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Can IOU Demand Response Programs Facilitate Integration of Wind and Solar Energy Needed to Achieve California's 33% Renewables Portfolio Standard ?

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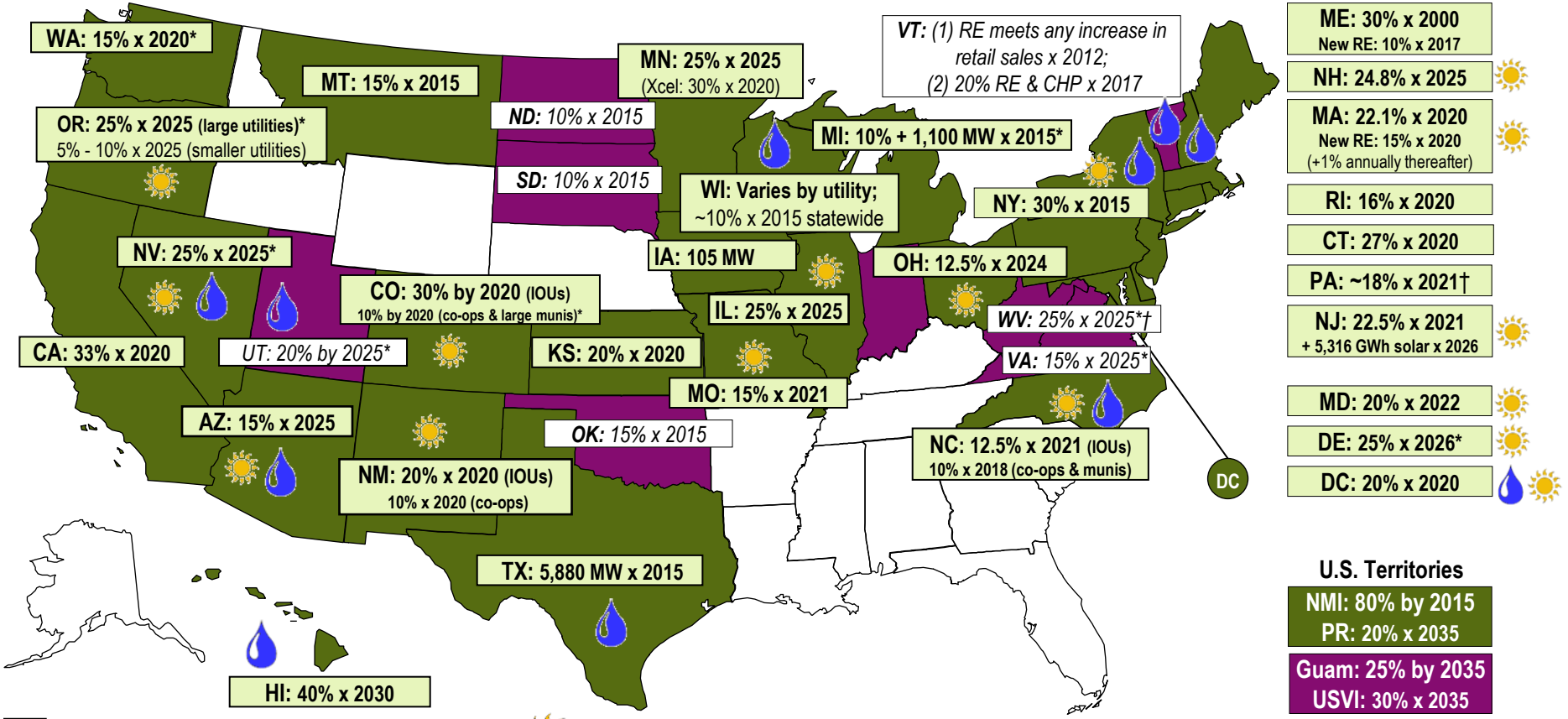
Twenty nine states plus DC and two U.S. territories have renewables portfolio standards (RPS). Another eight states plus two more U.S. territories have renewables portfolio goals.



Renewables portfolio standard

Renewables portfolio goal

Solar water heating eligible

Minimum solar or customer-sited requirement

* Extra credit for solar or customer-sited renewables

† Includes non-renewable alternative resources

SOURCE: www.dsireusa.org, June 2012.
Note: New York revised to correctly show as 30% by 2015.

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States with RPS standards/goals requiring greater reliance on wind & solar are increasingly concerned about renewable energy integration.

- Grid operators need to maintain supply-demand balance at all times through frequency control (50 Hz)

- Challenges in maintaining intra-hour grid stability due to uncertainties created by volatility of demand, variability of supply, and difficulty in forecasting supply and demand over different time intervals.

- Greater reliance on variable (wind and solar) renewable energy makes controlling power system frequency and maintain grid stability harder, because additional intra-hour variability in generation and difficulty in predicting that variation:
  - results in steeper system ramping requirements;
  - increases need for regulation, spinning reserve, and load following resources;
  - increases frequency/magnitude of over-generation events; and
  - result in less efficient dispatch of conventional generation resources.

- ***Therefore, greater reliance on variable wind and solar power increases need for services used to manage stability of grid.***

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Can IOU DR programs be used for renewable energy integration?

