Generation Inputs Workshop

August 24, 2016

Incremental Standard Deviation Methodology

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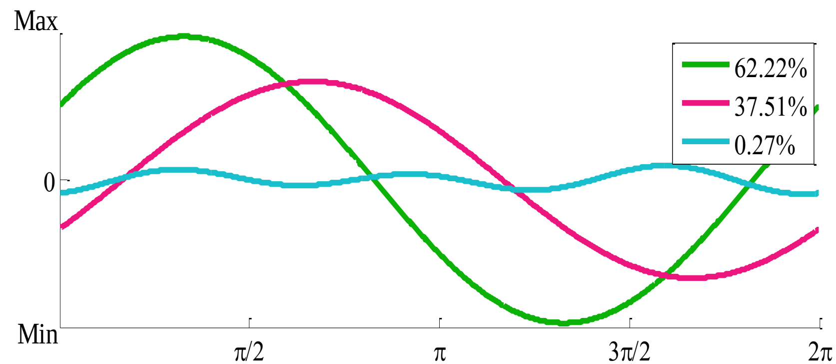
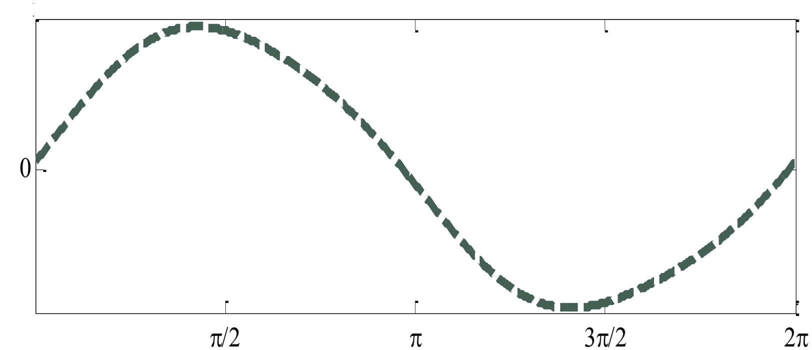
Incremental Standard Deviation Explanation

Incremental Standard Deviation (ISD) is the mechanism used in the rate case calculations to equitably allocate the total reserve amount calculated. It seeks to assign a higher percentage of the value to groups who contribute more error to the total error signal. To measure the size of this contribution, we measure the sensitivity of the total error signal with respect to the given individual error signal using the correlation between the given error signal and the total error signal along with the ratio of standard deviations. The more correlation between signals and/or the higher the ratio of standard deviation, the higher the contribution to the total error.

