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APPENDIX A

ISO Materials Presented at the CPUC Resource Adequacy Workshop

March 20, 2013



Methodology for Determining Flexible Capacity Procurement Requirements

Presented at the CPUC RA Workshop

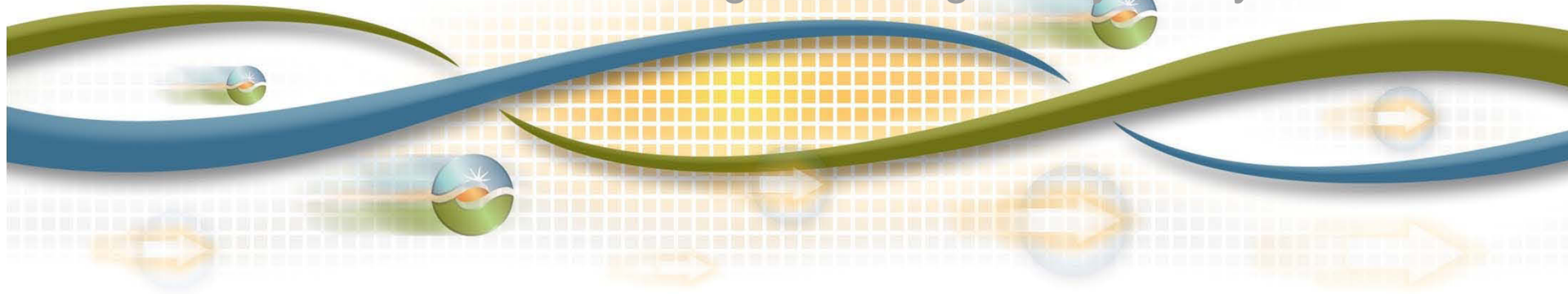
March 20, 2013 (Revised March 22, 2013 to reflect 80% fixed tilt solar fleet)

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John Goodin – Regulatory Policy Manager

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Overview

- Review of Actual Operational Observations from 2013
- Data Collection and Study Methodology for Calculating the Flexible Capacity Requirements
- 3-hour ramping requirements: Results for 2014-2016 assessments
- Calculating and Assessing Effective Flexible Capacity (EFC) of the Fleet
- Flexible RA Capacity Procurement Requirement Process Timeline

Key Takeaways

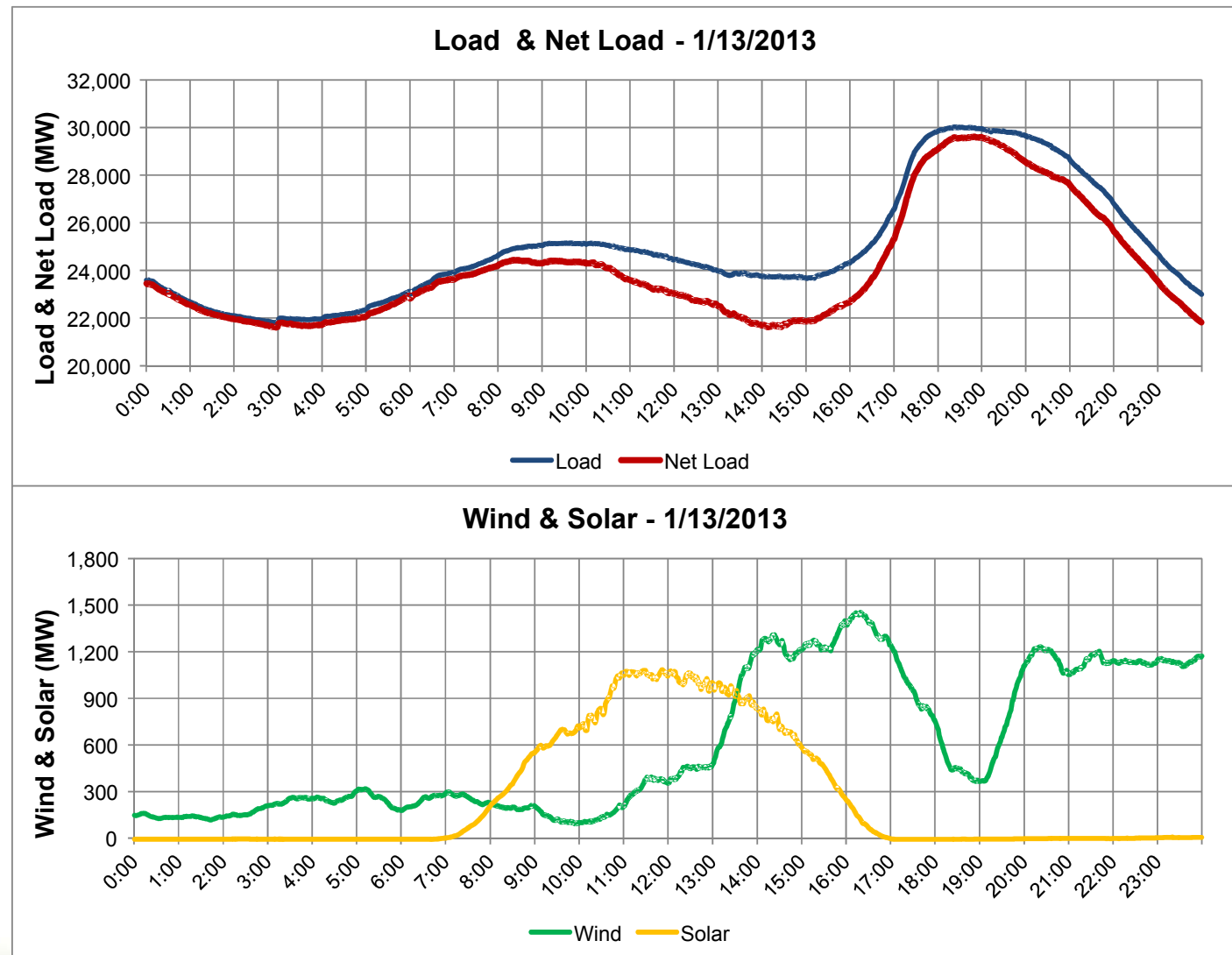
- Net Load Ramps have already exceeded 7,500 MW in 3-Hours
- The ISO is using an established and CPUC vetted methodology
- The most significant ramping needs occur in off-peak months and exceed 10,000 MW in 3-hours
- Ramps exceeding 3-hour length will continue to occur
- While there is enough EFC, the current RA procurement framework may not ensure that flexibility is available to the ISO when needed
- A flexible capacity procurement obligation will enhance operational certainty as early as 2014
- It is feasible and necessary to implement a Flexible Capacity procurement obligation for 2014