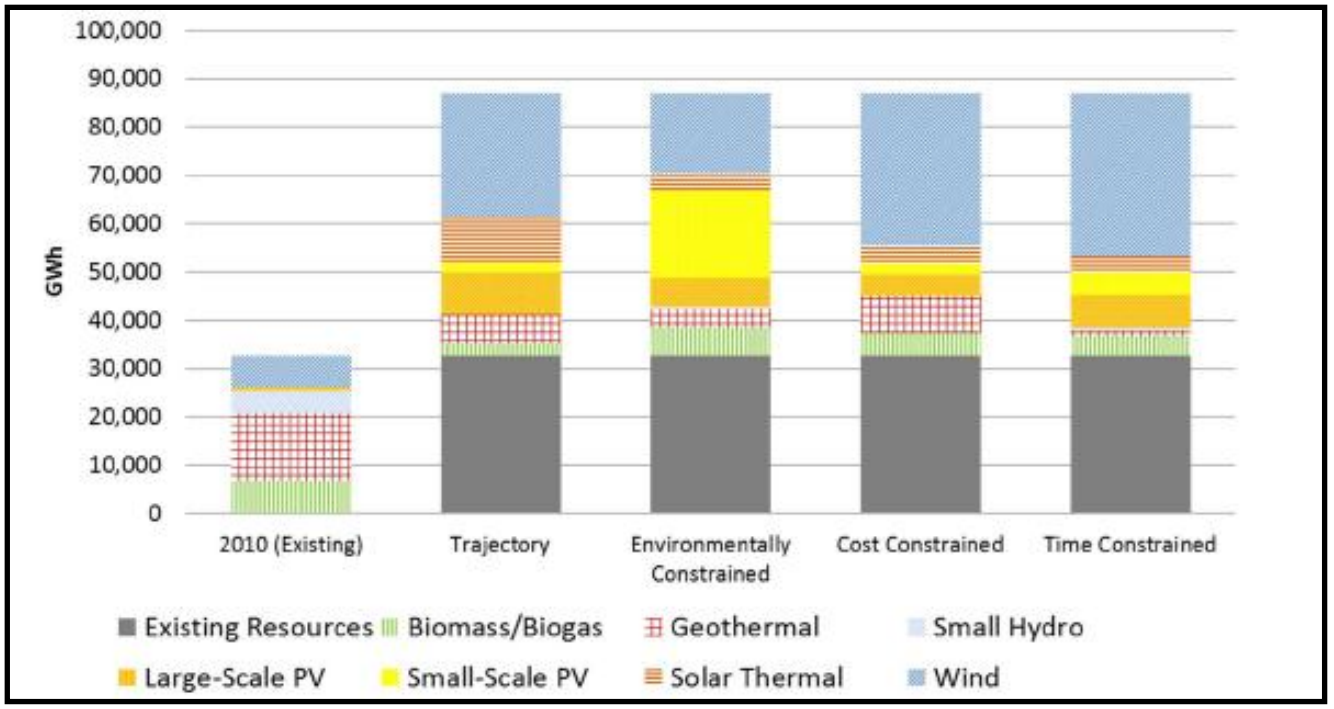
- In July 2012 Navigant completed white paper evaluating potential for using IOU DR programs to facilitate integration of wind & solar energy needed to achieve California's RPS target.
- Report prepared at request of DRMEC, composed of representatives of California's three IOUs, plus CEC and CPUC staff.

- That white paper (available at http://www.calmac.org/publications/7-18-12_Final_White_Paper_on_Use_of_DR_for_Renewable_Energy_Integration.pdf), aimed at policymakers and non-technical key stakeholder, had three objectives:
  - Identify/evaluate potential ability of existing & planned DR resources of each California IOU to meet renewable integration needs of CAISO;
  - Identify changes that would improve the ability of existing IOU DR programs to meet CAISO's future renewable integration needs, and
  - Evaluate/compare ways other ISOs and non-ISO utilities outside state use/plan to use DR resources in maintaining grid stability and/or integrating variable renewable energy.

California will need to rely more heavily on wind and solar to achieve ambitious 33% RPS target

» California's RPS target requires all investor-owned and publicly-owned utilities to obtain 33% of electricity delivered to retail customers from renewables by 2020.

» Variable wind and solar generation will provide virtually all of additional renewable energy California will use to achieve that goal.



Source: April 29, 2011 Joint IOU Submission to CPUC, "2010 Long-Term Procurement Plan System Analysis Preliminary Results", in CPUC R. 10-05-006.

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How much renewable energy integration capacity will California need in order to achieve the state's 33% RPS target?

- In 2011, California's three IOUs collectively obtained 20.6% of electricity delivered to retail customers from RPS-eligible renewable resources:
  - Pacific Gas and Electric (PG&E) 20.09%
  - San Diego Gas and Electric (SDG&E) 20.80%
  - Southern California Edison (SCE) 21.07%

  ***Source**: http://www.cpuc.ca.gov/PUC/energy/Renewables/*

- Greater reliance on wind and solar energy will increase need for renewable integration resources capable of providing ancillary & load following services needed to maintain system frequency and stability of grid
- Conventional quick-start generation capacity available to provide those services will be reduced by State Water Resources Control Board's order requiring owners to retrofit or retire 12,000 MW of once-through-cooling power plant capacity by 2017.[1]
- As of July 2012, multi-year CPUC proceeding (Track I, R. 10-05-006) that began in 2010 l had not yet definitively determined whether and how much additional new renewable integration capacity California will need to manage grid stability by 2020, when the state will be relying much more heavily on variable renewable energy in order to achieve California's 33% RPS target.

[1] Affects 17 coastal fossil-fueled power plants, as well as California's two nuclear power plants.

Other ISOs/RTOs and utilities have begun using DR programs to maintain grid stability and/or integrate variable renewables.