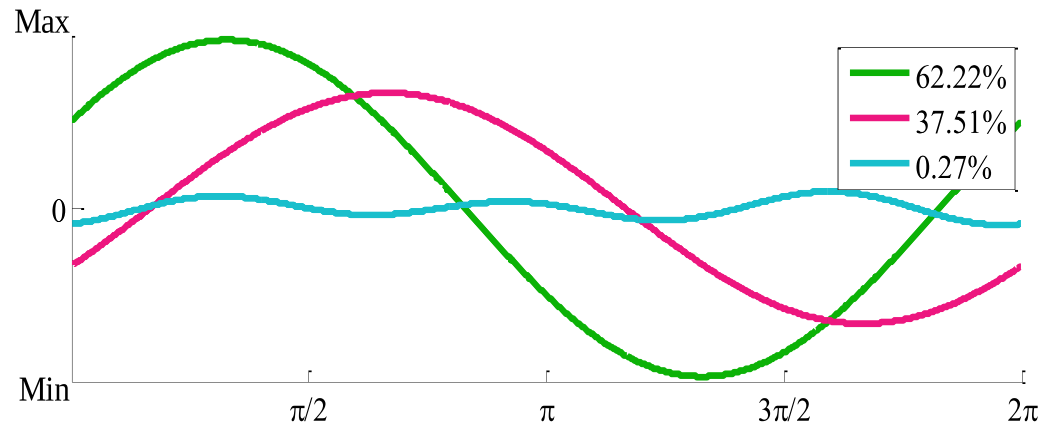


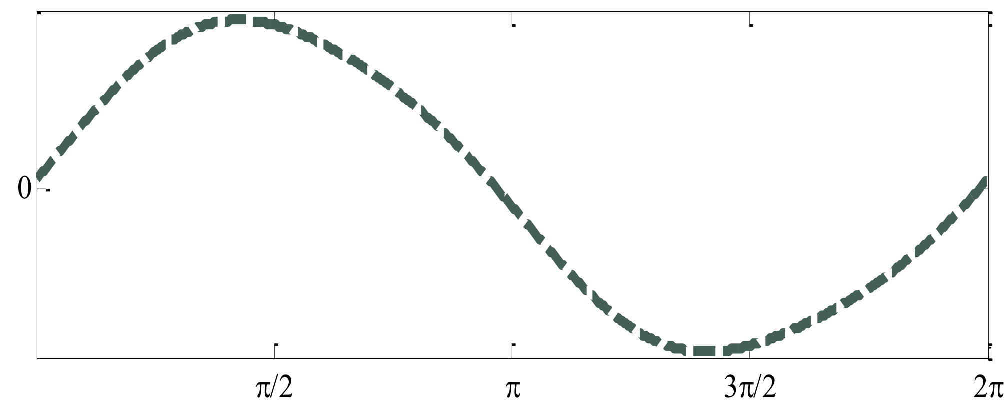


Incremental Standard Deviation Explanation

In the example shown here, we have calculated the allocation of total error for each of the three error signals shown. To do so, we sum the 3 signals to produce a total error signal, and we calculate the correlation and ratio of standard deviation between each individual error signal and the total error signal.

We see that the total error looks most similar to Error Signal 1, and thus Error Signal 1 has the highest allocation. Error signal 2 has the next most contribution to the error signal, and Error Signal 3 has the least.



