PWP 2015 IRP - EXHIBIT 5

CAISO LEVEL INTEGRATION COSTS

B&V PROJECT NO. 183304

PREPARED FOR

Pasadena Water & Power

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1. Overview of CAISO Level Integration Costs

As part of its 2014/2015 Integrated Resource Plan (IRP) process, Pasadena Water & Power (PWP) requested that Black & Veatch perform a parallel analysis to investigate integration costs at the CAISO balancing authority level. Costs related to renewable integration is not very well defined in the industry. Integrations costs span across multiple time spectrum as it relates to the operational and system planning processes.

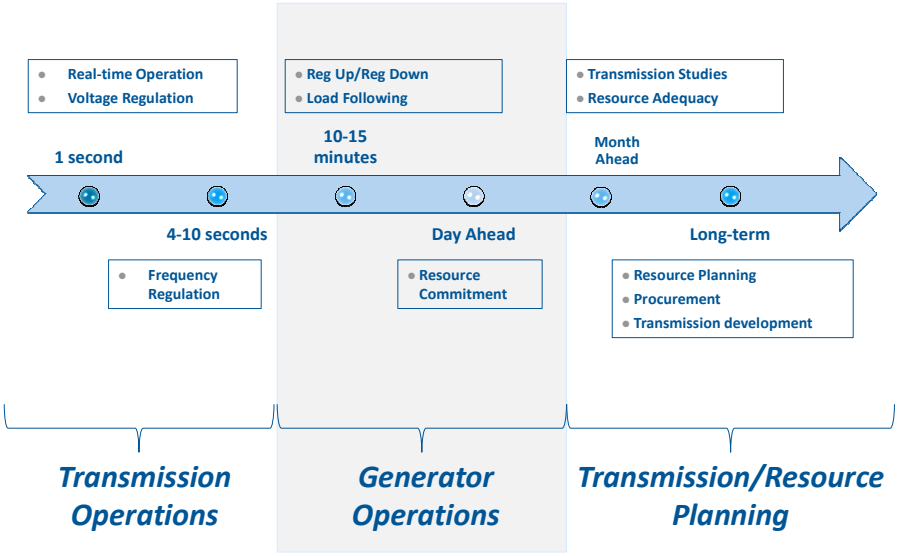


Figure 1 Renewable Integration Time Spectrum

In this parallel analysis for the 2014/2015 IRP Black & Veatch will focus on integration costs and issues at the CAISO a balancing authority levels. The CAISO is responsible for managing the transmission system, optimizing operations of the grid, and maintaining system reliability. As a member of the CAISO PWP adheres to the CAISO open access transmission tariff (OATT) and is responsible for ancillary service and renewable integration costs documented in the OATT. As more intermittent renewable resources are injected into the future the CAISO is keenly aware of the problems more renewable energy may cause on the system. To address those concerns the CAISO will need to procure more flexible fast ramping capacity and regulation to operate the system grid reliably.

- Flexible Resource Adequacy Requirement
- Frequency Regulation

FLEXIBLE RESOURCE ADEQUACY[1]

There are at least three key items that the CAISO believes must be in place to ensure California is attracting and sustaining investment in the right type and mix of resources while meeting California's goal to increase energy efficiency, demand response, and renewable energy. These issues are:

1) Obligations for flexible capacity procurement.

2) New rules addressing the ability of use-limited resources, like demand response, storage, renewable resources and resources with environmental restrictions, to provide flexibility, local, and system resource adequacy services.

[1] http://www.caiso.com/Documents/RevisedDraftFinalProposal-FlexibleRACriteriaMustOfferObligation-Clean.pdf

3) Multi-year forward resource adequacy requirements.

The CAISO conducts a study to determine the flexible capacity need for the entire ISO footprint for on a three year forward rolling basis as part of the CPUC's Resource Adequacy (RA) proceedings. The CAISO uses a similar methodology for the annual flexible capacity need assessment.

