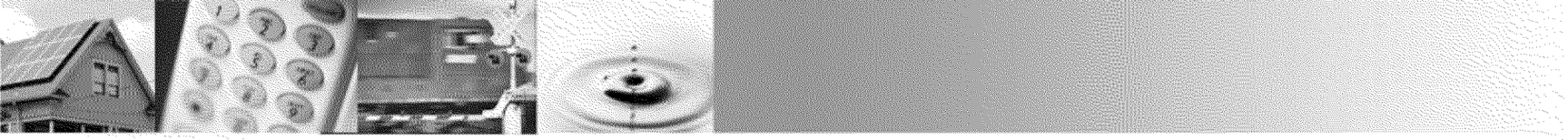


Revisions: Qualifying Capacity and Effective Flexible Capacity for Storage & Supply-Side DR

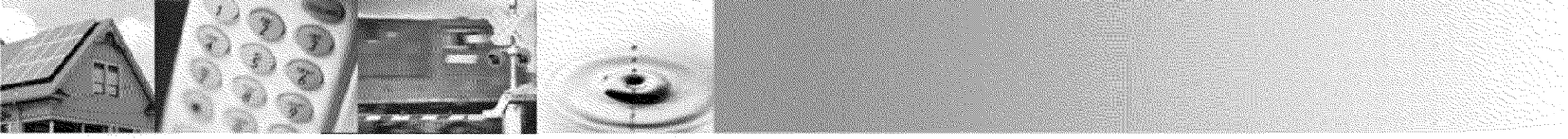
April 9, 2014

Resource Adequacy | Joanna Gubman

California Public Utilities Commission

Storage and DR resources may still be aggregated, but not with one another

- Several parties seemed concerned about the implementation of storage + DR aggregation and wanted more time to consider how this would work or what implications it might have
- Staff looks forward to revisiting this option in the future



DR Providers can pick a three-month testing window for Flexible RA

- Flexible RA DR Provider can pick which three month window
- CAISO can pick which date and time, as long as the time chosen falls into the resource's FRAC-MOO must-offer time window
  - System RA resource operators can self-schedule their test dates and times
- CAISO must provide advance warning in compliance with the resource's tariff
  - For example, a DR resource that is entitled to at least 30 minutes of notice in its tariff should receive at least 30 minutes notice of testing
- Resources offering both load curtailment and load increase must demonstrate both capabilities in testing

EFC: Yes, the methodology is complicated. But…

- System and Flexible RA are bundled for all other resources, and we want to be consistent
- We don't want anyone to game the system
- For fast-ramping resources, a lot of the complexity goes away
- It is simpler in pictures
- Flexibility is in an interim stage; we anticipate revisiting the methodology in future years

Nomenclature: Positive and Negative Generation

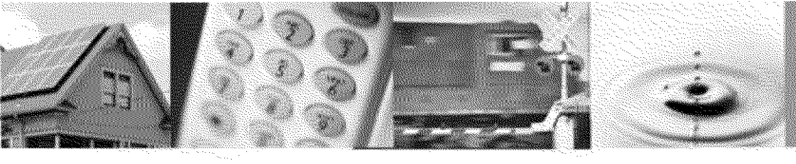
- Positive generation means discharge or load curtailment
- Negative generation means charge or load increase
- Both types need to be dispatchable by the CAISO to count as RA

Nomenclature: Power Output (in MW)

- **Pmax –** a resource's maximum rated power output
- **$Pmax_{RA}$ –** the maximum output sustainable for four hours; may be less than Pmax
- **$Psupply_{min}$ –** the minimum discharging or load curtailment sustainable for 3+ hours; only applicable to resources with positive generation
  - e.g., minimum dispatch level for a DR resource
- **$Pdemand_{min}$ –** a negative number representing the smallest magnitude of charging or load increase that is sustainable for the duration required in calculating EFC; only applicable to resources with negative generation
  - e.g., minimum pumping loads
- **$Pmin_{RA}$ –** either equal to $Psupply_{min}$ for resources with only positive operating ranges, or a negative number representing the largest magnitude of charging or load increase eligible for consideration in calculating EFC
- **Pmin –** a resource's minimum rated output; may be a positive or negative number, and is less than or equal to $Pmin_{RA}$