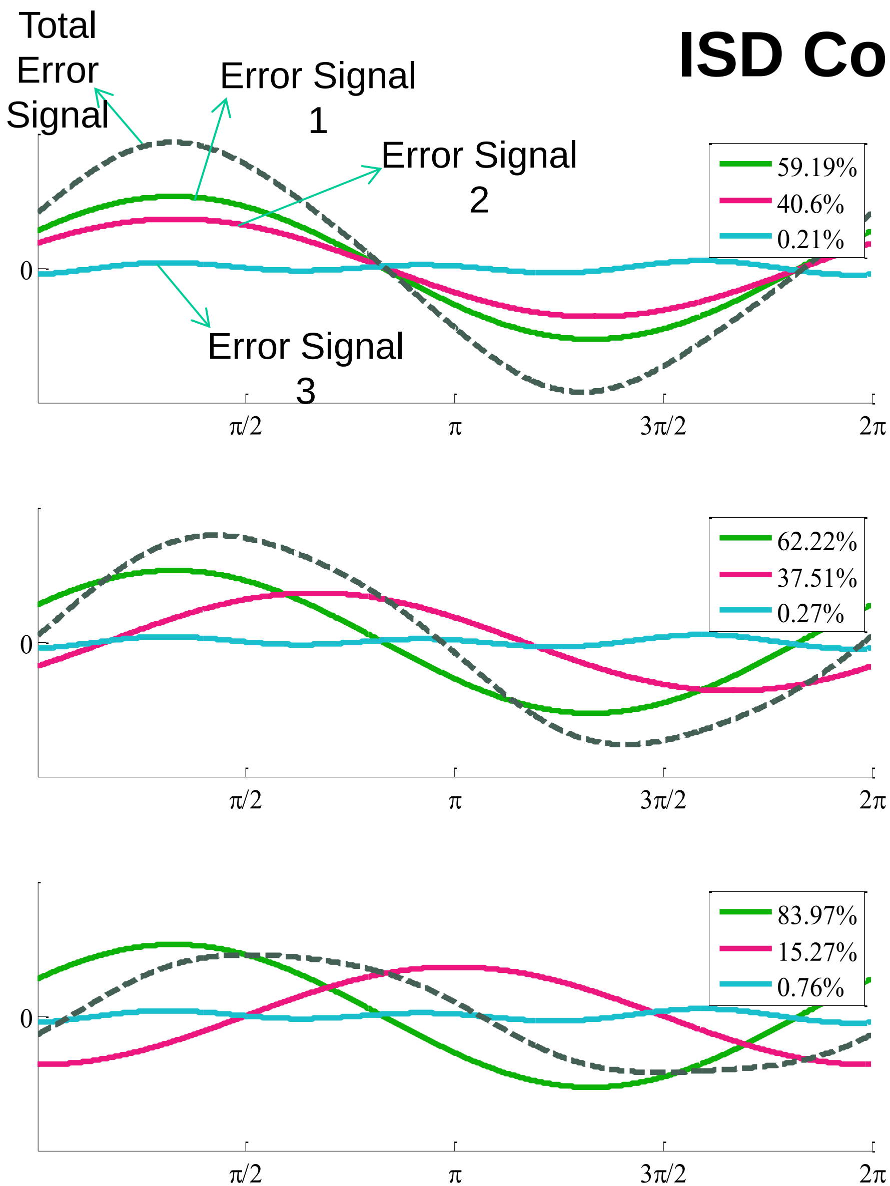


Error Signal 1   Error Signal 2

Error Signal 3

Error Signal 1+Error Signal 2+Error Signal 3 (Total Error Signal)

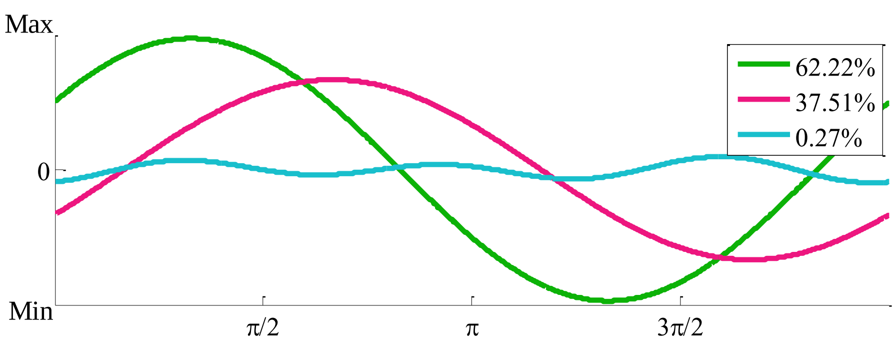
ISD Comparison

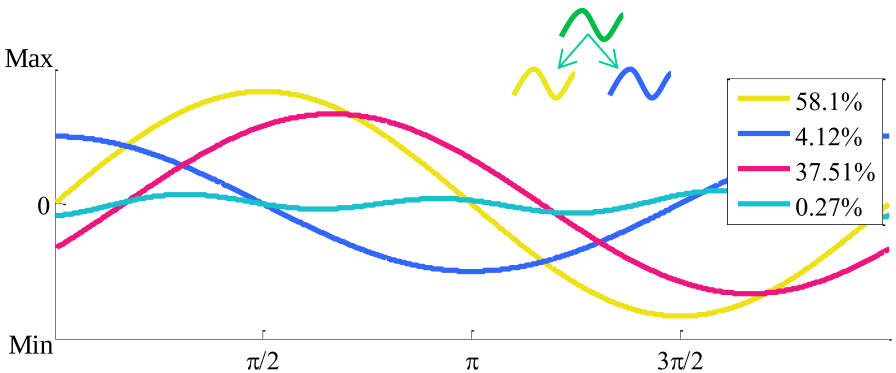


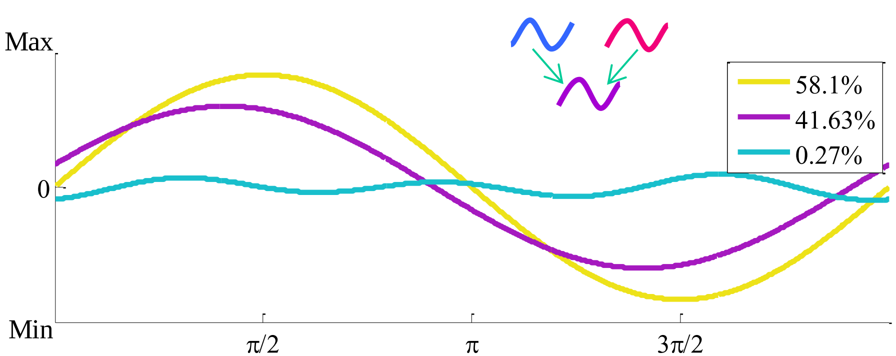
Here, the middle figure is identical to those in the previous slides; the top figure shows Error Signal 2 more in sync with Error Signal 1, and the bottom figure shows Error Signal 2 less in sync with Error Signal 1. When the two individual error signals are in sync, the allocations split between them fairly equally (though still somewhat larger for Error Signal 1 due to its larger magnitude). As Error Signal 2 slides out of sync with Error Signal 1, it contributes less and less to the total error signal, as the total error signal is still more in sync with Error Signal 1.