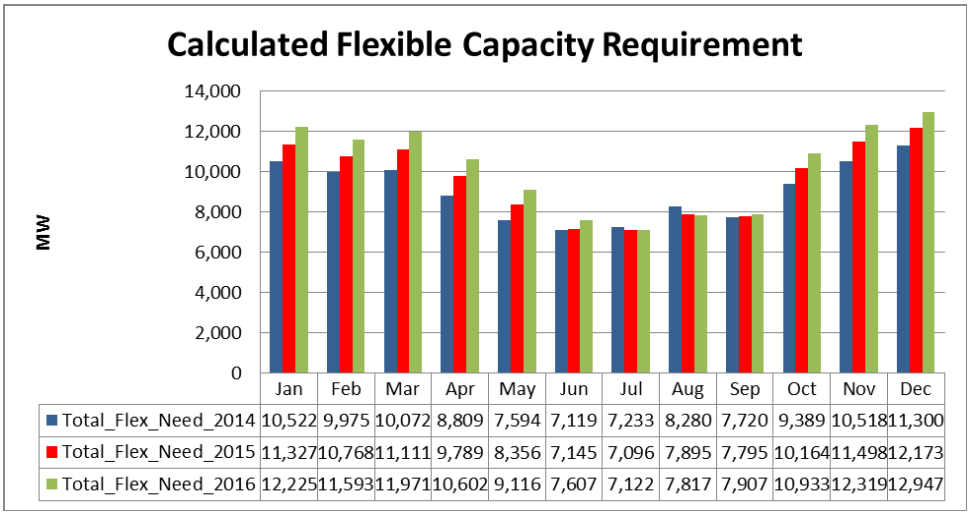
The flexible capacity need is calculated for each month using the following formula:
Where:

$$Flexibility\ Requirment_{MTH_y} = Max\left[\left(3RR_{HR_x}\right)_{MTH_y}\right] + Max\left(MSSC, 3.5\% * E\left(PL_{MTH_y}\right)\right) + \varepsilon$$

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 methodology

The introduction of the flexible RA program for 2015 and beyond is in direct response to the "duck curve" problem that the CAISO has been sounding the alarm on for over the past several years. As more solar resources are added onto the CAISO system in the future the resulting net load is expected to become very steep during the later afternoon/early evening hours causing an increased need for fast ramping, flexible resources to operate to meet the steep rise in the CAISO net load. The CAISO FRAC RA program creates resource designations that can be used to meet the FRAC requirement.

For the 2015 year the CAISO projects that around 12,000 MW of flexible capacity will be required on the system to integrate renewables for the entire CAISO system. As the renewable energy penetration increases each year the FRAC requirement will need to increase accordingly.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Total_Flex_Need_2014	10,522	9,975	10,072	8,809	7,594	7,119	7,233	8,280	7,720	9,389	10,518	11,300
Total_Flex_Need_2015	11,327	10,768	11,111	9,789	8,356	7,145	7,096	7,895	7,795	10,164	11,498	12,173
Total_Flex_Need_2016	12,225	11,593	11,971	10,602	9,116	7,607	7,122	7,817	7,907	10,933	12,319	12,947

Figure 2 CAISO Flexible Capacity Requirements (2014-2016)

The FRAC requirement also has a threshold of specific types of resources that can be used to meet the FRAC requirement. Category 1 is the most flexible resource and Category 3 is the least flexible (in terms

of hours of operation). These category designations are used to address operational constraints across generation technologies.

Category 1 (Base Flexibility):	Category 2 (Peak Flexibility):	Category 3 (Super Peak Flexibility):
• Meet minimum start requirements of either two starts per day or can ramp to cover the morning and late afternoon ramp. • **Aero-derivative, reciprocating engines, and most newer combined cycles would qualify for Category 1.**	• Resources must have flexible capacity that can be available to the ISO market through economic bids submitted daily for at least five hours per day. • **Traditional simple cycle gas turbines**	• Resources must have a minimum of 3 hours of run time per dispatch, and available for at least 5 flexibility based dispatches per month. • **Energy Storage**

Figure 3 CAISO Flexible Capacity Resource Types

Category 1 resources can be used to satisfy Category 2 and 3 resources, but not the other way around. Essentially these categories were designed to prevent an undesirable outcome of a system being built out using only energy storage resources.

The allocation of the entire CAISO FRAC requirement is based upon each load serving entities contribution of the maximum 3-hour net-load ramp. These components are measured over the three hour period and include:

1) Changes in load
2) Changes in wind output
3) Changes in solar PV
4) Changes in solar thermal
5) Changes in distributed energy resources

Therefore there is a positive correlation between a LSE's renewable penetration level and its allocated share of the FRAC requirement. Figure 4 below shows the 2015 FRAC procurement requirements for PWP using the FRAC formula above and the estimated total CAISO FRAC requirement.