Review of Actual Operational Observations from 2013*

* Additional Actual 2013 operational observations are contained in the Appendix

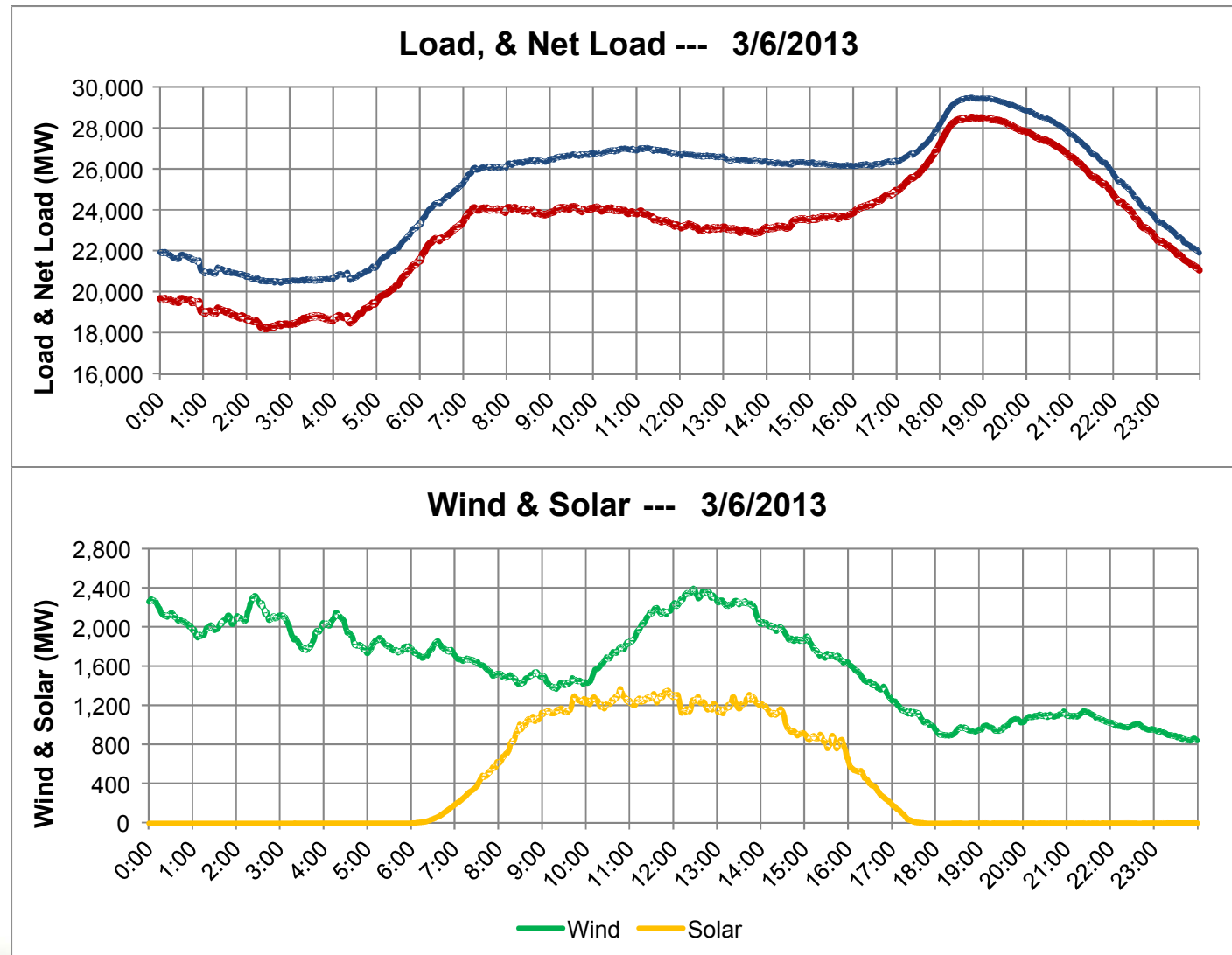
Wind and solar output drop simultaneously, resulting in a 7,500 MW 3-Hour Net Load ramp: January 13, 2013

- Maximum 3-Hour Load ramp was 6,285 MW
- Maximum 3-Hour Net Load ramp was 7,524 MW
- From 13:00, 807 MW of wind increased in 70 minutes during declining demand
- During the evening load ramp, wind dropped of by 991 MW and solar by 118 MW in 2 hours starting at 16:19



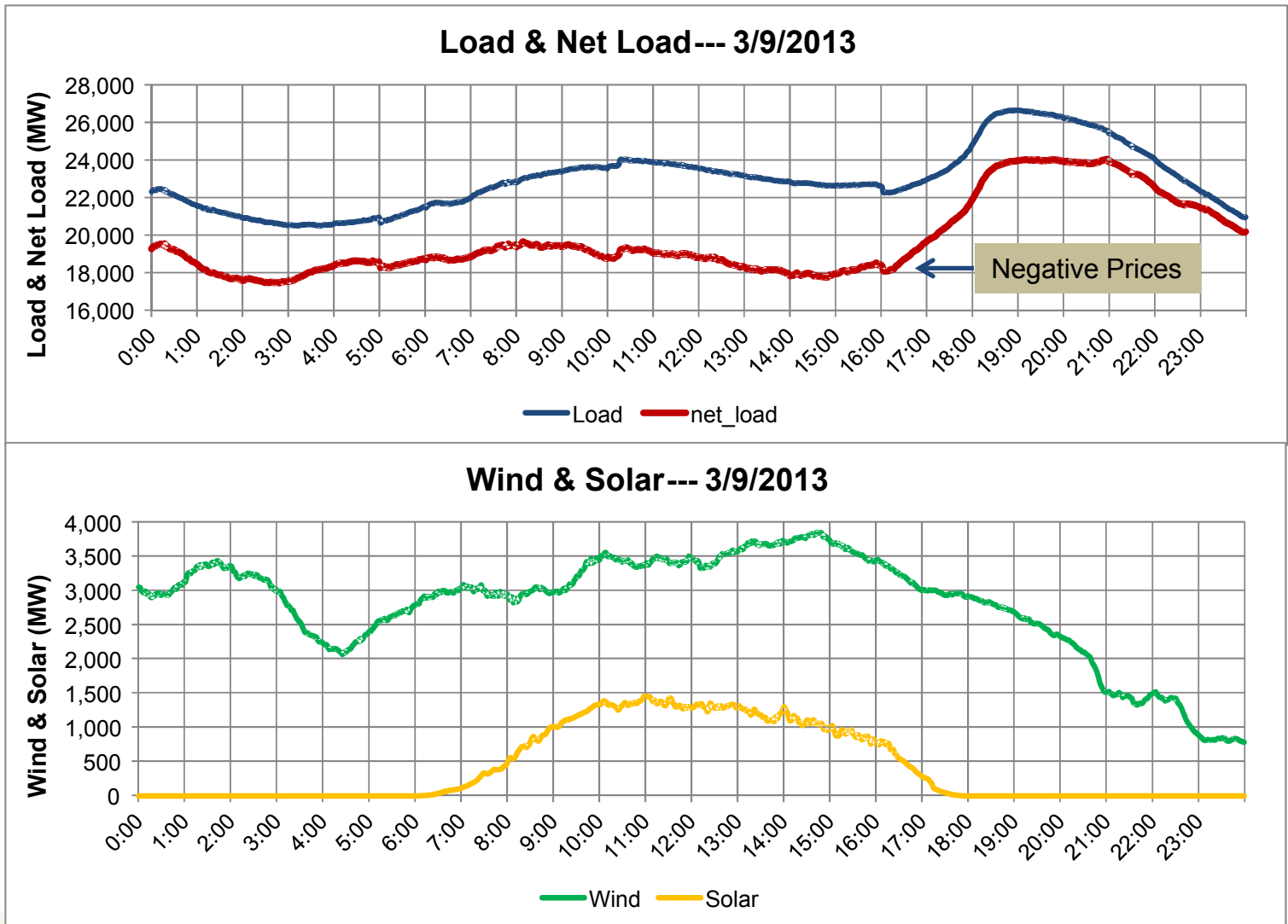
Wind and solar peaked and dropped simultaneously resulting in two distinct ramp-up periods

- Wind peaked at 2,391 MW @ 12:27
- Solar peaked at 1,367 MW @ 10:47
- Noticeable change in load and net load shape across mid-day
- Load increased by 3,500 MW in 2.5 hours
- Net Load increased by 5,000 MW in 3.5 hours



Wind production above 3,600 MW resulted in a net load below 18,000 MW and RTD negative prices for 11 5-minute intervals

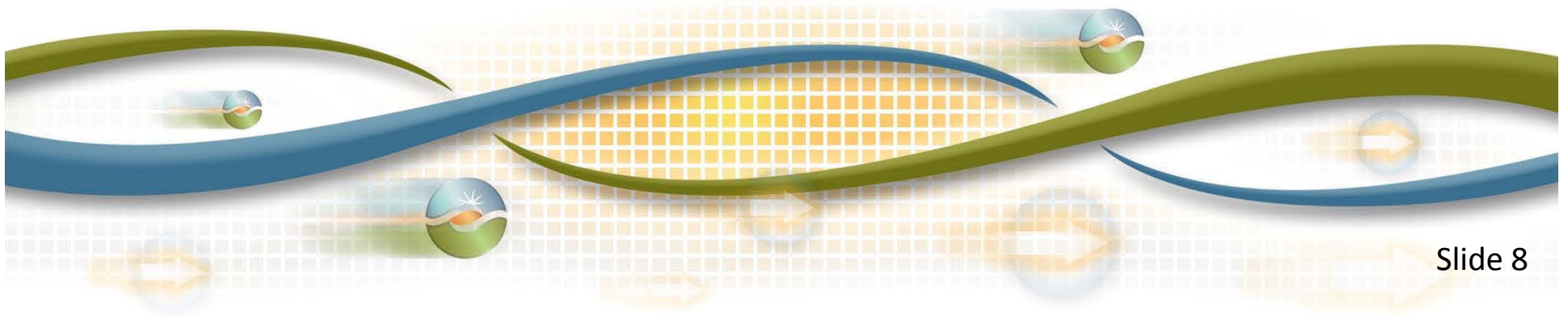
- Wind production above 3,600 MW
- Solar production around 1,000 MW
- Net Load below 18,000 MW
- Nine 5-minute intervals of negative RTD prices for HE15
- Two 5-minute intervals of negative RTD prices for HE 16