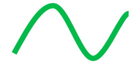
Additionally, we note that while Error Signal 3's allocation changes only slightly in absolute terms, it changes significantly relative to its size. This reflects impacts on a small magnitude signal, such as solar

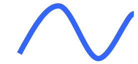
ISD Component Breakdown



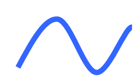


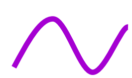


 $= 5\sin x + 3\cos x$

 $= 5\sin x$  $= 3\cos x$

Here, we demonstrate the component-dependent nature of ISD. Because each signal is compared to the sum of all signals, splitting a signal into the sum of its parts or combining two signals does not change the total allocation of the parts. For example, the original Error Signal 1 (green curve) is defined as 5sin(x)+3cos(x), and is allocated 62.22% of the total error signal need. Splitting it into Error Signal 1A (5sin(X)) and Error Signal 1B (3cos(x)), we get respective allocations of 58.10% and 4.12%, which add to 62.22%. Similarly, if we combine Error Signal 2 (pink curve), which is defined as 4sin(x-$^{\pi}/_{6}$) and has an allocation of 37.51%, and Error Signal 1B (3cos(x)), which has an allocation of 4.12%, we get an allocation of 41.63%, which is simply 37.51% + 4.12%.

 $= 4\sin\left(x - \frac{\pi}{6}\right)$  $= 3\cos x$

 $= 4\sin\left(x - \frac{\pi}{6}\right) + 3\cos x$

BONNEVILLE
POWER ADMINISTRATION

DERBS Rate Design Discussion

Lauren Tenney Denison

Rate Design Concerns

A few issues with the current DERBS rate design led to discussion with the DERBS sub team about changing from status quo:

1) Past under recovery of the DERBS costs
2) Whether incenting improvement of average scheduling behaviors is the correct price signal/reflects cost causation
3) Currently not all DERBS plants are equipped with revenue meters measuring generation in 5-minute increments. This is preventing implementation of DERBS using revenue meter data as originally envisioned

Issues With Status Quo Implementation

- The rate schedule currently states that BPA will use 5-minute Station Control Error data to charge the DERBS rate. Currently there are 8 out of 29 DERBS plants with revenue meters that do not record on 5-minute intervals which is preventing BPA from using revenue meters to apply DERBS charges for all customers. Two of these are customer owned.
- DERBS is currently billed on 5-minute averaged SCADA data, which is not considered revenue quality data (it is not validated and corrected as part of a regular monthly review like revenue meter data).
- If the status quo methodology is used in BP-18, BPA would like to move to using revenue meters during the rate period. This would not require a change to the rate schedule; it would only change the source of data from SCADA to revenue meters.

Rate Recovery Risk

- In the past several rate periods the DERBS rate has under recovered costs

	FY 2012	FY 2013	FY 2014	FY 2015
Actual Revenues	$4.08	$3.10	$1.65	$1.55
Rate Case Forecast	$5.75	$5.76	$3.12	$3.12
Actual less Rate Case	***-$1.66***	***-$2.66***	***-$1.47***	***-$1.56***

- Recent changes may have improved cost recovery
  - Large thermal facilities have moved out of the BA, reducing SCE for DERBS
  - DERBS customers' average Scheduling Control Error (SCE) has largely stabilized since 2013 which improves BPA's ability to forecast charges and recover costs under the current rate design
- A fixed billing determinant would ensure cost recovery
- Using fewer, variable data points to collect costs presents somewhat greater risk around cost recovery

Cost Causation Consideration

- The working numbers we have shared from the BP-18 reserve study assume BPA is holding out reserves to provide coverage in 99.7% of hours.
- This means that the amount of reserves held are not driven by a customer's average performance, but are driven by large scheduling errors.
- The current rate design has encouraged customers to improve their average scheduling behavior, but it hasn't significantly reduced the amount of reserves that BPA is holding on behalf of DERBS customers.