EFC is how much a resource can ramp or sustain output over 3 hours, up to NQC

- Let's start by looking at resources with very fast ramp rates



EFC for Fast-Ramping Resources

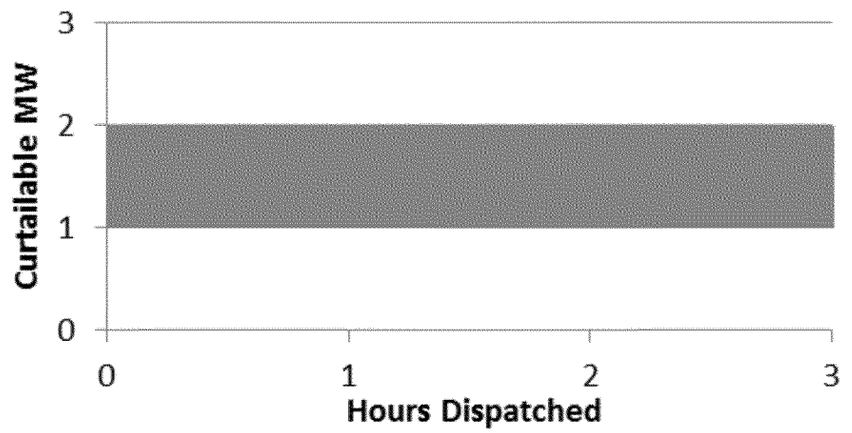
- Positive-generation resources (treated the same as other resource types):
  - EFC = NQC, if start-up time < 90 minutes
  - EFC = NQC – $Pmin_{RA}$, if start-up time > 90 minutes
- Negative-generation resources:
  - EFC = – $Pmin_{RA}$
- Bi-directional resources:
  - EFC = NQC – $Pmin_{RA}$

EFC is how much a resource can ramp or sustain output over 3 hours, up to NQC

- But what is the starting point? How is $Pmin_{RA}$ determined?

Positive generation resources: $Pmin_{RA}$ is the minimum sustainable 3-hr output

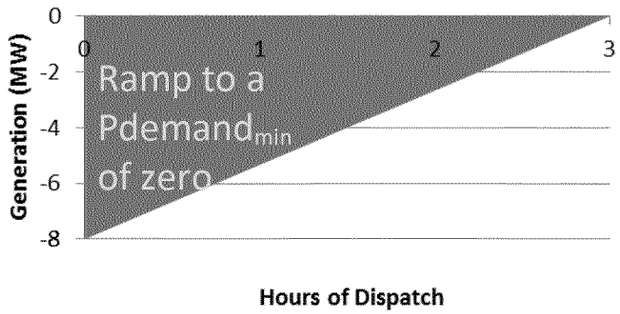
- Equivalent to $Psupply_{min}$
- May be zero, if there is no minimum output constraint
- Don't forget, $Pmax_{RA}$ is unchanged from the QC calculation

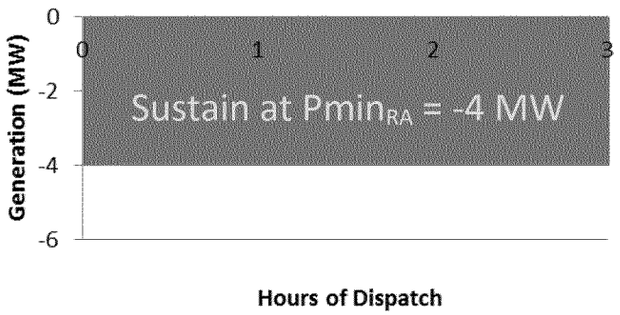


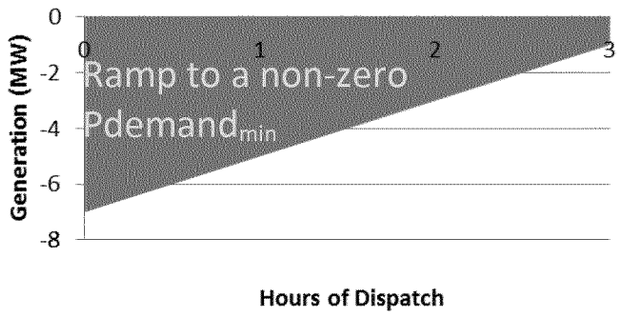
An example DR resource with $Pmin_{RA} = Psupply_{min} = 1$ MW