California ISO
Shaping a Renewed Future

Data Collection and Study Methodology for Calculating the Flexible Capacity Requirements



Expected IOU RPS portfolio build-out has been updated

- The three IOUs provided their latest RPS data
 - Data based on IOU 2012 RPS Compliance Reports
 - The ISO obtained public version of contracted MW of RPS plans
- Information collected on resources included:
 - Location
 - Contracted capacity
 - On-line date
 - Technology

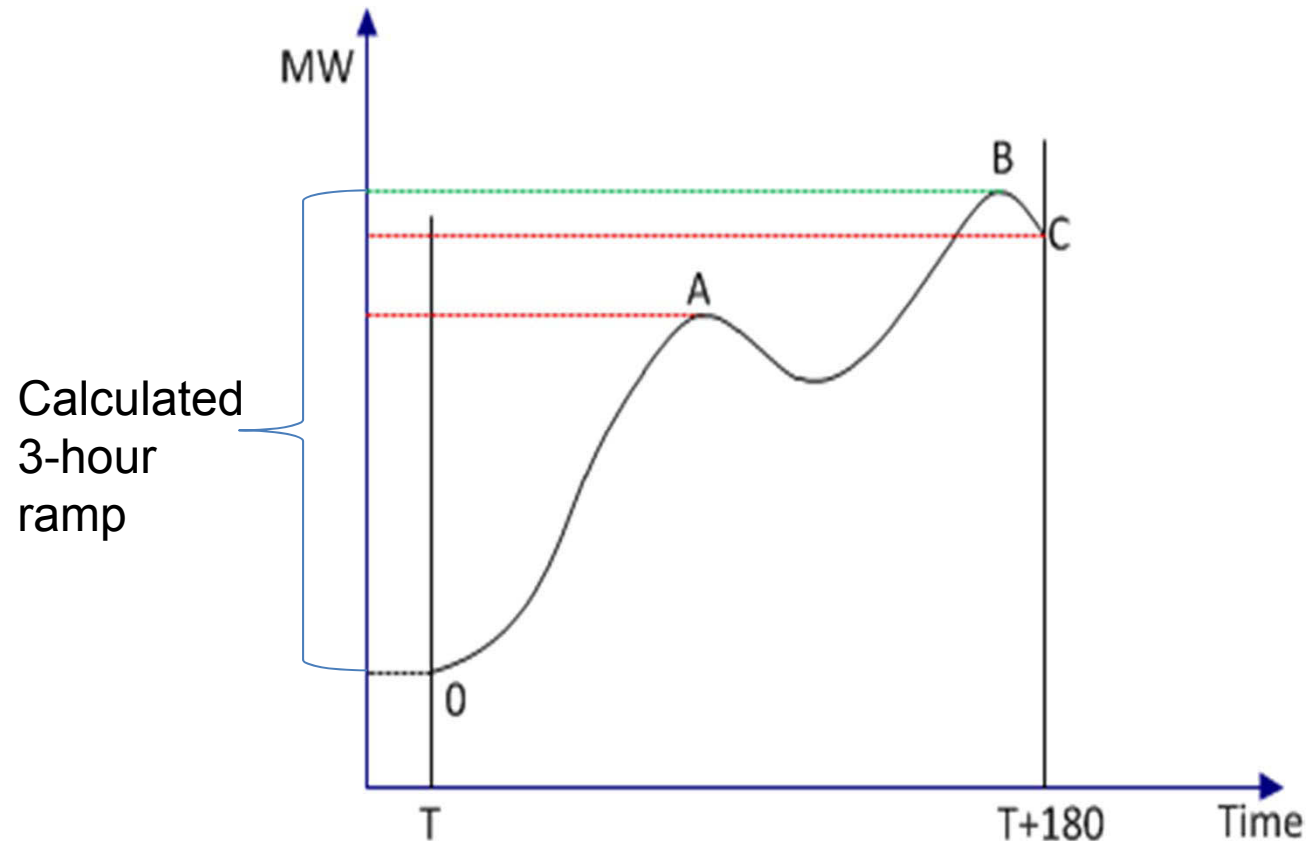
Using LTPP Base Case Assumption, Updated System-wide RPS Build-Out Shows 11,000 MW New Intermittent resources by 2017

- Relies on the same methodology and renewable profiles used in R.12-03-014
- Modified Assumptions:
 - Updated RPS data as previously defined*
 - Total Small PV figures are based on 2010 LTPP Assumptions

| | | Existing 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|--|---------------|------------------|---------------|---------------|---------------|---------------|---------------|
| Total Small PV (Demand Side) 2010 LTPP Assumptions | | 367 | 733 | 1100 | 1467 | 1833 | 2200 |
| ISO | Solar PV | 1,345 | 1,645 | 3,193 | 3,727 | 4,205 | 5,076 |
| ISO | Solar Thermal | 419 | 373 | 748 | 968 | 1,718 | 1,918 |
| ISO | Wind | 5,800 | 1,224 | 1,402 | 1,685 | 1,695 | 1,695 |
| Sub Total of Intermittant Resources | | 7,931 | 11,906 | 14,374 | 15,779 | 17,382 | 18,821 |
| Incremental New Additions in Each Year | | | 3975 | 2,468 | 1,405 | 1,603 | 1,439 |

* Additional detail regarding individual IOU build out is provided in the Appendix

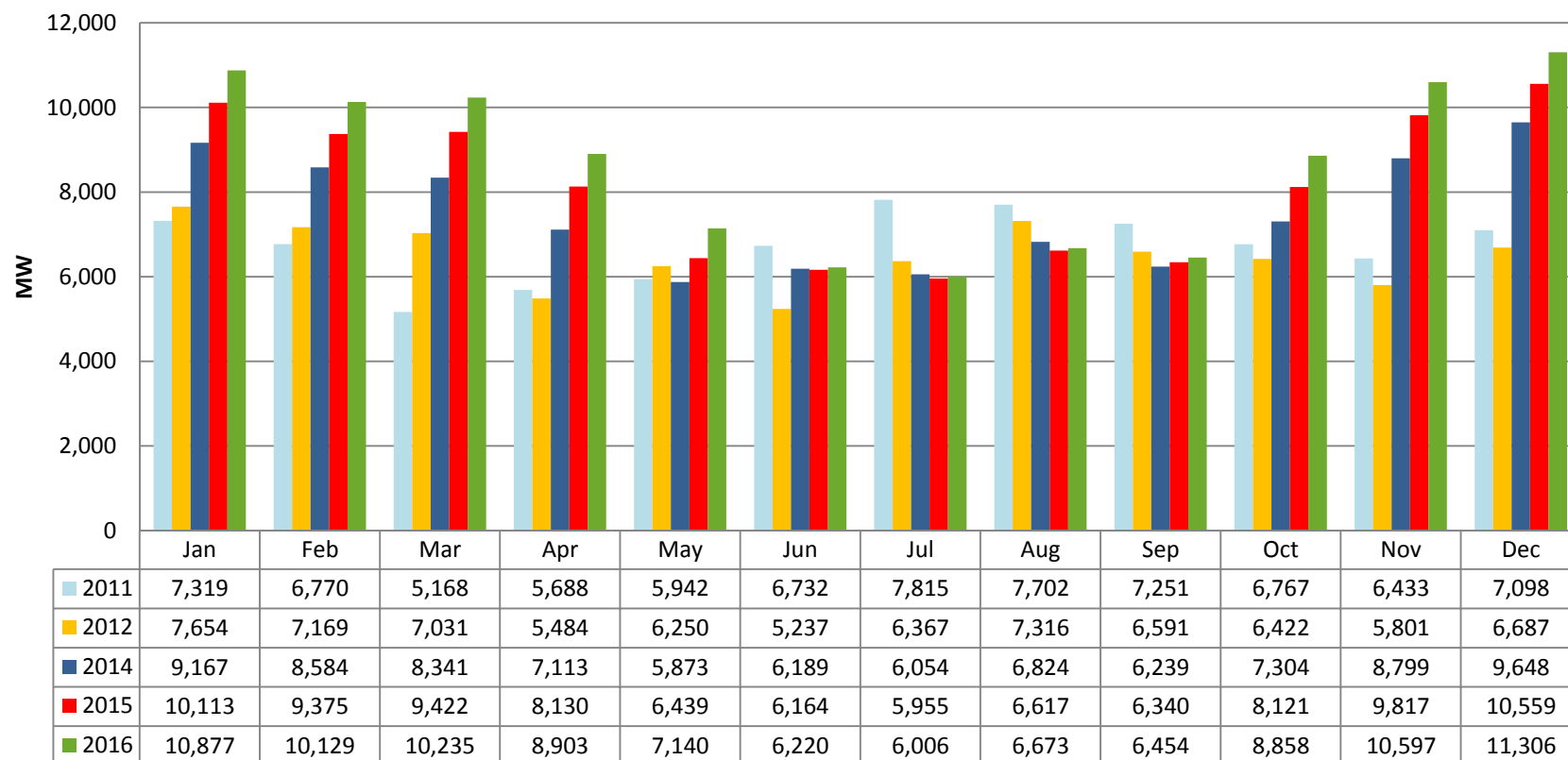
The 3-hour ramping need is calculated using the largest ramp during each 180 minute period