Rate Design Discussion

- The discussion with the DERBS sub-team led us to perform analysis on different rate designs to see if there is a better way to collect DERBS costs.
- If BP-18 costs are recovered through the status quo rate using SCADA data, the design results in 20-40% cost increases for most customers compared to BP-16.
- Any change from status quo will change how costs are allocated between customers.
- Using revenue meter data would result in similar rate results as SCADA data but with less billing errors.

Rate Design Alternatives

BPA Staff has analyzed several rate design alternatives. The different alternatives are summarized below and customer impacts are in the following slides:

1) Status Quo (including 3 MW deadband)
2) Status Quo without a deadband
3) Maximum Monthly Generation Imbalance
4) Nameplate
5) Nameplate in Operating Months

Analysis Assumptions

Revenue Requirement:

- Assumes Big 10 and Variable cost allocation (as presented at July 22 Gen Inputs rates workshop)
- All rate designs assumed to recover $2.17M total for DERBS

Customer Forecast for Status Quo Rate Design:

- Based on average monthly billing quantities from October 2013 – June 2016 for most customers
- Some exceptions for new plants or plants that appear to have had significant changes in operation during that time

Customer Forecast for Alternatives #2,#3:

- Based on average monthly performance from October 2013 – September 2015
- For plants which have historically been exempted from DERBS used “scaled” data based on nameplate (assumes average performance per MW)
- In initial analysis did not assume any changes in behavior based on rate design changes

Alternative #1: Status Quo

- Continue to use max 5-minute average scheduling control error during each hour (analyzed using SCADA data—would move to using billing meter data)
- Separate *Inc* and *Dec* rates
- Maintain 3 MW deadband

Pros:

- Incents customers to follow their schedule during the hour
- Customers that cause more imbalance pay more DERBS
- Deadband alleviates burden for small facilities that may generate in less than whole megawatt increments

Cons:

- Not directly tied to cost causation (avg performance does not drive the need for reserve capacity)
- Complex for customers to replicate/validate
- Risks around cost recovery
- Updates required to apply rate using revenue meters

Alt #1: Status Quo (Update to BP-18 Costs)

	(A)	(B)	(C)	(D)	(E)	(F)
						(E-D)/D
	Customer	Nameplate (MW)	Monthly Avg Total Gen (MWh)	BP-16 Rates	BP-18 Status Quo Rate Design	% Change from BP-16
1	Customer 1	248	136,473	43,357	59,770	38%
2	Customer 2	11	139	96,022	136,075	42%
3	Customer 3	74	21,967	37,649	46,880	25%
4	Customer 4	45	2	-	-	N/A
5	Customer 5	19	11,252	6,217	7,727	24%
6	Customer 6	39	12,822	5,427	7,475	38%
7	Customer 7	6	71	-	-	N/A
8	Customer 8	5.8	3,724	1,065	1,571	48%
9	Customer 9	752	235,032	287,756	373,361	30%
10	Customer 10	8	2,090	6,708	4,246	-37%
11	Customer 11	8	1,548	-	-	N/A
12	Customer 12	1636	514,930	467,995	593,468	27%
13	Customer 13	60	26,011	53,731	69,871	30%
14	Customer 14	62	27,701	149,507	196,712	32%
15	Customer 15	135.4	38,407	31,486	40,794	30%
16	Customer 16	3.4	2,200	897	1,316	47%
17	Customer 17	55	24,489	166,593	232,816	40%
18	Customer 18	10.6	2,025	2,254	3,251	44%
19	Customer 19	20	7,913	19,837	25,967	31%
20	Customer 20	36	9,758	86,256	119,083	38%
21	Customer 21	650	174,254	147,198	195,944	33%
22	Customer 22	17.9	6,740	7,796	11,218	44%
23	Customer 23	17.2	8,743	26,240	34,399	31%
24	Customer 24	34.75	2,568	7,804	10,977	41%
25	Customer 25	1.6	462	-	-	N/A
26	Customer 26	1.2	347	-	-	N/A

Alternative #2: Remove 3 MW Deadband

- Continue to use max 5-minute average scheduling control error (SCE) during each hour
- Separate *Inc* and *Dec* rates
- No deadband

Customer Impacts:

- Increases costs compared to status quo for customers whose SCE is often within the deadband allowing them to avoid DERBS charges

Pros:

- Incents customers to follow their schedule during the hour
- Customers that cause more imbalance pay more DERBS
- Increases likelihood of cost recovery because customers are not able to avoid DERBS costs by scheduling within the deadband

Cons:

- Not directly tied to cost causation (avg performance does not drive the need for reserve capacity)
- Complex for customers to replicate/validate
- Risks around cost recovery
- Customers who generate at less than a full MW are charged imbalance

Alt #2: Status Quo without Deadband

	(A)	(B)	(C)	(D)	(E)	(F)	(G)
						E-D	F/D
	Customer	Nameplate (MW)	Monthly Avg Total Gen (MWh)	BP-18 Status Quo Rate Design	BP-18 SCE Based No Dead band	$ Change from Status Quo	% Change
1	Customer 1	248	136,473	59,770	53,122	(6,648)	-11%
2	Customer 2	11	139	136,075	2,231	(133,844)	-98%
3	Customer 3	74	21,967	46,880	93,848	46,968	100%
4	Customer 4	45	2	-	21	21	N/A
5	Customer 5	19	11,252	7,727	38,412	30,685	397%
6	Customer 6	39	12,822	7,475	38,790	31,315	419%
7	Customer 7	6	71	-	773	773	N/A
8	Customer 8	5.8	3,724	1,571	31,391	29,819	1898%
9	Customer 9	752	235,032	373,361	359,564	(13,797)	-4%
10	Customer 10	8	2,090	4,246	20,558	16,311	384%
11	Customer 11	8	1,548	-	23,662	23,662	N/A
12	Customer 12	1636	514,930	593,468	461,490	(131,978)	-22%
13	Customer 13	60	26,011	69,871	45,858	(24,014)	-34%
14	Customer 14	62	27,701	196,712	206,786	10,073	5%
15	Customer 15	135.4	38,407	40,794	22,382	(18,412)	-45%
16	Customer 16	3.4	2,200	1,316	52,760	51,444	3910%
17	Customer 17	55	24,489	232,816	219,006	(13,810)	-6%
18	Customer 18	10.6	2,025	3,251	13,159	9,908	305%
19	Customer 19	20	7,913	25,967	42,675	16,708	64%
20	Customer 20	36	9,758	119,083	121,715	2,632	2%
21	Customer 21	650	174,254	195,944	167,313	(28,632)	-15%
22	Customer 22	17.9	6,740	11,218	29,934	18,716	167%
23	Customer 23	17.2	8,743	34,399	88,888	54,490	158%
24	Customer 24	34.75	2,568	10,977	37,108	26,131	238%
25	Customer 25	1.6	462	-	844	844	N/A
26	Customer 26	1.2	347	-	633	633	N/A

Alt #3: Max Hourly Generation Imbalance During the Month

- Bill based on the max positive and negative generation imbalance during the month
- Generation Imbalance reflects the average deviation from schedule over the hour
- Separate *Inc* and *Dec* rates
- No deadband

***Customer Impacts*:**

- Shifts to customers who currently schedule within the deadband
- Shifts to customers who schedule well on average, but experience some large deviations during the month

Pros:	Cons:
▪ More closely reflects cost causation (large deviations drive the amount of reserves needed) ▪ Provides incentive to match schedule ▪ Simple to implement/validate (same as GI charges) ▪ Could immediately implement with revenue meters	▪ Risks around cost recovery ▪ Does not capture minute-to-minute deviations within the hour ▪ Customer may schedule to avoid charges despite creating imbalance