- In addition to using DR to avoid system emergencies and/or wholesale price spikes, some ISOs/ RTOs are using/plan to use DR to manage intra-hour variability in supply & demand, including portion due to variable renewable generation.

- Thus far, ISOs/RTOs have focused primarily on demonstrating DR's abilities to provide ancillary services, and removing barriers to increased DR participation in wholesale ancillary services markets.

- Most have taken a cautious approach to using DR to provide ancillary services, beginning with pilot programs or limiting portion of balancing services provided by DR resources.

- Over time, in some jurisdictions those DR resources that demonstrate the necessary levels of reliability and precision have been permitted to provide a larger share of these ancillary services.

Navigant surveyed how DR is used by other ISOs and by two utilities with no organized wholesale markets.

	Use of DR for Ancillary Services			Use of DR to Avoid Capacity	Use of DR to Avoid Energy
	Spinning Reserves	Non-Spinning Reserves	Regulation		
ERCOT	Yes (50% cap)*	Yes	Yes	Not Applicable	Yes
NYISO	Yes	Yes	Yes	Yes	Yes
PJM	Yes (25% cap)*	Yes	Yes	Yes	Yes
ISO-NE	No	No	No	Yes	Yes
MISO	Yes (10% cap)*	Yes	Yes	Yes**	Yes
BPA***	No	No	Pilot Program (Load Following)	Yes	Not Applicable
HECO***	No	Pilot Program	No	Yes	Not Applicable

KEY:
Yes/Pilot Program = DR is able to participate, although participation may still be limited (e.g., virtually no DR participates in ERCOT's non-spinning and regulation markets).

No = Market/service exists in that jurisdiction, but DR is not able to participate.

Not Applicable = Market/service does not exist in that jurisdiction.

* Maximum percentage of ISO/RTO's spinning reserve requirements that DR is allowed to provide
** Bonneville Power Administration (BPA) has a voluntary market
*** Hawaiian Electric Company (HECO) has no organized markets

Based on information available as of April 2012.

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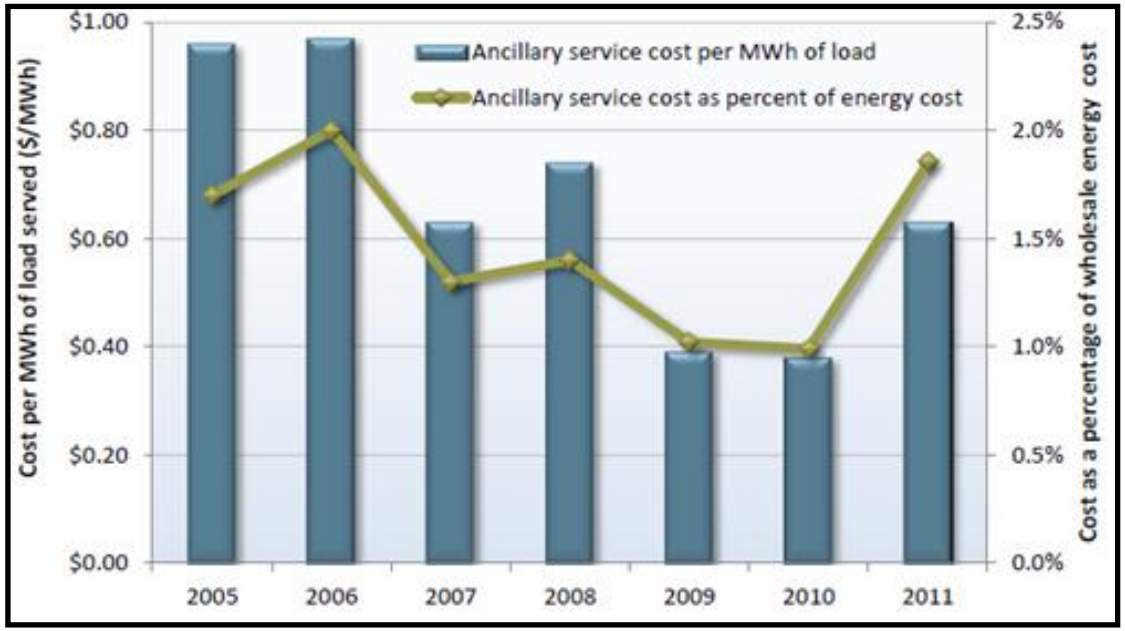
Although ancillary services now account for small share of total wholesale cost of electricity in California, achieving 33% RPS might increase that share.

- Total cost of ancillary services provided in California in 2011 was about $139 million (including estimated $33 million market value of ancillary services IOUs and LSEs provided for themselves).
- However, total cost of ancillary services procured or self-provided only accounted for about 1.9 percent of California's total wholesale energy costs in 2011, compared to just 1.0 percent in 2010.



Source: *CAISO's 2011 Annual Report on Market Issues & Performance*, available at http://www.caiso.com/Documents/2011AnnualReport-MarketIssues-Performance.pdf

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CAISO currently uses four types of ancillary services to maintain intra-hour grid stability.

- **Spinning reserve:** portion of unloaded capacity from units already connected or synchronized to grid that can deliver energy in 10 minutes and run for at least two hours.
- **Non-spinning (or supplemental) reserve:** extra generating capacity not currently connected or synchronized to grid that can be brought online and ramp up to a specified load within ten minutes.
- **Regulation up and regulation down energy:** used to control system frequency that can vary as generators access the system and must be maintained very narrowly around 60 hertz. Units and system resources providing regulation are certified by CAISO and must respond to 'automatic generation control' (AGC) signals to increase or decrease their operating levels depending upon the service being provided, regulation up or regulation down." (Unlike most other ISOs/RTOs, CAISO procures regulation up services separately from regulation down services.)

