use of the adder method to price the Standard Flexible Capacity Product (cont.)

- Does not require rules to determine if an outage or derate impacts flexible or generic capacity
  - Resource's bidding activity would demonstrate what portion of the capacity is out
- Can easily be transitioned to use a price signal received from a reliability services auction

Pricing the flexible capacity adder

- In the third revised straw proposal, the ISO proposed to price the SFCP at $23.25/kw-yr
  - Based on difference between the average price for system capacity with the 85th percentile for ISO system capacity using CPUC annual RA report
- Numerous reasons for differences in RA contract prices
  - Differences should not be attributed exclusively to flexibility

Pricing the flexible capacity adder

- Based on stakeholder comments, the ISO reassessed the three options for setting the flexible capacity adder:
  - The CPM rate
    - Designed to value genic capacity, not clear this is the correct price to value flexible capacity availability.
  - The average $/kw-yr equivalent for the flexi-ramp constraint
  - The publically available CPUC data for RA contract prices
    - Based on prices from CPUC's bilateral capacity market

The ISO evaluated the price of the flexible ramping constraint during only FRAC-MOO hours

- Price of flexible capacity adder should
  - Be reasonable relative to the price of generic capacity
  - Provide sufficient incentive to ensure the resource is available
- To determine the price of the flexible ramping constraint, the ISO considered
  1. Intervals in which flexible ramping constraint binding
  2. All intervals
- To create a consistent assessment, the ISO:
  1. Converted flexible ramping constraint prices to $/kw-yr
  2. Converted SFCP and SCP$/kw-yr prices to $/MWh over assessment hours

Pricing the SFCP using the flexible ramping constraint

Scenario	Capacity price ($/kw-yr)	Hours of availability	$/MWh
SCP with 5 hour weekday/non-holiday availability	$67.50/kw-yr	1250	$54.00/MWh
SFCP with 17 hours available, only intervals when flexible-ramping is constraint binding	$361.2/kw-yr*	6205	$58.21/MWh
SFCP with 17 hours available	$45.96/kw-yr*	6205	$7.41/MWh

- Conversions assume:
  - 5 hour SCP availability
  - 17 hour SFCP availability

* Corrected from fourth revised straw proposal

Converting $/MWh to $/kw-yr and back again

- Converting SCP from $/kw-yr to $/MW
  - CPM price*1000/(availability hours in a year) = 67.50*1000/(1250)
- Converting flexible ramping constraint from $/MWh to $/kw-yr
  - Average FRC price*(availability hours in a year)/1000 = $X*6205/1000

The ISO recommends using the average price of the flexible ramping constraint for all FRAC-MOO intervals

- Using only intervals when the flexible ramping constraint is binding does not produce reasonable relative price relative to generic capacity
- The average flexible ramping constraint price meets both criteria required of a flexible capacity availability incentive mechanism

Example of how the SCP and SFCP interact

1 MW resource

outage events converted to $/MWh equivalent

Time	Physically available	Economically bidding	SCP Charge (converted to $/MWh)	SFCP Charge if price set using FRC from all FRAC-MOO hours	Total charges
10:00 AM	yes	yes	$0/MWh	$0/MWh	$0/MWh
2:00 PM	yes	no	$0/MWh	$7.41/MWh	$7.41/MWh
4:00 PM	no	no	$54.00/MWh	$7.41/MWh	$61.41/MWh
8:00 PM	no	no	$0/MWh	$7.41/MWh	$7.41/MWh

The interaction of SCP and SFCP in the adder methodology

SCP Target	90 (87.5-92.5)
SFCP Target	85 (82.5-87.5)

Resource	SCP Availability	SFCP Availability	SCP charge or credit	SFCP charge or credit	Net Availability Credit or Charge
Resource 1	93	90	Credit	Credit	SCP Credit + SFCP Credit
Resource 2	85	90	Charge	Credit	SFCP Credit - SCP Charge
Resource 3	95	80	Credit	Charge	SCP Credit - SFCP Charge
Resource 4	85	80	Charge	Charge	-SCP Charge - SFCP Charge

The ISO must address potential between circular pricing signals between the SFCP and flexible ramping constraint

- The SFCP price could have a direct impact on the flexible ramping constraint price and vice versa
- Price will be frozen until
  1. resource flexible capacity availability levels are excessively low are excessively low
  2. A market based pricing mechanism for forward procurement of flexibility has been established or
  3. Three years, at which time the adder price will be reexamined

Flexible capacity availability incentive mechanism must ensure flexible capacity is available in both day ahead and real time markets

- Compliance in both day-ahead and real-time markets in each of these markets is important
  - Unit commitments in the day-ahead market
  - System balancing in the real-time market
- Flexibility is most useful in the real-time markets
- Measurement based on resource's must-offer obligation
  - For example:
    - Non-use-limited measured on 17 hour availability
    - DR measured on 5 hour availability