Alt #3: Max Gen Imbalance During the Month

	(A)	(B)	(C)	(D)	(E)	(F)	(G)
						E-D	F/D
	Customer	Nameplate (MW)	Monthly Avg Total Gen (MWh)	BP-18 Status Quo Rate Design	BP-18 Monly Max Hourly GI Rate Design	$ Change from Status Quo	% Change
1	Customer 1	248	136,473	59,770	172,769	112,999	189%
2	Customer 2	11	139	136,075	10,696	(125,379)	-92%
3	Customer 3	74	21,967	46,880	104,269	57,390	122%
4	Customer 4	45	2	-	326	326	N/A
5	Customer 5	19	11,252	7,727	26,718	18,991	246%
6	Customer 6	39	12,822	7,475	35,318	27,843	373%
7	Customer 7	6	71	-	380	380	N/A
8	Customer 8	5.8	3,724	1,571	15,826	14,255	907%
9	Customer 9	752	235,032	373,361	466,123	92,762	25%
10	Customer 10	8	2,090	4,246	12,294	8,048	190%
11	Customer 11	8	1,548	-	9,802	9,802	N/A
12	Customer 12	1636	514,930	593,468	457,228	(136,240)	-23%
13	Customer 13	60	26,011	69,871	113,047	43,176	62%
14	Customer 14	62	27,701	196,712	107,191	(89,521)	-46%
15	Customer 15	135.4	38,407	40,794	10,208	(30,585)	-75%
16	Customer 16	3.4	2,200	1,316	17,296	15,981	1215%
17	Customer 17	55	24,489	232,816	145,062	(87,755)	-38%
18	Customer 18	10.6	2,025	3,251	16,117	12,866	396%
19	Customer 19	20	7,913	25,967	84,164	58,197	224%
20	Customer 20	36	9,758	119,083	65,736	(53,347)	-45%
21	Customer 21	650	174,254	195,944	213,689	17,745	9%
22	Customer 22	17.9	6,740	11,218	19,785	8,566	76%
23	Customer 23	17.2	8,743	34,399	46,699	12,300	36%
24	Customer 24	34.75	2,568	10,977	20,777	9,800	89%
25	Customer 25	1.6	462	-	800	800	N/A
26	Customer 26	1.2	347	-	600	600	N/A

Alt #4: Nameplate

- Bill based on nameplate of each plant (similar to VERBS)
- *Inc* and *Dec* costs recovered through one rate

***Customer Impacts*:**
- Customers with a low average SCE pay more compared to status quo

Pros:

- Ensures cost recovery
- Larger nameplate correlated with driving need for balancing reserves

Cons:

- Does not incent customer to match their schedule
- Charged to customers regardless if they are operating

Alt #4: Nameplate

	(A)	(B)	(C)	(D)	(E)	(F)	(G)
						E-D	F/D
	Customer	Nameplate (MW)	Monthly Avg Total Gen (MWh)	BP-18 Status Quo Rate Design	BP-18 Nameplate Rate Design	$ Change from BP-18 Status Quo	% Change from BP-18 Status Quo
1	Customer 1	248	136,473	59,770	136,190	76,420	128%
2	Customer 2	11	139	136,075	6,041	(130,034)	-96%
3	Customer 3	74	21,967	46,880	40,637	(6,242)	-13%
4	Customer 4	45	2	-	24,712	24,712	N/A
5	Customer 5	19	11,252	7,727	10,434	2,707	35%
6	Customer 6	39	12,822	7,475	21,417	13,942	187%
7	Customer 7	6	71	-	3,295	3,295	N/A
8	Customer 8	5.8	3,724	1,571	3,185	1,614	103%
9	Customer 9	752	235,032	373,361	412,964	39,603	11%
10	Customer 10	8	2,090	4,246	4,393	147	3%
11	Customer 11	8	1,548	-	4,393	4,393	N/A
12	Customer 12	1636	514,930	593,468	898,416	304,948	51%
13	Customer 13	60	26,011	69,871	32,949	(36,922)	-53%
14	Customer 14	62	27,701	196,712	34,048	(162,665)	-83%
15	Customer 15	135.4	38,407	40,794	74,355	33,562	82%
16	Customer 16	3.4	2,200	1,316	1,867	551	42%
17	Customer 17	55	24,489	232,816	30,203	(202,613)	-87%
18	Customer 18	10.6	2,025	3,251	5,821	2,570	79%
19	Customer 19	20	7,913	25,967	10,983	(14,984)	-58%
20	Customer 20	36	9,758	119,083	19,770	(99,313)	-83%
21	Customer 21	650	174,254	195,944	356,950	161,006	82%
22	Customer 22	17.9	6,740	11,218	9,830	(1,388)	-12%
23	Customer 23	17.2	8,743	34,399	9,445	(24,953)	-73%
24	Customer 24	34.75	2,568	10,977	19,083	8,107	74%
25	Customer 25	1.6	462	-	879	879	N/A
26	Customer 26	1.2	347	-	659	659	N/A

Alt #5: Nameplate in Operating Months

- Bill based on nameplate of each plant (similar to VERBS)
- Customers are only charged in months when the plant operates
- *Inc* and *Dec* costs recovered through one rate

Customer Impacts:

- Compared to status quo increases costs for customers who are good average schedulers. Compared to Nameplate, reduces costs for units that are not often online.