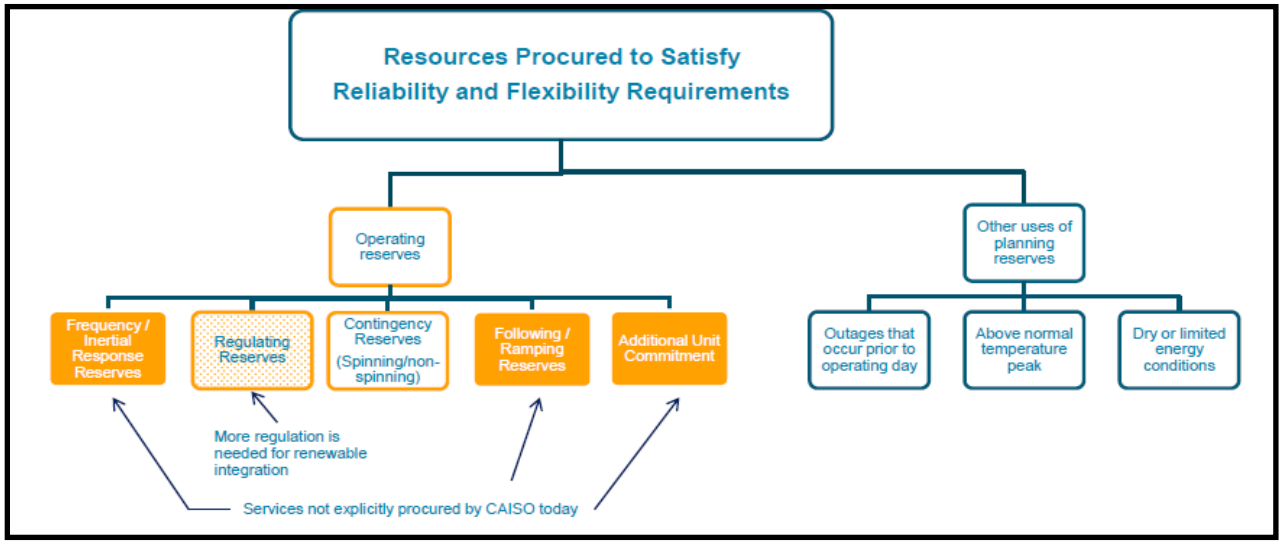
Source: CAISO See: http://www.caiso.com/market/Pages/ProductsServices/Default.aspx

CAISO is developing tariffs for new flexible capacity products to manage remaining uncertainty, and asked CPUC to add those products and regulation capacity to each IOU's RA requirement.

To manage remaining uncertainty, in early 2012 CAISO initiated stakeholder process to develop new flexible capacity product(s) with specific requirements for following attributes:

- **Maximum continuous ramping**: megawatt amount by which net load (load minus wind and solar) is expected to change in either an upward or a downward direction continuously in given month.
- **Load following**: ramping capability of a resource to match the maximum megawatts by which the net load is expected to change in either an upward or a downward direction in a given hour in a given month.

Source: January 12, 2012 CAISO filing in CPUC Resource Adequacy (RA) proceeding (R. 11-10-023).



Source: Alvarez, Antonio (PG&E), *A Planner's Insights about the Need for Operating Flexibility Reserves for Higher Penetration of Variable Generation*, WECC Webinar presentation (October 2011)

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Navigant used technical attribute requirements from CAISO ancillary service tariffs to evaluate potential ability of each IOU DR program to provide renewable energy integration services.

- **Advance Notice of Deployment ("Notice"):** Minimum amount of time between receipt of notice of deployment from CAISO, and receipt of a dispatch signal
- **Speed of Response to Control Signal ("Speed"):** Maximum amount of time between receipt of dispatch signal from CAISO, and provision of product/service
- **Duration of Response ("Duration"):** Minimum amount of time for which resource must be able to provide product/service each time that resource is dispatched
- **Frequency of Response ("Frequency"):** Frequency with which a resource will be dispatched to provide product/service
- **Range of Permissible Deviation ("Reliability"):** Maximum permitted deviation between amount of product/service a resource was scheduled to deliver, and amount that was actually delivered (i.e., an uninstructed deviation)

Attributes CAISO tariffs now require for ancillary services, and likely required attributes of new ramping/load following flexible capacity products.