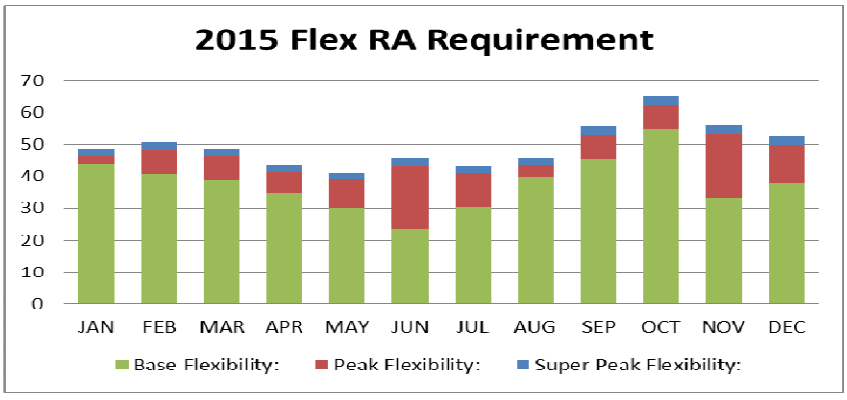


Figure 4 PWP 2015 Flexible Resource Adequacy Allocation

REGULATION AND IMBALANCE ENERGY

As more renewable energy is added to the CAISO system there will be a greater need to meet imbalance energy dues to the simple fact that it is difficult to forecast renewable energy. Differences between the amount of scheduled renewable energy and actual energy cause system imbalances that need to be addressed going forward. The CAISO Participation Intermittent Resource Program (PIRP) allows qualified renewable resources schedule power into the real time market without having to pay for energy imbalance charges should the energy delivered not match the scheduled energy. The PIRP program also provides centralization of forecasting services for wind and solar resources. Imbalance energy charges that are currently not covered by generators may be allocated to the cost of increased system regulation.

Traditionally since the CAISO schedules and settles energy on a hourly basis the energy imbalance between schedule loads and resources was being met primarily by the deployment of regulation. The CAISO procures regulation up, and regulation down in the day- ahead market. The regulation reserve market is used to procure energy on an intra-hour basis to address real time energy imbalances. With the continued push towards 33% and possibly even 50% in the future the CAISO could simply keep increasing the regulating reserve requirement to address increasing imbalances. Instead of just relying on regulating reserves the CAISO has launched an energy imbalance market (EIM) that allows energy to be procured on a 5 minute basis. The CAISO may need to procure additional regulation reserves in the future, but some of those regulating requirements may be mitigated by the implementation of the EIM, which is essentially an enhanced real time market. It is difficult to separate regulation energy and energy imbalance costs specific to PWP since it is possible that some of PWP's existing generating resources will be participating in the EIM.

2. Flexible Capacity Requirement Results

The primary integration cost that PWP will be responsible to meet is the FRAC requirement at the CAISO level. Since the PWP resource plan identifies portfolios that meet a 40%, 50%, and even 70% RPS requirement it is important that Black & Veatch forecasts the FRAC requirement for PWP at different RPS levels. The FRAC estimates for PWP uses the existing CAISO formulas, allocation methodology for load and renewable generation profiles.

In 2015 the CAISO has assigned PWP with a maximum monthly FRAC requirement of 65 MW. Using the CAISO formula for FRAC RA Black & Veatch calculated PWP forecasted FRAC requirement by the year 2030.

RENEWABLE ENERGY PORTFOLIOS

PWP business as usual plan includes plans to achieve and maintain a 40% RPS, which is above and beyond the state mandated 33% RPS. PWPs path to achieving the 40% RPS will include the procurement of additional wind and solar resources. The renewable procurement mix plays a large role in impacting the FRAC requirement. Wind resources and geothermal resource have a much smaller impact on the FRAC requirement, whereas solar resource contributes most to the FRAC requirement.

Table 1 PWP Renewable Capacity by 2030

RENEWABLE RESOURCE (MW)	40% RPS	50% RPS	70% RPS	GHG NEUTRAL
FS Kingbird Solar	20	20	20	20
Antelope Big Sky Solar	13	13	13	13
Windsor Reservoir Solar	.56	0.56	0.56	0.56
Columbia 2 Solar	3	3	3	3
Solar PV Tracking 1	43	46	111	111
Milford Wind	5.0	5	5	5
SCPPA Wind 1	0	10	10	10
SCPPA Wind 2	0	20	20	20
Geothermal 2		5	5	5

40% RPS FRAC REQUIREMENT

To reach a 40% RPS target Black & Veatch assumed that PWP would procure primarily new solar PV resources to meet the 40% RPS. 43 MW of new solar PV are required by 2030 to achieve a 40% RPS. The forecasted PWP FRAC requirement would increase to about 116 MW in 2030 from the current 65 MW requirement in 2015. The resource procurement requirement would be (116 MW-65 MW = 51 MW) which is the about equivalent to the size of GE LM6000 aero-derivative unit.