Negative gen: $Pmin_{RA}$ is the starting point to sustain output or ramp to $Pdemand_{min}$

- Limited by energy available to sustain or ramp at a constant rate for three hours
  - Examples: three resources, all with -12 MWh available





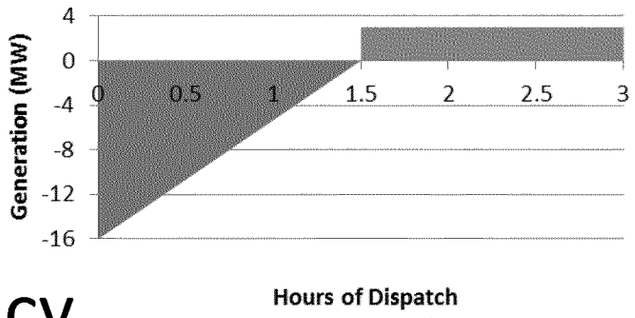


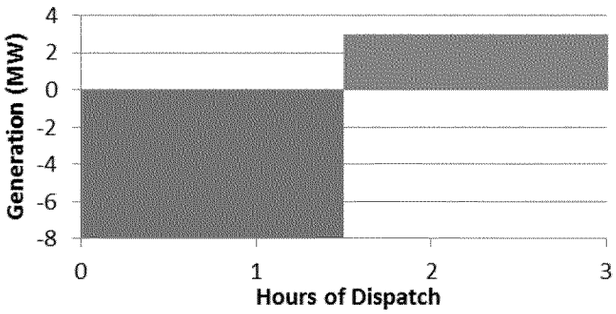
Bi-directional resources: $Pmin_{RA}$ same as negative gen, except 1.5-hour basis

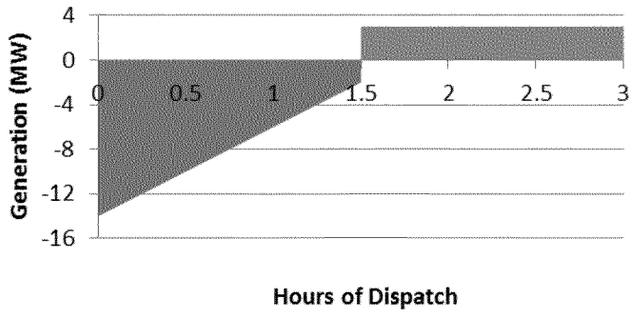
- $Pmin_{RA}$ is the starting point to sustain output or ramp to $Pdemand_{min}$
- Limited by energy available to sustain or ramp at a constant rate for 1.5 hours
- The other 1.5 hours of flexible operation are fulfilled by the capability to output at $Pmax_{RA}$ for 1.5 hours
  - $Pmax_{RA}$ remains unchanged; still based on constant 4-hour output

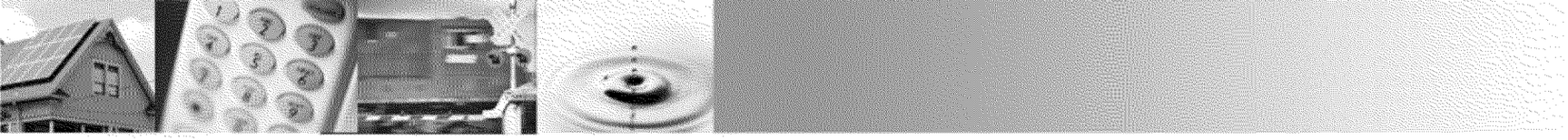
Bi-directional resources: $Pmin_{RA}$ same as negative gen, except 1.5-hour basis

- Examples: three resources, all with 12 MWh available and 100% round-trip efficiency