Products/Services Providing Energy, Capacity and/or Maintaining Grid Stability	Current Providers		Required Attributes								
									Reliability		
	IOUs and other LSEs	Other Generators	Procured and Scheduled by CAISO	Self-Scheduled by IOUs and/or Other LSEs	Minimum Resource Capacity	Advance Notice of Deployment	Speed of Response to Control Signal	Required Duration of Response	Frequency of Response	Range of Permissible Deviation from Schedule	Penalty for Failure to Deliver
Spinning reserves	x	x	Day Ahead, Hour Ahead, Real Time Markets	Yes	500 kW	~ 1 minute	< 10 min	30 minutes	~20-200 times/year	Max of 5MW or 3% of max output. Dynamic resources only	Uninstructed Deviation Penalties based on LMP
Non-spinning reserves	x	x	Day Ahead, Hour Ahead, Real Time Markets	Yes	500 kW	As quickly as possible	< 10 min	30 minutes	~20-200 times/year	Max of 5MW or 3% of max output. Dynamic resources only	Uninstructed Deviation Penalties based on LMP
Proposed Flexi-ramp product	x	x	Day Ahead, Hour Ahead, Real Time Markets	Currently Being Developed							
Regulation (proposed by ISO to be part of RA)	x	x	Day Ahead, Hour Ahead, Real Time Markets	Yes	500 kW	None	< 10 min	30-60 minutes	Continuous	Max of 5MW or 3% of max output. Dynamic resources only	Uninstructed Deviation Penalties based on LMP
Energy	x	x	Day ahead, hour ahead, real-time	Yes	None	Scheduled	Scheduled	Scheduled	As Scheduled	Max of 5MW or 3% of max output. Dynamic resources only	Uninstructed Deviation Penalties based on LMP
"Traditional" Resource Adequacy Capacity (local and system)	x		Not Applicable	90% year ahead, 10% month ahead	None	Day ahead	1 hour	Multiple hours	As Required	Not Applicable	None
Proposed Load-following Resource Adequacy Capacity (local and system)	x		Not Applicable	Per Proposed RA Requirements	Currently Being Developed						
Proposed Maximum Ramping Resource Adequacy Capacity (local and system)	x		Not Applicable	Per Proposed RA Requirements	Currently Being Developed						

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Some current IOU DR programs might be able to provide renewable energy integration services.

- Only some of current set of dispatchable IOU DR programs might be able to provide ancillary services used to maintain grid stability.
- "Reliability" DR programs used to avoid system emergencies and avoid overloading the grid tend to be larger & more numerous than "price-responsive" or "economic" DR programs that reduce demand in response to external price signals (e.g., spikes in wholesale electricity price spikes), or proxies for those prices (e.g., hot weather conditions or a high "market heat" rates).[1]
- As currently configured, some economic DR programs might have attributes needed to provide non-synchronous, non-spinning reserves. Smaller subset might be able to provide synchronized spinning reserves. (DR program that can provide spinning reserves can also provide non-spinning reserves).
- Smallest subset of all might have attributes needed to provide regulation up services (and, if coupled with energy storage, regulation-down services).
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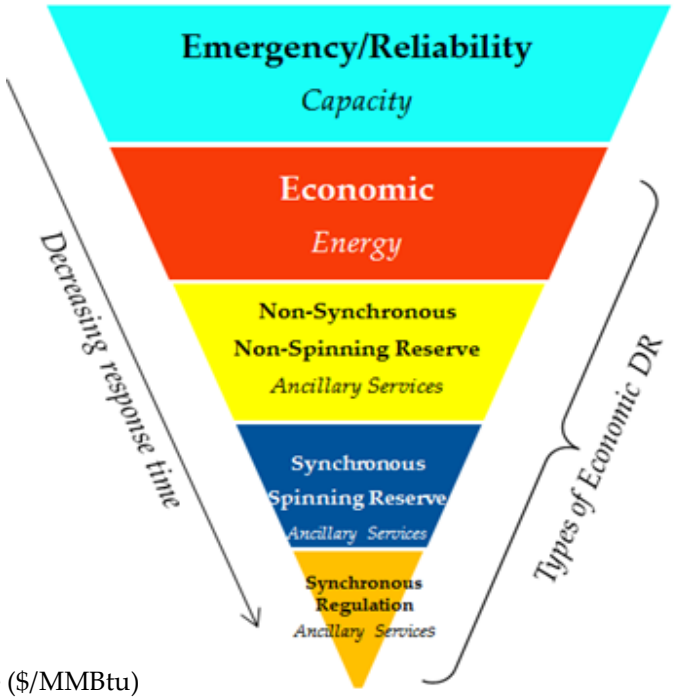

[1] Market Heat Rate = ratio of wholesale electricity price ($/MWh) to natural gas price ($/MMBtu)

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Key factors affecting potential ability of DR resource to provide services needed for renewable energy integration include:

- **Automated response –**automated response DR can change loads more quickly than manually initiated response, and therefore provide more rapid response required for ancillary services.
- **End uses capable of providing DR-based grid management services -** characteristics of end use loads used by DR resource play key role in determining which ancillary services that resource can provide.
- **Location of loads providing ancillary services –** geographic location of DR resources can affect their ability to provide ancillary services needed in certain parts of the grid.
- **Reliability –** non-automated dynamic-pricing DR programs are unlikely to be sufficiently reliable and predictable to be used in integrating variable renewable energy.

On average, current IOU DR programs have only limited ability to provide renewable energy integration services.