Table 2 PWP FRAC Capacity Requirement Forecast 2030 – 40% RPS Portfolio

MONTH	CATEGORY 1	CATEGORY 2	CATEGORY 3	TOTAL FRAC
January	40	60	6	**105**
February	43	58	6	**107**
March	64	44	6	**114**
April	50	37	5	**92**
May	54	21	4	**79**
June	68	12	5	**85**
July	69	36	7	**112**
August	56	22	5	**83**
September	79	7	6	**92**
October	69	33	6	**108**
November	67	43	6	**116**
December	46	53	6	**104**

50% RPS FRAC REQUIREMENT

In order to reach a 50% RPS PWP's FRAC requirement would increase only marginally to 119 MW because Black & Veatch assumes that PWP would be able to procure 5 MW of baseload geothermal in addition to 30 MW of wind to increase the RPS level from 40% to 50%. Wind and geothermal resource have minimal impact to the FRAC requirement

Table 3 PWP FRAC Requirement Forecast 2030 – 50% RPS Portfolio

MONTH	CATEGORY 1	CATEGORY 2	CATEGORY 3	TOTAL FRAC
January	40	62	6	**108**
February	44	59	6	**110**
March	65	46	6	**117**
April	51	38	5	**95**
May	54	24	5	**83**
June	70	12	5	**87**
July	69	38	7	**114**
August	57	23	5	**86**
September	80	8	6	**94**
October	69	34	6	**109**
November	69	44	6	**119**

MONTH	CATEGORY 1	CATEGORY 2	CATEGORY 3	TOTAL FRAC
December	47	54	6	**106**

70% RPS FRAC REQUIREMENT

The 70% RPS portfolio shows the largest calculated increase in FRAC requirement because solar is the incremental resource used to increase the RPS from 50% to 70%. The PWP FRAC requirement would increase to 177 MW in 2030MW from 65 MW in 2015. That would results in an incremental FRAC resource procurement target of 112 MW.

Table 4 PWP FRAC Requirement Forecast 2030 – 70% RPS Portfolio

MONTH	CATEGORY 1	CATEGORY 2	CATEGORY 3	TOTAL FRAC
January	44	111	9	**164**
February	69	91	9	**169**
March	91	82	9	**182**
April	84	66	9	**158**
May	70	68	8	**146**
June	136	8	8	**151**
July	101	67	9	**177**
August	83	51	8	**143**
September	114	18	8	**140**
October	82	60	8	**151**
November	110	53	9	**171**
December	70	78	8	**156**

PWP FRAC REQUIREMENT SUMMARY

The economics of intermittent renewable resources is complicated by the integration costs caused by different renewable resource technologies. While solar PV is still forecasted to be the lowest cost renewable resource on a levelized cost of energy (LCOE) basis the integration costs of solar in California need to be included to gain a true picture of the cost of solar. As PWP continues to procure renewable resources going

forward solar will continue to play an important role in providing PWP customers with a low cost, carbon free energy source.

Table 5 Summary Flexible Capacity by RPS Level

	2015 PWP	2030 - 40% RPS	2030 - 50% RPS	2030 - 70% RPS
January	49	105	108	164
February	51	107	110	169
March	49	114	117	182
April	44	92	95	158
May	41	79	83	146
June	46	85	87	151
July	43	112	114	177
August	46	83	86	143
September	56	92	94	140
October	65	108	109	151
November	56	116	119	171
December	53	104	106	156
Average	**50**	**100**	**102**	**159**
Max	**65**	**116**	**119**	**182**

However, given the resource planning implications of too much solar on the system PWP and other LSE's in California need to cognizant of the all the other integration costs at the CAISO level. LSE's should consider a diverse resource mix of resource across different technology mixes to minimize FRAC requirement costs. The CAISO imbalance market will helps to reduce the cost of integration renewables in to the CAISO grid by allowing a larger pool of resources to serve imbalance energy rather than rely on the deployment of regulating reserves.