Calculating a resource's SFCP availability

- Real-time economic bids weighed at 80 percent towards the SFCP calculation and day-ahead economic bids be weighed at 20 percent

$$SFCP\ Availability_{MTH_y} = \frac{\sum_{i,j}\begin{bmatrix}0.2 * (MW\ bid\ into\ hour\ i\ on\ day\ j\ into\ DAM\ ) + \\ 0.8 * (MW\ bid\ into\ hour\ i\ on\ day\ j\ into\ RTM)\end{bmatrix}}{Compliance\ hours\ in\ the\ month * Flexible\ capacity\ provided}$$

Substitution of flexible capacity on forced outage

- Flexible capacity resources forced out during a month may provide substitute capacity to cover the outage
- Any substitute capacity must be received and approved by the ISO prior to the close of the IFM
- Must provide substitute capacity to address the loss of both generic capacity and flexible attribute to avoid SCP and SFCP non-availability charges.
  - Substitute for flexible capacity need not come from the same resource that substitute for generic capacity
- If resource on outage has an EFC, but is not shown as flexible in an RA showing, the only generic capacity must be replaced
  - Local capacity must still be replaced

What defines unavailable for SFCP

- A resource will be considered unavailable under SFCP when:
  - It fails to submit an economic bid for the flexible capacity quantity for any reason
  - A use-limited resources reaches its use-limitation within a month without providing substitute capacity
    - Thresholds exempting use-limited resources from SFCP penalties have been removed
- A resource will be considered available under SFCP when
  - It is a long-start resources that not scheduled in the day-ahead market
  - It is on a planned and approved outage
  - It has reached a daily use-limitation

Thresholds exempting use limited resources for SFCP penalties have been removed

- However, the ISO believes that eliminating these thresholds will provide at least three important benefits:
  1. Could leave the ISO with insufficient flexible capacity by the end of the month.
     - Need for flexible capacity equally likely to occur in the final ten days of the month as in the first ten days.
  2. ensures comparable treatment for resources availability
     - Resources should not receive different treatment simply because of when during the month the resource is not available
  3. Provides an incentive to limit the amount flexible capacity resources that are at high risk of hitting their use-limitation before the end of the month

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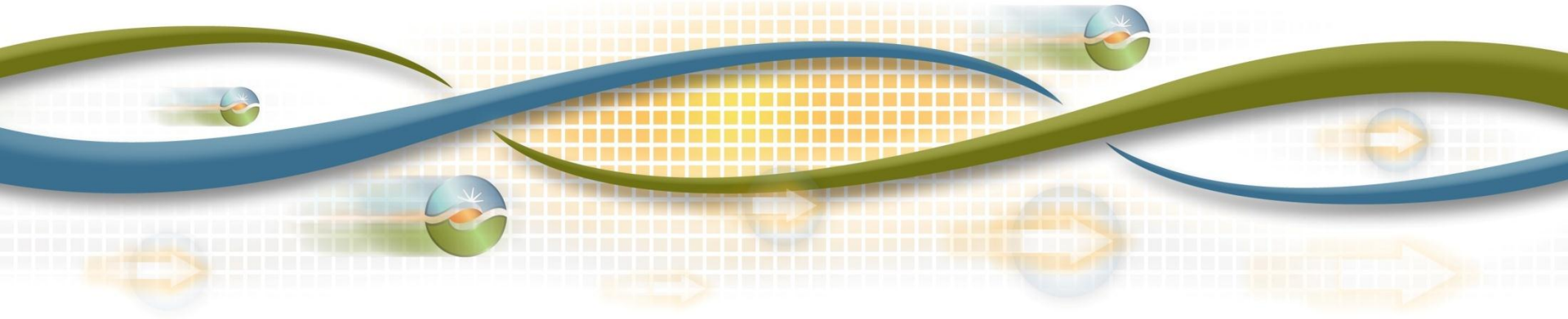
Proposed Flexible Capacity Backstop Procurement Authority

Karl Meeusen
Market Design and Regulatory Policy Lead



New backstop procurement authority to address deficiencies in an LSE's flexible capacity requirement

- ISO proposes backstop procurement authority that allows for backstop designations when:
  - An LSE has insufficient flexible capacity in either its annual or monthly Resource Adequacy Plan and
  - There is an overall net deficiency in meeting the total system annual or monthly flexibility requirements
- The ISO will apply adder method to backstop capacity
  - LSE will have 30 days to cure any deficiencies

Reliability Services Action will ultimately be primary backstop procurement mechanism

- Would provide market based mechanism to procure flexible capacity shortfalls
- Will likely have to maintain mechanism similar to CPM for more limited circumstances
- Compliments adder method by providing market based value for flexible capacity

Next Steps

- Comments on straw proposal
  - Comments Template posted November 14, 2013
  - Due November 27, 2013
  - Submit comments to fcp@caiso.com

- Board of Governors
  - February 2014