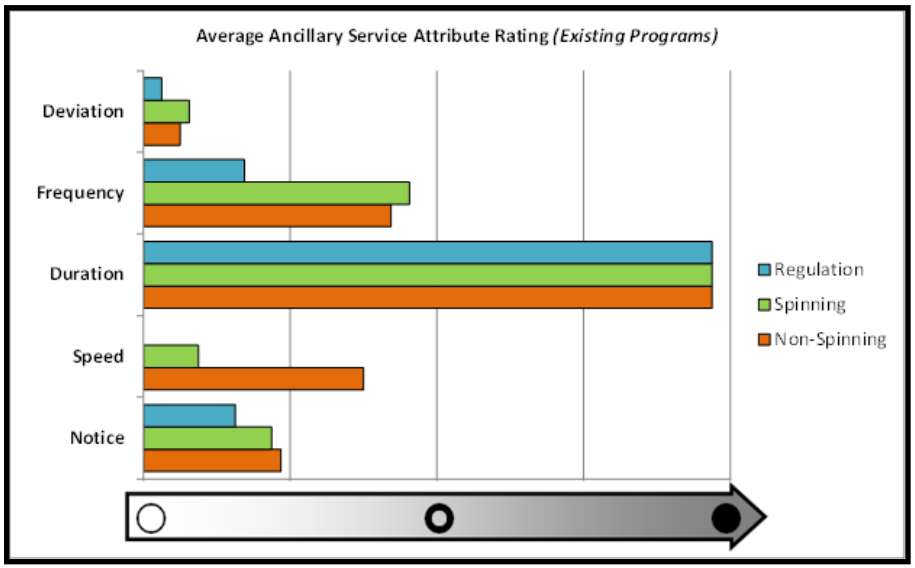
- On average, current IOU DR programs come closest to achieving required duration of response, which is not surprising because DR programs have generally been used for reliability and economic purposes, and DR "events" usually are at least several hours long, more than enough time to provide ancillary services.

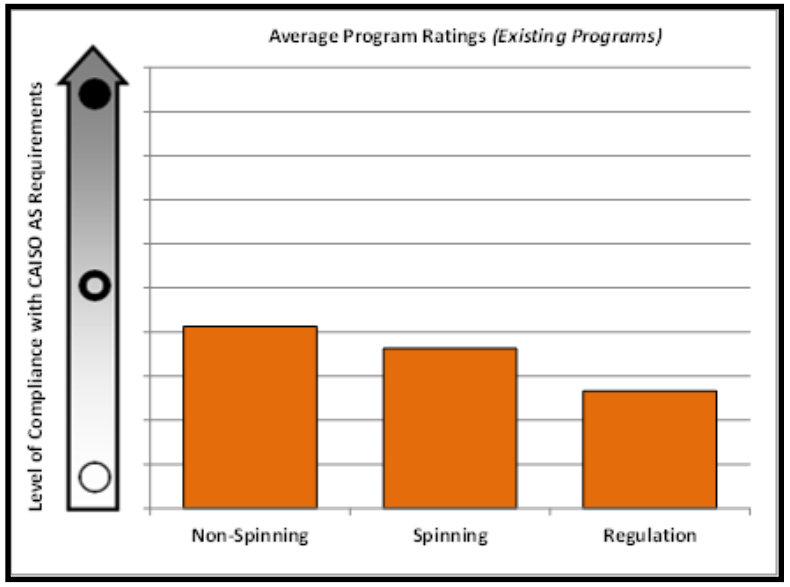
- Frequency with which current DR programs can be dispatched is greater limitation, because most cannot be dispatched more than once per day or no more than roughly 12 to 15 times per year.

- Amount of advance notice required before most current DR programs can be dispatched, and their limited speed of response to control signals, would prevent or at least limit ability of most current DR programs to provide ancillary services.

- Maximum permitted deviation (i.e., reliability) requirement is also difficult standard for most current IOU DR programs to meet, since few require real-time metering and automated response needed to monitor and adjust load response within a narrow band.

On average, current IOU DR programs have limited ability to provide services with attributes required by CAISO tariffs for regulation energy, non-spinning reserves, and spinning reserves.





- ● Meets CAISO requirements
- ◐ Partially or nearly meets CAISO requirements, or some participating load may meet requirements
- ○ Does not meet CAISO requirements

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However, several modifications would enable certain IOU DR resources to provide some ancillary services.

- Key modifications:
  - Telemetry for real-time communications, metering, and control;
  - Reduced/no advance notification time;
  - Automated response to control signals; and
  - Increasing number of times and frequency with which DR resource could be dispatched.

- Some modifications might reduce number of customers willing/able to participate in DR program. Others would fundamentally alter nature of or be incompatible with design of that program.

- If changes are adopted, five current IOU DR programs might be able to meet all CAISO tariff requirements for non-spinning reserves. Four programs also might meet requirements for spinning reserves. Three might also meet CAISO requirements for regulation services.

- ***If modified DR programs provide ancillary services identical to those provided by quick start flexible generation capacity, extent to which DR resources are used to provide those services will depend largely on relative costs of DR vs. generation resources, and supply and demand conditions in CAISO wholesale markets for ancillary services.***

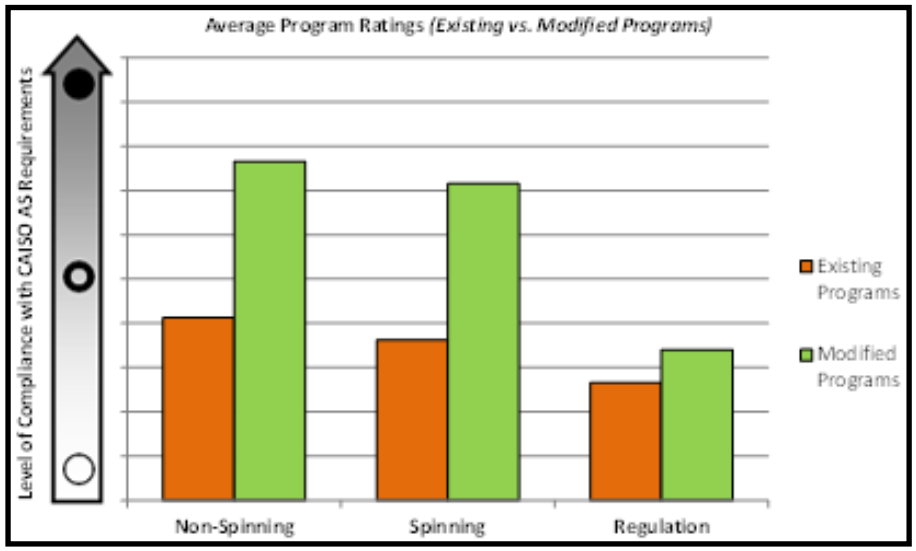
Modifications that would enable certain IOU DR programs to provide non-spinning reserves, spinning reserve services, and/or regulation energy.