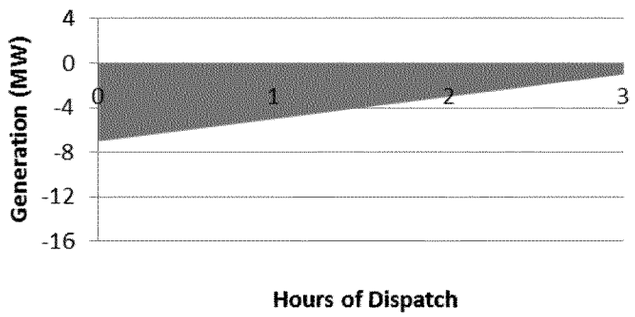


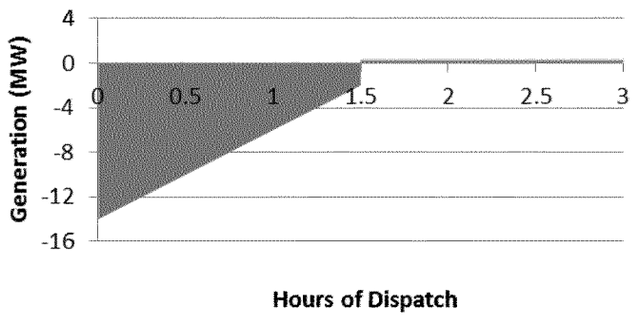
Bi-directional resources: transition time and discontinuity at zero are OK

- Staff proposes up to 45 minutes as acceptable transition time. Please address in comments!
- Transition discontinuity means $Pdemand_{min}$ and $Psupply_{min}$ can be non-zero
- The above characteristics are inconsistent with CAISO's NGR tariff as staff understands it
- Transition time does not count towards the three hours of operation – no gaming

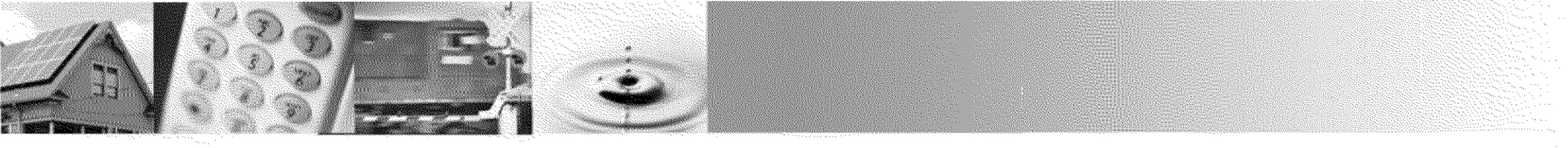
Bi-directional resources: approximate symmetry proposed, to limit gaming

- Staff proposes that available negative energy not exceed twice the available positive energy (equivalent to a round-trip efficiency of 50%)
  - Feedback requested as to whether parties find this to be a reasonable percentage