ISO tested all points using each methodology. Points B and C produced nearly identical needs for all months

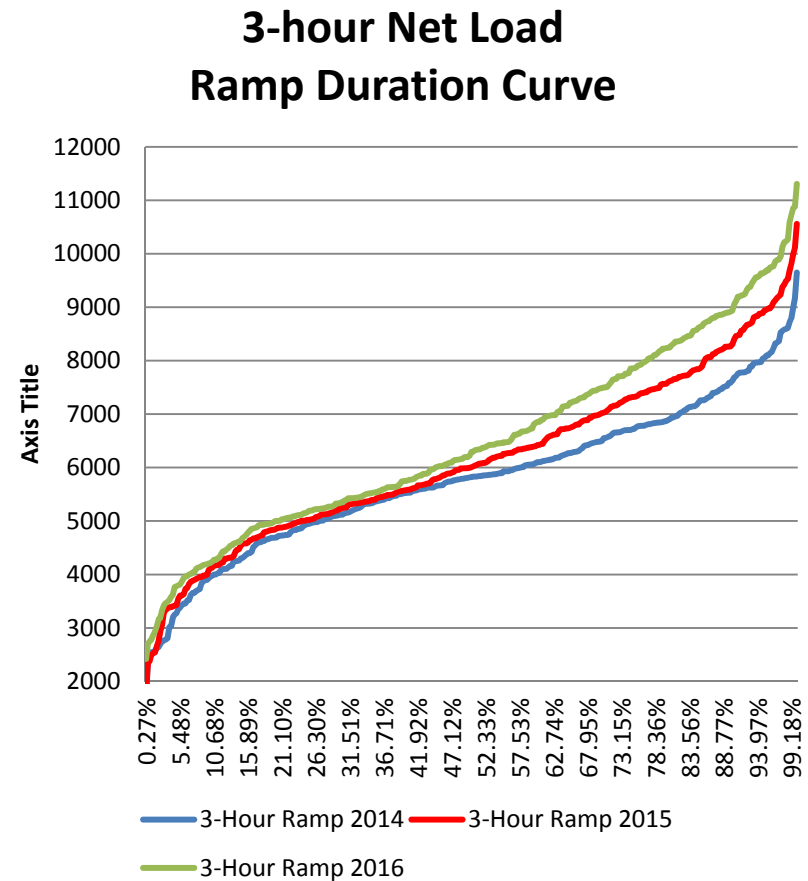
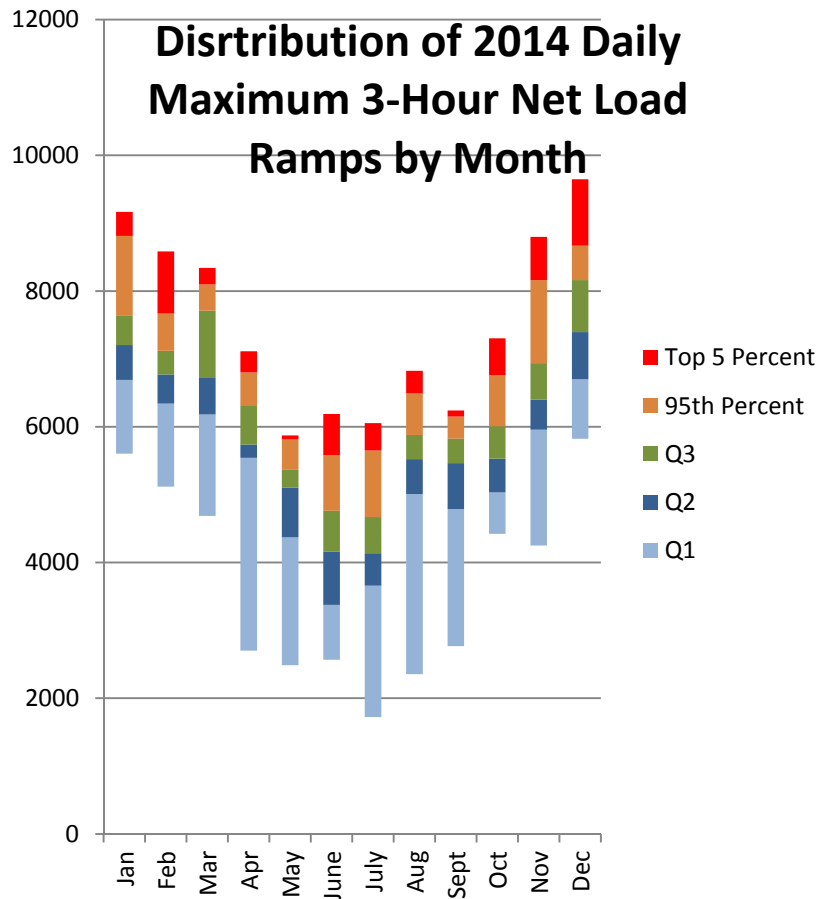
The maximum 3-hour net load ramp increases in each shoulder month by about 800-1000 MW year over year (revised to reflect 80% fixed tilt solar fleet)

Maximum 3-hour net load ramp



* 2011 and 2012 use actual ramp data, while 2014-2016 use minute-by-minute forecasted ramp data

There are opportunities for use-limited and DR resources to address “super-ramps” (revised to reflect 80% fixed tilt solar fleet)



The proposed interim flexible capacity methodology should provide the ISO with sufficient flexible capacity

- Methodology

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

Where:

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

$\text{E}(\text{PL})$ = Expected peak load

MTHy = Month y

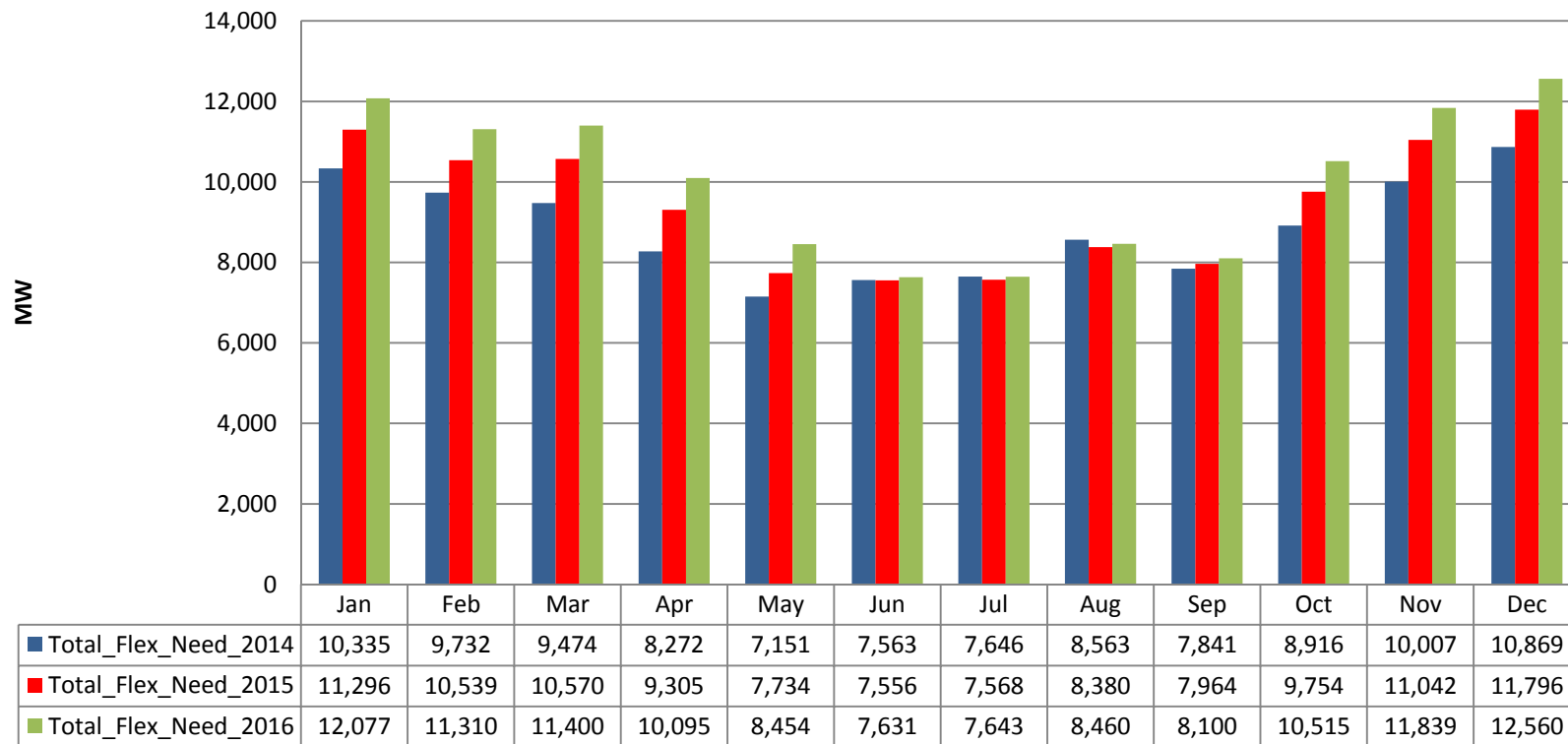
MSSC = Most Severe Single Contingency

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

- Methodology for 2017 and beyond needs to be developed

The forecasted peak ramping needs are greatest in the shoulder months and growing over time (revised to reflect 80% fixed tilt solar fleet)

Calculated Flexible Capacity Requirement



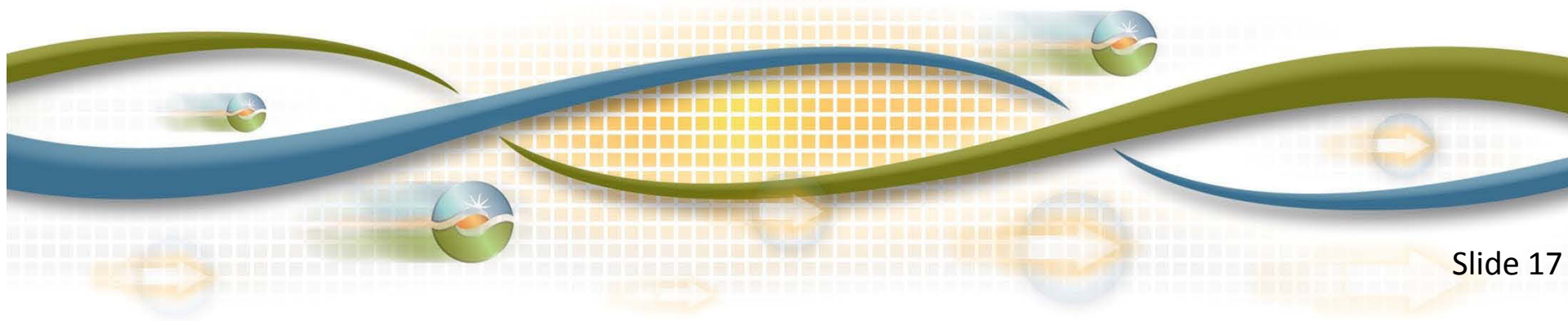
$$\text{Flexibility Requirement}_{\text{MTHy}} = \text{Max}[(3\text{RR}_{\text{HRx}})_{\text{MTHy}}] + \text{Max}(\text{MSSC}, 3.5\% * \text{E}(\text{PL}_{\text{MTHy}})) + \epsilon$$

Note: In the 2014-2016 assessments, the MSSC is never larger than the $3.5\% * \text{E}(\text{PL}_{\text{MTHy}})$

Summary of Findings

- Flexibility Capacity Need is largest in off-peak months
 - Flexible capacity will need to make up a greater percentage of the RA fleet in off-peak months
- The flexible capacity needs increase by about 800-1000 MW year over year in non-peak months
 - Increase almost exclusively caused by 3-hour ramp, not increase in peak load
- The most extreme ramps grow over time, showing increased ramping needs
- Daily maximum 3-hour ramps have significant monthly variance
 - Presents opportunity for Use-Limited resources, Demand Response, and Storage to meet “super ramps”

Calculating and Assessing Effective Flexible Capacity of the Fleet



Joint Parties proposal allows parties to determine a resource's effective flexible capacity

Start-up time greater than 90 minutes

$$\text{EFC} = \text{Minimum of (NQC-Pmin) or (180 min * RRavg)}$$

Start-up time less than 90 minutes

$$\text{EFC} = \text{Minimum of (NQC) or (Pmin + (180 min - SUT) * RRavg)}$$

Where:

EFC: Effective Flexible Capacity

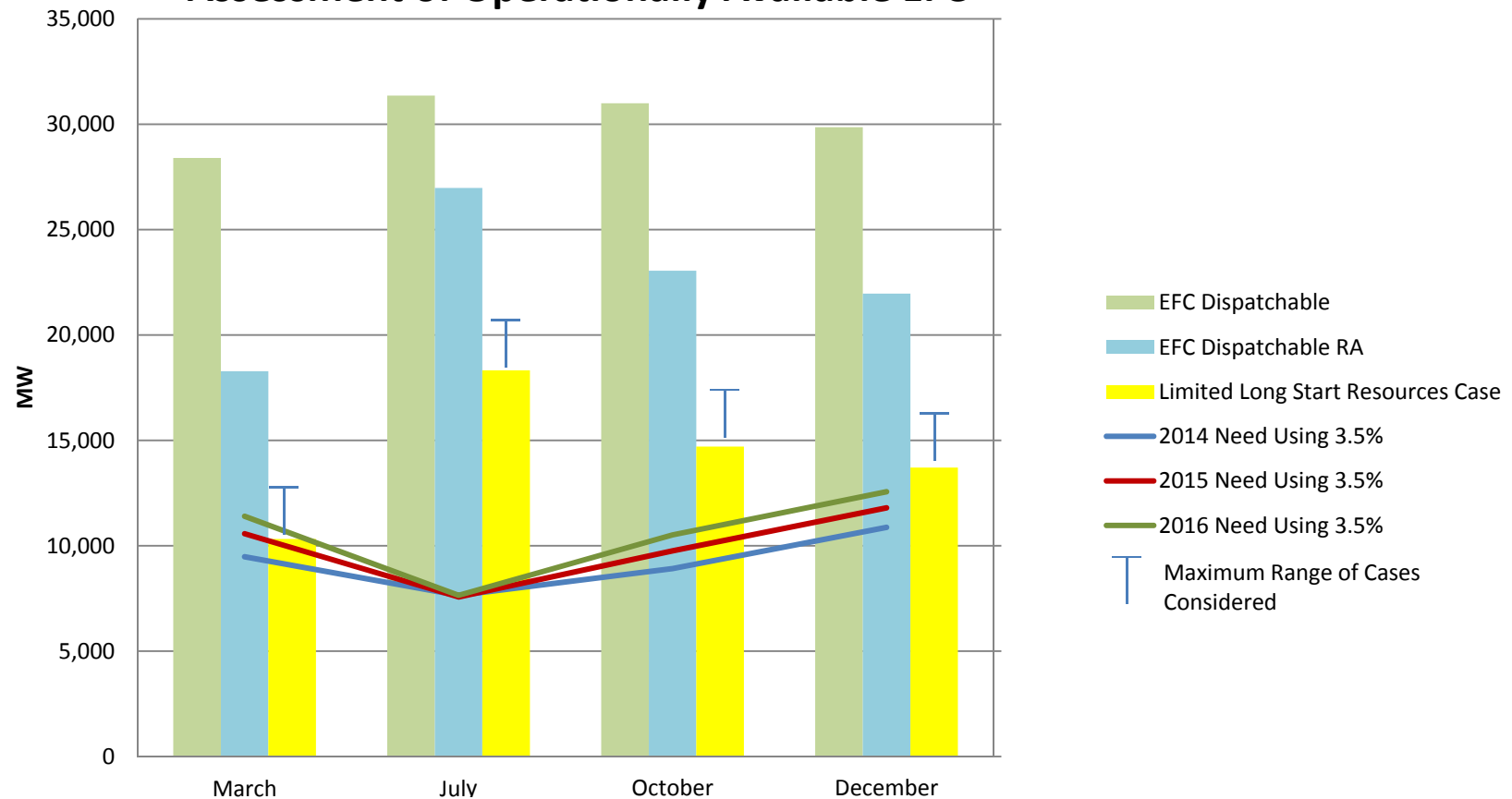
NQC: Net Qualifying Capacity

SUT: Start up Time

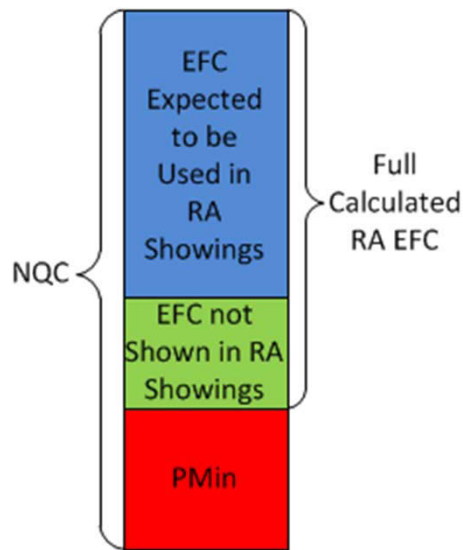
RRavg: Average Ramp Rate

Need a procurement rule to ensure sufficient flexibility in the procured RA resources (revised to reflect 80% fixed tilt solar fleet)

Assessment of Operationally Available EFC



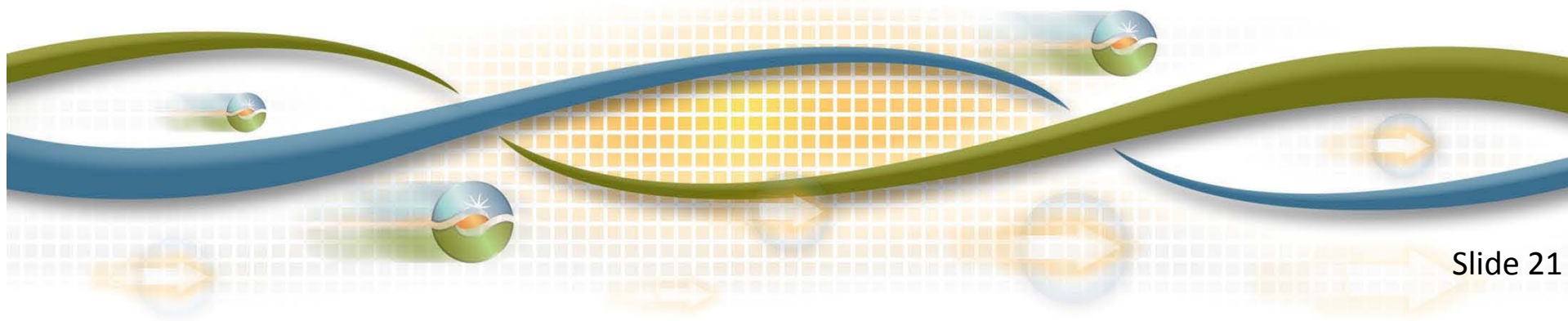
Need procurement rule that accounts for and ensures flexible capability is available for operational use



- Just because a resource has a calculated EFC, does not mean it will be listed as flexible in an RA showing and available for operational use.
- Simple case assessments* reflect potential of reduction of EFC for actual operation use due to:
 - Hydro conditions/run of river
 - Self-scheduling
 - Outages
 - Elections by resources to be inflexible

* Assumed reductions and additional cases are detailed in the Appendix

Flexible RA Capacity Procurement Requirement Process Timeline



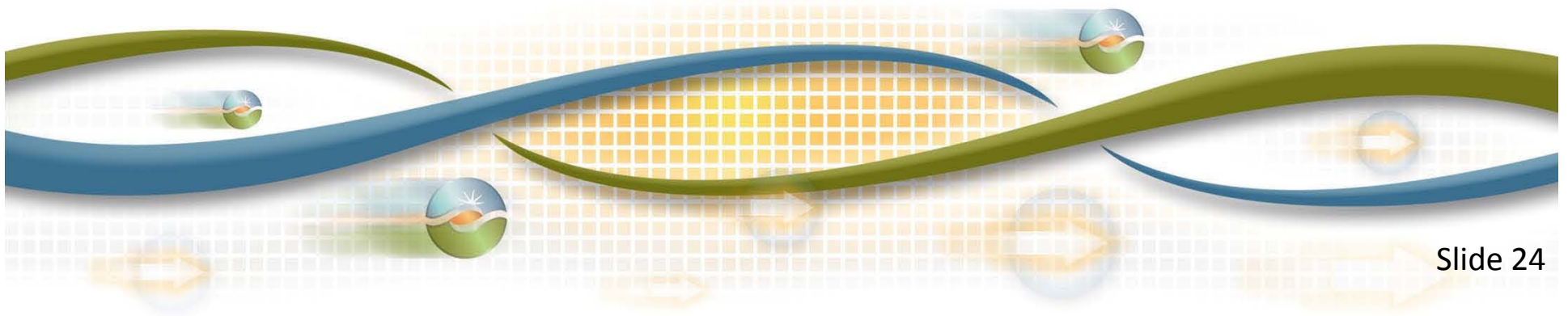
2014 Flexible RA Capacity Procurement Requirement Process Timeline

| Flexible Capacity Requirement Setting (Activities occurring in the year prior to RA compliance year) | |
|--|------------------------------------|
| • FCR methodology and assumptions paper and EFC amounts by eligible resource presented at CPUC workshop | Mar 20, 2013 |
| • Parties submit comments on workshop and ISO proposed 2014 flexibility requirements | Set by CPUC |
| • Publish draft final LCR study and EFC list of eligible flexible capacity resources | Mar 28, 2013 |
| - ISO stakeholder meeting to discuss LCR / FCR results | Apr 4, 2013 |
| - Stakeholders submit comments | Apr 18, 2013 |
| • Final 2014 LCR & FCR study | May 1, 2013 |
| • CPUC proposed and final annual RA decision incorporating LCR and FCR obligations | May / June 2013 |
| CPUC Procurement Obligation Allocation (System, local and flexible obligations for the following RA compliance year) | |
| • LSEs receive Year-Ahead obligations | Jul 31, 2013 |
| • Revised load forecasts for following RA compliance year | Aug 17, 2013 |
| • LSEs receive revised RA obligations | Sep 17, 2013 |
| Showings (Activities occurring during the RA compliance year) | |
| • Year-ahead showing of system, local, and flexible capacity (show 100% local and 90% system and flexible) | Oct 31, 2013 |
| • Month-ahead showings, including local and flexible true-ups | 2014 Operating Month (T) – 45 days |
| • ISO notifies LSEs and suppliers of any deficiencies of system, local, and or flexible capacity | T-25 days |
| • LSEs demonstrate to the ISO that identified deficiencies have been cured | T-11 days |