NOTE: Mass-market DLC programs include residential direct load control (DLC) programs as well as commercial programs that allow direct/automated control of loads (e.g., SCE's Summer Discount Plan (SDP) programs).

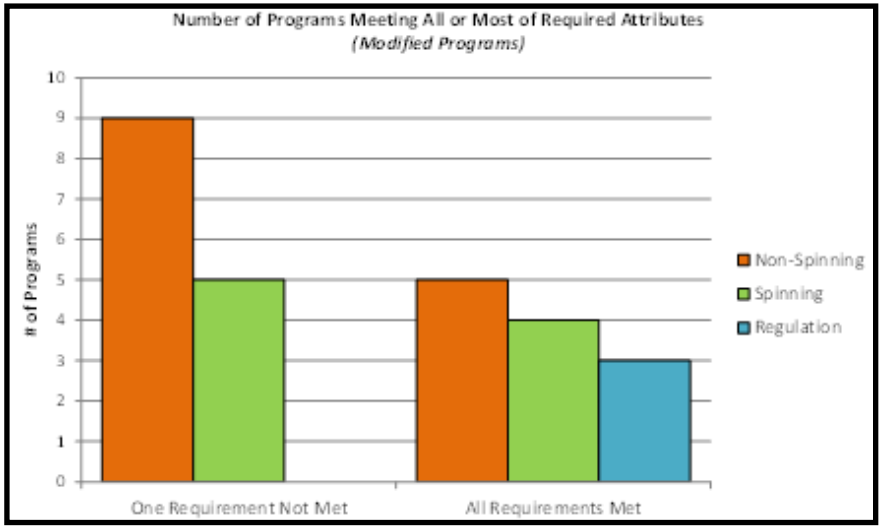
Program	Telemetry	Reduced Notification	Automated Response	Increase in Events	Extended Hours/Seasons
Aggregator DR program portfolios	X	X	X	Varies	X
Mass-market direct load control (DLC) programs*	X			X	X
Agricultural pumping	X			X	
Base Interruptible Program (BIP)*	X	X	X	X	
Capacity Bidding Program (CBP)	X	X	X	X	X

IOU	Program Name (Modified)	Ancillary Service
PG&E	Aggregator Managed Portfolio	Non-Spinning Reserves
SCE	Agg. & Pump Interruptible	Non-Spinning Reserves
SCE	Demand Response Contracts	Non-Spinning Reserves
SDG&E	Aggregator Managed Program	Non-Spinning Reserves
SDG&E	Peak Generation	Non-Spinning Reserves
PG&E	Aggregator Managed Portfolio	Spinning Reserves
SCE	Agg. & Pump Interruptible	Spinning Reserves
SCE	Demand Response Contracts	Spinning Reserves
SDG&E	Aggregator Managed Program	Spinning Reserves
PG&E	Aggregator Managed Portfolio	Regulation
SCE	Demand Response Contracts	Regulation
SDG&E	Aggregator Managed Program	Regulation

Effect of modifications on average ability of current vs. modified versions of IOU DR programs to provide services with attributes required by CAISO tariffs for regulation energy, non-spinning reserves, and spinning reserves.



● Meets CAISO requirements
o Partially or nearly meets CAISO requirements, or some participating load may meet requirements
○ Does not meet CAISO requirements



● Meets CAISO requirements
o Partially or nearly meets CAISO requirements, or some participating load may meet requirements
○ Does not meet CAISO requirements

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New IOU DR programs also could be designed to provide renewable energy integration services.

- New DR programs designed from scratch could provide services with specific attributes CAISO tariffs require for certain ancillary services products, including spinning and non-spinning reserves and regulation, and perhaps new continuous ramping and load following flexible capacity products CAISO is developing.

Attributes Needed to Provide Different Ancillary Services	Continuous Ramping/ Load Following	Spinning & Non-Spinning Reserves	Regulation Services
Telemetry	Required	Required	Required
Response time	Less than one hour, but some resources taking 10 hours or more could be used	Less than 10 minutes; less than 10 second to begin ramping is desirable	Less than a minute
Automated response	Required	Required	Required
Event limitations	10 hours or more duration, minimum of one hour	Dozens to more than 100 events lasting at least one hour each	Continuous availability desired
Daily/seasonal availability*	24x7 year-round, with seasonal variation	24x7 year-round	24x7 year-round
Target end uses	Commercial lighting and HVAC	Agricultural and municipal pumping, electric water heat (if available)	Temperature controlled warehouses, industrial motor loads on variable frequency drives

DR program-related obstacles to using IOU DR programs for renewable energy integration.

- Current IOU DR programs do not have most or all of technical attributes required in CAISO tariffs for ancillary services.
- Temporal variations in size and/or availability of end-use loads enrolled in current IOU DR programs affect their ability to provide ancillary services.
- Although tendency for DR capacity to be located in or close to major load centers is an advantage, DR capacity cannot be sited where loads do not exist, even if there is a need for grid management services in those locations.
- Unless DR programs are combined with energy storage, DR resources have only limited ability to provide regulation-down services.