Example: Absent a symmetry rule, an "aggregate" resource could inflate its EFC



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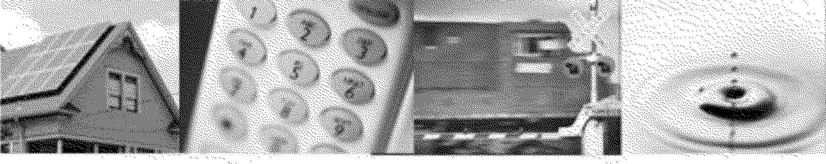
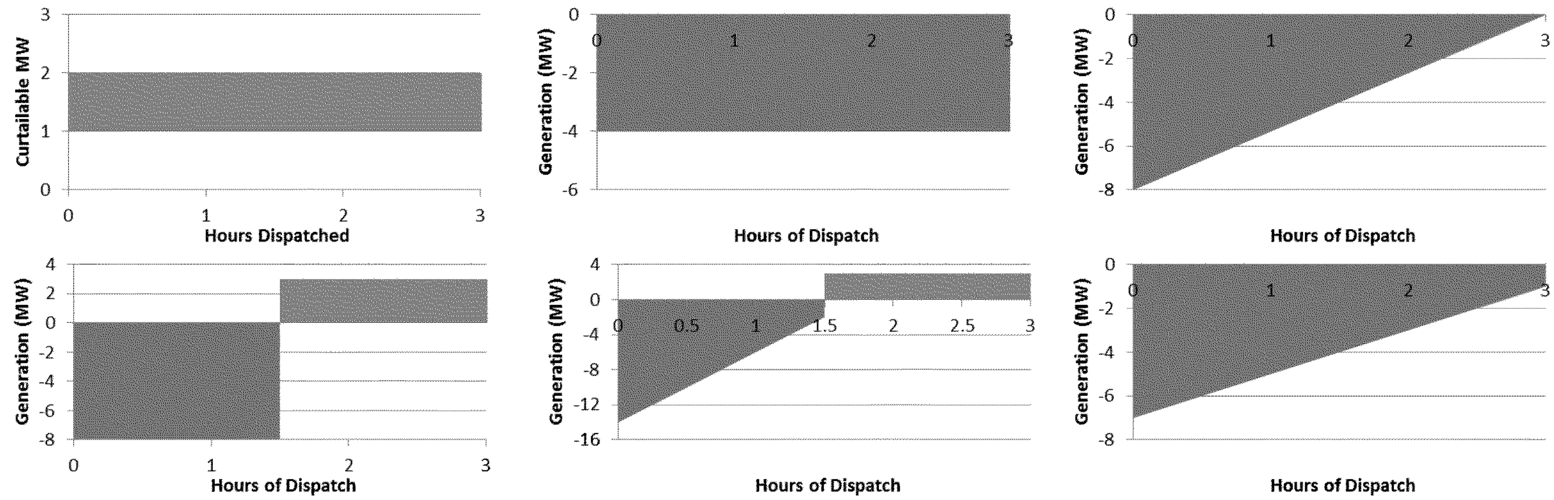
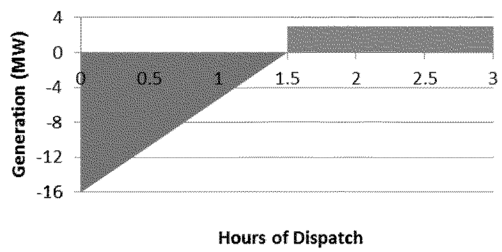


EFC for Fast-Ramping Resources

- Top MW minus bottom MW in relevant chart*





*Except the positive generation resource, which may just be Top MW, if start-up time is under 90 minutes. And all top numbers are subject to deliverability limitation (NQC).

Slower-ramping resources: EFC range is limited to what is physically possible

- Complicates the EFC formula, but conceptually similar to having a larger-magnitude $Pdemand_{min}$
- Use weighted average ramp rates (MW/min)
  - $ARR_{pos} = \frac{Pmax_{RA} - Psupply_{min}}{\text{Time to ramp up from } Psupply_{min} \text{ to } Pmax_{RA}}$
  - $ARR_{neg} = \frac{Pdemand_{min} - Pmin_{RA}}{\text{Time to ramp up from } Pmin_{RA} \text{ to } Pdemand_{min}}$

EFC for Fast-Ramping Resources

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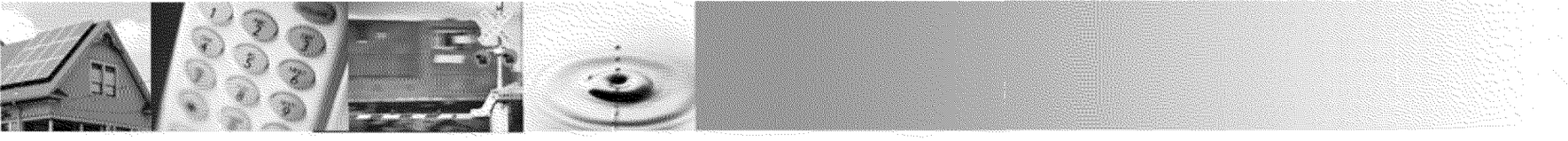
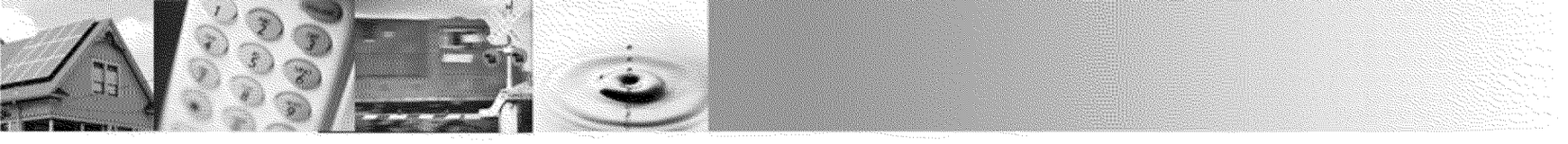