Illustrative 2015 & Beyond FCR Process Timeline

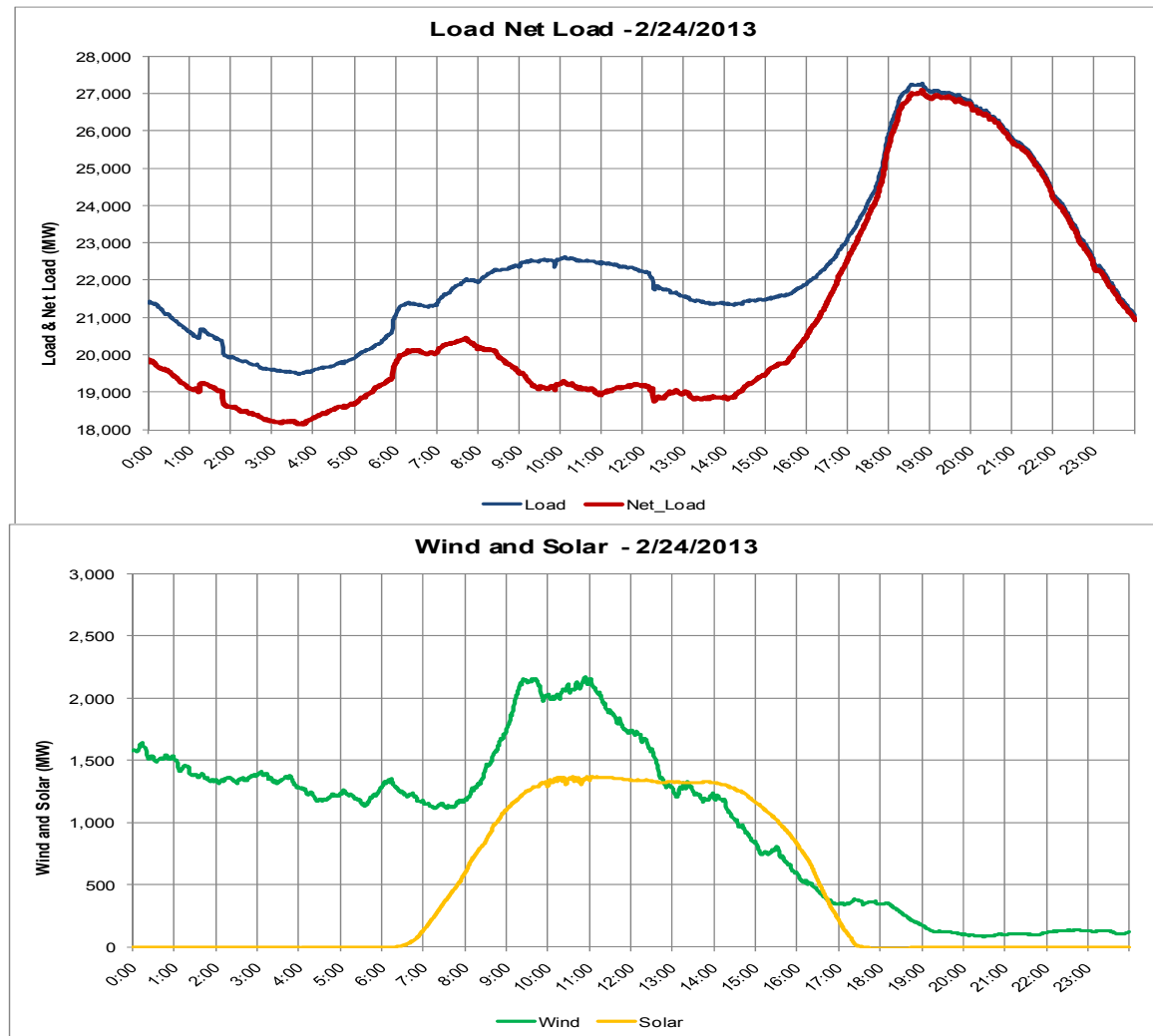
| Flexible Capacity Requirement Setting (Activities occurring in the year prior to RA compliance year) | |
|--|------------|
| Receive CEC load forecast used for TPP expansion plan | By Jan |
| Receive updated RPS build-out data from the IOUs | By Jan |
| Publish annual FCR assumptions paper | By Jan |
| – ISO stakeholder meeting to discuss assumptions | Feb |
| – Stakeholders submit comments | Feb |
| – Posting of comments with ISO response | Feb |
| Draft LCR and FCR study completed (including EFC list of eligible flexible capacity resources) | Mar 4 |
| – Local & flexible capacity needs stakeholder meeting | Mar 7 |
| Publish draft final LCR & FCR needs study | Mar 28 |
| – ISO stakeholder meeting to discuss LCR / FCR results | Apr 4 |
| – Stakeholders submit comments | Apr 18 |
| Final 2014 LCR & FCR study | May 1 |
| CPUC proposed and final annual RA decision incorporating LCR and FCR procurement obligations | May / June |
| CPUC Procurement Obligation Allocation (System, local and flexible obligations for the following RA compliance year) | |
| LSEs receive Year-Ahead obligations | Jul 31 |
| Revised load forecasts for following RA compliance year | Aug 17 |
| LSEs receive revised RA obligations | Sep 17 |
| Showings (Activities occurring during the RA compliance year) | |
| Year-ahead showing of system, local, and flexible capacity (show 100% local and 90% system and flexible) | Oct 31 |
| Month-ahead showings, including local and flexible true-ups | T -45 days |
| ISO notifies LSEs and suppliers of any deficiencies of system, local, and or flexible capacity | T-25 days |
| Final opportunity for LSEs to demonstrate to the ISO that any identified deficiencies have been cured | T-11 days |

Appendix



Wind and solar output drop simultaneously, resulting in a 7,100 MW Net load ramp: Actual Data from 2/24/2013

- 1,300 MW of solar & 800 MW of wind dropped off in 21/2 hours as load increased
- Wind & solar contribution at peak was about 300 MW
- Maximum ramp approx. 8,000 MW in 5-hours
- Maximum 3-Hour ramp 7,171 MW
- Steep evening ramps are real and expected to increase with more renewable resources



RPS Data Collection – By IOU

| | | 2013 | 2014 | 2015 | 2016 | 2017 |
|--|-------------------------|-------|-------|-------|-------|-------|
| Load (Replicating Base Case Scenario from R.12-03-014) | | 48870 | 49577 | 50240 | 50951 | 51625 |
| | | | | | | |
| Total by IOU, Technology, and Year | | 2013 | 2014 | 2015 | 2016 | 2017 |
| PG&E | Solar PV | 1,026 | 1,646 | 1,929 | 2,131 | 2,202 |
| PG&E | Solar Thermal | 373 | 748 | 968 | 1,718 | 1,918 |
| PG&E | Wind | 29 | 29 | 42 | 52 | 52 |
| SubTotal of PG&E New Additions | | 1,428 | 2,423 | 2,940 | 3,901 | 4,173 |
| Incremental PG&E Additions | | 1,428 | 995 | 517 | 961 | 272 |
| | | | | | | |
| SCE | Solar PV - Ground mount | 0 | 381 | 468 | 578 | 1,378 |
| SCE | Solar PV - Rooftop | 0 | 43 | 43 | 43 | 43 |
| SCE | Wind | 0 | 0 | 270 | 270 | 270 |
| SubTotal of SCE New Additions | | 0 | 423 | 780 | 890 | 1,690 |
| Incremental SCE Additions in Each Year | | 0 | 423 | 357 | 110 | 800 |
| | | | | | | |
| SDGE | Solar PV | 619 | 1,123 | 1,288 | 1,454 | 1,454 |
| SDGE | Wind | 1,195 | 1,373 | 1,373 | 1,373 | 1,373 |
| SubTotal of SDG&E New Additions | | 1,814 | 2,496 | 2,661 | 2,827 | 2,827 |
| Incremental SDGE Additions in Each Year | | 1,814 | 682 | 165 | 166 | 0 |