Technology obstacles to using IOU DR programs for renewable energy integration.

- Without telemetry for real-time, automated response, and verification of loads, DR programs cannot provide most ancillary services.
  - Processing interval meter load data obtained through Smart Meter systems typically takes at least a day before data can be accessed.
  - Due to that delay, data cannot be used to monitor real-time (or near real-time) load performance during DR event.
  - Aggregators providing DR services typically obtain data from customer meters, or separately sub-meter controlled loads, and use telemetry that allows them to monitor, control and verify event performance in real-time.
  - Performance speed requirements for providing balancing or regulation services are even higher. In order for DR resources to provide regulation, might be necessary to obtain four-second interval reads from enrolled loads, and sometimes capture more than only energy consumption (e.g., instantaneous power, reactive power, and other process characteristics).

Technology obstacles to using IOU DR programs for renewable energy integration (cont'd).

- Accomplishing that requires a high-speed communications overlay, as well as fairly direct access to load controls (i.e., working through a large building Energy Management System (EMS) may add too much delay for effective control of the resource for some uses).

- Although telemetry might not be needed for non-automated price-responsive and/or residential DR programs, technical attributes of these programs limit them to providing only non-spinning reserves, or no ancillary services at all.

- Unless a DR resource can provide automated load response, it will be unable to respond fast enough to a control signal to provide ancillary services.

- However, cost of automation can be a significant barrier to the willingness of customers to provide load curtailment through a DR program.

*Market obstacles t*o using IOU DR programs for renewable energy integration.

- **Customer Willingness.** Limited willingness of customers to participate in DR programs providing ancillary services could significantly limit the renewable integration capacity available from those programs.
  - Combined load reduction capacity of all California IOU DR programs is less than 5 percent of CAISO's system-wide peak load.)
  - Compared to reliability and economic DR programs , ancillary services DR programs would require greater automation, provide little or no advance notification, would be dispatched much more often and at different times, and require more flexibility in changing loads from moment to moment at different times of the day.
  - Those additional requirements might make customers less willing to enroll in DR programs that provide ancillary services than in existing DR programs.

Market obstacles to using IOU DR programs for renewable energy integration (cont'd).

- **Potential Conflicts with Other DR Programs.**
  - DR resources that provide ancillary services needed for renewable energy integration probably could, and for economic reasons also ought to provide emergency/reliability DR capacity.
  - In fact, for those DR resources to be cost effective, they might have to provide more than just ancillary services.
  - However, when loads enrolled in those programs provide load reductions in response to an actual or imminent grid emergency, those loads would not be available to help mitigate impacts of variations in renewable energy generation on system stability.

Regulatory obstacles to using IOU DR programs for renewable energy integration.

- California's "loading order preference" policy requires IOUs to first procure cost-effective DR and energy efficiency resources, then renewable resources, and only then conventional fossil-fueled generation resources.

- In order to be cost effective, an IOU DR program that has ability to provide ancillary services would have to provide them at a lower cost than generation resource that would otherwise provide identical ancillary services.

- Extent to which modified DR resources rather than generation resources will be used to provide ancillary services used to integrate variable renewables will depend largely upon differences between costs and technical attributes of ancillary services provided by DR vs. those provided by quick start generation resources.

Regulatory obstacles to using IOU DR programs for renewable energy integration (cont'd).

- That is likely to become increasingly important due to steps CPUC has taken to introduce and promote competition between IOU DR resources, third party DR aggregators, and end-use load customers in CAISO's wholesale markets for ancillary services.

- Market competition-based determination of mix of DR and generation resources used to provide ancillary services will be limited if CPUC adopts policies restricting mix of DR and generation capacity IOUs are required to have to meet any flexible capacity and/or regulation services capacity RA requirements adopted by CPUC.

Next steps in assessing ability of IOU DR programs to contribute to renewable energy integration in California.

- Increase coordination between IOU DR program administrators and CAISO in designing new wholesale DR products capable of facilitating integration of variable renewable generation.

- Conduct statewide evaluation of technical, economic, and commercially feasible market potential for modified/new IOU DR programs to provide ancillary services and any new continuous ramping and load following products (i.e., estimate customer loads that could /would be willing to adjust loads automatically in response to control signals, and be dispatchable in more months and hours than current DR programs).

- Detailed assessment of regulatory barriers to DR participation in CAISO's wholesale markets for ancillary services, and any new continuous ramping and load following products.

Next steps in assessing ability of IOU DR programs to contribute to renewable energy integration in California (cont'd).

- Assess/estimate relationship between customer willingness to enroll/participate in DR programs capable of providing services that could facilitate the integration of renewable energy, and:
  - end-user costs,
  - customer characteristics, and
  - monetary incentives.
- Establish pilot programs in each IOU's service territory to test new DR programs designed to provide different ancillary services products, and any new continuous ramping and load following products.

Next steps in assessing ability of IOU DR programs to contribute to renewable energy integration in California (cont'd).

- Perform cost-effectiveness and portfolio optimization evaluations of different options for supporting renewable energy integration, including;
  - ancillary services and any new continuous ramping and load following products, provided by:
  - conventional generation resources;
  - DR programs; and/or
  - fast-response battery storage,
- Assess the market for Smart Grid technologies that could facilitate automated DR, as well as the benefits and costs associated with deploying these technologies

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