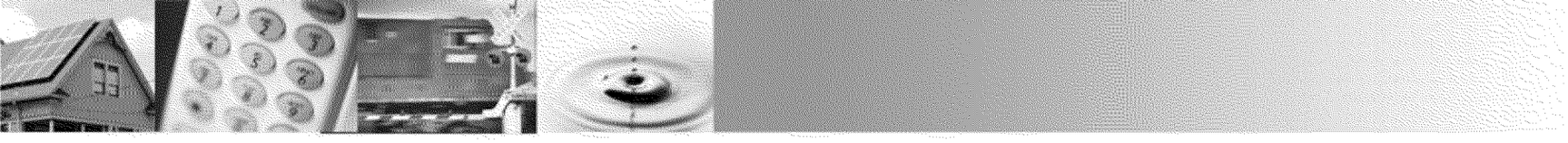
EFC for All Storage & DR Resources

- Positive-generation resources:
  - EFC = Minimum of (NQC) and ($Pmin_{RA}$ + (180 minutes – Start-up Time) * ARR_{pos}), if SUT < 90 minutes
  - EFC = Minimum of (NQC – $Pmin_{RA}$) and (180 minutes * ARR_{pos}), if SUT > 90 minutes
- Negative-generation resources:
  - EFC = Minimum of ($Pdemand_{min}$ – $Pmin_{RA}$) and (180 minutes * ARR_{neg}), plus the absolute value of $Pdemand_{min}$ iff 180 – ($Pdemand_{min}$ – $Pmin_{RA}$)/ARR_{neg} ≥ shut-down time (SDT)
- Bi-directional resources:
  - EFC = Minimum of (NQC) and ($Psupply_{min}$ + 90 min * ARR_{pos}) + Minimum of (– $Pmin_{RA}$) and (– $Pdemand_{min}$ + 90 minutes * ARR_{neg})



EFC for All Storage & DR Resources

- Positive-generation resources:
  - EFC = Minimum of (NQC) and ($Pmin_{RA}$ + (180 minutes – Start-up Time) * ARR_{pos}), if SUT < 90 minutes
    - i.e., start up, get to $Pmin_{RA}$, and ramp up as much as possible in the remainder of the three hours
  - EFC = Minimum of (NQC – $Pmin_{RA}$) and (180 minutes * ARR_{pos}), if SUT > 90 minutes
    - i.e., start at $Pmin_{RA}$ and ramp up for three hours



EFC for All Storage & DR Resources

- Negative-generation resources:
  - EFC = Minimum of ($Pdemand_{min}$ – $Pmin_{RA}$) and (180 minutes * ARR_{neg}), plus the absolute value of $Pdemand_{min}$ iff 180 – ($Pdemand_{min}$ – $Pmin_{RA}$)/ARR_{neg} ≥ shut-down time (SDT)
    - i.e., ramp up as much as possible over three hours from $Pmin_{RA}$ towards $Pdemand_{min}$; if there's enough time remaining in the three hours, shut down and get to zero

EFC for All Storage & DR Resources

- Bi-directional resources:
  - EFC = Minimum of (NQC) and ($Psupply_{min}$ + 90 min * ARR_{pos}) + Minimum of (– $Pmin_{RA}$) and (– $Pdemand_{min}$ + 90 minutes * ARR_{neg})
    - i.e., ramp up for 1.5 hours to get to $Pdemand_{min}$; transition to $Psupply_{min}$, and ramp for another 1.5 hours

Thank you!

For Additional Information:

www.cpuc.ca.gov

(Search: Resource Adequacy History)