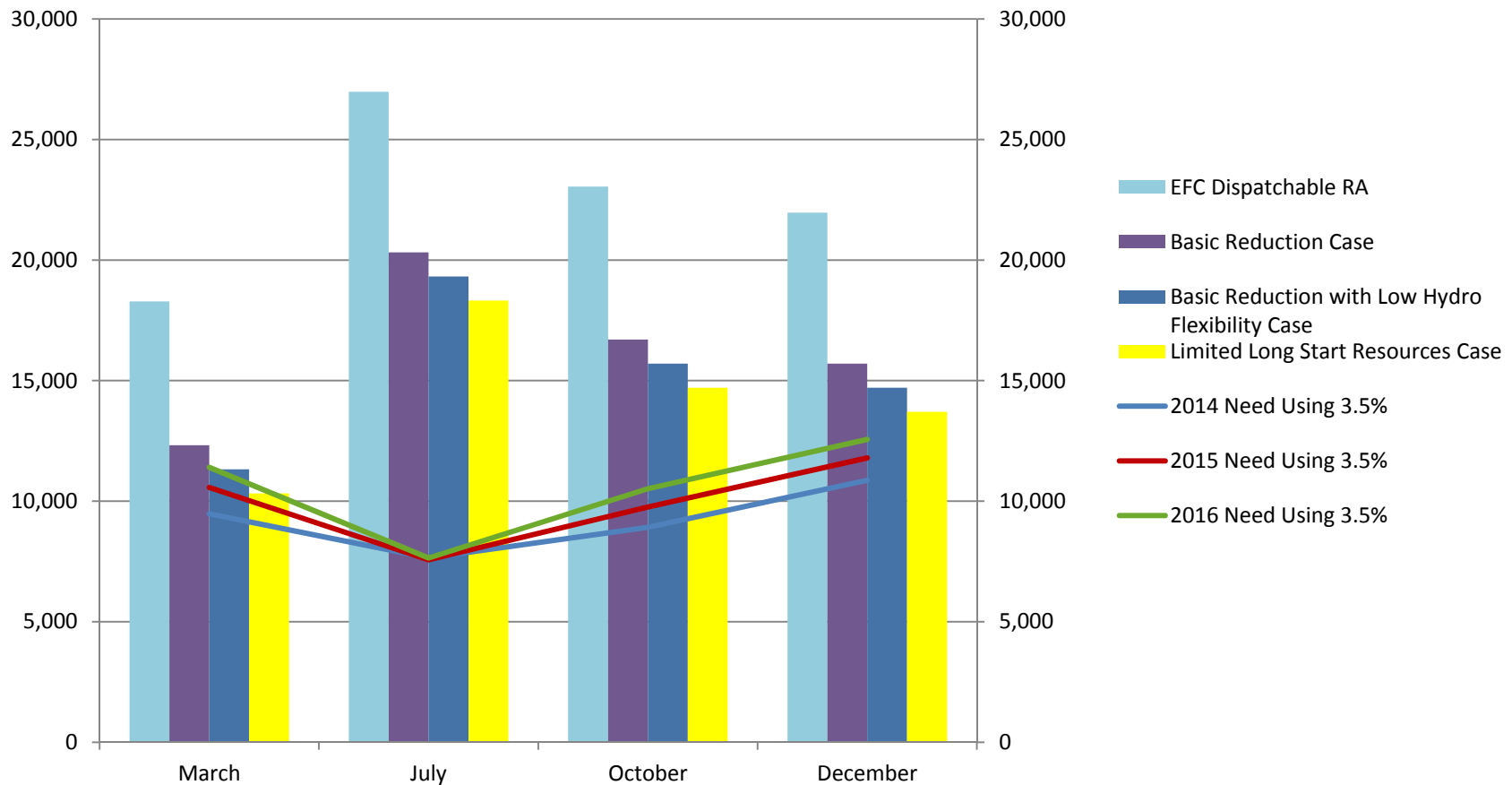
Reductions to EFC used in ISO case assessments, using 2012 Month-ahead RA showings

| | Run-of-River Hydro Reductions | Reduction in Hydro based on Hydro conditions** | Reductions for continued Self Scheduling | EFC OTC retirement in 2015 | Reductions based on election of inflexibility elections | Assumed outage rate of all remaining resources |
|-------------------------------------|-------------------------------|--|--|----------------------------|---|--|
| Basic Reduction Case | 1000 | 1000 | 2000 | 500 | 0 | 8% |
| Basic Reduction with Low Hydro Case | 1000 | 2000 | 2000 | 500 | 0 | 8% |
| Limited Long Start Resources | 1000 | 1000 | 2000 | 500 | 2000 | 8% |

* Full RA EFC calculated based on 2012 actual month-ahead RA showings

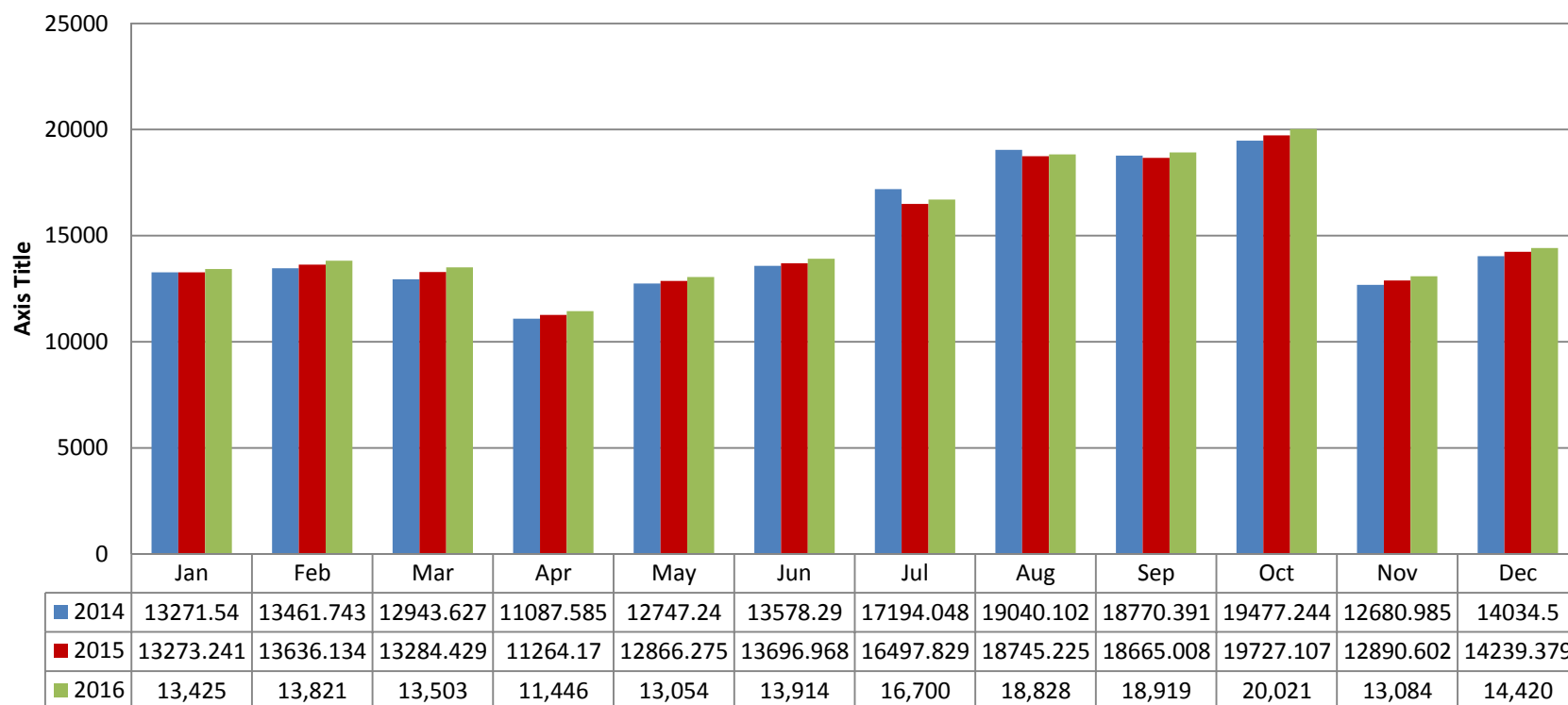
** Assumes all non-run-of river qualify as flexible capacity.

Need a procurement rule to ensure sufficient flexibility is procured from the RA Fleet (revised to reflect 80% fixed tilt solar fleet)



The ISO will still have to address net-load variations that last longer than the 3-Hour Ramp (revised to reflect 80% fixed tilt solar fleet)

**Peak-to-Trough: Largest Differences in Net load in a Single Day
(Independent of Continuity and Duration)**



Available EFC will reduce significantly as OTC resources retire