Pros:

- Does not charge customers when their plant is offline
- Larger nameplate correlated with driving need for balancing reserves

Cons:

- Only charging in operating months adds a risk of under-recovery
- Does not incent customers to follow their schedule

Alt #5: Nameplate During Operating Months

	(A)	(B)	(C)	(D)	(E)	(F)	(G)
						E-D	F/D
	Customer	Nameplate (MW)	Monthly Avg Total Gen (MWh)	BP-18 Status Quo Rate Design	BP-18 Namplate Charged in Operating Mo.	$ Change from BP-18 Status Quo	% Change from BP-18 Status Quo
1	Customer 1	248	136,473	59,770	130,539	70,769	118%
2	Customer 2	11	139	136,075	6,316	(129,758)	-95%
3	Customer 3	74	21,967	46,880	42,492	(4,388)	-9%
4	Customer 4	45	2	-	2,153	2,153	N/A
5	Customer 5	19	11,252	7,727	10,910	3,183	41%
6	Customer 6	39	12,822	7,475	22,394	14,920	200%
7	Customer 7	6	71	-	3,445	3,445	N/A
8	Customer 8	5.8	3,724	1,571	3,330	1,759	112%
9	Customer 9	752	235,032	373,361	431,811	58,450	16%
10	Customer 10	8	2,090	4,246	3,828	(418)	-10%
11	Customer 11	8	1,548	-	4,594	4,594	N/A
12	Customer 12	1636	514,930	593,468	939,420	345,951	58%
13	Customer 13	60	26,011	69,871	31,582	(38,289)	-55%
14	Customer 14	62	27,701	196,712	35,601	(161,111)	-82%
15	Customer 15	135.4	38,407	40,794	61,551	20,757	51%
16	Customer 16	3.4	2,200	1,316	1,952	637	48%
17	Customer 17	55	24,489	232,816	31,582	(201,234)	-86%
18	Customer 18	10.6	2,025	3,251	6,087	2,836	87%
19	Customer 19	20	7,913	25,967	5,742	(20,225)	-78%
20	Customer 20	36	9,758	119,083	18,088	(100,995)	-85%
21	Customer 21	650	174,254	195,944	342,138	146,194	75%
22	Customer 22	17.9	6,740	11,218	10,278	(940)	-8%
23	Customer 23	17.2	8,743	34,399	9,877	(24,522)	-71%
24	Customer 24	34.75	2,568	10,977	15,797	4,820	44%
25	Customer 25	1.6	462	-	817	817	N/A
26	Customer 26	1.2	347	-	595	595	N/A

Next Steps

- DERBS Sub-Team Meeting on Aug 30 to discuss analysis and customer positions
- Request customer comments by Friday, September 2 on whether a rate design is needed
- Staff will share leanings for Initial Proposal at Generation Inputs Workshop on September 15

Updates

Daniel Fisher

Level of Service for BP-18 Initial Proposal

- Balancing Reserve Capacity Forecast
  - *Incs* at 99.7%
  - *Decs* at 99.7%

Intentional Deviation

- All wind projects that elect Uncommitted Scheduling will be subject to Intentional Deviation.
- Persistent Deviation applies only to wind projects in the Customer-Supplied Generation Imbalance pilot.

Embedded and Variable Cost

- Entire System method
- Status Quo method of Big 10 will have to be adjusted for the refinancing
- Variable costs for *Incs* and *Decs*

Planning for Risk

- Methods used to address risk in ratemaking
  - Formula rates
  - Use of cash reserves
  - Other risk tools that Transmission Services may or may not use
- Compare to Status Quo BP-16 Settlement
- Should Transmission Services treat ancillary and control area service rates differently from other transmission rates?

No Mid- Rate Period Election for BP-18 Initial Proposal

- Customers will make elections by the first business day in April per the BPA business practice for the two-year rate period (October 2017-September 2019).
- For BP-18, this is 3 April 2017.